

# Selective Non-Operative Management of Abdominal Injury in the Military Setting

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### Introduction

The Trauma Working Groups of the Academic Department of Military Surgery & Trauma (ADMST) were established to examine published evidence, gain cross specialty consensus, and establish recommendations to inform an evidence based military surgical practice. The Torso Trauma Working Group (TTWG) met on 2<sup>nd</sup> February and 12<sup>th</sup> May 2011, to discuss the selective non-operative management of abdominal injury in the military setting. The members of the TTWG are listed at the end of this paper, as are those present for the initial meeting. This report summarises the recommendations and has been refined to obtain a consensus view via email.

### Background and Aim

The selective non-operative management of blunt abdominal solid organ injury and abdominal stab wounds is generally accepted, at least in the civilian setting [1]. The selective management of ballistic injury is more contentious, particularly in the military setting. There is, however, evidence that selective non-operative management of ballistic injuries is being practiced by military surgeons on deployment [2-4], and few would argue that torso fragmentation injuries confined to the subcutaneous tissues, with no evidence of cavitory penetration on cross-sectional imaging, require only local debridement, rather than laparotomy or thoracotomy.

This consensus statement is intended to provide guidance on the use of selective non-operative management in the military setting. It is not intended to be a protocol, and the TTWG accepts that the utilisation of this paradigm will depend on injury patterns, operational tempo, deployed facilities, and surgeons' training and experience. This document is furthermore not intended to *promote* the use of non-operative management, but to support those surgeons who wish to employ this strategy, in the small number of casualties in whom it may be feasible.

### Rationale

The aim of selective non-operative management of abdominal injury is to prevent morbidity, by minimising the number of patients undergoing non-therapeutic laparotomy, and the number of missed injuries and delayed interventions, whether therapeutic or not.

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### Ballistic Abdominal Injury

Until the 1990s, all ballistic abdominal injuries were treated with "mandatory laparotomy", based on a perception that the risk of intra-abdominal injury was high, and the risk of complications relating to non-therapeutic laparotomy low. This is incorrect. In civilian practice, the incidence of unnecessary laparotomy ranges from 14-47%, depending on the denominator applied [5-13]. Non-therapeutic laparotomy is not a benign procedure: 9-26% of patients develop complications [14-16], and although long-term problems such as adhesive obstruction and incisional herniae are difficult to evaluate in the trauma population, they are well recognised [15,17]. Complications increase the length of hospital stay [12,13,15,18], and non-therapeutic laparotomy is approximately \$10,000 more expensive than non-operative management [12]. There appears to be a reasonable argument for the selective non-operative management of ballistic injuries in civilian practice, and the Eastern Association for the Surgery of Trauma has recently published practice management guidelines to assist surgeons in implementing this strategy [19].

### Blunt Abdominal Solid Organ injury

The non-operative management of blunt splenic injury was pioneered by paediatric surgeons [20], and subsequently extrapolated to adult practice. Approximately 60-80% of blunt splenic injuries are amenable to non-operative management [21], with reported success rates ranging from 83-95% [20,22-25]. In the civilian setting, all grades of splenic injuries have been successfully treated non-operatively, but it is recognised that higher grades, as well as the volume of haemoperitoneum and age, are important predictors of failure [26,27]. Following the success of non-operative management of blunt splenic injury, the contemporary management of blunt hepatic injuries has also migrated towards non-operative management [28]. Eighty six percent of blunt hepatic injuries are now managed non-operatively [29,30], with reported success rates of 85-98% [21,31-33]. As with blunt splenic trauma, there are reports of successful non-operative management of all grades of blunt liver injury, but increasing grade of injury is similarly associated with a higher failure rate and incidence of complications [31-33], such as delayed haemorrhage, hepatic abscess and biloma.

### Failure

Failure of non-operative management may be due to persistent or recurrent bleeding from known solid organ injuries, or due to unrecognised hollow viscus injury. The natural history of failed non-operative management of blunt and penetrating injuries

differs. The anatomical disruption to abdominal solid organ injuries caused by blunt force trauma is presumably different from that caused by a projectile, and these differences manifest as different rebleeding risks. It is possible that failure after non-operatively managed ballistic injury is due to persistent bleeding, whereas late haemorrhage after non-operatively managed blunt trauma represents a new event. In non-operatively managed ballistic injury, failure due to bleeding almost always occurs early [6,9,12,13,34-38]. In contrast, bleeding after non-operatively managed blunt solid organ injury may occur up to several days later [27,30,39-43]. In a large study of nearly 1500 adult trauma patients by the Eastern Association for the Surgery of Trauma, the overall failure rate was 11%. Almost two thirds of failures occurred within 24 hours of admission, but 8% failed nine days or later after injury [43]. A further study, of 2300 splenic injury patients of all ages, found that 12% failed non-operative management more than five days from the time of the injury [27]. These findings have important implications for management, particularly in the deployed military setting.

Hollow viscus injury is relatively rare following blunt abdominal trauma, but should of course always be considered. An isolated injury to the liver or spleen has a 7% risk of being associated with a hollow viscus injury. Combined injuries are associated with disproportionately higher risks [44]. Missed hollow viscus injury is the Achilles' heel of non-operative management of ballistic injury, and the cause of most failures. The risk of failure declines with time from injury, and almost all missed injuries present within 48 hours of wounding.

The likelihood of successful non-operative management is proportional to the extent of the injury. In blunt abdominal solid organ injury, the risk of haemostatic failure is related to injury grade (although the relationship is not straightforward) and factors such as volume of haemoperitoneum and presence of contrast extravasation. There are no data on such a relationship in ballistic injury, although it seems likely that it exists. Similarly, the risk of missed hollow viscus injury is also presumably related to injury extent: A patient with a tangential fragmentation injury confined to the subcutaneous tissues is very unlikely to harbour "missed injuries". In contrast, a patient with a gunshot wound to the liver, even when the trajectory is deemed low-risk for hollow viscus involvement, is more likely to fail – but also has the most to gain.

### Tactical Considerations

The decision to manage a patient non-operatively must accord with the current and projected tactical situation. In particular, current and projected clinical workflows must not threaten frequency of consultant review of patients selected for non-operative management, or detract from the ability of named consultant staff to intervene and schedule the "failing" patient for laparotomy if required. Similarly, the bed-state and ability of the Role 3 must be consistent with the potential "hold" requirement for patients selected for non-operative management. As such, SNOM is likely to be less practical at Role 2 or in other resource constrained circumstances, even when other requirements (such as cross-sectional imaging) are in place.

### Terminology

"Non-operative management (of abdominal injury)" refers to the clinician's explicit decision not to explore a patient's abdomen (ie. perform laparotomy), unless there is a change in the patient's

condition. In the context of ballistic injury, this is somewhat of a misnomer, as patients may still require and undergo extraperitoneal procedures, such as wound debridements, or delayed laparoscopy, when there is concern about the integrity of the left hemidiaphragm. However, for the sake of consistency, and because alternatives which make this distinction are cumbersome, the original term has been retained throughout the literature, and in this article.

Non-operative management commences after initial clinical assessment and imaging has been completed. The decision to proceed to cross-sectional imaging, rather than directly to operation, does not constitute an attempt at non-operative management. "Failure of non-operative management" is defined as any unplanned "delayed intervention", operative or percutaneous, therapeutic or non-therapeutic. A "negative laparotomy" is an exploration which revealed no injuries at all. A "non-therapeutic laparotomy" is defined as either a negative laparotomy, or an abdominal exploration which revealed injuries which required no surgical treatment. A "missed injury" is an injury which was diagnosed late, usually leading to delayed intervention.

### Strength of Available Evidence

There is relatively little published evidence relating to the practice of non-operative management in the deployed military setting. The consideration of this strategy in military surgical practice is recent, and due to changing injury patterns during recent conflicts, the availability of cross-sectional imaging on deployment, and the application of civilian trauma surgical paradigms to the military patient. The following recommendations are therefore based on extrapolation from civilian data, where applicable, and expert opinion, and thus do not have the strength of a guideline or protocol.

### Recommendations

#### 1. Non-operative management should be considered in patients in whom there is no need for immediate operative intervention

Injuries caused by military munitions differ from civilian injuries, but there does not appear to be an inherent reason why the benefits of non-operative management should not extend to selected military patients. However, the TTWG acknowledge that the number of military casualties with abdominal injuries – irrespective of whether inflicted by blunt or ballistic trauma – who could be managed non-operatively is small. As in civilian practice, and regardless of the mechanism of injury, non-operative management should only be considered in the absence of indications for operative intervention. Persistent haemodynamic compromise, indicating the need for surgical control of haemorrhage, and peritonitis are absolute contraindications to attempting non-operative management. The presence of a decreased level of consciousness, in contrast, whether due to injury or therapeutic interventions, is a relative contraindication. Surgeons must therefore conduct a comprehensive assessment, taking into account clinical examination findings as well as other parameters, such as lactate levels and base deficit, which may indicate hypoperfusion. There may be a role for parameters such as the shock index in identifying relevant patients [45,46], but this requires further study.

The higher incidence of late haemostatic failure in patients with blunt splenic injury, and the unclear relationship with injury grade, makes it harder to recommend non-operative management for blunt solid organ injury in the military setting. In such patients, non-operative management may be considered, but only if facilities for continuous observation, as well as intervention, are available – for example, in local facilities – or the injury is of a very minor degree.

**2. The availability of computed tomography scanning is an absolute requirement for selective non-operative management**

High-quality computed tomography imaging, and expert, timely reporting, is a pre-requisite for selective non-operative management [2,19,47-51]. Selective non-operative management should not be considered if CT is not available. CT scans should be performed with intravenous contrast, but there is no need for the routine use of oral or rectal contrast.

**3. CT images should be reviewed jointly by a consultant trauma surgeon and consultant radiologist, to assess the likelihood of an injury requiring surgery being present**

This assessment should take into account both indirect signs, such as the presence of extraluminal gas and – in ballistic trauma – the presumed trajectory of the missile, and direct signs of organ injury, such as the presence of contrast extravasation, mesenteric stranding and bowel wall thickening, and the location of the projectile, if applicable. In many instances, this assessment will be straightforward. In more complex cases, and particularly following ballistic injury, when the peritoneum and/or retroperitoneum has been breached, clinicians should attempt to quantify the probability of an unrecognised hollow viscus injury, and the likelihood of solid organ injury requiring surgical haemostasis.

**4. The decision to manage a patient non-operatively must be explicit**

The decision to manage a patient non-operatively must be explicit, and documented in the patient's records. The entry should state that there are no clinical or radiological contraindications to attempting non-operative management, and include triggers for re-evaluation of the appropriateness of non-operative management.

**5. Patients with ballistic injuries who are managed without laparotomy may still require debridement of superficial wounds**

Patients with extraperitoneal wounds and patients with intra-abdominal injuries which are not deemed to require laparotomy may still require debridement of superficial wounds, to prevent infectious complications. Injuries inflicted by military munitions are characterised by high energy transfer, typically resulting in highly contaminated and necrotic wounds. Civilian gunshot wounds, in contrast, are often caused by small calibre handguns, which impart little energy, result in little contamination, and often require no surgical treatment at all. It therefore stands to reason that the

external parts of otherwise non-operatively managed military wounds should be treated like other military wounds, and carefully debrided and left open. This strategy is supported by the TTWG, although it is conceivable that military wounds which are amenable to non-operative management actually represent low energy transfer injuries, from missiles at the end of their trajectory.

**6. Non-operatively managed patients should be cared for in a clinical area appropriate to the complexity of their injury**

Patients with uncomplicated injuries can be cared for in a normal ward, whereas patients with complex injuries are more appropriately cared for in the intensive care unit. Similarly, the type of monitoring (frequency of vital sign recordings, invasive blood pressure monitoring) should also reflect the complexity of the injury.

**7. Patients with non-operatively managed solid organ injury should be observed for 48hrs before aeromedical evacuation or discharge**

Failure of non-operative management may be due to persistent or recurrent bleeding from known solid organ injuries, or due to unrecognised hollow viscus injury. After ballistic injury, the risk of failure declines with time from injury, and virtually all unrecognised injuries present within 48 hours of wounding. As expected, later failures are almost always due to hollow viscus injuries, and do not present with haemodynamic compromise [6,9,12,13,34-38]. In contrast, failure due to unrecognised hollow viscus injury is uncommon after blunt trauma. However, late haemostatic failure is more common.

In patients with blunt abdominal solid organ injury requiring aeromedical evacuation, non-operative management should only be considered when the injuries are minor, and the responsible consultant surgeon is confident that further haemorrhage is very unlikely. This decision should take into account injury grade and morphology, associated injuries, duration and mode of aeromedical evacuation, and the presence and volume of haemoperitoneum. Prediction of bleeding risk is notoriously difficult, and there is insufficient evidence to support a more precise statement.

In non-operatively managed patients with ballistic injury, the TTWG agreed that a 48 hour period of observation prior to aeromedical evacuation or discharge should ensure that essentially all failures are detected. Furthermore, any failures presenting after this time are unlikely to be due to haemorrhage.

**8. Non-operatively managed patients should be reassessed clinically at least twice per day**

Non-operatively managed patients should be reassessed clinically at least twice daily, with regards to haemodynamic status, which may indicate failure of non-operative management of solid organ injury, and development of symptoms and signs which indicate a missed hollow viscus injury. These reassessments should ideally be conducted by the consultant surgeon who saw the patient on admission,

and who made the decision to manage the patient non-operatively. More frequent reassessments may be indicated in patients with complex injuries.

#### **9. Non-operatively managed patients do not require bedrest**

There is no specific evidence that bedrest increases the likelihood of successful non-operative management following ballistic injury. There is, however, evidence that the timing of mobilisation of patients with blunt solid organ injuries does not contribute to delayed haemorrhage requiring laparotomy [52]. The TTWG consensus is that patients should be mobilised as able.

#### **10. Strategies for thromboembolism prophylaxis should be based on early mobilisation and mechanical methods**

There is recent evidence, from a small but well-conducted retrospective study, that thromboembolism prophylaxis with low molecular weight heparin does not increase the failure rate of non-operative management, or the transfusion requirements of non-operatively managed patients [53]. Thromboembolism risk should therefore be assessed on an individual basis, and managed with a combination of chemical and mechanical means, as deemed appropriate by the consultant in charge, and – where possible – early mobilisation.

#### **11. Non-operatively managed patients with ballistic injuries should receive co-amoxiclav until the debridement of superficial wounds has been completed.**

Antibiotics are an adjunct to surgical treatment. As discussed above, patients managed without laparotomy may still require debridement of superficial wounds. If there is subsequently concern about the possibility of infection, the patient must be thoroughly re-evaluated, with particular attention to the adequacy of source control, and the need for further debridement and laparotomy.

#### **12. Suspected ballistic left diaphragmatic injury, in the absence of other reasons for laparotomy or thoracotomy, is an indication for scheduled laparoscopy or laparotomy**

Unrecognised diaphragmatic injury after ballistic trauma may lead to herniation, which is often diagnosed late, sometimes with catastrophic consequences [54,55]. Laparoscopic examination (which may be more applicable after stab wounds rather than ballistic injuries) or laparotomy is therefore advisable when diaphragmatic injury is suspected, and there are no other indications for laparotomy or thoracotomy [19,56-58]. This should be regarded as a scheduled, rather than urgent, procedure and can be performed at Role 4. In local nationals, suspected left diaphragmatic injury is an indication for laparotomy. Right-sided diaphragmatic injury is less of a concern, as herniation is uncommon.

#### **13. Failure of non-operative management is primarily a clinical diagnosis**

Failure of non-operative management, whether due to persistent or recurrent bleeding from known solid organ injuries, or due to unrecognised hollow viscus injury, is almost always diagnosed clinically. When there is clinical concern, there is rarely a role for repeat imaging. However, if considered necessary, repeat CT scanning should usually be performed with both intravenous and oral contrast.

#### **14. Routine repeat CT scan prior to aeromedical evacuation or discharge is not necessary**

Given that failure of non-operative management is almost invariably clinically obvious, repeat CT scanning prior to aeromedical evacuation is also not usually necessary. In special circumstances, the need for such imaging should be discussed by the consultant surgeon, consultant radiologist, and – if applicable – the Critical Care Air Support Team (CCAST) consultant.

#### **15. Routine follow-up CT scanning is not necessary**

There is only limited evidence regarding the utility of follow-up imaging following non-operatively managed solid organ injury, which primarily relates to the management of blunt splenic injury, particularly in children. In this setting, follow-up imaging has not been shown to be of value [59]. Although there is no direct evidence, the TTWG consensus was that routine follow-up imaging is not necessary.

#### **16. Personnel with non-operatively managed solid organ injury can return to normal activity after three months**

There is, again, only very limited evidence regarding resumption of normal physical activity, including contact sports, which almost exclusively relates to blunt splenic injury. Recommendations vary from three weeks to three months [60]. Virtually all splenic injuries are radiologically healed after three months [61]. The TTWG therefore recommends that all personnel with non-operatively managed solid-organ injury can return to normal activity, including contact sports and military duties, after three months. Shorter periods may be appropriate depending on the severity and complexity of the injury, at the supervising consultant's discretion.

#### **17. The results of non-operative management should be audited**

The results of selective non-operative management should be audited. Particular areas of interest are the non-therapeutic laparotomy rate in patients undergoing primary surgical treatment, the missed injury rate, and the delayed intervention rate. The latter should be divided into delayed therapeutic interventions (including percutaneous), and delayed non-therapeutic interventions, which are relatively common. The TTWG recommends the establishment of a specific surgical data set to capture surgical data from point of surgery.

### **Summary**

This article represents a consensus view of those TTWG members present in Birmingham and taking into account the views of the other group members via email discussion. We believe it represents

clear guidance for the deployed clinician and recommend the use of selective non-operative management when appropriate.

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### Members Present at the Concensus Meeting – 2<sup>nd</sup> February 2011

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### References

- Hurtuk M, Reed RL, Esposito TJ, Davis KA, Luchette FA. Trauma surgeons practice what they preach: The NTDB story on solid organ injury management. *J Trauma* 2006; 61(2):243-54
- Morrison JJ, Clasper JC, Gibb I, Midwinter M. Management of penetrating abdominal trauma in the conflict environment: The role of computed tomography scanning. *World J Surg* 2011; 35(1):27-33.
- Wood AM, Trimble K, Loudon MA, Jansen J. Selective non-operative management of ballistic abdominal solid organ injury in the deployed military setting. *J R Army Med Corps* 2010; 156(1):21-4.
- Beekley AC, Blackburn LH, Sebesta JA, McMullin N, Mullenix PS, Holcomb JB, 31st Combat Support Hospital Research Group. Selective nonoperative management of penetrating torso injury from combat fragmentation wounds. *J Trauma* 2008; 64(2 Suppl):S108-16
- Dawidson I, Miller E, Litwin MS. Gunshot wounds of the abdomen. A review of 277 cases. *Arch Surg* 1976; 111(8):862-5.
- Demetriades D, Charalambides D, Lakhoo M, Pantanowitz D. Gunshot wound of the abdomen: Role of selective conservative management. *Br J Surg* 1991; 78(2):220-2.
- Lowe RJ, Boyd DR, Folk FA, Baker RJ. The negative laparotomy for abdominal trauma. *J Trauma* 1972;12(10):853.
- Moore EE, Moore JB, Van Duzer-Moore S, Thompson JS. Mandatory laparotomy for gunshot wounds penetrating the abdomen. *Am J Surg* 1980;140(6):847-51.
- Velmahos GC, Demetriades D, Foianini E et al. A selective approach to the management of gunshot wounds to the back. *Am J Surg* 1997; 174(3):342-6.
- Velmahos GC, Demetriades D, Cornwell EE, Asensio J, Belzberg H, Berne TV. Gunshot wounds to the buttocks: Predicting the need for operation. *Dis Colon Rectum* 1997; 40(3):307-11.
- Velmahos GC, Demetriades D, Cornwell III, EE. Transpelvic gunshot wounds: Routine laparotomy or selective management? *World J Surg* 1998; 22(10):1034-8.
- Velmahos GC, Demetriades D, Toutouzas KG, Sarkisyan G, Chan LS, Ishak R, et al. Selective nonoperative management in 1,856 patients with abdominal gunshot wounds: Should routine laparotomy still be the standard of care? *Ann Surg* 2001; 234(3):395-402
- Demetriades D, Velmahos G, Cornwell E et al. Selective nonoperative management of gunshot wounds of the anterior abdomen. *Arch Surg* 1997; 132(2):178-83.
- Demetriades D, Vandenbossche P, Ritz M, Goodmann D, Kowalszik J. Non-Therapeutic operations for penetrating trauma: Early morbidity and mortality. *Br J Surg* 1993; 80(7):860-1.
- Leppäniemi A, Salo J, Haapiainen R. Complications of negative laparotomy for truncal stab wounds. *J Trauma* 1995; 38(1):54-8.
- Renz BM, Feliciano DV. Unnecessary laparotomies for trauma: A prospective study of morbidity. *J Trauma* 1995; 38:350-6.
- Weigelt JA, Kingman RG. Complications of negative laparotomy for trauma. *Am J Surg* 1988; 156(6):544-7.
- Renz BM, Feliciano DV. The length of hospital stay after an unnecessary laparotomy for trauma. *J Trauma* 1996; 40:187-90.
- Como JJ, Bokhari F, Chiu WC et al. Practice management guidelines for selective nonoperative management of penetrating abdominal trauma. *J Trauma* 2010; 68(3):721-33.
- Upadhyaya P, Simpson JS. Splenic trauma in children. *Surg Gynecol Obstet* 1968; 126(4):781.
- Schroepfel TJ, Croce MA. Diagnosis and management of blunt abdominal solid organ injury. *Curr Opin Crit Care* 2007; 13(4):399.
- Haan JM, Bochicchio GV, Kramer N, Scalea TM. Nonoperative management of blunt splenic injury: A 5-year experience. *J Trauma* 2005; 58(3):492-8.
- Rajani RR, Claridge JA, Yowler CJ et al. Improved outcome of adult blunt splenic injury: A cohort analysis. *Surgery* 2006; 140(4):625-32.
- Cogbill TH, Moore EE, Jurkovich GJ et al. Nonoperative management of blunt splenic trauma: A multicenter experience. *J Trauma* 1989; 29(10):1312.
- Cadeddu M, Garnett A, Al-Anezi K, Farrokhyar F. Management of spleen injuries in the adult trauma population: A ten-year experience. *Can J Surg* 2006; 49(6):386-90.
- Bee TK, Croce MA, Miller PR, Pritchard FE. Failures of splenic nonoperative management: Is the glass half empty or half full? *J Trauma* 2001; 50(2):230.
- McIntyre LK, Schiff M, Jurkovich GJ. Failure of nonoperative management of splenic injuries: Causes and consequences. *Arch Surg* 2005; 140(6):563-8
- Badger SA, Barclay R, Campbell P, Mole DJ, Diamond T. Management of liver trauma. *World J Surg* 2009; 33(12):2522-37.
- Tinkoff G, Esposito TJ, Reed J, Kilgo P, Fildes J, Pasquale M, Meredith JW. American association for the surgery of trauma organ injury scale I: Spleen, liver, and kidney, validation based on the national trauma data bank. *J Am Coll Surg* 2008; 207(5):646-55.
- Kozar RA, Moore FA, Moore EE et al. Western trauma association critical decisions in trauma: Nonoperative management of adult blunt hepatic trauma. *J Trauma* 2009; 67(6):1144-8
- Malhotra AK, Fabian TC, Croce MA et al. Blunt hepatic injury: A paradigm shift from operative to nonoperative management in the 1990s. *Ann Surg* 2000; 231(6):804-13.
- Croce MA, Fabian TC, Menke PG et al. Nonoperative management of blunt hepatic trauma is the treatment of choice for hemodynamically stable patients. Results of a prospective trial. *Ann Surg* 1995; 221(6):744-53

33. Velmahos GC, Toutouzas K, Radin R et al. High success with nonoperative management of blunt hepatic trauma: The liver is a sturdy organ. *Arch Surg* 2003; 138(5):475-80
34. Demetriades D, Gomez H, Chahwan S et al. Gunshot injuries to the liver: The role of selective nonoperative management. *J Am Coll Surg* 1999; 188(4):343-8.
35. Demetriades D, Hadjizacharia P, Constantinou C et al. Selective nonoperative management of penetrating abdominal solid organ injuries. *Ann Surg* 2006; 244(4):620-8.
36. Inaba K, Barmparas G, Foster A et al. Selective nonoperative management of torso gunshot wounds: When is it safe to discharge? *J Trauma* 2010; 68(6):1301-4.
37. Navsaria PH, Nicol AJ, Krige JE, Edu S. Selective nonoperative management of liver gunshot injuries. *Ann Surg* 2009; 249(4):653-6.
38. Omoshoro-Jones JA, Nicol AJ, Navsaria PH, Zellweger R, Krige JE, Kahn DH. Selective non-operative management of liver gunshot injuries. *Br J Surg* 2005; 92(7):890-5.
39. Lee SK, Carrillo EH. Advances and changes in the management of liver injuries. *Am Surg* 2007; 73(3):201-6.
40. Kozar RA, Moore FA, Cothren CC et al. Risk factors for hepatic morbidity following nonoperative management: Multicenter study. *Arch Surg* 2006; 141(5):451-8
41. Pachter HL, Knudson MM, Esrig B et al. Status of nonoperative management of blunt hepatic injuries in 1995: A multicenter experience with 404 patients. *J Trauma* 1996; 40(1):31-8.
42. Galvan DA, Peitzman AB. Failure of nonoperative management of abdominal solid organ injuries. *Curr Opin Crit Care* 2006; 12(6):590.
43. Peitzman AB, Heil B, Rivera L et al. Blunt splenic injury in adults: Multi-Institutional study of the eastern association for the surgery of trauma. *J Trauma* 2000; 49(2):177-87
44. Nance ML, Peden GW, Shapiro MB, Kauder DR, Rotondo MF, Schwab CW. Solid viscus injury predicts major hollow viscus injury in blunt abdominal trauma. *J Trauma* 1997; 43(4):618-22
45. Cannon CM, Braxton CC, Kling-Smith M, Mahnken JD, Carlton E, Moncure M. Utility of the shock index in predicting mortality in traumatically injured patients. *J Trauma* 2009; 67(6):1426-30.
46. King RW, Plewa MC, Buderer NM, Knotts FB. Shock index as a marker for significant injury in trauma patients. *Acad Emerg Med* 1996;3 (11):1041-5.
47. Chiu WC, Shanmuganathan K, Mirvis SE, Scalea TM. Determining the need for laparotomy in penetrating torso trauma: A prospective study using triple-contrast enhanced abdominopelvic computed tomography. *J Trauma* 2001; 51(5):860-8
48. Demetriades D, Velmahos G. Technology-Driven triage of abdominal trauma: The emerging era of nonoperative management. *Annu Rev Med* 2003; 54:1-15.
49. Ginzburg E, Carrillo EH, Kopelman T et al. The role of computed tomography in selective management of gunshot wounds to the abdomen and flank. *J Trauma* 1998; 45(6):1005-9.
50. Inaba K, Demetriades D. The nonoperative management of penetrating abdominal trauma. *Adv Surg* 2007; 41:51.
51. Velmahos GC, Constantinou C, Tillou A, Brown CV, Salim A, Demetriades D. Abdominal computed tomographic scan for patients with gunshot wounds to the abdomen selected for nonoperative management. *J Trauma* 2005; 59(5):1155-60
52. London JA, Parry L, Galante J, Battistella F. Safety of early mobilization of patients with blunt solid organ injuries. *Arch Surg* 2008; 143(10):972-6
53. Eberle BM, Schnüriger B, Inaba K et al. Thromboembolic prophylaxis with low-molecular-weight heparin in patients with blunt solid abdominal organ injuries undergoing nonoperative management: Current practice and outcomes. *J Trauma* 2011; 70(1):141-6
54. Ahmad J, Beattie GC, Kennedy R, Clements WDB, Kennedy JA. Penetrating trauma to the junctional zone needs aggressive management. *BMJ* 2007; 334:257-8.
55. Murray JA, Demetriades D, Cornwell EE et al. Penetrating left thoracoabdominal trauma: The incidence and clinical presentation of diaphragm injuries. *J Trauma* 1997; 43(4):624-6.
56. Ivatury RR, Simon RJ, Weksler B, Bayard V, Stahl WM. Laparoscopy in the evaluation of the intrathoracic abdomen after penetrating injury. *J Trauma* 1992; 33:101-8.
57. Ivatury RR, Simon RJ, Stahl WM. A critical evaluation of laparoscopy in penetrating abdominal trauma. *J Trauma* 1993; 34:822-7.
58. Murray JA, Demetriades D, Asensio JA et al. Occult injuries to the diaphragm: Prospective evaluation of laparoscopy in penetrating injuries to the left lower chest. *J Am Coll Surg* 1998; 187(6):626-30.
59. Huebner S, Reed MH. Analysis of the value of imaging as part of the follow-up of splenic injury in children. *Pediatr Radiol* 2001; 31(12):852-5.
60. Gannon EH, Howard T. Splenic injuries in athletes: A review. *Curr Sports Med Rep* 2010; 9(2):111-4.
61. Brown RL, Irish MS, McCabe AJ et al. Observation of splenic trauma: When is a little too much? *J Pediatr Surg* 1999; 34:1124-6.