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Review Article

The Role, Capability and Limitations of Diagnostic Imaging in the Management of Unstable Torso Trauma

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Abstract **Diagnostic imaging has been recognized as a useful tool for management in stable trauma patients and it is believed that it has limitation for unstable patients. This article is an evidence based review on the role of diagnostic imaging in unstable torso trauma. Focused Assessment with Sonography for Trauma(FAST) has a great role for diagnostic hemorrhage in blunt abdominal trauma and blood in pericardial stab wounds. Extended-FAST(EFAST) has a promising role for diagnostic pneumothorax and hemothorax and is also useful to confirm the positions after placement of tubes and lines. A CT scan has limited role in unstable patients; however, there are reports that a CT scan can be used to identify sources of bleeding in selected situations.**

Diagnostic imaging has both capability and limitation in unstable torso trauma. Patient selections for each modality enhance accuracy for the imaging.

Keywords: **Multiple trauma, multimodal imaging, abdominal injuries**

1. Introduction

Half of trauma deaths occur in the first hour of injury[1]. Demetriades et al. reported that chest and abdominal injuries were the most common critical injured bodily injuries (32.3%) in traumatic death patients[1]. Identifying causes of injuries and proper correction is a key to the success to restore the physiology in unstable trauma patients. This article covers the role and limitations of diagnostic imaging in hemodynamic unstable torso trauma.

2.Ultrasonography

Ultrasonography has become a standard tool for assessing trauma patients. The original utility of ultrasonography is to identify free fluid in the intra-peritoneal cavity and intra-pericardium which we know as "Focused Assessment with Sonography for Trauma (FAST)". The accuracy of FAST in blunt abdominal injury patients was reported as 59.2 to 96%[2,3,4,5] which varies in the characteristics of injuries. Rozycki et al.[6] reported the sensitivity and specificity of FAST in stable blunt abdominal injury as 75.7% and 99.8%, respectively. However, from the same study, the sensitivity and specificity were reported as 100% in hypotensive patients. Wherrett et al.[4] found that no FAST negative hypotensive patients needed laparotomy which was defined as a systolic blood pressure equal to or less than 90 mmHg. Even though FAST seems to have promising results in hemodynamically unstable

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patients, data has demonstrated that a false negative rate still exists. Frises et al.[5] collected data in pelvic fracture patients who had a high risk for hemorrhage which was defined by age greater than 55 years, presented of shock (SBP<100mmHg), and an unstable fracture pattern. One third of the studied population had hypotension on arrival. They found 6 of the 14 patients with a negative FAST also had a therapeutic exploratory laparotomy. Another study from Holmes et al.[7] also found the same results with a false negative rate. Their study showed that 18 patients who had a negative result of FAST underwent a therapeutic laparotomy.

In conclusion, FAST is useful to diagnose intra-abdominal hemorrhage in unstable blunt abdominal injuries. If patients have a positive FAST they can go to the operative room immediately. However, FAST still has a limitation concerning the false negative rate. In hemodynamically unstable patients with a negative FAST, further investigations to exclude intra-abdominal injury should be performed such as diagnostic peritoneal aspiration and lavage.

In penetrating trauma, the role of FAST is debated. It is widely accepted that penetrated abdominal trauma patients should go to the operating room without any investigations[8]. However, the role of FAST is well established in penetrating wounds that are in proximity to the precordium[9]. A prospective study published by Rozycki et al.[10] that collected data in the patients who had stab or gun shot wounds in the precordial region showed a FAST sensitivity of 100%, specificity of 96.9%, and an accuracy of 97.3%. In this study, there were no false negative patients. Another study in penetrated trauma patients at the precordial region published by Meyer et al. also reported concordant results, sensitivity of 100%, specificity of 91%, and accuracy of 90% but the sensitivity dropped to 56% in patients who had hemothorax[11]. A later report found that all patients with an initially normal pericardial FAST who were subsequently diagnosed with cardiac injury had a hemothorax and the overall mortality was 40%[9].

In summary, FAST is a reliable diagnostic tool to evaluate blood in the pericardium. However, the utility of FAST in penetrating precordial wound depends on the clinical instability of the patients. In extremis patients, FAST has no role in this group, the proper management is Emergency Room thoracotomy. In hypotensive patients, a negative precordial FAST makes physicians move on to other sources of bleeding. A caveat is in patients who have a hemothorax may present with a negative of FAST while having cardiac injury because blood has already flown out into the pleural space.

Pneumothorax and hemothorax are reported in half of chest injuries[12]. The utility of ultrasonography has been extended into identifying injury in pleural cavities, so it is called Extended Focused Assessment with Sonography for Trauma (EFAST). Nadipati et al.[13] performed a prospective study in both blunt and penetrating patients and reported EFAST had the highest accuracy in the diagnosis of pneumothorax when compared with clinical examination and chest X-ray (CXR) (99%, 97%, 94%, respectively). Other studies that were published earlier also reported the same results that EFAST has higher sensitivity and specificity than CXR. However, most studies used CT scan as a gold standard and the studies were performed in hemodynamic stable patients which make applying the results to unstable patients not straightforward.

Hemothorax can also be identified by EFAST. The data from many reports showed superiority of ultrasonography to CXR. For instance, a study published by Sisley et al. reported that the sensitivity of ultrasound was 97.5% and specificity was 99.7%, compared to 92.5% and 99.7% for CXR[14].

For clinical application, EFAST is helpful in identifying pneumothorax in trauma patients. However, a pneumothorax that affects hemodynamic is a tension pneumothorax. Diagnosis of a tension pneumothorax is a clinical diagnosis and a prompt treatment with decompressing pleural cavity should be done without confirming imaging. For hemothoraxes, EFAST may be useful for detecting hemothorax in unstable patients because it is less time consuming.

An anteroposterior pelvic radiograph is recommended by Advanced Trauma Life Support protocol for initial evaluating of trauma patients. The utility of pelvic film has been challenged in hemodynamic stable patients. Duane et al.[15] reported no miss fractures by examination alone in alert patients. Other study[16] reported sensitivity of 68%-73% and specificity of 98% for detecting fractures from plain film pelvis by using a CT scan as a gold standard. And the sensitivity is worse for detecting injury at posterior ring structure. However, in hemodynamic unstable

patients that the physical examination is unreliable[17] and a CT scan is not safe, pelvic film is still be recommended[16] in order to get early identifying the injury and coordinate with angiography team simultaneously.

Besides identifying causes of bleeding, ultrasonography has been used as an extension of comprehensive physical examination[18]. Schuster et al.[19] studied in trauma patients who had Pulseless Electrical Activity (PEA) at the emergency department, they reported presenting of contractile cardiac activity from EFAST related with higher return of spontaneous pulse. However, all of the patients died eventually. So the conclusion on the utility of EFAST on identifying contractile cardiac activity in patients with PEA is identifying potential salvageable patients rather than for resuscitation.

Recently ultrasound has been used for confirmation of the location of tubes and lines. There are reports using ultrasound to confirm position of endotracheal tube placement. Even though all of them were not done in trauma patients, the results was promising and had a potential for further investigation in trauma situation especially in some places where ultrasound is more available than the end tidal capnography[20,21].

3. Computed tomography

A CT scan is not an ideal tool for hemodynamic unstable patients because of time spent on the process. However, it may have a benefit in selected patients. Fu et al.[22] reported utility of a CT scan in hemodynamic unstable patients (SBP < 90 mmHg) with negative finding on physical examination and FAST. According to the study, the patients who had an obvious source of injury that is feasible for angio-embolization such as unstable pelvic fracture or ongoing craniofacial hemorrhage would be sent to the angiogram suit directly. On the other hand, the patients who did not have an obvious source of injury would be sent for a CT scan while waiting for angio-embolization. The study found the CT scan helped to identify source of bleeding that lead to further procedures for stop bleeding. One third of patients who underwent a CT scan got angio-embolization afterward. Furthermore, timing to start embolization in the group that got a CT scan and the group that received angio-embolization directly was not different. The summary of this research is in trauma patients who received physical examination and FAST could not identify source of bleeding, A CT scan may be useful in order to give the information about source of bleeding. Angio-embolization in these patients is not possible without CT guidance. The caveat of applying this policy to other institutes is the facility of hospitals. In this study, the resuscitation room, operating room, a CT scan, and angiography suite were integrated in the same area and while the patients were in a CT scan, fluid resuscitation and close monitoring could be performed continously which is not possible in many hospitals.

4. Conclusion

Diagnostic imaging has a role in detecting sources of bleeding and identifying which cavity needs to be addressed. In patients that the source of bleeding is obvious such as penetrated abdominal patients with shock, diagnostic imaging is luxury. Ultrasonography has been more integrated in the process of initial assessment because it takes only few minutes to complete the study. However, false negative is an important issue especially in unstable patients. So other investigation should be done to confirm the negative result. Pelvic film still has a role in the initial assessment while other plain films have less importance. A CT scan in unstable patients is not practical but can be done in selected patients in selected places.

REFERENCES

1. Demetriades D, Kimbrell B, Salim A, Velmahos G, Rhee P, Preston C, et al. Trauma Deaths in a Mature Urban Trauma System: Is "Trimodal" Distribution a Valid Concept? Journal of the American College of Surgeons 2005;201(3):343-8.
2. Fleming S, Bird R, Ratnasingham K, Sarker S-J, Walsh M, Patel B. Accuracy of FAST scan in blunt abdominal trauma in a major London trauma centre. Int J Surg 2012;10(9):470-4.
3. Becker A, Lin G, McKenney MG, Marttos A, Schulman CI. Is the FAST exam reliable in severely injured patients? Injury. 2010;41(5):479-83.
4. Wherrett LJ, Boulanger BR, McLellan BA, Brenneman FD, Rizoli SB, Culhane J, et al. Hypotension after blunt abdominal trauma: the role of emergent abdominal sonography in surgical triage. J Trauma 1996;41(5):815-20.
5. Friese RS, Malekzadeh S, Shafi S, Gentilello LM, Starr A. Abdominal ultrasound is an unreliable modality for the detection of hemoperitoneum in patients with pelvic fracture. J Trauma 2007;63(1):97-102.
6. Rozycki GS, Ballard RB, Feliciano DV, Schmidt JA, Pennington SD. Surgeon-performed ultrasound for the assessment of

truncal injuries: lessons learned from 1540 patients. Ann. Surg 1998;228(4):557-67.
7. Holmes JF, Harris D, Battistella FD. Performance of abdominal ultrasonography in blunt trauma patients with out-of-hospital or emergency department hypotension. Ann Emerg Med. 2004;43(3):354-61.
8. Biffl WL, Kaups KL, Pham TN, Rowell SE, Jurkovich GJ, Burlew CC, et al. Validating the Western Trauma Association Algorithm for Managing Patients With Anterior Abdominal Stab Wounds: A Western Trauma Association Multicenter Trial. The Journal of Trauma: Injury, Infection, and Critical Care 2011;71(6):1494-502.
9. Ball CG, Williams BH, Wyrzykowski AD, Nicholas JM, Rozycki GS, Feliciano DV. A caveat to the performance of pericardial ultrasound in patients with penetrating cardiac wounds. J Trauma 2009;67(5):1123-4.
10. Rozycki GS, Feliciano DV, Ochsner MG, Knudson MM, Hoyt DB, Davis F, et al. The role of ultrasound in patients with possible penetrating cardiac wounds: a prospective multicenter study. J Trauma 1999;46(4):543-551;discussion 551-552.
11. Meyer DM, Jessen ME, Grayburn PA. Use of echocardiography to detect occult cardiac injury after penetrating thoracic trauma: a prospective study. J Trauma. 1995;39(5):902-907;discussion 907-909.
12. Matsushima K, Frankel HL. Beyond focused assessment with sonography for trauma. Current Opinion in Critical Care 2011;17(6):606-12.
13. Nandipati KC, Allamaneni S, Kakarla R, Wong A, Richards N, Satterfield J, et al. Extended focused assessment with sonography for trauma (EFAST) in the diagnosis of pneumothorax: experience at a community based level I trauma center. Injury 2011;42(5):511-4.
14. Ultrasound to detect haemothorax after chest injury. Emerg Med J 2007;24(8):581-2.
15. Duane TM, Tan BB, Golay D, Cole FJ Jr, Weireter LJ Jr, Britt LD. Blunt trauma and the role of routine pelvic radiographs: a prospective analysis. J Trauma 2002;53(3):463-8.
16. Guillamondegui OD, Pryor JP, Gracias VH, Gupta R, Reilly PM, Schwab CW. Pelvic radiography in blunt trauma resuscitation: a diminishing role. J Trauma 2002;53(6):1043-7.
17. Charani H, Wisborg T, Hansen KS, Brattebø G, Stenseth LB. Clinical examination of the pelvis in patients with multiple traumas is unreliable. Tidsskr Nor Laegeforen 2003;123 (20):2881-3.
18. Gillman LM, Ball CG, Panebianco N, Al-Kadi A, Kirkpatrick AW. Clinician performed resuscitative ultrasonography for the initial evaluation and resuscitation of trauma. Scand J Trauma Resusc Emerg Med 2009;17:34.
19. Schuster KM, Lofthouse R, Moore C, Lui F, Kaplan LJ, Davis KA. Pulseless electrical activity, focused abdominal sonography for trauma, and cardiac contractile activity as predictors of survival after trauma. J Trauma 2009;67(6):1154-7.
20. Sağlam C, Unlüer EE, Karagöz A. Confirmation of endotracheal tube position during resuscitation by bedside ultrasonography. Am J Emerg Med 2013;31(1):248-50.
21. Werner SL, Smith CE, Goldstein JR, Jones RA, Cydulka RK. Pilot study to evaluate the accuracy of ultrasonography in confirming endotracheal tube placement. Ann Emerg Med 2007;49(1):75-80.
22. Fu C-Y, Hsieh C-H, Shih C-H, Wang Y-C, Chen R-J, Huang H-C, et al. Selective Computed Tomography and Angioembolization Provide Benefits in the Management of Patients with Concomitant Unstable Hemodynamics and Negative Sonography Results. World J Surg 2012;36(4):819-25.

บทคัดย่อ **ประโยชน์และข้อจำกัดของการใช้ภาพวินิจฉัยในผู้ป่วยอุบัติเหตุบริเวณลำตัวที่มีสัญญาณชีพไม่คงที่**

โอสรี อัครบวร

สาขาศัลยศาสตร์อุบัติเหตุ ภาควิชาศัลยศาสตร์ คณะแพทยศาสตร์ มหาวิทยาลัยสงขลานครินทร์

มีการใช้ภาพวินิจฉัยในผู้ป่วยอุบัติเหตุที่มีสัญญาณชีพที่ดีมาอย่างแพร่หลาย และมีความเชื่อถึงข้อจำกัดสำหรับในผู้ป่วยที่สัญญาณชีพที่ไม่คงที่ บทความนี้ได้ทบทวนวรรณกรรมของบทบาทในการใช้ภาพวินิจฉัยในผู้ป่วยที่มาการบาดเจ็บของลำตัวที่มีสัญญาณชีพไม่คงที่ การใช้คลื่นเสียงความถี่สูงมีประโยชน์มากในการวินิจฉัยภาวะเลือดออกในช่องท้องในผู้ป่วยที่ได้รับบาดเจ็บแบบกระแทกและภาวะเลือดออกในเยื่อหุ้มปอดในผู้ป่วยที่ได้รับบาดเจ็บแบบแทงทะลุ ตลอดจนวินิจฉัยภาวะเยื่อหุ้มปอดมีลมและเลือด และดูตำแหน่งของสายสวนภายหลังการทำหัตถการ การใช้การถ่ายภาพรังสีระนาบยังมีข้อจำกัดมาก แต่ก็เริ่มมีการใช้เพื่อระบุตำแหน่งเลือดออกในบางกลุ่มประชากร

ภาพวินิจฉัยบริเวณลำตัวของผู้บาดเจ็บที่มีสัญญาณชีพไม่คงที่มีทั้งประโยชน์และข้อจำกัด การเลือกทำในผู้ป่วยที่เหมาะสมจะทำให้ได้ผลการตรวจที่ถูกต้องมากขึ้น