

Interfacility Trauma Triage & Transfer Guidelines

Trauma Reference Manual

Acknowledgements

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Introduction

Preface

Since the landmark white paper “Accidental Death and Disability: The Neglected Disease of Modern Society”, published in 1966 by the National Academy of Science and the National Research Council, there have been considerable improvements in the care of injured patients in the United States.¹ Although unintentional injuries are still the leading cause of death among children and adults ages 1-44, and cost an estimated \$117 billion per year in America,² the development of trauma systems across the country is significantly improving morbidity and mortality from injury. Inclusive trauma care systems are decreasing the number of preventable deaths by 15-20 percent.^{3, 4, 5, 6, 7}

Since serious injury is a time-sensitive condition, a public health safety net in the form of a trauma system must already be in place at the time of injury to get **the right patient to the right place in the right amount of time**. Trauma systems, by their very nature, are designed to recognize, stabilize and deliver severely injured patients to definitive care in the shortest amount of time possible. By doing so, trauma systems have been shown to reduce injury related morbidity and mortality. A truly mature trauma system can also have a potentially positive impact through prevention initiatives.

Regionalization of trauma systems in a defined geographical area is essential to provide the highest level of care possible without unnecessary duplication of resources. Coordination of emergency medical services, hospitals and rehabilitation facilities in a unified approach is imperative. Establishing triage criteria for both primary (prehospital) and secondary (interfacility) patient severity levels ensures uniformity in the prioritization of injured patients and provides a common language for the trauma system. Categorizing all hospitals (Inclusive System) according to their resources allows injured patients to be delivered quickly to the appropriate level of care. The Model Trauma Care System Plan provides useful guidelines for trauma system development.⁸ Both the American College of Emergency Physicians and the American College of Surgeons Committee on Trauma have provided decades of leadership in the promulgation of trauma system development.

The ultimate goal of the mature regional trauma system is simply to match the needs of injured patients to the closest hospital with the capability to provide definitive care in the most appropriate timeframe. Attention to undertriage as well as overtriage of injured patients is important. While overtriage may unnecessarily tax the resources of the higher level trauma centers, undertriage can result in unnecessary morbidity or mortality to patients. Secondary interfacility overtriage, like delayed transfers, can be problematic in an immature trauma system.^{9, 10, 11} Delayed transfers may be due to stabilization attempts but also caused by unnecessary testing. Once injuries beyond the capability of a referring hospital are identified, non-therapeutic testing should be suspended and prompt transfer initiated. Reducing both prehospital times and interfacility transfer times are essential components of an efficient and effective regionalized trauma system.

Despite improvements in patient outcomes demonstrated by trauma system development over the past three decades, much of the United States remains outside any organized system of trauma care and many difficulties and challenges remain.¹² Further

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regionalization of trauma care can only be accomplished by health care professionals working in collaboration with their public health colleagues at the local, state, regional and national levels in championing development. A survey conducted by HRSA in 2002 revealed that at least 34 states had passed enabling legislation allowing for trauma system development.

Despite the proven value of trauma systems, challenges remain to full implementation allowing all citizens immediate access to this lifesaving public health safety net.¹³ If fully incorporated into a system of injury prevention, acute care and rehabilitation, trauma systems not only serve those in need of acute care for injuries but also become the framework for disaster response as well as models and infrastructure for other acute time-sensitive conditions. Challenges to nationwide development and deployment include the need for provider education as well as educating the public and elected officials regarding the benefits of trauma systems. Adequate funding for both readiness and performance costs, and recognizing the need for all locales to organize into community wide on-call systems providing the maximum level of care for injured patients based on each respective area's resources and capabilities are additional challenges that must be met.

¹ Accidental Death and Disability: The Neglected Disease of Modern Society. National Academy of Science, Washington, D.C. 1966.

² Center for Disease Control Publications 2004-2006.

³ Mullins R., Mann N. (1999). Population-Based Research Assessing the Effectiveness of Trauma Systems. *Journal of Trauma* 47 (supplement), S59-S66; abstract.

⁴ Utter, G.H., Maier, R.V., Rivara, F.D., et al. (2006). Inclusive Trauma Systems: Do They Improve Triage or Outcomes of the Severely Injured? *Journal of Trauma* 60. 529-535; discussion 535-537.

⁵ Celso B., Tepas J., Langland-Orbon B., et al. (2006). A Systematic Review and Meta-Analysis Comparing Outcomes of Severely Injury Patients Treated in Trauma Centers Following the Establishment of Trauma Systems. *Journal of Trauma* 60, 371-378, discussion, abstract 378.

⁶ MacKenzie, E.J., Rivara, F.P., Jurkovich, G.J., et al. (2006). A National Evaluation of the Effect of Trauma Center Care on Morbidity. *New England Journal of Medicine* 354. 366-378. abstract.

⁷ Sampalis J.S (1999). Trauma Care Regionalization: A Process-Outcome Evolution, *Journal of Trauma* 01-Apr-1999; 46 (4): 565-79: discussion 579-81.

⁸ Model Trauma Care System Plan. Department of Health and Human Services. Health Resources and Services Administration, Rockville (MD) 1992.

⁹ Ciesla D., Sava J., Street J., et al. (2008) Secondary Overtriage: A Consequence of an Immature Trauma System. *Journal of the American College of Surgeons* Vol 206 (Issue 1)

¹⁰ Newgard C. D. (2007) The Benefit of Higher Level of Care Transfers of Injured Patients from Non-tertiary Hospital Emergency Departments. *Journal of Trauma* 63, (5): 965-71.

¹¹ Svensen J. (2008). Trauma Systems and Timing of Patient Transfer: Are We Improving: *American Journal of Emergency Medicine*-Vol 26, (Issue 4)

¹² MacKenzie E., Hoyt D. Sacra J., et al. (2003) National Inventory of Hospital Trauma Centers. *Journal of the American Medical Association* 289, 1515-22.

¹³ Hoyt D. Coimbra R. (2007) Trauma Systems *Surgical Clinics of North America* Vol 87 (Issue 1)

Introduction

Overview of Oklahoma Trauma System

The Oklahoma Institute for Disaster and Emergency Medicine (OIDEM), a part of the Department of Emergency Medicine at the OU School of Community Medicine, and the Oklahoma State Department of Health are pleased to provide this information on Oklahoma's Interfacility Trauma Triage and Transfer Guidelines.

This educational program represents one of the two main missions of OIDEM and the Department of Emergency Medicine-- to develop educational and research programs that support disaster medicine and emergency medicine, including trauma and other time-sensitive conditions. The other purpose of the Department of Emergency Medicine is to provide an Allopathic Emergency Medicine Residency Program for Oklahoma. OIDEM's faculty and staff contributed to the development of this material with the support of the Oklahoma State Department of Health.

To produce this material, OIDEM worked in partnership with the Oklahoma State Department of Health and its Trauma Division, the Lead Regulatory Agency in our state, along with the Oklahoma State Trauma System Medical Audit Committee (MAC), the Regional Trauma Advisory Boards (RTABS) and the Oklahoma Trauma System Improvement and Development Advisory Council (OTSIDAC). This trauma resource manual on Interfacility Trauma Triage and Transfer Guidelines is the first in a series of Oklahoma Trauma Education Programs (OTEP) to be developed to further the common goal of educating providers across the state in both system design and function of our state's Trauma System.

The word triage is derived from a French word meaning "to sort" and involves the initial evaluation of injured patients in either the prehospital setting or in a hospital emergency department. Proper triage in the prehospital setting should ensure that P-1 injured patients who are seriously injured are taken primarily to a trauma center capable of treating their injuries, or if in a rural setting and time and distance does not allow, to a Level III or IV Trauma Center for initial stabilization and secondary transfer. Most P-2 and P-3 injured patients can receive their definitive care at a Level III or Level IV Trauma Center unless there are occult or single system injuries requiring resources that exceed the hospital's capabilities. Interfacility or secondary transfer of seriously injured patients will often be necessary if the initial receiving hospital does not have the resources to

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definitively care for the patient's injuries. When this is the case, time should not be wasted in the performance of non-therapeutic testing, as time to definitive care has been proven to impact morbidity and mortality. Proper trauma triage should ensure that patients who are seriously injured are taken to a trauma center capable of treating their injuries in an appropriate time frame.

One of the accepted performance standards of any trauma system is overtriage and undertriage rates. While overtriage may unnecessarily tax the resources of the higher level trauma centers, undertriage can result in unnecessary morbidity and mortality. The measurement of overtriage and undertriage rates is equally important in both the prehospital as well as the hospital setting. Establishing triage criteria for both primary (EMS) and secondary (Interfacility) patient severity levels ensures uniformity in the prioritization of injured patients and provides a common language for the trauma system.

The goal of the Oklahoma Trauma System is to create a statewide system of care that delivers **the right patient to the right place in the right amount of time**. Achievement of this goal requires statewide coordination of providers and resources. Oklahoma's Trauma System starts with common definitions for categorization of hospitals and patient prioritization. It then matches patients on a regional basis with the closest facility with the capability to provide definitive care for each injury. If necessary, the interfacility transfer of patients, including transfer outside the region when needed, will be coordinated after initial stabilization taking into consideration the severity and time-sensitivity of injury.

Interfacility transfers may be coordinated through the Trauma Referral Center (TReC) which utilizes EMResource to determine the real time resources in all Oklahoma Hospitals thereby assigning each patient to the closest hospital with the capability to provide definitive care for their specific injury.

Oklahoma is divided into eight Trauma Regions each with its own RTAB. Each RTAB is charged with assessing the resources of its region and establishing a prehospital regional patient delivery plan for local emergency medical services based on OTSIDAC criteria. The care of most seriously injured patients begins with a 911 dispatched EMS unit. Each RTAB has developed a regional plan for delivering patients to the closest most appropriate facility depending on patient priority. Depending on time and distance, some patients may bypass closer lower level facilities to be delivered directly to a higher level trauma center. Likewise, some patients might require air transport, even air rendezvous with EMS, again, depending on time and distance.

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If the initial receiving facility is unable to definitively manage the patient's level of injury, then TReC will help facilitate an interfacility transfer based on a statewide plan utilizing common definitions for prioritization of patients and capabilities of trauma centers.

The purpose of this material in OTEP's Interfacility Trauma Triage and Transfer Guidelines is to provide education which will assist providers when an interfacility transfer is required. The program includes—

- A quick reference guide for establishing the priority of an injured patient
- A brief description of trauma center levels including numbers and locations
- Summary of patient priority criteria
- Introduction to TReC, how to contact and assist the call taker with your request
- Introduction to EMResource
- Patient Interfacility Triage and Transfer Guidelines
- Patient Stabilization Guidelines including air and ground considerations
- Significant single system injuries, their stabilization and transfer

OIDEM believes this OTEP educational module will help all providers better understand Oklahoma's Trauma System Design and purpose. We welcome your comments, questions or feedback.

otep@oudem.org

Introduction

Oklahoma Trauma Center Levels

Level I

This is the highest level of trauma center. A Level I Trauma Center has an emergency department staffed with emergency physicians and nurses, and maintains a surgeon-led trauma team with rigorous response standards and the capability of rapid surgical intervention when necessary. Comprehensive specialty services are available including but not limited to neurological, cardiovascular and orthopedic surgery. There is a hospital wide commitment with immediate access to surgery, recovery and critical care beds. In addition this level of trauma center provides research and education activities.

Level II

A Level II Trauma Center has the same resources and clinical capabilities of a Level I and is staffed to provide prompt and comprehensive care to seriously injured patients. A Level II like a Level I functions as a tertiary referral facility capable of managing all types of injured patients. Unlike a Level I a Level II will not provide the same level of research or education activities.

Level III

A Level III Trauma Center is a facility which staffs a 24 hr. emergency department with at least a physician and nursing staff and has general surgical and some surgical subspecialties such as orthopedics, on an on-call basis. Prompt anesthesia and operating room capabilities are required in addition to X-ray, laboratory services, recovery room and intensive care beds. This is an intermediate facility capable of handling minor to moderate trauma, including P-2 injured patients in a high energy event but currently stable and patients with less severe single system injuries.

A Level III trauma center can function as an enhanced trauma center on days when additional on-call resources, such as neurosurgery, are available in addition to general surgery and orthopedics. An enhanced Level III trauma center is referred to as a regional trauma center in this document as well as the prehospital trauma triage reference manual. This information is tracked through EMResources.

Level IV

A facility that staffs a 24 hr. emergency department with at least one of the following:

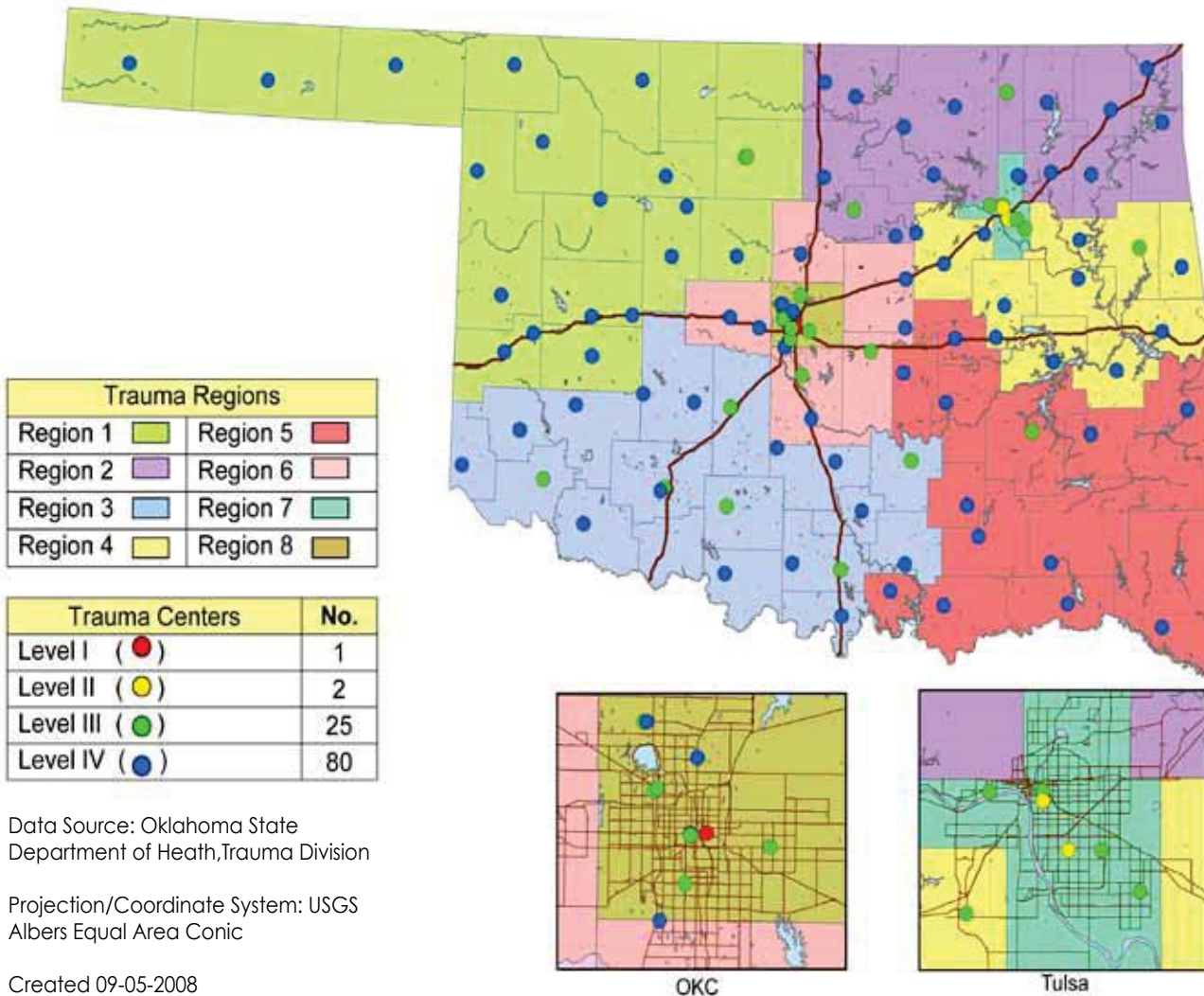
- Physician Assistant (licensed)
- Nurse Practitioner
- Registered Nurse
- Paramedic (with special trauma training as defined by that facility)

This is primarily a referral facility used for rapid stabilization and transfer of seriously and moderately injured patients to a higher level of trauma center for definitive care.

Each hospital is encouraged to maintain specialty on-call coverage consistent with its resources and capabilities. Patient transfers, when clinically indicated, should occur consistent with the injury to ensure that appropriate care is provided. Hospital-to-hospital transfers should be compliant with EMTALA regulations. EMTALA regulations are satisfied when patients are transferred consistent with Oklahoma's trauma system design or by adhering to an established communitywide on-call system.

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Trauma Regions and Hospitals by Trauma Level, Oklahoma, 2008



Data Source: Oklahoma State
Department of Health, Trauma Division

Projection/Coordinate System: USGS
Albers Equal Area Conic

Created 09-05-2008



Disclaimer: This map is a compilation of records, information and data from various city, county and State offices and other sources, affecting the area shown, and is the best representation of the data available at the time. The map and data are to be used for reference purposes only. The user acknowledges and accepts all inherent limitations of the map, including the fact that the data are dynamic and in a constant state of maintenance.



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PRE-HOSPITAL/FIELD TRAUMA TRIAGE

Patient Priority Criteria

Trauma Triage

Since patients differ in their initial response to injury, trauma triage is an inexact science. Current patient identification criteria does not provide 100% sensitivity and specificity for detecting injury. As a result, trauma systems are designed to over-triage patients in order not to miss a potentially serious injury. Under- triage of patients should be avoided since a potentially seriously injured patient could be delivered to a facility not prepared to manage their injury. Large amounts of over-triage is not in the best interest of the Trauma System since it will potentially overwhelm the resources of the facilities essential for the management of severely injured patients.

Priority One Trauma Patients

Patients with high energy blunt or penetrating injury causing physiological abnormalities or significant single or multi-system anatomical injuries

These patients have time sensitive injuries requiring the resources of a Designated Level I, Level II or Regional Level III Trauma Center. These patients should be directly transported to a Designated Level I Level II or Regional Level III facility for treatment but may be stabilized at a Level III or Level IV facility, if needed, depending on location of occurrence and time and distance to the higher-level trauma center. If needed, these patients may be cared for in a Level III facility if the appropriate services and resources are available.

Priority Two Trauma Patients

Patients with potentially time sensitive injuries due to a high energy event (positive mechanism of injury) or with a less severe single system injury, but currently with no physiological abnormalities or significant anatomical injury

These patients do not have physiological abnormalities or significant anatomical injuries and can be transported to a trauma facility with the resources to perform a trauma evaluation and provide appropriate care for their injury.

(More Trauma Triage Criteria on next page)

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(Trauma Triage Criteria continued from previous page)

Priority Three Trauma Patients

Patients without physiological abnormalities, altered mentation, neurological deficit, or a significant single system injury. These patients have generally been involved in a low energy event

These patients may be evaluated and treated at their hospital of choice or the closest appropriate hospital.

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Physiological Compromise Criteria

- Hemodynamic Compromise-Systolic BP < 90mmHg
Other signs that should be considered include:
 - Sustained tachycardia
 - Cool diaphoretic skin
- Respiratory Compromise- RR < 10 or > 29 breaths/minute
or < 20 in infant < 1 year
- Altered Mentation of trauma etiology- GCS < 14

Anatomical Injury Criteria

- Penetrating injury of head, neck, chest/abdomen, or extremities proximal to elbow or knee
- Amputation above wrist or ankle
- Paralysis or suspected spinal fracture with neurological deficit
- Flail chest
- Two or more obvious proximal long bone fractures (upper arm or thigh)
- Open or suspected depressed skull fracture
- Unstable pelvis or suspected pelvic fracture
- Tender and/or distended abdomen
- Burns associated with Priority 1 Trauma
- Crushed, degloved, or mangled extremity

High Energy Event or Positive Mechanism of Injury

Patient involved in rapid acceleration deceleration events absorb large amounts of energy and are at an increased risk for severe injury despite normal vital signs on their initial assessment. Five to fifteen percent of these patients, despite normal vital signs and no apparent significant anatomical injury on initial evaluation will have a serious injury discovered after a full trauma evaluation with serial observations. Determinates to be considered are direction and velocity of impact and the use of personal protection devices. Motor vehicle crashes when occupants are using personal safety restraint devices may not be considered a high energy event. Personal safety devices will often protect the occupant from absorbing high amounts of energy even when the vehicle shows significant damage.

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High Energy Events

- o Ejection (partial or complete) of the patient from an enclosed vehicle
- o Auto/pedestrian, auto/bike or motorcycle crash with significant impact (> 20 mph) with the patient thrown or run over by a vehicle
- o Falls greater than 20 feet for adult, > 10 feet for pediatric or distance 2-3 times height of patient
- o Significant assault or altercations
- o High risk auto crash
 - The following motor vehicle crashes particularly when the patient has not used personal safety restraint devices:
 - Death in the same passenger compartment
 - Rollover
 - High speed auto crash
 - Compartment intrusion greater than 12 inches at occupant site or > 18 inches at any site
 - Vehicle telemetry data consistent with high risk of injury

Examples of Priority 2 Single System Injuries

- **Neurology:** Isolated head trauma with transient loss of consciousness or altered mental status but currently alert and oriented.
- **Orthopedic:** Single proximal and distal extremity fractures (including open) from high energy event, isolated joint dislocations-knee, hip, elbow, shoulder without neurovascular deficits, and unstable joint (ligament) injuries without neurovascular deficits.
- **Maxillofacial trauma:** Facial lacerations such as those requiring surgical repair, isolated open facial fractures or isolated orbit trauma with or without entrapments, or avulsed teeth.

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Medic Discretion

Since trauma triage is an inexact science and patients differ in their response to injury, clinical judgment by the medic at the scene is an extremely important element in determining the destination of all patients. If the medic is concerned that a patient may have a severe injury which is not yet obvious, the patient may be upgraded in order to deliver that patient to the appropriate level Trauma Center. EMS provider suspicion for a severe injury may be raised by but not limited to the following factors:

- o Age greater than 55
- o Age less than 5
- o Extremes of environment
- o Patient's previous medical history such as:
 - Anticoagulation or bleeding disorders
 - End stage renal disease on dialysis
- o Pregnancy (> 20 weeks)

Examples of Priority 3 Single System Injuries

Same level fall with extremity or hip fracture

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Glasgow Coma Scale

The Glasgow Coma Scale (GCS) evaluates eye opening, verbal and motor responses, and brainstem reflex function.

- It is considered one of the best indicators of clinical outcome
- 15 is normal
- 13-14 is associated with mild head injury
- 8-12 is associated with moderate head injury
- <8 is associated with severe head injury

	Adult	1-5 years*	0-1 years**
Eye Opening			
4	<i>spontaneously</i>	<i>spontaneously</i>	<i>spontaneously</i>
3	<i>to command</i>	<i>to command</i>	<i>to command</i>
2	<i>to pain</i>	<i>to pain</i>	<i>to pain</i>
1	<i>no response</i>	<i>to response</i>	<i>to response</i>
Best Verbal Response			
5	<i>oriented</i>	<i>appropriate words, phrases</i>	<i>coos, babbles, smiles</i>
4	<i>confused</i>	<i>inappropriate words</i>	<i>cries</i>
3	<i>inappropriate words</i>	<i>cries, screams</i>	<i>inappropriate cries, screams</i>
2	<i>incomprehensible</i>	<i>grunts</i>	<i>grunts</i>
1	<i>no response</i>	<i>no response</i>	<i>no response</i>
Best Motor Response			
6	<i>obeys commands</i>	<i>spontaneous</i>	<i>spontaneous</i>
5	<i>localizes pain</i>	<i>localizes pain</i>	<i>localizes pain</i>
4	<i>withdraws from pain</i>	<i>flexion withdrawal</i>	<i>flexion withdrawal</i>
3	<i>abnormal flexion</i>	<i>abnormal flexion</i>	<i>abnormal flexion</i>
2	<i>extension</i>	<i>no response</i>	<i>no response</i>
1	<i>no response</i>	<i>no response</i>	<i>no response</i>

*age 2-5 for verbal response

**age 0-2 for verbal response

Teasdale G, Assessment of coma and impaired consciousness. *A practical scale*. Lancet 1974, 2:81-84

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Pediatric Trauma Score

Components	+2	+1	-1	Score
Weight	> 20 kg (44 lbs.)	10-20 kg (22-44 lbs.)	< 10 kg (22 lbs.)	
Airway	Patent ¹	Maintainable ²	Unmaintainable ³	
Systolic B/P	> 90 mm Hg	50-90 mm Hg	< 50 mm Hg	
Pulses	Radial	Carotid	Nonpalpable	
CNS	Awake	+ LOC ^a	Unresponsive	
Fractures	None	Closed or suspected	Multiple closed or open	
Wounds	None	Minor*	Major, penetrating or burns ^a	
Total Score				-6 to 12, decreases with severity of condition

9-12 - Minor trauma
 6-8 - Potentially life threatening
 0-5 - Life threatening
 < 0 - Usually fatal

¹ No assistance required.

² Protected by patient, but requires continuous monitoring for changes, may require positioning.

³ Requires airway adjuncts NPA, OPA and ET or suctioning.

^a Responds to voice, pain, or temporary loss of consciousness noted.

* Abrasions, minor lacerations, burns < 10% and not involving hands, face, feet, or genitalia.

^a Penetrating, major avulsions, lacerations, burns > 10% or involving hands, face, feet or genitalia.

TEPAS JJ et coll. The Pediatric Trauma Score as a predictor of injury severity in the injured child. *J. Pediat. Surg.* 1987; 22:14-8

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TReC

TReC is the Trauma Referral Center and its purpose is to facilitate the interfacility transfer of injured patients to the closest hospital with the capability to provide definitive care for the patient and to collect an accurate record of all transfers in Regions 7 and 8. It is not intended to interfere with normal referral patterns but is primarily intended for unassigned patients particularly those with time sensitive conditions.

Mission of TReC

1. Ensure patients are transferred to the closest and most appropriate facility
2. Refer patients within the Region of origin if possible
3. Reduce over-triage and under-triage to Region 7 and 8
4. Preserve highest-level resources for the most severely injured
5. Help limit demands on scarce specialists
6. Maintain a record of all transfers of injured patients into Region 7 and 8
 - a. Receive calls on all trauma patients transported into Regions 7 or 8 by ambulance including:
 - i. Pre-hospital direct patient transports
 - ii. Ambulance initiated data reporting of interfacility transports
 - iii. Hospital requested 'facilitation' of patient transfers
 - b. Ensure trauma patients from anywhere in the state inbound to facilities in region 7 or 8 are directed to facilities with appropriate clinical capacity and capability
 - c. Record each transport for quality improvement review

The following information is necessary to assist TReC in determining destination:

1. Determine **priority** of patient

If a patient is identified as Priority 1, implement the following immediately.

- Initiate internal Trauma Treatment Protocol if definitive surgical care and critical care monitoring are available.
- If definitive surgical care or critical care monitoring are not available then immediate stabilization & transfer per regional plan to appropriate designated facility.
- Stabilize life threatening conditions. **DO NOT delay transfer decision by performing unnecessary (non-therapeutic) diagnostic testing.**
- Consultation with receiving facility and/or physician is important as additional care may be necessary prior to transfer. Stabilization may involve surgical intervention prior to transfer.
- **DO NOT delay transfer waiting for diagnostic studies to be completed,** however they can be continued while transfer protocol is activated.

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2. Provide TReC with priority and geographic **location** of patient. TReC may assist with establishing the priority of the patient if necessary.
3. TReC will determine closest facility with capability and capacity for patient assignment
4. TReC will inform caller of transfer destination and steps needed to complete referral process
5. **TReC will transfer caller** to receiving facility to give report and receive any recommendations regarding stabilization prior to transfer
 - For unstable P-1 injured patients, either multi-system or potentially life or limb threatening single system, transferring the caller to the receiving facility should not interfere with the destination decision made by utilizing Oklahoma's Trauma System established criteria. In most instances, it should not unduly delay the stabilization and transfer of the patient. Exceptions for immediate transfers might exist if life threatening conditions can be temporarily managed at the referring facility. One example is surgical intervention to control hemorrhage.
 - In the case of non-life and non-limb threatening single system injuries, the patient might best be served by delayed transfer hours or days later.
6. Questions regarding specific patients and specific injuries can best be answered by phone consultation with a trauma center physician. TReC can arrange a consultation if necessary.

Documentation

- Ensure that complete documentation is transferred with the patient
 - Copies of all notes, exams, and consults
 - Copies of all lab results
 - Copies of all EKG's
 - Copies or CD's of all x-rays and CT scans
- Lab results and radiology reports can be faxed to the receiving hospital when they are available
- Recent H&P's, EKG's and x-rays for comparison would generally be helpful, if available
- Cell phones and internet connected computers are capable of sending and receiving quality digital pictures to the referral physician

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TReC Matrix

Simplified TReC Patient Prioritization and Hospital Selection Matrix					
1st - Determine Priority of Patient			2nd - Select Appropriate Hospital Type	3rd - Determine Location	
System:	Patient Priority:	Adult / Peds	Prioritization Criteria (TReC worksheets):	Disposition by Hospital Level:	Hospital Selection Notes: (check EMResource for availability)
Multi/unstable	P-1	Adult	≥ 16 y.o. & any "box" checked on P-1 page	Closest Level I, II or Regional Level III	
	P-1	Peds	≤ 16 y.o. & any "box" checked on P-1 page	St Francis (Region 7-Tulsa) / OU (Region 8-OKC)	
MOI or SS	P-2	Adult	No P-1 "Boxes", at least one P-2 box	Closest Level III in Region (with appropriate on-call capability)	-Spinal - Imaging capabilities, EP, Orthopedics -Thoracic - Imaging capabilities, EP, GS -Abdominal/Pelvic - Imaging capabilities, EP, GS -CNS - Imaging capabilities, EP -Skeletal - Imaging capabilities, EP, Orthopedics -MOI Alone - Imaging capabilities, EP -Hand, OMF, Burn, OB - See specific single system flow diagram
MOI or SS	P-2	Peds	No P-1 "Boxes", at least one P-2 box	St Francis (Region 7-Tulsa) / OU (Region 8-OKC)	
MOI or SS	P-3	Adult	No P-1 or P-2 "Boxes"	Closest Level III	
MOI or SS	P-3	Peds	No P-1 or P-2 "Boxes"	Closest Level III	
ORTHO	P-3	Both	No P-1 or P-2 "Boxes"	Closest Level III WITH ORTHO on Call	check EMResource for ORTHO capability
HAND	P-1	Both	See "Hand Injury"	Hand Surgeon On Call	Region 1, 3, 6 → Region 8 Region 2, 4, 5 → Region 7
HAND	P-2 & P-3	Both	See "Hand Injury"	Closest ORTHO On Call	check EMResource for ORTHO capability
MAXILLOFACIAL	P-1	Both	Requires OMF Surgeon	OMF Surgeon On Call	Region 7-Tulsa = "On Call" Level II or Level III
MAXILLOFACIAL	P-2 & P-3	Both	Requires Consultation	Phone to phone consult	Region 8 OKC-On Call Hospital Consult w/closest "on call" Maxillofacial, per EMResource
BURNS	P-1	Adult	Requires immediate care by burn specialist	Hillcrest (Region 7-Tulsa) / Baptist (Region 8-OKC)	
BURNS	P-1	Peds	Requires immediate care by burn specialist	Hillcrest (Region 7-Tulsa) Children's (Region 8-OKC)	
BURNS	P-2	Adult	Requires urgent consultation & poss. transfer	Closest Level III	
BURNS	P-2	Peds	Requires urgent consultation & poss. transfer	Hillcrest (Region 7-Tulsa) Children's (Region 8-OKC)	
BURNS	P-3	Adult		Closest Level III	
BURNS	P-3	Peds		Closest Level III	

See Single system Flow Diagram for Hand, Maxillofacial, Thermal, Burn and Obstetric Injuries

MOI = Mechanism of Injury SS = Single System injury

EP = Emergency Physician GS = General Surgeon OB = Obstetrician

Introduction

EMResource

What is EMResource?

EMResource is an Internet-based resource management communication tool developed primarily to manage ambulance diversion. Users within a region can log on to a secure website to view the diversion status of every hospital in their specific region. EMResource recently developed enhanced features that include additional functions such as biosurveillance, mass casualty resources, public health alerts and disease tracking.

While ambulance diversion remains the core application, Oklahoma's Trauma System design incorporates the system to track real time availability of all specialists statewide. This function enables TReC to locate the closest appropriate hospital with the capability to provide definitive care for an injured patient requiring an interfacility transfer. Combining this system with TReC allows prompt destination decisions to be made based on the availability in all trauma regions throughout the state, thus keeping all patients as close to home as possible and eliminating over and under triage into Region 7 and 8.

The Oklahoma State department of Health has provided the EMResource as well as the necessary computer equipment to all hospitals in the state of Oklahoma. Accurate and timely management of this resource by all hospitals is now a requirement of licensure by the OSDH.

EMResource in Oklahoma is utilized to manage the interfacility transfer of injured patients. EMResource is a proven Inventory and Resource Management solution that streamlines communications between medical response teams and healthcare providers by monitoring healthcare assets, emergency department capacity, behavioral health and dialysis bed status, and facilitates NDMS and HAvBED reporting and broadcasting. Additional incident specific resources are easily tracked, such as decontamination capability, ventilators, pharmaceuticals, and specialty services.

To learn more about EMResource in Oklahoma Contact the Trauma Division at 405.271.2657, or by email at Emsystem@health.ok.gov

Introduction

Screenshot of EMResource Communication Tool

The screenshot displays the EMResource Communication Tool interface. At the top, it says "Statewide Oklahoma" and includes links for "Contact Us", "Help", and "Log Out". There are also buttons for "EMTrack" and "EMCredential". Below this is a navigation bar with tabs: "View", "Other Regions", "Preferences", "Form", "Regional Info", "Instant Message", and "User Links". The "View" tab is selected, showing "Region Default" with a "refresh" link. Below the navigation bar, there are two sections: "11 ST FRANCIS-P I & II / OSUMC-SF SOUTH-P II" and "11 EDMOND (MERCY-NEURO)". The main table lists "OKC Area Hospitals" with columns for "ED Status", "Hosp Status", "CT Scan", "Srg", "Ortho", "NeuSrg", "Neuro", "OMF", "Hand", "Card", "NeoNat", and "OB/GYN". The table contains six rows of data for different hospitals, with status indicators in green (Open), red (No), and yellow (CAUTION).

OKC Area Hospitals	ED Status	Hosp Status	CT Scan	Srg	Ortho	NeuSrg	Neuro	OMF	Hand	Card	NeoNat	OB/GYN
Community Hospital	Open	Open	Yes	Yes	Yes	N/A	N/A	N/A	No	N/A	N/A	N/A
Deaconess Hospital	Open	Open	Yes	Yes	Yes	No	Yes	No	No	Yes	Yes	Yes
Edmond Medical Center	Open	Open	Yes	Yes	Yes	N/A	N/A	N/A	No	Yes	N/A	N/A
INTEGRIS Baptist Medical Center	Open	Open	Yes	Yes	Yes	Yes	Yes	Yes	No	Yes	Yes	Yes
INTEGRIS Canadian Valley	Open	Open	Yes	Yes	Yes	No	No	No	No	Yes	Yes	Yes
INTEGRIS Southwest Medical Center	Open	CAUTION	Yes	Yes	Yes	No	Yes	No	N/A	Yes	N/A	Yes

Patient Triage & Transfer Guidelines

Priority One Adult

Patients with high energy blunt or penetrating injury causing physiological abnormalities or significant single or multi-system anatomical injuries



Positive criteria

Use clinical history and physical to determine if any of the criteria below are positive. **Once any one is identified, implement the following immediately, do not wait for diagnostic studies to be completed,** however they can be continued while transfer protocol is activated:

- Initiate **Internal Trauma Treatment Protocol** if definitive surgical care and critical care monitoring are available.
- If definitive surgical care or critical care monitoring are not available then immediate stabilization & transfer per regional plan to appropriate designated facility.
- Consultation with receiving facility and/or physician is important as additional care may be necessary prior to transfer.

For unstable Priority 1 injured patients, either multi-system or potentially life or limb threatening single system, transferring the caller to the receiving facility should not interfere with the destination decision made by utilizing Oklahoma's Trauma System established criteria. In most instances, it should not unduly delay the stabilization and transfer of the patient. Exceptions for immediate transfers might exist if life threatening conditions can be temporarily managed at the referring facility. One example is surgical intervention to control hemorrhage.

Patient Triage & Transfer Guidelines

Priority One Adult Criteria

Respiratory Distress and/or Hemodynamic Instability

- ☐ Adult SBP consistently <90 or persistent tachycardia following 2 liters of crystalloid
- ☐ Respiratory distress with rate <10 or >29

Multi-System

- ☐ Significant injury to two or more body regions
- ☐ Head or spine injury combined with: face, chest, abdominal, or pelvic injury; or resulting from a positive mechanism of injury such as MVC, MCC, ATV, auto vs. pedestrian/bicycle, personal watercraft, aircraft, equine accidents with significant forces or velocity; or falls from a significant height
- ☐ Burns associated with significant injuries

Penetrating Injury

- ☐ Head, neck, chest/abdomen or extremities proximal to elbow or knee

Spinal

- ☐ Suspected or diagnosed fracture with neurological deficit

Thoracic

- ☐ Major chest wall or pulmonary injury with respiratory compromise
- ☐ Wide mediastinum or suspected great vessel, tracheobronchial or esophageal injury
- ☐ Cardiac injury (blunt or penetrating), including tamponade

Abdominal/Pelvic Injuries

- ☐ Hemodynamically unstable plus evidence of abdominal or pelvic trauma
- ☐ Ruptured hollow viscous
- ☐ Pelvic fracture plus shock or other evidence of continuing hemorrhage
- ☐ Open pelvic fracture or unstable pelvic ring disruption
- ☐ Rigid tender and/or distended abdomen

(More Priority One Adult Criteria on next page)

Patient Triage & Transfer Guidelines

(Priority One Adult Criteria continued from previous page)

Central Nervous System

- ☐ Glasgow Coma Scale ≤ 10 or deterioration of 2 or more points
- ☐ Penetrating/open head, neck injury or depressed skull fracture
- ☐ Lateralizing signs and/or paralysis
- ☐ CSF leak

Skeletal

- ☐ Fracture/dislocation with loss of distal pulses
- ☐ Amputation of extremity proximal to wrist or ankle
- ☐ Two or more long bone fracture sites
- ☐ Major vascular injuries documented by arteriogram or loss of distal pulses
- ☐ Crush Injury or prolonged extremity ischemia
- ☐ Compartment syndrome

Clinical Deterioration

- ☐ Needs mechanical ventilation
- ☐ Sepsis
- ☐ Single or multiple organ system failure (deterioration in CNS, cardiac, pulmonary, hepatic, renal or coagulation systems)
- ☐ Major tissue necrosis

No Priority One Adult Criteria

Proceed to **Priority 2** Inter-facility Transfer Criteria

Patient Triage & Transfer Guidelines

Priority Two Adult

2

Patients with potentially time sensitive injuries due to a high energy event (positive mechanism of injury) or with a less severe single system injury, but currently with no physiological abnormalities or significant anatomical injury

Positive Criteria and patient remains stable:

For any positive criteria below, perform complete trauma evaluation and appropriate serial observations. Consider admission if condition warrants.

Positive Criteria and patient becomes unstable:

Immediately activate Trauma System and prepare for RAPID transfer per regional trauma plan to the appropriate designated Trauma Facility, for any of the following if definitive surgical care or critical care monitoring are not available at your facility. **Do not wait for diagnostic studies to be completed,** however they can be continued while transfer protocol is activated:

- ☐ deterioration of Glasgow Coma Scale
- ☐ deterioration vital signs
- ☐ deterioration patient's condition
- ☐ significant findings on further evaluation [see Priority 1 criteria]

No positive criteria and stable

Consider admission if condition warrants after serial evaluation.

Patient Triage & Transfer Guidelines

Priority Two Adult Criteria

Spinal

- ☐ Any identified spinal fracture of the vertebral column without neuro deficits

Thoracic

- ☐ Isolated chest trauma – pain, mild dyspnea
- ☐ Rib fractures, pneumothorax, hemothorax without respiratory compromise
- ☐ Unilateral pulmonary contusion without respiratory compromise

Abdominal/Pelvic

- ☐ Hemodynamically stable isolated abdominal trauma
- ☐ Hemodynamically stable isolated solid organ injuries
- ☐ Stable Pelvic Fractures

Head & CNS

- ☐ Head Injury GCS >10
- ☐ Head injury with LOC <5 min.
- ☐ Head injury with transient neuro findings
- ☐ Isolated open facial fractures
- ☐ Isolated orbit trauma with or without entrapments

Skeletal

- ☐ Single proximal extremity fractures, including open from high energy event
- ☐ Distal extremity fractures, including open
- ☐ Isolated joint dislocations – knee, hip, elbow, shoulder without neurovascular deficits
- ☐ Unstable joint (ligament) injuries without neurovascular deficits

Comorbidity Considerations

(Potential upgrade from Priority 2 to Priority 1)

- ☐ Age >55
- ☐ Known cardiac, respiratory or metabolic disease
- ☐ Immunosuppression
- ☐ Bleeding disorder or anticoagulants

(More Priority Two Adult Criteria on next page)

Patient Triage & Transfer Guidelines

(Priority Two Adult Criteria continued from previous page)

Mechanism of injury Alone (No Priority 1 symptoms or findings)

- ☐ Ejection of patient from enclosed vehicle
- ☐ Adult auto/ pedestrian, auto/bike, or motorcycle crash with significant impact and patient thrown or run over by vehicle
- ☐ Falls greater than 20 feet for adult, > 10 feet for pediatric or distance 2-3 times height of patient
- ☐ Significant assault or altercations
- ☐ High risk auto crash
 - The following motor vehicle crashes particularly when the patient has not used personal safety restraint devices:
 - Death in the same passenger compartment
 - Rollover
 - High speed auto crash
 - Compartment intrusion greater than 12 inches at occupant site or > 18 inches at any site
 - Vehicle telemetry data consistent with high risk of injury

No Priority Two Adult Criteria

Proceed to **Priority 3** Inter-facility Transfer Criteria

Patient Triage & Transfer Guidelines

Priority Three Adult

Patients without physiological abnormalities, altered mentation, neurological deficit, or a significant single system injury. These patients have generally been involved in a low energy event



3

Perform appropriate emergency department evaluation.

No Priority 1 or 2 Criteria, stable:

Consider discharge or admit if condition warrants, after serial evaluation.

Only significant injuries as noted below:

Consult specialist for recommended management and follow-up discharge plan

Patient Triage & Transfer Guidelines

Priority Three Adult Criteria

Head & CNS

- ☐ Head Injury GCS 14 – 15 + normal CT brain. Low risk

Orthopedic

Closed without significant angulations or neurovascular compromise

- ☐ Proximal humerus
- ☐ Ankle / wrist
- ☐ Unstable finger joint

Burns

- ☐ Not meeting American Burn Association Burn Unit referral criteria

Comorbidity Considerations

(Potential upgrade from Priority 3 to Priority 2)

- ☐ Age >55
- ☐ Known cardiac, respiratory or end stage renal disease or dialysis
- ☐ Pregnancy >20 weeks
- ☐ Immunosuppression
- ☐ Bleeding disorder or anticoagulants

Development of positive Criteria, instability:

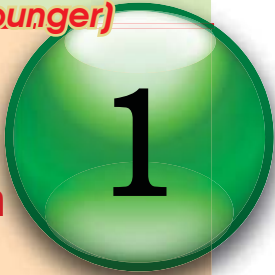
Activate Trauma System and prepare for RAPID transfer to the appropriate designated Trauma Facility according to the Regional Trauma Plan , for any of the following if definitive surgical care or critical care monitoring are not available at your facility. Do not wait for diagnostic studies to be completed, however they can be continued while transfer protocol is activated:

- ☐ deterioration of Glasgow Coma Scale
- ☐ deterioration vital signs
- ☐ deterioration patient's condition
- ☐ significant findings on further evaluation [see Priority 1 criteria]

Patient Triage & Transfer Guidelines

Priority One Pediatric (Ages 16 and younger)

Patients, ages 16 and younger, with high energy blunt or penetrating injury causing physiological abnormalities or significant single or multi-system anatomical injuries



1

Positive criteria

Use clinical history and physical to determine if any of the criteria below are positive. **Once any one is identified, implement the following immediately, do not wait for diagnostic studies to be completed,** however they can be continued while transfer protocol is activated:

- Initiate **Internal Trauma Treatment Protocol** if definitive surgical care and critical care monitoring are available.
- If definitive surgical care or critical care monitoring are not available then immediate stabilization & transfer per regional plan to appropriate designated facility. Stabilization may involve surgical intervention prior to transfer. Air transport may be necessary considering time & distance constraints.
- Consultation with receiving facility and/or physician is important as additional care may be necessary prior to transfer. Stabilization may involve surgical intervention prior to transfer.
- For unstable Priority 1 injured patients, either multi-system or potentially life or limb threatening single system, transferring the caller to the receiving facility should not interfere with the destination decision made by utilizing Oklahoma's Trauma System established criteria. In most instances, it should not unduly delay the stabilization and transfer of the patient. Exceptions for immediate transfers might exist if life threatening conditions can be temporarily managed at the referring facility. One example is surgical intervention to control hemorrhage.

Patient Triage & Transfer Guidelines

Priority One Pediatric Criteria (Ages 16 and younger)

Pediatric Trauma Score (PTS)

- ☐ ≤ 5

Respiratory Distress and/or Hemodynamic Instability

- ☐ SBP consistently <90 following 20 ml/kg liters of crystalloid
- ☐ Respiratory distress with rate:
 - ☐ Newborn: <30 or >60
 - ☐ Up to 1 yr <24 or >36
 - ☐ 1-5 yr <20 or >30
 - ☐ Over 5 yr <15 or >30

Multi-System

- ☐ Significant injury to two or more body regions
- ☐ Head or spine injury combined with: face, chest, abdominal, or pelvic injury; or resulting from a positive mechanism of injury such as MVC, MCC, ATV, auto vs. pedestrian/bicycle, personal watercraft, aircraft, equine accidents with significant forces or velocity; or falls from a significant height
- ☐ Burns associated with significant injuries

Penetrating Injury

- ☐ Head, neck, chest/abdomen or extremities proximal to elbow or knee

Spinal

- ☐ Suspected or diagnosed fracture with neuro deficit

Thoracic

- ☐ Major chest wall or pulmonary injury with respiratory compromise
 - ☐ Wide mediastinum or suspected great vessel, tracheobronchial or esophageal injury
 - ☐ Cardiac injury (blunt or penetrating), including tamponade
- (More Priority One Pediatric Criteria on next page)**

Patient Triage & Transfer Guidelines

(Priority One Pediatric Criteria continued from previous page)

Abdominal/Pelvic Injuries

- ☐ Hemodynamically unstable plus evidence of abdominal or pelvic trauma
- ☐ Ruptured hollow viscous
- ☐ Pelvic fracture plus shock or other evidence of continuing hemorrhage
- ☐ Open pelvic fracture or unstable pelvic ring
- ☐ Rigid tender and/or distended abdomen

Central Nervous System

- ☐ Glasgow Coma Scale ≤ 10 or deterioration of 2 or more points
- ☐ Penetrating /open head, neck injury or depressed skull fracture
- ☐ Lateralizing signs and/or paralysis
- ☐ New neurological deficits

Skeletal

- ☐ Fracture/dislocation with loss of distal pulses
- ☐ Amputation of extremity proximal to wrist or ankle
- ☐ Two or more long bone fracture sites
- ☐ Major vascular injuries documented by arteriogram or loss of distal pulses
- ☐ Crush Injury or prolonged extremity ischemia
- ☐ Compartment syndrome

Clinical Deterioration

- ☐ Needs mechanical ventilation
- ☐ Sepsis
- ☐ Single or multiple organ system failure (deterioration in CNS, cardiac, pulmonary, hepatic, renal or coagulation systems)
- ☐ Major tissue necrosis

No Priority One Pediatric Criteria

Proceed to **Priority 2** Inter-facility Transfer Criteria

Patient Triage & Transfer Guidelines

Priority Two Pediatric



Patients, ages 16 and younger, with potentially time sensitive injuries due to a high energy event (positive mechanism of injury) or with a less severe single system injury, but currently with no physiological abnormalities or significant anatomical injury

Positive Criteria and patient remains stable:

For any positive criteria below, perform complete trauma evaluation and appropriate serial observations. Consider admission if condition warrants.

Positive Criteria and patient becomes unstable:

Immediately activate Trauma System and prepare for RAPID transfer per regional trauma plan to the appropriate designated Trauma Facility, for any of the following if definitive surgical care or critical care monitoring are not available at your facility. Do not wait for diagnostic studies to be completed, however they can be continued while transfer protocol is activated:

- ☐ deterioration of Glasgow Coma Scale
- ☐ deterioration vital signs
- ☐ deterioration patient's condition
- ☐ significant findings on further evaluation [see Priority 1 criteria]

No positive criteria and stable

Consider admission if condition warrants, after serial evaluation.

Patient Triage & Transfer Guidelines

Priority Two Pediatric Criteria

Pediatric Trauma Score (PTS)

- ☐ 6-8

Spinal

- ☐ Any identified spinal fracture of the vertebral column without neuro deficits

Abdominal/Pelvic Injuries

- ☐ Hemodynamically stable isolated abdominal trauma
- ☐ Hemodynamically stable isolated solid organ injuries
- ☐ Stable pelvic fractures
- ☐ Seat belt contusions
- ☐ Visceral injuries

CNS

- ☐ Head Injury with GCS >10
- ☐ Head Injury with Transient loss of consciousness <5 min
- ☐ Head Injury with Transient neurological deficits
- ☐ Spinal cord injury without neurological deficits

Chest

- ☐ Isolated Chest Trauma- pain, mild dyspnea
- ☐ Rib fractures, sternal fractures, pneumothorax, hemothorax without respiratory compromise
- ☐ Unilateral pulmonary contusion without respiratory compromise

Comorbid

- ☐ Age <5
- ☐ Known cardiac, respiratory or metabolic disease
- ☐ Pregnancy
- ☐ Immunosuppression
- ☐ Bleeding disorder or anticoagulants

(More Priority Two Pediatric Criteria on next page)

Patient Triage & Transfer Guidelines

(Priority Two Pediatric Criteria continued from previous page)

Major Extremity Injury

- ☐ Single proximal extremity fractures, including open from high energy event
- ☐ Distal extremity fractures, including open
- ☐ Isolated joint dislocations-knee, hip, elbow, shoulder without neurovascular deficits
- ☐ Unstable joint (ligament) injuries without neurovascular deficits

Mechanism

- ☐ Ejection of patient from enclosed vehicle
- ☐ Auto/pedestrian, auto/bike, or motorcycle crash with significant impact and patient thrown or run over by vehicle
- ☐ Falls greater than 10 feet or a distance 2 - 3 times height of patient
- ☐ Significant assault or altercations
- ☐ Other "high energy" events (e.g. patients involved in motor vehicle crashes with significant vehicular damage and not using personal safety restraint devices)

Other

- ☐ Isolated open facial fractures
- ☐ Isolated orbit trauma with or without entrapments, without visual deficits

No criteria

Proceed to **Priority 3** Inter-facility Transfer Criteria

Patient Triage & Transfer Guidelines

Priority Three Pediatric

Patients, ages sixteen and younger, without physiological abnormalities, altered mentation, neurological deficit, or a significant single system injury. These patients have generally been involved in a low energy event.



3

Perform appropriate emergency department evaluation.

No Priority 1 or 2 Criteria, stable:

Consider discharge or admit if condition warrants, after serial evaluation

Only significant injuries as noted below:

Consult specialist for recommended management and follow-up discharge plan

Patient Triage & Transfer Guidelines

Priority Three Pediatric Criteria

Pediatric Trauma Score (PTS)

- ☐ 9-12

Head & CNS

- ☐ Head Injury GCS 14 – 15 + normal CT brain

Orthopedic

Closed without significant angulations or neurovascular compromise

- ☐ Proximal humerus
- ☐ Ankle/wrist
- ☐ Unstable finger joint

Burns

- ☐ Not meeting American Burn Association, Burn Unit referral criteria

Comorbidity Considerations

(Potential upgrade from Priority 3 to Priority 2)

- ☐ Age <5
- ☐ Known cardiac, respiratory or metabolic disease
- ☐ Pregnancy
- ☐ Immunosuppression
- ☐ Bleeding disorder or anticoagulants

Development of positive Criteria, instability:

Activate Trauma System and prepare for RAPID transfer to the appropriate designated Trauma Facility according to the Regional Trauma Plan , for any of the following if definitive surgical care or critical care monitoring are not available at your facility. Do not wait for diagnostic studies to be completed, however they can be continued while transfer protocol is activated:

- ☐ deterioration of Glasgow Coma Scale
- ☐ deterioration vital signs
- ☐ deterioration patient's condition
- ☐ significant findings on further evaluation [see Priority 1 criteria]

Priority One

Adult

Priority 1 Adult Definition: Patients with high energy blunt or penetrating injury causing physiological abnormalities or significant single or multi-system anatomical injuries

Respiratory Distress and/or Hemodynamic Instability

- ☐ SBP consistently <90 or persistent tachycardia following 2 L crystalloid
- ☐ Respiratory distress with rate <10 or >29

Multi-System

- ☐ Significant injury to 2 or more body regions
- ☐ Head or spine injury combined with: face, chest, abdominal, or pelvic injury; or resulting from a positive mechanism of injury such as MVC, MCC, ATV, auto vs. pedestrian/bicycle, personal watercraft, aircraft, equine accidents with significant forces or velocity; or falls from a significant height
- ☐ Burns associated with significant injuries

Penetrating Injury

- ☐ Head, neck, chest/abdomen or extremities proximal to elbow or knee

Spinal

- ☐ Suspected or diagnosed fracture with neurological deficit

Thoracic

- ☐ Major chest wall or pulmonary injury with respiratory compromise
- ☐ Wide mediastinum or suspected great vessel, tracheobronchial, or esophageal injury
- ☐ Cardiac injury (blunt or penetrating) including tamponade

Abdominal/Pelvic

- ☐ Hemodynamically unstable plus evidence of abdominal or pelvic trauma
- ☐ Ruptured hollow viscous
- ☐ Pelvic fracture plus shock or other evidence of continuing hemorrhage
- ☐ Open pelvic fracture or unstable pelvic ring disruption
- ☐ Rigid tender and/or distended abdomen

Central Nervous System

- ☐ GCS $\leq$ 10 or deterioration of 2 or more points
- ☐ Penetrating/open head, neck injury or depressed skull fracture
- ☐ Neurological deficits/lateralizing signs
- ☐ CSF Leak

Skeletal

- ☐ Fracture/dislocation with loss of distal pulses
- ☐ Amputation of extremity proximal to wrist or ankle
- ☐ Two or more long bone fracture sites
- ☐ Major vascular injuries documented by arteriogram or loss of distal pulses
- ☐ Crush Injury or prolonged extremity ischemia
- ☐ Compartment syndrome

Clinical Deterioration

- ☐ Needs mechanical ventilation
- ☐ Sepsis
- ☐ Single or multiple organ system failure (deterioration in CNS, cardiac, pulmonary, hepatic, renal or coagulation systems)
- ☐ Major tissue necrosis

Priority Two

Adult

Priority 2 Adult Definition: Patients with potentially time sensitive injuries due to a high energy event (positive mechanism of injury) or with a less severe single system injury, but currently with no physiological abnormalities or significant anatomical injury

Spinal

- ☐ Any identified spinal fracture without neurological deficits

Thoracic

- ☐ Isolated chest trauma – pain, mild dyspnea
- ☐ Rib fractures, pneumothorax, hemothorax without respiratory compromise
- ☐ Unilateral pulmonary contusion without respiratory compromise

Abdominal/Pelvic

- ☐ Hemodynamically stable isolated abdominal trauma
- ☐ Hemodynamically stable isolated solid organ injuries
- ☐ Stable Pelvic Fractures

Head & CNS

- ☐ Head Injury GCS >10
- ☐ Head injury with LOC <5 minutes
- ☐ Head injury with transient neuro findings
- ☐ Isolated open facial fractures
- ☐ Isolated orbit trauma with or without entrapments

Skeletal

- ☐ Single proximal extremity fractures, (including open) from high energy event
- ☐ Distal extremity fractures, (including open) from high energy event
- ☐ Isolated joint dislocations – knee, hip, elbow, shoulder without neurovascular deficits
- ☐ Unstable joint (ligament) injuries without neurovascular deficits

Comorbidity Considerations (Potential upgrade from Priority 2 to Priority 1)

- ☐ Age >55
- ☐ Known cardiac, respiratory or metabolic disease
- ☐ Immunosuppression
- ☐ Bleeding disorder or anticoagulants

Mechanism of Injury Alone (No Priority 1 symptoms or findings)

- ☐ Ejection of patient from enclosed vehicle
- ☐ Adult auto/pedestrian, auto/bike, or motorcycle crash with significant impact and patient thrown or run over by vehicle
- ☐ Falls >20 feet or distance 2-3 times height of patient
- ☐ Significant assault or altercations
- ☐ Other “high energy” events (e.g., patients involved with motor vehicle crashes with significant vehicular damage and not using personal safety restraints)

Priority One Pediatric

Priority 1 Pediatric Definition:

Patients, ages 16 and younger, with high energy blunt or penetrating injury causing physiological abnormalities or significant single or multi-system anatomical injuries

Pediatric Trauma Score (PTS)

- ☐ PTS Score ≤ 5

Respiratory distress and/or hemodynamic instability

- ☐ SBP consistently <90 or persistent tachycardia following 20 ml/kg crystalloid
- ☐ Respiratory distress with rate:
Newborn: <30 or >60
Up to 1 year: <24 or >36
1 to 5 years: <20 or >30
Over 5 years: <15 or >30

Multi-System

- ☐ Significant injury to 2 or more body regions
- ☐ Head or spine injury combined with: face, chest, abdominal, or pelvic injury; or resulting from a positive mechanism of injury such as MVC, MCC, ATV, auto vs. pedestrian/bicycle, personal watercraft, and aircraft, equine accidents with significant forces or velocity; or falls from a significant height
- ☐ Burns associated with significant injuries

Penetrating Injury

- ☐ Head, neck, chest/abdomen or extremities proximal to elbow or knee

Spinal

- ☐ Suspected or diagnosed fracture with neuro deficit

Thoracic

- ☐ Major chest wall or pulmonary injury with respiratory compromise
- ☐ Wide mediastinum or suspected great vessel, tracheobronchial, or esophageal injury
- ☐ Cardiac injury (blunt or penetrating) including tamponade

Abdominal/Pelvic

- ☐ Hemodynamically unstable plus evidence of abdominal or pelvic trauma
- ☐ Ruptured hollow viscous
- ☐ Pelvic fracture plus shock or other evidence of continuing hemorrhage
- ☐ Open pelvic fracture or unstable pelvic ring disruption
- ☐ Rigid tender and/or distended abdomen

Central Nervous System

- ☐ GCS ≤ 10 or deterioration of 2 or more points
- ☐ Penetrating/open head, neck injury or depressed skull fracture
- ☐ Neurological deficits/lateralizing signs
- ☐ CSF Leak

Skeletal

- ☐ Fracture/dislocation with loss of distal pulses
- ☐ Amputation of extremity proximal to wrist or ankle
- ☐ Two or more long bone fracture sites
- ☐ Major vascular injuries documented by arteriogram or loss of distal pulses
- ☐ Crush Injury or prolonged extremity ischemia
- ☐ Compartment syndrome

Clinical Deterioration

- ☐ Needs mechanical ventilation
- ☐ Sepsis
- ☐ Single or multiple organ system failure (deterioration in CNS, cardiac, pulmonary, hepatic, renal or coagulation systems)
- ☐ Major tissue necrosis

Priority Two

Pediatric

Priority 2 Pediatric Definition:

Patients, ages sixteen and younger, with potentially time sensitive injuries due to a high energy event (positive mechanism of injury) or with a less severe single system injury, but currently with no physiological abnormalities or significant anatomical injury

Pediatric Trauma Score (PTS)

- ☐ PTS Score 6-8

Spinal

- ☐ Any identified spinal fracture of the vertebral column without neurological deficits

Thoracic

- ☐ Isolated chest trauma – pain, mild dyspnea
- ☐ Rib fractures, pneumothorax, hemothorax without respiratory compromise
- ☐ Unilateral pulmonary contusion without respiratory compromise

Abdominal/Pelvic

- ☐ Hemodynamically stable isolated abdominal trauma
- ☐ Hemodynamically stable isolated solid organ injuries
- ☐ Stable Pelvic Fractures
- ☐ Seat belt contusions
- ☐ Visceral injuries

Head & CNS

- ☐ Head Injury GCS >10
- ☐ Head injury with LOC <5 min
- ☐ Head injury with transient neuro findings
- ☐ Isolated open facial fractures
- ☐ Isolated orbit trauma with or without entrapments

Skeletal

- ☐ Single proximal extremity fractures, (including open) from high energy event
- ☐ Distal extremity fractures, (including open) from high energy event
- ☐ Isolated joint dislocations – knee, hip, elbow, shoulder without neurovascular deficits
- ☐ Unstable joint (ligament) injuries without neurovascular deficits

Comorbidity Considerations (Potential upgrade from Priority 2 to Priority 1)

- ☐ Age <5
- ☐ Known cardiac, respiratory or metabolic disease
- ☐ Immunosuppression
- ☐ Bleeding disorder or anticoagulants

Mechanism of injury Alone (No Priority 1 symptoms or findings)

- ☐ Ejection of patient from enclosed vehicle
- ☐ Adult auto/pedestrian, auto/bike, or motorcycle crash with significant impact and patient thrown or run over by vehicle
- ☐ Falls >10 feet or distance 2-3 times height of patient
- ☐ Significant assault or altercations
- ☐ Other "high energy" events (e.g., patients involved with motor vehicle crashes with significant vehicular damage and not using personal safety restraints)

Priority Three

Adult

Priority 3 Adult Definition: Patients without physiological abnormalities, altered mentation, neurological deficit, or a significant single system injury. These patients have generally been involved in a low energy event.

Head & CNS
☐ Head Injury GCS 14 – 15 plus normal CT brain
Orthopedic
☐ Closed without significant angulations, or neuro vascular compromise ☐ Proximal humerus ☐ Ankle/wrist ☐ Unstable finger joint ☐ Same level fall with extremity or hip fracture
Burns
☐ Not meeting American Burn Association Burn Unit referral criteria
Comorbidity Considerations (Potential upgrade from Priority 3 to Priority 2)
☐ Age >55 ☐ Known cardiac, respiratory or metabolic disease ☐ Pregnancy > 20 weeks ☐ Immunosuppression ☐ Bleeding disorder or anticoagulants

Priority Three

Pediatric

Priority 3 Pediatric Definition: Patients, ages sixteen and younger, without physiological abnormalities, altered mentation, neurological deficit, or a significant single system injury. These patients have generally been involved in a low energy event.

Pediatric Trauma Score (PTS)
☐ PTS Score 9-12
Head & CNS
☐ Head Injury GCS 14 – 15 plus normal CT brain
Orthopedic
☐ Closed without significant angulations, or neuro vascular compromise ☐ Proximal humerus ☐ Ankle/wrist ☐ Unstable finger joint ☐ Same level fall with extremity or hip fracture
Burns
☐ Not meeting American Burn Association Burn Unit referral criteria
Comorbidity Considerations (Potential upgrade from Priority 3 to Priority 2)
☐ Age <5 ☐ Known cardiac, respiratory or metabolic disease ☐ Pregnancy > 20 weeks ☐ Immunosuppression ☐ Bleeding disorder or anticoagulants

Patient Triage & Transfer Guidelines

Once a patient is identified as a Priority 1 patient needing transfer to a higher level trauma center:

Stabilize life threatening conditions. **DO NOT delay transfer decision by performing unnecessary (non-therapeutic) diagnostic testing.**

DO NOT delay transfer waiting for diagnostic studies to be completed, however they can be continued while transfer protocol is activated.

Stabilization of Trauma Patients

Respiratory Distress and/or Hemodynamic instability

- **Airway/Breathing:** In critically injured patients, an endotracheal tube should be placed prior to transfer. 100% oxygen/controlled airway and respirations.
 - ❖ Inhalation injury – MUST be intubated prior to transfer
 - ❖ Chest X-ray and ABG before the transfer
 - ❖ Non-critical patients – 100% oxygen by non-rebreather face mask is always appropriate in trauma
 - ❖ Respiratory distress is PRIORITY 1 transfer
- **Hemodynamic instability:**
 - ❖ Insure that all external bleeding has been stopped with direct pressure, pressure bandages, or tourniquet
 - ❖ Infuse fluids for occult/abdominal/thoracic/pelvic hemorrhage or hemorrhage into multiple fractures
 - 2 Liters of normal saline in adults
 - 20 cc/kilogram of normal saline in children
 - Failure to respond with above fluid load is P-1
- **Intravenous Lines:** Place sufficient intravenous lines, including central lines (subclavian or internal jugular veins).

Patient Triage & Transfer Guidelines

Stabilization Guidelines

Patient Preparation for Transfer

The Oklahoma Institute for Disaster and Emergency Medicine (OIDEM) and the Medical Audit Committee (MAC) recommend that all injured patients needing interfacility transfer have appropriate stabilization. MAC is composed of nine physicians from both rural and urban areas, representing trauma surgery, emergency medicine, orthopedics, oral-maxillofacial surgery, neurosurgery, pediatric critical care and general surgery. MAC reviews cases from around the state for quality of care. Inadequate resuscitation and delayed transfers have both been identified as areas that would benefit from educational initiatives. Two main areas have been identified:

- Once a patient is recognized as exceeding the capabilities of a hospital, immediate contact with TReC should be made to arrange patient transfer.
- Appropriate resuscitation and stabilization is the key to optimal patient outcomes.

Arranging for the referring caregiver to speak to personnel at the receiving facility, as well as the receiving physician, is extremely important as specific recommendations may be made for further care prior to transfer.

- For unstable P-1 injured patients, either multi-system or potentially life or limb threatening single system, transferring the caller to the receiving facility should not interfere with the destination decision made by utilizing Oklahoma's Trauma System established criteria. In most instances, it should not unduly delay the stabilization and transfer of the patient. Exceptions for immediate transfers might exist if life threatening conditions can be temporarily managed at the referring facility. One example is surgical intervention to control hemorrhage.
- In the case of non-life and non-limb threatening single system injuries, the patient might be best served by delayed transfer hours or days later.

Stabilization and proper preparation of injured patients is essential for optimal outcomes. Following are recommendations for specific conditions:

Patient Triage & Transfer Guidelines

Penetrating Injury to head, neck, chest/abdomen, or proximal to elbow or knee

- Control hemorrhage as above
- Stabilize object if object is still present
- Infuse fluids as above.
- X-ray area and chest
- CT as time permits

Thoracic Injury

- Manage airway, breathing, and hemorrhage control as above
- Multiple rib fractures and flail chest may require intubation
- Pulmonary contusion may require intubation
- Ensure pneumothorax/hemothorax is identified and treated with a chest tube
- Treat cardiac tamponade with pericardial drainage procedure
- Give antibiotics for suspected esophageal injury
- Open pneumothorax may also require intubation
- X-ray chest
- CT chest as time permits

Spinal Injury

- Stabilize spinal fracture with long spine board and cervical immobilization.
- Watch for hypo/hypertension
- Discuss use of steroids with spine surgeon or accepting physician
- CT spine as time permits

Abdominal/Pelvic

- Hemodynamic instability – assume intra-abdominal injury
 - ❖ Treat hypovolemia as above
- Antibiotics for ruptured hollow viscus
- Pass NG/OG tube
- Stabilize pelvis with binder or other acceptable devices
- CT abdomen/pelvis as time permits

Central Nervous System

- Protect Airway – Intubate if GCS <10
- Cervical spine series/CT with sagittal reconstructions as time permits
- Stabilize cervical spine with immobilization and spine board
- Discuss antibiotics with neurosurgeon or accepting physician in open injuries

Patient Triage & Transfer Guidelines

Skeletal

- Reduce fracture if pulses are absent
- Stop hemorrhage in amputation
- Send amputated parts in iced saline solution as described in guideline
- Stabilize fracture with splint or long spine board
- Antibiotics for open fractures

Clinical Deterioration

- Ventilator patient – see airway/breathing
- Sepsis
 - ❖ Treat shock
 - ❖ Culture all orifices/fluids
 - ❖ Chest x-ray
 - ❖ Give antibiotics

Mode of Transport

Patient transit time is determined by more than the speed of the vehicle. For example, air transport includes mobilizing the transport team, time for the team to get to the patient, transport to/from the LZ/airstrip, and transfer of the patient from vehicle to aircraft, the time spent in stabilization, and the distance to definitive care as well as the number of transfers needed to move from hospital to hospital. The time spent preparing the patient correctly will speed up the transport process when the team arrives, regardless of being transported by air or ground.

Stabilization for Air Transport

After stabilization of the critically ill patient, with special attention to airway and fluid therapy, a number of standard procedures should always be followed when air evacuation is planned. When the patient is transported by air, the increase in altitude can cause expansion of any gas within the body. Gas expansion in body spaces can be life-threatening or cause further damage and dysfunction. Air evacuation occurs in a limited space and complex procedures may be far more difficult. Monitoring of the patient is significantly more difficult than in ground ambulances or in the emergency department. Proper preparation of the patient can prevent or ease these potential problems.

Patient Triage & Transfer Guidelines

- **Airway:** In critically injured patients, an endotracheal tube should be placed prior to takeoff. In-flight endotracheal intubation is difficult, even for experienced staff, especially in the reduced space of the cabin.
 - ❖ In patients with facial burns or facial trauma, it may be difficult to secure the endotracheal tube. To prevent accidental removal of the tube, it is advisable to use umbilical tape. This can be tied round the base of the tube and then circumferentially round the patient's head. Other commercially available tube fixation devices may also be used.
 - ❖ Inhalation injury – confined space, hypoxia, coughing sooty sputum, intra-oral soot, significant facial /nasal burns. These patients **MUST** be intubated prior to flight. Airway swelling may occur rapidly and make a difficult intubation in the aircraft impossible.
 - ❖ When smoke inhalation is suspected, chest radiography and blood gas evaluation must be performed in order to guarantee adequate oxygenation during the flight.
 - ❖ Chest radiography is important at this point because it can rule out the possibility of pneumothorax and to check proper placement of endotracheal tube.
 - ❖ Check with the flight crew about whether to fill the endotracheal tube's balloon with air or water. Air may expand and rupture the balloon at altitude or cause tracheal damage from increased pressure.
- **Intravenous Lines:** As the critically injured patient may need large quantities of fluids, care is taken to place sufficient intravenous lines, including central lines (subclavian or internal jugular veins).
 - ❖ This is particularly true for burn patients in the first 8 to 10 hours postburn.
 - ❖ For optimal fluid infusion, it is advisable to use plastic containers. This prevents possible perfusion problems due to decreased atmospheric pressure at high altitude.
- **Chest Tube:** If your patient has a significant pneumothorax or hemothorax, the patient **WILL NEED** a chest tube.
 - ❖ The normal chest drainage system must be replaced by a unidirectional valve system, as closed water seal drainage

Patient Triage & Transfer Guidelines

systems may be nonfunctional at high altitude. When the chest tube has been placed, another x-ray should be performed, if possible, in order to check the correct positioning of the drain, catheters and endotracheal tube, should these prove necessary

- ❖ If the patient has a hemothorax, note how much drainage is present.
- ❖ If your patient has significant chest trauma and you don't see a pneumothorax on x-ray consider placement of a chest tube on the traumatized side prior to transport. If a small pneumothorax is present, it will become larger at altitude and may be life threatening. If you have a chest CT, the enhanced accuracy of the CT will ensure that a small pneumothorax is not missed.
- ❖ For stable patients, without significant pneumothorax or hemothorax, in normal O2 sats, chest tube placements might not be necessary as long as flight crew is trained in the potential of expansion and the need for needle thoracotomy if patient desats.

○ **Foley Catheter**

- ❖ Although air transports are usually rapid, they may take over an hour – or more with poor weather. Ensure patient comfort
- ❖ Monitoring of urine output by placing a Foley catheter prior to transport
- ❖ Check with the flight crew about whether to fill the balloon with air or water. Air may expand and rupture the balloon at altitude

○ **NG Drainage**

- ❖ It is important to place a NG/OG tube prior to initiating air evacuation. The critically injured patient may have paralytic ileus and as air evacuation is associated with progressive expansion of intraluminal gases, there is increased risk of vomiting and thus of possible aspiration pneumonia.

○ **Orthopedic injuries**

- ❖ If plaster casts have been placed recently (i.e. less than 24 hours before), these should be split along their entire length and joined by an adhesive strip.
- ❖ This keeps the cast from becoming a tourniquet at altitude.
- ❖ Do not use air casts – the expansion can compress extremities

Patient Triage & Transfer Guidelines

and cause ischemia

- ❖ Posterior splints including the joint above and below the injury are preferred

○ Cardiovascular illnesses

- ❖ With patients suffering from cardiopulmonary conditions, certain altitude restrictions have to be observed: maximum altitude 10,000 feet; 6,000 feet in cases of recent (8-24 weeks) myocardial infarction; 4,000 feet in cases of pulmonary disease if no oxygen is available; 2,000 feet in cases of cardiac insufficiency.
- ❖ Hypoxia from the altitude can cause ischemia, cardiac failure, and worsen shock.
- ❖ Activity sensing pacers may malfunction at altitude

Stabilization for Ground Transport

Ground transport has some advantages over air transport. The ambulance can go door-to-door, stop or divert as needed. There are few weather restrictions in ground transportation, the ambulance is significantly less cost, and may have better room and internal lighting. Although ground transport has few problems with altitude, the team still has little room to maneuver, there may be rocking due to a high center of gravity with increased noise and vibration that may make monitoring somewhat more difficult. Since helicopter transport is more rapid, the patient may require more fluids and have more output from tubes and catheters.

Airway: In burns and facial trauma, the increased time of transport may mean increased airway swelling. Since intubation remains difficult in the ambulance, the airway should be secured before transport.

Intravenous lines: With increased transport times, fluid requirements may be higher. Ensure that the patient has two or more intravenous lines.

Foley catheter: The longer transport time of the ground ambulance might necessitate that a urinary catheter be placed. In patients with pelvic fractures or blood at the meatus, consult with the accepting physician is imperative prior to placement of a foley catheter.

NG/OG tube: Since vomiting remains a risk in ground transportation, insure that the patient has a gastric tube in place prior to transport.

Patient Triage & Transfer Guidelines

For Single System Injuries – such as hand, maxillofacial, pregnant patients, burn injuries, etc, please refer to the appropriate section of trauma reference manual for specific stabilization protocols.

Questions regarding specific patients and specific injuries can best be solved with phone consultation with a trauma or burn center physician.

Documentation

Ensure that complete documentation is transferred with the patient

- Copies of all notes, exams, and consults
- Copies of all lab results
- Copies of all EKG's
- Copies or CD's of all x-rays and CT scans
- Fax the radiologist interpretation of CT's to receiving hospital as soon as available

Lab results and radiology reports can be faxed to the receiving hospital when they are available.

Recent H&P's, EKG's and x-rays for comparison would generally be helpful, if available.

Remember, many current cell phones and internet-connected computers are capable of sending quality digital photographs to the referral physician and these photographs may save the patient unnecessary time and expensive ambulance transports.

Thermal Burn Patients

Priority One

Burns requiring immediate care and/or consultation/referral by a burn specialist

1

- ☐ Inhalation injury
- ☐ Significant burns that involve the face, genitalia, perineum, or major joints
- ☐ Circumferential burns of an extremity
- ☐ Significant electrical burns
- ☐ Any patient with traumatic injuries, such as fractures, in which the burn injury poses the greatest risk of morbidity or mortality. (If the trauma poses the greater immediate risk, then the patient should be stabilized in the nearest appropriate trauma facility before being transferred to the burn unit.)
- ☐ Partial thickness burns greater than 10% total body surface area
- ☐ Full thickness burns greater than 5% of total body surface area in any age group
- ☐ Significant burn injury to the hands or feet

Priority Two

Injuries requiring urgent consultation/referral with a burn surgeon and potential transfer

2

- ☐ Partial thickness burns <10% of total body surface area
 - ☐ Full thickness burns <5% of total body surface area
 - ☐ Lightning injuries
 - ☐ Significant chemical burns (burns with serious threat of functional or cosmetic impairment)
 - ☐ Burn injury in patients with significant pre-existing medical disorders that would complicate management or affect mortality
- (more Priority Two Criteria on next page)**

Thermal Burn Patients

(Priority Two Criteria continued from previous page)

- ☐ Moderate burn injury to the hands or feet
- ☐ Burn injuries in patients who require special social, emotional, and/or long term rehabilitative support, including cases involving suspected child abuse

Priority Three

Injuries normally requiring initial and ongoing treatment by a physician and do not normally require consultation/referral with a burn surgeon within a period of days

3

- ☐ All burn injuries not covered in above discussion

These referral guidelines for burns assume the burn injuries to be isolated. For patients with multiple injuries, please refer to the section on multiple traumas. The Oklahoma Trauma Education Program and TReC use the following priorities for treatment of burns for both adults and children.

Although the ABA guidelines suggest that burns are best cared for in a "burn unit," in Oklahoma, long transport times may dictate that some burns can be better cared for in a local setting. The transferring physician should carefully consider the magnitude of the injury, the time/distance travel requirements for family as well as the care provided by local physicians and surgeons in arranging a transport for a burn victim to a burn unit.

The vast majority of burns will not need the specialized care provided by a burn unit. From the ABA web site:

- Burn injuries receiving medical treatment per year: 500,000
- Hospitalizations for burn injury per year: 40,000
- Burn unit admissions: 25,000

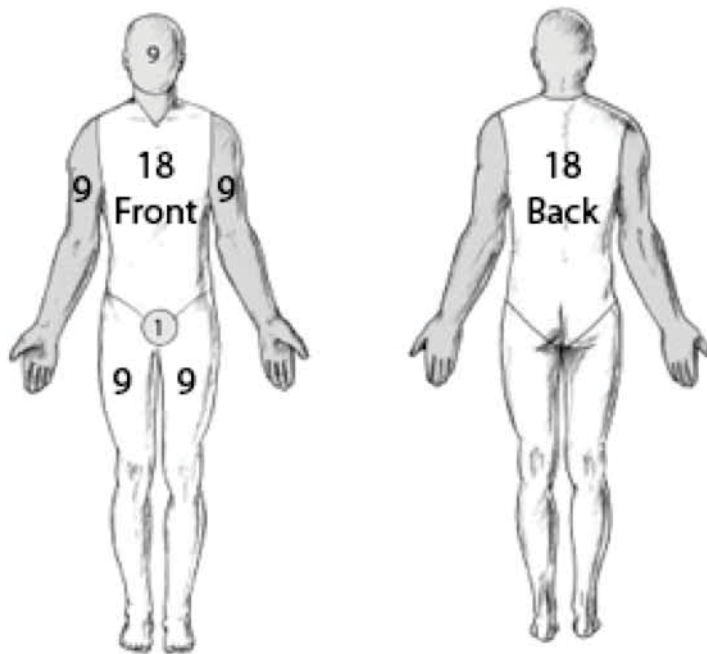
Telephone consultation with a burn surgeon can resolve potential problems. Current cell phones and internet-connected computers are capable of sending quality digital photographs to the referring physician. These photographs may save the patient time and expensive ambulance transports.

Questions regarding specific patients and specific injuries can best be solved with phone consultation with a burn center physician.

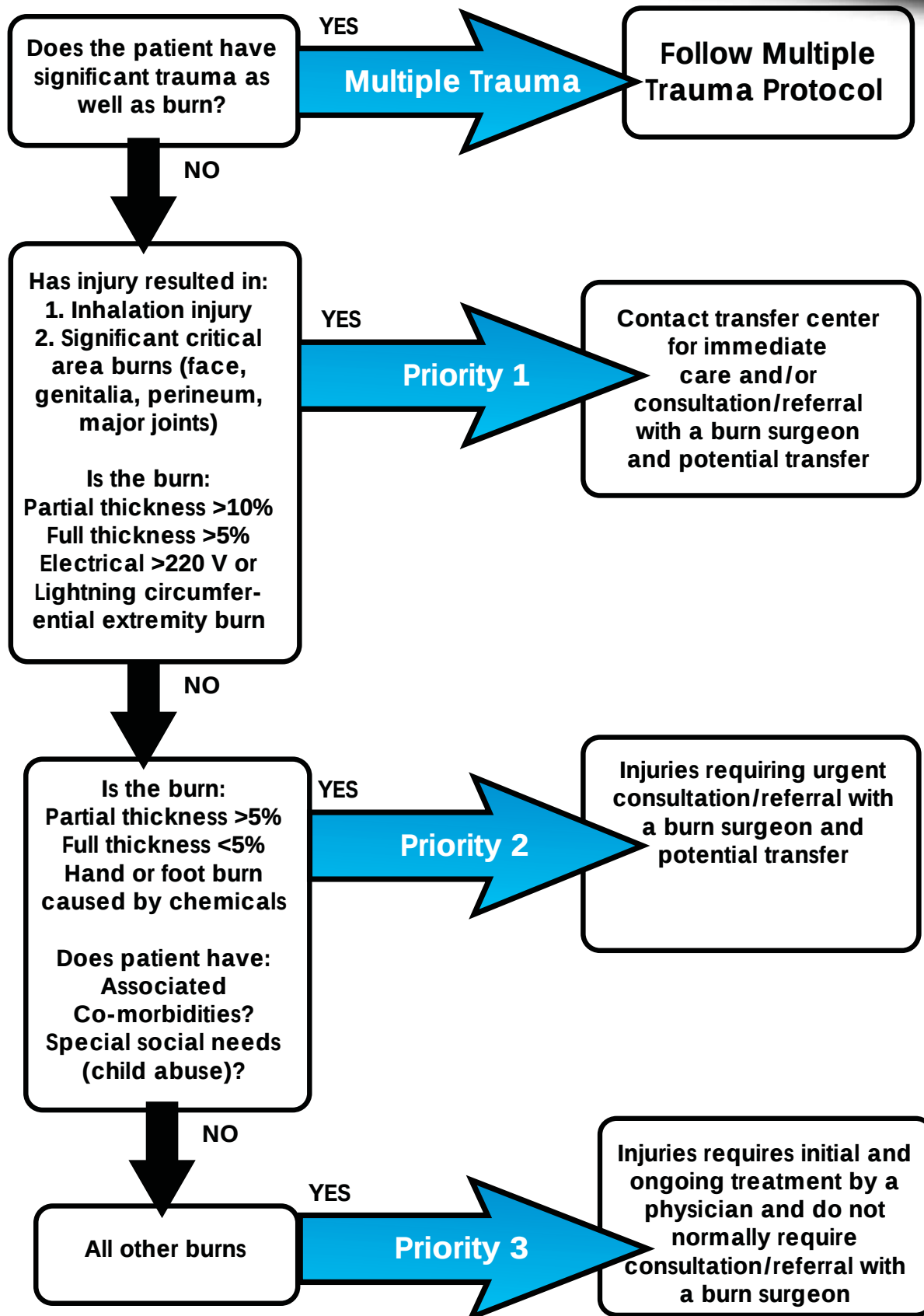
Above criteria are adapted from ABA recommendations.

Thermal Burn Patients

Rule of 9's



Thermal Burn Patients



Thermal Burn Patients

Stabilization

Pre-Hospital Care

Prior to any specific treatment, the patient must be removed from the source of injury and the burning process stopped. Burning clothing must be removed as soon as possible to prevent further injury. All rings, watches, jewelry, and belts should be removed as soon as possible as they can retain heat and act as a tourniquet. Do not use ice or ice packs to cool the wound as they can cause further injury or produce hypothermia.

Questions regarding specific patients and specific injuries can best be solved with phone consultation with a burn center physician.

Remember that many current cell phones and internet-connected computers are capable of sending quality digital photographs to the referral physician and that these photographs may save the patient unnecessary multiple hour and expensive ambulance transports.

Primary Assessment

1. The physician **MUST** ensure an **Airway**, if this hasn't been done by prehospital providers.
 - a. Exposure to heated gases from combustion results in damage to the respiratory tract. Direct heat to the upper airway causes edema and this may lead to airway obstruction. All patients who have hoarseness or other signs of inhalation injury should be intubated early in the course of the evaluation before edema obliterates the anatomy of the airway. Intubation will be required for unconscious burn patients, those in acute respiratory distress, and for patients with burns of the face and neck.
 - b. The physician must assume that if the patient with facial burns or potential of smoke inhalation needs transportation to a higher level of care, then that patient will need special attention regarding airway status which might include endotracheal intubation.
2. The physician **MUST** ensure that the patient is **Breathing** and continues to breathe.
 - a. Upper airway obstruction may develop rapidly following injury

Thermal Burn Patients

and the respiratory status must be continually monitored in order to assess the need for airway control and ventilatory support. Assisted ventilation with 100% humidified oxygen is required for all intubated patients.

- b. In circumferential chest burns, escharotomy may be necessary to relieve chest wall restriction and improve ventilation. These incisions may be done at the bedside under IV sedation using an electrocautery. Mid-axial incisions are made through the eschar but not into the subcutaneous tissue below the eschar.
3. The physician MUST assess the Circulation and Control bleeding
- a. All extremities should be examined for pulses, particularly when circumferential burns are present. A Doppler ultrasound flow meter is quite helpful in this evaluation. If pulses are absent, the involved limb may need urgent escharotomy for release of the constrictive, unyielding eschar.
 - b. In order to administer adequate fluids, the burn size and depth must be calculated. The size of the burn wound is most frequently estimated by using the rule of nines method. A more accurate estimate can be made using the Lund and Browder chart, which takes into account the changes of body part areas during growth of the child.
 - c. Establish adequate IV lines. A minimum of two large caliber IV catheters through non-burned areas should be started. If there are no unburned areas available, the lines can be established in burned tissue.
 - d. Oklahoma physicians are encouraged to use the Modified Brooke Army Burn formula promulgated by the United States Army Burn Unit at Brooke Army Medical Center. In this formula, 2 ml/kg/% Total Body Surface Area (TBSA) of lactated Ringers solution is given with one half in the first 8 hours post injury and the remainder over the following 16 hours. For pediatric patients, the initial resuscitation should be given at $5000 \text{ ml/m}^2/\% \text{TBSA burned/day} + 2000 \text{ ml/M}^2/\text{TBSA/day}$ 5% dextrose in Ringer's lactate. One half should be given in the first 8 hours post-injury and the remainder given over the following 16 hours.

Thermal Burn Patients

- e. The response to fluid administration and the physiological tolerance of the patient to large quantities of fluid are the most important determinants. The fluid resuscitation formula is a guide. Additional fluids are commonly needed with inhalation injury, electrical burns, associated trauma and delays in resuscitation.
 - f. The single best monitor of fluid replacement is urine output. Acceptable hydration is indicated by urine output of more than 30 ml/hour in an adult (or 0.5 ml/kg/h) and 1 ml/kg/hour in a child. Blood pressure is often difficult to assess in the burned patient. A rise in pulse rate may be a sensitive indicator of dehydration.
4. The physician MUST assess for neurological Disability and ensure that the patient's cervical spine is protected from further Damage. This may not be necessary in simple burn injuries, but escape from the burning area may cause significant other trauma.

Thermal Burn Patients

Stabilization Checklist

- Ensure that the airway is protected, early intubation may be life-saving
- Establish 2 large bore IV sites
- Start resuscitation with Modified Brooke burn formula

Adult	Child
First 8 hours 2-4 ml/kg/TBSA burned Give ½ calculated amount in first 8 hours, give remaining over next 16 hours	5000 ml/m ² /‰ burned TBSA Ringer's lactate + 2000 ml/m ² /Body surface area of 5% Ringer's lactate Give ½ calculated amount in first 8 hours Give remaining over next 16 hours
Ensure adequate pressure and pulse rate. Urine output should be about 30 ml/hour (0.5 ml/kg/hour).	Ensure adequate pressure and pulse rate. Urine output should be about 1 ml/kg/hour.

For burns <24 hours old, generally only lactated Ringer's solution is used.

- Insert a Foley catheter and monitor for acceptable urine output as noted above
- Maintain body temperature between 38 and 39 C rectally
- Stop all narcotics

Thermal Burn Patients

Introduction

Thermal burns are perhaps the most devastating injury suffered by an individual. The skin separates us from our environment. It provides the bulk of cooling for the stress of heat, regulates the egress of bodily fluids, and prevents outside agents and bacteria from entering the body. It is the largest organ in the body. When a burn breaches the skin, we lose some or all of these factors to a degree depending upon the extent of the burn. The skin also provides us with much of our concept of beauty. The emergency provider may find that caring for the burned patient to be stressful, frightening, and even repugnant.

Demographics

Among the environmental injuries sustained by man, by far the most common are burns. The National Consumer Commission has estimated that there are at least 2 million individuals in the United States alone that are burned each year. Of these patients, some 100,000 require hospitalization, and about 20,000 will die.¹ Burns are not only common but they can be lethal. While a minor burn requires little treatment, a 20% full thickness burn is an injury equivalent to having both legs crushed in the metabolic consequences to the body.²

Those at the extremes of age are more likely to suffer a thermal injury than individuals in the middle years of life. Children are active, curious, and unaware and uninformed, a combination of traits that can result in many burns. Indeed, children under six have more burns than any other age group.³

Children are most often victims of scald burns, while adults are more frequently burned with flammable liquids. More males are burned than females. Structural fires account for 45% of burn related deaths. These are primarily due to inhalation injuries.

Survival of the burn patient is dependent upon the amount and depth of the burn, the age of the patient, and associated other injuries. Predicting the mortality risk for a given patient helps when deciding where to transport the patient, determining the appropriate level of care, and choosing different therapies. There are many formulas that help calculate the expected mortality.⁴⁻⁷

Types of Burns

Burns are classified by the agent that causes them. Common categories include thermal, electric, radiant, and chemical burns. Additionally, thermal

Thermal Burn Patients

burns are subdivided due to the causes such as flame, flash, scald, and contact burns. Radiant burns are discussed in the sections on radiation and sunburn.

Pathophysiology of Thermal Burns

Burns are caused by the rapid transfer of energy to the skin at a faster rate than the body or skin can dissipate it. The depth of a burn depends upon the temperature and duration of the heat applied, and the ability of the tissues to dissipate the transferred energy. The rate of heat transfer is more critical than the total amount of heat transferred.

With scald burns, the magnitude of injury depends upon the heat transferred from a liquid. This, in turn depends on the specific heat of the liquid (the amount of heat needed to raise a certain volume of liquid a specific number of degrees). A higher specific heat means that the liquid's capacity to store and release heat is greater. Water has a higher specific heat than most substances found in nature. The heat stored in small quantities of hot water is sufficient to cause thermal injuries. The maximum temperature that liquid water can attain at sea level is 100°C (212°F). Other liquids such as tar, sulfur, or molten metals, can attain higher temperatures. Sulfur and tar also have higher specific heats than water, thus the burns from these two substances can be severe.

The length of time a liquid is in contact with the skin is also important. At temperatures above 70°C (158°F), water can cause complete necrosis of the epidermis in less than 2 seconds. It is fortunate that water is not particularly viscous and flows to the floor unless impeded by clothing. With immersion scalds, the duration of contact between the hot liquid and skin. Consequently, the resulting injury is more severe.

The extent of the injury will be exacerbated if the liquid solidifies on contact, is hotter than water, or ignites other materials. An example is the degree of severity of the molten metal burn. Here the liquid is hotter than water.⁸ Because it solidifies upon contact it remains on the skin longer.

Vascular Changes in Burned Skin

Almost immediately after the burn, the vessels in the adjacent area are altered. At first, an intense vasoconstriction is caused by the release of numerous vasoactive substances from the injured cells.

After a few hours, the vessels dilate as kinins are released from the damaged

Thermal Burn Patients

mast cells. During the vasodilatation, the capillaries become more permeable, allowing extravasation of plasma into the burned wound.

Ischemia from the initial vasoconstriction and subsequent microthrombus formation may extend the area of the injury. The ischemia may be present to a depth as much as three to seven times greater than the area of the cells directly damaged by the heat. Because of this ischemia, final determination of the depth of the burn may be delayed as long as 5 days.

Many authorities recognize three concentric layers of vascular changes due to the effects of the burn and subsequent ischemia.⁹ The center of the burn is often called the zone of coagulation and represents the area of direct cellular destruction by the heat.¹⁰ Within this region, all blood vessels are thrombosed. As the intensity of the heat or the length of the exposure increases, this zone of coagulation will become deeper and wider.

Surrounding the zone of coagulation is a zone of stasis. In this area there is vasoconstriction and some microvascular thrombosis. Some blood vessels will remain patent, even though blood flow is reduced overall. If circulation is promptly restored, some of the injured cells in this region will survive. However, a delay in treatment can cause more irreversible damage.

Surrounding the area of vascular stasis is an area of minimal damage, the zone of hyperemia. The bright red color that blanches on pressure is noted at the margin of all burn wounds, and in the most minimal cases may comprise the entire wound.

Water and Heat Losses

In addition to the direct reactions to a thermal burn, the destruction of the epidermis will allow increased insensible water losses of up to 15 times normal. As the water evaporates, body heat is lost which can lead to the development of hypothermia. These heat and water losses can be considerably increased if the patient is evacuated by helicopter with the subsequent increased airflow. These losses must be considered when putting together the treatment plans. Caloric requirements increase enormously as the body tries to adjust to this increase in metabolic rate.

Thermal Burn Patients

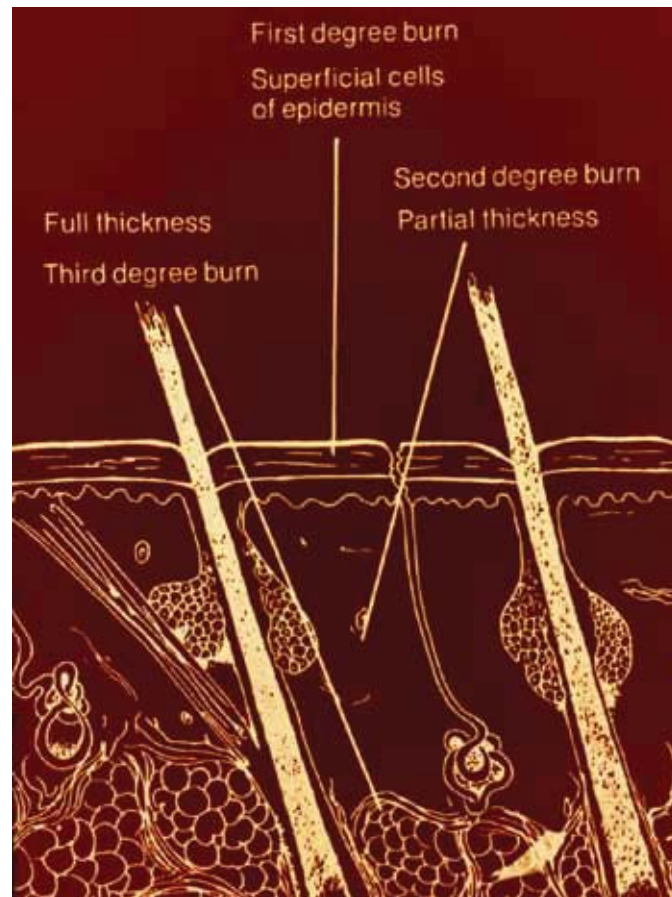
Infection Potential

Following a severe skin burn from any source, the skin undergoes coagulation necrosis and becomes an excellent growth medium for bacteria. Because the local blood supply is also compromised, the local defense mechanisms may be inadequate. The degree and consequences of the resultant bacterial invasion will vary directly with the severity of the wound and can be modified by subsequent therapy. This bacterial invasion is one of the most frequent, fatal complications of a serious burn and should be treated aggressively from the beginning.

Assessment of the Burn

The assessment of thermal burn injury involves two major factors: the depth and extent of the damage. These two factors help to determine the capacity for regeneration, and the potential for bacterial invasion, along with the victim and other complications. Included in the initial assessment of the burn should be the assessment of the potentially exacerbating factors such as age, prior medical history, allergies, and current medications.

Thermal Burn Patients



The Skin

The **epidermis** is the outer layer of the skin and is made up of 4 layers:

1. Stratum corneum - the layer that retains water. This layer consists of dead, dried out (keratinized) cells that are constantly being shed.
2. Stratum lucidum - Clear cell layer - cells are becoming keratinized.
3. Stratum granulosum - In this layer, the epidermal cells gradually die and start to keratinize.
4. Stratum germinativum - the layer in which new skin cells are produced. Injury to this layer may result in vitiligo; a mottled coloring of the skin. This is the layer that is destroyed in a third degree burn.

The true skin, **dermis** or corium is the inner layer of the skin, is composed of connective tissues and the pressure sensors, nerves, pain sensors, hair follicles, and sweat glands. This layer also controls heat balance. The germinal layer, stratum germinativum, extends into the dermis where the skin's hair follicles, sweat glands and other appendages are produced. It is from these skin appendages that deep third degree burns may regenerate the skin.

Thermal Burn Patients

Depth of the Burn

The depth of a burn provides the initial clue to the severity of the injury, but it may not be possible to accurately determine the depth of a burn until debridement has been performed. What initially appears to be a second degree burn may evolve into a third degree burn by infection or vascular changes from the original burn injuries. Determination of the depth of burn is most important for establishing wound care priorities.

First Degree Burns

A first degree burn affects only the epidermis. It results in vasodilatation and congestion of the dermal vessels. The resultant erythema will blanch upon pressure. There is no bullae formation, and the wound is painful. Premature cell death often results in desquamation or peeling a few days after the burn. Scarring or discoloration does not accompany healing and there is no substantial clinical significance to this injury in the otherwise healthy adult, unless a great extent of the body is involved.



Generally, a first degree burn is a Priority 3 injury that does not require consultation with a burn surgeon. In cases where patients have extensive first degree burns, telephone consultation may be indicated.

Second Degree Burns

A second degree burn involves a portion of the dermis and produces an epidermolysis. The resultant edema and fluid exudate leads to bullae formation, a hallmark of the second degree injury.

Thermal Burn Patients

By definition, the full thickness dermis is not destroyed in a second degree burn and the epidermis can regenerate over a period of time without significant scarring or contracture formation. Since nerve fibers in the skin are often spared, these burns are exquisitely painful.



The intact blisters provide a sterile waterproof covering for the wound and healing occurs by continued growth of the remaining basal cells. Underlying the blister formation may be an erythematous or waxy base, depending upon the depth of the burn. If the blister is broken, a weeping wound will result. There is then concomitant increase in evaporative water and heat losses, and exposure of naked nerve fibers.

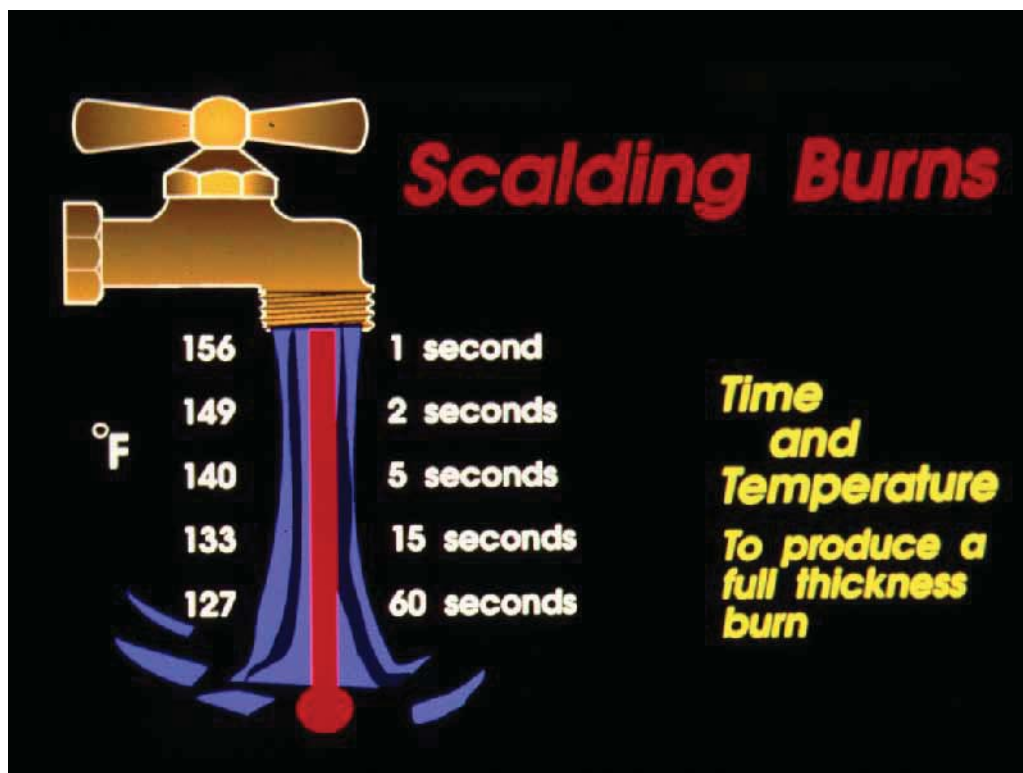
Deep second degree burns occur when the damage is extensive, but the deeper structures retain viable skin elements. This is most often true in deep burns of the back, palms and soles. At times, the only remaining elements may be very deep in the dermis, such as sweat glands and hair follicles. This burn may develop the same eschar as the third degree burn. It is important to recognize these deeper second degree burns in extensively burned patients because the skin may regenerate without skin grafting.

Deep second degree burns and second degree burns greater than 10% of the total body surface area should be treated as a Priority 1 injury with immediate consultation with a burn surgeon. An urgent transfer to a burn unit is likely.

Thermal Burn Patients

Although bullae are classically found with second degree burns, they may be also caused by infection or by superheated steam. Bullae due to second degree burns develop relatively promptly after the injury. Those bullae noted with infection present later, usually 24 or more hours after the insult. The provider should be suspicious of blisters appearing more than 16 hours after a burn injury. Superheated steam may also cause bullae because the high temperature causes water in the skin to boil and then vaporize which separates the dermis from the epidermis. The burns from superheated steam should be considered third degree at all times. Note that superheated steam is used only in commercial and marine boilers and is not a common source of injury.

These injuries are third degree burns and should be treated as such. Any third degree burn greater than 5% of the total body surface area is a Priority 1 injury. An urgent transfer to a burn unit is likely.



Thermal Burn Patients

Third Degree Burns

As the depth of injury increases in more severe burns, all epidermal and supporting structures are destroyed. The surface of a third degree burn is dry, leathery, and inelastic. The burned skin surface may appear white to gray, waxy, and translucent. Mottling and superficial coagulated vessels may be seen through the surface of the resultant eschar. The leathery eschar permits water losses to an excess degree and there is no functional barrier to bacterial invasion. These burns are often painless, due to the destruction of the nerve fibers.

By definition, the third degree burn will not regenerate except from the unburned edges of the skin or from a skin graft. For this reason, surgical intervention will usually be needed. New research with skin cell cloning may help some of these victims.



Mixed 2nd and 3rd degree burn

A 3rd degree burn of greater than 5% should be treated as a Priority 1 injury and requires immediate consultation with a burn surgeon. An urgent transfer to a burn unit is likely.

Thermal Burn Patients

Fourth Degree Burns

Though not used by all authorities, the classification of fourth degree burn is applied to burns that extend beyond the depth of the skin to involve underlying fascia, muscle, tendons, nerves, periosteum, and vessels. Occasionally even bone may be involved. This burn classification is most often used with electrical injuries, but severe charring of extremities may also be termed fourth degree lesions. The natural history of this wound is the same as a third degree burn but there is deeper destruction and more dysfunction. There is no difference in the initial treatment of a third degree burn and a fourth degree burn.



Extent of the Burn Surface

Unfortunately for burn surgeons, the surface area of the various parts of human frame is not easy to calculate. Our frame is irregular and varies in its irregularity with age and sex, making such calculations difficult. Because of the complexity, multiple schemes have evolved for the estimation of the burned surface area.

TBSA = Total Body Surface Area

%BSA = percentage of burned surface area

Thermal Burn Patients

Lund and Browder Chart

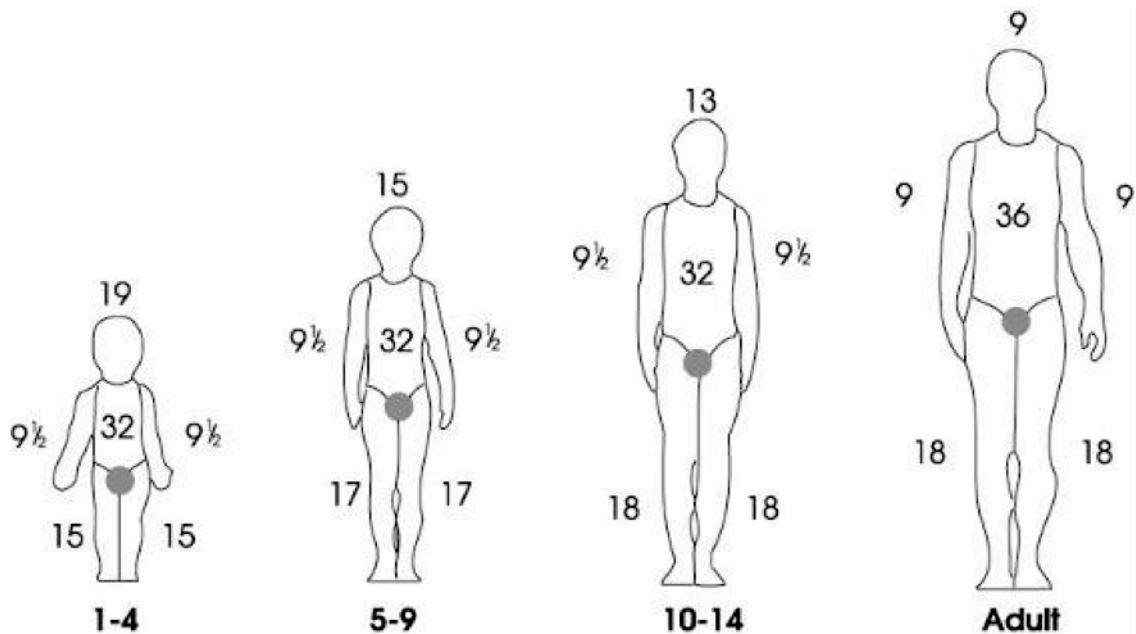
Since the proportions of surface areas of the younger patients will vary with age, schemes to approximate the burn surface area will fail unless these variations are taken into account. The most accurate method for determining the extent of the burn is the Lund and Browder Chart which accounts for changes in the sizes of the body parts occurring during growth.¹¹ These calculations can be quite time consuming, and the rule of nines is more frequently used in field emergency services (though less accurate for the pediatric population).

Age vs. Body Surface Area Proportions						(Percentage)
Area	Birth to 1 Year	1 to 4 Years	5 to 9 Years	10 to 14 Years	15 Years	Adult
Head	19 %	17 %	13 %	11 %	9 %	7 %
Neck	2 %	2 %	2 %	2 %	2 %	2 %
Ant. Trunk	13 %	13 %	13 %	13 %	13 %	13 %
Post Trunk	13 %	13 %	13 %	13 %	13 %	13 %
R. Buttock	2.5 %	2.5 %	2.5 %	2.5 %	2.5 %	2.5 %
L. Buttock	2.5 %	2.5 %	2.58 %	2.5 %	2.5 %	2.5 %
R.U. Arm	4 %	4 %	4 %	4 %	4 %	4 %
L. U. Arm	4 %	4 %	4 %	4 %	4 %	4 %
R. L. Arm	3 %	3 %	3 %	3 %	3 %	3 %
L. L. Arm	3 %	3 %	3 %	3 %	3 %	3 %
R. Hand	2.5 %	2.5 %	22.5 %	2.5 %	2.5 %	2.5 %
L. Hand	2.5 %	2.5 %	2.5 %	2.5 %	2.5 %	2.5 %
R. Thigh	5.5 %	6.5 %	8 %	8.5 %	9 %	9.5 %
L. Thigh	5.5 %	6.5 %	8 %	8.5 %	9 %	9.5 %
R. Leg	5 %	5 %	5.5 %	6 %	6.5 %	7 %
L. Leg	5 %	5 %	5.5 %	6 %	6.5 %	7 %
R. Foot	3.5 %	3.5 %	3.5 %	3.5 %	3.5 %	3.5 %
L. Foot	3.5 %	3.5 %	3.5v	3.5v	3.5	3.5
Genitalia	1 %	1 %	1 %	1 %	1 %	1 %

Thermal Burn Patients

Rule of Nines

The rule of nines apportions a nine percent segment to each of eleven major body surfaces and the remaining one percent is apportioned to the groin. This scheme is for the adult human. For children a greater percentage is assigned to the head and a lesser percentage for the lower extremities.



Rule of Palms

The rule of palms is convenient for measurement of small burn surfaces. The palm of the patient's hand is roughly 1% of the patient's total body surface area. Estimation of the number of palms for a small burn will give a rough approximation of the burned surface area. This method is not accurate for large burned surfaces.



Thermal Burn Patients

Classification of Burns

The American Burn Association guidelines are useful in determining the overall severity of a burn. Those burns that involve inhalation injuries or are caused by electricity are significantly more dangerous than just thermal burns.¹² Extensive burns and burns that involve areas that are difficult to treat or are associated with high rates of infection are more dangerous.

Finally, burn patients at the extremes of age or with preexisting disease will have more mortality or morbidity as a result of the injury.¹³ Preexisting diseases that increase the risk of a major burn include (but are not limited to): major cardiovascular or respiratory diseases, hepatic and renal diseases, insulin dependent diabetes, alcoholism, severe psychiatric illness, and head injuries with unconsciousness. Patients with sickle cell disease should also be considered to be in this category because they will frequently develop a sickle cell crisis in response to major burns.

Severity of Burns

Major Burn Injuries

- Second degree burns >25% TBSA in adults
- Second degree burns >25% TBSA in children
- Third degree burns >10% TBSA
- Significant burns of hands, face, eyes, ears, feet or perineum
- All inhalation injuries
- Electrical burns
- Burns complicated by fractures or other trauma
- Burns in poor risk patients

A major burn injury is a Priority 1 injury and immediate consultation with a burn surgeon and an urgent transfer to a burn unit is indicated.

Moderate Uncomplicated Burn Injuries

- Second degree burns greater than 15% TBSA in adults
- Second degree burns greater than 10% TBSA in children
- Third degree burns greater than 2% TBSA that do not involve ears, eyes, face, hands, feet, or perineum

A moderate burn injury is either a Priority 1 or a Priority 2 injury. Immediate consultation with a burn surgeon and an urgent transfer to a burn unit is appropriate.

Thermal Burn Patients

Minor Burn Injuries

- Second degree burns <15% TBSA in adults
- Second degree burns <10% TBSA in children
- Third degree burns that are <2% and do not involve any of the critical areas

These injuries are Priority 3 injuries and may not need an urgent transfer to a burn unit. If there is any question, contact your local surgeon.

History

Of particular importance is eliciting a detailed history upon first evaluation and transmitting this information with the patient to the next level of care. Obtain the history of the injury from the patient, relatives, or emergency response crew. Remember that although the burn may ultimately be fatal, if the patient has survived the initial insult, the burn wound itself is not likely to be the IMMEDIATE threat to life.¹⁴ Gas explosions, propane explosions, or other explosive injuries may cause substantial associated injuries. Confinement in an enclosed car or a room may be associated with pulmonary injuries from inhalation of toxic gasses. The patient may have been involved in an accident that preceded the burn, or may have leaped to escape being more severely burned. There may be penetrating injuries from associated blast effects, electrical injuries, or myriads of other complications. These potentially life-threatening injuries may take precedence over the burn wound management and should be dealt with as necessary.

Inhalation injury is diagnosed based on a history of a closed-space exposure and soot in the nares and mouth. Carbon monoxide intoxication is probable in persons injured in structural fires, particularly if they are obtunded; carboxyhemoglobin levels can be misleading in those ventilated with oxygen.

The history should include any associated illnesses such as diabetes, hypertension, metabolic disorders, or cardiac and pulmonary diseases. It is important to find out if there are any allergies and current drug therapy. The patient's age should be noted at this time. Remember that burns occurring at the extremes of age will be associated with the highest morbidity and mortality.

Thermal Burn Patients

Physical Exam

Appraisal of the Burn

Upon arrival of the patient, the physician needs to reassess the basics of Airway, Breathing, and Circulation.

Burn patients should be systematically evaluated using the methodology of the American College of Surgeons Advanced Trauma Life Support course. This evaluation is described by the primary survey, with its emphasis on support of the airway, gas exchange, and circulatory stability.

First evaluate the airway; this is an area of particular importance in burn patients. Early recognition of impending airway compromise, followed by prompt intubation, can be lifesaving. Airway swelling, respiratory distress, and signs of potential inhalation injury should be sought and corrected immediately.

Although impairment of circulation is not usually a problem in the early and uncomplicated burned patient, burned patients have frequently sustained additional trauma in the process of exiting the burning area or as a consequence of the burn. The patient should be examined thoroughly for the signs of additional trauma. As the formation of local edema in the burn progresses, hypovolemia (burn shock) becomes likely and must be corrected. Circumferential burns may impair local circulation to the extremities. This must be promptly treated.

The presence of trauma in a burned victim is not unusual and the examiner should carefully examine every burn patient for trauma. Not only do people leap out of buildings in order to escape a burning building, they can be in vehicular wrecks that start the fire.

Diagnostic Studies

Ensure that appropriate baseline laboratory data is obtained. This usually includes:

- CBC
- PT/PTT
- Electrolytes
- Electrolytes
- Carbon monoxide level
- Blood sugar

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- BUN and creatinine
- Chest X-ray
- Blood gasses
- Type and cross blood if the patient has greater than 35% burn
- Obtain baseline weight if at all possible
- Other studies as clinically indicated. (E.g. CT scan with head trauma or altered mental status, extremity and spinal x-rays if the patient jumped to escape the fire)

Treatment

Care of the Burn Patient at the Injury Scene

The first priority is to ensure that you don't become a victim. Under no circumstances should the emergency care provider enter a burning building without proper protective equipment, to include self-contained breathing apparatus. The rescuer that succumbs to smoke, toxic gasses, or flames has helped no one and becomes a casualty that needs to be extricated himself. Approaching a chemically contaminated victim should only occur after thorough preparation and donning of proper protective equipment for the agents involved.

Prior to initiation of medical care, the patient should be extricated from the source of heat if necessary, and the sources of heat removed from the body. Smother the flames with a blanket or by rolling the patient on the ground. If you are burning **"Stop, Drop, and Roll!"** Smoldering or burning clothing should be extinguished and then cut away. Failure to remove burning clothing, followed by use of oxygen therapy, is unnecessarily hazardous to both patient and medical staff. It is wise to remove all of a burn victim's clothing, to ensure that no embers or smoldering sections remain to be transported in the vehicle. Chemically contaminated garments should be removed and the victim washed with copious amounts of water (with only a few exceptions). Needless to say, washing of the victim should be done at a decontamination station, not in the vehicle.

Burns may be inflicted in children as a form of abuse. Contact burns with matches, cigarettes, irons, or hot metal appliances, and scald burns are common forms of this type of child abuse. If the history seems inconsistent with the trauma noted, or if the parent's concern seems inconsistent with the seriousness of the injuries of a child, the physician should be alerted to the

Thermal Burn Patients

possibility of child abuse. Frequent locations of non-accidental burn trauma include burns of the backs of the hands, and legs, buttocks, and feet.¹⁵⁻¹⁶

If the transport time to the hospital is less than 15 minutes, the burn patient may be covered with a sheet (sterile if possible) and transported without further delay. If the transport time exceeds 30 minutes, at least one large bore line of Ringer's lactate should be started in any available site. Use of intravenous lines through burned tissue should be avoided if at all possible. If the transport time is less than 30 minutes and greater than 15 minutes, local protocols should be consulted. For severe burns, associated injuries, inhalation injuries, and patients with associated preexisting diseases, air transport directly from site to a specialized burn center may be indicated.

If communications are available from the site to the receiving emergency department, the receiving emergency department should be notified so that appropriate arrangements can be made. Only the information that is used to classify the severity of the burned patient should be communicated to the hospital via radio (e.g. depth of burn, percentage of burned skin, location of the injuries, age of the patient, presence of inhalation or electrical injuries, and significant other illnesses).¹⁷

Moist soaks or ice applications are often recommended to relieve the pain of a superficial burn. If the patient has more than a single extremity burned, the patient should **not** be wrapped in cold compresses or have ice applied. If the burn is third degree, the patient also does not need treatment with ice or cold water. It is, unfortunately, entirely too common to have a patient brought to the emergency department by inexperienced EMT's or well meaning friends who have applied ice water to the burns and have the patient sitting in a pool of cold water on the cot. With an immersion of this sort, it is easy to imagine (and document) the rapid development of hypothermia. The patient with a burn does not need the additional stress of hypothermia and its associated problems.

Wet Dressings = Increased Risk of Hypothermia

Field Considerations (Long Transport Times)

If transport of the patient is delayed due to weather, unavailability of transport, distance or terrain (or any other factor), airway support and fluid status should be monitored carefully and corrected as needed. Any of the fluid resuscitation "burn budgets" described below may be used.

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During a long transport, if intravenous fluids are not available for any reason, oral fluid replacements may be required. The decision to give oral fluids in this situation should not be made lightly, as about 30% of patients with a burn of 20% or more of the body surface area will develop an adynamic ileus. The complications of an adynamic ileus and administration of oral fluids are obvious. If contraindications to the administration of oral fluids exist, such as abdominal trauma, facial trauma, or unconsciousness are present, oral fluids should not be given. The practitioner with a severely burned patient beyond the roadhead or in very inclement weather has a practical and therapeutic dilemma in prevention of burn shock.

Treatment of the patient's burned surface areas in the field during the first 48 hours should be limited to a gentle cleansing with diluted povidone-iodine solution or a diluted solution of baby shampoo or mild dish soap. Needless to say, water used to cleanse burns should be properly treated as described in the chapter on water purification. Grease-based ointments and salves should not be used. Water-soluble antibiotic creams such as Silvadene may be used if available. These dressings should be changed every 12 to 24 hours. Burn dressings should be fabricated from the cleanest cloths available, if no sterile dressings are at hand.

During long transports, care should be taken to keep burned extremities elevated so that excessive edema formation does not occur. Circumferential extremity burns should be treated as outlined below to prevent limb ischemia. Circumferential chest injuries may also necessitate an escharotomy prior to or during an extended transport to prevent respiratory embarrassment.

Emergency Department Management of Burns

Once the patient has arrived in the emergency department, definitive management of the burn begins. It should be remembered that for the patient with an extensive burn, this is only the beginning of a treatment program that may last for years. The emergency physician's goal is to enhance the maximum chance for survival of both body and burned surfaces for the patient. This may mean that the emergency physician's appropriate role is that of stabilization and referral rather than definitive therapy. Burn care has advanced tremendously over the past 20 years through the joint efforts of emergency providers and burn researchers in specialized burn units. The average hospital does not have the resources or training for management of the severely burned patient.

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Burn Shock

Following a severe burn, adult patients may lose up to 10 to 15 liters of fluid due to increased capillary permeability throughout the body. This isotonic fluid and protein leak from the intravascular compartment to the cellular interstitium is greatest losses during the first 8 to 12 hours.¹⁸⁻²¹ If untreated, this transfer of fluid may cause hypovolemic shock.

Fluid resuscitation “budgets” developed over the past two decades have virtually eliminated death due to burn shock. In fact, burn edema due to increased capillary permeability and simultaneous over zealous fluid administration is now the most common complication of a burn.²²

Fluid resuscitation becomes critical in adults who have sustained burns of more than 15% of their body surfaces and in children or elderly patients with 10% or more body surface burns. The goals of fluid resuscitation are to maintain cardiovascular hemodynamics, prevent renal and pulmonary complications, and to correct acid/base abnormalities.

Calculating Fluid Replacements

In 1952, Evans and associates devised a formula for calculating the fluid and electrolyte requirements of severely burned patients.²³ Our concepts of the fluid and electrolyte replacements for in the burned patient have been derived from suggestions by many investigators since that time. The author has had the most experience with the modified Brooke Burn Unit formula, which is the recommended resuscitation formula in Oklahoma, but all of the formulas appear to be based upon relatively sound principles.²⁴⁻²⁵ (See table 3A.2). Children will require even greater precision in fluid replacement than adults for similar burns.²⁶ (See pediatric formula below)

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Modified Brooke burn formula

Adult	Child
First 8 hours 2-4 ml/kg/TBSA burned Give ½ calculated amount in first 8 hours, give remaining over next 16 hours	5000 ml/m ² / % burned TBSA Ringer's lactate + 2000 ml/m ² /Body surface area of 5% Ringer's lactate Give ½ calculated amount in first 8 hours Give remaining over next 16 hours
Ensure adequate pressure and pulse rate. Urine output should be about 30 ml/hour (0.5 ml/kg/hour).	Ensure adequate pressure and pulse rate. Urine output should be about 1 ml/kg/hour.

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Burn Resuscitation Formulas In The First 24 Hours			
Investigator	Electrolyte	Colloid	Water
<i>Evans</i>	1 cc/kg/% Burn	1 cc/kg/% burn	D ₅ W 2000 cc
<i>Brooke Burn Unit</i>	1.5 cc/kg/% Burn	.5 cc/kg/% burn	D ₅ W 2000 cc
<i>Brooke (Rev. 1979)</i>	2-3 cc/kg/% Burn LR	None	None
<i>Baxter (Parkland)</i>	4 cc/kg/% Burn LR	None	None
<i>Monafo</i>	Hypertonic lactated Saline To maintain urine at 30 cc /hr (About 2 c c/kg/% Burn)		
Hypertonic Sodium Solution	Volume to maintain urine output at 30 cc/hr. Fluid contains 250 mEq Na ⁺ /L.		

Because the most drastic fluid shifts occur in the first 8 to 12 hours after the burn, most formulas advocate replacement of half of the first 24 hours calculated fluid requirements during the first 8 to 12 hours. When calculating the replacement, be certain to consider the time of the burn, not the time of arrival of the patient in the emergency department. On the other hand, care must be taken not to overwhelm the patient's cardiovascular system with massive fluid administration rates if the patient arrives late in the course of the burn. Judgment becomes

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critical when the patient arrives 4 to 6 hours after a severe burn and has not had adequate fluid resuscitation. This is an unfortunately common situation during transport of a burn from the outback, such as occurs with brush or forest fires.

Monitoring The State Of Hydration

All of the burn formulas and budgets are merely guidelines and a rigid application of formulas will ignore the variability of both burn and patient. The burn fluid replacement formulas frequently result in over or under hydration at the extremes of weight and burn size. Do not rely on a single parameter to judge the efficacy of fluid replacement. Look for a combination of the following factors:

1. Clear sensorium
2. Extremity capillary filling and warmth of extremities
3. Vital signs normal or near normal
4. Decreasing hematocrit
5. Adequate urine output
 - 30-50 cc/hr in adults.
 - 0.5-1 cc/kilogram/hr in children.

Hematocrit, blood pressure and pulse have significant limitations as indicators of shock in the burned patient. It is often quite difficult to obtain an accurate pulse or blood pressure through the thick tough eschar of a severe burn. Arterial lines may be needed for accurate blood pressure and pulse. The blood pressure in children and young adults is often stable until late in the clinical picture of shock. Hypertension may be found frequently in severely burned children. With the increased metabolic rates associated with thermal trauma, a pulse in excess of 100 is often found and is compatible with adequate fluid resuscitation.

Hematocrits of 55-60 are common in the first 24 hours after serious burn injuries, even with adequate fluid administration. Decreasing hematocrits are to be expected with adequate fluid resuscitation, but may also be a hallmark of occult bleeding. If the patient apparently requires fluid far in excess of the burn budget, a vigorous search for occult bleeding is indicated.

Central venous pressure lines may also not show the patient's fluid status if there are extensive burns. This is particularly true in the case of fluid overload. A more reliable indicator of fluid status is the pulmonary wedge pressure (Swan-Ganz catheter). A Swan-Ganz catheter may be required in as many as 10% of all severely burned patients.

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A patient with burn induced myoglobinuria or hematuria may require additional fluids or diuretics to protect the kidneys. These attempts to force urine output may also lead to edema formation. Use of mannitol to attain an osmotic diuresis makes urine output an even less reliable indicator of hydration.

Care of the Burn Wound

Care of the burn wound should be directed towards four principles:

1. Prevention of infection
2. Decrease of burn fluid losses
3. Relief of pain
4. Salvage of all viable burn tissue

It should be emphasized that the best coverage for tissue is skin. Although acceptable artificial substitutes are now available, there is still nothing better than the "real thing". If bullae are present, these skin coverings should be preserved if at all possible. All cleansing and debridement should be directed to ensure maximum salvage of tissue in the burned patient.

Cleansing the Wound

Before cleansing the burn, soak off charred clothing with sterile saline. Gently cleanse the burn with mild soap and water, debriding it of all foreign particulate matter and charred tissue. The process is easier if the affected area is immersed in warm saline or water.²⁷ The use of a Hubbard or similar immersion tank is ideal for treatment of larger burns, but washing under running tap water will suffice for smaller burns.

The question of whether or not to debride intact bullae remains controversial. The blister provides a sterile biologic dressing and should be left intact unless it is extremely large or inhibits motion. If the blisters are ruptured, hemorrhagic, or purulent, they should be debrided.

Use of Antibiotic Creams

There are a number of ways to manage a burn once it has been cleansed. For the early care of a burn, little wound coverage is needed. Dry sheets (sterile if at all possible) will prevent air exposure to the burned tissues and will decrease pain. If something must be applied to the wound, a water-soluble base is mandatory. Do not use petroleum-based ointments, unless the burn is caused by sulfur or tar.

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For smaller burns, treated on an outpatient basis, studies show that any of a variety of medications are appropriate. These medications include povidone-iodine, mafenide, and silver sulfadiazine. For the larger burn, an appropriate first choice is silver sulfadiazine. Mafenide (Sulfamylon) is thought to be better for electrical injuries because of a superior tissue penetration. Please check with the local burn center for their preferences. Some authorities do not wish to have any topical medications applied until they have evaluated the patient themselves.

Adjunctive Therapies

Nasogastric Suction

Nasogastric suction using a Salem sump or similar tube should be initiated early in the emergency department. Many patients with a burn of greater than 25% TBSA will develop an ileus in the first 24 to 48 hours that will often last for several days. If the patient has nausea, distention, or vomiting with lesser burns, a nasogastric tube will often help.

Curling's ulcer (burn stress ulcers) will often be prevented by instillation of cimetidine (Tagamet) or other H₂ blockers or antacids instilled into the nasogastric tube or given intravenously.

Blood

Erythrocyte hemolysis occurs after a major burn. The etiology of this hemolysis is not known. Between 3 and 15% of red blood cells may be lost in the first week or two after the patient's burn. A victim of a major burn will very likely need a transfusion for these red cell losses. Ensure that adequate blood is obtained for a cross match in preparation for transfusion.

Antibiotics

In the early post-burn period, antibiotics are rarely indicated. Please check with the burn unit physician prior to use of any antibiotics. The single exception to this is the patient who has been on antibiotics for an antecedent illness. These patients should be continued on their antibiotics.

Tetanus Immunization

The burn injury is considered a high risk wound for tetanus. If the patient has had a tetanus immunization within five years, no further therapy is needed. If the

Thermal Burn Patients

patient's last tetanus immunization is greater than five years ago, then a tetanus booster of 0.5 cc of age appropriate toxoid should be given. If the patient has never had a full series of tetanus immunizations, then the patient should receive hyperimmune tetanus anti-toxin and the tetanus immunization series initiated.

Potential Complications

Non-accidental trauma

Although most burns are unintentional, assess all burn patients for risk factors for intentional injury. Scald and contact burns are common in children and are also frequent findings in child maltreatment victims. A "pattern" burn (where there is a clear demarcation of an object in the burned skin), "glove" or "stocking" distribution of a scald burn or a history that is inconsistent with the injury and/or changing with each interviewer are suspicious circumstances for intentional injury. Remember that children may not be the only victims of abuse. These injuries must be reported per Oklahoma law.

Inhalation Injuries

Postburn lung dysfunction is a major cause of mortality in the burned patient. Of the 84 people who died in the 1980 MGM Grand Hotel fire in Las Vegas, 79 died of smoke inhalation.²⁸ Increasing use of plastics and other materials that liberate noxious fumes when ignited has increased the potential for such injuries. Objective criteria for diagnosis of inhalation injuries such as fiberoptic bronchoscopy and Xenon lung scans have demonstrated the presence of pulmonary insult in up to one third of all burn victims.²⁹⁻³⁰ These problems should not be underestimated. Patients with a burn and an inhalation injury have twice the mortality of patients with only a burn.

The emergency physician and nurse should anticipate the presence of a pulmonary or respiratory injury due to the inhalation of products of combustion. Suspect CO poisoning in all burned patients and obtain CO or carboxyhemoglobin levels when these levels are rapidly available.

Current recommendations also call for consideration of treatment of cyanide intoxication when CO intoxication is suspected. Many substances that produce CO during combustion will also produce large quantities of cyanide during this combustion.

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In cases with upper airway damage, rapid intubation may be lifesaving. Stridor is an ominous finding and implies at least 20% of the airway is occluded in the adult patient. Ensure that the patient is intubated with an endotracheal tube. Oral airways or intubation with an esophageal obturator airway is simply not sufficient - they do not protect the airway. Administer 100% humidified oxygen to prevent mucous membrane drying and ensure oxygenation of your patient.

Do not rely on pulse oximeters in the burn victim. Because they measure reflectance of bound hemoglobin, they are notoriously inaccurate in the presence of CO-bound hemoglobin and HS-bound hemoglobin.

An inhalation injury is a Priority 1 injury. After you assure that the airway is properly stabilized, consult a burn surgeon. An urgent transfer to a burn unit is appropriate for these patients.

Circumferential Burns

In severe burns of the extremities, especially those with circumferential or total involvement, it is imperative to establish the adequacy of perfusion. Marked edema from the deep dermal and third degree burn within the confines of inelastic eschar or the rigid fascial compartments of the extremity can limit the arterial supply and the venous outflow. The resultant tissue hypoxia can cause muscle necrosis that results in further swelling and further decrease in blood supply.

The appropriate preventative measures include early removal of rings and jewelry and elevation of the limbs. If the extremity appears cyanotic distal to the injury or capillary filling time is increased despite these measures escharotomy should be considered. Doppler flow detectors also may be used to assess small vessel blood flow. If the patient also has weak or absent distal peripheral pulses, progressive neurological signs such as paresthesias or deep tissue pain, escharotomy is indicated.

The escharotomy should be made in both the mid medial and the mid lateral line of the limb and carried down to the ends of the fingers or to unburned skin. The incisions should be carried across involved joints and should be incised only to the depth, which allows the cut edges of the eschar to separate. As the eschar has had the cutaneous nerve endings destroyed, there is generally no need for anesthesia.

Thoracic escharotomy may be required to prevent respiratory decompensation

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in the patient with circumferential chest burns. The incisions for thoracic escharotomy are made in the mid axillary lines, across the costal margins and along the clavicles. The need for such incisions should be considered in all patients with a circumferential chest injury, particularly if combined evaluation and transport time from injury to evaluation at a burn center is greater than 60 minutes.

Fasciotomy may become necessary in the following situations:

- A high-voltage injury with deep tissue damage
- Associated skeletal or crush injuries
- Thermal injuries that extend to the fascia (4th degree injuries)

When in doubt, perform a fasciotomy or escharotomy rather than risk a subsequent amputation. A tissue pressure of greater than 30 mm of mercury, obtained by inserting a needle into the tissues and attaching a manometer is indicative of impending vascular compromise. The technique is the same as is used for evaluation of a compartment syndrome in an injured extremity.

The patient with circumferential injuries to a limb has a Priority 1 injury. You will need to consult your burn surgeon urgently. After stabilization of the circulation, an urgent transfer to a burn unit is likely.

Pain Medication

Patients with extensive severe burns often experience little pain. More minor burns, paradoxically can be much more painful, as the cutaneous nerve endings are damaged but not destroyed. Only when the burn is superficial, do the pain nerve fibers escape damage. Deep burns have destroyed the pain fibers so that these burns are often not painful.

Burn patients with partial thickness injuries will experience environmental aggravation of the injury and will benefit by simply covering the burn with a sheet.

Although there is an overwhelming tendency for providers to employ narcotics for the burn patient early in the course of the burn, it may be unwise. Most assuredly, if narcotics are used, small frequent doses should be employed. There are no contraindications to the intravenous route, and it provides rapid action, assured uptake, and easy control.

Intramuscular and subcutaneous routes are not appropriate for the patient

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with cardiovascular compromise. Absorption of medications given by these routes are notoriously unpredictable. If the patient becomes hypovolemic for any reason, narcotics injected intramuscularly or subcutaneously will be poorly absorbed until the circulatory status is restored. Anxiolytics, such as diazepam 5-10 milligrams intravenously, may be just as effective as narcotics for relief of pain.

If the burn patient becomes restless or agitated, check the oxygenation, then check the fluid replacement status. Often, anxiety and agitation are early signs of hypovolemia and hypoxemia. To treat either of these conditions with narcotics or anxiolytics is to invite disaster. Since both conditions are commonly found in association with severe burns, **the patient must be evaluated for hypoxemia and hypovolemia before each dose of pain medication.**

Tar Burns

Tar or asphalt is the dark brown or black residue of petroleum processing. It is composed of paraffinic and aromatic hydrocarbons. Tar used in roofing is frequently heated to 230°C to liquify it. When this substance spills on a worker, it can cause a significant full thickness contact burn on the skin. Asphalt is usually heated to a lesser temperature, since it does not need to be pumped up to a roof. Burns due to contact with hot pitch and tar are one of the five safety problems that cause 62% of the injury cases and 76% of the worker's compensation costs in the roofing and sheet metal industries.³¹

The burns caused by tar, sulfur, or clinging materials such as plastics should be immersed in cold water to rapidly cool the substance to room temperature. These clinging substances cause burns, which are often third or deep second degree, leaving only the hair follicles to generate new skin growth. If the EMS providers have not done this at the scene, it should be done upon arrival at the emergency department, but the injury will be predictably worse. Total body immersion and subsequent risk of hypothermia should be avoided.

Mechanical debridement of these clinging substances can cause considerable tissue damage and pain. Pulling the clinging material off potentially removes the hair follicles as well. If there are bullae, then removal of the tar may occur with unroofing of the bullae.³²

Many substances have been tried to aid in removal of tar.³³ Petrolatum and petroleum based solvents have been found to be useful, but vary in effectiveness.³⁴ The best method of tar removal includes application of

Thermal Burn Patients

polyoxyethylene sorbitan based substances such as Neosporin ointment or TWEEN-80.³⁵ If all of the tar is not immediately removed, the wound should be dressed with the polyoxyethylene sorbitan ointment, and the dressings changed every 6 hours. Absorption of TWEEN-80 is not toxic and TWEEN-80 is water-soluble. Another agent that has been used successfully is a citrus and petroleum distillate, De-Solv-it (Medasol).³⁶

Sulfur and molten metals should also be rapidly cooled until they are at body temperature. These substances will form a hard cast, insoluble in soap and water. This cast will prevent further immediate therapy. If the cast separates readily from the skin, then it may be removed. If the cast is circumferential, then cutting tools may be necessary to remove it. Some jet injectors for molds may combine both an injection injury and a burn.³⁷

Beneath the molten metal, the burn will be small but very deep.³⁸ Many of these burns will be on the lower extremities and could be prevented by appropriate safety gear.³⁹ Molten metals also cannot be dissolved by any of these methods, but the application of petrolatum containing substances may create an emollient surface between the cast and the underlying skin.

The “FIRE DRILL”

1. Ensure that you are safe! Dead rescuers rescue nobody!
2. Remove all clothing “Undress to Assess”
Extinguish all smoldering clothing. Remove all chemicals.
3. Ensure that the airway is intact and start the patient on 100% oxygen by facemask. Assume that an inhalation injury exists until you prove otherwise. Intubate at the FIRST sign of airway embarrassment
4. Estimate a severity of burn. Ascertain the depth and extent of the burn. Seek associated illnesses, injuries, and potentially complicating past medical illnesses. Ensure that allergies and current medications are recorded.
5. Ensure that circulation is intact to all tissues.
Carefully evaluate circumferential burns for distal perfusion adequacy.
6. Calculate fluid requirements and ensure that replacement is underway if needed. If not at a burn unit, and the patient has a moderate or severe burn, ensure that the patient is appropriately transferred.
7. Ensure that baseline laboratory data is obtained. This usually includes:
 - CBC
 - PT/PTT

Thermal Burn Patients

- Electrolytes
 - Carbon monoxide level
 - Blood sugar
 - BUN and creatinine
 - Chest X-ray
 - Blood gasses
 - Type and cross blood if the patient has greater than 35% burn
 - Obtain baseline weight if at all possible
 - Other studies as clinically indicated. (E.g. CT scan with head trauma or altered mental status, extremity and spinal x-rays if the patient jumped to escape the fire)
8. The most common problem in transport is respiratory distress - BE PREPARED for this emergency! If there is any question, it is much simpler to intubate the patient early, before swelling develops.
 9. Ensure that all of your records, lab data, and x-rays are forwarded with the patient to the burn unit.

Transfer/Referral Considerations

Normally, TReC will handle all burn transfers. The priority classification listed in the front of this monograph and on the referral checklist is used to determine the rapidity of the transfer and to some extent, the destination. The following addresses and phone numbers are included for planning purposes in the unlikely event of mass burn casualties or disruption of communication

Thermal Burn Patients

Oklahoma Burn Units

Children's Hospital of Oklahoma
940 NE 13th Street
Oklahoma City, OK 73104
(405) 271-4733

Integrus Baptist Burn Center
3300 N. W. Expressway
Oklahoma City, OK 73112-4481
(405) 949-3345

Alexander Burn Center
Hillcrest Medical Center
1120 S. Utica Ave.
Tulsa, OK 74104
(918) 579-4580

Neighboring State Burn Units
Arkansas
Arkansas Children's Hospital Burn Center
800 Marshall St.
Little Rock, AR 77202-3591

Colorado
The Children's Hospital Burn Center
1056 E. 19th Avenue
Denver, CO 80218
(303) 861-6604

University Hospital Burn Unit
University of Colorado Health Sciences Center
4200 East 9th Avenue
Denver, CO 80262
(303) 372-0001

Western States Burn Center, North Colorado Medical Center
1801 16th St.
Greeley, CO 80631
(970) 350-6305

Kansas
Via Christi Trauma / Burn ICU
929 N. St. Francis Ave.
Wichita, KS 67214-3882
(316) 268-5388

Louisiana
Baton Rouge General Medical Center Burn Center
3600 Florida Blvd.
Baton Rouge, LA 70806
(504) 387-7716

Louisiana State University Medical Center Regional Burn Center
1501 Kings Highway
P.O. Box 33932
Shreveport, LA 71130-3932
(318) 675-6850

Missouri
George David Peak Memorial Burn Center One Hospital Drive
Columbia, MO 65212
(573) 882-7994

Children's Mercy Hospital Burn Unit
2401 Gillham Road
Kansas City, MO 64108
(816) 234-3520

St. John's Regional Health Center Burn Unit
1235 E. Cherokee
Springfield, MO 65804
(417) 885-2974

Barnes Jewish Hospital Washington University Medical Center
One Barnes Jewish Hospital Plaza, Ste. 6104
St. Louis, MO 63110
(314) 747-7000

St. John's Mercy Medical Center Burn Center
615 S. New Ballas Rd.
St. Louis, MO 63141
(314) 569-6055

Thermal Burn Patients

**St. Louis Children's Hospital
Burn Center**

One Children's Place
St. Louis, MO 63110
(314) 454-6022

**New Mexico
New Mexico Regional Burn Center**

2211 Lomas NE
Albuquerque, NM 87131
(888) 866-7257

Texas

Only the Texas burn units in cities closest to
Oklahoma are shown

**Southwestern Regional Burn Center
Parkland Memorial Hospital
University of Texas**

5323 Harry Hines Blvd
Dallas, TX 75235-9136
(214) 590-7635

Timothy J. Harnar Burn Center

602 Indiana Ave.
Lubbock, TX 79417
(806) 743-3406

US Army Institute of Surgical Research

3400 Rawley E. Chambers Ave.
Fort Sam Houston
San Antonio, TX 78234-5012
(210) 916-2720
(Brooke Army Burn Unit is included for military
referral purposes only)

Thermal Burn Patients

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Maxillofacial Patients

Priority One

Maxillofacial trauma requiring immediate care by a maxillofacial specialist

1

- Panfacial trauma with Lefort type (I, II, or III) or zygomaticomalar fracture with mandibular fracture
- Bilateral fracture of the mandible with flail symphyseal segment
- Multiple severe mandibular fractures with tracheostomy or intubation
- Depressed zygomaticomalar fractures with entrapment of the inferior rectus muscle or impingement on the optic nerve bundle
- Facial lacerations that involve major vessels, major branches of the facial nerve, or the parotid duct

Priority Two

Injuries requiring urgent consultation with a maxillofacial surgeon and potential transfer

2

- Open facial fractures
- Isolated orbit trauma with or without entrapments, without visual deficits
- Major facial lacerations

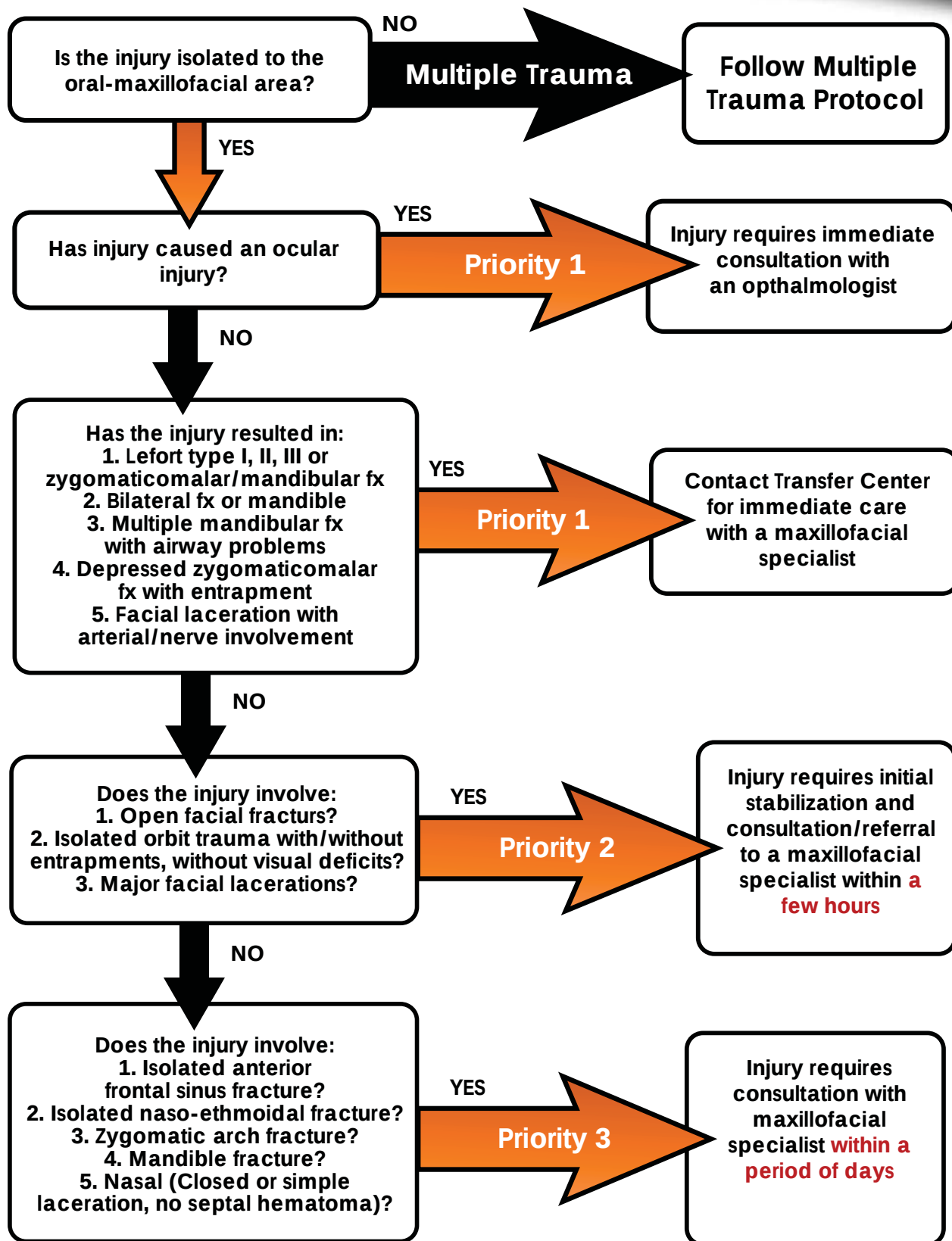
Priority Three

Injuries requiring consultation with a maxillofacial surgeon within a period of days

3

- Isolated anterior fontal sinus fracture
- Isolated naso-ethmoidal fracture
- Zygomatic arch fracture
- Mandible fracture
- Nasal [Closed or simple laceration, no septal hematoma]

Maxillofacial Patients



Maxillofacial Patients

Stabilization

Severe facial trauma often results in partial airway occlusion. The airway risk may increase due to bleeding, swelling in soft tissues, and hematoma formation. Patients with severe facial fractures may have decreased level of consciousness due to intracranial injury. While lifting the jaw and inserting an oral or nasal airway may temporarily help the situation, neck fractures are also common in these patients. Only when the patient's airway is stable, the bleeding has been controlled, and the cervical spine immobilized should the physician proceed in the evaluation.

1. The physician **MUST** ensure an **Airway** if this hasn't been done by prehospital providers.

Assess the patient for airway obstruction. Look for evidence of injury to the larynx and trachea, including crepitus of the surrounding soft tissues. Clinically, the patient may have noisy breathing, snoring, gurgling, or croaking. Remove foreign bodies with finger sweep, strong suction, or Madill forceps under direct visualization. After foreign bodies are removed endotracheal intubation and assisted ventilation may be appropriate. In some patients, cricothyroidotomy or emergent tracheotomy may be necessary. (Emergent tracheotomy may be needed with an associated fractured larynx. Hoarseness, subcutaneous emphysema and a palpable fracture are suggestive of laryngeal fracture.) Airway compromise may require an immediate operation to reduce the fractured facial bones that are impinging in the airway.

Airway compromise is common in persons with severe maxillofacial injuries. Generally, the physician must assume that if the patient with facial trauma needs a transport, then that patient needs a tube.

2. The physician **MUST** ensure that the patient is **Breathing** and continues to breathe
3. The physician **MUST** assess the **Circulation** and **Control** bleeding

Blood is supplied to the midface region from the branches of the sphenopalatine artery and greater palatine artery, and branches of the internal carotid artery such as the anterior and posterior ethmoid branch of the ophthalmic artery. Assuming that coagulopathy is absent, severe bleeding resulting from maxillofacial trauma is rare and the source can be properly controlled.

Maxillofacial Patients

Control of facial vascular injuries proceeds from simple direct wound pressure to vessel ligation for significant bleeding. Vessel ligation should only be performed under direct visualization of the bleeding vessel. Blind clamping can damage critical structures such as the facial nerve or the parotid duct. A Foley catheter placed into a wound and inflated may control bleeding from penetrating wounds.

Intra-oral bleeding must be controlled to ensure the airway remains patent. This bleeding is often from the nose and associated structures that drains through the posterior nasopharynx into the oral cavity.⁴⁰ A posterior nasal packing should be considered early in the control of oropharyngeal bleeding in any patient who has significant facial trauma. (Remember that a nasal balloon or Foley catheter may be inserted into the cranial vault in a patient with severe facial trauma and basilar skull or cribriform plate fracture.) If severe disruption of the hard palate or maxilla within the oral cavity occurs, control of the airway and packing of the oral cavity may also be required. Continued severe bleeding may require immediate surgery to ligate associated major vessels or to reduce broken facial bones and control hemorrhage. Transcatheter arterial embolization may be an alternative to surgical control of hemorrhage. This requires an arteriogram to visualize the site of bleeding before introduction of the embolus.⁴⁰

Large open wounds should be debrided and closed in a layered fashion. This will both decrease blood loss and subsequent infectious

complications. Wounds that may be used later for access to repair fractures may be closed in a temporary fashion.

4. The physician **MUST** assess for neurological **Disability** and ensure that the patient's cervical spine is protected from further **Damage**.

Unstable cervical spine injury is rare in neurologically intact penetrating facial wounds, but up to 10% of patients with significant blunt facial injuries will also have cervical spine injury.

Cell phones and internet connected computers are capable of sending and receiving quality digital pictures to the referral physician.

Maxillofacial Patients

Introduction

Among the myriad injuries seen in the emergency department, facial trauma is one of the most common. Trauma to the maxillofacial area mandates special attention. Contained within the face are the systems that control seeing, hearing, smelling, breathing, eating, and talking. With close proximity and frequent involvement, whenever the head and face are injured, the vital structures in the head and neck region must be evaluated. Additionally, the psychological impact of disfigurement associated with facial and maxillary trauma can be devastating.¹⁻³ Given this broad variety of facial injuries and potential concomitant complications, management can be complicated even for the most experienced of clinicians. The goal of this article is to assist the emergency physician in the initial management of patients who have sustained a facial injury. Since the emergency physician is rarely involved in operative decisions, there is no effort to discuss the surgical treatment of these fractures and soft tissue injuries beyond the initial management. This article does not discuss pure ocular or lid lesions.

Goals in the treatment of facial injuries include a return of normal ocular, masticatory, and nasal function, restoration of speech, rapid bone healing, and an acceptable facial and dental esthetic result. The treatment of facial trauma is associated with a plethora of potential complications.

With ever-increasing sophistication in computerized tomography, emergency providers can rapidly diagnose small facial fractures. However, despite imaging, and thorough physical examination, subtle complex facial fracture with CSF leaks, temporal bone fractures and cranial nerve injuries can remain undiagnosed. These missed or delayed diagnoses can lead to significant morbidity or death.

Maxillofacial injuries can often involve damage to a patient's central nervous system or result in immediate damage to a patient's sight. It is extremely important that the clinician be aware of compartment syndromes of the orbit which can jeopardize a patient's sight within a number of hours. Potentially sight threatening conditions such as a "retro-bulbar hematoma" should be looked for on initial exam as well as any CT studies. If present, immediate consultation with an ophthalmologist is necessary. Recognizing either a Battle's Sign (bruising behind the ear) as a possible sign of a basilar skull fracture, or Raccoon Eyes (bilateral periorbital bruising) indicative of a fracture at the frontal portion of the base of the skull is extremely important, and if either is present neurological consult is necessary.

Maxillofacial Patients

Epidemiology, Etiology, and Pathophysiology

Epidemiology and Etiology

More than 3 million facial injuries occur in the United States each year.⁴ There are a number of possible causes of facial trauma. Sports, accidental falls, motor vehicle accidents, assault, and work related accidents account for the majority of maxillofacial injuries.⁴⁻⁵ Depending on the trauma center, assaults vie with motor vehicle accidents for the number one spot.⁶⁻⁹ Among sport-related injuries, boxing is particularly associated with a high incidence facial injuries.¹⁰

In a series of two hundred consecutive facial fractures seen in an urban trauma center, assaults accounted for nearly 50%. The adult male to female ratio is 3:1, but this is reduced to 3:2 in pediatric patients.

The incidence of concomitant major injuries is reported to be as high as 50% in high-impact facial fractures, compared to 21% for lower impact fractures.⁶ Fractures are more commonly associated with motor vehicle collisions, rather than other blunt trauma. With respect to this topic, it is worthwhile to point out that for front-seat occupants, airbag deployment considerably decreases the incidence and severity of orbital fractures in frontal automobile crashes.⁵⁻¹¹

Fractures of the facial skeleton are relatively uncommon in children and adolescents.¹²⁻¹³ This low incidence may reflect the underdeveloped facial skeleton and paranasal sinuses and the un-erupted dentition which provide additional strength to the mandible and maxilla. The well-known flexibility of the pediatric skeleton will also reduce the frequency of fractures. The cause of facial fractures in children is also somewhat different. Children have more facial fractures due to blunt trauma from motor vehicle collisions, either as a passenger or as a pedestrian than from assaults.

Pathophysiology

Nasal Fractures

The nose is the most frequently injured facial structure, probably because of its prominent position in the center of the face. Indeed, in facial trauma, nasal fractures account for about 40% of bony injuries.¹⁴ Assaults and sports injuries cause most nasal fractures in adults, followed by falls and motor vehicle collision.

Maxillofacial Patients

Play and sports account for most nasal fractures in children. Nasal fractures may occur in association with other facial injuries or by themselves. Many nasal fractures are not diagnosed because some patients do not seek medical care for this problem.

The nose is supported by cartilage anteriorly and inferiorly and by bone posteriorly and superiorly. The paired nasal bones, the maxilla, and the nasal process of the frontal bone form a framework that supports the cartilaginous parts of the nose. The paired nasal bones are wedge-shaped and joined at the midline. The lower half of the nasal bone is thin and broad, whereas the upper portion is thicker and is firmly supported by an articulation with the frontal bone and the frontal process of the maxilla. The thinner portion of the nose is more liable to fracture while the thicker portion near the frontal bone is more difficult to injure.¹⁵ Nonetheless, the force required to fracture the nasal bones is less than for any other facial bone.¹⁵ Likewise, due to the natural taper of the nose, the supporting nasal septum becomes increasingly thin and tends to fracture more towards the tip of the nose. A fracture of the septum unfavorably affects the alignment of the nose during the healing process.

Many different methods have been proposed for classifying nasal and septal fractures. Factors to consider in patients with an injury to the nose include:

1. Cause of the trauma
 - a. A direct frontal blow can depress the dorsum of the nose, causing the bones to telescope posteriorly.
 - b. A strong force from any direction can comminute the nasal bones and cause an "open-book" fracture of the nose.¹⁵
 - c. A lateral blow can cause displacement to the opposite side of the face and leave a depression on the side of the impact.
 - d. Traction and torsion injuries can cause disruption of the cartilage.¹⁶
2. History of prior facial injuries
3. Any prior nasal deformity
4. Any prior nasal obstruction

The patient's conception of the original shape of his/her nose is often inaccurate and edema may mask bone deviation. Comparison with a picture taken prior to trauma is often helpful. (Such pictures are often found in ID documents such as passport or driver's license.)

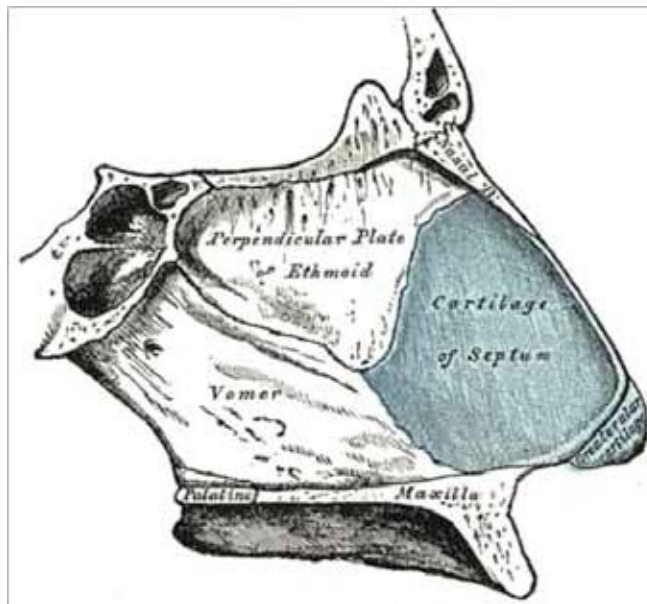
Bony fractures of the nose may involve one or both nasal bones, the frontal

Maxillofacial Patients

process of the maxilla, the bony septum, and in severe trauma, the nasal-orbital-ethmoid complex. The most likely area of fracture of the nasal bones is the thinner lower two-thirds.¹⁶ Simple nasal fractures must be separated from the more serious naso-orbito-ethmoidal fracture (NOE fracture) where the fracture extends into the nose through the ethmoidal bones. These fractures may cause injury to the dura and a subsequent cerebrospinal fluid leak.

Suspect a naso-orbito-ethmoidal fracture when the patient has telecanthus (widening of the nasal bridge with a detached medial canthus). These patients will often have either CSF rhinorrhea or epistaxis (or both).

Naso-orbito-ethmoidal fractures with CSF rhinorrhea are Priority 1 – Maxillofacial trauma requiring immediate care by a maxillofacial specialist.



Bones and cartilages of the nose (right side) – From Gray, 1918.

Epistaxis is commonly associated with nasal trauma and is easily explained by the dense vascular network (Kiesselbach's plexus) that supplies the nose. Bleeding can also originate from other locations within the nose when the nose is fractured. Anterior nasal bleeding can originate from the anterior ethmoid artery (a branch of the ophthalmic artery), and posteriorly from a branch of the sphenopalatine artery. Packing the nose usually controls this hemorrhage. If packing fails to control the bleeding, consultation with an otolaryngologist is appropriate as specific vessel ligation may be needed.¹⁷

Maxillofacial Patients

Complications most commonly encountered with nasal fractures include septal hematoma, nasal obstruction, and significant deformity. An unrecognized septal hematoma may strip the underlying septal cartilage of its vascular supply which can result in cartilage destruction. Secondary infection of the hematoma, often by *S. aureus*, can occur. Undiagnosed hematomas of the nasal septum that progress to abscess formation can cause cartilage necrosis and loss of nasal support leading to the so-called saddle-nose deformity and septal perforation.

Orbital Fractures

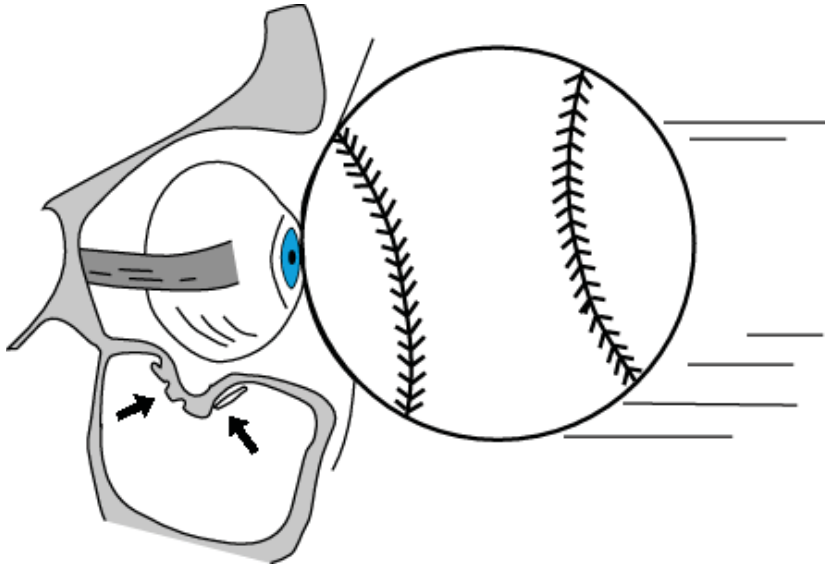
Trauma to the face can cause a fracture along the weak points of the orbit. The patterns of fractures are well described: orbital-zygomatic (discussed under zygomatic fracture heading), naso-orbito-ethmoid (discussed under nasal fracture heading), and internal orbital (blow-out). Different combinations of these basic patterns can produce combined or complex orbital fractures.

The thinnest and weakest area of the orbit is the floor. Typically the fracture occurs in the posteromedial region of the orbital floor – a “blow-out” fracture. The usual mechanism is a blow to the eye with the forces being transmitted by the soft tissues of the orbit downward through the thin floor of the orbit.¹⁸⁻¹⁹ When this fracture occurs, contents of the orbit including fat, soft tissues, the inferior oblique muscle, or the inferior rectus muscle can protrude through the fracture and become entrapped.²⁰ A retrospective review of 424 patients suggested that patients with a medial orbital floor component of fracture had a significantly higher incidence of diplopia.²¹

Entrapment of the inferior oblique or the inferior rectus muscle can lead to restriction of orbital movements and resultant diplopia. The entrapment of both muscle and soft tissues can displace the globe posteriorly and inferiorly adding to the diplopia and enophthalmos. The diplopia is most pronounced in upward gaze. (About 24% of these fractures are associated with ocular injury as well as the fracture.)²²

Because the infraorbital nerve passes through the orbital floor, hypesthesia often occurs in its sensory distribution with orbital floor fractures.

Maxillofacial Patients



Blow-out fracture mechanism

Illustration 1 Mechanisms of Injury (Permission from M.L. Richardson, MD)

Fractures of the superior, lateral, and inferior rims of the orbit can occur in isolation or in association with other cranio-facial injuries. Careful palpation may reveal a step off at the site of a fracture. Cheek paresthesias are commonly found with inferior orbital rim fractures that traumatize the infraorbital nerve.

Orbital floor fractures in children may have a higher incidence of 'trap-door' entrapment of muscle or fat. The softer, more flexible bones in children causes the orbital floor to bend, crack and form this 'trap-door'. The term "trapdoor" is used describe fractures with minimal displacement of the bony fragments. The resultant tissue displacement can cause a "white-eyed" appearance.²³⁻²⁴ In these patients, a shorter time to surgical intervention can yield significantly better outcomes.²⁵ In children, nausea and vomiting can be predictive of trapdoor fractures with entrapment.

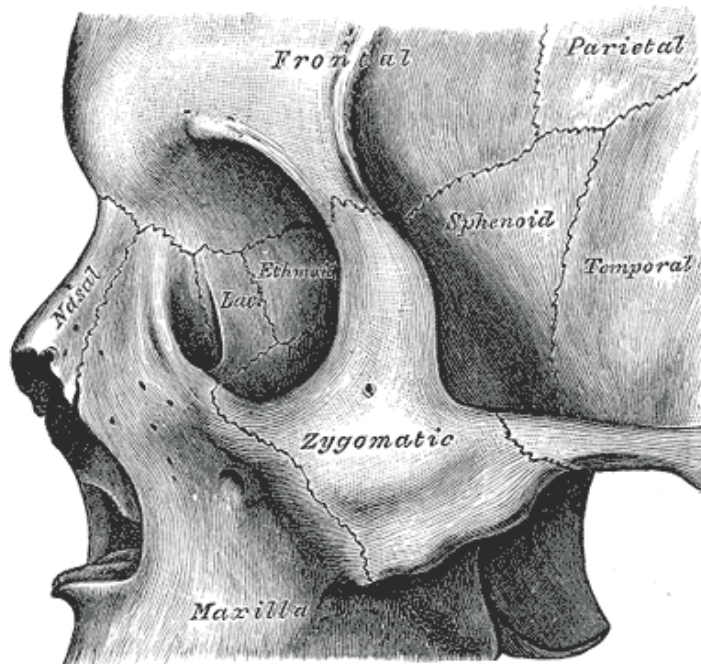
Depressed zygomaticomaxillary fractures with entrapment of the inferior rectus muscle or impingement on the optic nerve are Priority 1 – Maxillofacial trauma requiring immediate care by a maxillofacial specialist.

Orbital roof fractures in adults are uncommon and usually associated with high-impact injuries to the head and face.²⁶ The high impact forces involved means that multiple facial and neurological complications are common. In children, orbital roof fractures are seen with lesser force.

Maxillofacial Patients

Zygomatic Fractures

The zygoma forms the malar eminence, determines the amount of anterior and lateral cheek projection and supports the wall and floor of the orbit. It is a prominent bone in the face, making it subject to trauma and fractures. There are four parts or 'processes' that comprise the zygoma; the maxillary process, the temporal process, the frontal process, and the orbital process. Inferiorly, the maxillary process articulates with the maxilla at the zygomatico-maxillary suture. Laterally, the temporal process of the zygoma joins the temporal bone forming the zygomatic arch, anterior to the auditory canal. Medially, the orbital process articulates with the greater wing of the sphenoid bone. Superiorly, the frontal process articulates with the frontal bone at the zygomatico-frontal suture.



Picture is from 1918 Gray's anatomy, out of copyright.
Henry Gray (1825–1861). *Anatomy of the Human Body*. 1918.

Because the zygoma is a thick bone, it is rare to have an isolated fracture of the zygoma. Most commonly, the fracture extends through adjacent bones which are often thinner. Zygomatic arch fractures tend to occur in two (occasionally 3) places along the arch of the zygoma. A fracture may occur at each end of the arch and a third in the middle, resulting in a v-shaped fracture. This can

Maxillofacial Patients

impinge on the underlying temporalis muscle, resulting in trismus.

A zygomaticomaxillary fracture (tripod or malar fracture) results from a direct blow to the cheek. The fractures occur at the articulation of the zygoma with the frontal bone and the zygomatic arch. These fractures are orbital fractures, because the internal orbit can be disrupted by the displacement of the zygomatic body. Zygomaticomaxillary fractures are often associated with severe facial edema, so the true extent of the injury may be obscured. As with other fractures involving the orbit, diplopia may be reported by the patient.

Depressed zygomaticomaxillary fractures with entrapment of the inferior rectus muscle or impingement on the optic nerve are Priority 1 – Maxillofacial trauma requiring immediate care by a maxillofacial specialist.

Mandibular Fractures

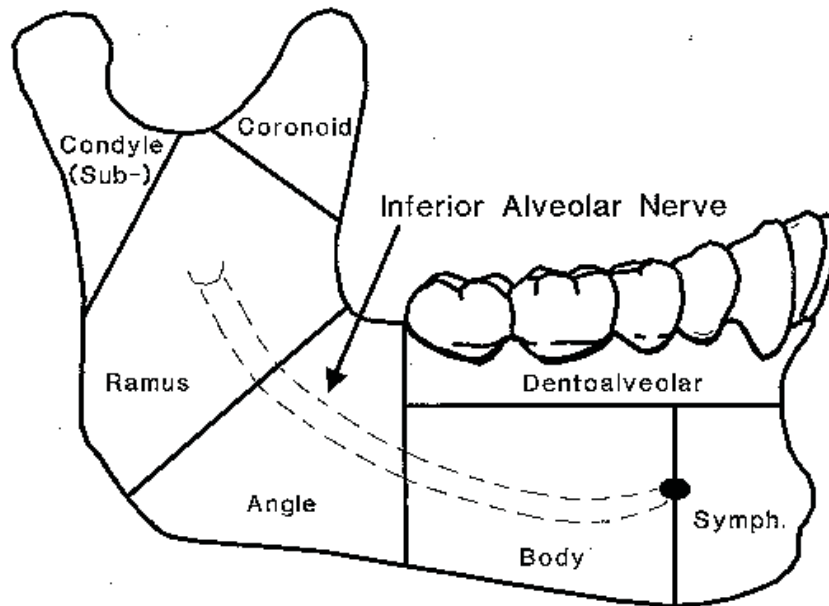
The mandible is the only mobile cranial bone and contains the lower dentition and significant blood vessels, muscles, and nerves, and surrounds the tongue. The mandible is actually two bones fused in the midline symphysis. Each bone has a thick buccal and lingual cortex and a thin medullary cavity. The inferior alveolar nerve enters the mandible at the mandibular foramen with the inferior alveolar artery and traverses the medullary cavity exiting at the mental foramen. It traverses the medullary cavity below the level of the tooth roots. This nerve provides sensation to the mandibular teeth and the skin and mucosa of the lower lip.

The mandible is connected to the cranium at the temporomandibular joint. The appropriate functioning of the mandible determines the occlusal contact of the teeth. Mandibular fractures can cause a variety of short and long-term impairments including temporomandibular joint pain, malocclusion, inability to masticate, salivary disorders, obstructive sleep apnea, and chronic pain. Mandibular fractures can be debilitating and disfiguring. The mandible is the tenth most commonly injured bone in the body and the second most commonly injured bone in the face.²⁷ Fractures of the mandible can be found in the symphysis, body, angle, ramus, and condyle or subcondylar areas.²⁸

Pediatric patients are more likely than adults to sustain a greenstick or incomplete fracture of the mandible.^{12, 29} This is due to the relative elasticity of the pediatric bones in comparison to the adult's. Because of the tooth buds and developing crypts, pediatric fractures may be longer and more irregular in character than similar fractures in adults.³⁰ Pediatric fractures are less likely to

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have comminution of the fracture. Pediatric mandibular fractures may occur as a result of abuse.³¹



Mandible showing anatomic regions where fractures occur. Permission applied for from Emergency Medicine Clinics of North America.

Fractures of the mandible can be located in the symphysis, body, angle, ramus or the condylar regions of the mandible. The mandible is often fractured at more than one location because of the ring structure formed by its articulation at the temporomandibular joint. In addition to the traditional fracture classifications—open, closed, simple, complex, or comminuted—mandibular fractures are also described as favorable or unfavorable, depending on whether the muscles of mastication tend to reduce or distract the fracture, respectively.

Alveolar fractures occur just above the teeth in the alveolar portion of the maxilla or mandible. Often a plate or a group of teeth are loose and blood may be found at the gingiva. Dentoalveolar fractures and fractures with dentoalveolar extension involve only the alveolar ridge and associated teeth and are, by definition, open fractures.

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The cause of the injury has some relationship to the location of the fracture. A population-based analysis of over ten thousand hospitalizations for mandibular fractures described the incidence and causes of these fractures.²⁷ The most common anatomic site for a fracture of the mandible is the body of the mandible from the symphysis to the angle of the mandible, including the alveolar ridge (43.5%).²⁷ Another 24.1% occurred in the ascending ramus of the mandible (between the condyle and the angle).²⁷ The remaining mandibular fractures in this very large data-mining study of fractures of the mandible were multiple or the region was not specified. This study did not deal with patients who were not hospitalized, so there may be some differences in the out-patient population.

This study addition found that the most common cause was assaults (50-75% of all their mandibular fractures).^{27, 32} Injuries sustained in altercations are more often located in the mandibular angle region. They are more common on the left than on the right, since the right hand person will usually strike a blow on the left jaw.³³ In altercations, the combination of a fracture of the mandibular angle on the side of impact and the opposite mandibular symphysis or body fracture is common.³³ The next most common cause was the motor vehicle collision, followed by falls. The rates for assaults were three times higher than for motor vehicle collisions. The study showed that use of motorcycle helmets decreased the incidence of mandibular fractures from motor vehicle collisions by 57% in one year alone.²⁷ High velocity impact also tends to increase the frequency of comminuted fractures and fractures in multiple regions of the mandible.

Although delay in treatment has been implicated in infectious complications in mandibular fractures, this was not shown to be the case in at least one retrospective study.³² In this study, intravenous drug use was the single biggest comorbidity for infectious complications. Likewise, use of perioperative antibiotics had no benefit in reducing the incidence of infections in patients undergoing surgical repair of mandibular fractures.³⁴ The complication rate of mandibular fractures is most correlated with the severity of the fracture. Minor correlates were alcohol and tobacco use.³⁵

For this reason, an open fracture of the mandible is Priority II, requiring consult and possible transfer to a designated trauma center.

Maxillary Fractures

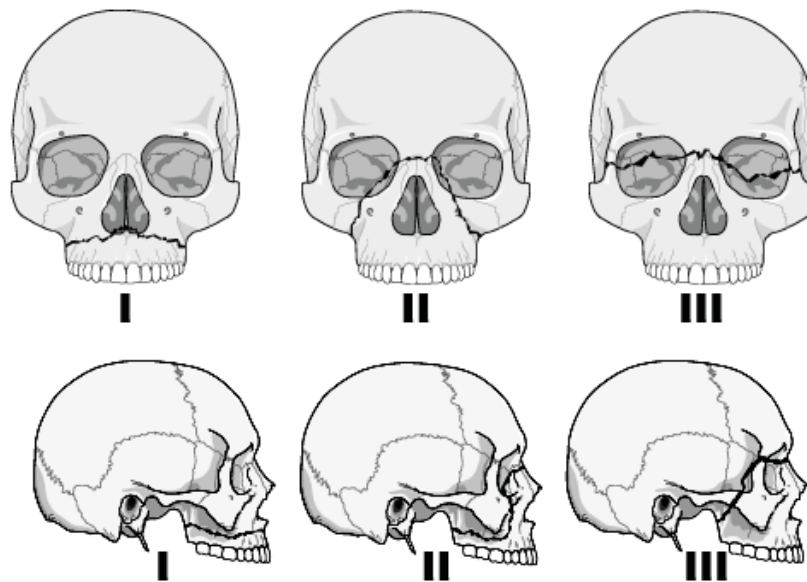
The maxillae bones are the largest bones of the face and together form the upper jaw. The maxilla (singular) consists of a body and four processes: zygomatic,

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frontal, alveolar and palatine. The maxilla forms the hard palate, floor of the nose, part of the orbits and the tooth sockets of the upper teeth.

Maxillary fractures are less common than mandibular fractures and are often associated with other facial fractures. Complaint of the “bite isn't right” is common as most maxillary fractures involve the dental occlusion. Children are much less likely to have maxillary fractures until age 10 due to the enhanced malleability of their bones and the stronger unerupted dentition.¹²

Classically, maxillary fractures are broken down into the Le Fort classification: In 1900, Rene Le Fort used cadaver trauma to provide detailed descriptions of 3 basic types of midfacial fractures.



Le Fort classification of maxillary fractures (Permission from M.L. Richardson, MD)

The **Le Fort I** fracture is a horizontal fracture above the roots of the teeth and extends from the piriform sinus of the nose to the pterygomaxillary fissure, separating the maxillary tuberosity from the pterygoid plates. The mobile fragment of maxillary bone is often likened to a loose upper denture, containing the teeth and palate. The fracture results from a horizontal blow applied to the anterior maxilla and can be a single fragment or comminuted fragments.

The **Le Fort II** fracture courses upward through the infraorbital rim, through the medial orbit and the nasal bones. Since the fragment forms a triangular shape, this is often called a pyramidal fracture.

The **Le Fort III** fracture crosses the maxilla, naso-ethmoid complex and the

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zygoma. This fracture is often termed a craniofacial dislocation or separation since the entire midface is now mobile. A complete bilateral Le Fort III fracture is rare and caused by massive trauma. Spinal fluid leakage is common. The remaining soft tissue attachments are often the optic nerves, so gentle evaluation is appropriate.

A “simple” Le Fort classification fracture is actually uncommon for two reasons. First, rarely do fractures in the mid face follow the suture lines describe by Le Fort. The fractures follow the path of least resistance and may be comminuted and multiple. The single-piece Le Fort fracture described may in reality be composed of multiple pieces with the nasal section or zygomatic section disconnected from the maxillary tooth-bearing fragment. Secondly, blows to the face are often from an angle, so that a facial fracture may have a Le Fort II component on one side and a Le Fort III component on the other side.

A Lefort Fracture is Priority 1 – Maxillofacial trauma requiring immediate care by a maxillofacial specialist. This fracture complex has significant morbidity and airway management problems associated with it.

Frontal Bone Fractures

The frontal sinus ranges from negligible to filling the entire forehead region of the frontal bone. The outer table is thick and heavy. The inner table is thin and lined with the dura mater of the meninges.

Frontal sinus injuries often result from blunt trauma such as the unrestrained passenger hitting dashboard or windshield in a motor vehicle collision in both adults and children.³⁶ Motor vehicle collisions were the leading cause of frontal sinus fractures, but this has decreased since the adoption of mandatory seat belt laws coupled with airbag technology.

When compared to other facial fractures, fractures of the frontal sinus are uncommon – probably due to the thickness of the bony ridges involved. The frontal sinus is fractured in 5-30% of patients who sustain maxillofacial injuries.³⁷ The frontal sinus is relatively resistant to fracture and a significant amount of force is needed for a fracture to occur. It takes about 800-1600 foot-pounds of pressure to fracture the anterior table of the frontal bone. In general, the greater the magnitude of force applied, the more likely that both tables of the bone will be broken. In one series only 24% of patients were conscious at the time of initial evaluation.³⁸

In general, repair of the posterior table is important for preventing central

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nervous system complication such as pneumocephalus or CSF leak.³⁷ Repair of the anterior table is important for cosmetic reasons.

Lacerations frequently accompany frontal sinus fractures and may obscure the deeper part of the injury. The examiner should be wary when dealing with a patient who has been struck in the forehead. These injuries should be carefully explored to ensure that any fractures are found. A CT of the head is indicated for complete evaluation, since patients can have displaced posterior table fracture without palpable anterior fractures. Crepitus may be found when the patient has multiple fragments of bone that are mobile.

A frontal bone fracture is generally treated as a Priority 1 injury due to this underlying blunt head trauma– In isolated cases without loss of consciousness, priority II may be appropriate for a frontal bone fracture with no evidence of underlying trauma on CT scan.

At birth, the frontal sinuses originate either as an expansion of the fronto-ethmoid air cells into the frontal bone or by superior extension of the frontal recess. The frontal recess represents the most anterior and superior portion of the infundibulum of the middle meatus. The frontal sinus is not pneumatized until the age of 2 and it can be first appreciated radiographically in individuals aged 6-8 years. Pneumatization is often not symmetric and may be partial or incomplete in about 20% of adults. Adult size of the frontal sinus is attained between 15 and 19 years of age. Since the pediatric frontal sinus is often not present, fractures of the frontal sinus are nearly twice as common in the adult population as in the pediatric population.

Differential Diagnosis

Since the etiology of the injury is often known, the clinician is left with identifying what was injured and to what extent it was damaged. The differential diagnosis of facial trauma contains all of the fractures, soft tissue abrasions, contusions, and lacerations discussed in this monograph. The examiner must be very careful not to stop the evaluation simply because one fracture or injury is noted. In multiple studies reviewed in this monograph, as many as 30% of the patients had two or more fractures or injuries noted.

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Prehospital Care

There is very little research on the prehospital care of the patient with maxillofacial trauma. When the patient is evaluated by the emergency services personnel, they need to ensure the ABC's of trauma care. This is particularly important in management of facial trauma where the possibility of airway damage or impingement by swelling or significant bleeding and cervical spine damage can simultaneously occur.

If possible, the events that surround the injury should be obtained from the patient, the police, family, or bystanders. (Remember that the patient's account may differ from other potentially more reliable sources.)

1. The EMS provider **MUST** ensure an **Airway**.
Immediate recognition of airway compromise is critical to the patient's survival.
2. The EMS provider **MUST** ensure that the patient is **Breathing** and continues to breathe.

Blood or edema resulting from the injury can cause upper airway obstruction. The tongue may obstruct the airway in a patient with a mandibular fracture. A fractured free-floating maxilla can fall back, obstructing the airway. Displaced tooth fragments can become foreign bodies in the airway.

3. The EMS provider **MUST Control** bleeding.
Injuries to the face are often accompanied by significant bleeding. Bleeding can be initially controlled with direct pressure.
4. The EMS provider **MUST** ensure that the patient's cervical spine is protected from further Damage.

During airway control, maintain cervical spinal immobilization in bluntly injured patients. Unstable cervical spine injury is quite rare in neurologically intact penetrating facial wounds, but up to 10% of patients with significant blunt facial injuries will also have cervical spine injury.³⁹ Conversely, 15-20% of cervical spine injuries are associated with facial fractures.

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ED Management

Upon arrival to the emergency department, the physician should re-evaluate the patient with the same four emergency steps listed above.

Severe facial trauma often results in partial airway occlusion. The airway risk may increase due to bleeding, swelling in soft tissues, and hematoma formation. Patients with severe facial fractures may have decreased level of consciousness due to intracranial injury. While lifting the jaw and inserting an oral or nasal airway may temporarily help the situation, neck fractures are also common in these patients. Only when the patient's airway is stable, the bleeding has been controlled, and the cervical spine immobilized should the physician proceed in the evaluation.

1. The physician **MUST** ensure an **Airway** if this hasn't been done by prehospital providers.

Airway compromise is common in persons with severe maxillofacial injuries. Assess the patient for airway obstruction. Look for evidence of injury to the larynx and trachea, including crepitus of the surrounding soft tissues. Clinically, the patient may have noisy breathing, snoring, gurgling, or croaking. Remove foreign bodies with finger sweep, strong suction, or Magill forceps under direct visualization. After foreign bodies are removed endotracheal intubation and assisted ventilation may be appropriate. In some patients, cricothyroidotomy or emergent tracheotomy may be necessary. (Emergent tracheotomy may be needed with an associated fractured larynx. Hoarseness, subcutaneous emphysema and a palpable fracture are suggestive of laryngeal fracture.) Airway compromise may require an immediate operation to reduce the fractured facial bones that are impinging in the airway.

2. The physician **MUST** ensure that the patient is **Breathing** and continues to breathe.
3. The physician **MUST** assess the **Circulation** and **Control** bleeding.

Blood is supplied to the midface region from the branches of the sphenopalatine artery and greater palatine artery, and branches of the internal carotid artery such as the anterior and posterior ethmoid branch of the ophthalmic artery. Assuming that coagulopathy is absent, severe bleeding resulting from maxillofacial trauma is rare and the source can be properly controlled.

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Control of facial vascular injuries proceeds from simple direct wound pressure to vessel ligation for significant bleeding. Vessel ligation should only be performed under direct visualization of the bleeding vessel. Blind clamping can damage critical structures such as the facial nerve or the parotid duct. A Foley catheter placed into a wound and inflated may control bleeding from penetrating wounds.

Intra-oral bleeding must be controlled to ensure the airway remains patent. This bleeding is often from the nose and associated structures that drains through the posterior nasopharynx into the oral cavity.⁴⁰ A posterior nasal packing should be considered early in the control of oropharyngeal bleeding in any patient who has significant facial trauma. (Remember that a nasal balloon or Foley catheter may be inserted into the cranial vault in a patient with severe facial trauma and basilar skull or cribriform plate fracture.) If severe disruption of the hard palate or maxilla within the oral cavity occurs, control of the airway and packing of the oral cavity may also be required.

Continued severe bleeding may require immediate surgery to ligate associated major vessels or to reduce broken facial bones and control hemorrhage. Transcatheter arterial embolization may be an alternative to surgical control of hemorrhage.⁴¹ This requires an arteriogram to visualize the site of bleeding before introduction of the embolus.⁴⁰

Large open wounds should be debrided and closed in a layered fashion. This will both decrease blood loss and subsequent infectious complications. Wounds that may be used later for access to repair fractures may be closed in a temporary fashion.

4. The physician **MUST** assess for neurological **Disability** and ensure that the patient's cervical spine is protected from further **Damage**.

As noted above, unstable cervical spine injury is quite rare in neurologically intact penetrating facial wounds, but up to 10% of patients with significant blunt facial injuries will also have cervical spine injury.

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History

Questions that the examiner should ask the responsive patient include:

1. **Which areas on you face hurt?** Although this is a basic question, the presence of pain in a specific location can direct the examiner towards the site of a fracture. This question may not be useful in the intoxicated patient or the patient with multiple injuries.
2. **Are there any areas of numbness on your face?** Any sensory deficit may show where a facial fracture has occurred and the fragments either impinge upon or have damaged the bony canals/grooves/foramina where the branches of the trigeminal nerve run.
 - a. **Is your lip or chin numb?** The inferior alveolar nerve runs through the center of the mandible from the middle of the ramus to the mental foramen, where it exits provide sensation to lower lip and the chin. If the patient feels numb on the lower lip or chin, it is likely that there is a fracture on the side of the numbness.
 - b. **Is your upper lip, side of the nose, or upper gingiva numb?** The infraorbital and superior alveolar nerves provide sensation to the maxillary teeth and gingiva, the upper lip, the side of the nose, and the lower eyelid. If the patient has numbness here, it is likely that a fracture exists in the maxilla or orbital floor.
 - c. **Is your lower eyelid or upper lip numb?** The infraorbital nerve courses along the floor of the orbit. It is often disrupted by a zygomaticomaxillary complex fracture.
3. **Does your bite feel 'normal?'** Mandibular and/or maxillary fractures are commonly associated with the feeling that the bite is not 'normal.' The location of contact of the teeth can often help the clinician find the site of the fracture.
4. **Does it hurt when you open your mouth? Where does it hurt?** Pain when the patient attempts functional movements of the mandible can indicate the presence of fractures of the mandible or maxilla.

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Contusions of the mandible or the temporomandibular joint can also produce similar pain. For example, pre-auricular tenderness with mandibular movement can indicate a condylar process fracture. Pain in the area of the cheek when the patient attempts to open the mouth can indicate a zygomaticomaxillary complex fracture. Pain at the angle of the mandible can indicate a fracture in that area. The masseter muscle attaches to the body of the zygoma and inserts onto the mandibular ramus. When fractures of the zygomaticomaxillary complex occur, they cause contraction of the masseter muscle and subsequent trismus. Rarely, the zygoma can be so displaced that it impinges on the coronoid process of the mandible, limiting the opening of the jaw.

5. **Are you having trouble seeing?** If possible, the victim's pre-injury visual status should be reviewed with the patient. The state of the vision immediately after the trauma should also be determined. Loss of light perception that returns suggests either a vascular occlusion or an optic nerve contusion. Immediate loss of light perception implies a severe damage to the retina or optic nerve. Initial good vision that deteriorates may suggest a compressive ocular neuropathy and constitutes an emergency. If the patient reports flashing lights or 'floaters,' a retinal tear or detachment or a vitreous hemorrhage should be suspected.
6. **Do you see double?** The presence of diplopia can indicate a periorbital fracture. It is a relatively non-specific symptom and can be caused by periorbital edema alone. If the patient notes diplopia, CT of the orbits/facial bones is indicated. Ocular symptoms of orbital facial fractures include orbital pain, enophthalmos, and vertical diplopia.
7. **Does your neck hurt?** This is not an unreasonable question given the association of facial trauma and cervical spine injuries.

If possible, the events that surround the injury should be obtained from the patient, the police or the EMS providers. (Remember that the patient's account may differ from other potentially more reliable sources.) This history can provide clues to the type of injuries that the patient has sustained. For example blunt trauma to the face is more likely to result in fractures while a sharp penetrating injury can injure nerves and major vessels. Interpersonal altercations tend to

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result in a higher incidence of nasal, blow-out, and mandibular fractures, while motor vehicle accidents result in more serious trauma. Heightened concern for serious injury should be present when evaluating the patient who has had a high velocity blow to the face, such as a baseball impact, baseball bat, or golf club impact.

Past medical history should always be assessed when possible. Particularly look for seizure disorders, alcohol abuse, prior head and neck trauma or surgery, temporomandibular joint problems, and nutritional or metabolic derangements. Use of 'blood thinning' agents such as aspirin, warfarin, Plavix, or Lovenox should always be ascertained as these agents may increase bleeding both in the wounds and within the skull.

Physical Examination

A careful physical examination is paramount for the diagnosis of craniofacial injury, since additional and potentially life-threatening injuries are not uncommon. During this initial survey, life-threatening injuries and systemic medical problems should be addressed.

The airway is the first critical injury that may be associated with facial trauma. The patient who has sustained a maxillofacial fracture may have airway compromise due to loss of tongue support secondary to facial fractures or obstruction of the airway by blood or debris. The unconscious patient with significant facial trauma needs intubation with rapid sequence technique or a surgical airway as indicated by the patient condition and ease of intubation. This intubation should be performed with appropriate cervical spinal precautions.

The patient who has sustained a significant facial fracture should be assumed to have an associated cervical spine injury. Studies have shown that 1% to 4% of patients with facial fractures have injuries of the cervical spine. Suspicion of concomitant spinal injury can range from low in the isolated nasal fracture from a blow to very high in the complex facial fracture sustained in a high-speed motor vehicle accident.

Once the patient's airway and hemodynamic status have been stabilized and the patient has been evaluated for cervical spinal trauma, the emergency physician needs to perform a systematic secondary survey. The tetanus status of all patients should be determined and managed appropriately. The dried blood and foreign bodies should gently be removed from wound sites in order to evaluate the depth and extent of the injury.

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As always in the trauma patient, associated injuries should be sought. The patient with facial injuries often has an altered sensorium and may not relate such details as "I got a good one in..." sustaining a fight bite laceration to the hand. A comprehensive physical examination to ensure that no significant other lesions are missed is not just a 'nice to have'... it's an imperative.

The patient should be examined for dental trauma and malocclusion.⁴² The oral cavity is examined for lacerations, penetrating injuries and continuing bleeding. The tongue is frequently lacerated in facial trauma and can produce both airway compromise with swelling and significant bleeding. Soft tissue injuries within the oral cavity should be explored for tooth fragments and other foreign bodies. The examiner should note areas of ecchymosis and facial swelling.

The dentition is evaluated and all empty tooth sockets are accounted for. Teeth can be displaced into soft tissues, pushed into the socket, or avulsed with subsequent aspiration, swallowing and left at the scene. Any missing tooth/teeth requires a chest x-ray to ensure that a tooth has not been aspirated. The dentition should be evaluated for mobility which would indicate an underlying alveolar fracture. The presence of a step-off or irregularity of the dentition may indicate an underlying fracture. The presence of blood at the gingiva should also prompt a search for underlying fracture. Frequently, hematomas on the lingular side of the jaw may extend into the floor of the mouth, causing discoloration and swelling of the floor of the mouth. Check for stability of the teeth in both the upper and lower jaw.

The clinical examination of the face begins with a detailed examination of the area for localized tenderness, numbness, bleeding, deformity, ecchymosis, periorbital edema, otorrhea, rhinorrhea and facial asymmetry.⁴³ Facial asymmetry is often easiest to examine by looking down from the head of the bed. The superior and inferior orbital rims, zygomatic arches, nose, maxilla, mandible, and both alveolar ridges should be palpated and evaluated.

Zygoma fractures commonly present with periorbital ecchymosis, lateral subconjunctival hemorrhage, infraorbital hypoesthesia, bony step-off of the orbital rim, and depression of the malar eminence. Displacement of the bone medially may impinge on the coronoid process of the mandible, resulting in trismus. Most zygomaticomaxillary fractures occur through the frontozygomatic suture and a step-off may be found at the junction of the superior one-third and inferior two-thirds of the lateral orbital rim.

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A depression of the malar eminence with tenderness suggests either a zygoma fracture, zygomatic tripod fracture or a zygomatic arch fracture. A zygomatic arch fracture can be clinically difficult to find as the only sign may be a depression of the arch or a decreased range of mouth opening. The patient may have marked edema due to the associated soft tissue trauma, so the depression may be obscured. The patient may note pain in the cheek, or pain in the cheek on movement of the jaw, or trismus. Trismus may be marked when the zygomatic fracture impinges on the temporalis muscle. A flat malar arch may best be assessed by palpation from behind the patient's head or viewing the supine patient from above the patient's head. Compare symmetry with the opposite side.

Suspect a tripod fracture after a blow to the cheek resulting in marked periorbital edema and ecchymosis. There may be flattening of the malar eminence, but resultant soft tissue trauma can obscure the flattening.

If the zygoma is displaced inferiorly, it may cause depression of the lateral canthus. When the fracture extends through the orbit, the infraorbital nerve may be damaged or bruised resulting in hypesthesia of the distribution of the infraorbital nerve.

If the examiner palpates the zygomaticomaxillary arch from within the mouth, a step-off may be found. Another step-off point is at the zygomaticofrontal suture or on the zygoma.

The eyes should be examined closely, even if the eye is swollen shut. Check for injury, abnormality of ocular movements, and visual acuity when possible. Eyelid ecchymosis, subcutaneous emphysema, ptosis, epistaxis, lacrimal system injuries, and pupillary dilation may each be associated with facial fractures. In particular, special attention should be paid to assess extraocular motility for extraocular muscle entrapment and to ensure that there is no orbital compartment syndrome present.²⁵

Whenever there is enough lid swelling or periorbital edema to restrict voluntary eyelid opening the examiner should use great caution. The mechanism of injury should be considered and a search should be made for a penetrating wound. The presence of hyphema, vitreous hemorrhage, or inability to visualize the fundi should prompt an urgent ophthalmologic consultation. If there is a through and through lid laceration, the ophthalmologist should be called to repair the tarsal plate which gives structure to the lids.

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The examiner should appraise midface stability. This can be accomplished by grasping the teeth and hard palate and gently pushing back and forth and then up and down. Look for movement or instability of the midface. If mobility is detected, determine the level of the fractures by palpating with the other hand on the face over the bridge of the nose, the infraorbital rims and along the zygoma.

1. A Le Fort I fracture includes facial edema and mobility of the hard palate. The examiner should grasp the incisors and hard palate and gently push in and out. In a Le Fort I fracture, these structures will move.
2. A Le Fort II fracture has marked facial edema, bilateral subconjunctival hemorrhage and mobility of the maxilla. Telecanthus is usually appreciated. The patient may have either epistaxis or CSF rhinorrhea. If the nasal bridge moves along with the maxilla, a Le Fort II fracture should be suspected
3. A Le Fort III fracture has facial flattening and elongation. The maxilla may be displaced posteriorly and leave the mouth open. Grasping the anterior teeth and moving them will result in movement of the entire front face (craniofacial dislocation). CSF rhinorrhea and epistaxis are both present. If the nose, infraorbital rims, and the zygoma move together with the maxilla, a Le Fort III fracture is probable.

The physical examination should involve both internal and external evaluation of the nose, regardless of the mechanism of injury. Palpate the nose for tenderness and crepitus. Clinical evidence of a nasal fracture includes swelling, tenderness, deformity, epistaxis, crepitus, nasal airway obstruction, and periorbital ecchymosis. In examination of the nose, the degree of bony deformity (laterally or depressed), the presence of cartilaginous deformity and associated soft tissue injury such as mucosal laceration, soft tissue swelling, epistaxis, septal or orbital hematoma and subcutaneous emphysema should be noted.

Inspect the nasal septum for septal hematoma. A bulging, bluish, tender septal swelling or mass indicates a septal hematoma and requires evacuation of the hematoma.

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The nose should be examined for CSF fluid. The presence of CSF rhinorrhea indicates disruption of the base of the skull, most commonly at the cribriform plate of the ethmoid bone (associated with a naso-ethmoidal fracture or from disruption of the posterior wall of the frontal sinus). An alternative site is a basal skull fracture or temporal bone fracture that leaks into the middle ear and then drains through the eustachian tube into the nose.

1. Distinguishing between CSF and serous nasal secretions may be difficult. Blood from head injured patients may mix with CSF and mask the recognition of a leak. The simplest tests for CSF fluid are easy to perform but not very accurate. If a sufficient sample of nasal drainage can be obtained, it can be sent to the lab and analyzed.
2. CSF is odorless, salty, and has a specific gravity of 1.006. The protein level is much less than nasal fluid, while the chloride level is greater. More importantly, CSF has a greater concentration of glucose than mucus or lacrimal secretions. The quantitative determination of a glucose level in nasal fluid not contaminated by blood can be diagnostic of CSF rhinorrhea if the nasal fluid contains more than 30mg/dl. Negative test results for glucose virtually eliminate the possibility of CSF.
3. Most of us have read about the halo sign. CSF will separate from blood when the mixture is placed on filter paper resulting in a central area of blood with an outer ring or halo. Blood mixed with tap water, saline, and rhinorrhea fluid also produces a ring. The halo sign does occur, but clearly does not clinch the diagnosis.
4. Another simple test involves collecting rhinorrhea on a handkerchief. Nasal secretions will dry and leave a stiff residue, whereas CSF will dry and leave the cloth soft. This test depends the lower protein level found in CSF.
5. Glucose oxidase paper or dextrose sticks have historically been used to identify CSF. However, they have been shown to be unreliable because lacrimal gland secretions and nasal mucus have reducing substances that may cause a positive reaction with glucose concentrations as low as 5 mg/dl.
6. The gold standard for laboratory diagnosis of CSF fistulae is beta-2-

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transferrin. This protein is found in only three bodily fluids – CSF, perilymph, and vitreous humor. Therefore production of clear nasal discharge that is positive for beta-2-transferrin is highly diagnostic for CSF. Unfortunately this test requires electrophoresis and often takes about 4 days for results.

Look at the nose for telecanthus and widening of the nasal bridge. Widening of the intercanthal distance (>40 mm) suggests the possibility of a naso-orbito-ethmoid fracture (NOE fracture).

A frontal laceration should make the examiner particularly suspicious of an underlying fracture in the patient who has been involved in a motor vehicle collision. The laceration must be carefully examined for a bony step-off. The orbits should also be carefully evaluated. The deformity of a fracture is often hidden by edema, so a physical examination alone may not be sufficient evaluation in the patient with substantial forehead lacerations.

Fractures of the mandible present in different fashions depending on the location and the severity of the injury. A fracture can be obvious if it has a large degree of displacement and has caused lacerations in the mucosa or skin. During the examination, look for signs of asymmetry and swelling. The most common presenting symptoms of patients with mandibular fractures are pain and malocclusion. Additional signs and symptoms include intraoral bleeding, lower lip and chin hypoesthesia or anesthesia, trismus, deviation with jaw movement, swelling or hematoma of the floor of the mouth, and ecchymosis of the gingiva.^{43, 44} Although a sublingual hematoma is not a consistent finding; when present, it is strongly suggestive of a mandibular fracture. Any of these findings should prompt the examiner to obtain further radiographic studies.

Occasionally a patient will have a widened appearance to the face. This may occur when both condyles are fractured combined with a fracture of the symphysis allowing the mandible to open like a book.

The tongue blade test (TBT) consists of having the awake patient grip a tongue blade with his/her teeth and the examiner breaks it by rotation (twisting).⁴⁵ If the patient is able to do this on both sides of the jaw, it is unlikely that a mandibular fracture exists.⁴⁶ This test has been shown to be 95.7% sensitive if the patient can break the blade without pain.⁴⁵

The external auditory canal can occasionally be damaged by a fracture of

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the mandible, so the canal should be visualized bilaterally in patients who have had trauma to the jaw. The temporal-mandibular joint can be felt by placing a finger into the ear canal and pressing forward (anteriorly). This may be more sensitive than palpation of the TMJ in the preauricular area. If the patient has no pain here, fracture is less likely.

In the conscious and cooperative patient, a detailed cranial nerve (CN) examination should be performed.⁴⁷ The optic nerve, cranial nerve II can be assessed by having the patient read and by visual field acuity. Extraocular movements test the integrity of CN III, IV, and VI.⁴⁸

Evaluate the supraorbital, infraorbital, inferior alveolar and mental nerve distributions for hypesthesia or anesthesia. Hypoesthesia of the face suggests cranial nerve V injury. Injury of the facial nerve, CN VII, produces paresis or paralysis of the muscles of facial expression.

The cranial nerve examination of the unconscious patient is more difficult and relies on the testing of brain stem reflexes.⁴⁷ Assessment of vision is quite difficult and fraught with hazard. Pupillary reflexes may remain intact as long as the efferent pathway of cranial nerve III is intact, even when complete unilateral vision loss is present.⁴⁹ Some evaluation of the CN II pathway and the efferent CN III parasympathetic pathway is possible in the unconscious patient with the swinging flashlight test.

Testing patients with unilateral afferent CN II damage reveals bilateral equal papillary constriction when the flashlight is directed towards the eye with remaining vision. When the light is directed towards the damaged eye, both pupils will dilate. This is the Marcus-Gunn pupillary reflex.⁴⁹

In the unconscious patient, extraocular movements can be tested with the doll's eye reflex (oculocephalic reflex). Testing of the gag reflex evaluates CN IX and CN X. The ice-water caloric test tests the function of CN VIII. The examiner washes the auditory canal and tympanic membrane with iced water and the patient develops nystagmus. (This test should not be performed when there is a rupture of the tympanic membrane.) The corneal reflex tests the afferent fibers of CN V and the efferent fibers of CN VII. The examiner touches the cornea with a small wisp of cotton and the eyelid closes.

Laboratory Analysis

There are few laboratory examinations that are useful in treatment of facial trauma. The use of Beta-transferrin in the diagnosis of CSF rhinorrhea is

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described above. Alcohol levels and presence of other intoxicating substances may be helpful in overall patient management. Other laboratory tests as indicated by either co-morbidity or concomitant injuries are at the discretion of the examining physician. Order those studies requested/required for pre-operative assessment per anesthesia and hospital protocol.

Diagnostic Imaging Studies

After the patient has been stabilized and examined, appropriate radiographs and computerized tomograms can be obtained. A patient with suspected cranial trauma should have CT scans of the brain as well as facial bone-specific radiographs and CT's. If there are obvious or suspected facial fractures, an appropriate approach would be to obtain axial cuts from the top of the skull through the entire cervical spine. Current generation spiral CT scanners can perform such an examination within minutes. Reconstruction of the films with computer-generated 3-dimensional imaging allow examination of the entire face.

Radiographs

A basic facial series consists of three or four films: a Waters view (PA view with cephalad angulation), a Caldwell view (PA view), a lateral view, and occasionally a submentovertex view. If a nasal fracture is suspected, then a lateral view of the nasal bone with special nasal technique may be done. Of these views, the most consistently helpful view in facial trauma is the Waters view. It tends to show all of the major facial structures at least as well and often better than other radiographic views of the face.

There are some suggestions that help with interpretation of the facial bone series.

1. Carefully look at the orbits. 60-70% of all facial fractures involve the orbit in some way. It is important to look carefully at the orbital borders and apex as well as the optic canal.
 - a. Exceptions include a localized nasal bone fracture
 - b. A zygomatic arch fracture
 - c. A LeFort I fracture
2. Know the COMMON facial fracture patterns and look for them.
 - a. Zygomaticomaxillary complex fracture (tripod fracture)
 - b. LeFort I,II,III
 - c. Zygomatic arch

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- d. Orbital blow-out fracture
- e. Alveolar process of the maxilla

On a Waters view, the examiner may see a soft tissue mass on the superior margin of the maxillary sinus, representing the herniated intraorbital soft tissues protruding into the maxillary sinus. A “trapdoor” fragment of bone may be seen protruding into the sinus, often hinged on the ethmoidal side. CT of the orbit will show these abnormalities much better.

- 3. Look at both sides of the facial films... Bilateral symmetry is a friend.
- 4. Direct signs of a fracture:
 - a. Nonanatomic linear lucency
 - b. Cortical defect or diastatic suture
 - c. Bone fragments overlapping creating a radiographic double density
 - d. Asymmetry of any part of the face
- 5. Indirect signs of a fracture:
 - a. Soft tissue swelling
 - b. Periorbital or intracranial air
 - c. Fluid in a paranasal sinus

Radiographic Views of the Nose

The use of x-ray to evaluate the patient with simple nasal trauma is common even in the 21st century, but is of limited value.⁵⁰ Decisions regarding the treatment of nasal trauma are based on clinical findings and radiographs of the nose have little value.^{15, 51} A plain nasal bone view cannot be reliable in exclusion of a nasoethmoid fracture and CT scan is therefore appropriate with persistent epistaxis or CSF rhinorrhea (or both.)

If deformity persists after the resolution of the edema, films may be ordered at follow-up examination to help plan the repair. This would not be the usual responsibility of the emergency clinician. Omission of nasal films would be cost-effective, since most nasal fractures will need no reduction.

Although isolated nasal fractures do not generally require radiographic studies,

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it is appropriate to order a CT scan after a thorough history and physical exam when other facial fractures are suspected. 3-D reconstruction may help the consultant plan surgical repair.

Radiographic Views of the Mandible

The mandibular series of radiographs consists of two lateral oblique films, a reverse Towne's view and an anterior-posterior projection. The Towne's view is an AP view with the neck flexed forward. The Towne's view is best to visualize condylar regions and the ascending rami of the mandible; a PA view is helpful in seeing the mandibular symphysis. In cases where missing teeth are unaccounted for, a chest x-ray should be performed to evaluate for aspiration. Cervical spine fractures are present in about 2% of patients with mandibular fractures and should be evaluated routinely.²⁸ Condylar and coronoid fractures are more difficult to detect than those in other areas of the mandible.

When the mandible is injured, it behaves as if it were a complete ring. The ring is rigid and connected at each end to the skull by a firm joint. If one fracture of the mandible is found in a radiograph, another fracture or dislocation is quite likely to be present. Fractures of the angle of the mandible on one side will often have a fracture of the mandibular condyle on the other side.

The single most informative radiologic study used in diagnosing mandibular fractures is the panoramic radiograph (Panorex is one manufacturer's version of the panoramic radiograph).⁵² When the panoramic radiograph is compared with simple radiographs, it is clear that the panoramic radiograph is superior to the plain film radiographs for diagnosis of mandibular fractures.^{53, 54} In one study, the panoramic radiograph was shown to diagnose 92% of fractures of the mandible.²⁸ The panoramic radiograph provides the ability to view the entire mandible in one radiograph.

CT

Computed tomography scans are not necessary for isolated mandibular fractures documented by x-rays; however, complex facial fractures involving the mandible may necessitate a CT scan and eliminate the need for plain radiographs. Many emergency physicians believe that routine use of CT is not justified as a standard of care for mandibular fractures due to the higher cost, increased radiation burden of the examination, and the potential for generation of artifacts from dental fillings and restorations. This is open to question and is discussed in the controversy section to follow.

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The utility of CT depends upon the generation/techniques used by the CT machine. Spiral scanning machines are significantly more accurate than older machines and may replace the panoramic radiograph as the diagnostic tool of choice.⁵⁵

Radiographic Views of the Orbit

The degree of orbital floor displacement and the presence of soft tissue protruding through a fracture are diagnosed accurately with coronal CT scans of the orbit and facial bones. Axial scans are useful, but not as accurate. Surgical intervention may be indicated with there is significant orbital floor disruption, entrapment, enophthalmos, or persistent diplopia.⁴⁷

Radiographic Views of the Zygoma

Zygomatic arch fractures can be seen on the under-exposed submental view (sometimes called a bucket-handle view). In this view, the arches will appear like bucket-handles, hence the nickname. A zygomatic arch fracture can also be seen on Water's view, a Towne view, or the facial series.

If a tripod fracture is suspected, the clinician should obtain a Water's view, Caldwell view, and the bucket-handle view. The Caldwell view evaluates the zygomaticofrontal suture and the frontal process of the zygoma.

If at all possible, when dealing with a suspected orbitozygomatic fracture, obtain a CT of the area. Although the Water's view may show some signs of a fracture, plain films are considered inadequate for evaluation of a fracture of the zygoma.⁵⁶

Radiographic Views of the Maxilla and Mid-Face

The mid-face skeleton is much more difficult to assess using plain films than is the mandible. The presence of very thin bones, fluid-filled sinuses (congestion vs. blood) and soft tissues make accurate assessment problematic. Diagnosis of all midface fractures has been enhanced by high-resolution CT scanning. Axial and coronal CT scans with thin cuts of the facial bones are recommended for all of these fractures.

Radiographic Views of the Frontal Bone

A CT of the head is indicated for complete evaluation of a frontal bone injury, since patients can have displaced posterior table fracture without palpable anterior fractures. Crepitus may be found when the patient has multiple

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fragments of bone that are mobile. CT's not only allow the evaluation of the anterior and posterior table of the frontal bone, they allow the examiner to evaluate for fluid within the sinuses, the presence of intracerebral injuries or air within the cranial cavity, and associated facial fractures.

Special Considerations

Occult mandibular fractures

In the awake patient, abnormal dental occlusion indicates a probable fracture of the mandible.

Pediatric injuries

An important difference between pediatric facial fractures and adult facial fractures is that injuries can result in growth dysplasias in children. Facial fractures in children are often missed on standard facial radiographs. The locations of fractures most at risk of being missed in pediatric facial bone studies included the ethmoid and sphenoid bones (~100% missed), the maxilla (~88% missed), the zygoma (~86% missed), and the orbits (~75% missed).¹³ Fractures of the frontal bone (38% missed) and the mandible (50% missed) are less likely to be missed. A CT scan of the facial bones is more important in children due to this higher likelihood of a missed fracture on plain film x-ray.

Orbital compartment syndrome

The presence of a retrobulbar hemorrhage (orbital compartment syndrome) is an acute emergency requiring immediate care.²⁸ The tearing of blood vessels within the orbit with resultant dissection of blood into the retro-orbital area causes acute increase in the volume of the orbital contents. The volume increase transmits pressure to the globe, causing increased intraocular pressure. The eye becomes proptotic, with hemorrhagic swelling of the conjunctivae. Ocular motility is limited and vision may be compromised. If initial medical management does not result in improvement, the emergent surgical treatment of choice is a lateral canthotomy by slitting the lateral canthal tendon to decrease the orbital pressure. Probably the most important factor in determining the outcome in cases of retrobulbar hemorrhage is recognizing the condition as early as possible and instituting treatment promptly.

Naso-Orbital-Ethmoid Fracture

If the inter-canthal distance in an adult is more than 40 mm (about the width

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of the patient's eye), then the patient should be evaluated for a possible naso-orbital-ethmoid (NOE) fracture.

Continued Epistaxis vs. CSF Rhinorrhea

Bleeding from the nose that continues beyond the immediate post-injury time may require the insertion of nasal packing or other commercially available device such as hemostatic balloon or Mycelelex sponges. The first step should be removal of the clot and the application of a topical vasoconstrictive agent. If this approach is unsuccessful, insertion of a nasal packing or other procedure may be required.

The examiner should be sure that the bleeding is not CSF rhinorrhea. For CSF rhinorrhea to occur, trauma to the anterior cranial fossa must disrupt the dura and fracture the bone. The incidence of meningitis following a CSF rhinorrhea is small. There are no significant studies that guide administration of antibiotics or which antibiotic would be appropriate. This decision is usually left to the consulting neurosurgeon.

Cutting Edge Controversies

Mandibular Fractures – CT or Panoramic Film?

The superiority of panoramic films over CT has recently been questioned and this may no longer be completely accurate for all CT machines.⁵⁵ The utility of CT depends upon the generation/techniques used by the CT machine. Spiral scanning machines are significantly more accurate than older machines and may replace the panoramic radiograph as the diagnostic tool of choice.⁵⁵ There is no question that fine-cut (1-3 mm) CT scanning will delineate mandibular fractures. Indeed in one study, the helical computed tomographic scan was 100% sensitive in diagnosis of mandibular fractures, compared with a Panorex which was only 86% sensitive.⁵⁷ The fractures missed by the Panorex were generally in the posterior mandible. This study also suggested that a dental root fracture may be better visualized by Panorex, particularly when the fracture is located in the angle.

Disadvantages of the panoramic radiograph include: A panoramic radiograph may not be available in some emergency departments. A panoramic radiograph requires an upright patient which renders it unsuitable for unstable trauma patients.⁵⁸ It lacks fine detail in the TMJ, symphysis, and dental/alveolar

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process regions with resulting missed fracture rates of about 8%.

A maxillofacial CT may be useful in mandibular fractures if the patient has multiple midface injuries, is in a cervical collar, or cannot otherwise undergo panoramic radiography.⁵⁵ This study will be significantly more expensive than the panoramic film. A CT of the head is obligatory if the patient has sustained a loss of consciousness due to trauma that results in a mandibular fracture. CT scanning with a spiral scanner can yield information in three dimensional reconstructions.

The question (and controversy) is which is the most cost-effective and reliable study. Since the studies comparing the two diagnostic techniques have relatively low numbers, it is entirely possible that the two techniques remain equivalent. In this case, the best test is suggested by other factors, such as mobility of the patient, associated injuries, and cost.

Clinical examination of the nose or radiographic imaging?

Simple nasal fractures from isolated nasal trauma frequently require no immediate intervention, unless there is profuse epistaxis. Displaced fractures are treated by open or closed reduction of the fractured bones and/or the septum into correct anatomic positions up to 5-10 days after the fracture in adults and 3-7 days in children.⁵⁹ A major controversy (not discussed in this monograph) among plastic and otolaryngologic surgeons is the utility of open vs. closed reduction of the nose.^{59, 60} The use of x-rays in patients with simple nasal trauma is common, but of limited value.¹⁵

In isolated nasal trauma, radiographs have a high number of false-negative results and a large, but unknown number of false positive results. Multiple studies have shown that radiographs do not help the clinician when a nasal bone fracture alone is suspected.^{50, 61} History taking and physical examination appear to be the best diagnostic tools for diagnosing nasal fractures and determining which nasal fractures require treatment by a consultant. Clinical evidence of a nasal fracture includes swelling, tenderness, deformity, epistaxis, crepitus, nasal airway obstruction, and periorbital ecchymosis. Nasal bone films should be abandoned as a clinical diagnosis is sufficient for accurate treatment.^{51, 62}

Should Antibiotics be used for Facial Fractures?

Mandibular and sinus fractures are essentially open fractures that should be considered contaminated. Fractures of the mandible that are in a tooth-

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bearing region are compound fractures, even if non-displaced. Because bacteria from the mouth and saliva bathe the surfaces of the fracture until the soft issues heal enough to seal the wound, most clinicians recommend immediate prophylactic antibiotics. This may be changing.

A recent prospective study showed no difference in the rates of wound infection in uncomplicated mandibular fractures with intraoral extension who received antibiotics versus those who received placebo only.³⁴ There is no comparable study for other facial or sinus fractures regarding use of antibiotics.

Less controversial indications for peri-operative antibiotics include heavily contaminated fractures, severely lacerated soft tissues, severely comminuted fractures, and delayed fracture treatments. Prophylaxis should be considered in patients who have valvular heart disease or prosthetic implants.

Disposition

Definitive repair of most facial fractures is not a surgical emergency and treatment is often delayed in the patient with multiple injuries. A recent study comparing patients undergoing repair within 3 days of a mandible injury to those repaired after 3 days found no increase in complication rates.³² With the exception of fractures that significantly alter normal dental occlusion or compromise the airway (mandibular fractures and some maxillary fractures), repair of facial fractures may be delayed for as much as 2 weeks. After concomitant injuries and comorbid conditions are evaluated, treatment planning can begin. The timing of the repair may be left to the consulting surgeon.

Consultation

All patients with visual acuity changes associated with mid-facial fractures should have benefit of consultation with ophthalmology.⁴⁹ This advice is clearly evidence based, since 28% of patients with midfacial fractures have moderate to serious eye injuries associated with the fracture.⁶⁹ Minor or transient eye injuries, such as corneal abrasion, mild impairment of visual acuity and accommodation, and orbital emphysema were found in 63% of patients. If there are any significant or questionable findings in patients with facial fractures, ophthalmologic consultation should be obtained. If the globe is proptotic and tense, a retrobulbar hematoma and subsequent orbital compartment syndrome should be suspected.

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Patients with complex facial fractures, displaced fractures of the nose, zygoma, frontal, or orbital fractures should have prompt consultation with an oral surgeon, otolaryngologic surgeon or plastic surgeon that performs this kind of surgery.

Patients with multiple trauma and/or significant co-morbidity should have consultation with the trauma surgeon.

Admission

Most complex facial injuries will be admitted to the hospital. Underlying co-morbidities, ingestion of recreational drugs and/or alcohol, additional concomitant injuries and mechanism of injuries will drive admission to the hospital for those patients with other associated problems. The awake patient with responsible home care and isolated mandibular or nasal injuries may be safely discharged.

Follow-Up

Facial fractures become difficult to move by 7-10 days and by 2-3 weeks are fixed. This may happen sooner in children. Follow-up for uncomplicated facial fractures should occur within this time.

Potential Complications

Did you get a cervical spine film?

Although most facial fractures are in fairly thin and fragile bones, significant force may be applied to the head and transmitted along the cervical spine. Consider a cervical spine series even when the patient is alert and talking.

Is alcohol the ONLY reason for the patient's altered sensorium?

Head trauma may be associated with facial trauma and the patient usually warrants a head CT. If the patient is intoxicated, check for other etiologies.

If there is a frontal sinus fracture, did you check for underlying cerebral bleeding?

In particular, when the thick frontal bone is broken, underlying cerebral trauma is common.

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Did you note the diplopia?

Diplopia is a subjective complaint that warrants a facial bone CT to examine for orbital fractures, masses, and displacement.

Did you check for orbital compartment syndrome?

After life-saving measures, maintenance of vision is the next most important goal in the care of the patient with maxillofacial trauma. Expanding hematoma in the orbit can jeopardize vision in that eye with an orbital compartment syndrome. If the globe is proptotic and tense, a retrobulbar hematoma and subsequent orbital compartment syndrome should be suspected. Urgent ophthalmologic consultation is indicated.

Did the patient have a nasal septal hematoma?

Septal hematoma can be potentially disfiguring and should be sought/noted in the chart.

Is the missing tooth aspirated?

A chest x-ray is appropriate when you have a missing tooth. You can check an abdominal film to ensure that the tooth was swallowed.

Is the discharge from the nose epistaxis or CSF rhinorrhea?

CSF rhinorrhea is common with a nasal ethmoidal fracture. It requires neurosurgical consultation.

Did you note the depression of the zygoma and underlying zygomatic arch and orbital/maxillary complex fracture?

Facial edema can mask these injuries easily. If the patient has significant facial edema, be sure to get facial bone x-rays or CT.

The patient is bleeding from the mouth...did you check the nose?

The nose should be explored as the site of bleeding in all patients who present with brisk oral bleeding after facial trauma.

Did you look for the fight bite injury to the hand?

Remember to look for associated injuries. It is not at all uncommon for the recipient of facial trauma to defend him/herself and sustain a tooth induced laceration to the hand that requires surgical debridement.

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Maxillofacial Patients

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Hand Injury Patients

Priority One

Injuries requiring immediate consultation/referral with a hand surgeon

1

- ☐ A severely crushed, degloved or mangled hand
- ☐ Complete or near-complete amputation of a hand
- ☐ High pressure injection injury
- ☐ Complete clean-cut amputation proximal to DIP
- ☐ Compartment syndrome in hand or forearm
(refer to orthopedic surgeon)

Priority Two

Injury requires initial stabilization and consultation/referral to an orthopedic or hand surgeon within a few hours

2

- ☐ Moderate crush injuries
- ☐ Open fractures of carpals or metacarpals, proximal digits
- ☐ Multiple angulated and/or displaced fractures or dislocations $>30^\circ$
- ☐ Wrist dislocation
- ☐ Deep space infections of the hand, such as suppurative flexor tenosynovitis

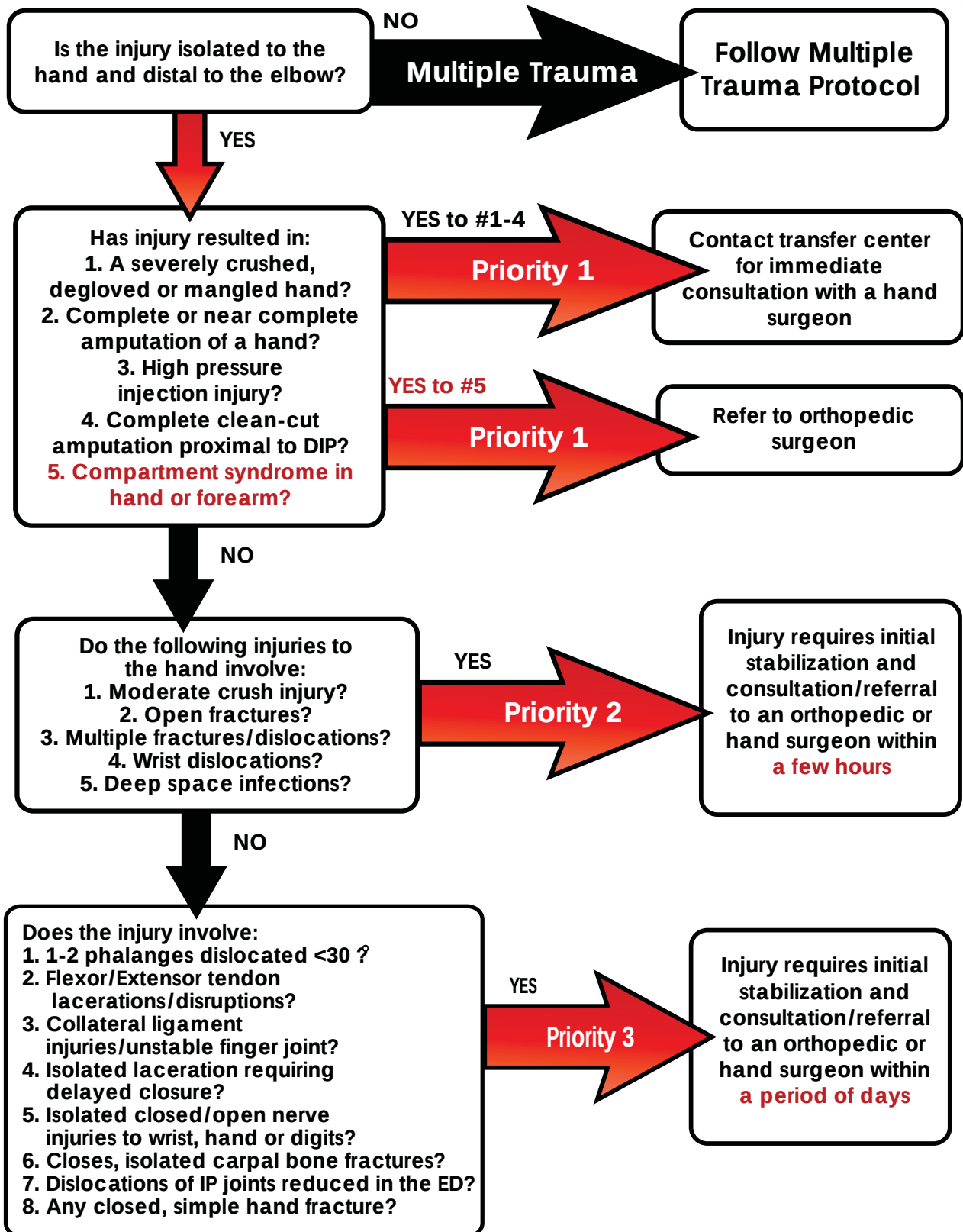
Priority Three

Injury requires initial stabilization and consultation/referral to an orthopedic or hand surgeon within a period of days

3

- ☐ 1-2 phalanges dislocated $<30^\circ$
- ☐ Flexor/extensor tendon lacerations and disruptions
- ☐ Collateral ligament injuries/unstable finger joint
- ☐ Isolated laceration requiring delayed closure
- ☐ Isolated [closed or open] nerve injuries to the wrist, hand or digits
- ☐ Closed, isolated carpal bone fractures
- ☐ Dislocations of IP joints reduced in the ED
- ☐ Any closed, simple hand fracture

Hand Injury Patients



Hand Injury Patients

Stabilization

1. **Assure that there are no other significant injuries. If there are other injuries, refer to the trauma resource manual.**
2. **Stop the bleeding**
A complete amputation may not bleed very much. The cut blood vessels may spasm, pull back into the injured part, and shrink. If there is bleeding, do the following:
 - Remove any visible objects in the wound that are easy to remove, and remove or cut clothing from around the wound.
 - Apply steady direct pressure for a full 15 minutes. If blood soaks through the cloth, apply another one without lifting the first. If there is an object in the wound, apply pressure around the object, not directly over it.
3. **Check and treat for shock**
4. **Remove jewelry as soon as possible, as they may be difficult to remove once swelling occurs.**
5. **Use rest, ice, compression, and elevation (RICE) for pain and swelling. Use narcotics as needed for pain that is not relieved with RICE.**
6. **Splint the injured area without trying to straighten the injured part.**
 - Cover the wound with a moist sterile dressing.
 - Splint in the position of function if possible.
 - Loosen the dressing around the splint if numbness, tingling, increased pain, swelling, or cool skin develops. Compartment syndrome can develop if the dressing is too tight.
7. **Amputated or partial amputations**
Instruct EMS to bring all parts. Although all tissues may not be replantable, portions may be used to reconstruct missing elements.
 - Rinse part(s) with normal saline to remove gross contamination. More extensive debridement is done in the operating room by the hand surgery team.
 - Wrap in moist sterile gauze and place in DRY plastic bag (zip-close).

Hand Injury Patients

- Place the plastic bag in another bag with ice mixed with water to prevent frostbite of the amputated part. The gauze and plastic prevent the tissue from coming into direct contact with the ice. This method is preferred to immersion or wrapping in a moist dressing to avoid maceration. Do not bury in ice because immersion may cause cold injury to the part. Do not use dry ice because it is too cold and causes tissue damage.
- Splint and elevate the injured part for comfort
- In cases of partial amputation, apply saline-moistened sponges to wound and cover with sterile, bulky dressing. Avoid extensive cleansing; this will be accomplished under anaesthesia.

NOTE: Do not inject the site of an amputation with local anesthesia. Local injection may cause vasoconstriction or direct vessel injury.

Cell phones and internet connected computers are capable of sending and receiving quality digital pictures to the referral physician.

Hand Injury Patients

HISTORY

Obtaining a good history on any trauma patient begins with the best medical and surgical history that time allows. General information such as past medical illnesses and current medications could be relevant, especially where healing might be compromised or infections more likely to occur (i.e., hemophilia, chronic corticosteroid use, diabetes mellitus, etc.).

The “AMPLE” mnemonic can help you remember the important components of a complete history in the traumatized patient:

- Allergies -- Is the patient allergic to medication or other physical substances (e.g., antibiotics, anesthetics, latex gloves) that may be used during treatment?
- Medications -- Does the patient take any licit or illicit medications (including alcohol)?
- Prior medical history and injuries -- In particular, document any previous injuries to the affected hand. This information may influence the diagnosis, treatment, and outcome of the present injury. Also, ask the patient which is his or her dominant hand, as this will have relevance during the patient's recovery.
- Last meal -- When did the patient last eat? This is important if immediate surgery is necessary.
- Events -- At what time did the injury occur? What happened before and after the trauma? Did the patient lose consciousness? What measures have been taken by the paramedics or referring physician since the injury? What possible contaminants might be present within the wound?

DOCUMENTATION

Proper documentation of the history and physical exam, with attention paid to the complete, accurate assessment of the injury, provides the hand surgeon with crucial information. Thoroughly chart your findings before and after any radiological or therapeutic manipulations, so that any future complications will be recognized as signs of progressive dysfunction rather than an initial oversight or the result of your manipulation. Remember that EMTALA requires records to be transferred with the patient.

Hand Injury Patients

GENERAL HAND EXAMINATION

Ensuring patient comfort and overhead lighting will ensure the best opportunity to visualize the injured hand. Place the patient in the most comfortable position available.

The Skin

Begin by observing the general appearance of the hand and fingers. What color is the skin? Is cyanosis, pallor, erythema, or ecchymosis present? Is there edema? Are lacerations, abrasions, burns or blisters present? Are scars, contractures or deformities from previous injuries identified?

The Fingers

The "Attitude," or "Cascade" of the fingers describes the curvature and symmetry of the injured digits; comparison with the opposite side will allow you to better identify subtle changes. To evaluate this, the hand must be cleaned and allowed to relax in a normal resting position. Are any fingers held in extension? (This indicates a possible flexor tendon injury.) When the fingers are held in flexion, is there any overlap? (This suggests a possible displaced fracture or dislocation.) Observe the fingertips "end on" to note any rotational deformity. When the fingers are held in a resting position, each fingernail should be parallel to the corresponding finger of the opposite hand, indicating rotational alignment. The best way to assess rotational deformity is with the digits flexed. Gentle passive flexion of the digits is nearly always possible and will make deformity in this plane much more evident.

Wounds

Inspect the hand for or abrasions. Hemostasis is critical to wound visibility; to reduce bleeding, be sure that the open wound initially has a sterile compression dressing (wet with sterile saline) in place and consider elevating the arm. When you are ready to examine the open wound, gently remove the dressing and determine whether hemostasis is adequate.

If bleeding continues despite a sterile compression dressing, wound exposure can usually be improved by judiciously applying a blood pressure cuff to the upper arm and inflating it to 100 to 150 mm Hg above the systolic blood pressure. To minimize patient discomfort and the risk of ischemic injury when using the cuff, only rarely should the inflation time exceed 30 minutes.

Hand Injury Patients

Although you may be tempted to clamp a bleeding vessel to achieve hemostasis, do not do so under any circumstances: the risk of potential complications, such as nerve, tendon, and/or vascular injury, is too great.

NEUROLOGIC EVALUATION

Next, assess the motor and sensory functions of the injured hand. This should be completed and documented prior to giving the patient any local anesthetic. Two peripheral nerves, the ulnar and median, enter the hand at the volar aspect; the radial nerve crosses the radial styloid from the volar to the dorsal surface at the level of the wrist. (Figure 1) Although anatomic variations are often present, a general understanding of the muscle innervations of each nerve is helpful to an accurate neurologic examination.

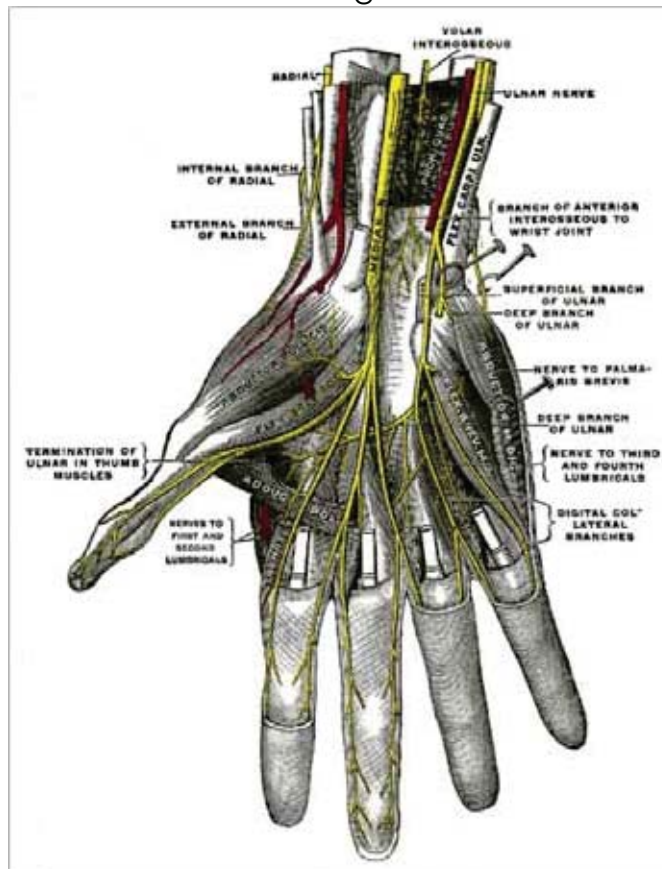


Figure 1: Two peripheral nerves, the ulnar and median, enter the hand at the volar aspect; the radial nerve crosses the radial styloid from the volar to the dorsal surface at the level of the wrist.

Hand Injury Patients

Motor Testing

The “RUM” mnemonic (radial, ulnar, median) can help you remember to test each of these nerves. The results of three simple motor tests provide an accurate assessment:

- o Thumbs up – Hitchhiker
- o Pinkie up – like a tea cup
- o Pinch here...

Radial Nerve: If the patient can extend the wrist and fingers and extend or abduct the thumb, you may be confident that the motor function of the radial nerve is intact. “Thumbs up! - Hitchhike”

Ulnar Nerve: If the patient can abduct the little finger, then the motor function of the ulnar nerve is preserved. “Pinkie up!”

Median Nerve: If the patient can maintain a strong thumb and index finger “pinch,” or touch the tip of the thumb to the tip of each finger, be assured that the median nerve motor function is undamaged. “Pinch”

Sensory Testing

Three key locations to examine the hand for sensory nerve dysfunction are illustrated in **Figure 2**:

Radial Nerve: The dorsal web-space between the thumb and index finger.

Ulnar Nerve: The volar surface of the finger pad of the fifth digit.

Median Nerve: The distal radial aspect of the volar surface.

Hand Injury Patients

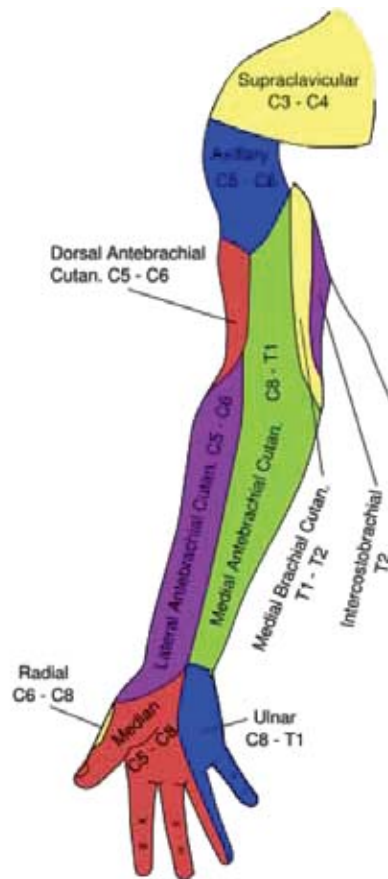


Figure 2: Although anatomic variations are often present, a general understanding of the muscle innervations of each nerve is helpful to an accurate neurological examination.

Determine and document the sensation to light touch and pain. With the patients eyes closed, use the ends of a straightened paper clip like calipers to test two-point discrimination on each digital pulp region and on the dorsal metacarpal thumb region. Generally, a patient should be able to discriminate between one and two points that are 5 mm apart, although there might be slight individual variations. By comparing these results with those of the opposite hand, you can accurately detect sensory dysfunction.

Hand Injury Patients

Sensory dysfunction in the absence of higher priority injuries, would be a Priority 3 injury, requiring treatment by a hand surgeon or orthopedist within a period of days to assure best chance of maintaining hand function. Because this treatment is vital to a good outcome, contact the accepting surgeon at the time of evaluation to minimize any delays.

A patient who detects only one point when two should be detected may have sustained a nerve injury. Conversely, a patient who repeatedly detects two points when there is only one may be guessing or deliberately trying to mislead you, as there is no pathophysiologic explanation for this result.

Skin-Wrinkle Testing

You can also evaluate the functional integrity of the nerves by soaking the injured hand in a basin of sterile water for several minutes. If a particular region has sustained nerve damage, the overlying skin will remain smooth, whereas the surrounding skin will become wrinkled.

VASCULAR EXAMINATION

The vasculature of the hand is complex and replete with normal variants. Following certain basic principles ensures a quick and thorough vascular examination. The ulnar and radial arteries supply the hand; each enters from the volar aspects of the wrist, where you can usually palpate them. Anastomoses of branches from each artery produced superficial and deep palmar arches. The digital arteries branch directly from these arches **(Figure 3)**.

Hand Injury Patients

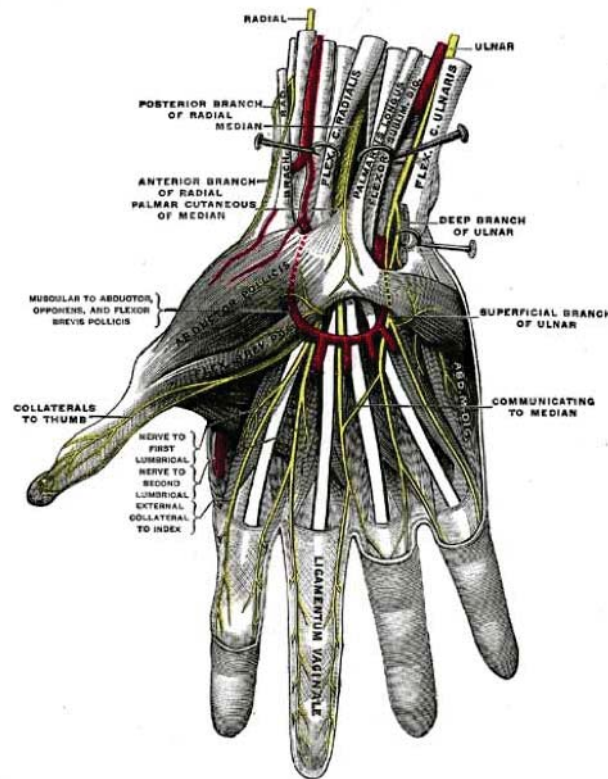


Figure 3: The ulnar and radial arteries supply the hand; each enters from the volar aspects of the wrist, where you can usually palpate them.

A deep penetrating injury with pulsatile bleeding suggests arterial disruption. A history of such bleeding may be the only clue to arterial injury, since the flow may stop or slow greatly after spontaneous vessel constriction. Previous injury to the hand may cause preexisting vascular compromise or a predisposition to certain vascular compromise.

Inspect the hand for disrupted vascular integrity or inadequate collateral blood flow between two arterial systems in every patient with a hand injury. Initially, observe the wound for active bleeding and for visible blood vessels. The five P's: pulses, pallor, pain, paresthesia, paralysis--are the components of a thorough vascular examination. Be sure to first control any active bleeding with a sterile compression dressing. An appropriate vascular examination of the hand cannot be performed if it is covered in blood.

Physical examination evidence of possible vascular disruption to the ulnar or radial arteries, or any portion of the deep palmar arch may be a Priority 1 injury

Hand Injury Patients

requiring immediate referral to a hand specialist capable of microvascular reconstruction.

Begin by palpating the arterial pulses as they cross the volar aspect of the wrist. Pulses may be transmitted through a soft clot, even in the presence of significant injury to the ulnar or radial artery. Bedside doppler examination can confirm pulsatile flow in the radial and ulnar arteries as well as the palmar arches and digital vessels even when pulses are not grossly palpable

Check the capillary refill time of each nail bed by comparing it with that of the opposite hand (if uninjured). If this is not possible, remember that a capillary refill time of less than 2 seconds is usually considered normal. Capillary refill may be falsely reassuring in the acute phase and prolonged capillary fill may occur in a hypothermic patient or a cold examining room. Carefully comparing the injured side to the contralateral side or an injured digit to an adjacent one may be helpful.

Pain distal to the injury out of proportion to the wound itself might indicate ischemia. Any paresthesia or paralysis of distal muscle groups indicates the possibility of vascular compromise, although these signs are not specific.

The Allen test demonstrates adequate collateral blood flow between the ulnar and radial arteries. To perform this test, apply sufficient pressure with your thumbs to occlude both arteries at your patient's wrist while he repeatedly opens and closes his hand until you note blanching. At that point, release the pressure on the radial artery and watch for a red flush of normal color into the palms and fingers as arterial flow returns. Then repeat this for the ulnar artery. Failure of the hand color to return indicates likely disruption of the arterial system.

Vascular injuries distal to the elbow are classified as critical or non-critical. In critical injuries the arterial injury results in the disruption of blood flow to all or part of the hand. This is a Priority 1 Injury and requires rapid vascular repair or reconstruction.

In non-critical injuries, adequate pulsatile flow is present to all digits despite the transection of either the radial or the ulnar artery. Most single artery injuries in the forearm do not result in a critical loss of flow to the hand because of the connections between the radial and ulnar systems. Patients with non-critical injuries may not require immediate surgical referral.

Hand Injury Patients

SKELETAL EXAMINATION

Fractures

Check for anatomic deformities of the hand by comparing the injured with the uninjured side. Certain hand fractures are associated with characteristic features, such as the direction and degree of angulation and displacement. These fracture characteristics are determined by the mechanism of injury and the sum of the forces exerted on the bones by the various musculotendinous units. For instance, a proximal phalanx fracture usually angulates to the volar aspect, while a proximal metacarpal shaft fracture typically angulates in the dorsal direction.¹

Isolated fractures/dislocations of one or two phalanges dislocated $<30^\circ$, are Priority 3 injuries, requiring treatment by a hand surgeon or orthopedist within a period of days.

Multiple fractures/dislocations of phalanges (three digits or more) are Priority 2 injuries, requiring urgent treatment by a hand surgeon or orthopedist within a period of hours.

Discrete point tenderness characterizes the site of a fracture. Careful palpation aids in identifying the radiographic views that will best delineate the fracture. Conversely, an old bony injury will not be tender to palpation despite radiologic evidence of fracture. Ask the patient to fully flex the digits while holding the metacarpophalangeal joints at about 45 degrees of flexion. Observe the axes of these flexed fingers: they should not overlap, and they should all point down toward the scaphoid bone in the wrist. In addition, palpate the carpal bones; any obvious defects or tenderness indicates a possible fracture. Radiography is an essential part of the skeletal examination; however, some acute fractures may not be visualized initially. This is because osteolysis, the first phase of fracture healing, causes the fracture line to appear more radiolucent at 7 to 10 days, before callus formation begins. Therefore, it is often wise to splint patients presumptively based on the history and examination, even if skeletal x-ray films appear normal.

Suspected fractures identified by physical exam but not by x-rays should be splinted as if a fracture is present. These injuries are Priority 3, requiring treatment by a hand surgeon or orthopedist within a period of days. The stated diagnosis

Hand Injury Patients

in the patient's medical record should avoid the use of definitive terms such as, "sprain", "strain" and "contusion", as these might imply that other, more serious injuries have been ruled out. More reasonable diagnoses would include, "hand/wrist injury" or "possible wrist fracture".

SOFT TISSUE EXAMINATION

Aside from direct visualization, simple functional testing is not the most reliable way to detect injuries to a muscle or tendon. Flexion and extension, though weakened, can still be accomplished with partially severed tendons. For this reason, it is important to test these functions against mild resistance. Do not be surprised if a partially torn ligament or tendon snaps completely when you add resistance. This simply justifies your suspicion of a significant laceration to the tendon. No harm is done if this occurs now that the diagnosis is recognized; the structure can be appropriately repaired. Pain along the course of a tendon during motion is another indication of injury.

Flexor/extensor tendon lacerations and disruptions represent Priority 3 injuries, requiring treatment by a hand surgeon or orthopedist within a period of days.

Collateral Ligament Injuries

Rule out collateral ligament injuries of the interphalangeal and metaphalangeal joints. While the patient holds the finger in extension, test the joint space on the radial or ulnar side of the joint do this by directing stress laterally toward the radial and ulnar sides of the joint.

Joint effusion and tenderness over the collateral ligaments are nonspecific indicators of collateral ligament tear, whereas joint opening in response to stress testing is the sine qua non of the diagnosis. It helps to compare the results with those of the uninvolved hand.

Suspected collateral ligament injuries represent Priority 3 injuries, requiring treatment by a hand surgeon or orthopedist within a period of days.

Thumb Opposition

Our ability to oppose the thumb with fingers from the same hand is one of our greatest physical assets. By asking the patient with a hand injury to perform this action, you are testing several intrinsic hand muscles.

Have the patient form a ring by touching the tips of each finger in turn with

Hand Injury Patients

the tip of the thumb. Ask the patient firmly oppose the thumb to each of the fingers on the same hand. To test the strength of the muscles innervated by the median nerve, try to force one of your fingers through each ring. The patient should be able to maintain a pinch strong enough to prevent you from breaking the ring.

Abduction and Adduction

Use abduction and adduction of the fingers to test, respectively, the dorsal and palmar interossei. Have the patient perform extended-finger spreading and closing against mild resistance placed by your fingers.

Also, have the patient abduct and adduct the fingers while in extension and then make a fist. This provides a nonspecific test of the multiple intrinsic muscles in the hand.

Extension

When testing extensor function of the fingers, have the patient place the hand palm down on a table and extend each finger off the table, one at a time, against mild resistance. Inability to perform this exercise may indicate extensor tendon injury.

If you suspect extensor tendon laceration or disruption but it is not visually apparent, place the hand in the position it was in when the injury occurred. Within the wound, the extensor tendon should be visible. Passive movement of the digit improves the likelihood of visualizing the injured tendon as it moves to and fro.

Flexion

To test the flexor digitorum profundus, ask the patient to place his hand palm up on a table. While restraining the proximal inter-phalangeal joint, have the patient attempt to flex the distal interphalangeal joint. Success indicates an intact flexor digitorum profundus in that digit.

Next, with the patient's hand in the same position, gently restrain three fingers while the patient attempts to flex the remaining fingers at the proximal interphalangeal joint. If this maneuver is successfully completed, the flexor digitorum superficialis in that digit is functional. Then have the patient flex the thumb so that it touches the hypothenar eminence and then try to pull the thumb out of flexion. This tests the flexor pollicis brevis and flexor pollicis longus.

Hand Injury Patients

To test the functional integrity of the extensor pollicis longus, have the patient place the thumb in the hitchhiker's position against resistance.

Flexor/extensor tendon lacerations and disruptions represent Priority 3 injuries, requiring treatment by a hand surgeon or orthopedist within a period of days.

ANESTHESIA

Various types of anesthesia are available to enable the evaluation and treatment of hand injuries. Of course, a complete neurologic examination should be performed before you proceed with anesthesia.

Local Anesthesia

Adequate anesthesia of most hand lacerations can be achieved using local infiltration. Local anesthesia is usually sufficient for smaller and more superficial lacerations of the palm and dorsum of the hand. Be aware that injection may distort the wound and possibly cause the loss of valuable skin landmarks before closure, making it a challenge to repair the wound accurately.

Nerve Blocks

Do not inject local anesthetic agents in the stump of an amputation. This may compromise microvascular repair of the injury.

Nerve Blocks

Nerve blocks are also commonly used in the hand. In no circumstance should a block be performed before complete assessment of the neurologic injury has been performed and documented. This cannot be overemphasized. Once the block is performed it will make assessment of nerve function impossible for some time. Even in the absence of a significant nerve injury, edema in the hand and digits commonly causes a temporary disruption in nerve function, which may occur by the time a local anesthetic wears off. Because of this it may be impossible to clinically confirm the status of a potentially injured nerve after the block without surgical exploration.

Begin by inserting a 27-gauge needle approximately 5 mm deep in a perpendicular direction. Attempt to aspirate first to ensure that you have not entered a vessel. Gentle pressure on the plunger of the syringe makes injection of the medication less uncomfortable for the patient. While gently withdrawing the needle, slowly inject the anesthetic into the region surrounding the nerve.

Hand Injury Patients

Larger needles cause more pain and are more likely to cause nerve injury. Do not use local anesthetics containing epinephrine in the hand; doing so may cause vascular spasm and fingertip necrosis if injected directly into an artery. Usually, no more than 2 or 3 mL of a local anesthetic is required for a single nerve block in the hand.

The objective of nerve block is not to inject directly into the nerve (this may cause injury) but rather to infiltrate the surrounding tissue so that the anesthetic can diffuse into the perineurium. Inadvertent injection of larger amounts directly into the nerve can cause nerve injury. If the patient complains of paresthesias when you insert the needle, withdraw the needle 2 or 3 mm before injecting a local anesthetic. Anesthesia may require 15 to 20 minutes to develop; patience is thus imperative to avoid the common mistake of manipulating the injured hand before the full benefits of the nerve block are realized.

A valuable nerve block technique is the digital block, which provides anesthesia to either or both sides of an individual digit. When performing this technique, be sure that the needle penetrates the skin at the midline of the finger and is directed at 45-degree angles to each side of the finger. Next, inject the anesthetic from the dorsal surface of the finger into the radial and/or ulnar aspects of the proximal digit.

Alternatively, you can use an entry site on the palmar surface; inject the anesthetic at a depth of about 3 mm at the level of the distal palmar crease where the flexor tendon crosses it. To anesthetize the thumb, make the injection at the volar aspect of the metacarpophalangeal joint bracketing the flexor tendon apparatus.

Interdigital web-space injections can also provide anesthesia to either or both sides of a single digit; some experts believe they are less painful. Such injections may be of greater benefit when adjacent sides of two fingers are injured. When making these injections, hold the needle parallel to the long axis of the fingers and direct it toward the wrist.

Although only rarely necessary, radial, ulnar, and median nerve blocks are generally effective and easy to perform. These blocks are recommended when a large area of the hand must be anesthetized. Ulnar nerve block is achieved by injecting the anesthetic approximately 1.0 – 1.5cm deep into the region just lateral to the ulnar pulse and beneath the flexor carpi ulnaris at the level of the proximal skin crease. You may also need to inject the superficial ulnar styloid to effect a complete block.

Injecting anesthetic deep into the region between the radial pulse and the flexor carpi radialis at the level of the proximal skin crease blocks the discrete trunk of the

Hand Injury Patients

radial nerve. A second, common procedure is local infiltration at the dorsal aspect of the wrist.³ Infiltrate the subcutaneous tissue up to the metacarpophalangeal joint of the digit, where the minor branches of the radial nerve enter; this anesthetizes the individual digits. Extend the anesthetic wheal to include the distance from the radial to the ulnar border of the metacarpal head (approximately 2 to 3 cm) to block all the sensory branches.

The median nerve lies deep in the region between the flexor carpi radialis and the palmaris longus tendons. To anesthetize this nerve, inject between those two tendons at the proximal crease of the wrist (level of the transverse carpal ligaments). ³

The String Technique to Remove Rings

When treating a patient with an injured hand, remove all rings as soon as possible. As inflammation develops, edema can complicate ring removal quite difficult. A tight-fitting ring can cause arterial compression and ischemia if not removed in time. Soap or lubricant jelly can facilitate your efforts to remove a ring. If unsuccessful, try the string technique.

Begin by wrapping a 25 inch piece of thick, silk suture or umbilical tape around the finger just distal to the ring in a distal direction. Next, slip the proximal end of the string under the ring. Then pull the proximal end of the suture over the ring and firmly retract it over the axis of the finger distally. As each coil of suture unwinds, it pulls the ring slightly over the bed of suture material until it is free.

If the string technique fails, remove the ring with a mechanical ring cutter. Take care to avoid injuring the patient's hand in the process.

TREATING HAND WOUNDS

Now attend to any skin wounds in the injured hand. Do not overlook small disruptions in the skin, since they may accompany more serious underlying injuries and harbor foreign bodies. This can be particularly true of small lacerations overlying fractures of the distal forearm, where a spicule of bone may have penetrated the skin; open fractures of this sort usually require operative irrigation and repair.

Open fracture(s) in the hand are Priority 2 injuries, requiring treatment by a hand surgeon or orthopedist within a period of hours.

After you have established adequate hemostasis, irrigate and cleanse the

Hand Injury Patients

wound of any debris. High pressure irrigation with normal saline is the most efficient way to clean an open wound and significantly reduces wound infection. Begin by connecting a splash guard to a 30-to 35-mL syringe filled with the normal saline. Recent studies have shown that tap water can also safely and effectively be used for irrigation of wounds in the emergency department. Next, depress the plunger as rapidly as possible while aiming the stream perpendicularly into the wound. This generates the 7 to 8 psi of pressure required to efficiently irrigate debris and bacteria from the wound. Although a bulb syringe provides a larger stream of water, it does not produce the requisite pressure.

The necessity of removing debris from heavily contaminated wounds outweighs the risk of slight subcutaneous tissue injury. Since high-pressure irrigation may be painful, we suggest anesthetizing the wound beforehand.

When washing wounds, minimize the use of scrubs and cleansers, including those containing iodine and hexachlorophene, directly into the wound. The current mantra is that these substances are toxic to wounds and delay healing by decreasing the migration ability and the life span of polymorphonuclear cells. Nevertheless, these topical anti-infective agents still have a role in cleaning the surrounding epidermis to produce a "sterile" field around which wound repair can be performed.

CLOSING SKIN WOUNDS

Three basic techniques are used for repairing skin injuries: primary, secondary, and delayed closure. Of course, effective anesthesia, cleansing, and irrigation should always precede closure.

Primary Closure

Use this technique for wounds not heavily contaminated and less than 8 hours old. Primary closure involves suturing the wound edges in approximation without causing inversion or overlap. Be sure to avoid any blanching at the wound edge; this indicates tissue ischemia at the margins and might compromise healing.

Secondary Closure

This method is appropriate for wounds heavily contaminated or inaccessible to high-pressure irrigation, such as puncture wounds. Leave shallow wounds open and deep wounds packed open. Packing keeps the skin from closing over the wound, thus preventing abscess formation. With secondary closure, the intent

Hand Injury Patients

is to facilitate the formation of granulation tissue from within the wound. The obvious disadvantage is increased scarring.

Change and repack the dressing daily. Although you can easily teach patients how to perform these measures, be sure to consider the level of discomfort (physical and emotional) and the patient's pain tolerance and reliability in carrying out the packing procedure before deciding on the appropriate degree of self-management

Delayed Closure

Use this technique to repair wounds that are large, gaping, and heavily contaminated. Clean and debride the wound as necessary and pack it open, as you would for secondary closure. If no signs of infection are present after 3 to 5 days, remove the packing and suture. This method is acceptable for many small defects, particularly on the palmar surface of the hand.

An isolated laceration requiring delayed closure can be sutured by any qualified physician. If the laceration is too complex for the treating physician, then this injury would be considered a Priority 3 injury, requiring treatment by a hand surgeon or orthopedist within a period of days. In this case, delayed primary closure will decrease the potential of infection in a contaminated wound.

Suturing

Use standard suturing methods when closing hand wounds. Usually, 4-0 and 5-0 prolene or nylon monofilament sutures are preferred in most locations. In the palmar surfaces and particularly the finger tips 4-0 chromic suture may be more appropriate. Given the paucity of subcutaneous tissue in the hand, avoid subcutaneous or layered closure techniques for the most part. Of note, deep sutures in the hand predispose to deep-space infections.

In complex wounds it may be difficult to obtain complete closure of the defect. Priority should be given to providing closure over exposed bone, tendon, nerve, or arteries, particularly if they have been injured. Loose closure is preferred and will help prevent compression of small but critical digital vessels as the hand swells. Leaving small portions of the wound with exposed subcutaneous fat or muscle is not unreasonable and typically does not result in an unacceptable outcome.

Because so many joints exert tension in the hand, the skin tension is much greater than in most other parts of the body. To prevent wound dehiscence, sutures need

Hand Injury Patients

to stay in place longer in the hand than in most other areas of the body. Remove sutures after 7 to 14 days, depending on the proximity to a joint and the relative skin tension involved.

Stabilize a joint with a splint when there is concern that undue tension may cause wound dehiscence.

PREVENTING INFECTION

One of the most important goals of managing hand injuries is preventing wound infection. To this end, high-pressure irrigation with normal saline on all skin wounds is helpful.

Infection-prone wounds require special attention. Although we rarely employ antibiotic prophylaxis in outpatients, we will do so when treating crush, grossly contaminated, and bite injuries. **(Figure 4)** Special case-by-case consideration is required for diabetic or immunocompromised patients.



Figure 4: Wound infection of the hand.

When you discharge a patient with an infection-prone wound, ask them to return for a wound check in 24 to 48 hours. Provide your injured patients with clear and concise wound care instructions and be sure to familiarize them with the signs and symptoms of infection.

NERVE INJURIES

There are three distinct categories of nerve injury--neurapraxia, axonotmesis, and neurotmesis. Each is associated with sensory and/or motor nerve deficit; clinical differentiation is based on whether and how quickly nerve function returns. At the time of injury all three present as complete loss of nerve function.

Neurapraxia results from blunt trauma to a nerve; a transient loss of function occurs, although the integrity of the nerve remains intact. The neurologic deficit usually resolves within 1 to 3 weeks, depending on the severity of the contusion.

Hand Injury Patients

Axonotmesis represents axon disruption within a preserved endoneural tube. Wallerian degeneration and subsequent gradual axon regeneration ensue at a rate of 1 to 3 mm per day. The patient eventually recovers full nerve function.

Neurotmesis occurs when all the structures within a nerve have been damaged. This typically occurs because of sharp transection. Unless surgical repair is timely, the loss of function is permanent.

Radial Nerve Injury

Damage can occur as the radial nerve passes over the dorsum of the wrist. However, injury most frequently occurs proximally and may manifest as an apparent “wrist drop” in which the patient cannot dorsiflex the wrist or demonstrates weakness in wrist dorsiflexion. This finding may also occur with fractures and acute compression injuries. Regardless of the cause, sensory deficits, paresthesias, and motor dysfunction can all be seen in the radial nerve distribution.

Median Nerve Injury

Lying between the flexor carpi radialis and palmaris longus tendons on the volar surface of the wrist, the median nerve supplies sensation to the radial aspect of the palm and to the palmar surfaces of the thumb, index and long fingers, and radial half of the ring finger.⁵ Deficits in median nerve sensory function must be specifically sought, since there is almost complete overlapping from the other nerve distributions. However, sensation to the tips of the thumb and index finger is usually provided only by the median nerve.² Therefore, examine these regions when testing sensory function of the median nerve.

Several possible traumatic causes for acute symptoms of median nerve damage exist; these include wrist fractures, crush injuries, hemorrhage within the flexor retinaculum, burn injuries, and vigorous hand exercises. More often, repetitive motions with the fingers held in flexion and the wrist held in extension--such as typing, driving, and piano playing--lead to chronic symptoms, including numbness, tingling, and burning pain in the tips of the index and middle fingers and of the thumb (carpal tunnel syndrome).

Neurologic examination in carpal tunnel syndrome patients typically reveals isolated thenar atrophy. Tinel’s sign refers to paresthesias produced along the median nerve distribution in response to percussion of the median nerve at the center of the volar aspect of the wrist. Phalen’s maneuver pertains to paresthesias generated when the patient holds his or her hand in full flexion for 60 seconds.

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Ulnar Nerve Injury

The ulnar nerve lies radial to the flexor carpi ulnaris as it passes along the volar surface of the wrist. Because of its proximity to the ulnar artery, injury to one frequently means injury to both.

Injury to the ulnar nerve produces loss of sensation of the volar and dorsal surfaces of the little finger and at least the ulnar half of the ring finger. The interossei muscles are usually weakened or paralyzed, rendering patients unable to spread their fingers.

Loss of lumbrical function in the ring and little fingers may lead to the classic clawhand deformity in response to ulnar nerve injury. Another indicator of damage to the ulnar nerve is Froment's paper sign--the inability to maintain strong adduction of the distal phalanx of the thumb against the index finger when holding a piece of paper between the two. A patient with a positive Froment's paper sign will also try to compensate by flexing the thumb against the index finger.

Isolated nerve injuries to the wrist, hand or digits are Priority 3 injuries, requiring treatment by a hand surgeon or orthopedist within a period of days. Because prompt treatment is vital to optimal outcome it is best to notify the accepting surgeon at the time of injury to minimize any delays.

Treatment

Any patient with suspected blunt trauma to a nerve, even if evidence of compartment syndrome is lacking, should be referred to a hand surgeon or orthopedist. If neurologic symptoms do not appear to improve over time, the physician may elect to explore the injured hand to search for and repair a surgically correctable lesion.

In open wounds with obvious direct nerve injury, prompt nerve repair by a hand surgeon is often performed, although it can be successfully delayed if the surgeon deems it necessary. When indicated, standard wound care, including immediate irrigation and suturing is necessary to prevent infection.

Any open nerve injury to the wrist, hand or digits are Priority 3 injuries, requiring treatment by a hand surgeon or orthopedist within a period of days.

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VASCULAR INJURIES

These may be classified as open or closed. Open vascular injuries are often easy to diagnose; the injury is usually accompanied by profuse, active bleeding. However, spasm can occur in a lacerated artery, which may cause minimal active bleeding.

In contrast, closed vascular injuries to the hand present a tremendous diagnostic challenge -- without an overlying wound, direct observation is not possible. Furthermore, the symptoms and signs of serious arterial injury or compromise may be subtle in a closed space.

Arterial laceration from a fracture fragment may impair blood flow. Vascular compromise may also follow dislocation, compartment syndrome, or vascular spasm. In addition, blunt trauma may lead to a false aneurysm or thrombosis and subsequent ischemia. Ischemia in any part of the hand after injury indicates arterial injury or compression. This requires consultation with a hand surgeon and surgical repair in the operating room.

After physical examination, any evidence of possible vascular disruption to the ulnar or radial arteries, or any portion of the deep palmar arch may be a Priority 1 injury requiring immediate referral to a hand specialist capable of microvascular reconstruction.

Controlling Bleeding

To most effectively control hemorrhage from a hand wound whether oozing from muscle or arterial bleeding, apply a compression dressing and elevate the extremity. Sterile gauze with an elastic wrap or direct pressure is ideal. Although the injury may appear spectacular, rarely is the hemorrhage life-threatening.

If these measures are unsuccessful, use a short-duration tourniquet-- preferably a pneumatic cuff--applied to the arm at slightly greater than the systolic arterial pressure. Be certain to record the start time of tourniquet application. Surgical consultation will be necessary if bleeding persists. Under no circumstance should you attempt to clamp a bleeding vessel, as the risk of catastrophic nerve or tendon damage is unacceptably high.

Palmar Arch Injury

Involvement of the palmar arch arterial system--a double arterial supply-- is

Hand Injury Patients

difficult to detect clinically. This is because collateral blood flow from the uninjured vessels often prevents ischemia.

You may not be able to see the palmar arches when you examine an open hand wound. An imaginary line drawn from the superior border of the thumb across the volar aspect of the hand can serve as a marker for the superior portion of the superficial palmar arch. Whenever a significant injury overlies the palmar arches, assume that an arterial injury is present and consult a hand surgeon immediately.

Physical examination evidence of possible vascular disruption to the ulnar or radial arteries, or any portion of the deep palmar arch may be a Priority 1 injury requiring immediate referral to a hand specialist capable of microvascular reconstruction.

Compartment Syndrome

When soft-tissue swelling in an extremity occurs in a limited space, an intra-compartmental pressure elevation can occur sufficient to restrict arterial blood flow to the tissues. The resulting compartment syndrome must be treated promptly in order to prevent permanent muscle or nerve impairment. Irreversible muscle damage may occur as early as 6 to 8 hours after the onset of ischemia.

Factors associated with compartment syndrome are muscle contusion, fractures, gas-forming infection and toxic envenomations. A conscious patient with compartment syndrome usually complains of severe pain and tenderness in the involved area. Findings may include obvious injury or massive tissue edema. Maintain a high degree of clinical suspicion for compartment syndrome because onset may be delayed. An even higher degree of suspicion is needed when the patient suffers mental status changes and thus cannot communicate or exhibit appropriate discomfort. Urgent intervention is required when compartment syndrome is present; so when the diagnosis is suspected, consult a hand surgeon immediately. The only definitive treatment is fasciotomy in the operating room, since measurement of muscle intracompartment pressure is not physically possible in the hand itself.

If compartment syndrome is suspected, this becomes a Priority 1 injury, requiring immediate referral to an orthopedist.

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INJURIES TO THE TENDONS AND LIGAMENTS

Flexor Tendon Injuries

These are fraught with potential complications, such as injury to the ligamentous pulleys (annular ligaments) that support the tendons, and thus necessitate immediate referral to a hand surgeon. Exploring wounds in the region distal to the mid-palmar crease and proximal to the proximal interphalangeal flexor crease is not advisable, owing to the high risk of damaging the flexor tendons and the annular ligaments in this region. This zone is termed “no man’s land” because of the difficulty in obtaining excellent surgical outcomes in the zone.⁶

More proximal injuries may be cautiously explored for occult injury to a flexor tendon that cannot be detected by clinical examination. There are differences in opinion regarding the need for immediate operative repair of flexor tendon injuries in the hand, and this decision is best left to the hand surgeon.

Flexor tendon lacerations and disruptions represent Priority 3 injuries, requiring treatment by a hand surgeon or orthopedist within a period of days. Because prompt treatment is vital to optimal outcome it is best to notify the accepting surgeon at the time of injury to minimize any delays.

Extensor Tendon Injuries

Managed improperly, these can lead to loss of hand or finger function; fortunately, management is straightforward. Refer any patient with a suspected extensor tendon injury to a hand surgeon within 3 to 5 days of the accident, whether or not repair was undertaken in the emergency department.

Left untreated, a partially separated extensor tendon may evolve into a complete separation with permanent motor dysfunction. An extensor tendon less than 50% lacerated need not always be repaired, however. In a region other than over the proximal interphalangeal joint, repair of an extensor tendon with an acute laceration through more than 50% of its diameter, may be carried out by a qualified physician in the emergency department. It is recommended that training for extensor tendon repair include several supervised repairs under the guidance of a specialist.⁷

With effective wound irrigation, skin closure, and splinting of the joint for 4 to 6 weeks, an extensor tendon that is less than 50% lacerated usually heals

Hand Injury Patients

completely with full function. An exception is an extensor tendon injured directly over the proximal interphalangeal joint. A hand specialist should attend to this injury as soon as possible to prevent what is commonly referred to as boutonniere deformity, flexion of the proximal interphalangeal joints and extension of the distal interphalangeal joint in response to volar displacement of the lateral bands.

Occasionally, the patient loses extensor function to the distal phalanx after an acute injury. The mechanism is usually one of forced flexion that has avulsed the insertion of the extensor tendon from the distal phalanx. Because the patient cannot extend at the distal interphalangeal joint, he maintains the finger in a flexed position, better known as a mallet finger deformity. **(Figure 5)**

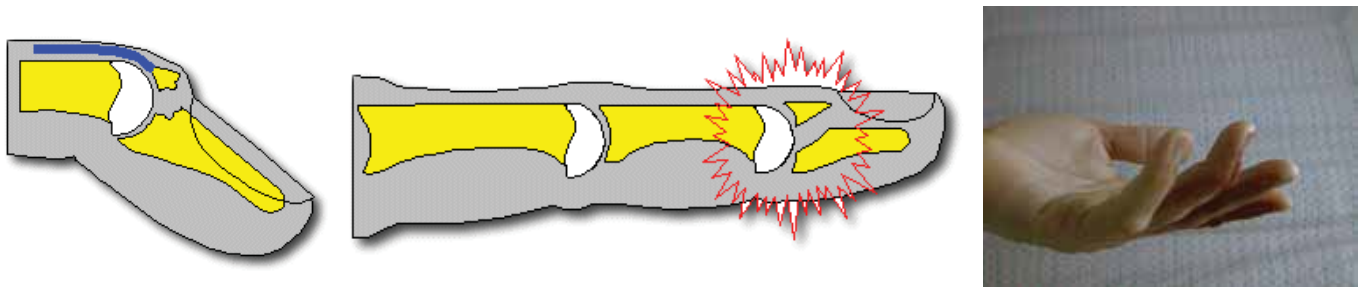


Figure 5: Because the patient cannot extend at the distal interphalangeal joint, he maintains the finger in a flexed position, better known as a mallet finger deformity.

When splinting a finger with an extensor tendon injury, place the hand in a "position of use" or "neutral" position. Specifically, make sure the joint nearest to the extensor tendon injury finger is held in slight hyperextension and that the uninvolved interphalangeal and metacarpophalangeal joints are allowed to move freely.

Management of a mallet finger deformity requires 6 to 8 weeks of splinting that keeps the distal interphalangeal joint in extension without restricting proximal interphalangeal joint mobility. If there is a coexistent intra-articular fracture, healing may be slowed, so consult with a hand surgeon regarding the suitability of operative repair.

The natural cascade describes the staggered fingertips when the hand is in its natural, motionless position and all involved voluntary muscles are relaxed.

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The first and fourth metacarpophalangeal joints flex at approximately 45 and 70 degrees, respectively, while each of the interphalangeal joints flexes at approximately 10 to 15 degrees. Before splinting, pad each interdigital web space with gauze, and bandage any lacerations with a protective sterile dressing.

Flexor/extensor tendon lacerations and disruptions represent Priority 3 injuries, requiring treatment by a hand surgeon or orthopedist within a period of days.

Ligamentous Injuries

These are frequently missed. The collateral ligaments extend across the interphalangeal and metacarpophalangeal joints and protect against lateral displacement of these joints. Hence, when these ligaments tear, instability of the joint space may occur, depending on the extent of injury.

To test the collateral ligaments across an interphalangeal joint, place pressure against the phalanx on either side of the joint you are examining; the aim is to open the joint space while the finger is held in extension.¹ When testing the collateral ligaments of a metacarpophalangeal joint, be sure that the finger is held in flexion.¹ Digital-block anesthesia is often required before the patient can fully cooperate, as injury to these structures can be quite painful.⁸

A joint-space opening of 2 to 3 mm indicates a mild collateral ligament tear. An opening of more than 3 to 4 mm suggests that a collateral ligament has ruptured and that a volar plate injury has possibly occurred.

Ligament ruptures and suspected volar plate injuries require splinting and immediate referral to a hand surgeon for possible operative repair. Recommendations for managing mild ligament strains without evidence of joint instability vary; follow the advice of the hand surgeon regarding immediate motion or immobilization. When splinting these injuries, flex the metacarpophalangeal joints at 45 to 50 degrees and keep the interphalangeal joints in a neutral position.

Suspected collateral ligament injuries represent Priority 3 injuries, requiring treatment by a hand surgeon or orthopedist within a period of days.

“Gamekeeper’s Thumb”

Chronic weakening and subsequent instability of the ulnar collateral ligament of the thumb causes Gamekeeper’s Thumb. **(Figure 6)** This injury leads to lateral

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instability and dislocations of the metaphalangeal joint. Use of a thumb spica splint or cast and referral to a hand surgeon or orthopedist is indicated.

Suspected collateral ligament injuries represent Priority 3 injuries, requiring treatment by a hand surgeon or orthopedist within a period of days.



Figure 6: Chronic weakening and subsequent instability of the ulnar collateral ligament of the thumb causes Gamekeeper's Thumb. This injury leads to lateral instability and dislocations of the metaphalangeal joint.

Nail Bed Trauma, Bites, Fractures and Dislocations

In this section, the approaches to managing fractures, dislocations, nail bed injuries, and bite wounds are discussed.

NAIL BED INJURIES

Both blunt and penetrating trauma to the hands commonly occurs to the nail bed. **(Figure 7)** When evaluating the injury, first obtain x-ray views of the injured fingers to rule out underlying fracture. Test for function of the flexor digitorum profundus over the distal interphalangeal joint, as described earlier.



Figure 7: An example of blunt trauma to the nailbed with resulting subungual hematoma.

If an acute subungual hematoma is present, assume that there is an underlying nail bed laceration. Most nail bed lacerations produce only subungual hematomas or minor wrinkles of the new nail plate as it regrows over time. In

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these cases, the intact nail plate serves as a splint for the healing nail bed injury, thus promoting a satisfactory result without intervention.

Subungual hematomas involving more than 25% to 30% of the nail plate are often drained because even small hematomas can cause intense pain. A microcautery device to bore a hole through the nail to release the subungual pressure of the hematoma can be used, or one can elevate the free edge of the nail plate with an 18-gauge needle to establish a drainage tract at the distal nail edge itself.

Nailbed repair is indicated when the bed is disrupted by a nail plate laceration, fractures of the distal phalangeal tuft, severe crush of the subungual area, and occasionally in the presence of phalangeal tuft fractures. Remove the nail plate itself to obtain access for the repair. Always precede nail removal with an effective digital nerve block. Next, use a small pair of hemostats under sterile conditions to fully separate the nail from the nail bed. Finally, clamp the hemostats at a lateral edge of the nail and gently roll the hemostats to the opposite side, taking the nail off the nail bed. Be particularly careful not to inadvertently damage the nail matrix further.

If the nail matrix was avulsed during the injury, retrieve it from the nail plate and replace it as a graft in the nail bed. Large pieces of an avulsed nail bed may require suturing with 7-0 chromic suture for accurate positioning. This technique often allows for healing with minimal scarring; however, it is difficult to perform without magnification and special instruments.

Accurate repair of the nail bed laceration with 6-0 or 7-0 absorbable sutures is indicated. If the nail fold is lacerated, use a layered closure to maintain the integrity of the germinal matrix and overlying eponychium; suture the matrix and eponychium independently.

If the removed nail is intact, consider using it as a protective sheath by placing it over the repaired laceration and suturing the proximal and distal ends down to the skin underneath. However, thoroughly scrub the nail with povidone-iodine solution and normal saline beforehand.

If you do not replace the nail plate, insert petrolatum gauze into the proximal nail fold; this prevents premature spontaneous closure of this space during the healing process. Apply a compression dressing, and have the patient wear it for about 2 to 3 weeks. The nail plate splint be removed after 2 to 4 weeks, depending on the rate of nail re-growth.

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BITE WOUNDS

Because abundant bacteria thrive as normal flora in the oral cavity, infection is a significant concern when dealing with bite wounds. Moreover, punctures, crush injuries, and irregular lacerations that result from bite wounds are infection-prone because of the associated tissue destruction.

First, copiously irrigate the wound and thoroughly search for foreign bodies. X-rays can help rule out a fracture or an embedded tooth.

Healing by secondary intention is the ideal way to manage bite wounds. However, if the injury is located in a region of cosmetic importance, consider primary closure after copious irrigation. Debridement in the operating room is indicated when a tendon sheath has been violated, abscess has developed, or an open fracture or joint injury is present.

Upon discharge, familiarize patients with the signs of infection, and advise them to return for follow-up in 24 to 48 hours. Antibiotic prophylaxis is recommended to cover the most likely organisms from the offending oropharynx. A patient who does not present until the wound is already infected requires immediate hospitalization and intravenous antibiotics.

Dog Bites

First, attend to cleaning and, if necessary, the debridement of common injuries. Determine whether rabies and tetanus could result from the injury; and administer prophylaxis if necessary. Organisms commonly responsible for infections in dog bite wounds are Viridans streptococci and *Pasteurella multocida*.

Cat Bites

Cat bites have higher rates of subsequent infection than dog bites, and infections are more likely to be caused by *P. multocida*. Whereas most wound infections take 2 to 3 days to develop, *Pasteurella* infections often become clinically evident within 24 hours.

Staphylococcus aureus is another common culprit. Cat bites rarely, if ever, should be sutured, since they are generally puncture wounds and, therefore, highly infection-prone. **(Figure 8)**

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Figure 8: An example of wound infection resulting from a cat bite.

Human Bites

The majority of these injuries are sustained while punching someone in the mouth (**Figure 9**). Sometimes the patient will not offer, or will even deny, a history of this sort. Therefore, consider all wounds on the dorsum of the hands as possible human bite wounds. In addition, consider the possibility of coexistent fractures, especially those involving the fourth and fifth metacarpals (boxer's fractures).

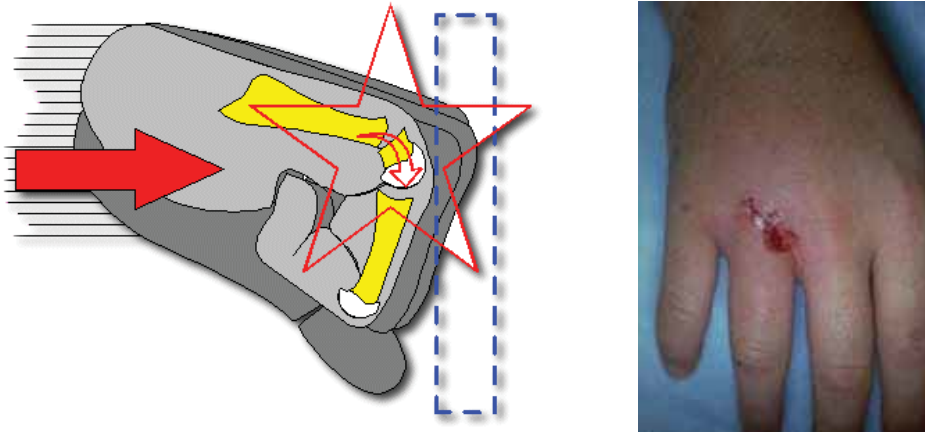


Figure 9: Consider all wounds on the dorsum of the hands as possible human bite wounds. In addition, consider the possibility of coexistent fractures, especially those involving the fourth and fifth metacarpals (boxer's fractures).

Eikenella corrodens is a unique organism sometimes responsible for human bite wound infections. *Viridans streptococci* and *Staphylococcus* and *Corynebacterium* species are also often implicated.

Tenosynovitis and deep space abscess are potential complications of bite wounds and when they occur prompt surgical intervention is usually required. Instruct all patients who incur bite wounds to return immediately for re-evaluation if any signs or symptoms of progressing infection develop.

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FRACTURES

Wrist, hand, and finger fractures often accompany various types of traumatic hand injuries. Several types of fractures are particularly important, either because of their frequency or because of the seriousness of potential complications if timely diagnosis and treatment are not provided. Open fractures of the hand and wrist may require more aggressive treatment to prevent infection.

Open fractures/dislocations of the carpals, metacarpals, and phalanges may be Priority 2 injuries, requiring urgent treatment by a hand surgeon or orthopedist within a period of hours. Because prompt treatment is vital to optimal outcome it is best to notify the accepting surgeon at the time of injury to minimize any delays.

Phalangeal and metacarpal fractures are common. With both, it is important to identify any intra-articular involvement; displacement or comminuting of these fractures often requires surgical reduction.¹ The management and prognosis of displaced fractures in phalanges or metacarpal will vary depending upon the particular bone fractured and the angle of displacement, degree of angulation and rotation. If reduction of a fracture is attempted in the emergency department and it appears stable, the patient can be splinted and referred to a hand surgeon for follow-up within days. If the fracture is not stable, the patient should be evaluated by a hand surgeon within hours, as it is not suitable for splinting.²

Phalangeal Fractures

Proximal phalangeal fractures are usually accompanied by volar angulation or displacement, and they require accurate reduction and proper splinting.

Using adequate anesthesia, place traction on the distal fragment while it is flexed; in essence, this recreates the injury, thereby reuniting the fractured ends. The angulation of a middle phalangeal fracture is not easy to predict, but the same principles of reduction can nonetheless be applied. After reducing a phalangeal fracture, place the finger in a splint that extends across the palm to immobilize the metacarpophalangeal joint in 90 degrees of flexion and the interphalangeal joints in a position of near full extension.

Isolated fractures/dislocations of one or two phalanges dislocated less than 30°, are Priority 3 injuries, requiring treatment by a hand surgeon or orthopedist within a period of days.

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Multiple fractures/dislocations of phalanges (three digits or more) may be Priority 2 injuries, requiring urgent treatment by a hand surgeon or orthopedist within a period of hours. Because prompt treatment is vital to optimal outcome it is best to notify the accepting surgeon at the time of injury to minimize any delays.

If reduction of a fracture is attempted in the emergency department and it appears stable, the patient can be splinted and referred to a hand surgeon or orthopedist for follow-up within days. If the fracture is not stable, the patient should be evaluated by a hand surgeon or orthopedist within hours, as it is not suitable for splinting.

Metacarpal Fractures

Because of the tension of the interosseous muscles, these injuries usually angulate dorsally. The boxer's fracture often occurs when a patient punches a solid object, such as a wall or an opponent's face. A transverse fracture results at the distal fourth or fifth metacarpal shaft. **(Figure 10)**



Figure 10: The boxer's fracture often occurs when a patient punches a solid object, such as a wall or an opponent's face. A transverse fracture results at the distal fourth or fifth metacarpal shaft.

Both boxer's and transverse fractures require reduction if the angulation exceeds 30 degrees. Apply pressure on the digits from the volar surface and put counterpressure on the proximal fragment from the dorsal surface. Then immobilize the hand until a hand surgeon can examine the patient (preferably within 3 to 5 days). The ulnar gutter splint, a short plaster arm splint placed along

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the ulnar region with extension under the phalanx of the involved digit(s), is ideal for this purpose. Position the wrist so that it is held in 15 to 30 degrees of extension while the metacarpal phalangeal joints are held in 70-90 degrees of flexion and the interphalangeal joints are held in extension.

Carpometacarpal Fractures

These are of particular concern, especially when the index and little fingers are involved. Rotational deformity at the fracture site often causes overlapping of digits; and also be identified by the patient's inability to properly clench his or her fist. A hand surgeon is often required to precisely reduce and internally fixate the bones to ensure correction of the rotational component of the fracture. Splint the injury and see that the patient is examined by a hand surgeon within 3 days.

Carpal Bone Fractures

Suspect one of these fractures in any patient who presents with wrist pain and tenderness. Plain radiography is indicated, but since it is not sufficiently sensitive to detect all acute carpal bone fractures, do not rely on it to exclude the diagnosis.

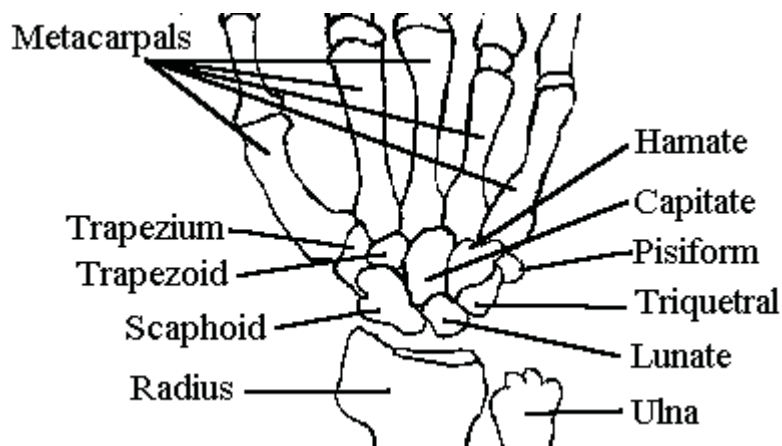


Figure 11: The hand is comprised of 8 carpal bones, acute fractures of which are not always visible on x-ray.

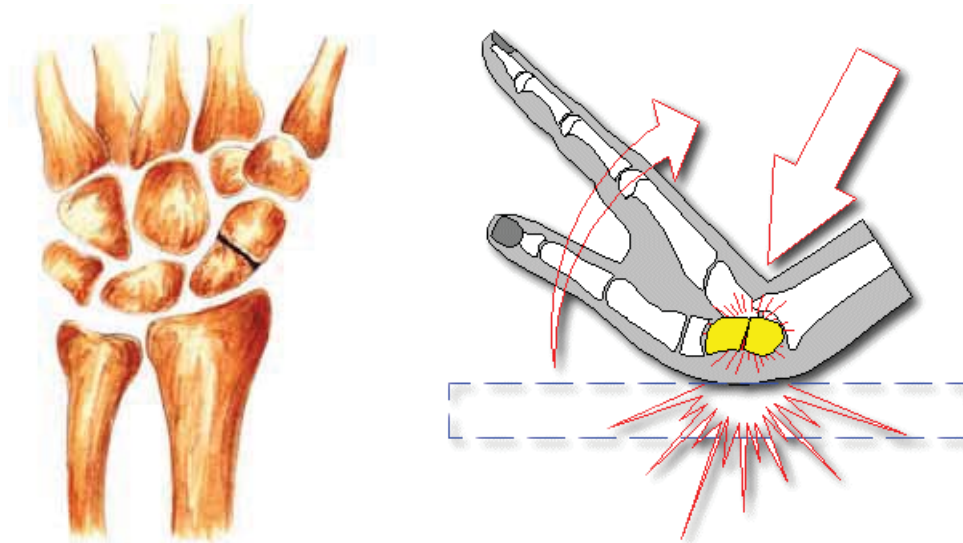
All patients with significant wrist pain and localized tenderness merit a presumptive diagnosis of carpal bone fracture and immobilization in a splint. Refer to a hand surgeon or orthopedist any patient who still complains of pain and tenderness after 7 to 10 days, if you have not already done so. Avoid giving the diagnosis of "sprained wrist" in the emergency department, as this might imply to the patient that a fracture has been ruled out.

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A follow-up plain film at days 7 to 10 will show bony resorption--the first sign of fracture healing--thereby rendering the fracture more visible than it was originally. Inadequately immobilized fracture sites can lead to avascular necrosis of the bone, arthritis, and chronic disability.

In descending order, the three most common carpal bone fractures are scaphoid, triquetrum (dorsal chip), and lunate fractures.¹²

A **scaphoid** fracture often results from a fall onto an outstretched hand. Tenderness in the anatomic snuff-box is classic (**Figures 12**). Avascular necrosis and nonunion are not uncommon complications of an untreated scaphoid fracture; chronic pain and disability may ensue leading to an unstable or dysfunctional hand.



Figures 12: A scaphoid fracture often results from a fall onto an outstretched hand. Tenderness in the anatomic snuff-box is classic. Avascular necrosis and nonunion are not uncommon complications of an untreated scaphoid fracture; chronic pain and disability may ensue leading to an unstable or dysfunctional hand.

A triquetrum (dorsal chip) fracture arises from an injury involving hyperextension and ulnar deviation of the wrist or a direct blow to the wrist. The triquetrum may be fractured transversely, but the fracture usually is minor and affects the dorsal aspect of the bone; it is usually best visualized on a lateral film view (Figure 5). Immobilization with a volar splint in the emergency department and referral to a hand surgeon or orthopedist is recommended.

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A **lunate** fracture also results from a dorsiflexion-related injury; pain and tenderness over the mid-dorsal aspect of the wrist at the radiolunate articulation are characteristic of the fracture. Because plain radiography may not reveal the fracture, base suspicion of this on the clinical finding of localized radio-lunate tenderness.

With the patient's wrist and thumb held in a neutral position, place a thumb spica splint on the injured fore-arm and wrist. Improperly managed, a lunate fracture can lead to avascular necrosis (Kienbock's disease) similar to that seen with untreated scaphoid fractures. The long-term complication of greatest consequence is loss of wrist stability and function.

Closed, isolated carpal bone fractures are Priority 3 injuries, requiring treatment by a hand surgeon or orthopedist within a period of days.

DISLOCATIONS

Distal And Proximal Interphalangeal Joint Dislocations

Dislocations in the hand most frequently affect the distal and proximal interphalangeal joints. The distal interphalangeal joint is well supported on all sides except dorsally--the usual direction of dislocation. The volar plate is usually disrupted with dorsal dislocations.

Following the initial roentgenographic evaluation, reduce the dislocation by placing the distal phalanx in longitudinal traction and extension of the distal end of the phalanx. Step the proximal end of the dislocated phalanx back into proper alignment with the distal tip of the middle phalanx. Complete the reduction by flexion of the distal tip of the distal phalanx to achieve the proper anatomic alignment of the joint.

Dislocations of the proximal interphalangeal joint usually occur in the dorsal or lateral directions.¹³ Use the same reduction technique as for the distal interphalangeal joint.

After successful reduction of either a distal or proximal interphalangeal joint dislocation, follow-up x-ray films are necessary, as is stress testing of the joint space to rule out an unstable ligamentous injury. Splinting for 3 to 5 weeks, depending on the extent of suspected ligamentous injury, and quick referral to a hand surgeon or orthopedist is indicated.

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Dislocations of interphalangeal joints require immediate reduction and will then be considered Priority 3 injuries, requiring treatment by a hand surgeon or orthopedist within a period of days.

Dislocations of the Thumb

Closed reduction of these uncommon injuries is very difficult and should be undertaken only by a physician experienced in their treatment. An ulnar collateral ligament rupture, or gamekeeper's thumb, is easy to miss and thus requires a high index of suspicion, especially when treating metacarpophalangeal dislocations of the thumb. The injury is detected only by stress testing of the metacarpophalangeal joint of the thumb to ensure the integrity of the ulnar collateral ligament at this level.

Dislocations of the thumb are Priority 2 injuries, requiring treatment by a hand surgeon or orthopedist within a period of hours.

Carpal and Carpometacarpal Dislocations

Always rule out these injuries when wrist tenderness or swelling is present, because inappropriate treatment carries the risk of potentially disastrous consequences. The complexities of these dislocations mandate immediate consultation with a hand specialist. Use anteroposterior and lateral x-ray films of the wrist to eliminate the possibility of displaced lunate and perilunate dislocations, and correlate the radiographic and clinical findings.

Carpal and carpometacarpal dislocations are Priority 2 injuries, requiring treatment by a hand surgeon or orthopedist within a period of hours.

High Pressure Injection Injuries

A high-pressure injection injury should be considered a potential surgical emergency. Immediate decompression and thorough cleansing of the offending material from the tissue is required to preserve optimal function. Most high-pressure injection injuries are industry-related from grease guns, spray guns, and diesel injectors. Other guns that reportedly cause such injuries include paint guns, concrete guns, and plastic injectors. Grease is the material injected most often, followed by paint.

High-pressure guns emit jet streams at pressures of up to thousands of psi. At these pressures, the injected material is forced through the skin, where spread can occur along fascial planes, tendon sheaths, and the neurovascular bundle.

Hand Injury Patients

The entrance site from HPI injuries is often deceptively small. The injected material acts as a projectile. The physician must look for possible exit sites as well. This benign appearance may lead clinicians to send the patient home with analgesia and reassurance. Invariably, the patient returns to the hospital in excruciating pain and unable to move the involved finger or hand.

Depending on the volume and materials injected, the finger may be distended, swollen, and tender on palpation. If vessels in the involved digit have been thrombosed or compressed, the digit may be pale, anesthetic, or even ischemic.

The severity of the high pressure injection injury is dependent on many factors, including the type, toxicity, temperature, amount, and viscosity of the material injected; the pressure of injection; the involvement of synovial sheaths; the anatomy and distensibility of the injection site; the site of penetration, secondary infection; and the time interval between injury and surgery.¹⁴ Overall incidence of amputation approaches 48%. Morbidity is dependent to a large degree upon the material injected. Paint solvents appear to cause the greatest damage and result in amputation in 60-80% of the cases.¹⁵ Grease, the more common injectant, causes a less severe inflammatory response. Amputation is necessary in about 25% of these patients.



Figure 13: Results of high pressure injection injury – courtesy of the Hydraulics Institute.

Treatment and stabilization of the high pressure injection injury

- Obtain radiographs of the hand – these may show extent of extravasation.
- Administer broad-spectrum prophylactic antibiotics.
- Update tetanus and administer parenteral analgesics.
- Splint the extremity and keep it elevated.

Hand Injury Patients

- Steroids may be beneficial in selected cases, especially when an intense inflammatory response develops or treatment is delayed.

High pressure injection injuries are Priority 1 injuries, requiring treatment by a hand surgeon within a period of hours.

For more information:

<http://www.emedicine.com/Orthoped/topic402.htm> - ref11

Amputations and mangling injuries in the Upper extremity

Patients who present with severe trauma to the upper extremity, including amputation, deserve special consideration. **(Figure 14)** They require aggressive, emergent care to achieve optimal outcome.



Figure 14: Examples of amputations and mangling injuries of the hand. Upper extremity amputation is a Priority 1 injury requiring immediate surgical care by a hand specialist capable of microvascular reconstruction.

These cases present emergently with injuries that can be very distracting for the patient and the physician. The physician must resist the temptation to wrap the hand in gauze and send the patient on their way. It is important that these patients are stabilized and carefully evaluated for the presence of other injuries. Overall assessment should include complete blood count and repeated

Hand Injury Patients

checking of the patient's vital signs as even injuries at the digital level can result in significant blood loss over time. Once the patient is stabilized and indicated resuscitation is initiated the extremity injury can be evaluated.

The extremity must be examined carefully. A gross examination is almost always possible despite the patient's discomfort. Bleeding must be controlled and the hand must be cleaned to assess the extent of the injury and adequacy of blood flow. The initial examination is often the only time that a good neurologic examination can be performed. Confirming and documenting the function of nerves in the extremity can be of significant value in the patient's definitive management. Determining which parts (if any) are not receiving adequate perfusion will help guide emergent surgical treatment.

If there are significant skeletal injuries it may be of value to gently reposition the injured part(s) in near anatomic alignment. This alone can greatly improve the patients comfort and reduce the deforming forces on kinked or stretched neurovascular structures. A splint should be applied to maintain this alignment.

Amputated parts should be examined, cleaned with saline if necessary, and packaged for possible replantation. This should be done as follows:

1. Wrap the part in gauze moistened in normal saline.
2. Place the part in a plastic bag.
3. Place this bag into a container of ice.
4. NEVER place the part directly on ice, or use dry ice.
5. Parts which are nearly but not completely amputated should not be removed from the patient. Instead dress with gauze moistened in normal saline and splint them in a relatively normal position.

The decision to salvage an amputated or mangled part must be made by the treating surgeon. Under no circumstance should a physician who is not prepared to personally perform it indicate to a patient that re-implantation or revascularization could, should, or will be done. The sometimes difficult clinical decision should be made by the hand surgeon with expertise in the surgical management of these injuries. In some cases, formalization of an amputation may be the best or only reconstructive procedure available for a patient. If the patient or family perceive that re-implantation is indicated it is more difficult for them to accept when this turns out not to be the case.

Hand Injury Patients

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Hand Injury Patients

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Obstetric Patients

Priority One

Trauma with non-reassuring fetal heart tones

***ACOG: Category III FHR Tracing**

Involve on-site OB at local facility and trauma consultant at Level I or II receiving facility. If fetus can be delivered while awaiting proper transport and not compromising mother, consider emergent cesarean delivery.

1

Priority Two

Trauma with non-reassuring fetal heart tones

***ACOG: Category III FHR Tracing**

Involve on-site OB at local facility and trauma consultant at appropriate trauma receiving facility. If fetus can be delivered while awaiting proper transport and not compromising mother, consider emergent cesarean delivery.

2

Priority Three

Trauma with or without reassuring fetal heart tones

Requires fetal monitoring and/or cesarean delivery and should be kept at local hospital if labor delivery resources available or transferred to nearest facility with those resources.

3

Priority One & Two

Trauma with reassuring fetal heart tones

***ACOG: Category I FHR Tracing**

All Priority 1,2, Trauma with reassuring fetal heart tones should maintain fetal monitoring throughout transport process.

*American College of Obstetricians and Gynecologists (ACOG): Three-Tier Fetal Heart Rate (FHR) Interpretation System

Obstetric Patients

Three-Tier Fetal Heart Rate Interpretation System

Category I

Category I fetal heart rate (FHR) tracings include all of the following:

- Baseline rate: 110–160 beats per minute (bpm)
- Baseline FHR variability: moderate
- Late or variable decelerations: absent
- Early decelerations: present or absent
- Accelerations: present or absent

Category II

Category II FHR tracings include all FHR tracings not categorized as Category I or Category III. Category II tracings may represent an appreciable fraction of those encountered in clinical care. Examples of Category II FHR tracings include any of the following:

Baseline rate

- Bradycardia not accompanied by absent baseline variability
- Tachycardia

Baseline FHR variability

- Minimal baseline variability
- Absent baseline variability not accompanied by recurrent decelerations
- Marked baseline variability

Accelerations

- Absence of induced accelerations after fetal stimulation

Periodic or episodic decelerations

- Recurrent variable decelerations accompanied by minimal or moderate baseline variability
- Prolonged deceleration 2 minutes but 10 minutes
- Recurrent late decelerations with moderate baseline variability
- Variable decelerations with other characteristics, such as slow return to baseline, "overshoots," or "shoulders"

Category III

Category III FHR tracings include either:

- Absent baseline FHR variability and any of the following:
 - Recurrent late decelerations
 - Recurrent variable decelerations
 - Bradycardia
- Sinusoidal pattern

Obstetric Patients

Characteristics of Decelerations

Late Deceleration

- Visually apparent usually symmetrical gradual decrease and return of the fetal heart rate (FHR) associated with a uterine contraction.
- A gradual FHR decrease is defined as from the onset to the FHR nadir of 30 seconds.
- The decrease in FHR is calculated from the onset to the nadir of the deceleration.
- The deceleration is delayed in timing, with the nadir of the deceleration occurring after the peak of the contraction.
- In most cases, the onset, nadir, and recovery of the deceleration occur after the beginning, peak, and ending of the contraction, respectively.

Early Deceleration

- Visually apparent, usually symmetrical, gradual decrease and return of the FHR associated with a uterine contraction.
- A gradual FHR decrease is defined as one from the onset to the FHR nadir of 30 seconds.
- The decrease in FHR is calculated from the onset to the nadir of the deceleration.
- The nadir of the deceleration occurs at the same time as the peak of the contraction.
- In most cases the onset, nadir, and recovery of the deceleration are coincident with the beginning, peak, and ending of the contraction, respectively.

Variable Deceleration

- Visually apparent abrupt decrease in FHR.
- An abrupt FHR decrease is defined as from the onset of the deceleration to the beginning of the FHR nadir of 30 seconds. The decrease in FHR is calculated from the onset to the nadir of the deceleration.
- The decrease in FHR is 15 beats per minute, lasting 15 seconds, and 2 minutes in duration.
- When variable decelerations are associated with uterine contractions, their onset, depth, and duration commonly vary with successive uterine contractions.

Obstetric Patients

Stabilization

Stabilization of the Pregnant Patient

Maternal stabilization is the priority. After the mother is stabilized, attention is given to the fetus. It is important to recognize that a pregnant patient may lose 30-35% of her blood volume before a significant drop in blood pressure occurs. This is related to the increased plasma volume in pregnancy.

Medications, tests, treatments, and procedures required for the mother's stabilization should not be withheld because of pregnancy.

Position

If at all possible, any patient over 20 weeks gestation should be placed in the left lateral decubitus position to avoid hypotension secondary to inferior vena caval compression by the uterus. Ideally, place woman on her left side with her back angled 15-30° back from the left lateral position. If the patient is immobilized on a backboard, the board can be tilted to the left or the uterus can be displaced to the left by a wedge under her right side, if one is available. A patient with unstable BP and questionable c-spine status, not on a backboard, should be logrolled with neck stabilized or uterus can be displaced to the left.

Airway and Oxygen

To avoid fetal hypoxia, high concentration oxygen supplementation should generally be given. All critically ill patients, including the pregnant patient should be promptly intubated. For intubation, the following drugs are recommended:

Fentanyl (Sublimaze): This synthetic narcotic is protein bound, which may limit transplacental transfer. There is a low fetal-to-maternal blood level ratio limiting fetal side effects. Doses of 50-100 µg IV per hour have been safely used during labor. The only significant finding was a brief decrease in fetal heart rate variability. For these reasons, fentanyl may be preferable to other parenteral narcotics.¹⁰

Neuromuscular blockade (e.g., succinylcholine, curare, vecuronium, atracurium) can be used in conventional doses if indicated. Transplacental passage is insignificant at usual dose for intubation relaxation. It is important to remember that if a paralytic agent is used, that it crosses the placenta in a dose-dependent fashion and will cause fetal heart rate tracing to become non-reactive.

Obstetric Patients

Hypotension, IV Fluids

The diagnosis of hypotension in pregnancy is sometimes difficult to make due to physiologic lowering of BP by pregnancy. Assume that the pregnant patient with hypotension is markedly volume depleted.

Large bore IV's with crystalloid (e.g., Lactated Ringers) should be administered. Avoid large loads of D5 solutions IV, as should the fetus require delivery, this will cause problems with glucose regulation in the neonate. Pregnant women have increased fluid requirements, thus liberal amounts can be given as indicated.

Blood Transfusion

If the degree of urgency calls for emergency transfusion of un-crossmatched blood, group O Rh-negative blood should be used. This is done to prevent antibody development in Rh-negative mothers. Autologous transfusion (e.g., from chest tube) should be considered whenever possible. One set of goals is to transfuse blood and crystalloid to maintain hematocrit at 25-30% and urine output above 30 cc/hr.

Fetal and Uterine Monitoring

Fetal monitoring for a viable fetus should be instituted as soon as the mother's status allows, preferably in the emergency department, if possible. Fetal morbidity or mortality can occur in mothers without significant injury. Non-reassuring fetal heart tones may not be apparent during the initial evaluation and may be the 1st sign of impending maternal deterioration, especially shock. Continuous monitoring can be discontinued after 4 hours if there are no fetal heart rate abnormalities, uterine contractions, bleeding, and/or uterine tenderness.

The use of electronic fetal heart and uterine monitoring in pregnant trauma patients after 20 weeks gestation may detect placental abruption. Multiple studies have shown that placental abruption was not seen if there were <6 contractions per hour over a 4-hour period of observation, and no uterine tenderness. If the uterine activity was at a greater frequency, 20% of patients had placental abruption.

Several large studies have shown that warning signs of uterine tenderness, contractions, bleeding, or fetal heart rate abnormalities will be present within 4 hours after a trauma event in women who have gone on to have adverse trauma-related outcomes.

Obstetric Patients

Tetanus Booster

This is safe to give, if indicated.

Antibiotics

Commonly given antibiotics for open wounds are generally safe for pregnant women; e.g., cefazolin or if penicillin allergic, clindamycin.

Rh Factor

40% of trauma victims will have a fetal-maternal bleed. All Rh-negative trauma victims should be considered for 1 vial of RhIG. Even with a negative Kleihauer-Betke (K-B) test, these patients may become sensitized, as the test may not be sensitive enough to detect very small quantities of fetal blood.³ The use of additional RhIG should be discussed with an OB consultant and is based on initial and serial K-B tests. If fetal-maternal hemorrhage has occurred, delivery may be needed. Factors influencing that decision may be maturity of the fetus or evidence of fetal distress. Remember, Rh-positive mothers can also develop fetal-maternal hemorrhage.

Fetal Death

If the mother's condition is stable, a cesarean delivery is not required. Method and timing of delivery can be planned with OB consultant.

If a laparotomy will be performed anyway, OB consultant should be notified immediately. A cesarean delivery is probably still not indicated but might be if it is critical to prevent labor or vaginal delivery (e.g., pelvic fractures) or to control bleeding from uterine injury. An OB consultant will need to make these decisions.

Penetrating Trauma

Consider laparotomy on all gunshot wounds or stab wounds to the upper abdomen. Stabs to the lower abdomen can receive nonsurgical management if the mother and fetus are free of significant injury. Fetal status can be evaluated with monitoring, ultrasound, and amniocentesis by an OB consultant. Maternal status is evaluated with DPL, local wound exploration, serial hematocrits, urine for blood, and vital signs.

Obstetric Patients

Indications to Consider Cesarean Delivery

- control of maternal hemorrhage
- viable fetus in distress
- gunshot to abdomen with viable fetus
- amniocentesis showing bleeding or bacteria (secondary to nonsterile penetration).
- A perimortem cesarean delivery may be indicated for fetus considered to be viable. (see below)

If the fetus is dead and cesarean delivery is not otherwise indicated, vaginal delivery should be considered.

Trauma and the Pregnant Patient

Introduction

The Emergency Physician is usually the 1st physician to see the pregnant woman who has been the victim of a serious injury. Prompt, effective trauma care can significantly improve fetal and maternal outcomes.

Obstetric Patients

Prenatal Trauma Management

Vitals	
Position	Hypotension treatment and prophylaxis > 20 wks, left lateral decubitus
Hypotension	see treatments below IV fluids transfusion
Hypertension	criteria = >140 s, >90 d treat >160s, >110d
Fetal and Uterine Monitoring	> 20 weeks, initiate ASAP
	If unable to offer OB intervention, stabilize & arrange prompt transfer
vaginal bleed	Treat hypotension as above, OB consultation, Rh neg gets D immune globulin
LAB	
CBC	Low H&H
Type screen	Rh negative
Kleihauer-Betke on Rh-	
Coagulation profile	INR, PTT, fibrin degrad., fibrinogen, i-Coombs
Diagnostic imaging	
RADIATION EXPOSURE	Patient education
ordered for the same general indications as in non-pregnancy coordinate with radiologist; consider ultrasound to replace x-ray where possible Shield maternal abdomen and thyroid when possible	
Treatments <i>Medications listed are commonly recommended</i>	
IV fluids	Larger fluid requirements when hypotensive, avoid dextrose (D5) loads
O2	To avoid fetal hypoxia, high concentration O2
Intubation & RSI	Generally similar to non-pregnancy
Narcotics	fentanyl 50-100 µg IV per hour other narcotics OK in moderate doses as needed
Antiemetics	metoclopramide 5-10 mg IV or IM ondansetron 4-8 mg IV
Antibiotics	cefazolin 1 g IV clindamycin 600 mg IV Pen. Allergy
Transfusion	CMV antibody-neg leukocyte-reduced
D immune globulin Rh-	1 ampule (300 µg)
Tetanus	Td safe
BP >160s, >110d	Labetalol 10-20 mg IV bolus
Seizure	Eclamptic MgSO4 4-6 Gm IV load over 15-20 minutes Non-eclamptic lorazepam 1-2 mg/min IV
CPR ACLS >20 wks	left lateral decubitus no response after 4 minutes CPR, consider cesarean of viable fetus
Disposition	
Admission and Monitoring	4 hours fetal monitoring of potentially viable fetus
Discharge	Prompt follow up with OB

Obstetric Patients

Incidence

Trauma is a leading cause of mortality of pregnant and non-pregnant women in the world (1 million/year).^{1,2}

Physiologic Changes

Physiologic changes in pregnancy may affect the type of injury and the mother's response to trauma. Generally the mother's physiologic response is to maintain her own survival even if there are resultant adverse effects on the fetus.³

Pulse

Resting pulse increases 15-20 beats/min to an average pulse rate of 80-95 by the 3rd trimester. Pulse >100 is still a sensitive marker of shock. Also using orthostatic vital signs, pulse is a more sensitive indicator of hypovolemia.

BP

Blood pressure decreases to an average of 102/55 in the 2nd trimester, and increases in the 3rd trimester to an average of 108/67. After 20 weeks a significant drop in supine BP can occur, usually due to uterine compression of the inferior vena cava. Turning the patient to the lateral recumbent position may relieve these effects of compression. As a general rule this position should be the initial treatment for hypotension in pregnancy. Left or right lateral recumbent positions are nearly equivalent. Nonsupine or lateral recumbent hypotension appears to be a more sensitive indicator of shock than supine BP.

Cardiac Output

Increased

CVP

Central venous pressure in the gravid female is lower than in non-pregnant women. Serial measurements are helpful. A fluid challenge of 250 cc Normal Saline or Lactated Ringers should raise the CVP 2-4 cm H₂O in the normovolemic pregnant patient.

Blood Volume

Plasma volume increases by 50% between the late 1st trimester to the early 3rd trimester. This allows the patient to lose 30-35% of blood volume before there is a significant drop in blood pressure.

Obstetric Patients

Hct/Hgb

Dilutional physiologic anemia may lead to hematocrit in the low 30% range by the 30th week. This may lead to confusion regarding the existence of true blood loss. Whenever possible, comparison with recent hgb/hct values are extremely helpful as are serial hematocrits.

WBC

WBC counts up to 15,000 (due to an increase in polymorphonuclear cells) may be a normal response to pregnancy. During labor and the puerperium the normal count may reach 20,000 or higher. Calling counts above 14,000 physiologic should be a diagnosis of exclusion. Evaluate for other causes of elevated WBC. Also remember, this pattern may be seen secondary to the stress of trauma.

Coagulation

Pregnancy is a recognized hypercoagulable state. This leads to an increased risk of clot formation or DIC with certain trauma. Abdominal trauma may cause abruptio placenta or intrauterine death, leading to DIC. Average fibrinogen level in pregnancy is 450 mg/dl.

Respiratory

Functional residual volume is decreased. The apneic pregnant woman develops hypoxia more rapidly. PCO₂ is decreased to 30 with a compensatory drop in maternal serum CO₂ to allow a gradient for diffusion of fetal CO₂.

Gastro-intestinal

The abdominal wall may be less sensitive to peritoneal irritation due to stretching of the abdominal muscles from uterine growth. Significant intraabdominal injury may be present without significant symptoms or signs.

General intestinal relaxation with slow gastric emptying may lead to an increased risk of aspiration.

Serum alkaline phosphatase is elevated in normal pregnancy.

Genitourinary

There is an increased risk of bladder injury. This is due to the bladder rising out of the pelvis with uterine enlargement through its attachment to the lower uterine segment.

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Heart: Chest X-ray, ECG

Elevation of the diaphragm causes elevation and forward rotation of the heart. This causes the following chest x-ray and ECG changes. On x-ray, there is straightening of the left heart border and indentation of the esophagus. The heart appears artificially enlarged. On ECG, there may be left axis deviation up to 15°. Lead III may show flat or inverted T waves.

Mechanism of Injury

Significant trauma should be anticipated with any of the following mechanisms of injury or types of injuries. (In pregnant women significant trauma may occur even with lesser mechanism):

- falls of 20 feet or more
- auto crash at 40 MPH or more
- significant deformity of car
- rearward displacement of front axle
- passenger compartment intrusion
- ejection from car
- rollover
- death of an occupant in the same car
- pedestrian hit at > 5 MPH or more
- 2 or more femur or humerus fractures
- combination of burns >14% body surface
- burns to the face or airway
- flail chest
- penetrating injuries to body except for extremities distal to elbow, knee
- pelvis fracture

Events Preceding Accident

Evaluate for possible pregnancy related cause of accident, e.g., seizure secondary to eclampsia in a 3rd trimester patient.

Diagnostic Tests

Medications, tests, treatments, and procedures required for the mother's stabilization should not be withheld because of pregnancy.

Lab Tests

Basic trauma lab can include CBC, chemistries, PT-PTT, drug screens, type &

Obstetric Patients

cross, Rh status and antibody test (indirect Coombs test) and urinalysis. The Kleihauer-Betke test for fetal-maternal hemorrhage has not been shown to predict adverse immediate injury or sequelae due to hemorrhage.⁴ Among women exhibiting signs of traumatic fetal-maternal hemorrhage, the average fetal to maternal transfusion is less than 15ml. 90% of the time the fetal to maternal transfusion is less than 30ml.⁴ Thus, 1 ampule (300 µg) of D immune globulin (e.g., RhoGAM®) will protect nearly all D-negative (Rh negative) trauma patients from Rh sensitization and should be given within a 72 hour period from the time of the accident. Therefore, the K-B test should not be routinely used for all trauma patients, but reserved for those **Rh-negative patients** whose exam is suggestive of severe trauma in which the K-B test may guide in the amount of D immune globulin to be given.

If placental trauma or abruption is suspected, a coagulation profile (fibrinogen and fibrin degradation products) should be added to the PT-PTT recommended above.

Peritoneal Lavage

Diagnostic peritoneal lavage (DPL) is 1 preferred method for evaluating intra-abdominal trauma for laparotomy. High suspicion should be maintained for intraabdominal trauma even with a benign belly exam since the pregnant abdominal wall is less likely to show signs of peritoneal irritability. The procedure should be an open peritoneal lavage (OPL). OPL is not necessary if there is **obvious** clinical evidence of intraperitoneal bleeding. Some indications for OPL include: abdominal signs or symptoms suggesting intraperitoneal bleeding, altered sensorium, unexplained shock, major thoracic injuries, multiple major orthopedic injuries. If the pelvis is fractured, DPL should be done through supraumbilical approach to avoid a false positive test from a hematoma. In general, abdominal gunshot wounds are managed by exploratory laparotomy. However, laparotomy can be used selectively.⁵

Culdocentesis

This procedure has been used to evaluate possible intra-abdominal bleed. Use beyond the 1st trimester is not recommended, and in general, its use in the pregnant trauma patient is controversial and difficult due to the uterus filling the pelvis. DPL is preferred to this method.

Radiography - CT Scanning

See the discussion of Radiation Exposure in Pregnancy in this section. Generally,

Obstetric Patients

a complete trauma exam with CT scanning will not approach levels that will adversely affect the fetus. If possible, fetal exposure to

ionizing radiation should be minimized by shielding of the uterus-abdomen with a lead apron. However, diagnostic techniques to evaluate potentially serious traumatic injury to the mother should not be withheld for fetal concerns.

CT scanning appears to be the best noninvasive method for evaluating certain internal injuries. Examples of its use include:

1. Head – CT scan is the study of choice in head trauma.
2. Aorta - Dynamic CT scan can be used to diagnose a ruptured thoracic aorta in a stable patient. Many experts prefer angiography. Unstable patients require immediate surgery rather than either diagnostic study.
3. Abdomen – CT scan is excellent for intra-abdominal trauma. DPL and ultrasound are alternatives. Consult your trauma specialist and radiologist as to which study is preferred for your individual patient.

IVP and Cysto-urethrogram

This has the same indications as in non-pregnancy. For the IVP, usually a limited study may be all that is needed. CT of abdomen and pelvis and CT cystogram generally provide better information.

RADIATION EXPOSURE

Occasionally a woman who is unaware of being pregnant will be x-rayed. There are several units for measuring radiation, mrad will be the unit used in this section. Summary of other units commonly seen is found at the end of this section.

Incidence

A high percent of pregnant women appearing in the emergency department will require radiography.

Indications

X-rays in pregnant women should be ordered for the same general indications as in non-pregnancy. However, abdominal shielding should be ordered to protect the fetus when feasible. Women need to be reassured as to the safety of usual x-ray studies.

Obstetric Patients

Reducing Exposures

Inform your radiologists that patient is pregnant. They may have suggestions on alternate studies. If appropriate, do the alternative studies. However, do not fail to do the necessary radiological studies because the patient is pregnant.

1. Use abdominal shielding as study allows.
2. Use ultrasound when study will provide data that allows for proper patient care (e.g., kidney stones).
3. Use Tc-sulfur colloid rather than Tc-DTPA for ventilation scans.
4. Avoid iodine containing radioactive isotopes – contraindicated in pregnancy.
5. Avoid repeat exams and use contrast media with caution.
 - a. Consideration should be given to minimizing x-rays that have not been shown to significantly alter patient care. Examples³:
 - Skull x-rays are rarely helpful. If studies are needed, consider CT brain.
 - LS strain from exertional injuries rarely yields positive LS spine.
 - Mid chest single rib injuries are usually adequately evaluated by a PA-lateral chest rather than rib detail series.
 - KUB is rarely helpful for nonspecific abdominal pain or tenderness. It is helpful in looking for free air or ileus when clinically indicated. Ultrasound is preferable for gallstones and possibly for kidney stones.

Consultants

If the patient is unusually concerned about the x-ray exposures that she received, despite your explanations, you can refer her to your genetic counseling resource.

Informed Consent

If the estimated dose is greater than 5,000 mrad (such as with repeated CT and longer fluoroscopy), consider having a physicist formally calculate the dose, and documenting on the chart, the opinions of the radiologist, the physician who referred the patient for the test, and the physicist. The patient then would be given an informed consent form to sign that notes her understanding of “increased risk” to the fetus. Of course, in the acute care setting (e.g., emergency department) when the patient's life may be at risk, such consent is often not feasible.

Obstetric Patients

Risk to Fetus^{6, 7}

Significant radiation around the time of implantation can lead to loss of the pregnancy. Potential for damage begins at radiological doses above 10,000 mrad. This represents a massive dose of radiation and is usually an all or nothing phenomenon, leading to loss of the pregnancy or no obvious consequences whatsoever.

Neurologic teratogenicity can potentially manifest at a threshold exposure of 10,000-50,000 mrad. These appear most commonly as microcephaly, mental retardation, and eye malformations; neural tube and bony anomalies have been reported. Irreversible intrauterine growth retardation can occur with doses starting at 25,000 mrad. Exposures at less than 5,000 mrad (50 mGy) appear to be safe for the developing fetus and are considered to be safe by both American College of Obstetrics and Gynecology as well as the American College of Radiology.⁸

Remember, most radiographic studies are below 5,000 mrad.

Obstetric Patients

Examples of common radiological exams and the fetal exposure associated with each of them⁸:

Exam	Dosage, mGy	Number of maternal exams that could hypothetically be performed and still be <50 mGy
Cervical spine (AP and lat)	<0.001	50,000
Chest (PA and lat)	<0.001	50,000
Abdomen	1–3	16–50
IVP	6	8
CT head	0	Very large
CT chest	0.2	250
CT angiogram coronaries	0.1	500
CT abdomen	4	12
CT abdomen and pelvis	25	2
CT angiogram of aorta (chest through pelvis)	34	1

These are exposures in an unshielded patient. Always shield your patient whenever possible. Even in a multi-trauma patient receiving multiple x-ray studies, the total fetal radiation exposure would rarely exceed a safe level.

Risk to Newborn

In late pregnancy high radiation doses could theoretically lead to sterility. A possible increased risk for childhood leukemia and adult cancer exists. The full genetic risks are not clear.

Obstetric Patients

Amniocentesis

Under some circumstances, amniocentesis may be needed during the 3rd trimester if maternal and fetal condition allows. Bloody fluid might represent placental abruption or fetal injury, while meconium might suggest non-reassuring fetal heart tones. When appropriate, the decision about doing this and the procedure is best left to the OB consultant.

Ultrasound

Ultrasound has a role in some patient evaluations. FAST scan (Focused Assessment with Sonography for Trauma) is a safe, rapid method to identify intraabdominal free fluid.^{9, 10} When available in this setting, ultrasound may be the most effective and efficient tool and can replace DPL and/or culdocentesis in trauma. OB ultrasound is best coordinated with an OB consultant.

Management

This section will not go into the overall details of trauma management, but will focus on aspects that are unique to the pregnant trauma victim. Advanced Trauma Life Support principles should be reviewed for an overall approach to the trauma patient.

Maternal stabilization is the priority. After the mother is stabilized, attention is given to the fetus. It is important to recognize that a pregnant patient may lose 30-35% of her blood volume before a significant drop in blood pressure occurs. This is related to the increased plasma volume in pregnancy.

Medications, tests, treatments, and procedures required for the mother's stabilization should not be withheld because of pregnancy.

Position

If at all possible, any patient over 20 weeks gestation should be placed in the left lateral decubitus position to avoid hypotension secondary to inferior vena caval compression by the uterus. Ideally, place woman on her left side with her back angled 15-30° back from the left lateral position. If the patient is immobilized on a backboard, the board can be tilted to the left or the uterus can be displaced to the left by a wedge under her right side, if one is available. A patient with unstable BP and questionable c-spine status, not on a backboard, should be logrolled with neck stabilized or uterus can be displaced to the left.

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Airway and Oxygen

To avoid fetal hypoxia, high concentration oxygen supplementation should be given. Physiological changes of pregnancy already cause increase oxygen demands and decrease oxygen reserve thus limiting the pregnant woman's ability to compensate during prolonged or unsuccessful intubation attempts.

Risk of gastric aspiration is increased due to anatomical shifting of the GI tract, increase in gastric acid secretion and decrease in motility. Pregnant women who aspirate have a higher mortality.

Intubation ¹¹

In the emergency setting, intubation can be a difficult procedure. Pregnant women have been shown to be more difficult to intubate than non-pregnant patients. Anoxia thus becomes a major risk for both the fetus and the mother. Whenever possible consideration should be given to avoiding situations requiring intubation e.g., the use of regional rather than general anesthesia for cesarean delivery.

Failed intubation is the cause of approximately 2 maternal deaths in the U.S. for every million births.

Failed intubations in obstetric population occur approximately 10 times more frequently than in the general surgical population.

In compromised respiratory settings, pregnant women have an increased tendency to develop rapid hypoxemia from:

1. Elevated hemidiaphragm
2. Obesity
3. Decreased expiratory reserve volume
4. Early airway closure in the supine position
5. Increased oxygen consumption throughout pregnancy and more so in 3rd trimester
6. Higher potential for regurgitation of gastric contents and aspiration

Anatomical and physiological changes of pregnancy that lead to increased intubation difficulty:

1. Laryngeal edema from water retention
2. Lingual and nasal mucosa swelling due to capillary engorgement
3. Increased facial adipose tissue affecting space for maneuvering

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- laryngoscope handle
4. Increased abdominal contents that elevate the diaphragm leading to anterior shifting of larynx
5. Pre-pregnancy anatomical findings leading to difficult intubation
6. Inability to visualize most of uvula (except base)
7. Inability to visualize soft palate
8. Short neck
9. Protruding maxillary incisors
10. Morbid obesity (>300 lbs). Mask ventilation may also be difficult in these patients due to increased intra-abdominal pressure and low chest compliance.⁵

Procedure should be similar to non-pregnancy. Unsuccessful intubation must be immediately recognized. Continuous pulse oximetry and carbon dioxide exhalation monitoring are extremely helpful. Options when encountering unsuccessful intubation until arrival of anesthesiologist or specialist skilled at fiberoptic intubation include:

Ventilate with 100% oxygen via mask.

1. Maintain cricoid pressure to minimize potential for gastric regurgitation and assist with intubation.
2. Avoid repeated intubation attempts that can lead to significant airway trauma with further edema.
3. If mask ventilation is inadequate, consider laryngeal mask airway.¹³
4. Next, consider an artificial airway, e.g., cricothyroidotomy with 12- to 14-gauge kink-resistant over-the-needle plastic catheter and transtracheal jet ventilation.

Neuromuscular blockade (e.g., succinylcholine, vecuronium, atracurium) can be used in conventional doses if indicated. Transplacental passage is insignificant at usual dose for intubation relaxation. It is important to remember that if a paralytic agent is used, that it crosses the placenta in a dose-dependent fashion and will cause fetal heart rate tracing to become non-reactive. Induction agents such as thiopental, propofol and etomidate appear to have a positive benefit vs. risk when used in the critical setting for pregnant women. Consider reviewing this with your OB anesthesiology and perinatal consultants.

Succinylcholine at 2-3 mg/kg appears safe. Massive doses (10 mg/kg) can lead to neonatal depression. Some pregnant women may have reduced

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pseudocholinesterase levels leading to prolonged depression. It is best to be sure neuromuscular function is returning before giving repeat doses.

With vecuronium, when used for rapid-sequence intubation, using a priming dose of 0.01 mg/kg followed 4-6 min later by the remainder of the dose had less effect on the fetus than giving it initially as a single bolus.¹⁴

Fentanyl® 100 µg IV may be helpful in patients requiring relaxation with assisted ventilation.

Anesthesiologist: early consultation for patients at high risk for general anesthesia to allow for earlier decision making and better coordination between OB and anesthesiologist.

Hypotension, IV Fluids

The diagnosis of hypotension in pregnancy is sometimes difficult to make due to physiologic lowering of BP by pregnancy.

See discussion on left lateral decubitus **position** earlier in this document. Large bore IV's with crystalloid (e.g., Lactated Ringers, NS) should be administered. Avoid large loads of D5 solutions IV, as should the fetus require delivery, this will cause problems with glucose regulation in the neonate. Pregnant women have increased fluid requirements, thus liberal amounts can be given as indicated. Also, a pregnant patient with hypotension is markedly volume depleted.

Blood Transfusion

If the degree of urgency calls for emergency transfusion of un-crossmatched blood, group O Rh-negative blood should be used. This is done to prevent antibody development in Rh-negative mothers. Autologous transfusion (e.g., from chest tube) should be considered whenever possible. One set of goals is to transfuse blood and crystalloid to maintain hematocrit at 25-30% and urine output above 30 cc/hr.

CMV is a concern with blood transfusion. Based on screened blood donors for antibody to CMV, more than 40% of healthy donors may have the potential to transmit CMV. The safest approach may be to use CMV antibody-negative products. If these are unavailable, use leukocyte-reduced products, because CMV is transmitted only by leukocytes. It is unclear which product provides the best protection against transfusion-associated CMV infection.¹⁵

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Fetal and Uterine Monitoring

Fetal monitoring for a viable fetus should be instituted as soon as the mother's status allows, preferably in the emergency department, if possible. Fetal morbidity or mortality can occur in mothers without significant injury. Non-reassuring fetal heart tones may not be apparent during the initial evaluation and may be the 1st sign of impending maternal deterioration, especially shock. Continuous monitoring can be discontinued after 4 hours if there are no fetal heart rate abnormalities, uterine contractions, bleeding, and/or uterine tenderness.

The use of electronic fetal heart and uterine monitoring in pregnant trauma patients after 20 weeks gestation may detect placental abruption. Multiple studies have shown that placental abruption was not seen if there were <6 contractions per hour over a 4-hour period of observation, and no uterine tenderness. If the uterine activity was at a greater frequency, 20% of patients had placental abruption.

Several large studies have shown that warning signs of uterine tenderness, contractions, bleeding, or fetal heart rate abnormalities will be present within 4 hours after a trauma event in women who have gone on to have adverse trauma-related outcomes.

Tetanus Booster

This is safe to give, if indicated.

Antibiotics

Commonly given antibiotics for open wounds are generally safe for pregnant women; e.g., cefazolin, ceftriaxone; or if penicillin allergic, clindamycin.

Nasogastric Tube and Foley Catheter

Use as indicated.

Anesthesia

There are no problems with local anesthesia. With general anesthesia, it may be preferable to avoid agents that increase uterine tone. Inhaled agents typically induce uterine relaxation.

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Analgesia

Narcotics can be used. Caution should be exercised in the 1st trimester because of possible teratogenicity; however, there is no definite relationship of teratogenicity with the usual narcotic agents. Fetal depression should be considered in the 2nd and 3rd trimesters. Analgesic medications may make the interpretation of FHR monitor strips more difficult.

Fentanyl: This synthetic narcotic is protein bound, which may limit transplacental transfer. There is a low fetal-to-maternal blood level ratio limiting fetal side effects. Doses of 50-100 µg IV 1 hour have been safely used during labor. The only significant finding was a brief decrease in fetal heart rate variability. For these reasons, fentanyl may be preferable to other parenteral narcotics.¹⁰

Rh Factor

40% of trauma victims will have a fetal-maternal bleed. All Rh-negative trauma victims should be considered for 1 vial of RhIG. Even with a negative Kleihauer-Betke (K-B) test, these patients may become sensitized, as the test may not be sensitive enough to detect very small quantities of fetal blood.³ The use of additional RhIG should be discussed with an OB consultant and is based on initial and serial K-B tests. If fetal-maternal hemorrhage has occurred, delivery may be needed. Factors influencing that decision may be maturity of the fetus or evidence of non-reassuring fetal heart tones. Remember, Rh-positive mothers can also develop fetal-maternal hemorrhage.

Fetal Death

If the mother's condition is stable, a cesarean delivery is not required. Method and timing of delivery can be planned with OB consultant. If a laparotomy will be performed anyway, OB consultant should be notified immediately. A cesarean delivery is probably still not indicated but might be if it is critical to prevent labor or vaginal delivery (e.g., pelvic fractures) or to control bleeding from uterine injury. An OB consultant will need to make these decisions.

Penetrating Trauma

Consider laparotomy on all gunshot wounds or stab wounds to the upper abdomen. Stabs to the lower abdomen can receive nonsurgical management if the mother and fetus are free of significant injury. Fetal status can be evaluated with monitoring, ultrasound, and amniocentesis by an OB consultant. Maternal status is evaluated with DPL, local wound exploration, serial hematocrits, urine for blood, and vital signs.

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Indications to Consider Cesarean Delivery

- Control of maternal hemorrhage
- Viable fetus with non-reassuring fetal heart tones
- Gunshot to abdomen with viable fetus
- Amniocentesis showing bleeding or bacteria (secondary to nonsterile penetration).
- A peri mortem cesarean delivery may be indicated for fetus considered to be viable. (See below)

If a small uterine wound is present and delivery is not otherwise indicated, a less than 36-week pregnancy can receive uterine repair with delay of delivery until 36 weeks.

If the fetus is dead and cesarean delivery is not otherwise indicated, vaginal delivery should be considered.

Maternal Arrest or Death

Consider immediate cesarean delivery for a viable fetus in any patient who cannot be resuscitated as described below under CPR Summary. Immediate cesarean delivery should be considered in those cases of a brain dead mother with intact cardiovascular system if there is any evidence of non-reassuring fetal heart tones. Consider maintaining life support management until the fetus is at an acceptable level of maturity for delivery. It is usually preferable to allow the fetus to remain in utero based on maturity and evidence of non-reassuring fetal heart tones.

CPR ACLS Summary

Effective CPR is difficult in the near term pregnant woman because of limited ability to perform chest compressions and displace the uterus.

Summary of CPR in pregnant patients over 20 weeks gestation

Before starting compressions, do one of the following:

1. Place the woman on her left side with her back angled 15-30 degrees back from the left lateral position.
2. Place wedge under her right side so she is tilted to the left.
3. Have one rescuer kneel to women's left side and pull gravid uterus laterally to relieve pressure on inferior vena cava.
4. Defibrillation as in non-pregnant patient. No significant electrical shock is transferred to fetus. Remove fetal or uterine monitors prior to shock.

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5. Establish advanced airway early with C-spine stabilized. Goal is to minimize risk of aspiration while establishing controlled airway.
6. Airway edema and swelling in pregnant woman may require slightly smaller ET tube.
7. Rapid sequence intubation (RSI) with continuous cricoid pressure is preferred technique.
8. Neuromuscular blockade (e.g., succinylcholine, vecuronium, atracurium) can be used in conventional doses if indicated. See discussion earlier.
9. Breathing: no modification of confirmation of tube placement. Note that the esophageal detector device may suggest esophageal placement despite correct endotracheal placement.
10. Ventilation volumes may need to be reduced because of elevated diaphragm.
11. Closed-chest compressions: 100 per minute using 30:2 ratio with ventilations.
12. At least 2 large bore IV lines with Lactated Ringers or blood as indicated. Avoid femoral or other lower extremity lines as drugs given via these sites may not reach maternal heart while fetus remains in-utero.
13. Advanced Cardiac Life Support (ACLS) drugs as indicated.
14. Treat any apparent injuries that might be compromising resuscitation, e.g. pneumo or hemothorax, external hemorrhaging, pericardial tamponade.
15. If no maternal response occurs after 4 minutes of CPR, fluid, and drug therapy, immediate cesarean delivery should be performed in ED by qualified physician, with proper support and resources, who has as determined viability of fetus. This is particularly applicable if mother is in pulseless electrical activity. Thoracotomy and open cardiac massage should also be considered at this time if the patient or fetus is believed to be salvageable.
16. Gestational age ≥ 24 weeks: attempt to save live of both mother and fetus.
17. Gestational age 20-23 weeks: primary attempt to save life of mother by improving aortocaval blood flow and cardiac output. Fetal survival is unlikely at this age.
18. Gestational age < 20 weeks: urgent cesarean delivery generally unnecessary as aortocaval compromise unlikely.
19. Assessment of fetal heart tones should be done throughout procedure as allowed by circumstances.

Admission and Monitoring

Viable Fetus

Viability is generally assumed in patients who are well into the 2nd trimester or beyond (usually about 24-26 weeks with accurate dates). Check with an OB consultant for recommended gestational age of viability. Remember, dates may be inaccurate. When in doubt, it is best to presume viability.

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Fetal monitoring should be instituted as soon as the mother's status allows. Fetal morbidity or mortality can occur in mothers without significant injury. Non-reassuring fetal heart tones may not be apparent during the initial evaluation, but should abruptio placentae occur, it would do so generally by 24 hours. However, this can be effectively screened for by 4 hours of fetal monitoring of the potentially viable fetus.

Admission for non-obstetric indications should be the same as in a non-pregnant patient.

Risks to Mother

- Vaginal bleeding: rule out placenta previa. Other possibilities are placental abruption, vasa previa, fetal trauma, uterine rupture, and preterm labor.
- Preterm rupture of membranes.
- Placental abruption.
- Pelvic fractures: There is increased hemorrhage risk due to increased pelvic vascularity and venous pressure. There is an increased risk for abruption. There is a risk of fetal head or other injury. Vaginal delivery may be compromised.

Risks to Fetus

- There is a risk of fetal death (see discussion earlier on Fetal Death)
- Direct trauma can lead to fractures especially skull, clavicles, and long bones. Head injuries may also include intracranial hemorrhages.
- Indirect injury is generally due to fetal hypoxia secondary to: maternal hypotension, fetal hemorrhage, placental abruption or other injury, cord injury, uterine injury.
- Other risks include spontaneous abortion, preterm delivery, and RBC sensitization

Referrals

Prenatal patients involved in significant trauma should be considered for consultation by a trauma team that may include any or all of the following specialists: Emergency Physician, Trauma Surgeon, Obstetrician, Maternal Fetal Medicine specialist, Neonatologist, Pediatrician, Pediatric Surgeon, and Anesthesiologist, depending on the trauma and community.

Strongly consider immediate OB consult for any of the following:

- Vaginal bleeding
- Uterine irritability or tenderness
- Abnormal fetal heart tones
- Abdominal pain
- Any respiratory or hemodynamic instability

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If mother and baby are stable, then OB consultation should be obtained as soon as possible. Under certain circumstances, the consultant may recommend patient can be followed up as outpatient. Arrange a prompt, definitive appointment and give patient education.

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