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Part 4. Clinical Practice Guideline for Surveillance and Imaging Studies of Trauma Patients in the Trauma Bay from the Korean Society of Traumatology

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The following recommendations are presented herein: All trauma patients admitted to the resuscitation room should be constantly (or periodically) monitored for parameters such as blood pressure, heart rate, respiratory rate, oxygen saturation, body temperature, electrocardiography, Glasgow Coma Scale, and pupil reflex (1C). Chest AP and pelvic AP should be performed as the standard initial trauma series for severe trauma patients (1B). In patients with severe hemodynamically unstable trauma, it is recommended to perform extended focused assessment with sonography for trauma (eFAST) as an initial examination (1B). In hemodynamically stable trauma patients, eFAST can be considered as the initial examination (2B). For the diagnosis of suspected head trauma patients, brain computed tomography (CT) should be performed as an initial examination (1B). Cervical spine CT should be performed as an initial imaging test for patients with suspected cervical spine injury (1C). It is not necessary to perform chest CT as an initial examination in all patients with suspected chest injury, but in cases of suspected vascular injury in patients with thoracic or high-energy damage due to the mechanism of injury, chest CT can be considered for patients in a hemodynamically stable condition (2B). CT of the abdomen is recommended for patients suspected of abdominal trauma with stable vital signs (1B). CT of the abdomen should be considered for suspected pelvic trauma patients with stable vital signs (2B). Whole-body CT can be considered in patients with suspicion of severe trauma with stable vital signs (2B). Magnetic resonance imaging can be considered in hemodynamically stable trauma patients with suspected spinal cord injuries (2B).

Keywords: Diagnostic imaging; Practice guideline; Multiple trauma

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Based on the revised recommendations, the final recommendations were confirmed after collecting opinions from trauma experts, experts from the Korean Society of Traumatology, and research method experts using the Delphi technique (Table 1).

WHAT BIOLOGICAL SIGNS SHOULD BE MONITORED IN TRAUMA PATIENTS IN THE RESUSCITATION ROOM?

Recommendation

All trauma patients admitted to the resuscitation room should be constantly (or periodically) monitored for parameters such as blood pressure, heart rate, respiratory rate, oxygen saturation, body temperature, electrocardiography (ECG), Glasgow Coma Scale (GCS), and pupil reflex (1C).

Evidence review or evidence summary

Franklin et al. [1] showed that about 50% of patients with hypotension before and after presenting to the emergency room required emergency surgery or hospitalization in the intensive care unit (ICU). In addition, Tinkoff and colleagues reported that in hypotensive patients after trauma, the overall mortality rate was 24 times higher, ICU admission was seven times higher, and emergency operations were 1.6 times more common than in normotensive patients [2]. Henry [3] of the New York State Trauma Registry reported a mortality rate of 32.9% in trauma patients with systolic blood pressure less than 90 mmHg, and 28.8% in trauma patients with respiratory rates of fewer than 10 or more than 29 breaths per minute.

ECG monitoring is essential for all severe trauma patients. In particular, ECG monitoring is necessary to discriminate cardiac arrest that may require defibrillation in patients whose pulse is not palpable. In addition, it can be used as a basic test in patients who are likely to have complications of heart damage due to blunt injury [4-6]. Fildes et al. [7] reported that 74 trauma patients with no underlying heart disease, hemodynamic stability, and a normal initial ECG did not develop cardiac complications. It was reported that 184 children who suffered blunt heart damage, but showed normal ECG in the emergency room, also did not develop complications. In a meta-analysis of 41 studies, it was found that patients with abnormal ECG at hospitalization were more likely to experience complications requiring treatment [7]. Complications occurred in 13 of 133 patients with suspected blunt heart damage, but no complications were observed in patients with a normal initial ECG [8]. In a study by Miller et al. [9], four of 172 patients had complications requiring treatment, and those four patients had abnormal initial ECG readings. In addition, Wisner et al. [10] reported complications in four of 95 patients with suspected blunt heart damage, and only one of those four patients showed a normal ECG at the time of admission.

Measurement of oxygen saturation is also essential in patients with multiple traumas. Oxygen saturation is especially important in patients experiencing cardiac arrest, in whom the oxygen saturation waveform can be lost.

The only clinical symptoms that can predict the prognosis of head-injured patients are enlarged fixed pupils and a low GCS. These two findings are associated with poor treatment outcomes. Therefore, it is necessary to detect deterioration of the patient's consciousness early through repeated confirmation of neurological findings [11-13].

In addition, end-tidal CO_2 ($EtCO_2$) monitoring or securing arterial cannulation can be used to monitor trauma patients admitted to the resuscitation room. The reasons are as follows [14]:

1) $EtCO_2$ is important for monitoring multiple trauma patients, especially since a sudden drop of $EtCO_2$ occurs in cases of sudden cardiac arrest.

2) More than 7% of tracheal intubation attempts have been reported to enter the esophagus. Therefore, auscultation and $EtCO_2$ partial pressure monitoring are essential to confirm the successful and proper placement of the tracheal tube.

3) Early cannulation of the femoral artery for continuous blood pressure monitoring is an objective method for diagnosing cardiac arrest and confirming the effectiveness of resuscitation in an emergency department. However, intraarterial cannulation should not interfere with or delay resuscitation.

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Table 1. Scores from the Delphi technique (Likert scale 1-9)

Key question	Recommendation	Mean	SD
What biological signs should be monitored in trauma patients in the resuscitation room?	All trauma patients admitted to the resuscitation room should be constantly (or periodically) monitored for parameters such as blood pressure, heart rate, respiratory rate, oxygen saturation, body temperature, ECG, GCS, and pupil reflex (1C).	8.2	1.5
Is the trauma series clinically beneficial compared to other imaging tests for the initial primary evaluation in severe trauma patients?	Simple chest radiography (chest AP) and pelvic radiography (pelvic AP) should be performed as the standard initial trauma series for severe trauma patients (1B).	8.4	0.8
In patients with severe trauma, is the eFAST credible and clinically useful as an initial imaging tool?	In patients with severe hemodynamically unstable trauma, it is recommended to perform eFAST as an initial examination (1B).	8.4	0.9
	In hemodynamically stable trauma patients, eFAST can be considered as the initial examination (2B).	7.9	1.6
What is the appropriate imaging test for suspected head injury trauma patients?	For the diagnosis of suspected head trauma patients, brain CT should be performed as an initial examination (1B).	8.5	1.2
Is C-spine CT clinically useful as an initial imaging test for patients with suspected cervical spine injury?	C-spine CT should be performed as an initial imaging test for patients with suspected cervical spine injury (1C).	8.5	0.5
In patients with suspected chest injury, is chest CT clinically useful as an initial imaging test?	It is not necessary to perform chest CT as an initial examination in all patients with suspected chest injury, but in cases of suspected thoracic or high-energy damage due to the mechanism of injury, chest CT can be considered for patients in a hemodynamically stable condition (2B).	7.5	1.9
Is it diagnostically useful to perform abdominal CT in patients with suspected abdominal trauma with stable vital signs?	CT of the abdomen is recommended for patients suspected of abdominal trauma with stable vital signs. (1B)	8.0	1.7
Is it diagnostically useful to perform abdominal CT in patients with suspected pelvic trauma with stable vital signs?	CT of the abdomen should be considered for suspected pelvic trauma patients with stable vital signs (2B).	8.4	0.7
Is it diagnostically useful to perform whole-body CT in patients with suspected severe trauma with stable vital signs?	Whole-body CT can be considered in patients with suspicion of severe trauma with stable vital signs (2B).	7.2	1.5
In hemodynamically stable patients with suspected spinal cord injuries, is it diagnostically useful to perform MRI in patients with suspected pelvic trauma with stable vital signs?	MRI can be considered in hemodynamically stable trauma patients with suspected spinal cord injuries (2B).	8.0	1.6

eFAST: extended focused assessment with sonography for trauma, ECG: electrocardiography, SD: standard deviation, GCS: Glasgow Coma Score, CT: computed tomography, C-spine CT: cervical spine CT, MRI: magnetic resonance imaging.

Acceptability and applicability

Since all the recommended surveillance items are implemented in the majority of emergency departments in Korea, there will be no difficulty in accepting and applying them as guidelines for monitoring trauma patients in the resuscitation room.

In addition, many hospitals are already evaluating the appropriateness of the location of tracheal intubation by monitoring the partial pressure of $EtCO_2$ after intubation. Therefore, the basis for its acceptance and applicability is sufficient. Furthermore, since the majority of hospitals in Korea already secure an arterial line, the likelihood of acceptance and application is considered sufficient.

IS THE TRAUMA SERIES CLINICALLY BENEFICIAL COMPARED TO OTHER IMAGING TESTS FOR THE INITIAL PRIMARY EVALUATION IN SEVERE TRAUMA PATIENTS?

Recommendation

Simple chest radiography (chest AP) and pelvic radiog-

raphy (pelvic AP) should be performed as the standard initial trauma series for severe trauma patients (1B).

Evidence review or evidence summary

Three guidelines were reviewed to determine the recommended initial emergency radiographic imaging protocol for patients with severe trauma. In the American College of Radiology (ACR) appropriateness criteria, simple chest radiography is recommended for patients with high-energy mechanisms or hemodynamic instability [15]. The National Institute for Health and Care Excellence (NICE) guideline recommends simple chest and pelvic radiography when hemodynamically unstable patients do not respond to fluid therapy [16]. The S3 guideline recommends performing simple chest radiography, pelvic radiography, and C-spine lateral imaging in the emergency room [17].

In the process of developing this guideline, seven studies were examined to determine the value of performing computed tomography (CT) scans. Two of those seven studies suggested that CT scans should be minimized when simple chest radiography shows normal findings [18,19], while three studies reported that performing a CT scan is invaluable regardless of the results of the chest X-ray [20-22]. In addition other studies have suggested that CT scans should be performed selectively depending on the patient's condition [23]. Five studies were examined to determine the value of performing pelvic X-rays, of which two recommended performing pelvic X-rays to diagnose pelvic bone fractures, while three recommended omitting pelvic X-rays if a CT scan can be performed [24-28]. Lastly, three studies were examined to determine the value of performing C-spine lateral imaging, and two of these three papers recommended cervical spine CT as a screening test for cervical spine injury [29-31]. In these studies, cervical lateral radiography was determined to have little diagnostic value.

Acceptability and applicability

The trauma series can be applied in Korea for patients who are hemodynamically unstable and do not respond to fluid therapy, for whom mobile imaging is required. However, consideration should be given for cases in which immediate or mobile imaging is not possible depending on hospital circumstances

IN PATIENTS WITH SEVERE TRAUMA, IS THE EXTENDED FOCUSED ASSESSMENT WITH SONOGRAPHY FOR TRAUMA (EFAST) CREDIBLE AND CLINICALLY USEFUL AS AN INITIAL IMAGING TOOL?

Recommendation

1. In patients with severe hemodynamically unstable trauma, it is recommended to perform eFAST as an initial examination (1B).
2. In hemodynamically stable trauma patients, eFAST can be considered as the initial examination (2B).

Evidence review or evidence summary

Three guidelines were selected to assess the viability of eFAST in this study [15-17]. The ACR appropriateness criteria recommend FAST/eFAST in hemodynamically unstable patients and patients with high-energy injuries. The NICE and S3 guidelines recommend limited use of FAST/eFAST in situations where CT cannot be performed.

In addition to these three guidelines, 11 other studies were reviewed. In trauma patients, FAST is widely accepted as a means to search for free fluids in the abdominal cavity and pericardium. Furthermore, eFAST is widely accepted as a means to search for pneumothorax or hemothorax [32-34]. However, there are conflicting reports on the recommended use of FAST/eFAST as a screening test for blunt abdominal injuries [32-35]. In one study, FAST/eFAST was recommended even in hemodynamically stable patients [36]. In another study, it was suggested that the use of FAST/eFAST was appropriate in chest penetrating injuries, but there was no benefit in case of abdominal penetrating injuries [37].

Acceptability and applicability

This recommendation is applicable. However, it is necessary to consider the application of FAST/eFAST fees.

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WHAT IS THE APPROPRIATE IMAGING TEST FOR SUSPECTED HEAD TRAUMA PATIENTS?

Recommendation

For the diagnosis of suspected head trauma patients, brain CT should be performed as an initial examination (1B).

Evidence review or evidence summary

Two guidelines were selected to study the initial imaging process for patients with suspected head trauma. The ACR appropriateness criteria recommend CT as a means of initial imaging for head trauma patients, and for patients with minor brain injury, it is recommended that clinicians decide whether to proceed with the examination according to guidelines such as New Orleans Criteria (NOC), Canadian CT Head Rules (CCHR), and National Emergency X-ray Utilization Study (NEXUS)-II [15]. Korean clinical imaging guidelines recommend CT or magnetic resonance imaging (MRI) for head trauma patients. In children, CT is recommended according to clinical criteria [38].

In addition to the two guidelines, nine additional papers were further reviewed. Neuroimaging plays a crucial role in detecting traumatic brain injury and determining whether immediate treatment is needed. The GCS is commonly used to classify traumatic brain injuries. CT is a fast and effective imaging test with high sensitivity to detect the lump effect, size and arrangement of the ventricle, fracture, and intracranial hemorrhage. MRI is not recommended as an initial imaging test due to its limitations in terms of time and location [39-41]. NOC, CCHR, and NEXUS-II are representative guidelines describing indications for CT. Other studies are being conducted to prevent the abuse and misuse of CT for minor head injuries [42-44]. Non-contrast CT is recommended for patients with moderate to severe head trauma [45-47].

Acceptability and applicability

Brain CT without intravenous contrast is applicable in Korea. However, it is necessary to consider insurance coverage for the usage of brain CT without simple imaging.

IS CERVICAL SPINE CT (C-SPINE CT) CLINICALLY USEFUL AS AN INITIAL IMAGING TEST FOR PATIENTS WITH SUSPECTED CERVICAL SPINE INJURY?

Recommendation

C-spine CT should be performed as an initial imaging test for patients with suspected cervical spine injury (1C).

Evidence review or evidence summary

Two treatment guidelines were reviewed to determine whether C-spine CT should be performed for patients with a suspected cervical spine injury. The ACR appropriateness criteria recommend C-spine CT as an initial imaging test for patients with high-risk clinical criteria (NEXUS or CCR) [15]. In the S3 guidelines, C-spine CT is recommended for patients who have sustained severe trauma injuries who have been hemodynamically stabilized before exiting the ICU. It is also recommended that all patients with suspicion of a cervical spine injury should undergo simple cervical images. If any abnormalities are found on simple images, C-spine CT is recommended [17].

In addition to the two guidelines, four additional studies were reviewed. For patients with suspected cervical spine injury, simple cervical radiography was changed to CT. One study reported that the accuracy of diagnosis through CT was significantly higher than that of diagnosis using simple cervical spine radiography [48]. Conflicting findings have been reported regarding whether CT is sufficient or MRI should be performed additionally [49-51].

Acceptability and applicability

In patients with suspected cervical spine damage, performing C-spine CT is preferable over simple imaging. Currently, it is believed that CT scans are possible at most emergency centers in Korea, and domestic acceptance is considered sufficient.

IN PATIENTS WITH SUSPECTED CHEST INJURY, IS CHEST CT CLINICALLY USEFUL AS AN INITIAL IMAGING TEST?

Recommendation

It is not necessary to perform chest CT as an initial examination in all patients with suspected chest injury, but in cases of suspected vascular injury in patients with thoracic or high-energy damage due to the mechanism of injury, chest CT can be considered for patients in a hemodynamically stable condition (2B).

Evidence review or evidence summary

Three guidelines were reviewed to determine the validity of performing chest CT in chest trauma patients. All three guidelines recommend contrast-enhanced chest CT for patients with high-energy injuries, patients responding to resuscitation, or patients who are hemodynamically stable (in the case of the NICE guidelines) [15-17]. However, the ACR appropriateness criteria recommend that chest CT can be excluded depending on clinical findings [15]. The NICE guideline recommends simple portable chest imaging and eFAST as the initial imaging workup for hemodynamically unstable patients or patients with severe respiratory difficulties [16].

In addition to these three medical guidelines, six other studies were reviewed. In the diagnosis of chest trauma, contrast-enhanced chest CT is becoming more standardized than simple chest imaging [52,53]. Some studies have recommended contrast-enhanced chest CT as a test for chest vascular injury in cases of chest trauma [53-56]. Furthermore, it has been recommended that chest CT be divided into arterial and venous phases [56]. It has also been reported that chest CT significantly improved the diagnosis of diaphragm injuries [57].

Acceptability and applicability

In all patients suspected to have chest trauma, the universal application of chest CT is disadvantageous in terms of both cost and exposure to radiation. Its application in Korea seems limited, but its acceptance could be appropriate.

IS IT DIAGNOSTICALLY USEFUL TO PERFORM ABDOMINAL CT IN PATIENTS WITH SUSPECTED ABDOMINAL TRAUMA WITH STABLE VITAL SIGNS?

Recommendation

CT of the abdomen is recommended for patients suspected of abdominal trauma with stable vital signs (1B).

Evidence review or evidence summary

Early diagnosis and treatment are important in severe trauma patients. In a study by Liu et al. [58] of 55 hemodynamically stable patients, the sensitivity, specificity, and accuracy of abdominal CT were 97.2%, 94.7%, and 96.4%, respectively. In terms of accuracy, abdominal CT was superior to abdominal ultrasonography (92.7%) and diagnostic peritoneal lavage (94.5%). Therefore, abdominal CT has diagnostic superiority compared to abdominal ultrasonography or diagnostic abdominal lavage for detecting retroperitoneal injuries and has the advantage of providing additional information on spinal or pelvic trauma [58,59].

In a study of 372 hemodynamically stable patients with abdominal blunt injuries, FAST had a sensitivity of 42% and a specificity of 98%, which was insufficient as a screening test for intra-abdominal organ damage [60]. Therefore, in hemodynamically stable patients with abdominal blunt injuries, abdominal CT is necessary to make an accurate diagnosis.

Traditionally, laparotomy has been the main treatment for hemodynamically stable patients with abdominal penetrating injuries. However, laparotomy is being performed more selectively depending on the patient's injuries. Studies that applied selective laparotomy in hemodynamically stable patients with abdominal wounds involving penetration from the anterior aspect, wounds from the back, and solid organs consistently reported successful results [61,62]. In addition to hemodynamic stability, these studies suggested that another prerequisite for selective laparotomy is the absence of evidence of peritoneal signs on physical examination and intestinal injuries on abdominal CT. Therefore, abdominal CT is considered necessary for hemodynamically stable patients with abdominal injuries.

In hemodynamically stable patients with suspected ab-

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dominal trauma and decreased mentality, abdominal CT has been reported to diagnose hidden abdominal trauma and lower the mortality rate [63,64]. Negative results on abdominal CT show very high specificity for excluding abdominal damage, shortening the hospital stay for follow-up [65].

Acceptability and applicability

The recommendations presented above are applicable and acceptable.

IS IT DIAGNOSTICALLY USEFUL TO PERFORM ABDOMINAL CT IN PATIENTS WITH SUSPECTED PELVIC TRAUMA WITH STABLE VITAL SIGNS?

Recommendation

CT of the abdomen should be considered for suspected pelvic trauma patients with stable vital signs (2B).

Evidence review or evidence summary

On physical examination, the specificity of the diagnosis of unstable pelvic fractures is high in patients with pelvic trauma, but the sensitivity is very low, ranging from 8% to 44% [66,67]. When comparing simple radiographs and CT, one study found that the diagnosis rate of pelvic fractures by simple radiographs was 66%, which was significantly lower than that of 86% using CT [68]. These findings are consistent, and researchers have often argued that if CT is performed, simple radiographs of the pelvis are unnecessary [26,27,69].

In pelvic trauma, the most important initial evaluation is finding signs of bleeding. According to Berg et al. [68], 73% of contrast leakage seen on CT corresponds to significant hemorrhage seen on angiography. However, since CT often shows negative findings in patients with contrast leakage on angiography, the effectiveness of CT in diagnosing bleeding from pelvic trauma has been debated [70,71]. In a study on the effectiveness of FAST in pelvic trauma, the FAST diagnosis of pelvic bleeding showed a sensitivity of 26% and a specificity of 96%, indicating that negative FAST findings did not exclude bleeding in the pelvic cavity [72].

Pelvic fractures are often accompanied by damage to organs in the abdominal cavity, and solid organ and intestinal damage has been reported in 11% and 4.5% of cases, respectively [73]. Since intestinal injury is an immediate indication for open abdominal surgery, the treatment of choice changes considerably depending on the results of CT. In addition, pelvic trauma is often accompanied by damage to the urinary system such as the bladder and urethra, and according to one report, 6% of all pelvic trauma cases were accompanied by damage to the genitourinary system [74]. In a 10-year study of 54 bladder injuries, 79.8% of patients were found to have a pelvic fracture [75]. Most bladder injuries associated with pelvic trauma are extra-abdominal injuries (80%). For intraperitoneal injuries, the treatment method can be determined by laparotomy [72].

In summary, CT in hemodynamically stable pelvic trauma patients is the best test so far for diagnosing trauma to the pelvic bone. Secondly, with the exception of angiography, CT is the best test for diagnosing intrapelvic bleeding. Thirdly, CT is an excellent test for organ damage in the abdominal cavity/pelvic cavity. It can be used as a screening test for diagnosing and determining the treatment for intestinal or urinary system damage.

Acceptability and applicability

The recommendations presented above are applicable and acceptable.

IS IT DIAGNOSTICALLY USEFUL TO PERFORM WHOLE-BODY CT IN PATIENTS WITH SUSPECTED SEVERE TRAUMA WITH STABLE VITAL SIGNS?

Recommendation

Whole-body CT can be considered in patients with suspicion of severe trauma with stable vital signs (2B).

Evidence review or evidence summary

Severe trauma patients often have multiple traumatic injuries. CT of the head, chest, abdomen, pelvis, and spine in patients with stable vital signs is a powerful test that can determine the treatment options. The S3 guideline, the

Eastern Association for the Surgery of Trauma guideline, and the NICE guideline recommend performing CT as an initial imaging test. Although whole-body CT is thought to yield many advantages, such as shortening the time for the diagnosis and ultimately improving the prognosis, the evidence is insufficient [16,17,75].

In a large cohort study of 1,696 patients at 14 hospitals in France by Matlock et al. [76], the 30-day mortality rate of the whole-body CT group was 16%, which was significantly lower than that of the control group. In Germany, a study using the trauma registry also showed a higher survival rate in the whole-body CT group than in the control group [77]. The only randomized controlled study of whole-body CT to date is the REACT-2 trial [78]. In this study, which enrolled 1,403 patients, the examinations were completed more quickly in the whole-body CT group (30 vs. 37 minutes). However, there was no difference in the mortality rate. As research results may differ across institutions, follow-up studies are needed.

An important consideration regarding whole-body CT is the radiation dose. Although the radiation dose was different between the whole-body and selective CT groups in the REACT-2 study, the difference was not significant [78]. There are several advantages of performing whole-body CT in terms of the radiation dose. The first is that the radiation dose can be significantly reduced if the test is conducted efficiently. The second is that a whole-body CT can reduce the need for further CT scans in the future. The third is that different protocols and indications for performing partial CT can expose patients to additional doses of radiation. Further follow-up studies are needed.

In summary, whole-body CT has the advantage of shortening the examination time. It is recommended that whole-body CT should be performed on patients suspected of severe trauma with stable vital signs.

Acceptability and applicability

The recommendations presented above are applicable and acceptable.

IN HEMODYNAMICALLY STABLE PATIENTS WITH SUSPECTED SPINAL CORD INJURIES, IS IT DIAGNOSTICALLY USEFUL TO PERFORM MRI IN PATIENTS WITH SUSPECTED PELVIC TRAUMA WITH STABLE VITAL SIGNS?

Recommendation

MRI can be considered in hemodynamically stable trauma patients with suspected spinal cord injuries (2B).

Evidence review or evidence summary

Spinal injuries are common (with reported rates of 13–30%) in multiple trauma patients [79-82]. Until spinal injuries are ruled out, the cervical vertebrae should be fixed, movement should be limited, and manual in-line stabilization should be maintained. However, this not only impedes various procedures or operations, but also has a number of side effects, including airway aspiration, bedsores, and an increased prevalence of pneumonia. For these reasons, spinal injuries should be excluded as soon as possible [83,84]. MRI for spinal injuries is the best option to diagnose damage to the spinal cord and soft tissue around the spine. However, the sensitivity of vertebral fracture diagnosis by MRI (12% according to one study) is much lower than that of CT [85]. The sensitivity of simple radiographs for vertebral fractures is also reported to be around 32–75%, which is much lower than that of CT, which has a sensitivity of 95–100% [86,87]. Therefore, CT is preferentially recommended as an initial examination for hemodynamically stable patients with suspected spinal injuries.

It has been reported that the delayed treatment of spinal cord injuries adversely affects the neurological prognosis and recovery [88-90]. Spinal cord injury can be suspected if neurological abnormalities are found and if there are signs of a fracture in the spine on a simple radiographic examination or CT. Therefore, it is recommended that MRI should be additionally performed for hemodynamically stable trauma patients with suspected spinal cord injuries.

Acceptability and applicability

The recommendations presented above are applicable and

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acceptable.

REFERENCES

1. Franklin GA, Boaz PW, Spain DA, Lukan JK, Carrillo EH, Richardson JD. Prehospital hypotension as a valid indicator of trauma team activation. J Trauma 2000;48:1034-7; discussion 1037-9.
2. Tinkoff GH, O'Connor RE. Validation of new trauma triage rules for trauma attending response to the emergency department. J Trauma 2002;52:1153-8; discussion 1158-9.
3. Henry MC. Trauma triage: New York experience. Prehosp Emerg Care 2006;10:295-302.
4. Biffl WL, Moore FA, Moore EE, Sauaia A, Read RA, Burch JM. Cardiac enzymes are irrelevant in the patient with suspected myocardial contusion. Am J Surg 1994;168:523-7; discussion 527-8.
5. Dowd MD, Krug S. Pediatric blunt cardiac injury: epidemiology, clinical features, and diagnosis. Pediatric Emergency Medicine Collaborative Research Committee: Working Group on Blunt Cardiac Injury. J Trauma 1996;40:61-7.
6. Faller JP, Feissel M, Kara A, Camelot R, Simon G. Ventilation in prone position in acute respiratory distress syndrome of severe course. 3 cases. Presse Med 1988;17:1154..
7. Fildes JJ, Betlej TM, Manglano R, Martin M, Rogers F, Barrett JA. Limiting cardiac evaluation in patients with suspected myocardial contusion. Am Surg 1995;61:832-5.
8. Maenza RL, Seaberg D, D'Amico F. A meta-analysis of blunt cardiac trauma: ending myocardial confusion. Am J Emerg Med 1996;14:237-41.
9. Miller FB, Shumate CR, Richardson JD. Myocardial contusion. When can the diagnosis be eliminated? Arch Surg 1989;124:805-7; discussion 807-8.
10. Wisner DH, Reed WH, Riddick RS. Suspected myocardial contusion. Triage and indications for monitoring. Ann Surg 1990;212:82-6.
11. Gabriel EJ, Ghajar J, Jagoda A, Pons PT, Scalea T, Walters BC; Brain Trauma Foundation. Guidelines for prehospital management of traumatic brain injury. J Neurotrauma 2002;19:111-74.
12. Marmarou A, Lu J, Butcher I, McHugh GS, Murray GD, Steyerberg EW, et al. Prognostic value of the Glasgow Coma Scale and pupil reactivity in traumatic brain injury assessed pre-hospital and on enrollment: an IMPACT analysis. J Neurotrauma 2007;24:270-80.
13. Tien HC, Cunha JR, Wu SN, Chughtai T, Tremblay LN, Brenneman FD, et al. Do trauma patients with a Glasgow Coma Scale score of 3 and bilateral fixed and dilated pupils have any chance of survival? J Trauma 2006;60:274-8.
14. Warner KJ, Cuschieri J, Garland B, Carlbom D, Baker D, Copass MK, et al. The utility of early end-tidal capnography in monitoring ventilation status after severe injury. J Trauma 2009;66:26-31.
15. Neumar RW, Shuster M, Callaway CW, Gent LM, Atkins DL, Bhanji F, et al. Part 1: executive summary: 2015 American Heart Association guidelines update for cardiopulmonary resuscitation and emergency cardiovascular care. Circulation 2015;132(18 Suppl 2):S315-67.
16. National Clinical Guideline Centre (UK). Major trauma: assessment and initial management [Internet]. London: National Institute for Health and Care Excellence 2016 [cited 2017 Oct 5]. Available from: https://www.ncbi.nlm.nih.gov/books/NBK344252/.
17. Lendemans S, Ruchholtz S; German Society of Trauma Surgery (DGU). S3 guideline on treatment of polytrauma/severe injuries. Trauma room care. Unfallchirurg 2012;115:14-21.
18. Barrios C, Malinoski D, Dolich M, Lekawa M, Hoyt D, Cinat M. Utility of thoracic computed tomography after blunt trauma: when is chest radiograph enough? Am Surg 2009;75:966-9.
19. 19. Barrios C Jr, Pham J, Malinoski D, Dolich M, Lekawa M, Cinat M. Ability of a chest X-ray and an abdominal computed tomography scan to identify traumatic thoracic injury. Am J Surg 2010;200:741-4; discussion 744-5.
20. Błasińska-Przerwa K, Pacho R, Bestry I. The application of MDCT in the diagnosis of chest trauma. Pneumonol Alergol Pol 2013;81:518-26.
21. Chardoli M, Hasan-Ghaliaee T, Akbari H, Rahimi-Movaghar V. Accuracy of chest radiography versus chest computed tomography in hemodynamically stable patients with blunt chest trauma. Chin J Traumatol 2013;16:351-4.
22. McLellan BA, Ali J, Towers MJ, Sharkey W. Role of the trauma-room chest x-ray film in assessing the patient with severe blunt traumatic injury. Can J Surg 1996;39:36-41.
23. Rodriguez RM, Hendey GW, Mower WR. Selective chest imaging for blunt trauma patients: the national emergency X-ray utilization studies (NEXUS-chest algorithm). Am J Emerg Med 2017;35:164-70.
24. Edeiken-Monroe BS, Browner BD, Jackson H. The role of stan-

dard roentgenograms in the evaluation of instability of pelvic ring disruption. Clin Orthop Relat Res 1989;(240):63-76.
25. Young JW, Burgess AR, Brumback RJ, Poka A. Pelvic fractures: value of plain radiography in early assessment and management. Radiology 1986;160:445-51.
26. Stewart BG, Rhea JT, Sheridan RL, Novelline RA. Is the screening portable pelvis film clinically useful in multiple trauma patients who will be examined by abdominopelvic CT? Experience with 397 patients. Emerg Radiol 2002;9:266-71.
27. Kessel B, Sevi R, Jeroukhimov I, Kalganov A, Khashan T, Ashkenazi I, et al. Is routine portable pelvic X-ray in stable multiple trauma patients always justified in a high technology era? Injury 2007;38:559-63.
28. Their ME, Bensch FV, Koskinen SK, Handolin L, Kiuru MJ. Diagnostic value of pelvic radiography in the initial trauma series in blunt trauma. Eur Radiol 2005;15:1533-7.
29. Como JJ, Diaz JJ, Dunham CM, Chiu WC, Duane TM, Capella JM, et al. Practice management guidelines for identification of cervical spine injuries following trauma: update from the eastern association for the surgery of trauma practice management guidelines committee. J Trauma 2009;67:651-9.
30. Brohi K, Healy M, Fotheringham T, Chan O, Aylwin C, Whitley S, et al. Helical computed tomographic scanning for the evaluation of the cervical spine in the unconscious, intubated trauma patient. J Trauma 2005;58:897-901.
31. Holmes JF, Akkinepalli R. Computed tomography versus plain radiography to screen for cervical spine injury: a meta-analysis. J Trauma 2005;58:902-5.
32. Wongwaisayawan S, Suwannanon R, Prachanukool T, Sricharoen P, Saksobhavivat N, Kaewlai R. Trauma Ultrasound. Ultrasound Med Biol 2015;41:2543-61.
33. Montoya J, Stawicki SP, Evans DC, Bahner DP, Sparks S, Sharpe RP, et al. From FAST to E-FAST: an overview of the evolution of ultrasound-based traumatic injury assessment. Eur J Trauma Emerg Surg 2016;42:119-26.
34. Ojaghi Haghighi SH, Adimi I, Shams Vahdati S, Sarkhoshi Khiavi R. Ultrasonographic diagnosis of suspected hemopneumothorax in trauma patients. Trauma Mon 2014;19:e17498.
35. Stengel D, Rademacher G, Ekkernkamp A, Güthoff C, Mutze S. Emergency ultrasound-based algorithms for diagnosing blunt abdominal trauma. Cochrane Database Syst Rev 2015;2015:CD004446.
36. Rajabzadeh Kanafi A, Giti M, Gharavi MH, Alizadeh A, Pourghorban R, Shekarchi B. Diagnostic accuracy of secondary ultrasound exam in blunt abdominal trauma. Iran J Radiol 2014;11:e21010.
37. Governatori NJ, Saul T, Siadecki SD, Lewiss RE. Ultrasound in the evaluation of penetrating thoraco-abdominal trauma: a review of the literature. Med Ultrason 2015;17:528-34.
38. Jung JS, Oh SW, Jang J, Choi CH, Kim SC, Moon WJ, et al. Korean clinical imaging guidelines for diagnosis of headache based on the 2017 evidence-based clinical imaging guidelines. J Korean Soc Radiol 2019;80:880-95.
39. Wintermark M, Sanelli PC, Anzai Y, Tsiouris AJ, Whitlow CT; ACR Head Injury Institute; ACR Head Injury Institute. Imaging evidence and recommendations for traumatic brain injury: conventional neuroimaging techniques. J Am Coll Radiol 2015;12:e1-14.
40. Wintermark M, Sanelli PC, Anzai Y, Tsiouris AJ, Whitlow CT; American College of Radiology Head Injury Institute. Imaging evidence and recommendations for traumatic brain injury: advanced neuro- and neurovascular imaging techniques. AJNR Am J Neuroradiol 2015;36:E1-11.
41. Potapov AA, Krylov VV, Gavrilov AG, Kravchuk AD, Likhterman LB, Petrikov SS, et al. Guidelines for the management of severe head injury. Part 1. Neurotrauma system and neuroimaging. Zh Vopr Neirokhir Im N N Burdenko 2015;79:100-6.
42. Currie S, Saleem N, Straiton JA, Macmullen-Price J, Warren DJ, Craven IJ. Imaging assessment of traumatic brain injury. Postgrad Med J 2016;92:41-50.
43. Amyot F, Arciniegas DB, Brazaitis MP, Curley KC, Diaz-Arrastia R, Gandjbakhche A, et al. A review of the effectiveness of neuroimaging modalities for the detection of traumatic brain injury. J Neurotrauma 2015;32:1693-721.
44. Haydel MJ, Preston CA, Mills TJ, Luber S, Blaudeau E, DeBlieux PM. Indications for computed tomography in patients with minor head injury. N Engl J Med 2000;343:100-5.
45. Alali AS, Burton K, Fowler RA, Naimark DM, Scales DC, Mainprize TG, et al. Economic evaluations in the diagnosis and management of traumatic brain injury: a systematic review and analysis of quality. Value Health 2015;18:721-34.
46. Valle Alonso J, Fonseca Del Pozo FJ, Vaquero Álvarez M, Lopera Lopera E, Garcia Segura M, García Arévalo R. Comparison of the Canadian CT head rule and the New Orleans criteria in patients with minor head injury in a Spanish hospital. Med Clin (Barc) 2016;147:523-30.
47. Mata-Mbemba D, Mugikura S, Nakagawa A, Murata T, Kato Y, Tatewaki Y, et al. Canadian CT head rule and New Orleans

Criteria in mild traumatic brain injury: comparison at a tertiary referral hospital in Japan. Springerplus 2016;5:176.
48. Kanji HD, Neitzel A, Sekhon M, McCallum J, Griesdale DE. Sixty-four-slice computed tomographic scanner to clear traumatic cervical spine injury: systematic review of the literature. J Crit Care 2014;29:314.e9-13.
49. Patel MB, Humble SS, Cullinane DC, Day MA, Jawa RS, Devin CJ, et al. Cervical spine collar clearance in the obtunded adult blunt trauma patient: a systematic review and practice management guideline from the Eastern Association for the Surgery of Trauma. J Trauma Acute Care Surg 2015;78:430-41.
50. Raza M, Elkhodair S, Zaheer A, Yousaf S. Safe cervical spine clearance in adult obtunded blunt trauma patients on the basis of a normal multidetector CT scan--a meta-analysis and cohort study. Injury 2013;44:1589-95.
51. Malhotra A, Wu X, Kalra VB, Nardini HK, Liu R, Abbed KM, et al. Utility of MRI for cervical spine clearance after blunt traumatic injury: a meta-analysis. Eur Radiol 2017;27:1148-1160.
52. Palas J, Matos AP, Mascarenhas V, Herédia V, Ramalho M. Multidetector computer tomography: evaluation of blunt chest trauma in adults. Radiol Res Pract 2014;2014:864369.
53. Demehri S, Rybicki FJ, Desjardins B, Fan CM, Flamm SD, Francois CJ, et al. ACR Appropriateness Criteria(®) blunt chest trauma--suspected aortic injury. Emerg Radiol 2012;19:287-92.
54. Mokrane FZ, Revel-Mouroz P, Saint Lebes B, Rousseau H. Traumatic injuries of the thoracic aorta: the role of imaging in diagnosis and treatment. Diagn Interv Imaging 2015;96:693-706.
55. Raptis CA, Hammer MM, Raman KG, Mellnick VM, Bhalla S. Acute traumatic aortic injury: practical considerations for the diagnostic radiologist. J Thorac Imaging 2015;30:202-13.
56. Iacobellis F, Ierardi AM, Mazzei MA, Magenta Biasina A, Carrafiello G, Nicola R, et al Dual-phase CT for the assessment of acute vascular injuries in high-energy blunt trauma: the imaging findings and management implications. Br J Radiol 2016;89:20150952.
57. Patlas MN, Leung VA, Romano L, Gagliardi N, Ponticiello G, Scaglione M. Diaphragmatic injuries: why do we struggle to detect them? Radiol Med 2015;120:12-20.
58. Liu M, Lee CH, P'eng FK. Prospective comparison of diagnostic peritoneal lavage, computed tomographic scanning, and ultrasonography for the diagnosis of blunt abdominal trauma. J Trauma 1993;35:267-70.
59. Novelline RA, Rhea JT, Rao PM, Stuk JL. Helical CT in emergency radiology. Radiology 1999;213:321-39.
60. Miller MT, Pasquale MD, Bromberg WJ, Wasser TE, Cox J. Not so FAST. J Trauma 2003;54:52-9; discussion 59-60.
61. Demetriades D, Hadjizacharia P, Constantinou C, Brown C, Inaba K, Rhee P, et al. Selective nonoperative management of penetrating abdominal solid organ injuries. Ann Surg 2006;244:620-8.
62. Demetriades D, Rabinowitz B, Sofianos C, Charalambides D, Melissas J, Hatzitheofilou C, et al. The management of penetrating injuries of the back. A prospective study of 230 patients. Ann Surg 1988;207:72-4.
63. Hong ZJ, Chen CJ, Yu JC, Chan DC, Chou YC, Liang CM, et al. The evolution of computed tomography from organ-selective to whole-body scanning in managing unconscious patients with multiple trauma: a retrospective cohort study. Medicine (Baltimore) 2016;95:e4653.
64. Kimura A, Tanaka N. Whole-body computed tomography is associated with decreased mortality in blunt trauma patients with moderate-to-severe consciousness disturbance: a multicenter, retrospective study. J Trauma Acute Care Surg 2013;75:202-6.
65. Benjamin ER, Siboni S, Haltmeier T, Lofthus A, Inaba K, Demetriades D. Negative finding from computed tomography of the abdomen after blunt trauma. JAMA Surg 2015;150:1194-5.
66. Pehle B, Nast-Kolb D, Oberbeck R, Waydhas C, Ruchholtz S. Significance of physical examination and radiography of the pelvis during treatment in the shock emergency room. Unfallchirurg 2003;106:642-8.
67. Shlamovitz GZ, Mower WR, Bergman J, Chuang KR, Crisp J, Hardy D, et al. How (un)useful is the pelvic ring stability examination in diagnosing mechanically unstable pelvic fractures in blunt trauma patients? J Trauma 2009;66:815-20.
68. Berg EE, Chebuhar C, Bell RM. Pelvic trauma imaging: a blinded comparison of computed tomography and roentgenograms. J Trauma 1996;41:994-8.
69. Duane TM, Dechert T, Wolfe LG, Brown H, Aboutanos MB, Malhotra AK, et al. Clinical examination is superior to plain films to diagnose pelvic fractures compared to CT. Am Surg 2008;74:476-9; discussion 479-80.
70. Brown CV, Kasotakis G, Wilcox A, Rhee P, Salim A, Demetriades D. Does pelvic hematoma on admission computed tomography predict active bleeding at angiography for pelvic fracture? Am Surg 2005;71:759-62.
71. Brasel KJ, Pham K, Yang H, Christensen R, Weigelt JA. Significance of contrast extravasation in patients with pelvic fracture. J Trauma 2007;62:1149-52.

72. 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;63:97-102.
73. Demetriades D, Karaiskakis M, Toutouzas K, Alo K, Velmahos G, Chan L. Pelvic fractures: epidemiology and predictors of associated abdominal injuries and outcomes. J Am Coll Surg 2002;195:1-10.
74. Kommu SS, Illahi I, Mumtaz F. Patterns of urethral injury and immediate management. Curr Opin Urol 2007;17:383-9.
75. Seamon MJ, Haut ER, Van Arendonk K, Barbosa RR, Chiu WC, Dente CJ, et al. An evidence-based approach to patient selection for emergency department thoracotomy: a practice management guideline from the Eastern Association for the Surgery of Trauma. J Trauma Acute Care Surg 2015;79:159-73.
76. Matlock KA, Tyroch AH, Kronfol ZN, McLean SF, Pirela-Cruz MA. Blunt traumatic bladder rupture: a 10-year perspective. Am Surg 2013;79:589-93.
77. Huber-Wagner S, Lefering R, Qvick LM, Körner M, Kay MV, Pfeifer KJ, et al. Effect of whole-body CT during trauma resuscitation on survival: a retrospective, multicentre study. Lancet 2009;373:1455-61.
78. Sierink JC, Treskes K, Edwards MJ, Beuker BJ, den Hartog D, Hohmann J, et al. Immediate total-body CT scanning versus conventional imaging and selective CT scanning in patients with severe trauma (REACT-2): a randomised controlled trial. Lancet 2016;388:673-83.
79. Laurer H, Maier B, El Saman A, Lehnert M, Wyen H, Marzi I. Distribution of spinal and associated injuries in multiple trauma patients. Eur J Trauma Emerg Surg 2007;33:476-81.
80. Berne JD, Velmahos GC, El-Tawil Q, Demetriades D, Asensio JA, Murray JA, et al. Value of complete cervical helical computed tomographic scanning in identifying cervical spine injury in the unevaluable blunt trauma patient with multiple injuries: a prospective study. J Trauma 1999;47:896-902; discussion 902-3.
81. Heyde CE, Ertel W, Kayser R. Management of spine injuries in polytraumatized patients. Orthopade 2005;34:889-905.
82. Woltmann A, Bühren V. Shock trauma room management of spinal injuries in the framework of multiple trauma. A systematic review of the literature. Unfallchirurg 2004;107:911-8.
83. Morris CG, McCoy EP, Lavery GG. Spinal immobilisation for unconscious patients with multiple injuries. BMJ 2004;329:495-9.
84. Vickery D. The use of the spinal board after the pre-hospital phase of trauma management. Emerg Med J 2001;18:51-4.
85. Klein GR, Vaccaro AR, Albert TJ, Schweitzer M, Deely D, Karasick D, et al. Efficacy of magnetic resonance imaging in the evaluation of posterior cervical spine fractures. Spine (Phila Pa 1976) 1999;24:771-4.
86. Herzog C, Ahle H, Mack MG, Maier B, Schwarz W, Zangos S, et al. Traumatic injuries of the pelvis and thoracic and lumbar spine: does thin-slice multidetector-row CT increase diagnostic accuracy? Eur Radiol 2004;14:1751-60.
87. Wintermark M, Mouhsine E, Theumann N, Mordasini P, van Melle G, Leyvraz PF, et al. Thoracolumbar spine fractures in patients who have sustained severe trauma: depiction with multi-detector row CT. Radiology 2003;227:681-9.
88. Hsu JM, Joseph T, Ellis AM. Thoracolumbar fracture in blunt trauma patients: guidelines for diagnosis and imaging. Injury 2003;34:426-33.
89. Meldon SW, Moettus LN. Thoracolumbar spine fractures: clinical presentation and the effect of altered sensorium and major injury. J Trauma 1995;39:1110-4.
90. Poonnoose PM, Ravichandran G, McClelland MR. Missed and mismanaged injuries of the spinal cord. J Trauma 2002;53:314-20.

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