For emergency medicine and trauma professionals

TRAUMA rounds

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Canthotomy and Cantholysis: A Sight-Saving Intervention

by Roxana Fu, MD, and Evan Waxman, MD, PhD

Case

A 77-year-old woman was transferred from an outside hospital after sustaining a ground-level mechanical fall. Her history is significant for anticoagulation with warfarin for her bovine mitral valve replacement and recent hemispheric CVA. She is found to have an intraparenchymal cerebral hemorrhage, right-sided orbital and zygomatic fractures, and a supratherapeutic international normalized ratio of 3.7. She was given two units of fresh frozen plasma and sent to UPMC for further management.

Upon questioning, she endorsed eye pain and decreased vision in her right eye. She was only able to appreciate hand motion in her right eye. Examination of her pupils revealed a right afferent pupillary defect (APD). Measurement of her intraocular pressure (IOP) with a tonopen showed it was elevated in her right eye at 42 and normal in her left eye at 15. The remainder of her exam was significant for severe periorbital ecchymosis, swelling, proptosis, and decreased abduction and adduction of her right eye.

Questions and Answers

How is the clinical diagnosis of an optic nerve compromising retrobulbar hemorrhage made?

In the setting of trauma, decreased vision, proptosis, and decreased eye movement should raise clinical suspicion for a retrobulbar hemorrhage causing optic neuropathy. The aforementioned signs and symptoms should prompt further examination for an APD and increased IOP. A CT scan demonstrating intraconal or extraconal hemorrhage is helpful (Figures 1 and 2), but not necessary for diagnosis.

How would you manage this patient?

Once the diagnosis is made, an urgent orbital decompression is warranted by performing a lateral canthotomy and cantholysis. Decreasing the intraorbital pressure, and subsequently her IOP, restores normal circulation and prevents further vision loss. Visual recovery is possible if orbital decompression is performed in a timely manner.

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Canthotomy and Cantholysis: A Sight-Saving Intervention *(Continued from Page 1)*

How else may patients with orbital compartment syndrome present?

Outside of the setting of trauma, retrobulbar hemorrhage may present spontaneously or iatrogenically after retrobulbar injection of anesthesia and after surgical procedures such as orbital surgery, blepharoplasty, or sinus surgery. Other nonhemorrhagic causes include orbital cellulitis with or without abscess formation and orbital apex syndrome in the setting of acute adjacent inflammatory conditions (such as sinusitis without direct orbital involvement).

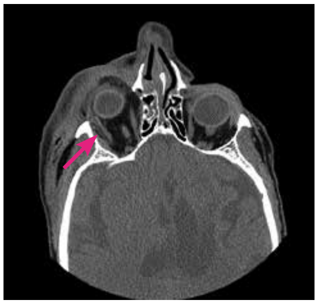

Figure 1. Axial CT scan with right extraconal orbital hemorrhage (arrow) and marked proptosis.

Figure 2. Coronal CT scan with right extraconal orbital hemorrhage (arrow) and complete opacification of the maxillary sinus with blood.

Figure 3. Incision to perform a lateral canthotomy: the lateral canthus is cut approximately one centimeter.

Figure 4. Lateral canthotomy.

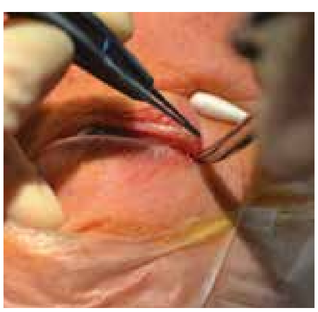

Figure 5. Incision of the inferior limb of the lateral canthal tendon: holding the lower eyelid anteriorly with forceps, the cantholysis is performed by strumming the scissors along the inferior orbital rim to find the tendon. After palpating the tendon with the scissors, the distinct corded entity is cut.

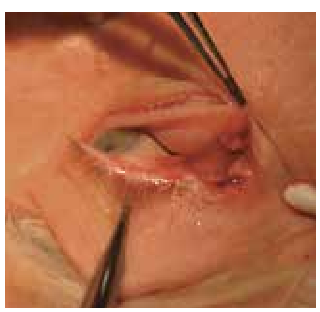

Figure 6. Laxity of the lower eyelid status post-canthotomy and cantholysis.

Discussion

Retrobulbar hemorrhage causing acute loss of vision is a rare but serious and potentially blinding condition. Hemorrhage can occur with minor trauma or in a delayed fashion. As ophthalmic consultation may not be always readily available, physicians triaging ocular trauma must familiarize themselves with the needed examination and interventional skills.

Any trauma to the orbit can cause a retrobulbar hemorrhage. Severe hemorrhage can cause orbital compartment syndrome, like any space-occupying lesion. The orbit is enclosed by bony anatomy, and any forward displacement is limited by the eyelid apparatus and tethering of optic nerve to the globe. As intraorbital pressure rises, ocular perfusion pressure decreases, leading to ischemia. Multiple cranial nerves within the orbit may be compromised, including the optic nerve and nerves controlling eye movement. Animal studies have shown signs of ischemia after 100 minutes of central retinal artery occlusion; therefore, prompt reversal of high intraorbital pressure is recommended.

The eyelids are fixated to the lateral rim by the lateral canthal tendon. A lateral canthotomy is performed to expose the inferior limb of the lateral canthal tendon (Figure 3). The inferior portion of the lateral canthal tendon is palpable as a distinct corded entity along the orbital rim, and the tendon is cut to ensure laxity of the lower eyelid (Figure 4). The endpoint of the procedure is to allow for additional forward movement of the intraorbital contents, and less so for actual drainage of the hematoma.

While there are no large published case series guiding when treatment should be initiated, the finding of an APD is diagnostic of optic nerve compromise and should prompt urgent intervention when accompanied by the aforementioned signs and symptoms. In a darkened room, the pupils are examined with a bright light source with the patient fixating at a distant target. The light is repeatedly swung from the unaffected eye to the affected eye. An APD is present if dilation, instead of constriction, is seen in the affected eye in response to light.

While a multitude of adjunctive medical therapy has been described, such as systemic and topical IOP lowering agents and high-dose corticosteroids, these measures should not delay surgical intervention. Some causes of retrobulbar hemorrhage can be medically managed, but this should be reserved for cases with close collaboration with ophthalmology. Further decompression of the orbit in the operating room may be needed if surgical and medical therapies fail to decrease the patient's IOP.

Our patient underwent a bedside lateral canthotomy and inferior cantholysis within one hour of presentation and ultimately eight hours after injury. Thirty minutes after the procedure, her IOP was 23. Three months after injury, the patient's vision ultimately recovered from hand motions vision to 20/50.

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Trauma Triage: The Right Patient in the Right Hospital at the Right Time

by Matthew R. Rosengart, MD, MPH

Trauma affects one out of five Americans, requiring the expenditure of $400 billion in direct medical costs each year. Regionalization-tiered levels of care that distribute the sickest patients to the highest intensity hospitals (trauma centers) reduce mortality and morbidity[1,2]. In fact, regionalization in trauma has become the standard of care, and evidence suggests that inclusive trauma systems improve outcomes by matching patient needs with institutional resources. Ideally, therefore, patients with moderate to severe injuries should receive care at trauma centers (TC), while those with minor injuries should receive care at non-trauma centers (NTCs).

Thirty years ago, The American College of Surgeons Committee on Trauma (ACS-COT) published guidelines for the triage of trauma patients. Providers at outlying hospitals could use a simple algorithm to identify patients with moderate to severe injuries, who would benefit from transfer to a Level I/II trauma center. Emphasizing the principle of triage, the proposed algorithm relied on information gathered with a history, physical examination, chest x-ray and pelvis x-ray. These well-established clinical practice guidelines specify when to triage patients to specialty trauma centers (Figure 1).

Despite evidence that ACS-COT guidelines improve morbidity and mortality, as well as concerted efforts to address known barriers to compliance, some patients who meet criteria for transfer to a TC remain at NTCs, referred to as under-triage[3]. Other studies have reported a large proportion of severely injured patients with signs of physiologic compromise (for example, hypotension and tachycardia) undergo CT scan imaging at community hospitals prior to transfer to a TC[4]. Interestingly, in this study pretransfer scans did not change outcomes but did substantially increase system costs and potentially delay access to a trauma center. Clearly the decision to transfer a patient is complex and involves processing a far greater amount of information than the mere application of validated guidelines. Nonetheless, if outcomes depend on the speed with which patients receive definitive care, it is imperative that we identify areas of improvement in patient safety.

Regionalization depends on the ability of health care providers to correctly identify patients who would benefit from transfer to a TC. However, the clinical uncertainty associated with triage decisions makes discrimination necessarily imperfect. Balancing pragmatism with expert opinion regarding best practices, the ACS-COT has recommended that mature trauma systems strive to achieve rates of less than 5% under-triage (treatment of patients with moderate to severe injuries at NTCs) and less than 50% over-triage (treatment of patients with minor injuries at TCs). However, a recent retrospective cohort analysis of trauma patients demonstrated that current rates of secondary under-triage and over-triage do not approach the recommendations[5]. In this study a 70% rate of secondary under-triage suggested that physician discrimination between patients with minor and moderate to severe injuries may play a significant role in ongoing failures to accomplish regionalization[5]. Furthermore, given the existing inability of physicians to discriminate among patients with minor injuries and moderate to severe injuries under conditions of uncertainty, the appropriate transfer of 95% of the moderately to severely injured patients would require transfer of a far high proportion of patients with minor injuries. Quality

(Continued on Page 6)

Rebirth of the Tourniquet

by Gregory A. Watson, MD, FACS

Despite one's feelings regarding armed conflict, one thing is certain: every war has ushered in major medical advances. The recent conflicts in both Iraq and Afghanistan are no exception. We have seen major advances in transfusion medicine, hemorrhage control, and battlefield resuscitation, just to name a few. One of the hallmark injuries of these recent conflicts is blast injury, and along with that we have seen a resurgence in the interest in and use of tourniquets. As recent worldwide and domestic terroristic events have proven, these injuries are no longer of interest only to military surgeons but also to civilian first-responders and trauma surgeons. In the following review, I will briefly discuss the pathophysiology of blast injuries and the role of tourniquets as a life- and potentially limb-saving intervention.

Figure 2. The Combat Application Tourniquet® (C-A-T®).

Blast injury represents the ultimate polytrauma (Figure 1). Four major mechanisms are responsible for the spectrum of injuries seen following a blast event. The primary blast injury results from the blast wave itself. Stress and shear waves occur in tissues, and these waves are reinforced and reflected at tissue density interfaces. Gas-filled organs such as the lungs, ears, and intestines are at particular risk. Common injuries include rupture of the tympanic membranes, blast lung injury, eye injuries, concussions, and hollow viscus injury. Secondary blast injury results from missiles being propelled by the blast itself. These are classic penetrating injuries, lacerations, and traumatic amputations. Tertiary blast injury occurs as a result of the blast wave propelling the individual into a surface or object, or as a result of a structure falling on the victim. These cause typical blunt injuries as well as crush injuries and compartment syndrome. Quaternary blast injury occurs as a result of other explosion-related injuries, illnesses, or diseases. This may involve burns, inhalation of toxic gases, or injury from other environmental contamination. A blast event generally occurs in a populated area and mass-casualty events are commonplace.

Figure 1. Afghan soldier wounded by an improvised explosive device (IED). Note the injuries to all four extremities, the application of tourniquets, and the relatively uninjured torso (victim was wearing body armor).

Primary, secondary, and tertiary blast injury can all result in severe extremity injury, and the presence of a traumatic amputation has been reported to be associated with a mortality rate of 50%. Throughout history, the use of tourniquets has been both championed and challenged and, until these recent conflicts, has been very controversial (refer to an excellent review by Kragh et al. for further information). However, data from the recent military actions in both Iraq and Afghanistan clearly show that early and appropriate tourniquet use saves lives. A 2008 study from a combat support hospital (CSH) in Baghdad reported that survival rates were higher with prehospital versus hospital use (89% and 78%), higher with use before shock onset versus after (96% and 4%), and higher with tourniquet use versus without (87% and 0%). Complications associated with tourniquet use were reported to be infrequent and often minor and temporary.

All deploying U.S. servicepersons receive a Combat Application Tourniquet® (C-A-T®; North American Rescue, Greer, S.C.) and are instructed in its use (Figure 2). Furthermore, the Tactical Combat Casualty Care (TCCC) guidelines call for early application of a tourniquet in all cases of life-threatening extremity hemorrhage and in cases of traumatic amputation(s). The tourniquet should be applied two to three inches above the wound and tightened until bleeding has stopped. If possible, confirm the absence of a distal pulse as a venous tourniquet can exacerbate blood loss (Figure 3).

If one tourniquet is ineffective, a second should be placed. The time of tourniquet application should also be noted, and the patient rapidly evacuated to a facility with immediate surgical capabilities. Adherence to these guidelines clearly saves lives, particularly if initiated before the onset of shock. In a study of 2,600 combat fatalities from Vietnam and a second study of 982 fatalities from the early years of the Afghanistan and Iraq conflicts, the incidence of death from extremity hemorrhage was essentially unchanged at 7.4% and 7.8%, respectively. However, a recent review of 4,596 U.S. combat fatalities from 2001 to 2011 (after widespread implementation of the TCCC guidelines) has shown that the incidence of preventable death from extremity hemorrhage has decreased to 2.6%.

Given these findings, tourniquets have been increasingly applied in the civilian sector, though their use is still not widespread (Figure 4). Though the types of injuries seen in combat should be infrequently seen in the civilian setting, recent events such as the Boston Marathon bombing suggest that we must be prepared for these events. The Hartford Consensus, designed to increase survivability in a mass-casualty event, stresses early hemorrhage control and the use of tourniquets. The acronym THREAT is used to describe the needed response in such events. T calls for threat suppression, H for early hemorrhage control, RE for rapid extrication to safety, A for assessment by medical providers, and T for transport to definitive care. As far as hemorrhage control, early application and use of tourniquets (and hemostatic dressings) by tactical EMS and police officers is stressed. Recently, an expert panel from the American College of Surgeons Committee on Trauma EMS Committee published guidelines for prehospital hem under specific clinical practice guidelines, that proper device training be administered, and that education in its use be expanded to include all prehospital personnel.

Figure 3. An Afghan soldier who sustained a gunshot wound to the distal right thigh with a femoral vein injury. This picture depicts an incorrectly applied "venous tourniquet." Note the swelling of the right leg relative to the left, the venous engorgement, and the sizeable hematoma of the right thigh. This patient had intact distal pulses and should have had the tourniquet tightened or a second one applied.

Figure 4. A young male patient who sustained an open femur fracture with vascular injury following a motorcycle crash. A tourniquet was applied by prehospital personnel.

In conclusion, blast injuries are no longer solely the concern of military health care providers. Blast injuries, as well as certain blunt and penetrating extremity injuries, have the potential for significant blood loss. Early, effective hemorrhage control (before the onset of shock) of the injured extremity clearly saves lives, and the use of a tourniquet can be a valuable adjunct to first responders. Though its application and effectiveness in the military is well-established, the adoption of the tourniquet by civilian prehospital personnel is not as widespread, though guidelines and training continue to be developed and refined.

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Trauma Triage *(continued from Page 3)*

Figure 1: 2011 Guidelines for Field Triage of Injured Patients

1 — Measure vital signs and level of consciousness

- Glasgow Coma Scale ≤13
- Systolic Blood Pressure <90 mmHg
- Respiratory Rate <10 or >29 breaths per minute, or need for ventilatory support (<20 in infant aged <1 year)

YES → **Transport to a trauma center.** Steps 1 and 2 attempt to identify the most seriously injured patients. These patients should be transported preferentially to the highest level of care within the defined trauma system.

NO ↓

2 — Assess anatomy of injury

- All penetrating injuries to head, neck, torso, and extremities proximal to elbow or knee
- Chest wall instability or deformity (e.g. flail chest)
- Two or more proximal long-bone fractures
- Crushed, degloved, mangled, or pulseless extremity
- Amputation proximal to wrist or ankle
- Pelvic fractures
- Open or depressed skull fracture
- Paralysis

YES → **Transport to a trauma center.** Steps 1 and 2 attempt to identify the most seriously injured patients. These patients should be transported preferentially to the highest level of care within the defined trauma system.

NO ↓

3 — Assess mechanism of injury and evidence of high-energy impact

- **Falls**
  - Adults: >20 feet (one story is equal to 10 feet)
  - Children: >10 feet or two or three times the height of the child
- **High-risk auto crash**
  - Intrusion, including roof: >12 inches occupant site; >18 inches any site
  - Ejection (partial or complete) from automobile
  - Death in same passenger compartment
  - Vehicle telemetry data consistent with a high risk of injury
- **Auto vs. pedestrian/bicyclist thrown, run over, or with significant (>20 mph) impact**
- **Motorcycle crash >20 mph**

YES → **Transport to a trauma center**, which, depending upon the defined trauma system, need not be the highest level trauma center.

NO ↓

4 — Assess special patient or system considerations

- **Older Adults**
  - Risk of injury/death increases after age 55
  - SBP <110 may represent shock after age 65
  - Low impact mechanisms (e.g. ground-level falls) may result in severe injury
- **Children**
  - Should be triaged preferentially to pediatric-capable trauma centers
- **Anticoagulants and bleeding disorders**
  - Patients with head injury are at high risk for rapid deterioration
- **Burns**
  - Without other trauma mechanism: triage to burn facility
  - With trauma mechanism: triage to trauma center
- **Pregnancy >20 weeks**
- **EMS provider judgment**

YES → **Transport to a trauma center** or hospital capable of timely and thorough evaluation and initial management of potentially serious injuries. Consider consultation with medical control.

NO ↓

Transport according to protocol

When in doubt, transport to a trauma center.
Find the plan to save lives at www.cdc.gov/Fieldtriage

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improvement initiatives that merely raise the number of transfers without reallocated resources would significantly burden TCs. Thus, new educational strategies for helping physicians discriminate among patients may be of greater value.

At the physician level, existing quality improvement efforts have focused on increasing knowledge, modifying attitudes, and removing structural and economic barriers to transfer. The extent to which cognitive aspects of physician decisionmaking contribute to under-triage is unknown. In an elegant study using signal detection theory, Mohan et al identified several aspects of physician cognition that may underlie either failure to or delays in transfer[6]. When presented with case vignettes, most physicians demonstrated limited perceptual sensitivity (the ability to discriminate between patients who do and do not meet clinical practice guidelines for transfer). Perceptual sensitivity reflects both physicians' knowledge of the clinical practice guidelines and intuitive judgments (heuristics) about which patients meet those guidelines. This study also identified a group of physicians with a high decisional threshold (the tendency to err on the side of false positive or false negative decisions) for transfer. Decisional threshold reflects variables such as attitudes towards the guidelines, incentives, and organizational normal. Currently the ACS-COT uses ATLS, an educational program that operationalizes the clinical guidelines, as one of its primary tools to standardize the treatment of trauma patients. Although most physicians in this study had received ATLS certification, triage decisions only weakly corresponded with ACS-COT criteria for transfer.

One possible explanation for variability in physician performance is that volume influences outcomes. Physicians who treated a greater number of patients with moderate to severe injuries were more likely to triage them in accordance with clinical practice guidelines[7]. That result echoes studies in cancer, coronary artery disease, and critical care where greater experience translates into better outcomes. However, a recent study highlighted that patient volumes at non-trauma centers preclude physicians from obtaining significant experience to triage patients with moderate to severe injuries[7]. In that study, only one out of 50 patients presenting after trauma, and one out of 1,000 patients presenting overall, had an injury that met guidelines for transfer. Moreover, patients who met the guidelines had a mean Injury Severity Score (ISS) of 12, lower than the ACS-COT cutoff for patients that warrant transfer regardless of their specific injuries. This may contribute to the observation in that study

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that physicians discharged home one-third of patients the ACS-COT would classify as having moderate to severe injuries.

Current quality improvement efforts in trauma triage assume that the same barriers affect all physicians equally. However, the prior studies that highlight individual performance differences suggest the need for a more nuanced approach that targets the specific impediments, whether they be perceptual sensitivity or decisional threshold. Merely increasing the willingness to transfer patients may increase over-triage and impose a burden on Level I TCs. An analysis of triage patterns in Pennsylvania demonstrates that simply shifting decisional thresholds to achieve ACS-COT targets for triage would result in a five-fold increase in transfers to TCs[5]. Moreover, NTCs would lose an important source of revenue and the opportunity to provide care for patients in their community. It is clear that identifying the critically injured patient that would benefit from higher-level care and then deciding to transfer is difficult and complex. Further research is required to determine how cognitive aspects of physician decisionmaking affect the triage of patients in real practice, as well as how best to intervene.

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The Importance of Diagnosing Alcohol Withdrawal Syndrome

Patients with alcohol dependency who are admitted for routine surgery or following traumatic injuries may develop alcohol withdrawal syndrome (AWS) due to an acute cessation of chronic ethanol intake. This syndrome may complicate the hospital course and, if undertreated, may increase morbidity and mortality.

The clinical findings of AWS are systemic manifestations of central nervous system (CNS) hyperexcitation. Tachycardia, hypertension, and tremor represent the mildest form of AWS. Subjective complaints include nausea, hallucinations, and anxiety. Severe AWS may include seizures, though they are often brief. These symptoms may be confused for alternative diagnoses, especially in the context of a patient with multiple traumatic injuries. Therefore, keep a wide differential diagnosis when evaluating a patient with the above signs and symptoms.

Correctly diagnosing AWS is imperative for initiating appropriate treatment. The treatment is centered on early, aggressive front-loading of benzodiazepines, primarily diazepam. We recommend a symptom-triggered approach with rapidly escalating doses every few minutes until symptoms are controlled.

If this technique does not control symptoms, consider alternative diagnoses or adding a barbiturate, such as phenobarbital. UPMC Medical Toxicology also recommends intravenous sub-dissociative ketamine for delirium tremens when benzodiazepines have not adequately controlled symptoms or normalized vital signs.

Contact the UPMC Division of Medical Toxicology or the Pittsburgh Poison Center for any additional treatment recommendations.

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