Trauma Forensics: Saving Lives and Preserving Evidence

by Louis Alarcon, MD

Emergency medical service providers, emergency medicine physicians, and trauma surgeons often care for patients who are victims of interpersonal violence. In addition to our responsibilities for treating these injured patients, we have a duty to preserve the forensic evidence. Most health care providers have little or no training in the forensic aspects of trauma, and as a result necessary evidence may be inadvertently discarded or improperly handled, which may hamper legal authorities in the investigation or prosecution. Clinical forensic medicine is a discipline that addresses both the legal and medical aspects of patient care. Physicians and first responders caring for patients who sustain intentional injury are responsible for documenting the injuries as well as collecting and preserving potential evidence. Health care providers may be called upon to testify in civil or criminal cases involving these patients, and appropriate documentation of the injuries, the care provided, and any evidence obtained is extremely helpful in this regard.

The types of physical evidence that may be encountered in the course of caring for trauma patients include clothing, bullets, shrapnel, bloodstains, hairs, fibers, and fragments of other material such as metal, glass, paint, and wood. Preservation of evidence requires simple steps and some forethought. Removal of the patient’s clothing in the trauma bay often requires cutting clothing off a patient. When possible, avoid cutting through defects or holes, as this area may contain gunshot residue and other important evidence necessary for the investigation. Each item of the patient’s clothing and belongings should be placed into separate paper bags, labeled with patient identifiers and the date and initials of the person who collected the items, and turned over to legal authorities per hospital protocols. Plastic bags should be avoided, as these retain moisture and may cause evidence degradation from fungal or bacterial growth.

Documentation Is Key

Documentation of injuries in the medical record should be clear and concise, with simple descriptions of the pertinent physical findings. Medical providers should document only what they participated in or directly observed. Documentation should be factual; the provider should not conjecture about the intent of the injury, what occurred before the patient arrived at the emergency department, or the nature of the injury outside of his or her expertise and training. Health care providers should not attempt to classify a gunshot wound as “entrance” or “exit.” From a clinical perspective, whether a wound is entrance
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or exit is immaterial. Instead, they should simply document the location of the wound and its appearance rather than speculate about the bullet’s direction of travel. Inconsistent descriptions between the providers (who in general are not forensic experts) and the medical examiner may hinder the legal case.

Supplementing the written description with diagrams or photographs of the injuries can be very useful. From a clinical perspective, it is important to remember that the number of gunshot wounds plus the number of bullets on radiographs should equal an even number. Otherwise, either a wound or a bullet has not been accounted for, and further examination and radiographs may be indicated. Caveats are that bullets may fragment when they pass through bone or other dense material, and it is possible that retained foreign bodies seen on x-ray may be the result of previous injury. Whenever possible, surgical procedures (such as chest tube insertion) should not be done through existing wounds. If a procedure will alter a wound, this should be documented. For example, if a laparotomy incision goes through a gunshot wound, documentation should be made of the location and description of the wound before it was altered.

Bullets and other projectiles embedded in a patient may be important physical evidence, but should be removed if clinically indicated and accessible, not simply for forensic reasons. These should be removed without damaging or deforming. A gloved hand or gauze should be used to handle the foreign body. Metal instruments should not be used to handle bullets, as doing so may alter the rifling marks in the soft metal that can be used to identify the gun from which it was shot. Each bullet should be placed in a separate specimen container, which is labeled with patient identifiers and turned over to authorities according to hospital policy. The health care provider should document where each bullet was found or the site from which it was removed.

Impaled knives or other foreign bodies in general should be removed in the operating room. The object may have injured major blood vessels or other organs. The embedded object may tamponade bleeding, which may become active if the object is removed. The surgeon should be prepared to manage these injuries immediately if encountered. Any weapons found in the possession of a patient or removed from a patient should be handled by security.

An important concept in the handling of potential evidence is the preservation of the chain of evidence. This means accounting for the whereabouts of the evidence at all times, until it is turned over to the legal authorities. Failure to maintain a clear chain of evidence may render it inadmissible in a court of law. Hospitals should have protocols in place for documenting and securing all such items. Any belongings, foreign bodies, or bodily fluids removed from the patient should be considered potential evidence.

Conclusion
Health care providers involved in the care of trauma patients should have an understanding of clinical forensic medicine. Hospital and emergency departments should have protocols in place to manage potential forensic evidence. In addition to our responsibilities to save lives, we also have a responsibility to collect and preserve forensic evidence.

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Additional Reading
Regional Blocks for Rib Fractures: A Review

by Beverly Pearce-Smith, MD, and Qing Liu, MD, PhD

Pathophysiology/Epidemiology
Rib fractures are common, and the associated pain is usually intense. With traumatic multiple fractured ribs (MFR), concomitant lung injury is expected. The effect of this injury is exacerbated when the pain of MFR leads to guarding, shallow breaths, and suboptimal chest physiotherapy. Pain limits one’s ability to cough and breathe deeply, resulting in sputum retention, atelectasis, and a reduction in functional residual capacity (FRC). These factors in turn result in decreased lung compliance, ventilation-perfusion mismatch, hypoxemia, and respiratory distress. Atelectasis, pneumonia, consolidation, and respiratory failure ensue, necessitating or prolonging assisted ventilation and increasing morbidity and mortality. The overall mortality rate for patients with rib fractures was 10 percent, ranging from 5.8 percent for a single rib fracture to 34.4 percent for patients with eight or more fractures. A review of the National Trauma Data Bank showed that mechanical ventilation was required in 60 percent of patients for an average of three days. Hospital length of stay (LOS) averaged seven days, and ICU LOS averaged four days. Elderly patients are especially prone to fracturing a rib, with an incidence as high as 60 per 100,000 persons per year. One proposed explanation for this increased frequency in the elderly is loss of cortical bone mass caused by skeletal demineralization (osteoporosis), which allows ribs to fracture when less kinetic force is applied to the thorax relative to the force required in younger patients. Despite lower indices of injury severity, and after adjusting risk for comorbidities, mortality is increased in older patients sustaining rib fractures.1

Effective analgesia and respiratory care is the mainstay of management of patients with MFR. Together they improve respiratory parameters and allow many patients to avoid the need for tracheal intubation and assisted ventilation. The ability of superb analgesia in preventing secondary pulmonary complications is particularly relevant in the elderly, in whom comorbidities and poor reserves conspire to increase morbidity and mortality.1

Treatment Modalities
For healthy patients with one or two fractured ribs, systemic analgesics may suffice. Systemic opioids are commonly used and are often the first-line management for relieving pain resulting from MFR. They are used as intermittent on-demand injections, continuous intravenous infusion, or intravenous patient controlled analgesia (IVPCA). Unfortunately, opioids are associated with many unwanted side effects, such as sedation, nausea, and respiratory depression. Thus, opioid-sparing analgesia should be offered to patients over 65 years of age and for those with three or more rib fractures. Among all the opioid-sparing analgesia approaches, such as systemic NSAIDS and acetaminophen, regional anesthesia with nerve block was recommended as top choice, both because local anesthetics injected with nerve block have very mild side effect profile, and nerve blocks provide a direct effect on the nerves innervating the fractured ribs, avoiding systemic effects.2

Thoracic epidural (TE) and thoracic paravertebral (TPV) blocks are the most commonly used regional anesthesia approaches for MFR patients. Each has unique advantages and disadvantages.

Thoracic Epidural (TE) Block
Many studies have shown that TE nerve blocks with local anesthetics (LA), opioids, or a combination was able to produce dramatic analgesia in patients with multiple rib fractures. Pulmonary functions such as functional residual capacity, forced vital capacity, airway resistance, maximal inspiratory force, and maximal tidal volume were also reported improved by TE analgesia.3,4 The use of TE blocks, however, is limited by many factors, such as technical difficulty and frequently associated hypotension. Indeed, in a report of 408 patients with multiple rib fractures, Bulger et al., showed 224 (64 percent) had associated injuries that excluded epidural placement, the majority of which were spine fractures (61 percent).5 Another absolute contraindication to epidural insertion is coagulopathy. According to recently published guidelines of Regional Anesthesia in Patients Receiving Antithrombotic Therapy by American Society of Regional Anesthesia and Pain Medicine, neuroaxial nerve block (including epidural block) should not be placed when international normalized ratio (INR) is greater than 1.3, and the catheter should not be removed when INR is greater than 1.5 or platelet count is less than 75,000.6 It was reported that nearly 25 percent of trauma patients presenting to an emergency department have coagulation abnormalities, which will make using epidural analgesia in these patients very challenging. In addition, according to the clinical guidelines of Prevention of Venous Thromboembolism by American College of Chest Physicians, all major trauma patients should receive routine low molecular weight heparin (LMWH) thromboprophylaxis. Thus, epidural block should be delayed at least 10 to 12 hours after the LMWH dose, and the catheter should be removed a minimum of 10 to 12 hours after the last dose of LMWH.6 These various settings of coagulopathy before or after epidural catheter placement will either further limit the use of epidural block or prolong the patients’ hospital stay.

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Antithrombotic Medications in Injured Adults

by Katherine Fitzpatrick, MD, and Charissa Pacella, MD

Older adults represent a growing proportion of trauma patients and experience worse outcomes than younger patients. In 2012, patients older than 65 accounted for 25 percent of traumatic events reported in the National Trauma Data Bank and 39 percent of all fatalities. The higher mortality in this population is partly attributable to the presence of medical comorbidities and the use of antithrombotic (blood-thinning) medications. Several retrospective studies have demonstrated association between anticoagulant or antiplatelet medications and mortality, but the optimal initial management of these patients is less clearly defined. In this article, we discuss specific antithrombotic medications in common use and implications for management in the setting of acute bleeding.

**Vitamin K antagonists**

Warfarin is the most commonly prescribed oral anticoagulant in the United States, with a prevalence approximating 15 percent in geriatric trauma patients. Patients on warfarin are at significantly higher risk of hemorrhage and death following blunt trauma, particularly if they have intracranial hemorrhage (ICH). Studies cite an incidence of major bleeding between 1.4 and 3.4 percent per year for patients treated with warfarin, and intensity of anticoagulant effect plays an important role in determining patient outcome. A recent retrospective study showed that international normalized ratio (INR) greater than 1.5 was independently associated with higher mortality, and that odds of death increased 30 percent for each unit increase in INR. Vitamin K antagonists like warfarin inhibit the synthesis of vitamin K-dependent clotting factors (II, VII, IX, and X), and restoration of hemostasis takes 60 to 80 hours following the last dose of warfarin.

The measured INR, presence or absence of major hemorrhage, and indication for anticoagulation direct the clinical decision to reverse anticoagulation. Major hemorrhage is defined here as intracranial hemorrhage, transfusion of two or more units of blood, or other life-threatening hemorrhage. Reversal of anticoagulation merits consideration when the INR is greater than 1.5 in the setting of major bleeding, or when a patient requires an emergent surgical procedure.

The goal of reversal is to replace vitamin K-dependent clotting factors rapidly. Strategies include administration of vitamin K, transfusion of fresh frozen plasma (FFP), and administration of prothrombin complex concentrate (PCC). Some patients are at higher risk for thrombotic and thromboembolic complications following reversal of anticoagulation, including those with prosthetic heart valves or underlying hypercoagulable states.

Vitamin K is administered to promote the endogenous production of clotting factors. Reversal of anticoagulation is attained in about 12 hours following IV vitamin K and 24 hours following oral vitamin K administration. Time to reversal depends on the patient’s own hepatic synthetic function. Administration of IV vitamin K is associated with serious adverse events including life-threatening anaphylactoid reactions. Due to delay in effect, vitamin K is used most often in conjunction with reversal by other means if the need is emergent.

Fresh frozen plasma contains exogenous clotting factors and can achieve more rapid reduction in INR. FFP is also a potent intravascular volume-expander. At the recommended initial dose (15 ml/kg), FFP administration can lead to clinically significant volume overload manifest as pulmonary edema and respiratory failure. Older patients as well as those with underlying heart failure or respiratory dysfunction are at greatest risk for complications.

Four-factor PCCs contain factors II, VII, IX, and X and produce rapid reversal of anticoagulation with a much smaller volume of medication administered (typically <50 mL). The FDA recently approved the first four-factor PCC for use in the United States. Data from meta-analysis and a recent, randomized controlled trial suggest that reversal of coagulopathy following PCC administration is more rapid than reversal following administration of FFP. Retrospective and in vitro data suggest that PCCs may also achieve more complete reversal of anticoagulation than FFP. Three-factor PCC products (lacking in VII) are also available and can be used in conjunction with recombinant factor VIIa products for similar indications. Concerns have been raised about the cost of PCC products and potential for thrombotic complications, but published data in these areas are inconclusive.

**Antiplatelet Agents**

Antiplatelet medications like aspirin and clopidogrel are also common among older trauma patients. Retrospective studies demonstrate increased morbidity in patients on antiplatelet agents who suffer head trauma, and increased mortality for those with ICH. One study reported 23 percent mortality in patients with ICH.
on aspirin as compared with 9 percent in controls with similar injuries.\(^6\) Restoration of hemostasis takes five to 10 days after last dose of aspirin and one to two days after last dose of clopidogrel.

Platelet transfusion is often recommended for patients on antithrombotic medications who have ICH or require an emergent procedure. Unfortunately, platelet transfusion is associated with serious complications including volume overload, infection, anaphylaxis, and acute lung injury. Recent literature questions the utility of platelet transfusion in trauma patients. One meta-analysis found inadequate evidence to support the routine use of platelet transfusion in patients with ICH on antithrombotic medications.\(^9\) This finding may reflect the fact that roughly 50 percent of platelets remain dysfunctional even after platelet transfusion and that individual response to antithrombotic medications varies.

In an effort to determine which patients benefit from platelet transfusion, a study done at UPMC examined the utility of the aspirin response test. Data suggest that the aspirin response test can be used to restrict administration of platelets to those patients with demonstrable platelet dysfunction (aspirin response test <550 units). In addition, the test result can guide the volume of platelet transfusion: one six-pack of platelets increases the aspirin response by an average of 70 units.\(^10\) Our current recommendation is to perform the aspirin response test on patients with ICH taking aspirin and to limit platelet administration to those most likely to benefit. For patients on aspirin alone, desmopressin may be used as an adjunct to enhance platelet aggregation and endothelial adherence.

**Direct Thrombin and Factor Xa Inhibitors**

Several newer antithrombotic medications are increasingly prescribed to prevent the thromboembolic complications of atrial fibrillation. Dabigatran is a direct thrombin inhibitor, while rivaroxaban and apixaban inhibit factor Xa. Hemorrhage-related morbidity and mortality for patients on dabigatran, rivaroxaban, and apixaban are not well described, but anecdotal reports suggest that hemorrhage in this population can be severe and difficult to manage. Measured prothrombin time (PT) and partial thromboplastin time (PTT) values generally are not helpful since they correlate poorly with bleeding risk. Hemostasis occurs about 12 hours after the last dose of medication in each class, and options for active reversal are limited. Dialysis is an option to reverse the effects of dabigatran, but only 60 percent of the drug is removed after three hours, and dialyzing a patient with ongoing hemorrhage may be impossible. For rivaroxaban, PCC has been shown to reverse coagulopathy (PTT) in healthy volunteers and might be of some benefit for patients with major hemorrhage.\(^11\)

In summary, antithrombotic medications are common among older adults, and their use is associated with increased morbidity and mortality in the trauma setting. Injured patients should be screened for the use of anticoagulant and antiplatelet medications including the underlying indication. Coagulation studies, and sometimes aspirin response test, can help guide treatment. Providers should assess the risks and benefits to the individual patient when deciding if and how to initiate reversal of antithrombotic medications.

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**References**

Regional Blocks for Rib Fractures: A Review (Continued from Page 3)

**Thoracic Paravertebral (TPV) Block**
Paravertebral nerve block is a regional anesthetic technique in which a single injection of anesthetic or a continuous infusion is delivered to the thoracic paravertebral space at the level of rib fractures, producing a unilateral, multilevel, somatic, and sympathetic block. It is simple to perform and technically easier than a TE, especially in a patient distressed with pain. TPV block is associated with a low incidence of complications (including urinary retention), requires no additional nursing surveillance, and has very few absolute contraindications. A study has shown that continuous TPV blocks with 0.5 percent bupivacaine at 0.1 to 0.2 ml/kg/h for four days administered to 15 patients with isolated unilateral rib fractures significantly improved the analogue pain scores, vital capacity, and peak expiratory flow rate. When comparing with TE block, TPV block with continuous infusion of 0.25 percent bupivacaine produced comparable pain relief effects in patients with unilateral fractured ribs. These two techniques were also comparable with respect to improvement in respiratory functions, including respiratory rate and peak expiratory flow rate. The incidence of hypotension, however, was greater with epidural analgesia. Some of the absolute contraindications to epidural insertion do not exclude the use of paravertebral technique. For example, while epidural technique is contraindicated in the setting of coagulopathy due to the risk of hematoma and subsequent cord compression, the margin of safety is much higher with a paravertebral block and the more distensible paravertebral space.

Pre-existing neurologic disease such as raised intracranial pressure or spinal cord injury (which often occurs in the setting of multiple rib fractures) may contraindicate the use of an epidural technique. A paravertebral nerve block still can be used safely in this setting. Indeed, a case report on the use of thoracic paravertebral nerve block in a multiple rib fracture patient with concomitant lumbar spinal injury demonstrated a clear advantage of this technique over epidural analgesia, in that the unilateral segmental thoracic nerve blockade spares the lumbar and sacral nerve roots, allowing regular neurologic assessment for spinal compression.

Based on the emerging evidence for the advantages of TPV blocks over TE block, UPMC has adopted TPV blocks as a standard care for MFR patients. For the past 10 years, clinicians at UPMC have performed continuous TPV blocks in patients receiving DVT thromboprophylaxis, either postoperatively or in the setting of trauma. Anticoagulants with prophylactic doses are not discontinued with either catheter placement or with catheter removal. This practice has not been associated with any significant bleeding.

**Conclusion**
Effective pain relief has become the cornerstone of the care in patients with traumatic rib fractures. There is universal agreement that regional anesthesia technique confers greater benefits than systemic opioids. Currently available evidence points to a comparable analgesic efficacy between thoracic epidural (TE) nerve block (with or without opioids) and thoracic paravertebral (TPV) nerve blocks. The use of epidural block is largely limited by its complexities of coagulation issues as well as various associated complications. This is especially true in patients over 65 years old, who have the highest mortality rates among all age groups. When taking into account the simplicity and safety of the procedure, TPV nerve block shows superiority over TE block in MFR patients. Furthermore, our success at UPMC with the extensive use of thoracic paravertebral blocks (more than 800 blocks each year) in MFR patients provides practical experience attesting the efficacy of this technique.

The decision regarding institution of pain relief in patients with blunt chest trauma should be made early, and the most appropriate method should be determined by someone who has a thorough and clear understanding of the safety and efficacy of the various available methods. Therefore, the patient should be referred to the Acute Pain Management Service early. Pain relief is individualized on the basis of a thorough history, clinical examination, and review of the pertinent radiology and laboratory investigations.

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**References**
UPMC Prehospital Care also hosts numerous continuing education classes in western Pennsylvania. For a full, up-to-date calendar and online registration, visit UPMC.com/PrehospitalClasses.

### Course Name

**Advanced Trauma Life Support at UPMC Mercy**

**Date(s):** Full Course: June 23-34
Recertification: June 24
Full Course: October 27-28
Recertification: October 28

**Contact:** Diana Luketic
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412-232-7786

**Advanced Trauma Life Support at UPMC Presbyterian**

**Date(s):** Full Course: February 10-11
Recertification: February 11
Full Course: April 14-15
Recertification: April 15

**Contact:** Jennifer Maley
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412-647-8115

**Advanced Trauma Life Support at UPMC Altoona**

**Date(s):** Full Course: May 8-9
Recertification: May 9
Full Course: October 9-10
Recertification: October 10

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**Advanced Burn Life Support at UPMC Mercy**

**Date(s):** June 25

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To view the video or to learn out more about UPMC Trauma Services, visit [UPMC.com/Trauma](http://UPMC.com/Trauma).

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