

Review Article

Approach to an abdominal injured patient

Amonpon Kanlerd

Abstract

The incidence of abdominal injury is 7-10% of all trauma cases and trends to increase the frequency by 1.6% per year. Currently, hemodynamic status and mechanism of injury is the key to abdominal injury approaches. In the patient with hemodynamic instability most of them are required immediate abdominal exploration to identify the source of bleeding and control. But in the hemodynamic stability patient, two critical questions must be clarified; 1) Does the patient have an intra-abdominal injury? and 2) If the patient has an intra-abdominal injury, which organ is involved and how severely? These answers can guide physicians to make appropriate investigations and treatments.

Key words: Abdominal injury, Blunt abdominal injury, Penetrating anterior abdominal injury, Penetrating flank and back, Penetrating thoraco-abdomen, Gunshot abdomen

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Department of Surgery, Faculty of Medicine, Thammasat University

Corresponding author: Amonpon Kanlerd (MD., FRCST) Trauma and Surgical Critical Care Unit, 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 incidence of abdominal injury is 7-10% of all trauma cases and trending to increase frequency by 1.6% per year from 2009 – 2016.^{1,2} Abdominal injury divided into blunt and penetrating abdominal injury. A penetrating injury can be categorized into low energy stab wound and a gunshot wound. Clinical anatomy of the abdomen can be classified into 1) anterior abdomen, which extends from the xiphoid process along both costal margins to the anterior axillary line and anterior superior iliac spine, then convergent at the pubic symphysis. 2) flank is the area between anterior axillary line to posterior axillary line. 3) back refer to the area between both posterior axillary lines and 4) thoraco-abdomen is the area under nipple line to costal margins. This article aimed to summarize the appropriate management of abdominal injury in various clinical situations to help clinicians dealing with abdominal trauma patients.

Current approach to an abdominal injured patient

1. Blunt abdominal injury with hemodynamic instability

A patient with a blunt abdominal injury and hemodynamic instability may have a number of multisystem injuries. A clinician should evaluate which one is the possible source of bleeding. In major trauma cases with hemodynamic instability from bleeding, there are five potential sources of bleeding; 1) external bleeding, 2) intrathoracic, 3) intra-abdominal, 4) pelvic and retroperitoneal and 5) long bone fracture. A trauma with hemodynamic instability may not be due to bleeding such as neurogenic shock which associates with a severe head injury and high spinal cord injury (SCI), cardiogenic shock which associates with myocardial injury, and obstructive shock which associates with tension pneumothorax, cardiac tamponade or pulmonary embolism.

A focused assessment sonography in trauma (FAST) is a proper investigation to exclude intra-abdominal bleeding. *Rozycki et al.* reported a 100%

sensitivity and 100% specificity of FAST performed by a surgeon to exclude intra-abdominal bleeding in multisystem trauma patients.³ Therefore, if a surgeon-performed FAST is negative for abdominal bleeding, the abdomen is not the source of bleeding, and a clinician should continue searching for other causes. In an area where ultrasound is not available or FAST is equivocal, a clinician may use diagnostic peritoneal aspiration (DPA) to exclude abdominal bleeding. A blunt abdominal injury with hemodynamic instability and FAST/DPA positive for intra-abdominal bleeding is an absolute indication for immediate abdominal exploration. This type of injury mostly involves solid organ(s) and abdominal vessels (abdominal aorta, vena cava, or iliac vessels) that usually exsanguinate and need a massive blood transfusion.

The resuscitative endovascular balloon occlusion of the aorta (REBOA) is the new technology to help in resuscitation of hemodynamically unstable torso injury. Traditionally, when a patient is suffering from exsanguinate torso bleeding, an emergency thoracotomy with clamping the descending thoracic aorta is a majority treatment. However, the result of this method is not quite adequate, especially in blunt torso injury. The new technology of endovascular balloon occlusion has been developed and there is hope of improving the outcome. The REBOA balloon is drawn through the femoral artery then inflated inside the aorta to decrease hemorrhage into a distal area and improve cardiac and central nervous system (CNS) function. Currently, REBOA is used for hemorrhage control below the diaphragm, in which case the balloon is inflated at the distal thoracic descending aorta (zone I), but in case of pelvic hemorrhage, the balloon is inflated above the aortic bifurcation (zone III).⁴ REBOA can significantly increase systolic blood pressure (SBP) by almost 50 mmHg after the balloon is inflated, in cases of persistent hypotension (SBP < 90 mmHg) or transient responder group.^{5,6} Complications involving REBOA such as arterial dissection, pseudoaneurysm,

hematoma, thromboembolism, acute kidney injury, lower extremity ischemia, and risk of amputations have been reported.^{5, 7} The newest data from the 2015-2016 American College of Surgeons Trauma Quality Improvement Program data set in the use of REBOA in civilian trauma concluded REBOA in severe torso injury significantly increased mortality and had a higher risk of complication especially acute kidney injury and lower limb amputations.⁷ Nowadays, REBOA needs more studies to confirm clinical value. There are also many challenging aspects such as indications, arterial assessment, instruments and techniques including management of troubleshooting.

2. Blunt abdominal injury with hemodynamic stability

A stable patient with blunt abdominal injury usually needs further investigations to diagnose and answer two main questions; 1) Does the patient have an intra-abdominal injury? and 2) If the patient has a specific injury, which organ is involved? and how bad is the injury? For the first question, a clinician can use various methods. Physical examination is the first step, but test reliability may be compromised in many

situations. FAST is a currently useful investigation to exclude intra-abdominal injury. FAST has a reasonable specificity for hemoperitoneum (90-100%), but is not sensitive (28-97%) even on an experienced hand.⁸ If FAST positive, FAST negative with clinical suspicions (a gastrointestinal tract (GI) bleeding or a genitourinary tract (GU) bleeding or localized abdominal pain), or FAST equivocal with a patient is a candidate for non-operative management (NOM), a patient should undergo contrast-enhanced computed tomography (CT). Although, CT scan can answer the second question and guide a surgeon to choose appropriate management. Many factors are used to determine which patient is fit for NOM; 1) a patient has clinical accessibility (not fit for the patient with deterioration of consciousness, spinal cord injury, or patient conditions that preclude regular examination), 2) enough physicians to reassess the patient, and 3) center that can provide operations 24 hours. The patient who is not a candidate for NOM should be operated on. The algorithm for blunt abdominal injury management is described in Figure 1.

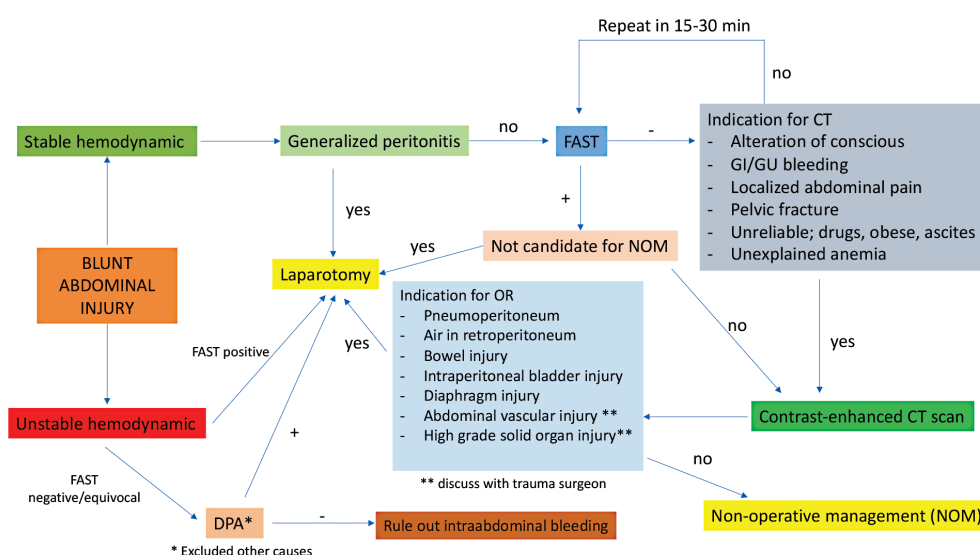


Figure 1 Management algorithm for blunt abdominal injury

FAST: focused assessment sonography in trauma, CT: computed tomography, GI: gastrointestinal tract, GU: genitourinary tract, NOM: non-operative management, DPA: diagnostic peritoneal aspiration

3. Penetrating anterior abdomen with hemodynamic instability

With the hemodynamically unstable patient with a stab wound, the priority is to confirm intra-abdominal bleeding and proceed to the operation. A surgeon can move to laparotomy if the patient has absolute indications such as generalized peritonitis, internal organ evisceration, or impalement *in situ*. But if not, a point-of-care sonography (POCS) with FAST is a useful investigation to exclude intrathoracic cause and confirm an intraperitoneal hemorrhage. As a blunt injury, DPA can be used if equivocal FAST or ultrasound machine is not available.

4. Penetrating anterior abdomen with hemodynamic stability

After excluding a patient with absolute indications from immediate laparotomy, a local wound exploration (LWE) is a useful initial evaluation to identify the peritoneal involvement. LWE should be performed with proper instruments, lights, and under adequate anesthesia (local anesthesia with short-acting drugs including adrenaline). The wound can be extended for adequate exposure, and determine whether the deepest point of the wound track has penetrated through the fascia to the peritoneum or not. Digital or instrument probing is not sufficient and may risk further injury. There are two clinical pathways after LWE; 1) if fascia is not penetrated the patient is safe to discharge home, 2) if penetrated through the fascia, current evidence suggests not an indication for laparotomy (based on 30-50% non-therapeutic laparotomy rate even with positive LWE) but further investigation required or closed observation.⁹ LWE has 100% sensitivity, 54% specificity, and 100% negative predictive value (NPV) in the case of an anterior abdominal stab wound.¹⁰

There are other clinical pathways to evaluate the case of anterior abdominal stab wound without LWE. Serial clinical examinations (SCE) including serial abdominal examinations, repeated vital signs and

laboratory assessment of new or ongoing bleeding is the safest choice. SCE can be used as the primary method or the secondary if positive LWE, and is reasonable to use with patients having a short-duration impairment such as intoxications or intubations.⁹ SCE should be performed by the same investigator, which can detect deterioration of abdominal signs and the possibility of ongoing bleeding. If the center cannot provide a reliable physician for SCE, imaging such as CT abdomen is another option. SCE can reduce the non-therapeutic laparotomy rate from 52% to 12% compared to mandatory laparotomy.¹¹ SCE has 100% sensitivity, 96% specificity, 100% NPV and failure rate 2-10%.^{9, 10} Current evidence suggests to SCE in in-patient department (IPD) within at most 24 hours.⁹ SCE has three possible results within 24-hr observation; 1) the patient develops peritonitis or shock from ongoing bleeding, This is an absolute indication for immediate laparotomy, 2) the patient has a gradual decline of hemoglobin level (significant drop Hb > 3 g/dL) and develops leukocytosis. The patient should proceed to contrast-enhanced CT scan or optional diagnostic peritoneal lavage (DPL) or diagnostic laparoscopy (DL) and 3) the patient is stable through 24-hr, and can be allowed to eat and be discharged.

In the patient that may not be fit for SCE or is in a limited-resource center which can't provide proper SCE, the definitive diagnosis can be made by CT scan. Appropriate contrast-enhanced CT imaging should include lower chest, abdomen, and pelvis with high-resolution 3-mm slices. If the CT scan shows evidence of diaphragm injury, GI injury, intraperitoneal bladder rupture, significant abdominal vascular injury, or high-grade solid organ injury, the patient should undergo laparotomy. But if negative primary CT scan or no signs that need the operative exploration, the patient should be promptly admitted and put under close observation. When discharging a patient after negative primary CT scan, clinicians should be aware

that, based on a study from Biffl WL *et al.*, delayed exploration of 8/92 cases with initially negative CT scan and CT scan had significantly lower sensitivity compared to SCE.¹² CT scan has 77% sensitivity, 73% specificity, and 91% NPV.¹⁰ There are many new techniques in CT scan to improve sensitivity and specificity such as CT tractography which inject the contrast into the wound to evaluate the peritoneal violation, an intrapleural contrast to evaluate diaphragm injury, or a high-resolution fine cuts with

multiplanar reconstruction to improve visualization but current study still reported overall 8.7% false negative rate of CT scan.¹³ Other investigations such as DPL or DL have a role in evaluating peritoneal penetration but they may have less specificity in identifying which organ is injured, except DL role in diaphragm injury that will be discussed later. The surgeon determines when DPL or DL are to be used. The algorithm for penetrating anterior abdominal injury management is illustrated in Figure 2.

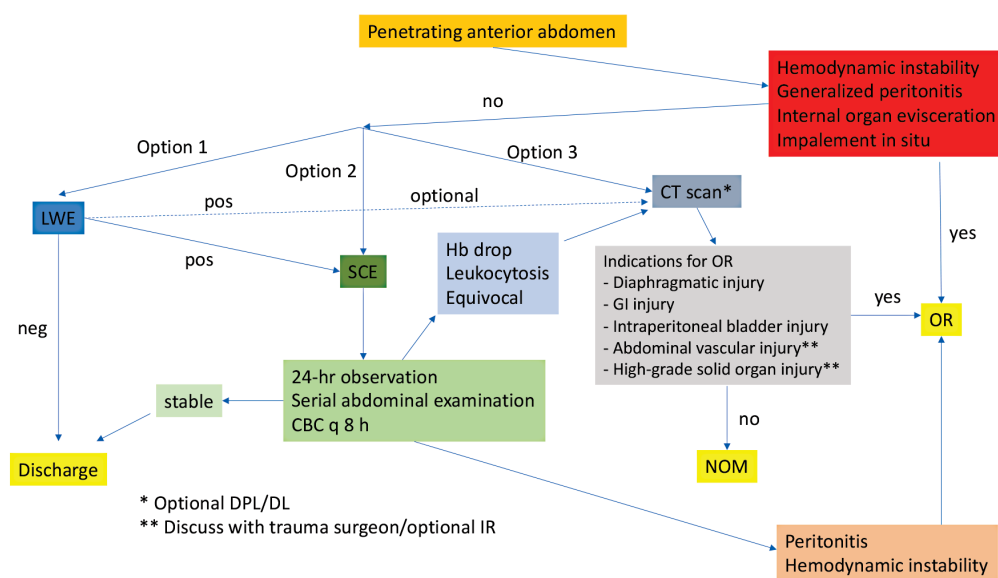


Figure 2 Management algorithm for penetrating anterior abdominal injury

LWE: local wound exploration, SCE: serial clinical examination, CBC: complete blood count, Hb: hemoglobin level, CT: computed tomography, OR: operation, GI: gastrointestinal tract, NOM: non-operative management, DPL: diagnostic peritoneal lavage, DL: diagnostic laparoscopy, IR: intervention radiology

Omental evisceration is currently a relative indication for immediate laparotomy. This is a controversial issue, and in some centers, it still is an absolute indication for laparotomy. But the data from DeSilva M *et al.*, who studied anterior abdominal stab wound with eviscerations (both organ and omentum), found 6/31 omental eviscerated patients who had no peritonitis or severe abdominal pain were successfully

managed non-operatively. They suggested that evisceration should continue to prompt operative intervention. An exception can be made to a select few patients with omentum evisceration with benign abdominal findings.¹⁴ Nowadays, this issue must be discussed with a trauma surgeon before choosing appropriate management.

5. Penetrating thoraco-abdomen

A penetrating injury in the thoraco-abdominal region is defined as a line below the nipples to costal margins having a 15% risk of violating the diaphragm and >45% risk of violating the abdomen.¹⁵ In cases of hemodynamic instability, the surgeon must define which cavity is the most likely cause. A tube thoracotomy should be inserted, and amount of hemothorax must be noted. Any abdominal sign, especially peritonitis, should be examined combined with FAST and then decide which cavity should be explored first; thoracotomy or laparotomy. Matsushima K *et al.* studied 103 hypotensive patients with penetrating thoraco-abdomen and found the pericardial FAST was highly sensitive and could determine the need for pericardiotomy or not. A positive finding of abdominal FAST identified the need for an exploratory laparotomy, but negative abdominal FAST did not exclude the abdominal cavity as a bleeding source.¹⁶

A reasonable initial approach to penetrating thoraco-abdominal injury with hemodynamic stability can use a combination of bedside investigations such as an upright chest film (CXR) and FAST; 1) if CXR positive for intrathoracic injury combined with FAST positive for intraabdominal fluid, indicate a high risk of traumatic diaphragmatic injury (TDI) and suggests employ tube thoracostomy (ICD) with DL. 2) if CXR negative with FAST positive, indicating a low risk of TDI and should be managed as a penetrating anterior abdomen. 3) if CXR positive with the FAST negative, there is little risk of TDI also and can be managed as penetrating chest injury. 4) if both CXR and FAST negative, this is equivocal area and may need further investigation such as DPL, CT scan or DL based on a surgeon's index of suspicion.¹⁰ Although an extended focused assessment sonography in trauma (E-FAST) can be used to substitute for a combination of CXR and FAST, the missed diagnosis of TDI still has a high incidence of 40%, which usually is clinically silent.⁹ This means that even if the initial investigation has a

low risk for TDI, it may be missed and there is a chance of delayed diaphragmatic hernia.

A small penetrating wound in the diaphragm may be occult or difficult to see on many imaging modalities, and surprisingly most penetrating diaphragm wounds are small (80% less than 2 cm). TDI secondary to penetrating injury is generally diagnosed on the left side (75%), and less often on the right. The right side TDI has less morbidity and mortality compared to the left. CT scan is currently a useful investigation for diagnosis of TDI. The use of modern multidetector CT scan has 77% sensitivity and 98% specificity for TDI.⁹ There are many signs on CT scan to diagnose TDI. Herniation-related signs such as protrusion of abdominal fat or organs into thoracic cavity, constriction of diaphragm around the hernial neck or collar and dependent visceral sign. Secondary or indirect signs such as organ injury contiguous on both sides of the diaphragm, the wound track almost or completely through the diaphragm, diaphragmatic thickening, diaphragmatic wound without herniation, extravasation near the diaphragm, and elevation of abdominal organs.^{10, 17, 18} However, a study in 2014 reported 47% of cases missed TDI secondary to penetrating trauma in primary CT scan mis-reading.¹⁸ The Western Trauma Association (WTA) suggested -up close post-discharge follow-up and repeat CT scan at 6-12 months to assess any missed TDI and diaphragmatic hernia if the patient had a negative primary CT scan.⁹

DL is now the best option to diagnose TDI because both diagnosis and treatment can be performed at the same time. The Video-Assisted Thoracoscopic Surgery (VATS) is another option for diagnosis and treatment as DL in TDI. VATS also has a benefit above DL in treatment of intrathoracic injury, namely retained hemothorax. DL and VATS can be used in combination for treating of TDI to reduce conversion to laparotomy or thoracotomy.¹⁹ However, laparotomy still has a role in multiple intra-abdominal

organ injuries which DL can't repair, or in doubtful situations. Laparotomy may also be used as primary TDI investigation if the patient has indications for immediate laparotomy. A surgeon can examine and

repair at the same time. The algorithm for penetrating thoraco-abdominal injury management is depicted in Figure 3.

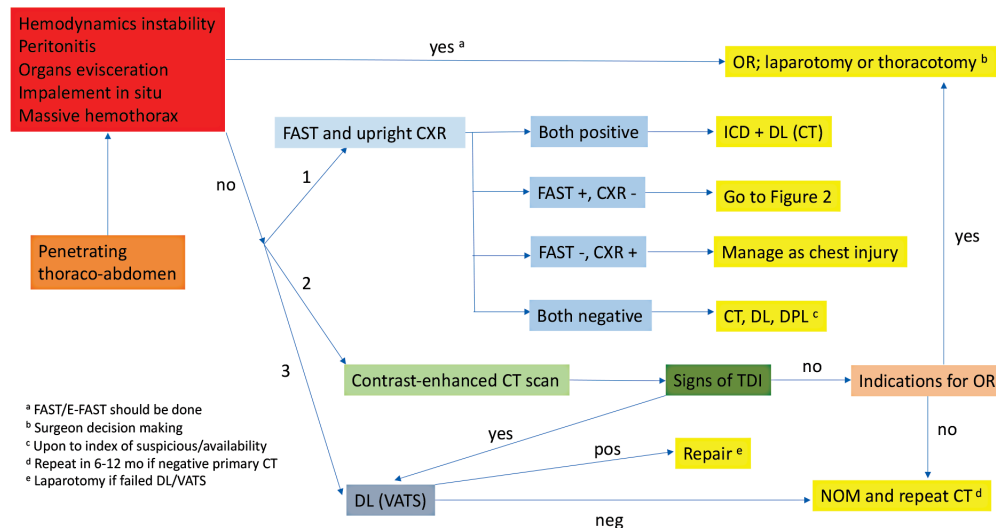


Figure 3 Management algorithm for penetrating thoraco-abdominal injury

OR: operation, FAST: focused assessment sonography in trauma, CXR: chest x-ray, ICD: tube thoracostomy, DL: diagnostic laparoscopy, CT: computed tomography, DPL: diagnostic peritoneal lavage, TDI: traumatic diaphragmatic injury, VATS: video-assisted thoroscopic surgery, NOM: non-operative management, E-FAST: extended focused assessment sonography in trauma

6. Penetrating flank and back

Flank and back refer to the area posterior to the anterior axillary line. Penetrating injury in this area has low probability to injure intraperitoneal organs due to the thickness of the postero-lateral abdominal wall. However, there still is a risk of damaged retroperitoneal organs and major abdominal blood vessels. Similar to penetrating injury in other areas of the abdomen, if the patient with hemodynamic instability, generalized peritonitis, evisceration, or impalement there are indications for immediate laparotomy. However, in the stable patient recent studies suggest contrast-enhanced CT scan to evaluate intra-abdominal and retroperitoneal organs. Triple-contrast study (intravenous, oral, and rectal contrast) has recently been debated. Previous

research of triple-contrast CT scan reported 100% sensitivity, 96% specificity, and 100% NPV for identifying injury and deciding for laparotomy.²⁰ However, the study from Meyer DM *et al.* demonstrated the good results of the double-contrast study (without rectal contrast) in the evaluation of stab wound flank and back.²¹ The value of the triple-contrast CT scan may need more investigations.

CT scan results can be used to guide a surgeon to decision-making; a low-risk group means no penetration or penetration of the subcutaneous tissue; the patient can be discharged from the ED without worry. A moderate-risk group refers to penetrating wound into the muscle layer or retroperitoneal hematoma without evidence of organ injury; the patient should be admitted and serial examination

conducted. And a high-risk group means visible of GI injury (contrast extravasation, free air around retroperitoneal bowel, or intraperitoneal free fluid), significant GU injury (major urine extravasation from collecting system and ureters), abdominal vascular

injury (contrast brushing or significant hematoma), and diaphragm injury. These findings are significant and indicate laparotomy.¹⁰ The algorithm for penetrating flank and back management is shown in Figure 4.

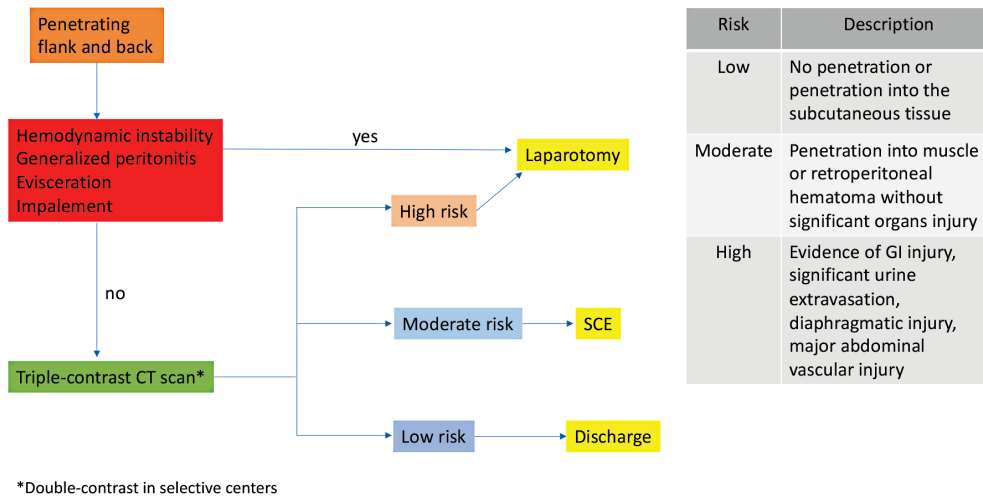


Figure 4 Management algorithm of penetrating flank and back injury
CT: computed tomography, SCE: serial clinical examination, GI: gastrointestinal tract

7. Gunshot abdomen

Based on historical data, the gunshot abdomen was 90% associated with intra-abdominal organ injury, which gave rise to the philosophy of mandatory exploration in gunshot abdomen, which can prove whether the trajectory passed to the peritoneal cavity.²² However, some investigators found 15-27% negative exploration in gunshot abdomen who received mandatory laparotomy. Recently, the concept has been changed to selective non-operative management.²³ Many reports of successful selective non-operative management have been published in the last decade. The systematic review from Lamb CM et al. including 18,602 civilian gunshot abdomen patients from 22 studies and found 32.2% of patients received non-operative management initially, only 15.5% required a delayed laparotomy which are similar outcomes compared to the

mandatory laparotomy group. They concluded selective non-operative management was safely applied and could reduce negative or non-therapeutic exploration.²⁴

A gunshot abdominal injury patient with hemodynamic instability, peritonitis, GI bleeding, and evisceration still needs immediate laparotomy. However, in a stable case contrast-enhanced CT scan abdomen is suggested to identify trajectory and organ(s) injury. Although metallic components of the bullet can produce discordant noise in CT images, the trajectory can predict which organ will be injured. The selective non-operative management may be effective in solitary solid organ injury with hemodynamic stability, especially the liver. But if CT provides evidence of GI injury or there is doubtful pathology, an immediate laparotomy should be performed. For the non-operative management

patient who develops progressive abdominal pain or on-going bleeding the regime should be terminated and proceed to laparotomy.

Conclusions

For the physician who faces with abdominal injury patient, hemodynamic status and mechanism of injury are the key for selecting appropriate investigations and management. In the patient with hemodynamic instability most of them are needs immediate laparotomy, but in the hemodynamic stability patient, two critical questions must be clarified; 1) Does the patient have an intra-abdominal injury? and 2) If the patient has an intra-abdominal injury, which organ is involved? and how severely? These answers can guide physicians to make appropriate management.

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บทคัดย่อ

การตรวจประเมินผู้ป่วยอุบัติเหตุช่องท้อง

อมรพล กันเลิศ

ภาควิชาศัลยศาสตร์ คณะแพทยศาสตร์ มหาวิทยาลัยธรรมศาสตร์

อุบัติการณ์การบาดเจ็บของช่องท้องพบได้ร้อยละ 7-10 ของการบาดเจ็บทั้งหมดและมีแนวโน้มเพิ่มสูงขึ้นถึงร้อยละ 1.6 ต่อปี ปัจจุบันปัจจัยที่มีผลต่อการพิจารณาแผนการตรวจรักษาผู้ป่วยกลุ่มนี้คือ ความคงที่ของระบบไหลเวียน และกลไกการบาดเจ็บ ซึ่งแต่ละชนิดล้วนมีวิธีการตรวจประเมินและแนวทางการรักษาที่แตกต่างกัน ในกลุ่มผู้ป่วยที่มีระบบไหลเวียนไม่คงที่กลุ่มนี้มักต้องการการรักษาด้วยการผ่าตัดเพื่อหาจุดเลือดออกและทำการห้ามเลือด ส่วนกลุ่มผู้ป่วยที่มีระบบการไหลเวียนคงที่นั้น การตรวจประเมินจำเป็นต้องตอบคำถามสำคัญสองประการให้ได้ ได้แก่ การบาดเจ็บดังกล่าวกระทบต่ออวัยวะภายในช่องท้องจริงหรือไม่ และหากกระทบต่ออวัยวะในช่องท้องจริง การบาดเจ็บนั้นโดนอวัยวะใดบ้างและมีความรุนแรงแค่ไหน คำตอบของคำถามเหล่านี้จะเป็นตัวตัดสินใจวิธีการรักษาที่เหมาะสมต่อไป

คำสำคัญ: การบาดเจ็บของช่องท้อง, การบาดเจ็บของช่องท้องจากแรงกระแทก, การบาดเจ็บแบบแทงทะลุช่องท้องส่วนหน้า, การบาดเจ็บแบบแทงทะลุซี่ข้างและหลัง, การบาดเจ็บแบบแทงทะลุช่องอกส่วนล่าง, การบาดเจ็บของช่องท้องจากกระสุนปืน