

Review Article

Abdominal Injury from the past to the present

Amonpon Kanlerd

Abstract

The incidence of abdominal injury is 7 - 10% of all trauma cases and trending to increase frequency by 1.6% per year. Abdominal injury management is changing over time. Currently, the paradigm shifted from mandatory exploration to the era of selective non-operative management, based on the evidence of 25 - 40% non-therapeutic exploration rate in penetrating anterior abdominal injury and blunt abdominal injury who received mandatory laparotomy. However, classic indications for immediate laparotomy remain the same such as hemodynamic instability, generalized peritonitis, evidence of GI injury, diaphragm injury, intraperitoneal bladder rupture, evisceration and impalement in situ.

Keywords: Abdominal injury, History of abdominal injury management, Initial assessment of abdominal injured patient, Indications for immediate exploration

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Unit of Trauma and Surgical Critical Care, Division of General Surgery, Department of Surgery, Faculty of Medicine, Thammasat University

Corresponding author: Amonpon Kanlerd (M.D., FRCST) Division of General Surgery, Department of Surgery, Faculty of Medicine, Thammasat University, Klongluang, Pathumtani, Thailand 12121 E-mail: amonponk@hotmail.com; kamonpon@tu.ac.th Tel: (66)2-926-9999, (66)2-926-9523 Fax: (66)2-926-9530

Introduction

The World Health Organization (WHO) reported approximately 56.9 million deaths/year from any cause, and 4.9 million deaths from injury in 2016.¹ In Thailand, which is a high-middle income country, approximately 531,000 deaths/year from any cause has been reported, and 39,500 deaths from trauma.² The incidence of abdominal injury is 7 - 10% of all trauma cases and trending to increase frequency by 1.6% per year from 2009 - 2016.^{3, 4} Approach to an abdominal injured patient is changing over time because of the evolution of anatomical knowledge, diagnostic tools, imaging technology, data registration, and data analysis. This article aims to summarize the evolution of abdominal injury management and current initial approach to an injured abdominal patient.

History perspective

The oldest record in human history of surgical treatment on an injury is thought to be dated around 1600 BCE (3000 to 2500 BC) within the Edwin Smith Papyrus. This ancient Egyptian medical textbook describes 48 patients who were mainly victims of trauma and were treated with surgical techniques which included stitches, nasal packing, cauterization, reduction of fractures and splinting. Unfortunately, this textbook did not mention abdominal injury.^{5, 6} Hippocrates in 460 - 370 BC reported an abdominal wound with omental evisceration as "*mortifies imperatively*" in Corpus Hippocraticum. Celsus in 25 BC - 50 AD described how to reduce and restore the colon back into the abdomen and close the abdomen in layers. His suggestions covered only the return and repair of an eviscerated colon wound, not a small bowel. Galen of Pergamum (129 - 199 AD) and Albucasis (936 - 1013), both suggested enlarging the abdominal wound before returning the eviscerated bowel and then repair the wound. Guy de Chauliac in 1300 - 1369 stated that "*nothing is more dangerous to the intestine than the contact with air*" and offered suggestions on reducing and repairing an eviscerated

perforated colon.⁷ Jean Baudens, a French military surgeon in 1804 - 1857, suggested using the finger or small sponge probing into the abdominal wound for diagnosis of peritoneal damage and was against performing laparotomy if negative for blood, feces or gas bubbles during the Crimean war. He also reported the success of laparotomy in an abdominal gunshot wound with enterotomy during the French Algerian war in 1830. He performed it in two cases, and one survived.^{5, 8}

The modern era of abdominal injury diagnosis and treatment started in the late 18th to the first half of the 19th century. At that time, there was intense debate about how to manage abdominal trauma. Laparotomy was not performed for abdominal trauma patients except for particular cases. Based on the report from George Alexander Otis in 1877, 82% mortality was documented in 3,690 soldiers with penetrating abdominal injury treated with conservative methods during the Civil War.⁹ An index case that changed the way to treat penetrating abdominal trauma was James A Garfield, the 20th US president who died of gunshot wound to the right posterior lower thorax on September 19, 1881. He was treated with conservative management for 79 days. Every day the wound was probed with the surgeon's finger but did not improve. The autopsy result showed a fracture of the 1st lumbar vertebra and a possible missed pancreatic injury, a ruptured splenic artery aneurysm, and an intra-abdominal abscess.¹⁰ Some critics supported operative management in penetrating abdominal injury.

The first formal laparotomy in abdominal gunshot trauma was recorded on July 13, 1881, by Gorge E. Goodfellow. He treated abdominal gunshot with six holes in the small and large intestine by suturing. The patient survived.¹¹ Then on November 3, 1884, William T. Bull, a surgeon in New York, repaired perforated small bowel wounds, and a sigmoid colon wound. Also, he removed intestinal content, swabbed pelvis with 2.5% carbonic acid

then closed a midline abdominal incision. At the sixth postoperative day, the patient developed a subfascial abscess. Bull took the patient back to the operating room and reopened the midline suture, then a large number of skin grafts were applied on two occasions. The patient survived and was discharged on the 58th postoperative day.¹² In 1886, Bull also reported the second successful laparotomy in a patient with an abdominal gunshot wound. The American Surgical Association symposium on penetrating abdominal gunshot in May 1887 concluded with the consensus in favor of the operative treatment, even in those cases in which the diagnosis of injury to important intraperitoneal structures was in doubt.¹³

After this time, aggressive operative management was favored in all types of abdominal trauma. Until the second half of the 19th century, when the development of trauma centers in the US was successful, and the data of abdominal trauma patients was collected and analyzed, they found the non-therapeutic laparotomy rate was as high as 25 - 40% in penetrating anterior abdominal injury and blunt abdominal patients who received a mandatory laparotomy. This rate was higher at 70 - 85% in penetrating flank and back injury and was 15 - 27% in abdominal gunshot wounds.⁵ With the development of surgical critical care, diagnostic techniques such as computed tomography (CT), ultrasound (US), endoscopy, laparoscopy, and intervention radiology (IR), changes in the philosophy of abdominal injury management from mandatory laparotomy to the era of selective non-operative management have occurred.

In Thailand, the first surgery in trauma was recorded on January 13, 1837, by Dan Beach Bradley (1804-1873). He performed an upper extremity amputation in a monk who suffered from a blast injury. The operation was successful without anesthesia, and the patient survived.¹⁴ Surgery in abdominal trauma in Thailand was not well recorded and has

been developed in parallel with the development of medical schools/surgical training programs. Nowadays, most of the Thai surgeons practice selective non-operative management in abdominal injury more than mandatory laparotomy.

Initial assessment and current indications for laparotomy in abdominal trauma

An appropriate approach to the abdominal trauma patient should be stepwise and systematic, as stated in Advanced Traumatic Life Supports (ATLS) guidelines. Primary surveys should be initiated in all trauma patients; airway, breathing and circulation issues must be managed immediately. In centers where the resource is available, the multisystem approach can be provided and resuscitation can proceed in parallel. The priority in abdominal injury is to rule out a life-threatening hemorrhage. Combination of the mechanism of injury, hemodynamic status, abdominal signs and bedside investigations is used to exclude intra-abdominal bleeding. The patient with hemodynamic instability should be attended immediately with prompt resuscitation and may need immediate exploration. Rapid transfer of an abdominal injury patient with hemodynamic instability is the key to success. Meizoso J P *et al.* reported that a hypotensive gunshot abdomen with delayed operation more than 10 minutes had a 3-fold increased mortality.¹⁵ Hemodynamic instability in abdominal injury patients is usually from bleeding, and primary sources are mostly solid organs or abdominal vessels. Early blood and blood products resuscitation should be considered more than a crystalloid solution because a rapid large volume of crystalloid may disrupt coagulation cascades, inhibit clot forming, and cause exsanguinate. A damage control resuscitation and a massive transfusion protocol should be activated. Therefore, permissive hypotension, balance component resuscitation ratio (1:1:1), early tranexamic acid, and rapid definitive hemostasis should be considered. In a patient with evidence

of abdominal injury, both antecubital veins should be cannulated with a large-bore needle (14 - 16 G), lower extremity veins including femoral vein should be avoided due to the risk of abdominal vascular injury. If intraosseous cannulation is needed, bilateral humeral heads are preferable. Also, central venous access should be done above the diaphragm.¹⁶

In hemodynamically unstable patients with evidence of pelvic fracture, application of a pelvic binder is still preferable and well-established in ATLS. The benefit of the pelvic binder is to reduce pelvic volume, limit inter-fragment motion, decreased transfusion requirement, reduced pain, reduced length of hospital stays and reduced mortality particularly in anterior-posterior compression (APC) and vertical shear (VS) injury mechanisms. Proper positioning of the pelvic binder should be centered over the greater trochanters rather than over the iliac crests. In these patients, manipulation of the pelvis should be avoided to reduce dislodgement of blood clots and cause further bleeding.^{17, 18}

Many bedside investigations can be used to exclude intra-abdominal bleeding; Focused Assessment Sonography in Trauma (FAST) is a mainstay investigation in a hemodynamically unstable patient due to its acceptability, reliability and speed, if FAST is performed by trained personnel. The FAST examination is completed in 4 regions; the subxiphoid area to inspect pericardial sac, the right subcostal region to examine hepatorenal fossa, the left subcostal region to evaluate splenorenal fossa, and the pelvis to assess pouch of Douglas. FAST positive refers to accumulation of intraperitoneal fluid more than 200 ml in that area. The advantage of FAST is that it is repeatable and can detect the intrathoracic cause of hypotension such as cardiac tamponade. However, FAST can be false negative in the very early post-injury phase, an obese patient, previous abdominal surgery or presence of bowel gas, and also false positive in a patient with ascites. FAST is an operator-

dependent investigation and diaphragmatic injury or retroperitoneal organ injury may be missed. The FAST has currently developed to an extended-FAST (E-FAST), which is becoming convenient for point-of-care sonography (POCS). An E-FAST can detect a small amount of pneumothorax that is usually missed on a conventional supine chest film, and also recognizes hemothorax as little as 20 ml which also cannot be detected in supine chest film.^{18, 19}

After FAST and E-FAST became famous and an essential adjunct POCS in trauma care, it eliminated the necessity of diagnostic peritoneal aspiration (DPA) from current clinical practice. However, DPA still has a role in the patient who is too unstable for CT with equivocal FAST result. In this situation, DPA can determine who must be operated on or not. DPA involves entering the peritoneal cavity by a small sub-umbilical midline incision and inserting a catheter to the pouch of Douglas, then aspirating the fluid. DPA is positive when aspirated with 10 ml of fresh blood, feces, bile, food particles, or urine and is an indication for immediate laparotomy. Note that DPA should be done after emptying of the stomach and urinary bladder contents, and the incision should be made above the umbilicus in case of pregnancy or suspected pelvic fracture. DPA has disadvantages that it cannot be repeatable, is invasive with a risk of bowel injury, it interferes with further investigation with both FAST and CT scan, and also misses diaphragmatic and retroperitoneal organ injury.¹⁸ Both FAST and DPA have good sensitivity but poor specificity that means they are useful for diagnosis of abdominal injury but cannot specify which organ could be injured.

In hemodynamic stability, many choices of investigation can be used upon the mechanism of injury and clinical signs. CT scan is currently a useful investigation for a hemodynamically stable patient suffering both blunt and penetrating trauma. CT scan requires transporting the patient to the radiation suite with a risk of exposure to radiation and contrast media.

CT scan can provide information about specific organ injuries and severity of injury inside the abdomen.

CT scan also gives information about retroperitoneal

structure but it can miss a small diaphragmatic injury, an early gastrointestinal injury, and pancreatic injury.¹⁸

Table 1 Advantages, disadvantages, false positive and false negative conditions of common investigations for abdominal injury

	FAST	DPA	CT
Advantages	Rapid, accessible, accepted, reliable, repeatable	Bedside, rapid (with experienced hand), early determination of laparotomy, can diagnose bowel injury	High sensitivity and specificity, details of specific organ and severity, can diagnose bowel and retroperitoneal organ injury, repeatable
Disadvantages	Operator-dependent, high-quality machine, needs some training	Need experience, invasive with risk of bowel injury, not repeatable, interferes	May need radiologist, risk of radiation hazard and contrast-media with further investigations toxicity, need to transfer the patient, <i>Contraindicate in hemodynamic instability</i>
False positive	Ascites	Subcutaneous and abdominal wall bleeding during procedure, penetrating injury	Poor imaging interpretation
False negative	Early post-injury period, diaphragmatic injury, retroperitoneal organ injuries, gastrointestinal injury, obesity, previous abdominal surgery, bowel gas	Poor surgical technique, diaphragmatic injury, retroperitoneal organ injuries	Early hollow organ injury, small diaphragmatic injury, pancreatic injury, patient with metallic instrument or impalement and bullet

FAST: focused assessment sonography in trauma, DPA: diagnostic peritoneal aspiration, CT: computed tomography

Clinical signs especially abdominal tenderness and peritonitis are the critical points in cases of abdominal injury, but there may be compromise when a patient has one of these conditions; 1) intoxication, 2) use of illicit drugs, 3) alteration of consciousness from any causes such as shock or brain injury, 4) loss of abdominal sensation mostly associated with spinal cord injury, 5) lower rib fracture, and 6) pelvic fracture. The clinician should be aware of these conditions and select an appropriate investigation to making a diagnosis.

In the era of selective non-operative management and the development of diagnostic technology, the need for immediate exploration for abdominal injury is reduced, and some indications have changed over time. Indications for laparotomy in abdominal trauma are shown in Table 2.

Table 2 Indications for immediate laparotomy in abdominal injury^{5, 16}

Absolute indications

1. Blunt or penetrating abdominal injury with hemodynamic instability (and positive FAST/DPA in blunt abdominal injury)
 2. Generalized peritonitis on initial examination or subsequent
 3. Evisceration of bowel
 4. Impalement
 5. CT evidence of gastrointestinal tract injury (free air, retroperitoneal air, intra-abdominal bleeding without solid organ injury in blunt abdominal injury, GI contrast extravasation), intra-peritoneal bladder ruptured, diaphragm ruptured
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Relative indications; must be discussed with trauma surgeon

1. Evidence of bleeding from GI, or GU following penetrating injury (NG tube, bleeding per rectum, gross hematuria, bleeding per vagina, or CT)
 2. Plain film evidence of pneumoperitoneum (air may track from thoracic or external source especially in penetrating trauma)
 3. CT evidence of an active extravasation of contrast media or solid organ injury with high injury grading (AAST OIS > grade IV) in blunt abdominal trauma
 4. CT evidence of free air and free fluid without solid organ injury in penetrating injury
 5. Gunshot abdomen with hemodynamic stability
 6. Omental evisceration
 7. Multisystem injuries with ongoing hemodynamic instability and unidentified source of bleeding
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FAST: focused assessment sonography in trauma, **DPA:** diagnostic peritoneal aspiration, **CT:** computed tomography, **GI:** gastrointestinal tract,

GU: genitourinary tract, **NG:** nasogastric, **AAST:** The American association for the surgery of trauma, **OIS:** the organ injury scales

Conclusions

Abdominal injury management is changing over time because of the quality of data collection and analysis. Recently, the paradigm shifted from mandatory exploration to the era of selective non-operative management. However, classic indications for immediate laparotomy still remain the same namely, hemodynamic instability, generalized peritonitis, *evidence* of GI injury, diaphragm injury, intraperitoneal bladder rupture, evisceration and impalement in situ. A physician and a surgeon who faces an abdominal *injury* patient should determine these indications and proceed to the operation as soon as possible.

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บทคัดย่อ

วิวัฒนาการของการดูแลผู้ป่วยบาดเจ็บช่องท้องจากอดีตถึงปัจจุบัน

อมรพล กันเลิศ

หน่วยศัลยศาสตร์อุบัติเหตุและการดูแลผู้ป่วยวิกฤตศัลยกรรม สาขาศัลยศาสตร์ทั่วไป
ภาควิชาศัลยศาสตร์ คณะแพทยศาสตร์ มหาวิทยาลัยธรรมศาสตร์

อุบัติการณ์การบาดเจ็บช่องท้องพบได้ร้อยละ 7-10 ของการบาดเจ็บทั้งหมดและมีแนวโน้มเพิ่มสูงขึ้นถึงร้อยละ 1.6 ต่อปี การดูแลรักษาผู้ป่วยที่ได้รับบาดเจ็บบริเวณช่องท้องมีการเปลี่ยนแปลงแนวทางตามยุคสมัยด้วยเหตุจากองค์ความรู้เกี่ยวกับอุบัติการณ์ของการผ่าตัดเปิดช่องท้องที่ไม่จำเป็นสูงถึงร้อยละ 25-40 ในผู้ป่วยถูกแทงที่หน้าท้องหรือถูกกระแทกที่หน้าท้องหากเลือกการรักษาด้วยการผ่าตัดเปิดช่องท้องทันที ทำให้ปัจจุบันแนวทางการดูแลรักษาผู้ป่วยบาดเจ็บช่องท้องมีแนวโน้มจะเป็นการรักษาแบบอนุรักษ์และเลือกทำการผ่าตัดในกรณีที่มีข้อบ่งชี้เท่านั้น อย่างไรก็ตามข้อบ่งชี้สำหรับการผ่าตัดเปิดช่องท้องฉุกเฉินยังคงไม่แตกต่างจากในอดีต ได้แก่ ผู้ป่วยที่มีระบบไหลเวียนไม่เสถียร ผู้ป่วยที่มีอาการของการอักเสบของเยื่อช่องท้อง ผู้ป่วยที่มีการบาดเจ็บต่อท่อทางเดินอาหาร การบาดเจ็บต่อกระบังลม และการบาดเจ็บต่อกระเพาะปัสสาวะชนิดที่มีการรั่วซึมของปัสสาวะเข้าสู่ช่องท้อง รวมถึงผู้ป่วยที่มีอวัยวะภายในทะลักออกมาสู่ภายนอก และผู้ป่วยที่มีวัสดุเสียบคาอยู่ในช่องท้องอีกด้วย

คำสำคัญ: การบาดเจ็บช่องท้อง, ประวัติศาสตร์ของการรักษาการบาดเจ็บช่องท้อง, การตรวจประเมินเบื้องต้นสำหรับผู้ได้รับบาดเจ็บช่องท้อง, ข้อบ่งชี้ของการผ่าตัดช่องท้องฉุกเฉิน