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Latest progress of research on acute abdominal injuries

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ABSTRACT

Major abdominal trauma, both blunt and penetrating, is commonly seen nowadays, being particularly difficult to manage due to the frequent altered mental status of the patients and severity of associated injuries. The review article aims to make an uptodate study of the current strategies for therapeutic approach of abdominal injuries in polytrauma setting. Review of the medical literature is up to 2015, by using the PubMed/Medline, Science Direct, Cochrane Library and Web of Science databases. We have used different combinations of the keywords of "abdominal trauma", "liver", "spleen", "renal", to review the reference list of retrieved articles for further relevant studies. Nowadays, we are facing a major change in abdominal trauma therapeutic approach, due to the continuous extending indications and very high successful rate of selective nonoperative management, completed or not with minimally invasive techniques like angiography and angiographic embolization. New imaging methods offer a high-quality characterization of solid organ injuries, being a secure support for decision algorithm in polytrauma patients. After a continuous decrease in number of laparotomies for trauma, new techniques should be developed for maintaining and developing the trauma surgeons' skills. According to the current standards, for a low morbidity and mortality, the trauma patients may be approached by a multidisciplinary and experienced trauma team. Even if nonoperative management is continuously expanding, this may be applied only by a trained and skillful trauma surgeon, who is able to perform difficult surgical techniques at any moments.

1. Introduction

Like in all other European countries, blunt abdominal trauma is commonly seen in Romanian Emergency Departments[1]. These injuries are particularly difficult to manage due to the frequent altered mental status and associated injuries, and that the patients are often presented with a complex clinical picture of head, thoracic, abdominal and limb trauma[2]. The penetrating stab and gunshot wounds are much less common than blunt injuries compared to United States of America or South Africa[3]

In a 30-month prospective polytrauma study from our hospital, the most common were blunt injuries in 92.8% of cases and penetrating trauma in only 7.2% of cases. Most severe trauma was caused by road accidents (61.9%), either as drivers or an occupant of a vehicle or by vehicle-pedestrian collision. Motorcycle accidents were found in 2% of cases. They were followed by falls and human aggressions (15.0% and 15.6% respectively). Occupational injuries were the least common, being encountered in 4.8% and autoaggressions in 0.7% of cases respectively[4].

The prevalence of abdominal organ injuries among patients with blunt trauma examined in the Emergency Departments is approximately 13% of cases, the spleen being damaged in over 60% of these cases[5]. Although there are substantial diagnostic challenges, from a surgical perspective, only 4.7% of cases require therapeutic laparotomy or angiographic embolization[5]. The selective nonoperative management (SNOM) of abdominal visceral lesions is one of the most important and

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challenging changes that occurred in the traumatized patients over the last 20 years, and the main advantage is the avoidance of an unnecessary or non-therapeutic laparotomy. More than 95% of blunt abdominal injuries may be nonoperatively managed, with a morbidity similar to or even lower than operative treatment[6].

Currently, the resuscitation of the trauma patients can be divided into two time periods: the 10 platinum minutes and the golden hour. During the 10 platinum minutes, the prehospital trauma team should address the airways as well as hinder the exsanguination and the critical patients should be transported from the trauma scenes. During the golden hour, the hospital trauma team should identify all the trauma lesions and address all life-threatening injuries[7].

Although polytrauma patients represent only 10% of trauma victims, they account for 50% of in-hospital mortality. The most frequent injured body areas in multi-trauma patients are the limbs and pelvis, but abdominal and thoracic lesions are strongly correlated with mortality in younger trauma victims[8,9]. The polytrauma deaths are generated by cranial injuries in 40%–50% of cases, by hemorrhage in 30%–35% and by multiple organ failure in 5%–10% of cases[9].

The clinical exam of abdominal injuries, depending on the clinical scenario, may be completed with the following diagnostic methods: peritoneal aspiration, abdominal ultrasonography, computed tomography (CT) and angiography.

According to the meta-analysis of Nishijima *et al.*, the intra-abdominal injuries are suggested by the presence of the seat belt sign [likelihood ratio (LR) range, 5.6–9.9], rebound tenderness (LR, 6.5), hypotension (LR, 5.2), abdominal distension (LR, 3.8), and abdominal guarding (LR, 3.7)[5].

The intraperitoneal free fluid or organ injuries on abdominal ultrasonography overpasses the accuracy of history and physical exam (LR, 30.0). The workup suggests abdominal visceral injuries when there is a base deficit less than −6 mEq/L (LR, 18.0), increased liver transaminases (LR range, 2.5–5.2), hematuria (LR range, 3.7–4.1), anemia (LR range, 2.2–3.3) and abnormal thoracic X-ray (LR range, 2.5–3.8)[5].

It is very important to recognize that overlooked injuries and delayed diagnosis are still common problems in the nowaday management of polytrauma patients[10]. After a review of the literature, Pfeifer and Pape found a widespread distribution of missed and delayed diagnosis incidence (1.3%–39.0%), as much as 22.3% of patients with missed injuries having significant missed lesions. The authors stress the importance of a standardized tertiary trauma survey for earlier detection of clinically significant missed injuries[11].

2. Imagistic workup

Ultrasonography – focused abdominal sonography for trauma (FAST) performed by radiologists, emergency medicine physicians or trauma surgeons is a rapid and highly accurate method for detecting haemoperitoneum[12,13]. Its valuable role is especially for haemodynamic compromise patients[14]. As FAST can miss or underestimate the degree of injury, a CT examination is recommended in haemodynamically stable patients with negative FAST[15–17], because of the recommendation of Miller *et al.*: not so fast[18].

CT is the most informative radiological technique for head and abdomino-pelvic trauma. During the latest decade, the major developments of CT technology, such as higher spatial resolution, faster image acquisition and reconstruction, and improved patient safety, made the “panscan” the fundamental element in early evaluation and decision-making algoritm[19]. An important but still less standardized use of CT examination is its ability to predict failure of SNOM for abdominal visceral lesions. Although the medical literature presents some imagistic parameters that correlate with SNOM failure, there is no a diagnostic algorithm for selecting patients who will benefit from SNOM. In our trauma center, the abdominal visceral lesions of high grade [grades III, IV or V according to organ injury scale (OIS)] or lesions with actively contrast extravasation on emergency CT scan, are evaluated through an emergency diagnostic and/or therapeutic angiography[20]. Ochsner shows that the presence of a contrast pool in liver trauma means active bleeding and significantly correlates with need for surgery[21]. For splenic injuries, the contrast extravasation in the arterial phase is associated with SNOM failure[21]. We consider contrast extravasation or high-grade visceral lesions, in a haemodynamically stable patient, as an indication for angiography and not for emergency laparotomy[22–24].

Angiography has evolved dramatically in the recent years, first as an assistance of the operative approach rather than the nonoperative one[25]. The angiographic embolization can be successfully done in liver, spleen, kidney or pelvic bleeding[22,26,27]. In their study, Velmahos *et al.* presented a success rate of 91% for angiographic hemostasis in these conditions[28].

3. Damage control surgery

The hemorrhagic shock is generated by a unique factor, the massive acute blood loss that causes a complex and heterogeneous clinical picture[29]. Blood *et al.* analyzed the hospital records of 210 fatal combat casualties who died after the medical treatment was started. About 25% of the deaths were produced by massive exsanguination and were beyond current medical resources, but 19% of additional deaths were preventable, of which 10% were due to thoracic exsanguination and 19% to peripheral exsanguination[30].

Bailout surgery or damage control surgery was one of the major changes in the thinking of trauma surgery during the last 20 years, challenging the traditional concept of definitive one-step surgery[31]. Nowadays, trauma surgeons have evolved surgical techniques and protocols for managing more and more severe thoracic, abdominal, extremity and peripheral vascular injuries according to principles of damage control[32,33].

Damage control laparotomy is usually performed in high-grade liver and major vascular injuries[34]. Major liver injuries should be explored after inflow occlusion by using the Pringle maneuver, surgical hemostasis through direct vessel ligation in depth of the laceration and the abbreviated technique ended with compression of the liver lesions between packs. We should stress that packing is only an adjunctive measure to be performed only after the hemostasis of the major hepatic vessel(s).

Major vascular injuries can be approached by using a combination of different techniques: (a) ligation of the bleeding vessel, excepting the aorta or the proximal superior mesenteric artery and retrohepatic vena cava; (b) temporary shunting of the vessel, even with a chest tube.

Damage control thoracotomy is performed for penetrating thoracic injuries through a fifth anterolateral intercostal space with an aim to find out the bleeding source, to rule out the cardiac tamponade and to cross clamp the descending aorta[35–37].

Damage control orthopedics should be used for rapid and temporary stabilizations of the pelvic and femoral fractures, usually with an external fixator[38,39].

4. Liver trauma

The surgical approach of a high-grade liver injury represents one of the most challenging aspects of trauma surgery, due to its massive bleeding in a difficult position to control area, associated with a profoundly altered physiology, without the benefits of a clear anatomy as obtainable for elective hepatic resections. Over the past 20 years, the nonoperative management of liver injuries became the dominant therapeutic strategy[40].

The hemodynamically unstable patient with a liver trauma should be transported to the operating room for emergency laparotomy and rapid control of the bleeding. After a large midline laparotomy, the surgeons have to pack all the four quadrants of the abdomen. If a liver injury is suspected, the right upper quadrant should be explored last[41]. If the hemostasis was achieved after packing and the physiology of the patient is altered, the procedure may be one of damage controls, and the patient will be returned into the operating room after 36–72 h. There are many advanced techniques for liver hemostasis, even for major liver resections, that can be used by the trauma surgeons and adapted to a specific patient with a specific physiological status[42].

The surgeon facing a liver trauma in a hemodynamically stable patient, without signs of peritoneal irritation should apply the standard of care, represented by nonoperative management, regardless of the severity of injury (Figure 1)[43].

In high-grade liver lesions addressed nonoperatively, severe complications may occur like ongoing bleeding, bile collections, pseudoaneurysm formation with haemobilia or gallbladder necrosis. For their management, the surgeon should use minimally invasive techniques like angiography, CT-guided drainage or laparoscopic drainage.

In a study from our trauma center[44], the liver was injured in 50 out of 207 cases (24.2%), being the major abdominal trauma in 38 patients (18.4%). According to OIS classification of American Association for the Surgery of Trauma (AAST), 10 patients (26.3%) had grade I liver injury, 12 (31.6%) grade II lesions, 11 (28.9%) grade III and 5 (13.2%) grade IV.

Out of these injuries, 19 (50%) were successfully nonoperatively managed, 18 (47%) were surgically explored and the failed nonoperative management was for one case (3%) due to bleeding (Figure 2).

Surgical approach by laparotomy was in 11 cases (73.3%) and laparoscopy in 4 cases (liver was the major injury in two major cases) (26.7%). In one case, laparoscopy was converted to open approach. About 70% of laparotomies and 75% of laparoscopies were non-therapeutic.

5. Splenic trauma

SNOM replaced the methods for spleen conservation like splenorrhaphy, and up to 70% of splenic injuries are now being treated nonoperatively[45]. Initially, complex splenic injuries, the spleen with a pre-existing pathology, needed for transfusion, and patients with severe brain injury, aged over 55 years were considered inappropriate for SNOM; today, however, these conditions are not universally accepted[45,46]. Currently, it is considered that SNOM can be applied safely in patients over 55 years and in carefully selected patients with severe head trauma[6,47]. According to a recent meta-analysis of predictive factors and outcome for failure of SNOM in blunt splenic trauma, the following factors may lead to early identification of patients at high risk for SNOM failure, who will benefit from splenic angioembolization instead: AAST scores, size of haemoperitoneum, age and injury severity score[48].

The angiographic embolization of splenic artery is a very useful tool for achieving hemostasis, but there are concerns regarding the immune function of the angioembolized spleen. Walusimbi *et al.*, in a study analyzed the circulating cellular and humoral elements of immune function following splenic arterial embolization or splenectomy in trauma patients[49], and found that splenic embolization for trauma did not affect total T-lymphocytes, total helper T-lymphocytes, total suppressor T-lymphocytes, complements C3 and C4 or propending concentrations. The evidence supports the idea that systemic immune function is not impaired by the splenic arterial

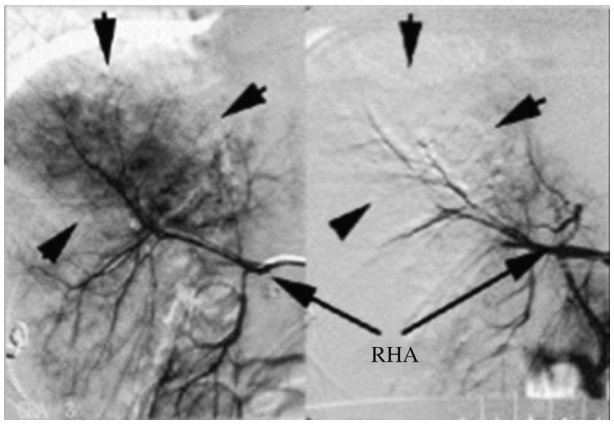

Figure 1. Bleeding at the level of the right lobe of the liver treated by angioembolization.
RHA: Right hepatic artery.

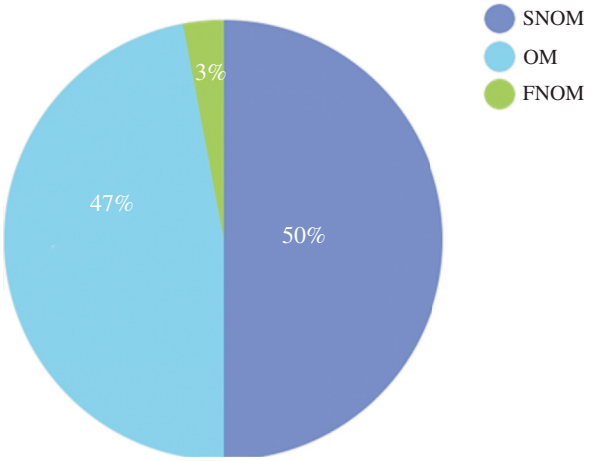

Figure 2. Therapeutic approach of liver injuries in polytrauma patients in our center.
OM: Operative management; FNOM: Failed nonoperative management.

embolization[49]. In the same study from our trauma center[44], the spleen was injured in 131 (63.3%) out of 207 trauma patients, being the most severe abdominal injury in 95 patients (45.9%). According to OIS classification of AAST, 14 patients (14.7%) had grade I splenic injury, 42 (44.2%) grade II, 23 (24.2%) grade III, 15 (15.8%) grade IV and 1 (1.1%) grade V.

Out of these injuries, 55 (57%) were successfully managed nonoperatively, 29 (31%) were approached by an operative approach and in 11 patients (12%), the initial nonoperative management failed (Figure 3).

Surgical approach by laparotomy was in 26 cases (89.7%) and by laparoscopy in 4 cases (1 case totally laparoscopic, three cases converted to open approach). Splenic surgery was conservative in 11 cases (37.9%) and splenectomy in 13 cases (44.8%). In 5 cases (17.2%), there was a non-therapeutic laparotomy.

6. Renal trauma

The kidney is a very suitable organ for SNOM, with an overall success rate of 90% and 50% in grade V lesions[50,51]. Renal injuries of increasing grade were addressed nonoperatively, given the much higher rate of nephrectomy in surgical group (35.0% versus 12.6%[52,53]). SNOM became the standard treatment for I-III renal injuries[6,54]. Elashry and Dessouky support the conservative management of grade IV blunt renal parenchymal injuries in the absence of hemodynamic instability of renal origin[55]. Out of 57 patients with grade IV and 15 patients with grade V renal injuries, 70.8% (48 for grade IV and 3 for grade V) were managed conservatively, with lower transfusion requirements, shorter hospital stays and fewer complications[55]. Umbreit *et al.* showed that surgical exploration could be avoided in over 72% of grade IV renal lesions, with a rate of, at least partial, kidney salvage of 95%[56].

We have found that kidney was injured in 30 cases (14.6%), being the major abdominal lesion only in 8 cases (3.9%)[4]. According to OIS classification of AAST, there were 2 (25.0%) grade I patients, 3 (37.5%) grade II patients, 1 (12.5%) grade III, 1 (12.5%) grade IV and 1 (12.5%) grade V. Out of these 8 cases, 6 (75%) were successful nonoperatively managed and 2 by operative approach. There was no failure for nonoperative management (Figure 4).

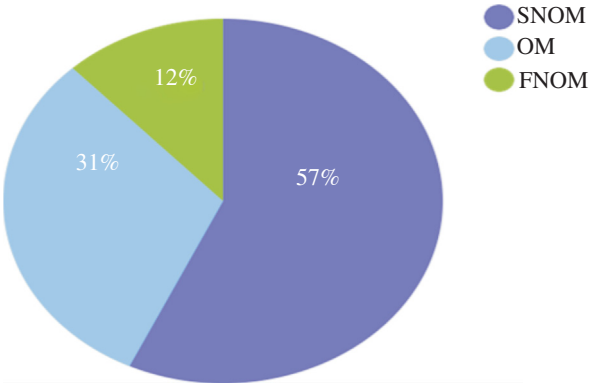

Figure 3. Therapeutic approach of splenic injuries in polytrauma patients in our center.
OM: Operative management; FNOM: Failed nonoperative management.

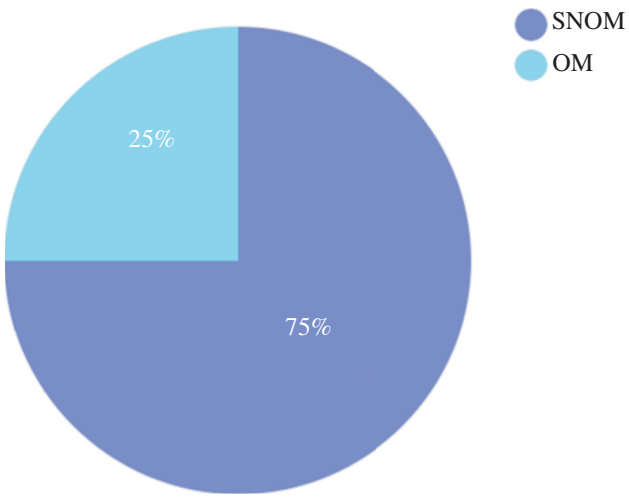

Figure 4. Therapeutic approach of renal injuries in polytrauma patients in our center.
OM: Operative management.

7. Conclusions

Nowadays, we are facing a major change in therapeutic approach for abdominal trauma due to the continuous extending indications and very high successful rate of SNOM, completed or not with minimally invasive techniques like angiography and angiographic embolization. After a continuous decrease in number of laparotomies for trauma, new techniques should be developed for maintaining and developing the trauma surgeons' skills.

Conflict of interest statement

The authors report no conflict of interest.

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