Traumatic pneumothorax and hemothorax: What you need to know

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ABSTRACT: Thoracic trauma occurs in approximately 25% of all traumas, and one third of these patients will present with a pneumothorax, hemothorax, or a combination of the two. Hemodynamically abnormal patients require expeditious tube thoracostomy drainage, while the decision to intervene on a hemodynamically normal patient is guided by radiographic imaging. Ultrasonography, chest x-ray, and computed tomography (CT) scans are the most common imaging modalities for traumatic thoracic pathologies. A pneumothorax greater than 20% of the thoracic volume on chest x-ray or greater than 35 mm on CT, measured radially from the chest wall to the lung parenchyma, should be treated with tube thoracostomy. Pneumothoraces smaller than this may be observed; approximately 10% of these will fail observation and require tube thoracostomy treatment. Hemothorax size may be measured using the Mergo formula on a chest CT scan. It is recommended that a hemothorax larger than 300 mL should be drained. Irrigation with warm sterile saline upon placement of a thoracostomy tube has been shown to decrease the rate of secondary interventions, such as additional tube thoracostomies, or surgical intervention. Antibiotic administration prior to tube thoracostomy is recommended. This review article discusses the diagnosis, management, and complications of pneumothoraces and hemothoraces and their treatment. (*J Trauma Acute Care Surg.* 2025;00: 00–00. Copyright © 2025 Wolters Kluwer Health, Inc. All rights reserved.)

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Thoracic trauma is common, occurring in approximately 25% of all traumas.[1] One in three patients with thoracic trauma will have a pneumothorax, hemothorax, or a combination of the two.[2] The decision to intervene on these patients is primarily dictated by physiologic status; that is, if a patient is hemodynamically abnormal, they require expeditious treatment. On the other hand, in a patient with appropriate hemodynamics, the trauma team may use a variety of evaluation techniques and well-elucidated data to determine the necessity of pneumothorax or hemothorax drainage with chest tube placement. Herein, we describe the key aspects and relevant data regarding diagnosis, management, and complications of pneumothoraces and hemothoraces.

DIAGNOSIS

Clinical Signs and Symptoms

The rapid diagnosis of a pneumothorax or hemothorax may be made based on mechanism, index of suspicion, and patient status at presentation. A patient in extremis requires expeditious treatment. Mechanism of injury and clues from the scene of injury may aid in the diagnosis; for example, a bent steering wheel, rapid deceleration, airbag deployment, seatbelt usage, and penetrating trauma to the chest may all trigger a heightened awareness of the trauma team that thoracic injury has occurred. Physical examination characteristics, such as crepitus, chest instability, a sucking chest wound, paradoxical chest wall movement, hypoxia, tracheal deviation, and ecchymosis or obvious traumatic deformities, may be present. In a patient with any of these findings who presents in extremis, pneumothorax and hemothorax must be considered, and chest tube placement may be warranted prior to any imaging.

Imaging Modalities

If a patient is hemodynamically appropriate, the trauma team may evaluate for thoracic pathology using a variety of imaging modalities. An extended focused assessment of sonography in trauma examination evaluates not only the pericardium and abdomen but also the bilateral lung fields. The advantages of an extended focused assessment of sonography in trauma examination include the rapidity with which it may be performed, reproducibility, and the ability to perform this test during the trauma resuscitation. The classic loss of lung sliding is pathognomonic for a pneumothorax; other signs include A-lines, loss of comet tails, and the lung point sign.[3] Although some commonly cite interoperator variability, chest ultrasound is more sensitive for the detection of pneumothorax when compared with chest x-ray (CXR; 91% vs. 47%); both have similar specificities (100% vs. 99%).[4,5] In the setting of a hemothorax, ultrasound may also be used to identify fluid within the chest and, when combined with CXR, may in fact decrease the rate of unnecessary tube thoracostomy placement.[6]

A CXR is often obtained as an adjunct to the primary and secondary surveys. To best identify a pneumothorax, the patient should be in an upright position. If this is not possible, there are a number of radiographic findings that suggest the presence of a pneumothorax: an obvious edge of the visceral pleura that is not directly apposing the parietal pleura, with loss of distal lung markings; a deep sulcus sign, where the pulmonary markings appear to extend into the abdomen[7,8]; or subcutaneous emphysema. The

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latter two examples are subtler signs. If the CXR is negative but a pneumothorax is seen on a subsequent computed tomography (CT) scan, it is defined as an occult pneumothorax. Occult pneumothoraces can occur in up to 22% of blunt trauma patients.[7] The position of the patient during the CXR also impacts the appearance of the hemothorax. If the patient is upright, it may appear as a blunt costophrenic angle. Often, the patient is supine, and therefore, the blood layers posteriorly and appears as a more subtle haziness of the hemithorax. A large volume of blood will appear as a whiteout of the hemithorax whether the patient is supine or upright. The volume of hemothorax is directly related to its ease of visualization on CXR.

If a patient remains hemodynamically appropriate throughout the resuscitation and CT scanning is possible, a variety of thoracic pathologies may be readily identifiable. Computed tomography remains the criterion standard for identification of pneumothoraces and hemothoraces and may be extremely useful in quantifying their volumes, which can guide the decision to place a tube thoracostomy, discussed in the next section.

MANAGEMENT

Prophylactic Antibiotics

For hemothoraces and pneumothoraces that require drainage, prophylactic antibiotics must be considered. In a patient in extremis due to their thoracic pathology, this step may be omitted in favor of expeditious treatment. However, if time allows, antibiotics should be administered prior to the procedure to prevent the development of empyema. In 2022, the Eastern Association for the Surgery of Trauma (EAST) conditionally recommended a single dose of antibiotic prophylaxis given prior to tube thoracostomy placement. While a specific antibiotic or antibiotic regimen was not studied, the most common antibiotic in this meta-analysis was cefazolin. Patients with a penetrating mechanism may derive more benefit from antibiotic administration than blunt trauma patients.[9]

Pneumothorax

The Western Trauma Association algorithm for the management of a pneumothorax starts with the assessment of patient stability (Fig. 1).[10] In hemodynamically abnormal patients with a pneumothorax, prompt treatment by finger thoracostomy, needle thoracostomy, or, ideally, tube thoracostomy should be performed. In hemodynamically normal patients, however, the size of the pneumothorax should be evaluated prior to placement of a chest tube. On CXR, a pneumothorax that encompasses >20% of the lung field should be decompressed.[10] On CT scan, a pneumothorax greater than 35 mm in the largest dimension, when measured radially with a line drawn perpendicular to the chest wall (Fig. 2), should also be decompressed.[11] Patients with pneumothoraces smaller than these criteria may simply be safely observed, recognizing that there is about a 10% failure rate, even in the face of positive-pressure ventilation.[10,11] If being observed, a follow-up CXR should be performed at 4 to 6 hours and 24 hours to ensure that the pneumothorax has not expanded even if the patient is asymptomatic. If a patient becomes symptomatic, an emergent CXR should be performed and a tube thoracostomy may be needed.

The 35 mm rule originated from the occult pneumothorax score, which graded occult pneumothoraces based on their size and relationship to the pulmonary hilum.[12] While the calculation of the occult pneumothorax score was feasible, the authors felt that using their cutoff of 35 mm served as an appropriate guideline for insertion of a chest tube. A number of retrospective and prospective studies support the use of placing a tube thoracostomy in pneumothoraces greater than 35 mm, including in patients on positive pressure ventilation.[11,13–15] This guideline was implemented in a large Level I trauma center that recommended tube thoracostomy drainage of pneumothoraces greater than 35 mm

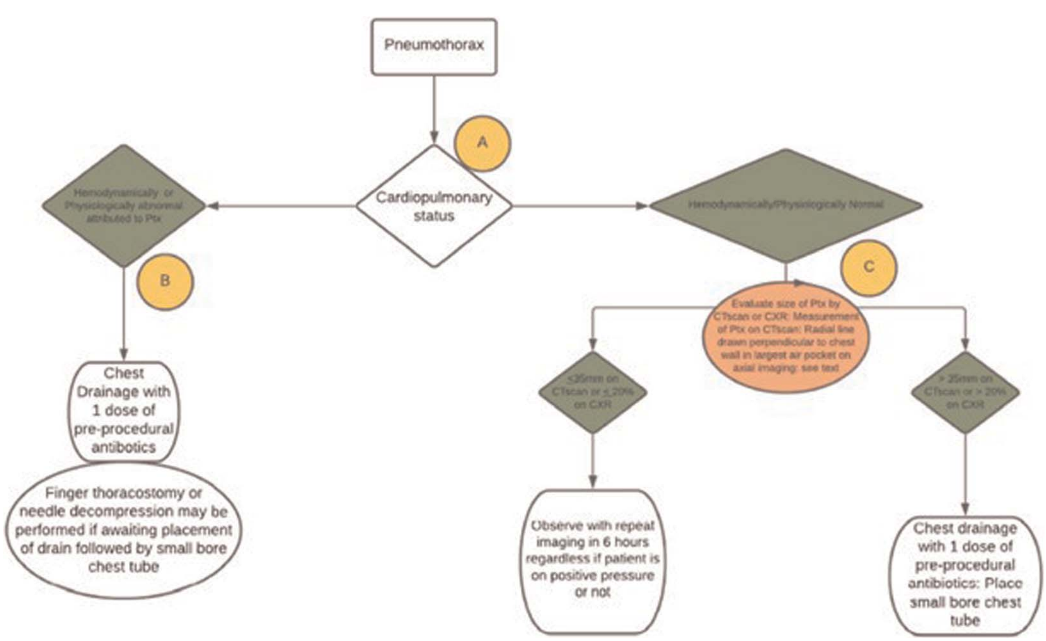

Figure 1. Western Trauma Association algorithm for the management of a pneumothorax.[10]

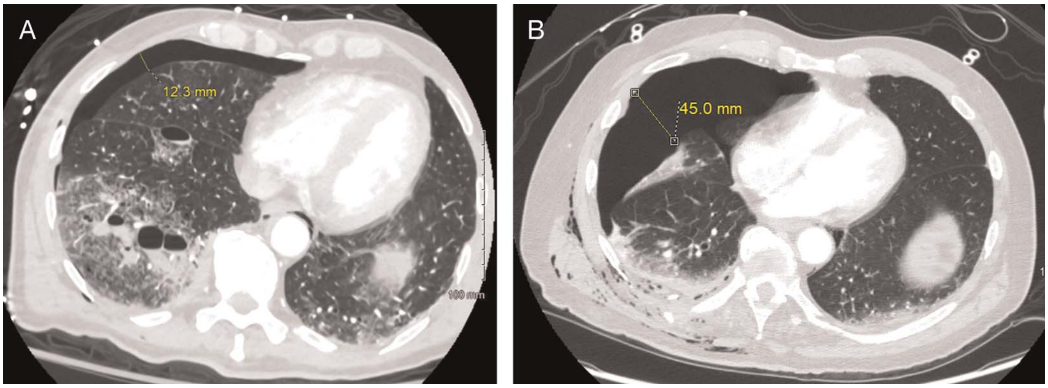

Figure 2. Patient A did not require tube thoracostomy drainage; Patient B did require tube thoracostomy.

as measured on CT scan.[11] After implementation of the guideline, tube placement rates decreased from 28% to 18% ($p = 0.04$), with no difference in observation failure rates, hospital length of stay, intensive care unit (ICU) length of stay, complications, readmissions, or mortality. Observation failure rates were 13.1% before implementation and 12.6% after implementation; observation failures were most often secondary to development of hemothoraces in both cohorts. While retrospective, this study does help guide surgeons on appropriate indications for pneumothorax intervention and minimizes unnecessary interventions, such as tube thoracostomy.[11]

Hemothorax

Like pneumothoraces, hemothoraces are treated based on patient stability first and volume second (Fig. 3).[16] Again, in a hemodynamically abnormal patient, placement tube thoracostomy immediately upon diagnosis is warranted, particularly if there is a high index of suspicion, for example, with a gunshot wound to the chest. A postintervention CXR should be obtained. If initial drainage is >1,500 mL, if drainage persists at a high rate (classically described as 200 mL per hour for 4 hours), or the patient has continued hemodynamic instability, an operative thoracotomy is warranted.[17]

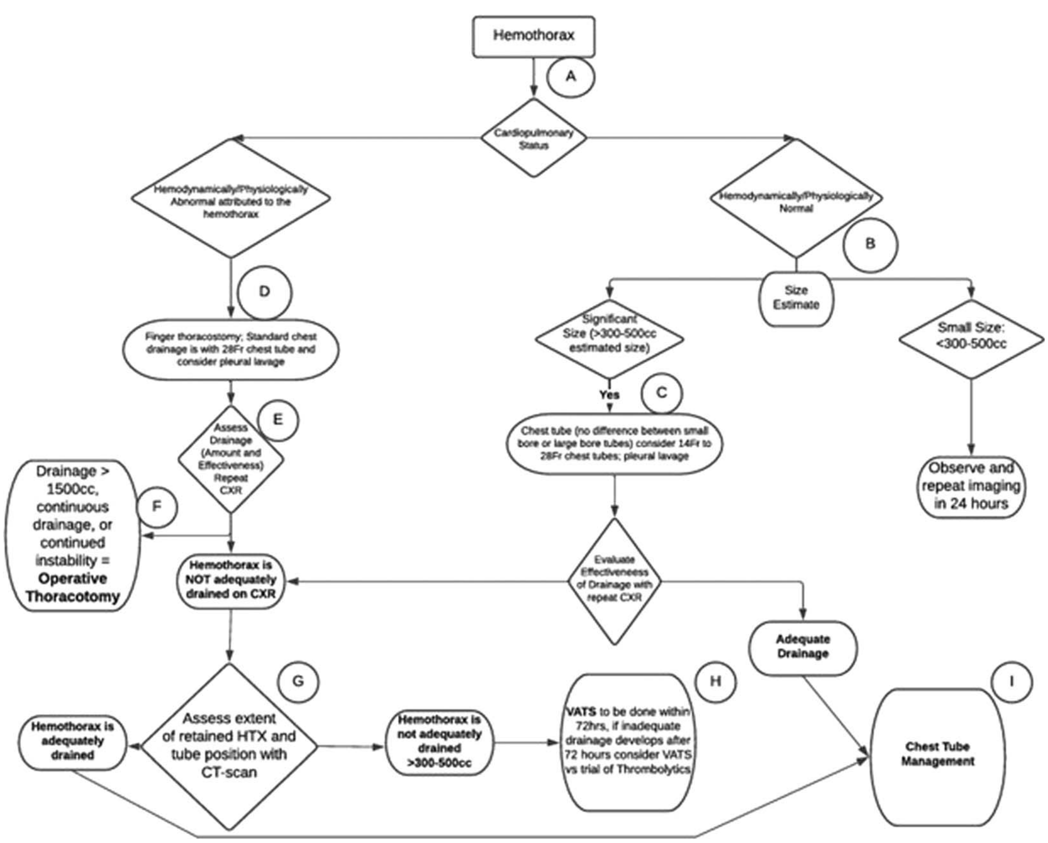

Figure 3. Western Trauma Association algorithm for the management of a hemothorax.[12]

If a hemothorax is identified on initial assessment, and the patient remains stable for CT evaluation, the Mergo formula may be used for volumetric estimation.[18] This formula provides a rough estimate of the hemothorax volume, which can be used to guide treatment. The volume cutoff for intervention, however, has not been validated. A retrospective single-center study at a Level I trauma center investigated observation of traumatic hemothoraces.[19] When comparing observation of hemothoraces smaller than 300 mL to those larger than 300 mL, they found that hemothoraces larger than 300 mL were predictive of observation failure.[19] At this institution, therefore, a guideline was implemented that recommended placement of a tube thoracostomy in hemothoraces greater than 300 mL. This was retrospectively reviewed by Al Tannir and colleagues[20]; implementation of the guideline decreased tube thoracostomy placement rates without a concurrent increase in observation failures or complications. In their EAST multi-institutional trial, Prakash and colleagues[21] evaluated patients with small (<300 mL), medium (300–900 mL), and large hemothoraces (>900 mL) and the need for drainage. Larger initial hemothorax volumes were predictive of retained hemothorax, and every 100 mL of hemothorax corresponded to a 15% increased risk of retained hemothorax.[21] Based on these data, hemothorax volume of 300 mL may be used to guide decision for drainage.

Chest Irrigation for Hemothorax

It is the authors' practice and recommendation that any tube thoracostomy placed for a hemothorax in a stable patient should be irrigated. Upon placement of a chest tube, any hemothorax is suctioned out. Next, 1 L of warm sterile saline is instilled via the chest tube in two 500-mL aliquots. This is again suctioned out, and the chest tube is connected to a closed-suction drainage system.[22] In a multi-institutional trial by Carver and colleagues,[23] this practice decreased the need for additional interventions, such as additional tube thoracostomy placement or operative intervention, by 44%.

Size of Chest Tube

Tube thoracostomy size has been hotly debated in recent literature. Percutaneous chest tubes are generally 8 to 14 Fr, whereas open chest tubes are larger than 16 Fr, most commonly 28 to 32 Fr. Animal experiments have demonstrated that percutaneous and open chest tubes are able to drain similar amounts of pleural fluid.[24] One explanation for this finding is that percutaneous chest tubes are generally placed in less emergent settings, and it is feasible that fluid has had more time to accumulate, resulting in a higher volume of drainage after initial placement.[24] Additionally, large-bore chest tubes are usually placed in more emergent settings, which can add to the selection bias between percutaneous and open chest tubes. In the case of a pneumothorax, small-bore chest tubes are associated with less pain at the insertion site than large-bore tubes, without any clinically significant differences in tube function.[25]

A multicenter randomized clinical trial investigated outcomes after placement of small-bore percutaneous chest tubes to large-bore open chest tubes in the setting of a hemothorax.[26] They found no significant difference between the two groups regarding failure rate, defined as patients requiring additional interventions for retained hemothoraces (additional chest tube placement, thrombolytics, or surgical intervention). Interestingly, the smaller-bore tubes were more successful at initial drainage, although these volumes equalized by 48 and 72 hours. The patients who received small-bore chest tubes reported improved tolerance of the procedure as compared with patients who received larger tubes.[26]

Additionally, a large meta-analysis regarding hemothorax drainage determined that there was no difference in failure rates, initial drainage output, ICU length of stay, ventilator days, and hospital length of stay when comparing percutaneous chest tubes (≤14 Fr) to open chest tubes (≥16 Fr). This study also found a significantly shorter tube duration and a lower rate of subsequent video-assisted thoracoscopic surgery (VATS) for percutaneous tubes.[27] Additionally, given the higher rate of VATS in the open chest tube group, these patients had a high rate of postoperative complications.[27] The EAST guidelines recommend placement of a percutaneous chest tube rather than an open chest tube in hemodynamically stable patients.[17]

Needle Decompression

Needle thoracostomy is a practice commonly used in the prehospital setting or in a setting where chest tube equipment is not available. This involves the placement of an angiocatheter in the fifth intercostal space in the midaxillary lines or in the second intercostal space at the midclavicular line anteriorly. The second intercostal space can be identified using the topographical anatomic landmark of the junction between the sternal body and manubrium, or the Angle of Louis. A cadaveric study by Inaba and colleagues[28] demonstrated that needles inserted at the lateral position more frequently entered the thoracic cavity, potentially because of the thinner chest wall tissue at this site. Needle decompression is not without its risks, namely, iatrogenic pneumothorax or intra-abdominal injury. If a pneumothorax is small, there is risk of iatrogenic parenchymal injury with needle decompression. Similarly, if a patient has challenging anatomic landmarks, a needle may be inadvertently placed in the abdomen. Therefore, this procedure should only be undertaken in the setting of a lack of supplies, as in prehospital care.

Travel

A commonly held belief is that it is unsafe for air travel after sustaining a traumatic pneumothorax. This is problematic for many travelers who sustain an injury while far from home. Commercial flights are pressurized but not to the level that one would experience on the ground.[29] There exist very little empiric data regarding flying after traumatic pneumothoraces. A retrospective review demonstrated that it is safe to fly as early as 72 hours after traumatic pneumothorax resolution.[30] Most societies recommend waiting to fly for approximately 1 to 2 weeks after radiographic resolution of a pneumothorax.[31] Some societies place contingencies on travel, such as recommending that a patient with a pneumothorax have a Heimlich valve in place, or one must travel with a medical accompaniment. Still, there exist no randomized data regarding air travel after a traumatic pneumothorax.

Chest Tube Removal

Chest tube removal is dictated by the initial indication for tube thoracostomy. If a chest tube was placed for a pneumothorax, in general, the tube is removed once the pneumothorax has resolved and the tube is no longer on suction. Conversely, a hemothorax must be nearly completely drained prior to tube removal. The literature varies regarding the volume threshold below which it is safe to remove a chest tube after a hemothorax, with a range of 150 to 200 mL of output per day.[32–34]

COMPLICATIONS

Retained Hemothorax

Chest tubes may not always be successful in completely draining a hemothorax. This is especially true in the case of a loculated hemothorax. Additional intervention options include placement of additional chest tubes, use of intrapleural thrombolytics, and surgical intervention either via VATS or open thoracotomy. While the volume of a retained hemothorax is debated in the literature, a hemothorax is considered "retained" if it persists beyond 72 hours after injury.[35] Initial treatment using thrombolytics was extrapolated from a double-blind randomized controlled trial that used DNase and tissue plasminogen activator in the treatment of empyema. This study found that the combination of the two thrombolytics reduced the rate of surgical management and hospital length of stay than either thrombolytic alone or a placebo.[36]

While this treatment may be used in traumatic hemothorax,[37] operative management should be considered for surgical candidates.[17] Eastern Association for the Surgery of Trauma has performed a meta-analysis regarding management principles of a retained hemothorax. Although the quality of evidence is low, EAST conditionally recommends VATS over intrapleural thrombolytic therapy because of the improvement in hospital length of stay, patient preference, and resource utilization.[17] When VATS is performed early, there is a significant improvement in hospital length of stay.[38] Early VATS (≤4 days) is recommended by EAST secondary to the improvement in drainage, decreased risk of thoracotomy, and decrease in hospital length of stay, ICU length of stay, ventilator days, and inpatient mortality.[17]

Recurrent Pneumothorax and Hemothorax After Chest Tube Removal

One must be cognizant that a pneumothorax may reaccumulate after removal of a thoracostomy tube placed for either indication; recurrent pneumothoraces occur at a rate of around 6% to 14%.[39] Some cite a thin body habitus as a contributing factor to recurrent pneumothoraces. Others practice chest tube removal on end-inspiration or end-expiration. While robust data are lacking, a South African study of patients with traumatic pneumothoraces after thoracic stab wounds determined that removal of a chest tube on end-inspiration had the same rate of recurrent pneumothoraces as removal on end-expiration, which was confirmed in a large meta-analysis.[40,41] This is also true of patients on positive-pressure mechanical ventilation.[42]

The thoracic literature states that chest tube removal need not be followed by a postremoval CXR if the patient is asymptomatic and has a sufficient observation period.[43,44] However, there are little data regarding chest tube removal in traumatically injured patients. One study stated that less severely injured patients who were not ventilated may be safely observed without CXR after chest tube removal.[45] If one wishes to avoid additional x-rays, ultrasound evaluation may be used. A prospective study of chest tube removal after traumatic pneumothorax demonstrated that bedside ultrasound has appropriate sensitivity and specificity for detecting a recurrent pneumothorax 3 hours after removal.[46]

Prolonged Air Leak

Chest tubes may be plagued by air leak, which signifies either tracheobronchial disruption or, more commonly, unresolved pulmonary parenchymal laceration. A prolonged air leak is one that persists for >5 days from placement.[47] There are very little data regarding the management of this issue. A retrospective review by Halat and colleagues[47] demonstrated that patients with severe air leaks (constant stream of bubbles within the water chamber) benefitted from early surgical management, whereas minor air leaks (minimal bubbling) were likely to resolve without surgical intervention.[47] The thoracic literature demonstrates that there is no difference in prolonged air leak, chest tube duration, or hospital length of stay when chest tubes are placed to −20 cm H_2O suction or water seal.[48] Additionally, interventions such as chemical pleurodesis, endobronchial valves, and blood patch placement have been investigated, but none have been evaluated in a randomized fashion.[49]

CONCLUSION

Pneumothoraces and hemothoraces are common traumatic injuries. Management should be based first on the patient's physiology and second by the volume of the pneumothorax or hemothorax. Percutaneous and open chest tubes are equally effective, although open chest tubes are more likely to be used in emergent situations. Preprocedure antibiotics should be used in nonemergent situations. Retained hemothoraces should be managed with VATS in the appropriate surgical candidate; this procedure should be performed within 4 days of injury.

AUTHORSHIP

J.J.B. and M.A.D. contributed to the outline of this manuscript. J.J.B. drafted the manuscript, figures, and tables, which were edited by M.A. D. M.A.D. provided critical revisions. All authors have approved of this manuscript.

DISCLOSURE

Conflicts of Interest: Author Disclosure forms have been supplied and are provided as Supplemental Digital Content (http://links.lww.com/TA/E641).

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