Abdominal Trauma in Combat

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Abstract

Evaluating and managing patients with abdominal trauma remains one of the most challenging, resource-intensive and satisfying aspects of combat care. It demands a thorough understanding of the pathophysiology of trauma and shock, excellent clinical acumen and the ability to think and operate rationally in a chaotic milieu.

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Introduction

Combat surgeons frequently encounter Abdominal Trauma (AT), mostly penetrating and occasionally blunt. These injuries may be confounded by altered mental status secondary to head trauma, distracting injuries, delayed presentation and lack of historical information, and hence may present challenges in management. However, in the last several years, novel approaches including Focused Assessment by Sonography for Trauma (FAST), newer generation computed tomography (CT) scans, ability for selected nonoperative management, understanding 'Damage Control' and increased experience offer new options in treatment for the surgical team. Rapid evacuation, early intervention and advances in anesthesia have also resulted in improved survival.

Penetrating Abdominal Trauma (PAT)

Background: Improvised Explosive Devices (IEDs) and mine blasts are causing an increasingly dangerous and different type of PAT not usually seen with gunshot wounds (GSW). Bowel injury is most often found, followed by hepatic injury.

Pathophysiology: The specific characteristics of wounds due to GSW and IEDs are as follows. They involve high-energy transfer; hence have an unpredictable pattern of injuries. Secondary missiles, such as bone fragments inflict additional damage. Ricochet injuries can occur. Thermal and shearing damage lateral to the missile tract.

Stab wounds have a more predictable pattern of organ injury.

Initial assessment and presentation: All trauma care personnel should exercise universal precautions. Assessment of the patient and basic life support measures are applied at the scene of the incident and en route to the 'Forward Surgical Centre' (FSC). Exposed bowel loops should be covered with a sterile towel and not reposted inside the abdomen.

Physical Examination

In evaluating PAT, the abdomen must be taken to extend from the nipples to the knees. The evaluation is to be accomplished with the entire patient in mind. The abdomen should neither be ignored nor the sole focus of the treating surgeon.

Patients sustaining PAT are completely undressed and thoroughly examined. Multiple missiles may be retained within the body. Trajectory of GSWs helps determine presence of intraperitoneal injury. IEDs cause multiple irregular shrapnel to wobble and cause severe destruction. Palpation may reveal peritonitis. Tension pneumothorax, hemothorax and pericardial tamponade must be considered in unstable patients.

Emergency management: At the surgical centre, maximal available history is elicited quickly and ATLS protocols initiated [1]. Airway protection and ventilatory support are followed by circulatory resuscitation (Ringer's lactate). Efforts are made to limit hypothermia. Antibiotics are administered. A nasogastric tube and Foley catheter are inserted. At this stage the treating surgeon should be able to decide as to whether the patient requires 'Urgent mandatory laparotomy'; 'Early laparotomy' or 'Observation'. Penetrating wounds to the thoracoabdominal area may require chest tube

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placement to relieve hemothorax/pneumothorax. *Urgent mandatory laparotomy*: Indications include hemodynamic instability, the presence of gross peritoneal signs on physical examination and evisceration [2,3]. The patient is rushed to the OT without any investigations. *Early laparotomy*: These patients should undergo basic laboratory testing. As compared to BAT, a significantly larger number of patients with PAT will go for urgent or early laparotomy. *Observation*: When the clinical picture is confusing and patient relatively stable, further evaluation ensues with diagnostic and imaging studies to establish peritoneal penetration. For a select few, nonoperative treatment is gaining favor [4]. Tangential GSW and stab wounds may not produce peritoneal violation [5]. Judicious use of local wound exploration, USG, CT, DPL, and laparoscopy coupled with repeated physical examination can help select patients appropriate for nonoperative management [6]

Imaging

Plain radiograph: Chest and abdominal radiographs can reveal air under the diaphragm which indicates peritoneal penetration, determine missile trajectory and can account for retained missiles. FAST has become an extension of the physical examination of the abdomen. 3.5 to 5 MHz curved probe is optimal. Four standard sonographic windows (right and left hypochondrium, epigastric and pelvic) are used. Fascial violation can be determined in stable patients with anterior abdominal stab wounds [7] [Fig 1]. CT scan is selectively used in the evaluation of stable patients with tangential GSWs to the flank the back and stab wounds. Triple contrast (ie, oral, intravenous, rectal) is used to maximize sensitivity [8]. Signs of peritoneal penetration include wound tract outlined by hemorrhage or air, bullet or bone fragments that clearly extend into the peritoneal cavity, presence of intraperitoneal free air, free fluid and obvious intraperitoneal organ injury [9,10].

Blunt Abdominal Trauma (BAT)

Introduction and Incidence: BAT is occasionally seen in combat because of vehicular accidents or formidable terrain. The spleen is the most often injured organ [11].

Pathophysiology: BAT is explained by 3 mechanisms [12]. First rapid deceleration causes differential movement among adjacent structures. Secondly intra-abdominal contents are crushed between the abdominal wall and vertebral column and thirdly external compression forces result in a sudden rise in intra-abdominal pressure culminating in hollow viscus rupture.

History: Historical data, while often lacking, may provide invaluable information. Important factors include information regarding fatalities at the scene, vehicle type and velocity and steering wheel deformity, etc [13].

Fig. 1: The four standard sonography windows in FAST: epigastric, right and left hypochondrial and pelvic.

Physical examination: While some studies cite physical examination as only 55-65% sensitive for BAT, it is still the cornerstone for primary assessment [14]. Injuries involving the respiratory or CVS may take precedence over an abdominal injury [15]. Ecchymosis across the lower abdomen, the "seatbelt sign," portends intra-abdominal injury in one-third of patients [16]. Palpation may reveal guarding or rigidity suggesting peritoneal injury. A rectal examination should be performed [17]. The objective is to rapidly identify patients who need a laparotomy [18].

Emergency Management

Priorities in resuscitation and diagnosis are established and proceed as for PAT. Hypotensive patients with gross abdominal signs should be rushed to the OT. Unstable patients with doubtful abdominal signs are rapidly investigated for hemoperitoneum. Chest and pelvic radiograph may aid in the diagnosis of ruptured hemidiaphragm, pneumoperitoneum, fractures of the thoracolumbar spine. FAST is performed by combat surgeons to detect hemoperitoneum. Reported sensitivities and negative predictive values for FAST in the detection of hemoperitoneum are 78-99% and 93-99%, respectively [19]. CT Scan remains the criterion

standard for the detection and grading of solid organ injuries. In addition, it can reveal vertebral and pelvic fractures, retroperitoneal injuries and determine the source of hemorrhage. Solid organ injury grading on CT can help observe hemodynamically stable patients by nonoperative management. [20]. Hollow viscus injury (HVI) and diaphragmatic injuries remain difficult to detect and can be missed [21]. A CT is considered positive for HVI if there is presence of bowel wall thickening, bowel perforation, free intraperitoneal air, free fluid without solid organ injury, and mesenteric laceration or hematoma [22]. Diagnostic peritoneal lavage (DPL) is indicated in (1) patients with spinal cord injury and BAT, (2) multiple injuries and unexplained shock, (3) obtunded patients with possible BAT and (4) patients with potential BAT who will undergo prolonged anesthesia for another procedure. DPL is positive if grossly bloody, bilious or fecal aspirate is obtained before infusion of the lavage fluid or if the siphoned lavage fluid (ie, 1 L normal saline infused into the peritoneal cavity via a catheter, allowed to mix and then drained by gravity) has > 100,000 RBC/mL, > 500 WBC/mL, elevated amylase content, bile, bacteria, vegetable matter or urine. With the availability of noninvasive and better imaging modalities, the role of DPL is now limited.

Surgical Details for PAT and BAT

Preoperative: Fluids and blood products are administered via warm lines. Extremities are warmed. Broad spectrum antibiotics are started. Laparotomy can release tamponade resulting in a precipitous hypotension, so the anesthesia team must be informed at incision.

Intraoperative: The generous versatile midline incision is used. It can be extended into the thorax or towards the flank in a T-shaped manner. Essential components include control of bleeding, identification of injuries, control of contamination, and reconstruction (if possible). Initial control of bleeding is accomplished with 4 quadrant packing using laparotomy pads above the liver and spleen and in both sides of the pelvis. The packs are removed one quadrant at a time, starting away from the site of apparent bleeding.

Enter via generous midline incision. GSW tracts or entry/exit wounds should not guide the laparotomy incision.

Stomach: The stomach is a vascular organ and does well after almost any repair. Injuries are debrided and primarily closed in one or two layers. The lesser sac is always entered to determine posterior wall injuries.

Duodenum: Missed duodenal injuries have devastating morbidity. Minor injuries are repaired primarily. Major injuries should be repaired if the lumen is narrowed by

< 50%. Options for closing injuries of > 50% lumen are closing the duodenal wall over a large malecot's or T-tube as tube duodenostomy; using Roux-en-Y jejunal limb for duodeno-jejunostomy or using the serosa of a jejunal loop without opening it to patch the defect. Another option is doing a gastrojejunostomy and duodenal exclusion by closing the duodenum from inside using non-absorbable sutures (Fig 2). Associated pancreatic and biliary injuries are dealt with by biliary diversion and extensive drainage.

Small-Bowel Injuries: Wound edges are debrided to freshly bleeding tissue. Closure is done in one or two layers. Exteriorization should be done in unstable patient and those with extensive contamination.

Colon Injury: Simple, isolated colon injuries brought early in a stable patient are repaired primarily in one or two layers after debridement and ensuring good vascularity. For complex injuries, colostomy/diversion is strongly considered especially when associated with massive blood transfusion, on-going hypotension and hypoxia. 'Hartmann's procedure' is done for rectal injuries.

Diaphragm: Penetrating injuries to the diaphragm require closure with running/ interrupted non-absorbable suture and placement of a chest tube. Large defects may require prosthetic patch.

Splenic Injuries: Splenic injury should prompt exploration for associated diaphragm, stomach, pancreatic and renal injuries. Spleen is rapidly mobilized and bleeding controlled by incising the anterior leaf of lienorenal ligament and controlling the vessels. Splenic salvage has little place in combat surgery.

Pancreatic Injuries: Although pancreatic ductal integrity determines morbidity, the same is difficult to establish in combat scenario. Hence even if ductal injury is not identified, it should be presumed and drained. Clearly nonviable pancreatic body/tail tissue is resected. Thorough drainage is the thumb rule.

Major injuries to the head of the pancreas may require pancreaticoduodenectomy, which **SHOULD NEVER BE ATTEMPTED** in an austere environment but instead treated by the principles of damage control surgery: **DRAIN, DRAIN, and DRAIN.**

Fig. 2 : Repair of duodenal injury with pyloric exclusion and GJ.

Liver Injuries: Generous exposure is achieved early by extending incision into right chest and mobilizing the triangular and coronary ligaments. Laparotomy pads are placed above the dome of the liver. Most liver injuries can be successfully treated with direct pressure and packing followed by aggressive resuscitation and correction of coagulopathy. Short duration clamping of hepatic artery and portal vein (Pringle maneuver) may be required. Large lacerations of the liver parenchyma are controlled by taking overlapping mattress sutures of thick Vicryl on round body needle over 'Surgicel' or omental pack.

Avoidance of coagulopathy, hypothermia and acidosis is essential in successful management of major liver injuries. DCS should be applied early. Urgent major surgical resection or repair of retrohepatic caval injuries is strongly discouraged.

Complications: Complications following surgery for PAT and BAT can be early or late:

Early postoperative complications include ongoing bleeding, coagulopathy, and abdominal compartment syndrome. The latter is treated with opening of the abdomen and temporary closure. Later complications are acute respiratory distress syndrome, pneumonia, sepsis, intra-abdominal fluid collections, wound infections, and enterocutaneous fistulae. Late complications comprise small bowel obstruction and incisional hernias.

Special Issues

1. **Role of Laparoscopy in PAT and BAT:** In spite of significant advances in imaging, 10-15% cases undergo unnecessary laparotomy. CT scan can miss HVI, bile leaks, diaphragmatic injuries and ongoing bleed. In tangential thoraco-abdominal stab wounds, diaphragmatic injuries may be missed [23]. GSW with questionable tangential trajectory may not penetrate the peritoneum as may stab wounds [24]. Laparoscopy may be beneficial in all these cases at a tertiary centre.

2. **Damage Control Surgery:** In spite of heroic surgery, a number of patients were not surviving. In 1981, the bloody vicious cycle due to the lethal combination of coagulopathy, hypothermia and metabolic acidosis was described [25]. The wise surgeon should control bleeding and contamination, exteriorize bowel and opt for a temporary abdominal wall closure with an intravenous fluid bag or mesh. The patient is shifted to ICU on ventilator for continued resuscitation and warming. Reconstruction takes place upon return to the OT after 24-48 hours.

Conflict of Interest

None identified

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Journal Scan

Navin DM, Sacco WJ, McGill G. Application of a new resource-constrained triage method to Military-age victims. *Mil Med* 2009; 174:1247-55.

The objective of the study was to evaluate the resource-constrained, evidence-based, and outcome-driven Sacco Triage Method (STM) for Military-age victims of blunt, penetrating, and blast overpressure-like trauma. STM is based on a mathematical model of resource-constrained triage. Its objective is to maximize expected survivors given constraints on transport and treatment resources. STM uses estimates of time-dependent victim survival probabilities and expected deteriorations. A respiration, pulse, and best motor response (RPM) score predicts survivability. Logistic function-generated survival probability estimates from 99,369 military-age victims were assessed using calibration and discrimination statistics at USA. The consensus building Delphi method was used to provide aggregate expert opinion on victim

deterioration rates. The models were solved using linear programming. Rule-based (not requiring software) protocols were determined using a greedy algorithm for Iraqi combat scenarios, and simulations enabled comparison of STM to the widely known Simple Triage and Rapid Treatment (START) method. The authors found that the RPM was an accurate predictor of survival probability, equivalent to the Revised Trauma Score and exceeding the Injury Severity Score. In 18 simulations, STM and STM rule-based protocols increased survivorship over START from 20% to an 18-fold increase. Thus the STM offers lifesaving and operational advantages for military-age victims of blunt, penetrating, and blast overpressure-like trauma.

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