American College Of Radiology
ACR Appropriateness Criteria™

IMAGING OF THE MULTIPLY INJURED PATIENT

Expert Panel on Musculoskeletal Imaging: Richard H. Daffner, MD[1]; Murray K. Dalinka, MD[2]; Naomi Alazraki, MD[3]; Thomas H. Berquist, MD[4]; Arthur A. DeSmet, MD[5]; George Y. El-Khoury, MD[6]; Thomas G. Goergen, MD[7]; Theodore E. Keats, MD[8]; B.J. Manaster, MD, PhD[9]; Arthur Newberg, MD[10]; Helene Pavlov, MD[11]; Robert H. Haralson, III, MD[12]; John B. McCabe, MD[13]; David Sartoris, MD[14].

Summary of Literature Review

Background

Trauma is the leading cause of death in the United States for persons younger than age 30. Victims of multiple traumas present a challenging problem to the trauma surgeon, the consulting surgeons (orthopedics, neurosurgery, etc.), and to the radiologist. With the full armamentarium of diagnostic imaging studies available, the trauma surgeon must choose the most expeditious methods that will provide the most information in the shortest time. The current climate of cost containment also is a factor in deciding which imaging studies need to be performed.

The most likely lethal injuries, as gleaned from trauma center registries, are exsanguination, cardiopulmonary compromise, and intracranial abnormalities. Imaging protocols are therefore directed toward finding those abnormalities.

Literature Review

Twenty-nine papers (bibliography appended) were deemed appropriate for use in this study after a review of 70 papers on multiply injured patients. These papers dealt with a variety of injuries and combination of injuries found in 8940 patients. Most of the literature is surgical. There is no clear-cut consensus among the authors on the ideal protocols for imaging and managing trauma patients, although most follow the Acute Trauma Life Support (ATLS) guidelines of the American College of Surgeons. In many institutions imaging studies that are performed are "protocol driven" and based on mechanisms of injuries regardless of the clinical status. There is general agreement, however, that life-threatening problems such as severe internal hemorrhage should take precedence over imaging studies, particularly when deciding whether to perform cranial imaging. Surgeons still rely on diagnostic peritoneal lavage (DPL) or "mini laparotomy" to determine if there is intra-abdominal visceral injury despite the evidence that abdominal CT, particularly using helical (spiral) technology, can be performed rapidly. In addition, while DPL is sensitive in identifying intraperitoneal bleeding, it cannot identify the source. Furthermore, surgeons are convinced bedside ultrasound is a rapid and accurate method of detecting intraperitoneal fluid. Again, like DPL, ultrasound cannot identify the source of the fluid. Radiologists need to convince the surgeons of the value of thoraco-abdominal CT for these problems. Radiologists should be part of the planning processes for new emergency departments or trauma centers. The proximity of state-of-the-art CT to the trauma areas is a key factor in the decision of which study will be used. In hospitals that meet these requirements, CT has replaced DPL.

In 1990, Vandemark (27) identified a group of clinical and historical indicators for identifying the patient at high risk to have (cervical) vertebral trauma. Many of these, such as high-velocity blunt trauma, multiple fractures, altered mental status, fall of more than 10 feet, and significant head injury, can be directly applied to the multiply injured patient.

[1]Principal Author, Allegheny General Hospital, Pittsburgh, Pa; [2]Panel Chair, University of Pennsylvania Hospital, Philadelphia, Pa; [3]Emory University Hospital, Atlanta, Ga; [4]Mayo Clinic, Jacksonville, Fla; [5]University of Wisconsin, Madison, Wis; [6]University of Iowa Hospitals & Clinics, Iowa City, Iowa; [7]Palomar Medical Center, Escondido, Calif; [8]University of Virginia Medical Center, Charlottesville, Va; [9]University of Colorado Health Sciences Center, Denver, Colo; [10]New England Baptist Hospital, Boston, Mass; [11]Hospital for Special Surgery, New York, NY; [12]Southeast Orthopedics, Knoxville, Tenn, American Academy of Orthopedic Surgeons; [13]SUNY Health Sciences Center, Syracuse, NY, American College of Emergency Physicians; [14]Thornton Hospital, La Jolla, Calif.

The complete work of the ACR Appropriateness Criteria™ is available from the American College of Radiology (1891 Preston White Drive, Reston, VA 20191-4397) and may be accessed at http://www.acr.org/ac_pda. Additional topics will be made available online as they are completed.

Reprint requests to: Richard H. Daffner, MD, Department of Quality & Safety, American College of Radiology, 1891 Preston White Drive, Reston, VA 20191-4397.

Definition of Terms

Multiply Injured: Severe head or facial injury combined with multiple extremity fractures, blunt abdominal trauma or thoracic trauma. Having Vandemark's high-risk criteria.

Patient Alert: No history of loss of consciousness. Patient oriented to time, place, and person. Patient able to understand commands. Glasgow coma score of 15. CAUTION: pain extinction phenomenon.

Patient Obtunded: Patient unconscious or semiconscious. Patient under influence of drugs, alcohol, or both. Visible head injury present.

Hemodynamically Stable: Patient able to maintain pulse and blood pressure without mechanical or pharmacologic assistance.

Hemodynamically Unstable: Low or absent blood pressure. Decreasing blood pressure, increasing heart rate, and decreased respiration. These findings indicate severe internal bleeding (if there is no obvious external source of blood loss). Bleeding may be due to visceral injury to liver, spleen, or kidney; to aortic injury; or to pelvic vascular injury in the presence of fracture(s).

Diagnostic Peritoneal Lavage-Normal: Implies no significant injury to intraperitoneal viscera or vessels. May be negative if a visceral hematoma is contained within the organ's capsule. Not considered reliable by most radiologists.

Abnormal: Implies rupture of liver or spleen with intraperitoneal hemorrhage. Patients with this finding usually go directly to the operating room if they are hemodynamically unstable.

Results

This review involved the choice of initial imaging to be performed on patients suffering multiple traumas. Various clinical groups have used all of the imaging studies listed. Overall, there was consensus by the group on the indications for the following imaging studies:

1. Chest radiographs: All patients.

2. Pelvic radiographs: All patients.

3. Vertebral radiographs: Indicated on all obtunded patients. Should also be performed on all patients who fit into the "high risk" group as defined by Vandemark (27). Must be delayed if the patient requires immediate surgery.

4. Extremity radiographs: Should be determined by clinical exam. Extremity trauma generally takes a "back seat" to life-threatening injuries.

5. Transesophageal ultrasound: Performed almost exclusively by surgeons. Has its drawbacks. Should be replaced by spiral CT.

6. Cranial CT: Necessary in patients who are obtunded. Exact timing of when this exam is performed will be dictated by the need for immediate surgical intervention.

~~7.~~ Thoracic/mediastinal CT: Indicated for all cases of suspected mediastinal hemorrhage and mediastinal widening in an otherwise stable patient. If the patient is unstable, angiography is the "gold standard".

8. Abdominal/pelvic CT: Indicated in patients with normal DPL who are unstable. Has high reliability. Patients with an abnormal DPL and who are unstable will generally go directly to the operating room. If they are stable, the surgeons may want a more definitive look at the abdomen. Helical CT will shorten examination time.

9. Cranial MRI: Not indicated.

10. Angiography: Group consensus was that it was not indicated in most instances unless there are good clinical grounds. The "gold standard" for the diagnosis of thoracic aortic injury. May be useful in the patient with pelvic bleeding that cannot be controlled by external fixation. Surgical literature indicates it is indicated for patients with blunt chest trauma and fractures of the first rib(s) owing to a high (24%) incidence of vascular injuries in those patients.

11. Embolization: General consensus was that it is not necessary. Has been shown to be effective in pelvic bleeding not controlled by other means.

12. Cystourethrography: Consensus was that it is not indicated routinely. Virtually all patients with multiple trauma have microscopic or occasionally gross blood in the bladder upon catheterization. The yield is small. In most cases, nothing more than a pelvic hematoma associated with a pelvic fracture is demonstrated.

Anticipated Exceptions

None.

Review Information

This guideline was originally developed in 1995. A complete review and revision of this document was approved in 1999. All Appropriateness Criteria™ topics are reviewed annually and updated as appropriate.

Citation Information

The American College of Radiology suggests the following format for citation of this document as a source:

American College of Radiology. "Imaging of the Multiply Injured Patient," *ACR Appropriateness Criteria ™*, 1999. Available at http://www.acr.org/ac_pda. Accessed: <*date*>.

Clinical Condition: **Multiply Injured Patient, Initial Imaging Evaluation**

Variant 1: **Patient alert, hemodynamically stable, peritoneal lavage normal or not performed.**

Radiologic Exam Procedure	Appropriateness Rating	Comments
Chest x-ray	9	
Cervical spine	9	High-risk patients. Imaging of rest of vertebral column is dependent on symptoms.
Pelvis x-ray	8	High-risk patients.
Transesophageal ultrasound	1	
CT Cranial	1	
Thoracic	1	
Abdominal/pelvic	1	
Invasive Angiography	1	
Embolization	1	
Cystourethrography	1	Indicated if pelvic disruption is present.
Cranial MRI	1	

Appropriateness Criteria Scale

1 2 3 4 5 6 7 8 9

1=Least appropriate **9=Most appropriate**

Clinical Condition: **Multiply Injured Patient, Initial Imaging Evaluation**

Variant 2: **Patient alert, hemodynamically stable, peritoneal lavage abnormal**.

Radiologic Exam Procedure	Appropriateness Rating	Comments
Chest x-ray	9	
Pelvis x-ray	9	
Cervical spine	9	High-risk patients (if patient does not go to surgery). Imaging of rest of vertebral column is determined by presence of clinical symptoms.
CT Abdominal/pelvic	9	
Cranial	1	
Thoracic	1	
Transesophageal ultrasound	1	
Cranial MRI	1	
Invasive Angiography	1	Not indicated unless there is clinical suspicion present.
Embolization	1	
Cystourethrography	1	Indicated if pelvic disruption present.
Appropriateness Criteria Scale **1 2 3 4 5 6 7 8 9** **1=Least appropriate** **9=Most appropriate**		

Clinical Condition: **Multiply Injured Patient, Initial Imaging Evaluation**

Variant 3: **Patient alert, hemodynamically unstable, peritoneal lavage normal or not performed.**

Radiologic Exam Procedure	Appropriateness Rating	Comments
Chest x-ray	9	
Pelvis x-ray	9	
Cervical spine	9	Imaging of rest of vertebral column is dependent on symptoms.
Transesophageal ultrasound	1	
CT Cranial	1	
Thoracic	1	May be indicated if hematoma is present.
Abdominal/pelvic	1	
Cranial MRI	1	
Invasive Angiography – Invasive	4	Depends on chest x-ray or history.
Embolization	1	May be indicated if bleeding source is determined to be from a pelvic fracture.
Cystourethrography	1	Indicated if pelvic disruption is present.
Appropriateness Criteria Scale **1 2 3 4 5 6 7 8 9** **1=Least appropriate** **9=Most appropriate**		

Clinical Condition: **Multiply Injured Patient, Initial Imaging Evaluation**

Variant 4: **Patient alert, hemodynamically unstable, peritoneal lavage abnormal.**

Radiologic Exam Procedure	Appropriateness Rating	Comments
Chest x-ray	9	
Pelvis x-ray	9	
Cervical spine	9	High-risk patients (if patient does not go to surgery). Imaging of rest of vertebral column is determined by presence of clinical symptoms.
CT Abdominal/Pelvic	9	Important only if patient is not going to surgery.
Cranial CT	1	
Thoracic CT	1	Spiral CT if patient is not going directly to surgery.
Transesophageal ultrasound	1	
Cranial MRI	1	
Invasive Angiography	1	Not indicated unless clinical suspicion is present.
Embolization	1	May be indicated if angiography demonstrates a source of hemorrhage.
Cystourethrography	1	Indicated if pelvic disruption is suspected.
Appropriateness Criteria Scale **1 2 3 4 5 6 7 8 9** **1=Least appropriate** **9=Most appropriate**		

Clinical Condition: **Multiply Injured Patient, Initial Imaging Evaluation**

Variant 5: **Patient obtunded, hemodynamically stable, peritoneal lavage normal.**

Radiologic Exam Procedure	Appropriateness Rating	Comments
Chest x-ray	9	
Pelvis x-ray	9	
Entire spine x-ray	9	
CT Cranial	9	
Thoracic	1	
Abdominal/pelvic	1	Probably indicated, if lavage was not performed or was unsuccessful.
Transesophageal ultrasound	1	
Cranial MRI	1	
Invasive Angiography	1	
Embolization	1	
Cystourethrography	1	Indicated if pelvic disruption is suspected.
Appropriateness Criteria Scale **1 2 3 4 5 6 7 8 9** **1=Least appropriate 9=Most appropriate**		

Variant 6: **Patient obtunded, hemodynamically unstable, peritoneal lavage normal.**

Radiologic Exam Procedure	Appropriateness Rating	Comments
Chest x-ray	9	
Pelvis x-ray	9	
Entire spine x-ray	9	
CT Cranial CT	9	
Abdominal/pelvic	6	To look for intracapsular injuries missed by diagnostic peritoneal lavage.
Thoracic CT	1	If chest x-ray showed normal findings.
Transesophageal ultrasound	1	
Cranial MRI	1	
Invasive Angiography	1	For thoracic aortic injury.
Embolization	1	May be indicated if source of hemorrhage is identified.
Cystourethrography	1	Indicated if pelvic disruption present.
Appropriateness Criteria Scale **1 2 3 4 5 6 7 8 9** **1=Least appropriate 9=Most appropriate**		

Clinical Condition: **Multiply Injured Patient, Initial Imaging Evaluation**

Variant 7: **Patient obtunded, hemodynamically stable, peritoneal lavage abnormal.**

Radiologic Exam Procedure	Appropriateness Rating	Comments
Chest x-ray	9	
Pelvis x-ray	9	
Entire spine x-ray	9	
CT Cranial	9	
Abdominal/pelvic	9	
Thoracic CT	1	Assuming chest x-ray normal.
Transesophageal ultrasound	1	
Cranial MRI	1	
Invasive Angiography	1	May be indicated to identify source of suspected bleeding.
Embolization	1	May be indicated if source of bleeding is identified.
Cystourethrography	1	Indicated if pelvic disruption is present.
Appropriateness Criteria Scale **1 2 3 4 5 6 7 8 9** **1=Least appropriate** **9=Most appropriate**		

Variant 8: **Patient obtunded, hemodynamically unstable, peritoneal lavage abnormal.**

Radiologic Exam Procedure	Appropriateness Rating	Comments
Chest x-ray	9	
Pelvis x-ray	9	
Entire spine x-ray	9	High-risk patients (patient usually goes to surgery).
CT Cranial	9	May be delayed if patient is going directly to surgery.
Abdominal/pelvic	9	Only if patient is not going directly to surgery.
Thoracic	1	Spiral scan may be done if patient does not go directly to surgery.
Transesophageal ultrasound	1	
Cranial MRI	1	
Invasive Angiography	1	May be necessary if source of bleeding is not found at surgery.
Embolization	1	May be necessary if source of bleeding is not found at surgery.
Cystourethrography	1	May be necessary if source of bleeding is not found at surgery.
Appropriateness Criteria Scale **1 2 3 4 5 6 7 8 9** **1=Least appropriate** **9=Most appropriate**		

References

1. Blow O, Bassam D, Butler K, Cephas GA, Brady W, Young JS. Speed and efficiency in the resuscitation of blunt trauma patients with multiple injuries: the advantage of diagnostic peritoneal lavage over abdominal computerized tomography. J Trauma 1998; 44(2):287-290.
2. Bridges KG, Welch G, Silver M, Schinco MA, Esposito B. CT detection of occult pneumothorax in multiple trauma patients. J Emerg Med 1993; 11:179-186.
3. Buzzas GR, Kern SJ, Smith RS, Harrison PB, Helmer SD, Reed JA. A comparison of sonographic examinations for trauma performed by surgeons and radiologists. J Trauma 1998; 44(4):604-608.
4. Catoire P, Orliaguet G, Liu N, et al. Systematic transesophageal echocardiography for detection of mediastinal lesions in patients with multiple injuries. J Trauma 1995; 38(1):96-102.
5. Cohn SM, Lyle WG, Linden CH, Lancey RA. Exclusion of cervical spine injury: a prospective study. J Trauma 1991; 31(4):570-574.
6. Ferrera PC, Verdile VP, Bartfield JM, Snyder HS, Salluzzo RF. Injuries distracting from intraabdominal injuries after blunt trauma. Am J Emerg Med 1998; 16(2):145-149.
7. Fulton RL, Everman D, Mancino M, Raque G. Ritual head computed tomography may unnecessarily delay lifesaving trauma care. Surg Gynecol Obstet 1993; 176: 327-332.
8. Gelman R, Mirvis SE, Gens D. Diaphragmatic rupture due to blunt trauma: sensitivity of plain chest radiographs. AJR 1991; 156:51-57.
9. Gupta A, Jamshidi M, Rubin JR. Traumatic first rib fracture: is angiography necessary? A review of 730 cases. Cardiovasc Surg 1997; 5(1):48-53.
10. Harris MB, Waguespack AM, Kronlage S. 'Clearing' cervical spine injuries in polytrauma patients: is it really safe to remove the collar? Orthopedics 1997; 20(10): 903-907.
11. Heinrich SD, Gallagher D, Harris M, Nadell JM. Undiagnosed fractures in severely injured children and young adults. Identification with technetium imaging. J Bone Joint Surg Am 1994; 76(4):561-572.
12. Hildingsson C, Hietala SO, Toolanen G, Björnebrink J. Negative scintigraphy despite spinal fractures in the multiply injured. Injury 1993; 24(7):467-470.
13. Hölting TH, Buhr HJ, Richter GM, Roeren TH, Friedl W, Herfarth CH. Diagnosis and treatment of retroperitoneal hematoma in multiple trauma patients. Arch Orthop Trauma Surg 1992; 111:323-326.
14. Kinnunen J, Kivioja A, Poussa K, Laasonen EM. Emergency CT in blunt abdominal trauma of multiple injury patients. Acta Radiol 1994; 35(4):319-322.
15. Klein SR, Saroyan RM, Baumgartner F, Bongard FS. Management strategy of vascular injuries associated with pelvic fractures. J Cardiovasc Surg 1992; 33:349-357.
16. Laham JL, Cotcamp DH, Gibbons PA, Kahana MD, Crone KR. Isolated head injuries versus multiple trauma in pediatric patients: do the same indications for cervical spine evaluation apply? Pediatr Neurosurg 1994; 21(4):221-226.
17. Livingston DH, Lavery RF, Passannante MR, et al. Admission or observation is not necessary after a negative abdominal computed tomographic scan in patients with suspected blunt abdominal trauma: results of a prospective multi-institutional trial. J Trauma 1998; 44(2):273-282.
18. Raptopoulos V. Abdominal trauma. Emphasis on computed tomography. Radiol Clin North Am 1994; 32(5):969-987.
19. Richardson JD, Wilson ME, Miller FB. The widened mediastinum: diagnostic and therapeutic priorities. Ann Surg 1990; 211(6):731-737.
20. Rogers LF, Hendrix RW. Evaluating the multiply injured patient radiographically. Orthop Clin North Am 1990; 21(3):437-447.
21. Ross SE, O'Malley KF, DeLong WG, Born CT, Schwab CW. Clinical predictors of unstable cervical spinal injury in multiply injured patients. Injury 1992; 23(5):317-319.
22. Rozycki GS, Ochsner MG, Jaffin JH, Champion HR. Prospective evaluation of surgeons' use of ultrasound in the evaluation of trauma patients. J Trauma 1993; 34(4):516-527.
23. Samuels LE, Kerstein MD. 'Routine' radiologic evaluation of the thoracolumbar spine in blunt trauma patients: a reappraisal. J Trauma 1993; 34(1):85-89.
24. Thomason M, Messick J, Rutledge R, et al. Head CT scanning versus urgent exploration in the hypotensive blunt trauma patient. J Trauma 1993; 34(1):40-45.
25. Trupka A, Waydhas C, Hallfeldt KK, Nast-Kolb D, Pfeifer KJ, Schweiberer L. Value of thoracic computed tomography in the first assessment of severely injured patients with blunt chest trauma: results of a prospective study. J Trauma 1997; 43(3):405-412.
26. Spain DA, Trooskin SZ, Flancbaum L, Boyarsky AH, Nosher JL. The adequacy and cost effectiveness of routine resuscitation-area cervical spine radiographs. Ann Emerg Med 1990; 19:276-278.
27. Vandemark RM. Radiology of the cervical spine in trauma patients: practice pitfalls and recommendations for improving efficiency and communication. AJR 1990; 155:465-472.
28. Werkman HA, Jansen C, Klein JP, Ten Duis HJ. Urinary tract injuries in multiply-injured patients: a rational guideline for the initial assessment. Br J Surg 1991; 22(6):471-474.
29. Wisner DH, Victor NS, Holcroft JW. Priorities in the management of multiple trauma: intracranial versus intra-abdominal injury. J Trauma 1993; 35(2):271-278.