Resident Manual of Trauma to the Face, Head, and Neck

First Edition

AMERICAN ACADEMY OF OTOLARYNGOLOGY–HEAD AND NECK SURGERY
FOUNDATION

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Preface

The surgical care of trauma to the face, head, and neck that is an integral part of the modern practice of otolaryngology–head and neck surgery has its origins in the early formation of the specialty over 100 years ago. Initially a combined specialty of eye, ear, nose, and throat (EENT), these early practitioners began to understand the inter-relations between neurological, osseous, and vascular pathology due to traumatic injuries. It also was very helpful to be able to treat eye as well as facial and neck trauma at that time.

Over the past century technological advances have revolutionized the diagnosis and treatment of trauma to the face, head, and neck—angiography, operating microscope, sophisticated bone drills, endoscopy, safer anesthesia, engineered instrumentation, and reconstructive materials, to name a few. As a resident physician in this specialty, you are aided in the care of trauma patients by these advances, for which we owe a great deal to our colleagues who have preceded us. Additionally, it has only been in the last 30–40 years that the separation of ophthalmology and otolaryngology has become complete, although there remains a strong tradition of clinical collegiality.

As with other surgical disciplines, significant advances in facial, head, and neck trauma care have occurred as a result of military conflict, where large numbers of combat-wounded patients require ingenuity, inspiration, and clinical experimentation to devise better ways to repair and reconstruct severe wounds. In good part, many of these same advances can be applied to the treatment of other, more civilian pathologies, including the conduct of head and neck oncologic surgery, facial plastic and reconstructive surgery, and otologic surgery. We are indebted to a great many otolaryngologists, such as Dr. John Conley's skills from World War II, who brought such surgical advances from previous wars back to our discipline to better care for patients in the civilian population. Many of the authors of this manual have served in Iraq and/or Afghanistan in a combat surgeon role, and their experiences are being passed on to you.

So why develop a manual for resident physicians on the urgent and emergent care of traumatic injuries to the face, head, and neck? Usually the first responders to an academic medical center emergency department for evaluation of trauma patients with face, head, and neck injuries will be the otolaryngology–head and neck surgery residents. Because there is often a need for urgent evaluation and treatment—bleeding and airway obstruction—there is often little time for the resident to peruse a reference or comprehensive textbook on such trauma. Thus, a simple, concise, and easily accessible source of diagnostic and therapeutic guidelines for the examining/treating resident was felt to be an important tool, both educationally and clinically.

This reference guide for residents was developed by a task force of the American Academy of Otolaryngology—Head and Neck Surgery (AAO-HNS) Committee on Trauma. AAO-HNS recently established this standing committee to support the continued tradition of otolaryngology–head and neck surgery in the care of trauma patients. An electronic, Portable Document Format (PDF), suitable for downloading to a smart phone, was chosen for this manual to facilitate its practical use by the resident physician in the emergency department and preoperative area.

It should be used as a quick-reference tool in the evaluation of a trauma patient and in the planning of the surgical repair and/or reconstruction. This manual supplements, but does not replace, more comprehensive bodies of literature in the field. Use this manual well and often in the care of your patients.

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Acknowledgments

This quick reference guide for resident physicians in trauma management reflects the efforts of many individuals in the American Academy of Otolaryngology—Head and Neck Surgery and a special task force of the AAO-HNS Committee on Trauma.

The editors would like to thank all of the authors who generously gave their time and expertise to compose excellent chapters for this Resident Manual in the face of busy clinical and academic responsibilities and under a very narrow timeframe of production. These authors, experts in the care of patients who have sustained trauma to the face, head, and neck, have produced practical chapters that will guide resident physicians in their assessment and management of such trauma. The authors have a wide range of clinical expertise in trauma management, gained through community and military experience.

A very special appreciation is extended to Audrey Shively, MSHSE, MCHES, CCMEP, Director, Education, of the AAO-HNS Foundation, for her unwavering efforts on behalf of this project, and her competent and patient management of the mechanics of the Resident Manual's production. Additionally, this manual could not have been produced without the expert copyediting and design of diverse educational chapters into a cohesive, concise, and practical format by Joan O'Callaghan, Director, Communications Collective, of Bethesda, Maryland.

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Since it takes a group of dedicated professionals to produce an educational and clinical manual such as this, all have shared in the effort, and each individual's contribution has been outstanding.

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Chapter 2: General Principles in Treating Facial, Head, and Neck Trauma

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Understanding the general principles of trauma repair in the face, head, and neck region is very important to achieving optimal outcome for the patient. Foundational is the knowledge of mechanisms of injury, tissue damage, and implications for surgical repair, based on the etiology of the trauma. Concomitant injuries of associated structures, such as the brain, spinal cord, and soft tissues, require a comprehensive knowledge of the anatomy, functional physiology, and potential risks and complications. These general principles will be reinforced in the subsequent sections of this Resident Manual for emphasis.

I. Special Mechanisms of Injury

A. GUNSHOT WOUNDS

1. Ballistic Sequences

Ballistics can be divided into three sequences:

- *Internal ballistics*—What happens between the cartridge being fired and the projectile leaving the muzzle.
- *External ballistics*—The flight of the projectile from the muzzle to the target.
- *Terminal ballistics*—What happens after the target is struck.

2. Main Factors Affecting Projectile Strike

Terminal ballistics determine the wounding capacity of a bullet. The effect of projectile strike depends on three main factors:

- *Kinetic energy* of the projectile [$KE = \frac{1}{2}(mv^2)$].
- *Projectile design*—e.g., composition, shape, jacket, weight distribution.
- *Target tissue* composition and elasticity.

a. Kinetic Energy

Low-energy projectiles from handguns or .22-caliber rifles have a muzzle velocity of <2000 feet per second (fps). High-energy projectiles from military assault rifles have a muzzle velocity of >2000 fps. These are jacketed with copper or polymer to hold the projectile together, as the lead begins to melt from heat generated at speeds >2000 fps (Table 2.1).

Table 2.1. Caliber, Muzzle Velocity, and Energy of Commonly Used Weapons

Caliber	Muzzle Velocity	Energy (ft-lb)
.32	745	140
.357	1410	540
.38	855	255
.44	1470	1150
.45	1850	390
9 mm	935	345
.243 Winchester	3500	1725
M16 (.223 cal or 5.56 mm)	3650	1185
7.62 Nato rounds	2850	1535
AK47	3770	1735

ft-lb = foot-pounds; mm = millimeter.

b. Projectile Design

i. Projectile Characteristics Influencing Energy Transfer

All projectiles passing through soft tissue create a permanent cavity, or tract, that is generally apparent on initial examination. If a bullet destabilizes upon contact with tissue, it deforms, yaws, tumbles, or fragments, causing greater tissue destruction (Figure 2.1). Thus, exit wounds tend to be larger than entry wounds. Tissue damage is proportional to the energy transferred to the tissues. The energy transfer is influenced by four projectile characteristics:

- *Yaw*—The deviation of the projectile in its longitudinal axis.
- *Tumble*—The forward rotation around the center of mass.
- *Deformation* of the projectile.
- *Fragmentation* of the projectile.

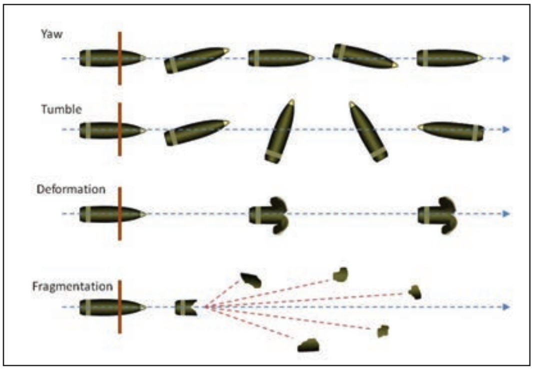

Figure 2.1

Four characteristics of projectile missiles.

ii. High-Energy Projectiles

High-energy projectiles also create a temporary cavity that may not be apparent on initial exam. The temporary cavity is produced as the energy wave of the projectile displaces surrounding tissue, which rapidly collapses back into place. The higher the energy of the projectile, the larger the temporary cavity created.

A previously held concept suggested tissue that is displaced in this fashion is disrupted and irreversibly damaged. Hunt et al. note that post-injury observation of wounds with a temporary cavity in an animal model demonstrates that the momentary stretch produced does not usually cause cell death or tissue destruction. Although vasospasm or cautery from the heat of the projectile may cause reversible ischemia, they suggest that debridement of high-velocity injuries should be confined to obviously devitalized tissue.

iii. Multiple Projectiles

Shotguns fired at close range (<40 feet) cause massive tissue destruction from multiple, rapidly destabilized pellets. Embedded wadding may be found in the wound if the shot was within 10–15 feet.

c. Target Tissue Composition and Elasticity

Tissues of higher density (e.g., muscle or liver) present greater mass to a projectile and absorb more energy from a projectile. Tissues of lower elasticity (e.g., bone or cartilage) resist deformation and will absorb energy until they fracture. The actual destruction of the permanent cavity and stretch caused by the temporary cavity are better tolerated by more elastic tissues, such as the lung, as opposed to a more rigid tissue, like bone.

B. BLAST INJURIES

1. Mechanisms for Causing and Types of Blast injury

Explosions produce seven potential mechanisms for causing physical injury, which vary in degree by type of explosive, proximity of victim to the blast, and additional factors affecting exposure (e.g., body armor, enclosed space):

- Interaction of the blast pressure wave with the body/organs.
- Acoustic energy causing hearing loss.
- Light energy causing blindness.
- Thermal energy causing burns.
- Energized debris/shrapnel.
- Release of toxic gases.
- Psychological effect—*Do not overlook.*

As shown in Table 2.2, blast injuries are commonly grouped into four types. Table 2.2 also presents the mechanisms related to those types of injuries.

Table 2.2. Types of Blast Injury and Mechanisms for Causing Those Injuries

Types	Mechanisms for Causing Injury
Primary	Interaction of the blast wave with the body.
Secondary	Debris (shrapnel) accelerated by the blast striking the body.
Tertiary	Physical displacement of the body by the blast wind.
Quaternary	All other effects of exposure to the blast (e.g., psychological or burns).

a. Primary Blast Injury
Tissue damage from the blast wave, referred to as primary blast injury, can cause occult trauma to the ocular, aural, pulmonary, cardiovascular, musculoskeletal, and neurologic systems. Awareness of the type of blast and circumstances is key to understanding the pathophysiology and making early diagnoses.

b. Auditory Blast Injury
Kerr reported that the tympanic membrane will rupture at overpressures as low as 35 kilopascals (kPa), and half the damaged tympanic membrane will have ruptured by the time the overpressure reaches 104 kPa. However, this correlates poorly with blast injury elsewhere, and is of no use as a predictive marker. Leibovici and colleagues report nearly 650 survivors of explosion exposure, 193 of whom had evidence of blast injury. Three-quarters had isolated eardrum rupture—none subsequently had other blast injuries, whereas nearly 10 percent of cases had pulmonary blast injury with intact tympanic membranes.

c. External Blast Wave Injury
Explosions in enclosed spaces, or external blast waves that enter an enclosed space, can dramatically increase the energy, as the reflected blast wave combines with the incident wave to increase the magnitude of the overpressure.

II. Traumatic Brain Injuries

A. CLOSED HEAD INJURIES

Classification of severe head injury may be based upon clinical, radiological, or anatomical findings. Mild traumatic brain injury (TBI) is the medical term for concussion, and the terms are often used interchangeably. The term "mild" does not describe the symptoms; rather, it describes the injury sustained. The 2009 Veterans Administration-Department of Defense clinical practice guidelines (CPGs) are currently the highest-rated mild TBI CPG. All patients with a moderate or severe head injury require a head computed tomography (CT) scan.

1. Classification by Presenting Signs and Symptoms

Table 2.3 presents a system of classification by presenting signs and symptoms.

Table 2.3. Classification by Presenting Signs and Symptoms

Injury Severity	Glasgow Coma Scale	Loss of Consciousness	Neurological Deficit
Minimal	15	No	No
Mild	14–15	<5 minutes	No
Moderate	9–13	>5 minutes	Yes

2. Classification by CT Findings

The CT classification (Marshall Scale) was developed from the data accumulated from the National Institutes of Health Traumatic Coma Data Bank. It was the first to highlight the poor outcomes associated with the presence of effacement of the basal cisterns and/or midline shift over 5 mm on the initial CT scan.

3. Classification by Anatomy

The anatomical classification of head injuries divides them into (1) focal injuries, including contusions and traumatic hematomas, and (2) diffuse injuries, such as concussion and diffuse axonal injury (DAI). These categories are not mutually exclusive, as a severe underlying DAI may explain poor recovery following a technically perfect evacuation of an acute subdural hematoma.

4. Initial Assessment

The Glasgow Coma Scale score that is most useful in determining the patient's neurologic prognosis is the score after adequate resuscitation.

Early pupillary changes seen in severe head injury may be related to brainstem hypoperfusion, rather than brainstem compression.

Pupillary inequality after resuscitation mandates a CT scan of the head. A difference of up to 1 mm between pupils is seen in up to 20 percent of the healthy population.

Neurosurgical advice should be sought when:
- There is a positive head CT scan.
- A patient fulfills criteria for CT scanning, but this cannot be done for 24 hours.
- The patient continues to deteriorate irrespective of CT scan findings, or if there is a compound depressed skull fracture, penetrating injury, or cerebrospinal fluid (CSF) leak.

B. PENETRATING HEAD INJURY

Penetrating head injury—displaced skull fractures, evidence of CSF leak or exposed brain—warrants consultation with a neurosurgeon

C. CAUTIONARY NOTES ON THE ACUTE MANAGEMENT OF PATIENTS WITH HEAD INJURY

- *Do not use nasogastric tubes*—A nasogastric tube should not be placed in any patient with a suspected base-of-skull fracture.
- *Avoid hypotonic fluids*—Hypotonic fluids, such as Ringer's or dextrose/saline, should be avoided.
- *Do not use Mannitol*—Using Mannitol to maintain cerebral blood flow remains controversial.
- *Avoid steroids*—Steroids are not recommended in the current management of the head-injured patient.
- *Apply prophylactic anticonvulsants strategically*—Prophylactic anticonvulsants are recommended for acute subdural hematoma, penetrating injuries, cortical contusions, a history of significant alcohol abuse, and epilepsy.
- *Use antibiotics sparingly*—Antibiotics are not recommended, unless a wound overlying a skull fracture or open skull injury is grossly contaminated. In these cases, a broad-spectrum cephalosporin is recommended. Metronidazole should be added if a sinus injury is suspected.
- *Avoid secondary insults*—A critical concept in the management of the head-injured patient is avoidance of further injury from hyperthermia, hypoxia, hypocarbia, hypotension, and hyperglycemia, which are common in the head-injured patient.

III. Principles of Soft Tissue Wound Management

A. INITIAL WOUND MANAGEMENT

1. Cleansing

Manually remove gross contaminants and irrigate wounds copiously with saline (2 liters or more per site), gently massaging the tissues as soon as is practical. Do not use pulse irrigation under pressure.

2. Debridement

Debride frayed, shredded, or burned skin and muscle conservatively in the operating room as soon as practical. The incidence of wound-healing complications from gunshot wounds that traverse the oral cavity is high. This is due to direct inoculation of the tract by the projectile and the presence of devitalized tissue. Early initial debridement of necrotic tissues from severe facial injuries and beginning antibiotic treatment as soon as possible is strongly recommended.

3. Passive Drains

Use passive drains (e.g., Penrose) liberally in contaminated wounds or wounds that communicate with mucosal surfaces.

4. IV Antibiotics and Tetanus Toxoid

Administer IV antibiotics and tetanus toxoid preoperatively.

5. Inspection and Documentation

Inspect to the depth of the wound, and document the extent of the injury (nerve, duct, muscle, cartilage or vessel).

B. PRIMARY VERSUS DELAYED CLOSURE

1. Closing Clean Wounds Primarily

Close clean wounds primarily, or as soon as practicable. In the head and neck, there is generally no advantage to delayed closure.

- Definitively treat all wounds within 24 hours whenever possible. Grossly contaminated wounds should be meticulously cleaned, debrided, and irrigated.
- When conditions prevent early closure, dress with saline-soaked gauze changed twice daily.
- Simple lacerations may be closed up to 3 days post-injury.
- Complex lacerations may be closed up to 2 days post-injury.
- Avoid closure under tension. Undermining uninjured skin or mucosa to effect a tensionless closure is acceptable.
- Mucosal closure of deep wounds or wounds that communicate with the neck should be at least two-layer closures and should be water-tight.

- Wound VAC (vacuum-assisted closure) dressings may be applied to water-tight wounds of the face, head, or neck that are not suitable for primary closure to facilitate wound contracture and enhanced closure by secondary-intent healing.

2. Avoiding Additional Incisions

Avoid additional incisions until a clear plan for later stages of reconstruction is developed. It is better to line the wounds with saline-dampened gauze changed twice daily and to delay closure for up to 72 hours while a definitive plan is made, rather than to make releasing incisions for local flaps that limit subsequent reconstructive options.

3. Reconstructing the Facial Framework Early

Scar contracture, which begins as early as 72 hours after injury, can make definitive soft tissue repair more challenging. According to Futran, enough underlying bone reconstruction should be performed to prevent contracture of the facial soft tissues.

- Temporary bone grafting may be performed in areas with unsatisfactory soft tissue coverage for interim stenting of the surrounding soft tissues.
- Locking reconstruction plate fixation of segmental mandibular defects may be performed until definitive bone reconstruction can be accomplished.
- Flap coverage may be required.

C. LACERATION CARE AFTER REPAIR

- Keep laceration covered with petroleum jelly.
- Remove sutures in 3–5 days.
- Support skin edges with Steri-Strips™ for 2 weeks.
- Keep abraded lacerations covered with petroleum jelly for 2 weeks.
- Revise in 6–9 months.

D. BITE WOUNDS

According to Akhtar et al., although bite wounds are likely to be contaminated, primary closure is still recommended for these wounds after thorough irrigation. They suggest that the result will be no worse if an attempt at closure is made, even if the wound eventually becomes infected, when compared with leaving the wound open to heal by second intention.

Broad-spectrum antibiotic administration is warranted and should be directed at a polymicrobial spectrum, including alpha-hemolytic streptococci, *Staphylococcus aureus*, and anaerobes.

IV. Principles of Plating

A. RECONSTRUCTIVE GOALS

Reconstructive goals include restoration of function (airway, mastication) and form (occlusion, facial height, and facial projection).

B. TECHNICAL OBJECTIVES

1. Stability at Each Fracture Site

Stability at each fracture site is essential. Fixation must overcome natural forces acting at the fracture site long enough for the bone to heal.

2. Three-Point Fixation of Mobile Segments

Three-point fixation of mobile segments is optimal for stability and to distribute forces acting on the points of fixation (the screws engaging the bone). Plating systems provide this by using multiple screws, angled plates, locking plates, and multiple plates, or by engaging multiple cortices with one screw.

- If a single plate is used to fix bone fragments, using three screws on either side of the fracture is desirable.
- Bicortical screws add significant stability to a plating system, but risk damage to intervening structures (nerves, blood vessels, tooth roots).
- Locking plates that are not in direct contact with the bone effectively establish two points of fixation at every screw, adding stability. They have the additional advantage of permitting preservation of periosteal attachments to the bone, and the disadvantage of creating a higher profile beneath the covering skin or mucosa.

3. Bone Fragment Contact

Bone fragment contact promotes neo-osteogenesis and bridging at the fracture. Compression plates were developed to enhance bone contact by drawing bone fragments closer together. These plates continue to have useful applications. However, “compressing” bone fragments has not proved more effective than ensuring passive contact and stability at the fracture site through use of locking plates.

C. PLATING SYSTEMS

Two choices exist for craniofacial plating materials: metal and resorbable plating.

1. Metal Plating

Metal plating systems are most commonly titanium alloys with proven biocompatibility and strength. These systems all have generally analogous application, but are not interchangeable among manufacturers. Differences in alloy composition, plate hole sizes, and screw head/driver design prevent mixing systems.

2. Resorbable Plating

Bioabsorbable materials are most commonly high-molecular-weight polyalphahydroxy acids: polylactic acid, polyglycolic acid, and polydioxanone. These systems also have generally analogous application but are not interchangeable.

- Experience is required in both selection and use of resorbable plating systems.
- Resorbable plating systems vary significantly in mechanical strength, handling characteristics, biodegradability, and absorption.
- The majority of absorbable plates currently on the market maintain 60–90 percent of their strength through the 3-month mark.
- Pediatric trauma absorbable systems are well suited for non–load-bearing regions in the upper and middle thirds of the face.

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The American Academy of Otolaryngology—Head and Neck Surgery Foundation's education initiatives are aimed at increasing the quality of patient outcomes through knowledgeable, competent, and professional physicians. The goals of education are to provide activities and services for practicing otolaryngologists, physicians-in-training, and non-otolaryngologist health professionals.

The Foundation's AcademyU® serves as the primary resource for otolaryngology–head and neck activities and events. These include an online library of expert-developed learning courses, learning platforms, and e-books, as well as Patient Management Perspectives in Otolaryngology and the Home Study Course. In addition, the AAO-HNSF Annual Meeting & OTO EXPO is the world's largest gathering of otolaryngologists, offering a variety of education seminars, courses, and posters. Many of the Foundation's activities are available for *AMA PRA Category 1 Credit™*.

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