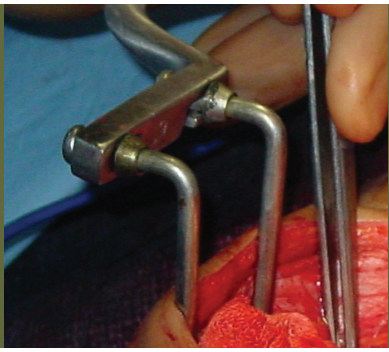
# Chapter IX
# SPECIAL SCENARIOS



# IX.1 Penetrating Pediatric Trauma, I

## CASE PRESENTATION

This 5-year-old host nation male was injured by some form of exploding ordnance or improvised explosive device (IED). The patient sustained numerous penetrating fragment wounds. He presented awake, alert, and hemodynamically stable. Secondary survey revealed an open comminuted right mandibular fracture (Fig. 1), an open right nasomaxillary fracture, evisceration through a large abdominal wound to the right of the umbilicus, multiple penetrating injuries to the abdominal wall, and amputation of one digit on the right hand (Fig. 2). These injuries warranted immediate laparotomy, and the patient was taken directly to the operating room. Through a generous midline laparotomy (Fig. 3), it was discovered that he had sustained multiple intestinal perforations, including 1 hole in the gallbladder, 2 holes in the second portion of the duodenum, 8 holes in the small bowel, and 4 holes in the colon. The patient also had a large liver laceration that was bleeding minimally. His gallbladder was removed, and the common bile duct and pancreas were uninjured. There was a small bridge of duodenum connecting the two penetrating injuries that allowed debridement of the wounds, removal of the intervening bridge, and examination of the sphincter of Oddi, which was uninjured. The duodenum and portions of the small bowel and colon were repaired (with two primary anastomoses). Several other enterotomies that did not fall within reasonable resection margins were also repaired. A closed-suction drain and a Stamm gastrostomy were placed next to the duodenal repair. Postoperatively, the patient did well, although he required jaw wiring for his mandibular injury. The nasomaxillary fracture was caused by a fragment that lodged intracranially in the interhemispheric sulcus and was not removed. This condition left him with mild neurological deficits, including some gait disturbance that improved with time and therapy. A duodenal contrast study on postoperative day 7 was normal (Fig. 4), and he was allowed to eat, which resulted in a prompt and significant weight gain. The drain was removed at that time. The patient continued to do well and was eventually discharged.


## TEACHING POINTS

1. Blast and fragment injuries to children from explosive remnants of war cause enormous public health issues worldwide.

FIGURE 1. *Open mandible fracture. An open right nasomaxillary fracture is barely visible in this photograph.*

2. Children differ greatly from adults in ways that impact evaluation and management. Their vital signs vary with age and could give a false impression of physiological derangement. They have a greater ability to autoregulate perfusion than adults and are able to maintain normal blood pressures up until the last moments prior to irreversible cardiovascular collapse. Early recognition of the shock state is critical. Indicators such as tachypnea; tachycardia; ashen color; cool, clammy extremities; mottled appearance; and delayed capillary refill may be more useful than blood pressure. In children who have completely healthy hearts and lungs, the tendency should be to overtreat shock. It is unlikely that an otherwise healthy, injured child will be hydrated into congestive heart failure.
3. Airway access can be much more difficult to obtain than in adults. Even brief periods of apnea can lead to cardiac arrest. In the prehospital setting, bag-valve mask ventilation is preferred to endotracheal intubation because it is easier, quicker, and does not affect survival adversely.
4. Vascular access can be very difficult in small children. It is exacerbated by blood loss and agitation. Peripheral intravenous access should be the first choice, with a very short threshold to resort to intraosseous infusion. Insertion of an intraosseous needle is a rapid and simple procedure that may be a lifesaving bridge to more definitive venous access. Central lines should only be attempted by experienced pediatric providers and come after intraosseous infusion in order of priority.
5. Children have relatively large heads, predisposing them to head, cervical spine, and spinal cord injury. They have a larger body surface to body mass ratio, which results in a greater tendency to hypothermia. Every attempt must be made to ensure that they remain warm during resuscitation and operation.
6. Children have incompletely ossified skeletons that tend to be very elastic. Children subjected to very high-energy traumas may have relatively few fractures, but may still have sustained significant internal injuries.
7. An infant's abdomen (from birth to 12 months) is largest in the transverse direction. In this age group, a transverse incision approximately 1 fingerbreadth above the umbilicus affords maximum exposure. Above 1 year of age, midline incisions are preferable.

## CLINICAL IMPLICATIONS

1. Simple duodenal injuries are best repaired primarily provided the lumen will not be reduced by more than 50%. Complex injuries may require full duodenal exposure (Kocher maneuver) and primary anastomosis or Roux-en-Y duodenojejunostomy. Pyloric exclusion should be used in all complex wounds or where repair is tenuous. This procedure can be done with absorbable pyloric sutures placed intraluminally through a distal gastrotomy or by a noncutting transverse staple line across the pylorus. Neither technique is permanent, and the lumen recanalizes in several weeks.

FIGURE 2. *Right-hand injury after surgery.*

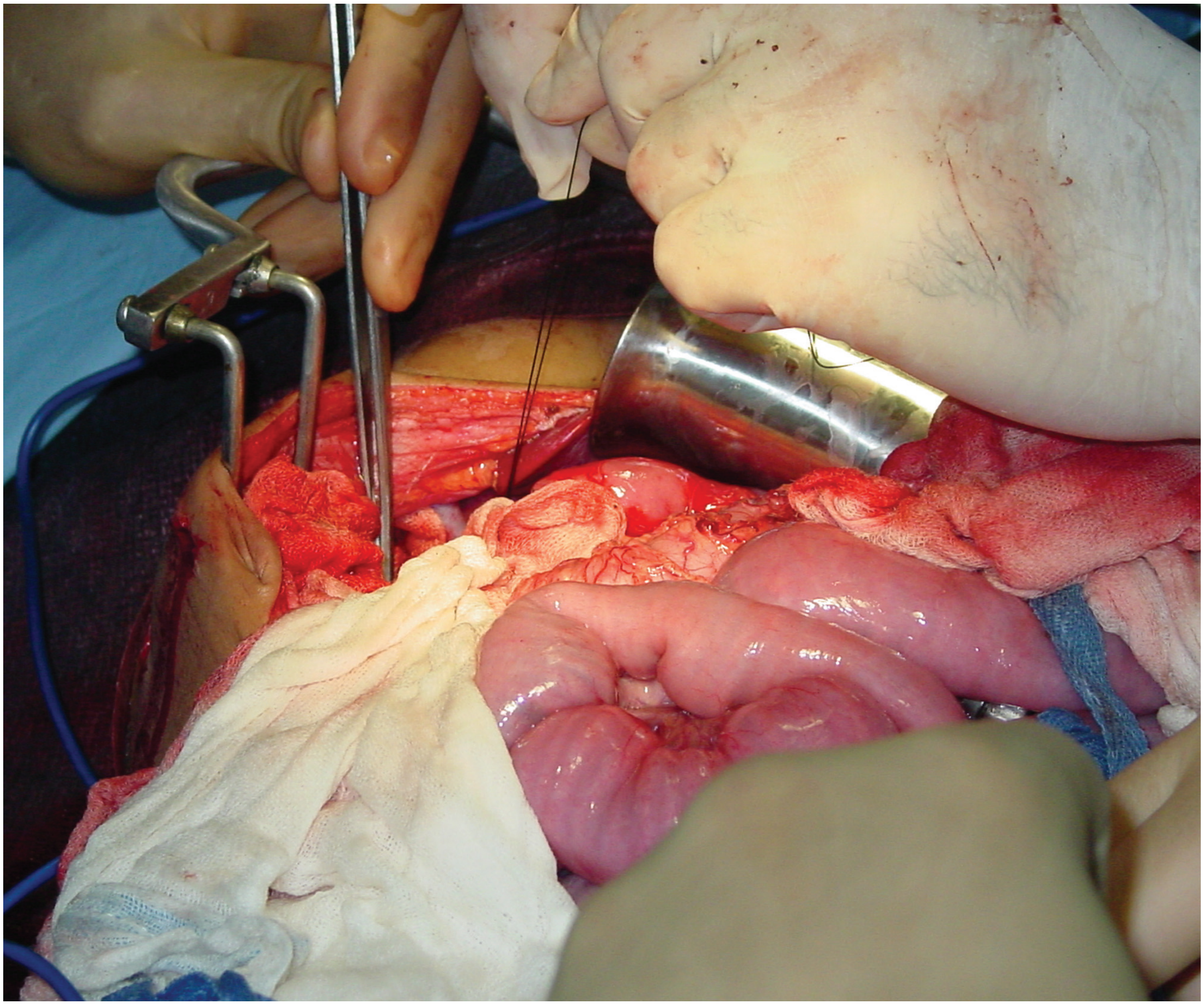


Figure 3. *Laparotomy in a 5-year-old male performed through a midline incision.*

2. Duodenal repairs are prone to leak, especially if complicated by shock and injuries to multiple organ systems. The patient's condition, concomitant injuries, and external factors (eg, echelon of care, total number of injured patients, and critical care assets) must be considered when deciding on treatment options.
3. Upper gastrointestinal contrast study with fluoroscopy can be performed at most level III medical treatment facilities and can be very useful prior to initiation of feeds and removal of tubes and drains.
4. Gallbladder injuries are rare and are best treated by cholecystectomy.
5. In children who have any degree of hypotension, hypoxia, hypothermia, and significant soilage or tissue destruction, primary intestinal anastomoses should be avoided. In this setting, the repair of multiple colonic perforations should be diverted proximally. The same is advisable for the small intestine, although very proximal small intestinal ostomies should be avoided because of profound postoperative derangements from intestinal fluid losses. Multiple perforations alone or combined with multiple concomitant injuries are not contraindications of primary repair. If, during such repairs, the child becomes unstable, this strategy should be switched immediately to damage control.

## DAMAGE CONTROL

1. Controlling sepsis is much more important for immediate survival than intestinal continuity or definitive reconstruction.

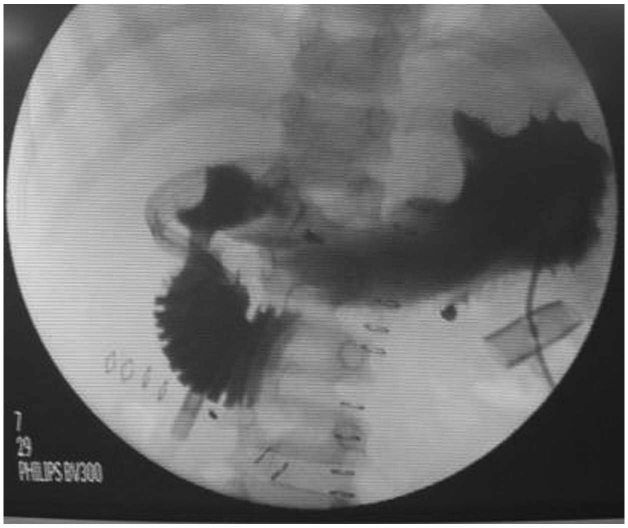



FIGURE 4. *Gastroduodenal fluoroscopy revealed no extravasation of contrast on postoperative day 7.*

2. When faced with a persistently unstable or hypothermic patient, a duodenal injury can be rapidly controlled with stapled pyloric exclusion, duodenostomy tube decompression, and multiple closed-suction drains placed around the injury. This can lead to a quick end to the operation and an opportunity to pursue aggressive rewarming and resuscitation so that the patient can survive and become stable for a second, more definitive surgery.

## SUMMARY

This is an unusual case of fragment wounds in a 5-year-old boy causing multiple intestinal perforations, including gallbladder and duodenal injuries. To provide optimal care, it is important to consider anatomical and physiological differences between children and adults. Duodenal injuries vary greatly in complexity and can be highly morbid. The judicious use of adjuncts—such as gastrostomy tube, pyloric exclusion, duodenostomy tube, and closed-suction drainage—will, hopefully, minimize the risk and sequelae of postoperative leak. In some instances, multiple intestinal and colonic perforations may be primarily repaired without diversion. Surgeons should divert proximal repairs if the patient has suffered any physiological derangement prior to or during surgery.

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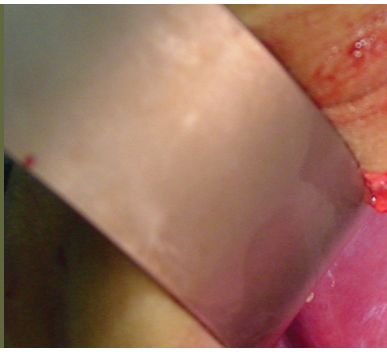

# IX.2 Penetrating Pediatric Trauma, II

## CASE PRESENTATION

This 5-year-old male, one of three children who presented to a combat support hospital (CSH), was wounded after triggering an unexploded ordnance (Fig. 1). His lower extremity injuries included a right femur fracture with significant associated tissue injury, as well as other soft-tissue injuries (Figs. 2 and 3). The patient had multiple wounds of the abdomen and lower extremities. After initial resuscitation, he was taken to the operating room. During surgery, colon and kidney (Fig. 4) injuries were found. The midtransverse colon injury was closed in two layers (Fig. 5), and the right kidney laceration required no further treatment after it was identified. The open femur facture was treated with external fixation after a washout. Later, the wounds were skin grafted with excellent results.

## TEACHING POINTS

1. In combat zones, Forward Surgical Teams (FSTs) and CSH personnel must be prepared to treat pediatric patients. The medical rules of engagement during Operation Iraqi Freedom provided for treatment of Iraqi civilians who were injured during US Armed Forces operations. Many children were brought to US medical facilities by their parents. Treatment of medical and congenital surgical conditions was frequently authorized.
2. In a combat environment, a multispecialty team approach is normally required with all types of patients. This patient, with serious abdominal and lower extremity injuries, required general surgery and orthopaedic surgery. Pediatricians are an essential part of this team, but are typically not assigned to the CSH. Prolonged care at the CSH was necessary for this patient because civilian facilities were not available.
3. The external fixator placed on the femur fracture remained until healing was complete. Skin grafting was also performed. During his 3-month stay, the patient gained 15 pounds.
4. Family members of the patient frequently visited the hospital and interacted with staff. They were grateful for the care that the child received. Care also included hiring local, English-speaking civilians to work as translators.

## CLINICAL IMPLICATIONS

The initial, Advanced Trauma Life Support (ATLS) approach to pediatric

FIGURE 1. *A 5-year-old Iraqi male on admission to the CSH.*

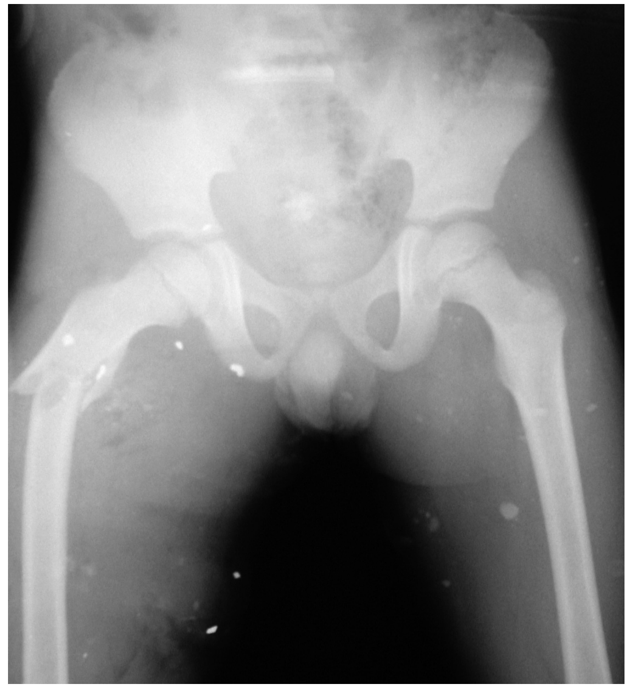

FIGURE 2. *Radiograph of the right pelvis. Note femur fracture and multiple fragments in the soft tissues.*

FIGURE 3. *Large soft-tissue injuries associated with the right femur fracture.*

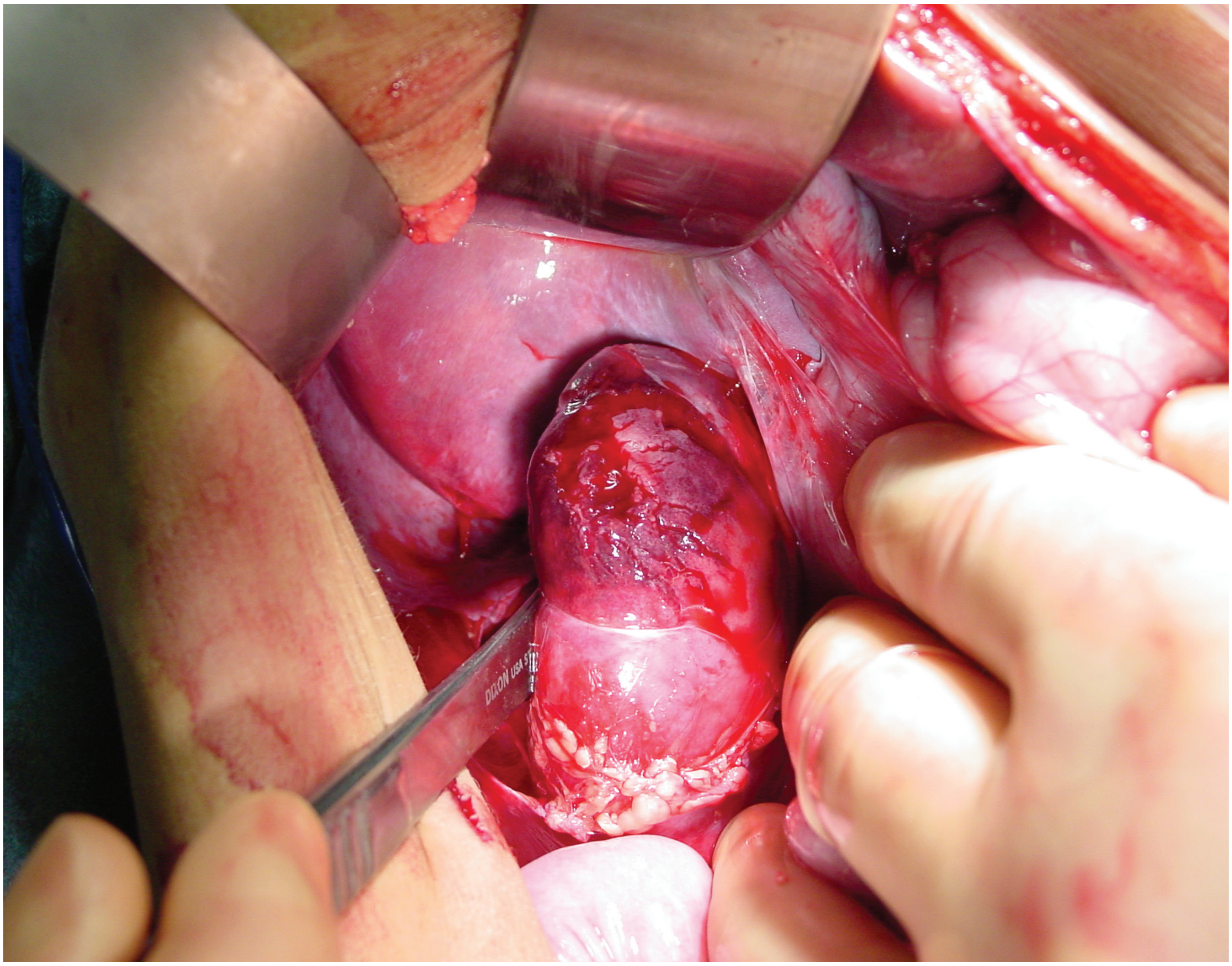

FIGURE 4. *Right kidney laceration.*

trauma patients is the same as for adults. However, there are also special considerations:

1. Infants and young children are especially prone to heat loss and must be kept warm.
2. Systolic blood pressure less than 90 mm Hg is associated with high mortality rates, and early blood transfusion is often necessary in young children with multiple wounds.
3. Children more than 3 months old have a blood volume of about 70 cc/kg. This means that a child weighing 15 kg has a total blood volume of 1,050 cc.
4. FSTs and CSHs should be equipped with the Broselow/Hinkle Pediatric Resuscitation System.
5. As a general guideline, transverse incisions should be used in infants to minimize postoperative dehiscence while still allowing adequate exposure.

## DAMAGE CONTROL

If intravenous (IV) access cannot be obtained in a peripheral or femoral vein, intraosseous access is an effective alternative. The needle should be placed 2 to 3 cm below the tibial tuberosity. IV fluid, blood, and drugs (including bicarbonate, epinephrine, antibiotics, and atropine) can be infused through the intraosseous line. Fracture sites should not be used.

## SUMMARY

Pediatric trauma is common in the combat environment and should be anticipated. To obtain optimum care, pediatric patients require a multispecialty team approach. Meticulous attention to postoperative care that recognizes the limited reserve of young patients is essential.

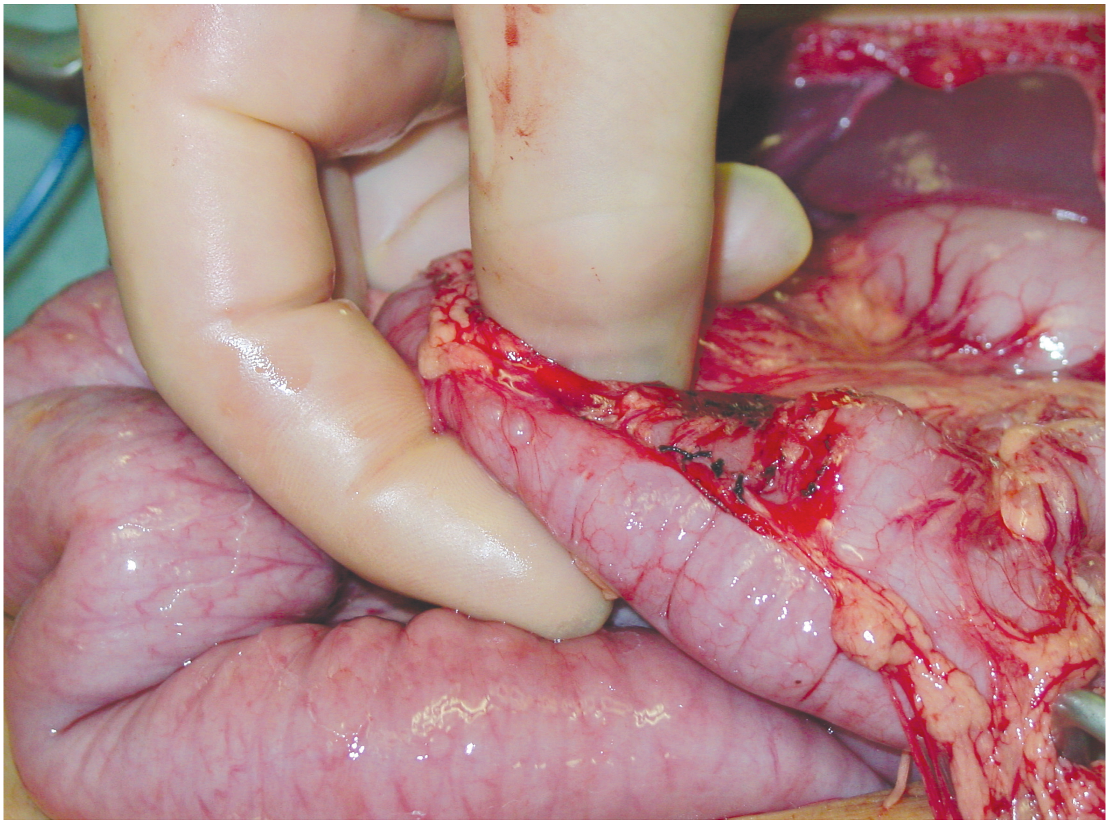

FIGURE 5. *Colon injury repaired in two layers.*

**BROSELOW/HINKLE PEDIATRIC RESUSCITATION SYSTEM**

This patented system is commonly used for emergency pediatric resuscitative care. It was developed by James Broselow, MD, and Alan Hinkle, MD. This resuscitative system takes into consideration the direct correlation between the pediatric patient's body length and the proper size of emergency supplies and correct drug dosages. The Broselow/Hinkle system consists of the following items:

- Tape measure with eight color zones.
- Corresponding series of color-coded, single-patient use emergency kits.

These items are all organized and identified in a nylon organizer bag that is ready for any pediatric emergency.

## SUGGESTED READING

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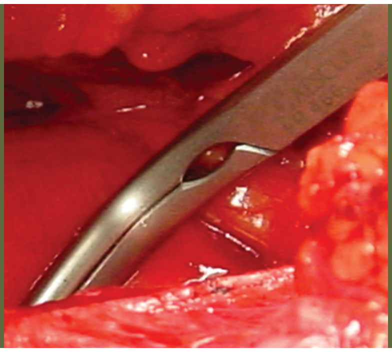

# IX.3 Removal of an Unexploded Ordnance

## CASE PRESENTATION

A 23-year-old male soldier was air evacuated to a Forward Surgical Team (FST) facility. The patient was described in-flight as hypotensive and having metallic fragments in the abdomen. Upon arrival, the primary survey revealed an impaled rocket. Only the tail was visible, with the majority of the rocket—and potentially the warhead—inside the patient. The rocket entered the left iliac wing, traversed the abdominal cavity, and tented the skin over the right greater trochanter (Fig. 1). The medical treatment facility was evacuated, except for the surgeon in charge of resuscitation and three medics. The explosive ordnance disposal (EOD) team was contacted. The patient's clinical condition deteriorated with worsening hypotension, marked bradycardia, and respiratory distress. Emergent intubation was performed, followed by aggressive volume resuscitation that included packed red blood cell transfusion. In addition, intravenous epinephrine was administered to reverse the bradycardia and hypotension. Epinephrine and volume resuscitation were sufficient to return the blood pressure and heart rate to within normal limits. Radiographs were used to determine the status of the suspected unexploded ordnance (UXO). No further movement of the patient was attempted because it presented an additional risk for detonation of the UXO. Radiographs revealed that the warhead was not attached to the round (Fig. 2). The patient was then moved to the operating room (OR). The decision was made to remove the UXO expediently. First, the skin was incised over the right anterior hip, where the tip of the round was protruding (Fig. 3). To gain control of the round and to remove bulky clothing that was pulled into the wound tract, a midline laparotomy was performed. While the surgeons stabilized the shaft of the rocket in the abdomen, an EOD team member sawed off the tail of the rocket at the level of the skin on the patient's left side. This allowed the UXO to be removed by pulling the round, in a left-to-right direction, across the pelvis through the abdomen (Fig. 4). Intraoperative findings included multiple, small-bowel perforations, as well as cecal and sigmoid colon perforations. These were repaired. In the original exploration, no major vascular, ureteral, or bladder injuries were identified. In addition to the intraabdominal injuries, a comminuted fracture of the left iliac crest, third-degree burns over the right proximal thigh, and extensive contamination of the lateral right thigh muscles were noted. The patient was then transferred to a level

FIGURE 1. *UXO tenting the subcutaneous tissue of the right thigh, having traversed the pelvis in a left-to-right transit. The extruding tail of the rocket at the patient's left is visible in the photo* (arrow).

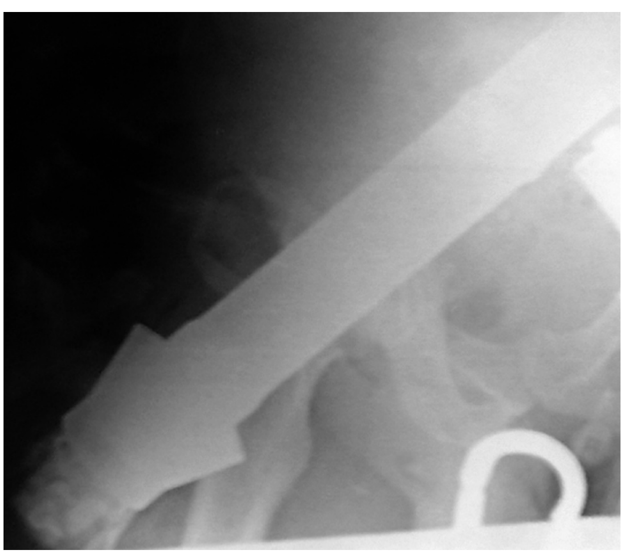

FIGURE 2. *Radiograph of the UXO embedded in the pelvis and femur. The warhead is not attached to the rocket.*

III medical treatment facility in stable condition. He survived his injuries and recovered well.

## TEACHING POINTS

1. Identification of a patient with embedded UXO is critical in order to properly triage, transport, and manage the individual. Recommended management of a UXO includes triaging the patient as nonemergent and placing the patient far apart from other patients. If helicopter transport is deemed necessary, appropriate precautions include grounding the patient to the aircraft, limiting the flight crew, ensuring that the flight crew is wearing body armor, and putting other patients on a separate flight. In this case, failure to identify the UXO lead to the patient being transported by helicopter to an FST simultaneously with three routine patients, placing everyone on the aircraft at risk.

2. Proper notification of the treatment team of a patient with an embedded UXO is imperative to allow for preparation of the medical facility and expedient management of the patient. In this case, the receiving facility did not get a report indicating that the patient had a UXO. As a result, the patient was taken directly to the medical treatment facility for urgent resuscitation and damage control laparotomy, placing the entire facility and treatment personnel at risk.
3. It is necessary to isolate the patient in an area separate from the main OR and to use the minimal number of personnel required to remove the ordnance safely and treat the patient. The patient and the treatment personnel should be protected by sandbags. All personnel involved in patient treatment should wear body armor, ballistic eye protection, and helmet protection. Lein et al,[1] in a retrospective review of a 50-year military experience removing UXOs from patients, recommended that anesthesia personnel leave the OR after induction of anesthesia. From our experience, this recommended practice is situation-dependent and dictated by the type of operation planned. Further recommendations include, whenever possible, that the round be removed under spinal or local anesthesia. However, with torso injuries, positioning the patient for a spinal anesthetic would be difficult, if not impossible. It is prudent to keep the patient paralyzed during treatment to minimize physical disturbance of the ordnance. Therefore, it is simpler and quicker to intubate the patient, providing general anesthesia using a nondepolarizing paralytic agent for induction.
4. Diagnostic adjuncts must be chosen carefully. Plain radiographs have been demonstrated to be safe.[1,2] Although not substantiated, it is wise to avoid use of CT, magnetic resonance imaging (MRI), and defibrillators during the initial evaluation. During surgery, electrocautery and electromagnetic instruments should be avoided until the UXO is removed. Interestingly, Schlager et al[2] demonstrated the safety of ultrasound in identifying explosive small arms rounds seen in civilian trauma. However, it is unknown if this experience can be applied to the military, where larger munitions (eg, rocket-propelled grenades or mortars) are encountered.

## CLINICAL IMPLICATIONS

1. The presence of EOD personnel is critical to the proper handling and disposal of UXO. Although resuscitation should be initiated immediately, prior to definitive removal of the UXO the presence of EOD personnel is strongly advised.
2. In the most recent review of UXO by Lein et al,[1] 31 of 31 patients survived without further injury to the patient or medical personnel.

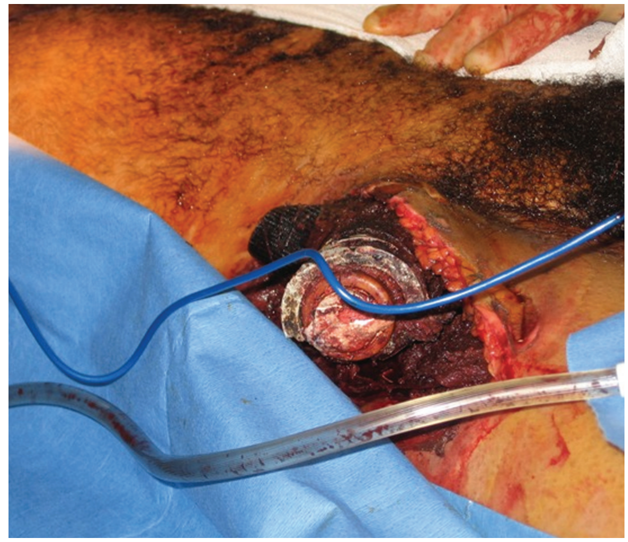

FIGURE 3. *Round protruding from the right hip.*

FIGURE 4. *Removed missile.*

## DAMAGE CONTROL

1. Based on the tactical situation and casualty flow, the patient with an embedded UXO may not be treatable despite apparent survivable injuries.
2. En bloc resection is the most expeditious way to minimize manipulation and risk associated with UXO removal. Manipulation of the UXO during the removal should be minimized. If embedded in an extremity, amputation should be considered.

## SUMMARY

Embedded UXO is rare, but it presents many challenges to the operating surgeon. Despite previous recommendations, this clinical presentation requires constant reassessment. The type of equipment, diagnostic adjuncts, and number of personnel necessary for treatment depend on multiple factors, including the following:

1. Type of ordnance.
2. Location of the injury.
3. Condition of the patient.
4. Facilities and resources available.
5. Tactical situation/casualty flow.

We recommend that the UXO be removed in the most efficient and expedient manner possible, with minimal physical disturbance to the ordnance. To control the environment, use general versus spinal anesthesia. Having the appropriate, rather than the minimal, number of assistants in the OR to provide optimal visualization and assistance will lead to the most successful outcome.

## REFERENCES

1. Lein B, et al. Removal of ordnance from patients: A 50-year military experience and current recommendations. *Mil Med*. 1999;164(3):163–165.
2. Schlager D, et al. Safety of imaging exploding bullets with ultrasound. *Ann Emerg Med*. 1996;28(2): 183–187.

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Chapter 17: Abdominal injuries. In: *Emergency War Surgery, Third United States Revision*. Washington, DC: Department of the Army, Office of The Surgeon General, Borden Institute; 2004.

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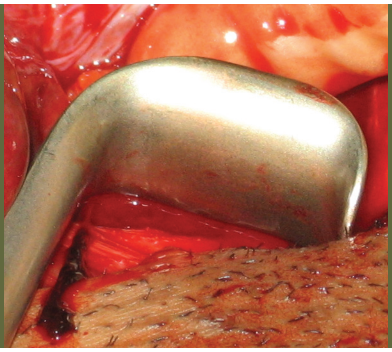
*Editor's Note*: The use of epinephrine, as was done in this case, is not recommended in present ATLS (Advanced Trauma Life Support) protocols for the resuscitation of shock. We suspect this intervention may have been in response to the patient presenting with bradycardia. It has been noted elsewhere, however, that relative bradycardia may commonly accompany acute shock.



# IX.4 Ectopic Pregnancy

## CASE PRESENTATION

A 28-year-old female soldier presented to the combat support hospital (CSH) with complaints of unscheduled vaginal bleeding and pelvic pain. She was unsure of her last menstrual period, did not use a reliable form of contraception, and reported having unprotected intercourse 3 weeks previously while on mid-deployment leave. Physical examination revealed a tender pelvic area, old blood in the vaginal vault without active bleeding, and a closed cervical os. Laboratory results included a normal hematocrit and a positive, qualitative serum β-human chorionic gonadotropin (β-hCG) assay (quantitative titers were not available). Pelvic ultrasound revealed a cystic mass with a yolk sac in the left adenexa. The patient underwent a laparotomy. Hemoperitoneum was discovered on entry, and the left adenexa was delivered through the incision (Figs. 1 and 2) to allow a linear salpingostomy (using electrocautery) to remove the products of conception. Hemostasis was achieved, and the laparotomy incision was closed in the usual manner.

## TEACHING POINTS

1. Women comprise approximately 15% of active-duty personnel in the US Armed Forces.[1] A similar proportion constitutes the forward deployed forces, therefore making the capacity to perform emergent gynecological surgery essential.
2. In a clinically stable patient suspected of having an ectopic pregnancy, laparoscopy has virtually replaced laparotomy as the standard of care within the United States. However, laparoscopic equipment is typically not available at the CSH.
3. Availability of ultrasound varies based on level of care, mobility of the unit, and the tactical situation. These conditions may make diagnosis and treatment of ectopic pregnancy difficult.


## CLINICAL IMPLICATIONS

1. Surgeons skilled in the diagnosis and treatment of emergent gynecological conditions are critical to a deployed CSH.
2. Variations in available technology make the diagnosis of ectopic pregnancy more challenging and may necessitate changes in usual practice patterns.

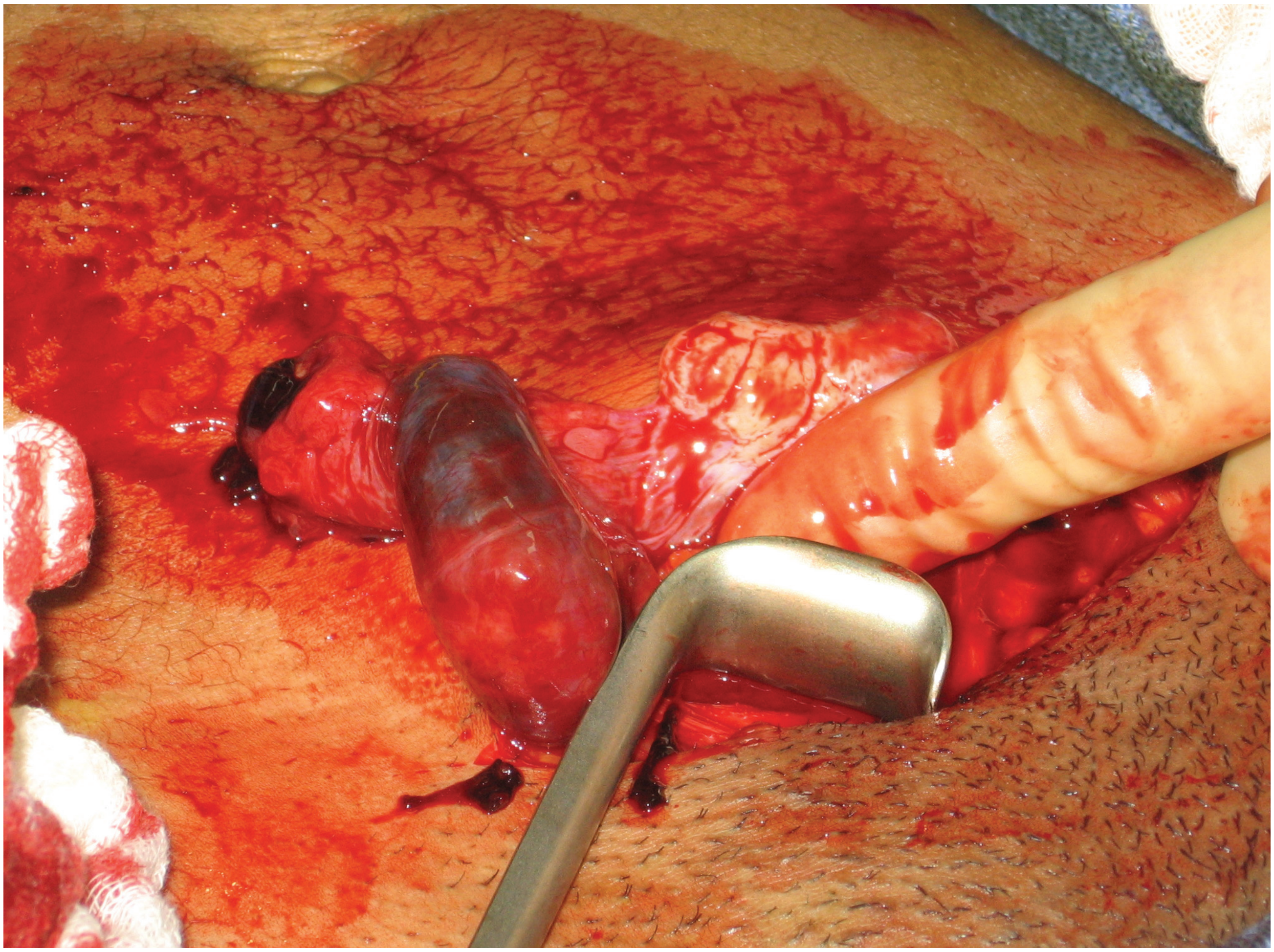


FIGURE 1. *Ectopic (left tubal) pregnancy.*

## DAMAGE CONTROL

In the deployed environment, any female soldier presenting with an acute abdomen and having a positive, qualitative β-hCG should undergo an exploratory laparotomy. Choice of salpingectomy versus linear salpingostomy should be based on risk of subsequent bleeding, condition of the fallopian tube, and future fertility desires.

## SUMMARY

Emergent gynecological surgery will occur in theater. Availability of diagnostic and operative tools, as well as individual skill sets, provides unique clinical challenges to the deployed clinician. Ultrasound is increasingly available, but the ability to perform and interpret these scans will vary based on tactical and clinical settings. Laparotomy replaces laparoscopy as the standard approach, if the latter is unavailable. Before deployment, female soldiers must have a negative pregnancy test. Consideration should be given to expanding this policy to include documenting a negative test before returning from leave in an effort to maintain combat power and avoid unscheduled evacuation from theater operations.

## REFERENCE

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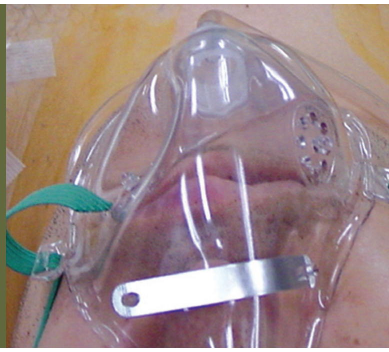
Figure 2. *Fallopian tube is exposed through a laparotomy incision.*



# IX.5 Continuous Peripheral Nerve Block

## CASE PRESENTATION

A 21-year-old male sustained a rocket-propelled grenade fragment injury to his left calf. A tourniquet was applied in the field, and the patient arrived at the Combat Support Hospital (CSH) within 60 minutes of injury (Fig. 1). The soldier was in significant discomfort on arrival at the CSH despite being treated with intravenous (IV) morphine sulfate (18 mg) that was given during transport and at the CSH. His vital signs were normal, with the exception of mild tachypnea at 27 breaths/minute. His oxygen saturation was 100%, and his hematocrit was 44.4%. Neurological examination of the wounded extremity indicated loss of motor and sensory functions of the left tibial nerve. Perfusion and neurological function were otherwise intact. The patient was prepared for an emergency exploration and debridement of the wound. He was offered a left lumbar plexus and a left sciatic nerve continuous peripheral nerve block (CPNB) for surgical anesthesia and prolonged perioperative pain control. The CPNB catheters were placed by an anesthesiologist trained in advanced regional anesthesia. The patient was sedated for the block with midazolam (4 mg IV) and fentanyl (175 µg) in divided doses. He remained alert and conversant throughout the block procedure, which lasted approximately 20 minutes. He experienced complete pain relief in his left leg within 3 minutes of local anesthetic injection (30 mL of 1.5% mepivacaine with 1:400,000 epinephrine injected at each CPNB catheter site). Surgical level block was confirmed in the left extremity, with loss of hip flexion and foot dorsiflexion. The patient was lightly sedated with propofol and remained intermittently conversant throughout the 85-minute surgical procedure that included inadvertent fracture of the patient's tibia intraoperatively. Postoperatively, the patient was alert and pain free in the CSH recovery area and required minimal nursing intervention (Fig. 2). That evening, he was transported to the airport via a 40-minute helicopter flight, followed by a 5-hour flight to a level IV medical treatment facility. He remained pain free with his CPNB infusions (Fig. 3) during the flight. He required no further flight nurse interventions, allowing the nurses to focus on other patients. The patient continued using the CPNB catheters for a total of 16 days throughout dressing changes and continuous perioperative pain management during his evacuation to the United States and subsequent recovery at Walter Reed Army Medical Center. During this time, the catheters were used four additional times to reestablish a surgical level

FIGURE 1. *Traumatic left calf wound.*


FIGURE 2. *Patient is alert, interactive, and pain free just minutes after the operation.*

nerve block. Surgical exploration revealed complete loss of the tibial nerve and deep venous system. After a prolonged course complicated by continuous ischemic pain, he elected to undergo below-the-knee amputation. The patient returned to duty with a left leg prosthesis. He remains pain free and is an active runner.

## TEACHING POINTS

1. This case illustrates some of the advantages of early advanced pain control at the CSH in the management and evacuation of a seriously wounded soldier. This technique requires minimal logistics support (compared with general anesthesia techniques), produces profound pain control during long evacuation flights (Fig. 4), and reduces the patient care burden on medical personnel during long evacuation flights. The use of CPNB in extremity wounds for surgical anesthesia promotes less anesthetic drug use, resulting in alert, pain-free patients who can participate actively in their own evacuations. The ability to reestablish surgical blocks for frequent dressing changes and surgical procedures further enhances the value of this anesthetic choice in saving medical resources. The local anesthetics


Figure 3. *"ambIT" pain pump currently approved for CPNB on military aircraft. (See http://www.arapmi.org for information on pain pump infusion technology currently approved for military use.) Photograph used with permission from Sorenson Medical, Inc, West Jordan, Utah.*

used in CPNB do not cause sedation or respiratory depression. These anesthetics reduce the patient's requirement for opioid pain medications that do manifest these side effects.

2. Neurological examination of the body region to be blocked is required before institution of the CPNB procedure. All CPNBs should be placed in consultation with the operative surgeon.
3. The use of advanced regional anesthesia in combat trauma patients requires significant experience and training. The level III CSH is likely the first point where advanced regional anesthesia can be practiced with consistency.
4. Specialized equipment and practice protocols are needed for safe implementation of the technology. Advanced regional anesthesia is most effective when practiced as part of a multimodal pain therapy plan instituted by the healthcare facility's acute pain service.

## CLINICAL IMPLICATIONS

1. CPNB is an important battlefield anesthetic option for improved, acute pain management and evacuation.
2. Personnel trained in advanced regional anesthesia are an integral part of any deployed acute pain service.
3. It is important to note that CPNB—like other analgesic technologies—will not completely cover the pain of ischemia associated with a developing compartment syndrome. Vigilance and frequent reexamination are still required to identify this complication.

## DAMAGE CONTROL

This technique is not appropriate for healthcare facilities without an acute pain service and trained personnel to manage CPNB catheter infusions.

## SUMMARY

This case demonstrates the clinical advantages of CPNB in austere medical environments when appropriate resources are available for acute pain management at the CSH.


FIGURE 4. *Bilateral intraclavicular CPNB in a different patient with bilateral arm amputations following a Black Hawk tire explosion. This soldier also benefited from profound pain control during evacuation to the United States.*

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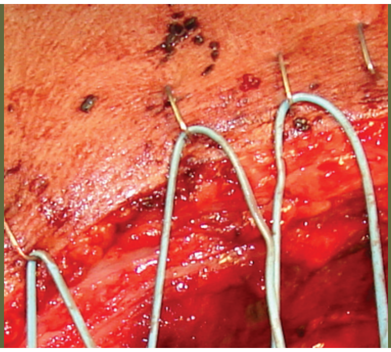

# IX.6 Pediatric Popliteal Artery Trauma

## CASE PRESENTATION

A 10-year-old Afghan male presented at a Forward Surgical Team (FST) facility 4 hours after being shot. The patient presented with a heart rate of 86 beats per minute, blood pressure of 120/86 mm Hg, and was awake and alert. He had an entrance wound lateral and superior to the right knee with a medial exit wound at the level of the knee (Fig. 1). A large hematoma limited the patient's range of motion at the knee joint. There were no palpable anterior tibialis or dorsalis pedis pulses. Doppler flow was also undetectable distally. The extremity was cool to the touch and appeared dusky. However, the patient was able to move his toes, and sensation was intact to light touch. No other injuries were identified. Clinical presentation in this male was consistent with popliteal artery injury. The decision was made to attempt limb salvage at the FST based on the time elapsed since injury. Per the Afghanistan culture norm, the father of the patient would only consent to an attempt to save the leg. Therefore, amputation was not considered an immediate option in this case. The patient was taken to the operating room, prepped, and draped from the nipples to the feet of both extremities. A no. 8 French Foley catheter was placed, as well as two 18-gauge intravenous catheters. The proximal femoral artery and femoral vein were exposed, and the artery was isolated with a vessel loop. The popliteal artery and vein were then approached medially (Figs. 2 and 3). On entering the hematoma, there was significant hemorrhage. Proximal control was obtained at the level of the femoral artery using the previously placed vessel loop. This maneuver allowed exposure of the popliteal artery. The artery was completely transected, and approximately 2.5 cm of the vessel had been destroyed. The proximal and distal ends of the artery were secured with vessel loops. The popliteal vein was intact. Several bridging veins were injured and secured with 3-0 silk ligatures. A no. 8 French Argyle shunt was then placed in the popliteal artery, the proximal vessel loop was loosened, and 2,500 units of heparin was administered. This did not result in acceptable distal flow determined by the absence of either palpable or Doppler flow distal to the injury. A segment of the ipsilateral greater saphenous vein was harvested and reversed. A 20-gauge angiocatheter was inserted into the reversed end of the vein and used to dilate it with normal saline. The popliteal artery was then debrided proximally, and an oblique incision was created in the artery and saphenous vein. Proximal anastomosis was made with 5-0 Prolene, and this process was repeated distally (see Fig. 2). A four-compartment fasciotomy was performed through generous medial and lateral incisions.

FIGURE 1. *Appearance of the extremity shortly after admission.* Arrow *indicates presumed exit wound.*

The patient had palpable distal pulses at the end of the case and a normal neurological examination.

## TEACHING POINTS

1. Personnel assigned to this facility were obligated to care for this patient. There is no doubt pediatric patients will be seen by combat surgeons. Despite this fact, authorized equipment for deployed medical units is lacking in pediatric supplies. This must be corrected in the future; meanwhile, medical personnel must be proactive in obtaining required pediatric equipment and supplies.
2. Infants less than 6 months old have tremendous collateral potential even for major vessels. Control the injured vessel with bulldog clamps and see if distal perfusion is intact. If distal perfusion is adequate, then major vascular repair need not be attempted at that time, even with large vessels like the subclavian or femoral artery.
3. Because there is tremendous potential for recannulization of thrombosed vessels resulting from intimal flaps, these vessels need only be repaired if there is absence of distal flow.
4. Generally, the small shunts required in pediatric vessels are too small to provide adequate flow. This is also true of prosthetic grafts. Vein grafts or patches are usually required.
5. Unless contraindicated by other injuries, always heparinize.
6. Good technique is critical in children, and a running suture should never be used because there will be no growth potential in the injured vessel. Use interrupted sutures. As the child grows, revision of the graft may be necessary.

## CLINICAL IMPLICATIONS

With the exception of the previously described teaching points, vascular injury in children is approached the same as in adults. The following points are emphasized:

1. Hard signs of vascular injury (eg, pulsatile external bleeding, enlarging hematoma, absent distal pulses, thrill/bruit, or an ischemic limb) should be explored surgically and do not require further studies.
2. External bleeding should be controlled immediately with direct pressure or a tourniquet.

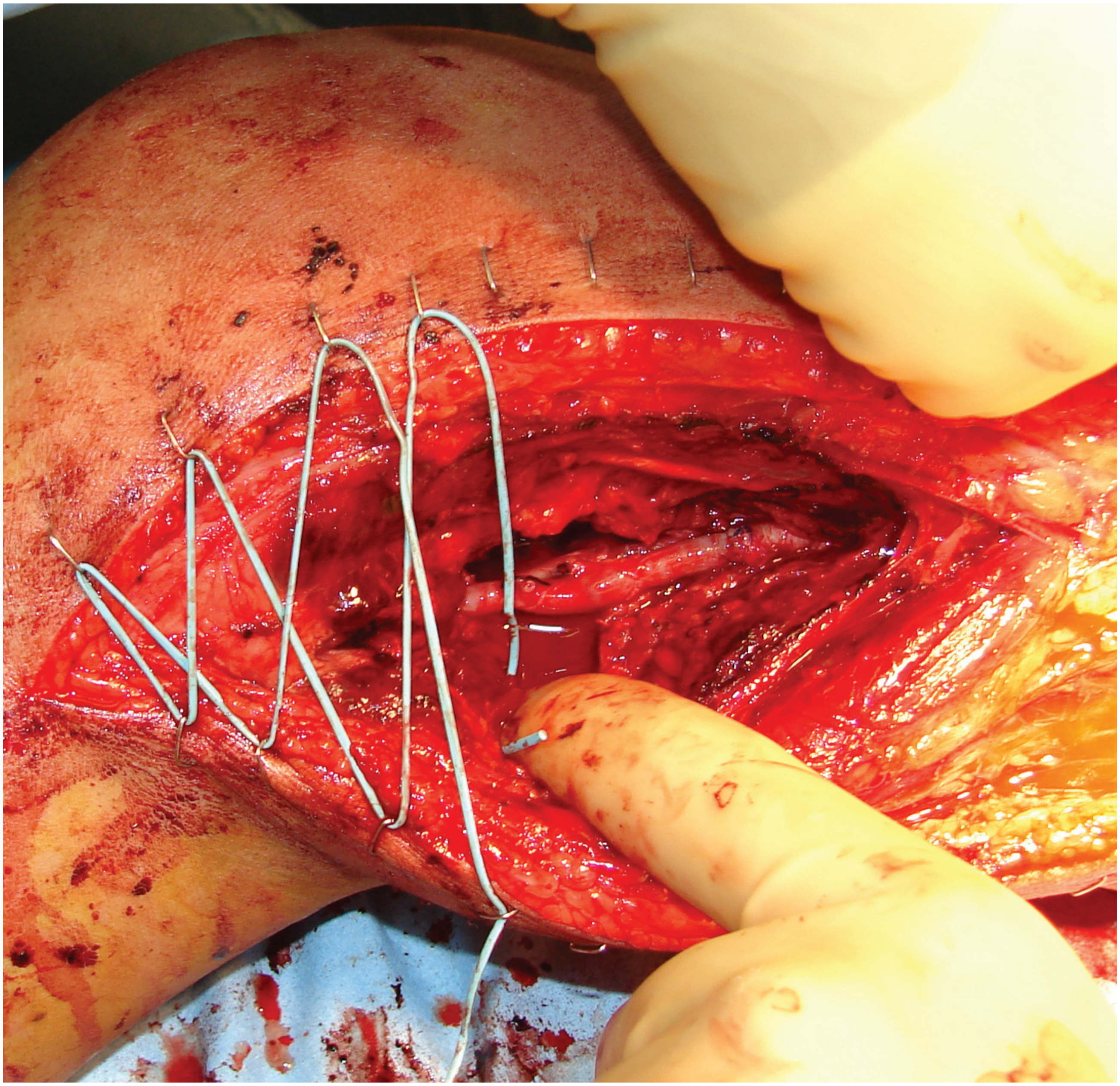

FIGURE 2. *A reverse saphenous interposition graft has been used to repair the popliteal artery defect.*

3. Combat trauma wounds are frequently caused by high-velocity missiles (> 3,000 f/s) and can cause arterial injury without major external injury. When hard signs of vascular compromise are present, thrombosis should be suspected. Soft signs of vascular injury should prompt evaluation with arteriogram, duplex ultrasound, and ankle-brachial indices.
4. Both the injured and uninjured extremities should be prepared and draped to facilitate obtaining the vein graft. If the major vein of the injured extremity is damaged, obtain the vein graft from the contralateral extremity to preserve the superficial outflow. Large injured veins should be repaired to preserve outflow.
5. The vein graft should be covered with the surrounding soft tissue at the end of the case to prevent desiccation.
6. Fasciotomy should almost always be performed in the combat setting after vascular repair.

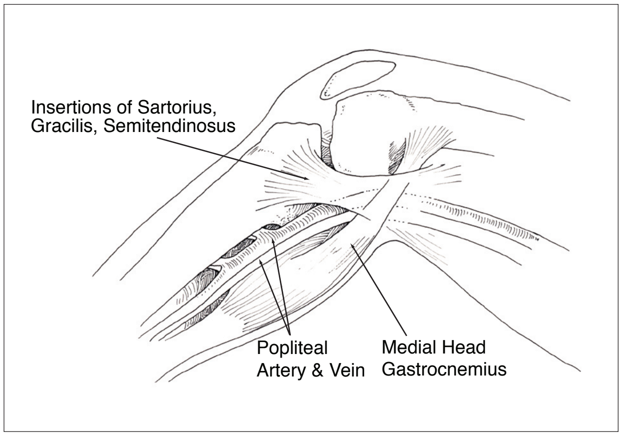


Figure 3. *Medial approach to popliteal vessels.*

## DAMAGE CONTROL

Ligation of the injured vessel may be required if life-threatening injuries preclude repair. Shunting may be attempted; but, in pediatric vascular injuries, it may be inadequate due to the size of the shunted vessels. If shunting or collateral flow is inadequate, amputation will be required.

## SUMMARY

When vascular injuries to children occur on the battlefield, combat surgeons will be required to manage these injuries. Basic tenets of vascular surgery apply, but infants and small children may not need major vascular repair due to good collateral flow. However, surgical intervention will be required if clinical evidence of distal ischemia exists.

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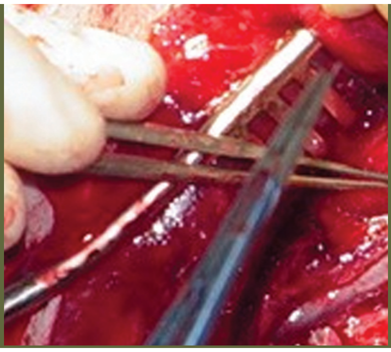

# IX.7 Tetanus

## CASE PRESENTATION

A 29-year-old Afghan male was brought to the combat support hospital (CSH) with a necrotic below-the-knee amputation, an inability to open his mouth fully, and spasmodic movements of the extremities. The patient reported stepping on a small landmine approximately 1 week previously and self-treating the injury with a bandage wrap. Two days prior to admission, the patient noted "stiffness" in his jaw, which had steadily worsened. He also noted involuntary muscular contractions of his arms and legs. The patient had no significant past medical history and had never received vaccinations. He was taking no medications and reported no allergies. Vital signs showed mild hypertension (150/90 mm Hg), tachycardia (pulse of 100 beats per minute), and a normal temperature. Physical examination was significant for a necrotic left below-the-knee amputation (Fig. 1) and trismus (Fig. 2). Episodic, involuntary contractions of both arms and legs were noted. An urgent amputation of the necrotic stump was performed, and the patient underwent subsequent tracheotomy for prolonged mechanical ventilation. Human tetanus immunoglobulin (hTIG) and (equine) tetanus antitoxin (TAT) were administered, at separate sites, intramuscularly. Metronidazole was infused intravenously. An intravenous infusion of midazolam was administered for sedation, but the patient required paralysis with vecuronium bromide for complete suppression of the spasms. Each day, cessation of paralysis/sedation was performed to assess the patient's clinical status, and the contractions gradually improved. After 20 days in the intensive care unit, he was finally extubated and discharged home.

## TEACHING POINTS

1. The presence of trismus and involuntary muscular contractions in the setting of a necrotic wound quickly lead clinicians to a diagnosis of tetanus in this patient.
2. Although tetanus is fairly uncommon in developed countries, lack of routine vaccination and poor access to medical care make tetanus much more prevalent in developing regions.

## CLINICAL IMPLICATIONS

1. Risus sardonicus (a grimace caused by increased tone in the orbicularis oris), trismus (or lockjaw), and generalized spasm (with

FIGURE 1. *Necrotic lower extremity, traumatic amputation site.*

flexion of the arms and extension of the legs) are the hallmarks of generalized tetanus.[1] Dysphagia follows. This neurological disorder is caused by the release of a toxin from *Clostridium tetani*. The vast majority of adult cases are associated with lacerations and punctures. The organism is found in soil worldwide, and spores may survive for years. Symptoms generally occur 3 to 10 days following inoculation. Generalized muscle spasms, induced by the slightest stimulation, may become sustained, severe, and compromise respiratory effort. Diagnosis is secured by clinical observation. Culture of suspected wounds is not useful because cultures are frequently negative, and a positive culture may be present without disease in patients with adequate immunity.

2. Treatment is supportive and relies on providing a secure airway, as well as maintaining nutrition and having good nursing care. Benzodiazepines are used for control of spasms, although occasionally neuromuscular junction blockade is required. Passive immunization with hTIG shortens the course of tetanus, and active immunization should also be initiated. Antimicrobial therapy with metronidazole is recommended. Autonomic dysfunction may occur as hypertension and/or hypotension.

## DAMAGE CONTROL

Tetanus is a preventable disease by using vaccination. A series of three monthly intramuscular injections of tetanus toxoid provides protection for at least 5 years,

FIGURE 2. *Trismus (risus sardonicus). Patient is unable to open his mouth fully on command.*

with booster vaccinations recommended every 10 years. Patients suffering from tetanus-prone wounds (puncture wounds, dirty wounds, etc) who have not received adequate vaccination within the past 5 years should receive passive immunization with hTIG, in addition to active immunization.

## SUMMARY

Most physicians having received medical training in the United States will be unfamiliar with diseases afflicting patients who have not benefited from modern medical care. Tetanus is one such disease. Clinical presentation of a patient with a wound and muscular spasms should prompt the diagnosis. Although the mortality for severe tetanus is reportedly as high as 60%, many patients who receive intensive medical support, not always available in a forward medical facility, will survive.[2]

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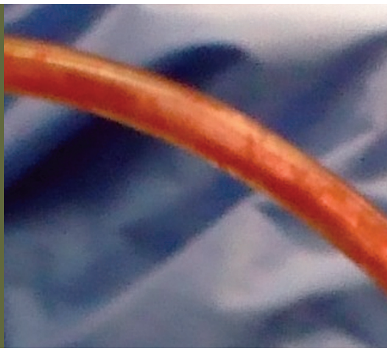

# IX.8 Penetrating Abdominal Trauma in the Pregnant Patient

## CASE PRESENTATION

This 30-year-old female sustained a single gunshot wound to the abdomen from an AK-47 rifle. She was approximately 34 to 38 weeks pregnant. The bullet entered the abdomen just left of the umbilicus and exited the left side of the abdominal wall, leaving a substantial exit wound and obvious evisceration of the small bowel. Despite being 2 hours postinjury on arrival, the patient was alert, awake, and hemodynamically stable, with a heart rate of 122 beats per minute and blood pressure of 124/88 mm Hg. Fetal heart tones could not be assessed. Large-bore intravenous access was obtained, as well as initial laboratory values. The patient was then taken to the operating room for exploratory laparotomy. A midline incision was used to deliver the gravid uterus into the operative field and also to provide exposure for obvious bowel injuries. On initial inspection, a through-and-through wound from the uterine fundus to the left lateral aspect of the uterus was seen. The exit wound was large, and the fetus was presumed to be in distress. Therefore, the vesicouterine fold was mobilized and an emergency cesarean section was performed using a standard low transverse incision (Fig. 1). Once delivered and the cord controlled, the baby boy was aggressively suctioned and stimulated (Figs. 2 and 3). The initial Apgar score was 2, but with continued efforts the child began to breathe spontaneously, his color improved, and he began to move all extremities (Fig. 4). The child was passed off the operative field, and attention was turned back to the mother. The placenta was delivered without incident, and the uterus was massaged vigorously to cause contraction and achieve hemostasis. At initial surgery, there were no agents available to produce uterine contraction; therefore, uterine massage and selective ligation of several large bleeding sites were used to achieve hemostasis. The uterus was closed using a running locking 0 VICRYL suture, and the two bullet wounds were debrided and closed in a similar fashion. With the uterus contracted, the remainder of the patient's abdomen was evaluated for injuries. The only significant injuries found were four small bowel enterotomies located in the mid-jejunum. Resection and primary anastomosis were performed. During rescusitation and surgery, the mother received 5 units of packed red blood cells, 4 units of fresh frozen plasma, 1 dose of recombinant Factor VIIa, 2 units of whole blood, and 3 L of crystalloid. The abdomen was thoroughly irrigated, and the bowel and colon were reinspected.

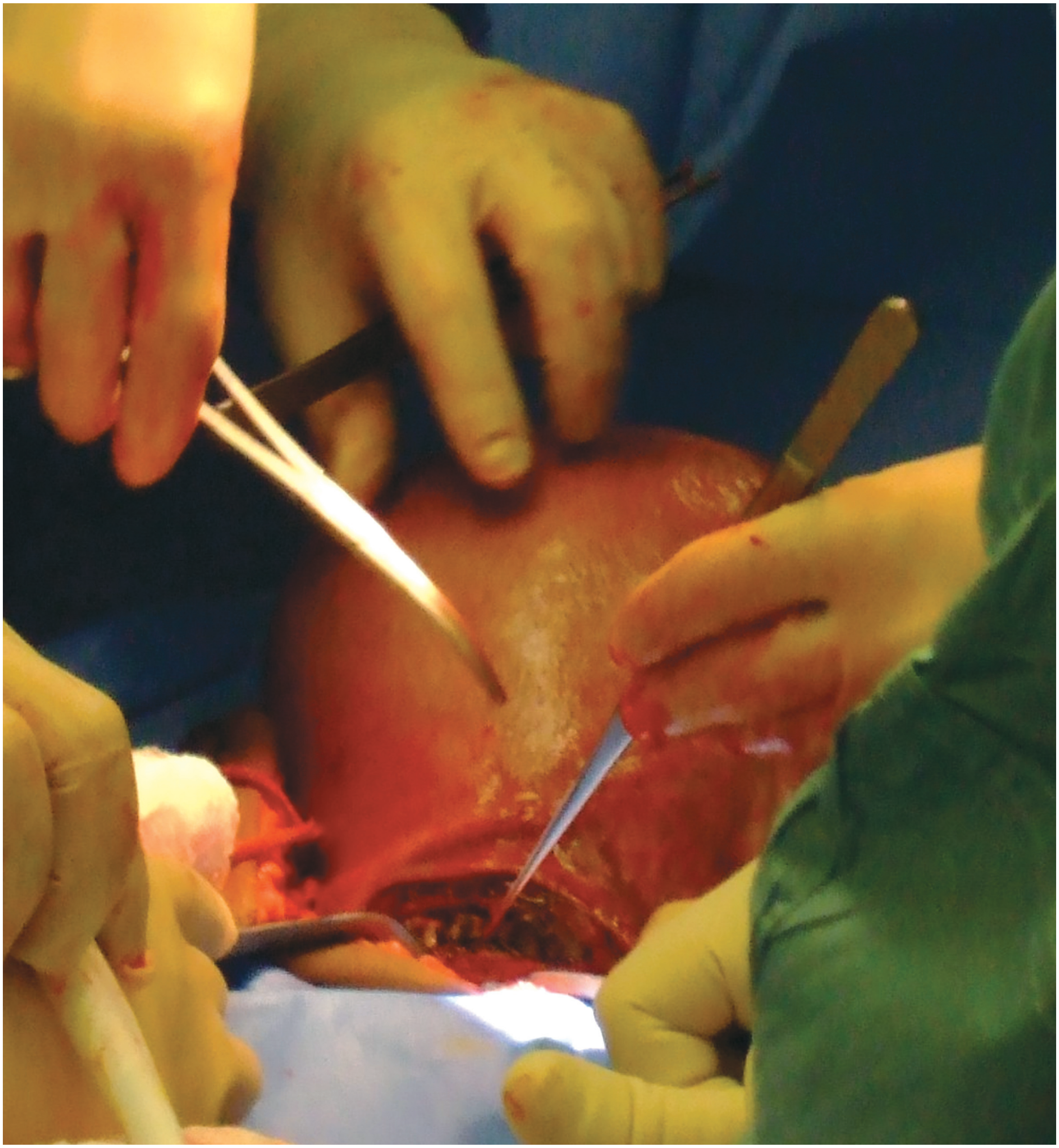

FIGURE 1. *The abdomen is opened with a vertical midline incision, and a low transverse incision has been made on the uterus.*

FIGURE 2. *A baby boy has been delivered from the uterus.*

The lateral abdominal wall defect (exit wound) was closed by approximating the peritoneum and the fascia. Laxity of the lateral abdominal wall allowed a tension-free fascial closure. The abdomen was closed using a no. 1 looped PDS suture (polydioxanone suture) in a running fashion. The lateral wound was packed open using Kerlix sponges, and the patient was transferred in stable condition to a postoperative holding area. Following the mother's surgery, the baby was evaluated and found to have a minor tangential wound from the bullet. This wound was dressed, and both patients were transferred to a level III medical treatment facility for continued care.

## TEACHING POINTS

Penetrating abdominal trauma in pregnant females is likely to include injury to the uterus and fetus. The incidence of injury increases in proportion to the size of the uterus as the pregnancy progresses. The upward displacement of abdominal organs in late pregnancy

FIGURE 3. *The neonate is suctioned in the operative field and given an initial Apgar score of 2.*

FIGURE 4. *After resuscitation, the neonate was given an Apgar score of 10 and did well.*

**SUPINE HYPOTENSIVE SYNDROME OF PREGNANCY**

In late pregnancy, the large gravid uterus can compress the inferior vena cava resulting in decreased return of blood to the heart. This may result in tachycardia, hypotension, sweating, nausea, and dizziness. It is also possible for the uterus to compress the aorta, thus decreasing blood flow to the uterus and placing the fetus in jeopardy. Both of these conditions can be prevented by placing the patient on the left side or, if the spine is not cleared, by slanting the patient on the backboard to the left.

can result in multiple organs damaged in wounds that involve the upper abdomen. Resuscitation and surgical intervention of the pregnant patient have several unique aspects.

1. The most common cause of fetal death in the traumatized pregnant patient is maternal death. The priority in resuscitation is the mother, and the primary ATLS (Advanced Trauma Life Support) survey is completely focused on the mother.
2. As soon as feasible, place the mother on her left side to shift the weight of the uterus off the inferior vena cava and prevent supine hypotensive syndrome of pregnancy (see box on page 396).
3. Evidence of shock during pregnancy suggests massive blood loss. Signs of shock in the pregnant patient will manifest late when the patient has lost as much as 35% of circulating blood volume.
4. Mild hypoxia in the mother results in severe hypoxia for the fetus. Start all pregnant patients on supplemental oxygen and maintain their saturation at 95% to 100%, if possible.
5. X-ray examination of the patient should be carefully planned, but needed radiographs should be obtained. When possible, shield the abdomen with a lead apron. Ultrasound is an excellent modality and may be used to assess both the mother and fetus.
6. The secondary survey includes assessment of the reproductive organs and the fetus. Consultation with an obstetrician is highly desirable, if possible at this point.

    a. The presence of any blood in the vagina is suggestive of injury to the uterus in penetrating trauma or of placental abruption in blunt trauma.
    b. Initial assessment should include fetal heart tones. Normal fetal heart rate is 120 to 160 beats per minute. A fetal heart rate of less than 120 indicates fetal hypoxia. If available, a cardiotocographic device will allow continuous assessment of the fetus and detect uterine contractions that may indicate preterm labor.
    c. If available, ultrasound and CT can be used to further assess the fetus, uterus, and placenta.
    d. Measuring fundal height will give an estimation of fetal age. When the fundus is at the level of the umbilicus, the fetal age is roughly 20 weeks. When the fundus is palpated midway between the umbilicus and the xiphoid, fetal age is approximately 26 weeks. At this age, when a neonatal intensive care unit is available, the fetus is considered viable in a normal hospital setting. This level of sophistication will rarely be encountered in the combat setting, and viability of the prematurely delivered neonate will depend largely on its physiological maturity.

7. Almost all patients with penetrating abdominal injuries in the combat setting will require surgical exploration. This includes pregnant patients.

    a. The patient should be approached just like any other trauma patient and damage control performed as needed.
    b. The uterus should be carefully examined and, if injured and the fetus is in good condition, it may be repaired using 0 VICRYL suture.
    c. If injury to the uterus causes fetal distress and the fetus is mature enough for delivery, perform a cesarean section (Fig. 5).

8. In the event the baby is delivered, it may require resuscitation and other necessary equipment, including warm towels, a bulb syringe, a stethoscope, oxygen, and a suction catheter. Airway management instruments should be available immediately.
9. Injury to the uterus can be controlled usually with suture ligation. After the cesarean section, uterine atony may result in uncontrollable hemorrhage. In this case, if tocolytic agents are available, they should be given and uterine massage performed. If this fails to arrest the bleeding, ligation of the uterine arteries or hysterectomy may be required.

## CLINICAL IMPLICATIONS

The physiological changes that occur during pregnancy impact the patient's ability to respond to trauma and should be remembered when caring for the injured pregnant patient. Some of these changes are reviewed here briefly.

1. Pregnant patients retain sodium and total body water resulting in a 30% to 40% increase in plasma volume. There is a concurrent increase in red blood cell mass of about 15%. This results in a

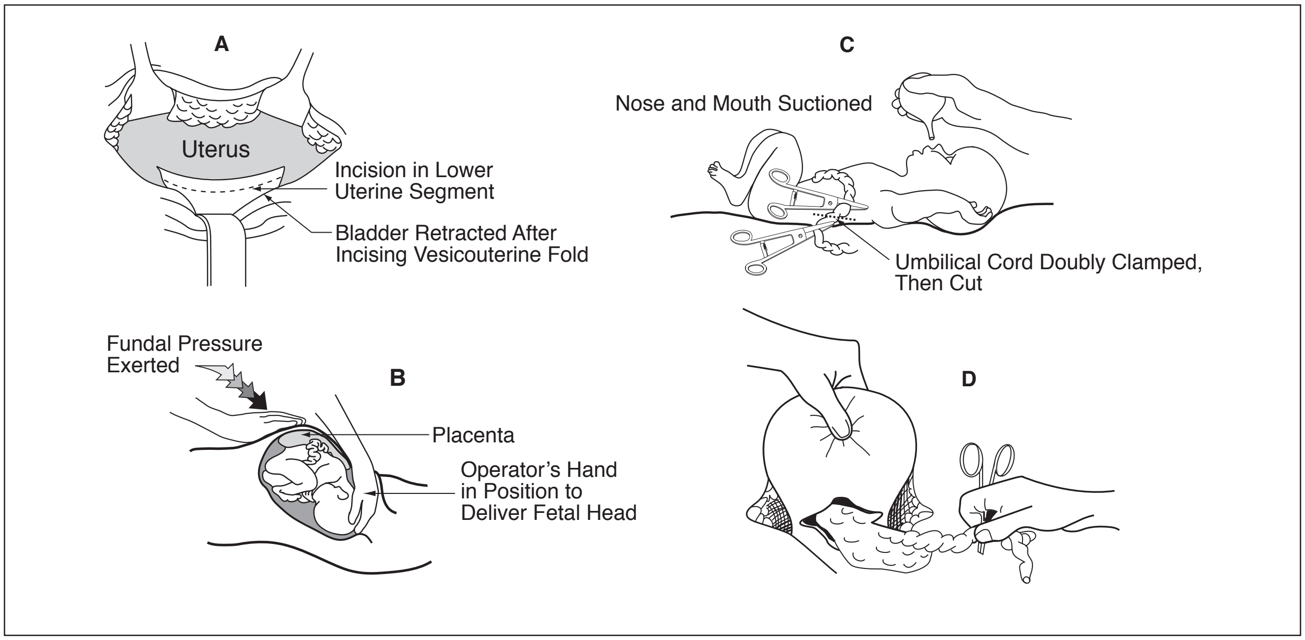


FIGURE 5. *Emergency cesarean section.* (A) *Uterine incision.* (B) *Delivery of fetus.* (C) *Delivered infant on abdomen.* (D) *Uterine fundus exteriorized.*

normal hematacrit of 30% to 36%. A moderate leukocytosis is also common.

2. Cardiac output and resting heart rate increase in pregnancy. Heart rate will typically increase 10 to 20 beats per minute for a given patient. Peripheral vascular resistance is slightly decreased, and average blood pressure is also decreased 10 to 15 mm Hg.
3. Significant changes occur in the pregnant patient's respiratory system. Anatomical changes occur that result in an increased subcostal angle and increased chest circumference. As the pregnancy progresses, the diaphragm is increasingly elevated. The result of all these changes is an increase in tidal volume and minute ventilation. However, functional residual capacity is decreased. The $P_{CO_2}$ is also decreased, and the body compensates for this by decreasing bicarbonate. This results in a compensated respiratory alkalosis during pregnancy.
4. Hormonal and anatomical changes in the pregnant patient lead to decreased intestinal mobility and decreased lower esophageal sphincter competency. They are particularly susceptible to aspiration. Naso-gastric decompression should be considered early.
5. Trauma patients are hypercoaguable with increased levels of Factor VII, VIII, IX, X, XII, and fibrinogen and decreased fibrinolysis. Heparin does not cross the placenta and can be used in pregnant patients.

## DAMAGE CONTROL

The damage control approach to the pregnant patient is the same as any patient. However, the uterus can be a source of rapidly fatal hemorrhage. If bleeding from the uterus cannot be controlled, then cesarean section—followed by emergency hysterectomy—may be required and can be lifesaving. If the fetus is dead, it should be delivered either vaginally or by cesarean section as soon as practicable. This may be delayed if damage control is required.

## SUMMARY

This case demonstrates that civilians injured in combat zones inevitably will include the pregnant female. In this case, a Forward Surgical Team (FST) operating in an austere environment was able to safely deliver a viable infant and salvage the gravely wounded mother and her reproductive organs. The physiological maturity of the fetus, appropriate resuscitation of the mother, and the professional knowledge of the team all contributed to the successful outcome in this case.

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COMMENTARY

# Management of Pediatric Trauma

*by COL Kenneth S. Azarow, MD*

When dealing with children in wartime situations, two principles need to be understood. The first principle is to be prepared. Soldiers will be dealing with children. American history demonstrates that the US Army Medical Department has taken care of children in every conflict that our nation has been involved in. Generally, the American soldier will try to help a child immediately, regardless of whether that child has been injured as a result of "collateral damage" or if that child is part of the enemy force. In addition, the soldier will bring a child to his own medical facility rather than to the local medical facility.

The second principle is that children are not small adults, and infants are not small children. Given the same mechanism of injury, both infants and children are usually more physiologically forgiving than adults. Management principles of trauma are the same in all age groups. However, the means to achieve those goals are different. In the cases presented in this chapter, the surgeons should be complimented on their pediatric trauma management skills, and a few practical points should be emphasized: IV access, resuscitation, and operative decision making.

## IV ACCESS

Given a severe traumatic injury and no identifiable peripheral veins, the first choice for peripheral access is the external jugular vein for all age groups. It is reliably present in the vast majority of patients when they are positioned in a small degree of Trendelenburg. If central access is required, the first choice is the femoral vein in all age groups. The femoral vein has reliable landmarks. If the vein is missed while attempting access, very little harm is done relative to the alternative choices for access. Unless the provider has significant experience in placing subclavian lines in pediatric patients, cannulization is not recommended in almost any circumstance. If these sites are unavailable, access in children under the age of 6 can be an intraosseous line (and is described in the case comments). The caveat is that your unit has to have intraosseous lines in stock. You can use a 16-gauge or an 18-gauge spinal needle for that purpose. However, these are harder to place, and most deployed units do not have spinal needles of that size readily available.

## RESUSCITATION

After the first few months of life, blood volume drops from 80 cc/kg to 70 cc/kg. For practical purposes, think of all children as having a blood volume of 80 cc/kg. This is important because we think of giving fluid and blood products in terms of 20 cc/kg boluses. Think of this as one-quarter blood volume boluses. Just as in adults, children—undergoing massive transfusions—need 1:1 packed red blood cells to fresh frozen plasma, unless they are receiving whole blood. Although the definition of a massive transfusion in adults is 10 units, in children it should be 1.5 blood volumes (ie, 120 cc/kg). Airway management is simple: obtain one and secure it without performing a cricothyroidotomy. Remember, the formula for tube size is as follows: (age + 16)/4. Also, remember that children have an intense vagal response and a profound bradycardia when their vocal cords are manipulated; pretreat when possible.

## OPERATIVE DECISION MAKING

When in a deployed combat environment, there is a much higher percentage of penetrating trauma than when working in a nonhostile environment. However, blunt trauma still occurs. The usual nonoperative management of most blunt traumatic injury can only be followed if adequate blood products are available. When the decision is made to operate, all subsequent decisions with regard to vascular control, damage control, and resuscitative surgery apply. To make these decisions easier, the following guidelines are useful. In the setting of severe abdominal and thoracic trauma, always operate on the abdomen first (even more so for children than for adults). In general, patients will triage themselves out of the immediate hemorrhagic catastrophe in the chest if they have survived transport. The incision of choice is a midline incision, unless the child is less than 18 months of age. For those patients, a transverse supraumbilical incision can give better exposure to retroperitoneal structures. When deciding what operation to perform, know what the local resources are for postoperative rehabilitation and nutrition. For example, it serves no purpose to insert a jejunal feeding tube if there are no replacement tubes available and no jejunal feeds available. However, a major challenge is to have the proper size tube available in the operating room (OR). Although Broselow kits are popular and most resuscitative bays have appropriately sized instruments and tubes for resuscitation, once in the OR there is a void of pediatric equipment unless prior planning included it. A few helpful items include the following:

- Size 10 French nasogastric tubes,
- Size 14-gauge and 16-gauge Malecot catheters,
- Size 12 French red rubber catheters,
- Size 12 French t-tubes, and
- Size 6 and 8 French Foley catheters.

Colostomies should be used if indicated; however, keep in mind that bags may be an issue. Thus, if given the choice between a colostomy and an ileostomy—although an ileostomy is preferred in the United States—a colostomy is easier to take care of and is preferable when deployed.

One of the most emotional challenges the OR staff will face is a decision to amputate a child's extremity. It is well known that prosthetics, wheelchairs, and even crutches are not available in most theater ORs. Thus, an amputation is not only a life-changing event, but also it may be a life-ending event over time. This fact is not new to deployed surgeons. For adults, Argyle shunts can be placed to preserve blood flow when in damage control mode, and delayed vascular reconstruction can save some limbs that have sufficient muscle mass and neurological function remaining. Because of blood vessel size, if shunts are placed in children, they must be fully heparinized immediately. Therefore, do not place a shunt as the first step to damage control. Clamp the vessels, stop all bleeding, then heparinize, place shunts, and perform fasciotomies. Unfortunately, amputations to save lives are a gruesome reality of war, especially where children are concerned.

When an individual is injured and needs to undergo operation, postinjury and postoperative pain will be an unavoidable consequence. Use of continuous peripheral and continuous regional anesthetic techniques has been a major advance that has been used by deployed anesthesia providers (see Case IX.5). Although there have been concerns about transportation of the electrically driven pump to provide continuous local or regional anesthetic, the principle is sound and has many advantages. The most obvious advantage is decreased use of narcotics. For abdominal and thoracic procedures, a continuous epidural has been a major advance in postoperative pain relief. Caution should be taken not to place an epidural when a neurosurgeon is more than 8 hours away for fear of the inability to decompress an epidural hematoma. However, when an epidural is utilized, it is the optimal method of pain relief to avoid all complications associated with postoperative narcotic usage. For both regional and peripheral techniques, if pump compatibility with electronic configuration of the aircraft is of concern, the catheter can be simply left in place, and intermittent injections by a flight medic or nurse can be administered.

The unborn fetus represents an infrequent patient to a deployed surgeon. The unborn fetus can present to a deployed surgical team in two ways. First, a patient with an ectopic pregnancy can appear (see Case IX.4). This is not a diagnosis that can be easily made at a Forward Surgical Team (FST) facility without a laboratory or an ultrasound unit. Transportation to a level III medical treatment facility should be triaged as urgent (surgical) when the diagnosis is suspected. However, in the case of a ruptured ectopic pregnancy with a significant hemoperitoneum, the diagnosis can be made on a FAST examination. On diagnosis, treatment is a relatively straightforward surgical intervention to remove the tube, ovary, and ectopic fetus.

Second, the fetus may also present as a maternal traumatic injury. Successful treatment of the mother will be the optimal treatment for the fetus. Even if the mother's outcome is poor, there have been many reports of successful, traumatic cesarean sections (or C-sections). Neonatal ventilators are not available for deployed units. Thus, traumatic C-sections will have a chance at being successful when the newborn is mature enough to breathe without support (a minimum of 34–36 weeks gestation). After ventilation, temperature control and heat loss are the next immediate challenges. Dry the infant and use plastic wrap (especially covering the head) if incubators are not available. Intravenous access, if required, is easily obtained via the hands/wrist/scalp/or external jugular vein. If the mother survives, breast milk is the only acceptable choice. If the mother does not survive, look to the family or local village for nursemaids because it will be very unusual for infant formula or total parenteral nutrition to be available for this age group. The best advice for a forward or rear echelon surgical unit in this scenario, in which a fetus is recovered and resuscitated, is to gain access to a pediatric specialist as soon as possible. Physiological changes that occur during the transition out of the uterus vary, depending on the maturity of the infant. Pediatric subspecialty expertise can be very helpful.