AMERICAN COLLEGE OF EMERGENCY PHYSICIANS
SCIENTIFIC ASSEMBLY
1999

Updates in Diagnostic Imaging: Use of Spiral CT, Fluoroscopy, TEE, and MRI in the Emergency Department

New diagnostic imaging modalities are becoming widely available. Which of these are useful to the emergency physician and under what circumstances should they be used? This session will explore spiral CT scanning, fluoroscopy, TEE, and MRI. The uses and limitations of each modality will be examined as they apply to a variety of emergency medical conditions.

- Describe the application of these imaging modalities to the practice of emergency medicine.
- Discuss the advantages and disadvantages of each imaging technique.
- List the indications for each imaging technique.

TH-221
Thursday, October 14, 1999
11:00 AM - 11:55 AM
Room # N250
Las Vegas Convention Center

FACULTY

Scott W Melanson, MD, FACEP

Assistant Clinical Professor of Medicine, Temple University School of Medicine, Philadelphia, Pennsylvania; Associate Director, Emergency Medicine Residency, St. Luke's Hospital, Bethlehem, Pennsylvania

Updates in Diagnostic Imaging: Use of Spiral CT, Fluoroscopy, TEE and MRI in the Emergency Department

Scott W. Melanson, M.D., FACEP

I. Course Description

The potential uses of spiral CT, fluoroscopy, TEE and MRI in emergency medicine are becoming increasingly appreciated. Emergency physicians need to understand the uses and limitations of these modalities. Proper use of these tests can improve the diagnostic accuracy of the emergency physician. This course will review the potential uses and limitations of these modalities in emergency care.

II. Course Outline

A. Spiral CT (a.k.a. helical CT)

1. Spiral CT differs from standard CT in means of data acquisition and processing.
   a. Standard CT: images body in multiple discrete planes.
   b. Spiral CT: continuously collects data as x-ray tube spirals around the patient moving through the gantry. Computer reconstructs data into images.

2. Advantages of spiral CT
   a. Dramatically shortened examination times.
   b. Allows reconstruction of anatomic data in any plane.
   c. Improved visibility of vascular structures.
   d. Lower contrast load with contrast enhanced scans.

3. Emergency Medicine Applications
   a. **Appendicitis**
      - ♦ Primary CT findings in appendicitis:
        - Enlarged appendix (diameter > 6mm)
        - Periappendiceal inflammatory changes
      - ♦ Excellent accuracy. Study results:

Author	(N)	Sensitivity (%)	Specificity (%)	Accuracy (%)	Contrast
Lane ’97	109	90	97	94	none
Balthazar ’98	146	97	97	97	po, iv
Funaki ’98	100	97	94	95	pr, po
Rao ’97	100	98	98	98	pr
Schuler ’98	97	98	91	96	po, iv
Rao ’97	100	100	95	98	pr, po
Choi ’98	124	100	92	99	iv, po

Table 1. Results of spiral CT studies evaluating possible appendicitis.

      - ♦ Often assists in making alternative diagnosis when

appendicitis not present. Study results:

Author	(N)	Alternative dx (%)
Balthzar '98	146	26
Lane '97	109	34
Schuler '98	97	36
Funaki '98	100	54
Rao '97	100	62%
Rao '97	100	80%

Table 2. Percentage of patients in whom alternative diagnosis was made by spiral CT when appendicitis was not identified.

- Several studies (Schuler et al (1998), Rao et al, NEJM (1998), Rhea et al (1997), and Rao et al, Clin Rad (1998)) have found sCT to be a cost-effective test in most scenarios.

b. **Renal Colic**

- Study completed in < 5 minutes
- Unenhanced scans => no risk/expense of contrast
- Identifies extraurinary pathology (i.e. AAA, diverticulitis, appendicitis)
- No information on renal function or degree of obstruction
- sCT helpful in predicting stone passage. Factors associated with decreased likelihood of spontaneous stone passage:
  - Stone > 5mm
  - Stone in proximal 2/3 of ureter
  - Stone seen on $\geq$ 2 consecutive CT images
- Impressive results as noted below:

Author	N	Sensitivity (%)	Specificity (%)	Accuracy (%)
Boulay '99	99	100	96	98
Chen '99	100	100	94	97
Niall '99	40	100	92	98
Fielding '98	100	98	100	99
Viewig '98	105	98	98	96
Smith '98	210	97	96	97
Miller '98	106	96	100	98
Dalrymple '98	417	95	98	97
Yilmaz '98	97	94	97	95
Shelley '99	180	86	92	89

Table 3. Summary of studies evaluating sCT in renal colic.

c. **AAA**

- ♦ Provides excellent imaging of aorta and branches (much better than standard CT).
- ♦ Can be used as the sole method for preoperative evaluation of AAA.

d. **Pulmonary Embolism**

- ♦ Goal = direct visualization of pulmonary emboli.
- ♦ Allows for conclusive diagnosis more often than V/Q scan.
  - Cross et al, 1998

	confident diagnosis
sCT	90%
V/Q	54% p<.001

- ♦ Studies have yielded variable accuracy data.

Investigator	N	Sensitivity (%)	Specificity (%)
Drucker '98	47		
group 1observers		60	81
group 2 observers		53	97
Goodman '95	20	63	89
Van Rossum '98	123	75	90
Sostman '96	28	75	89
Mathis '99	117	85	100
Grenier '98	142	87	95
Mayo '97	139	87	95
Kim '99	110	92	96

Table 4. Studies of spiral CT in evaluation of pulmonary embolism.

- ♦ Variability in results may be due to scanning protocols (2mm vs 5mm slices), operator experience, and patient selection.
- ♦ sCT poor at identifying isolated subsegmental PE (~6% of PE's). Clinical significance of these PE unclear.
- ♦ Can often provide alternative diagnosis if PE not identified:

Alternative Diagnosis Made with sCT	
Cross '98	33%
Kim '99	67%
Van Rossum '98	93%

- ♦ Interrater reliability better with sCT (Kappa = .85) than with V/Q (Kappa = .61) (Mayo et al, 1997).

- More clinical data necessary before conclusion can be drawn regarding role of CT in evaluation of possible PE.

B. Magnetic Resonance Imaging

1. Technology: Protons in the body are subjected to a particular radio frequency. They respond by emitting a signal as they realign themselves with the strong magnetic field of the MRI scanner. These signals are registered by the scanner and processed by a computer to generate an image.

2. Advantages: No radiation exposure, contrast agents less toxic, can create images in any orientation, excellent imaging of soft tissue.

3. Emergency Medicine Applications

   a. **Spinal Emergencies**
   - Metastatic lesions
   - Primary spinal or paraspinal lesions
   - Trauma
   - Inflammatory disease

   b. **Musculoskeletal Disorders**
   - Bones/joints (hip, knee, shoulder)

   c. **Venography**
   - Magnetic resonance venography has been found to be ≥ color Doppler in detecting DVT.
     - Evans et al, 1993. N=61

	Pelvis DVT	Thigh DVT	Calf DVT
Sensitivity	100	100	87
Specificity	95	100	97

   - Other studies:

Author	N	Sensitivity (%)	Specificity (%)
Carpenter '93	85	100	96
Laissy '96	37	100	100
Catalano '97	43	100	94
Erdman '90	100	90	100

Table 5. Studies evaluating MR venography for possible DVT

4. Disadvantages: Magnet prevents use of metallic life support equipment, slow (30–60 min. exams), claustrophobic

environment.

C. Transesophageal Echocardiography (TEE)

1. Technology: A 5 MHz ultrasound transducer is attached to the tip of an endoscope. Endoscope tip can be moved in 2 planes with control wheels on TEE probe handle. Requires mild sedation in the awake patient.

2. Imaging through the esophageal wall, which lies against the heart, allows for high resolution imaging of the aorta and cardiac structures. Provides better visualization than transthoracic imaging (TTE).

3. Emergency Medicine Applications
   a. **Traumatic Disruption of the Aorta (TDA).**
      - Accuracy similar to aortography in most studies:

Author	N	Sensitivity (%)	Specificity (%)	Accuracy (%)
Buckmaster '94	160	100	100	100
Kearney '93	69	100	100	100
Smith '95	93	100	98	99
Chirillo '96	131	93	98	98
Vignon '95	32	91	100	97
Saletta '95	114	63	84	82
Minard* '96	29	57	91	83

*TEE performed by trauma surgeon or fellow (not cardiologist or anesthesiologist)

Table 6. Studies evaluating TEE in the diagnosis of traumatic disruption of the aorta

      - Performed at bedside, no contrast and faster than aortography (average exam time <30 minutes).

   b. **Aortic Dissection**
      - TEE has sensitivity and specificity similar to aortography and CT for this diagnosis. TEE also images aortic valve and pericardial fluid collections.
      - Only bedside test available to diagnose aortic dissection
      - Sarasin et al, recommends obtaining whichever of the following is most available with high probability of dissection: TEE, CT, aortography or MRI. If suspicion is high and initial test negative, obtain second confirmatory test.

4. Disadvantages

a. Requires immediate availability of experienced sonographer.
b. Sedation necessary.
c. Area or the aorta from distal ascending aorta to mid transverse aortic arch is poorly visualized.
d. Gendreau et al, (1999), reported complications in 12.6% of patients undergoing TEE in ED but most other studies report complication rate < 3%.

D. **Fluoroscopy**

1. Mobile "mini C-arm" units can create static images or continuous live images. These utilize much less radiation than traditional x-ray machines; lead aprons not necessary for most ED applications.

2. Allows for imaging in an unlimited number of planes with magnification of up to 5x.

3. Emergency Medicine Applications

a. **Foreign Body Localization and Detection**

- Identifies glass, metal, gravel and graphite but missed plastic and wood in tissues.
- Can help localize f. b. better than standard radiographs
- Wyn et al, 1995. Fluoroscopy identification of foreign bodies in beef cubes.

Object	Sensitivity (%)
Glass	100
Metal	100
Gravel	100
Graphite	90
Plastic	0
Wood	0

- Interobserver agreement excellent (Kappa = 0.75)

b. **Fracture Identification and Reduction**

- Low energy fluoroscopy limits use to distal extremities

- ♦ Helpful with reduction attempts. Compared with standard follow-up radiographs, fluoroscopy results in less radiation, more successful attempts and less trips to radiology department. (Lee et al, 1994)
- ♦ Cannot exclude fracture with fluoroscopy in strobe mode:
  - Sensitivity = 70%
  - Specificity = 93%
  - Accuracy = 85% (Jones et al, 1995)
  - No study has examined ED fluoroscopy in the continuous mode for the diagnosis of fractures.

c. **Confirmation of Intraosseous Needle Placement.**

- ♦ Improves success rate of placement 100% with vs. 85% without. (Mitchell et al, 1997)

Selected References

Spiral CT

1. Balthazar EJ, Rofsky NM, Zucker R. Appendicitis: the impact of computed tomography imaging on negative appendectomy and perforation rates. *American Journal of Gastroenterology*. 1998;93:768-71.
2. Boulay I, Holtz P, Foley WD, White B, Begun FP. Ureteral calculi: diagnostic efficacy of helical CT and implications for treatment of patients. *AJR Am J Roentgenol*. 1999;172:1485-90.
3. Chen MY, Zagoria RJ. Can noncontrast helical computed tomography replace intravenous urography for evaluation of patients with acute urinary tract colic? *J Emerg Med*. 1999;17:299-303.
4. Choi YH, Fischer E, Hoda SA, et al. Appendiceal CT in 140 cases. Diagnostic criteria for acute and necrotizing appendicitis. *Clinical Imaging*. 1998;22:252-71.
5. Cross JJ, Kemp PM, Walsh CG, Flower CD, Dixon AK. A randomized trial of spiral CT and ventilation perfusion scintigraphy for the diagnosis of pulmonary embolism. *Clinical Radiology*. 1998;53:177-82.
6. Dalrymple NC, Verga M, Anderson KR, et al. The value of unenhanced helical computerized tomography in the management of acute flank pain. *Journal of Urology*. 1998;159:735-40.
7. Drucker EA, Rivitz SM, Shepard JA, et al. Acute pulmonary embolism: assessment of helical CT for diagnosis. *Radiology*. 1998;209:235-41.
8. Errington ML, Ferguson JM, Gillespie IN, Connell HM, Ruckley CV, Wright AR. Complete pre-operative imaging assessment of abdominal aortic aneurysm with spiral CT angiography. *Clin Radiol*. 1997;52:369-77.
9. Fielding JR, Silverman SG, Samuel S, Zou KH, Loughlin KR. Unenhanced helical CT of ureteral stones: a replacement for excretory urography in planning treatment. *AJR. American Journal of Roentgenology*. 1998;171:1051-3.
10. Funaki B, Grosskreutz SR, Funaki CN. Using unenhanced helical CT with enteric contrast material for suspected appendicitis in patients treated at a community hospital. *AJR. American Journal of Roentgenology*. 1998;171:997-1001.
11. Goodman LR, Curtin JJ, Mewissen MW, et al. Detection of pulmonary embolism in patients with unresolved clinical and scintigraphic diagnosis: helical CT versus angiography. *AJR Am J Roentgenol*. 1995;164:1369-74.
12. Grenier PA, Beigelman C. Spiral computed tomographic scanning and magnetic resonance angiography for the diagnosis of pulmonary embolism. *Thorax*. 1998;53 Suppl 2:S25-31.
13. Holbert JM, Costello P, Federle MP. Role of spiral computed tomography in the diagnosis of pulmonary embolism in the emergency department. *Annals of Emergency Medicine*. 1999;33:520-8.
14. Kim KI, Muller NL, Mayo JR. Clinically suspected pulmonary embolism: utility of spiral CT. *Radiology*. 1999;210:693-7.
15. Lane MJ, Katz DS, Ross BA, Clautice-Engle TL, Mindelzun RE, Jeffrey RB, Jr. Unenhanced helical CT for suspected acute appendicitis. *AJR. American Journal of Roentgenology*. 1997;168:405-9.
16. Mathis G, Bitschnau R, Gehmacher O, et al. Chest ultrasound in diagnosis of pulmonary embolism in comparison to helical CT [In Process Citation]. *Ultraschall Med*. 1999;20:54-9.
17. Mayo JR, Remy-Jardin M, Muller NL, et al. Pulmonary embolism: prospective comparison of spiral CT with ventilation-perfusion scintigraphy. *Radiology*. 1997;205:447-52.
18. Miller OF, Rineer SK, Reichard SR, et al. Prospective comparison of unenhanced spiral computed tomography and intravenous urogram in the evaluation of acute flank pain. *Urology*. 1998;52:982-7.
19. Niall O, Russell J, MacGregor R, Duncan H, Mullins J. A comparison of noncontrast computerized tomography with excretory urography in the assessment of acute flank pain. *J Urol*. 1999;161:534-7.
20. Rao PM, Rhea JT, Novelline RA, Mostafavi AA, Lawrason JN, McCabe CJ. Helical CT combined with contrast material administered only through the colon for imaging of suspected appendicitis. *AJR. American Journal of Roentgenology*. 1997;169:1275-80.
21. Rao PM, Rhea JT, Novelline RA, et al. Helical CT technique for the diagnosis of appendicitis: prospective evaluation of a focused appendix CT examination. *Radiology*. 1997;202:139-44.
22. Rao PM, Rhea JT, Novelline RA, Mostafavi AA, McCabe CJ. Effect of computed tomography of the appendix on treatment of patients and use of hospital resources. *New England Journal of Medicine*. 1998;338:141-6.
23. Schuler JG, Shortsleeve MJ, Goldenson RS, Perez-Rossello JM, Perlmutter RA, Thorsen A. Is there a role for abdominal computed tomographic scans in appendicitis? *Archives of Surgery*. 1998;133:373-6; discussion 377.
24. Sheley RC, Semonsen KG, Quinn SF. Helical CT in the evaluation of renal colic. *Am J Emerg Med*. 1999;17:279-82.

25. Smith RC, Dalrymple NC, Neitlich J. Noncontrast helical CT in the evaluation of acute flank pain. *Abdominal Imaging*. 1998;23:10-6.
26. Sostman HD, Layish DT, Tapson VF, et al. Prospective comparison of helical CT and MR imaging in clinically

suspected acute pulmonary embolism. *J Magn Reson Imaging*. 1996;6:275-81.
27. van Rossum AB, Pattynama PM, Mallens WM, Hermans J, Heijerman HG. Can helical CT replace scintigraphy in the diagnostic process in suspected pulmonary embolism? A retrolective-prolective cohort study focusing on total diagnostic yield. *European Radiology*. 1998;8:90-6.
28. Vieweg J, Teh C, Freed K, et al. Unenhanced helical computerized tomography for the evaluation of patients with acute flank pain. *J Urol*. 1998;160:679-84.
29. Yilmaz S, Sindel T, Arslan G, et al. Renal colic: comparison of spiral CT, US and IVU in the detection of ureteral calculi. *European Radiology*. 1998;8:212-7.

MRI

1. Carpenter JP, Holland GA, Baum RA, Owen RS, Carpenter JT, Cope C. Magnetic resonance venography for the detection of deep venous thrombosis: comparison with contrast venography and duplex Doppler ultrasonography. *J Vasc Surg*. 1993;18:734-41.
2. Catalano C, Pavone P, Laghi A, et al. Role of MR venography in the evaluation of deep venous thrombosis. *Acta Radiol*. 1997;38:907-12.
3. Erdman WA, Jayson HT, Redman HC, Miller GL, Parkey RW, Peshock RW. Deep venous thrombosis of extremities: role of MR imaging in the diagnosis. *Radiology*. 1990;174:425-31.
4. Evans AJ, Sostman HD, Knelson MH, et al. 1992 ARRS Executive Council Award. Detection of deep venous thrombosis: prospective comparison of MR imaging with contrast venography. *AJR Am J Roentgenol*. 1993;161:131-9.
5. Evans PD, Wilson C, Lyons K. Comparison of MRI with bone scanning for suspected hip fracture in elderly patients. *J Bone Joint Surg Br*. 1994;76:158-9.
6. Koch D, Wakhloo AK, van Velthoven V. Magnetic resonance imaging in spinal emergency. *Acta Neurochir (Wien)*. 1995;134:100-7.
7. Laissy JP, Cinqualbre A, Loshkajian A, et al. Assessment of deep venous thrombosis in the lower limbs and pelvis: MR venography versus duplex Doppler sonography. *AJR Am J Roentgenol*. 1996;167:971-5.
8. Liu SH, Osti L, Henry M, Bocchi L. The diagnosis of acute complete tears of the anterior cruciate ligament. Comparison of MRI, arthrometry and clinical examination. *J Bone Joint Surg Br*. 1995;77:586-8.
9. Miller GK. A prospective study comparing the accuracy of the clinical diagnosis of meniscus tear with magnetic resonance imaging and its effect on clinical outcome. *Arthroscopy*. 1996;12:406-13.

Transesophageal Echocardiography

1. Adachi H, Omoto R, Kyo S, et al. Emergency surgical intervention of acute aortic dissection with the rapid diagnosis by transesophageal echocardiography. *Circulation*. 1991;84:III14-9.
2. Buckmaster MJ, Kearney PA, Johnson SB, Smith MD, Sapin PM. Further experience with transesophageal echocardiography in the evaluation of thoracic aortic injury. *J Trauma*. 1994;37:989-95.
3. Chirillo F, Totis O, Cavarzerani A, et al. Usefulness of transthoracic and transoesophageal echocardiography in recognition and management of cardiovascular injuries after blunt chest trauma. *Heart*. 1996;75:301-6.
4. De Simone R, Haberbosch W, Iarussi D, Iacono A. Transesophageal echocardiography for the diagnosis of thoracic aorta aneurysms and dissections. *Cardiologia*. 1990;35:387-90.
5. Fabian TC, Richardson JD, Croce MA, et al. Prospective study of blunt aortic injury: Multicenter Trial of the American Association for the Surgery of Trauma. *J Trauma*. 1997;42:374-80; discussion 380-3.
6. Gendreau MA, Triner WR, Bartfield J. Complications of transesophageal echocardiography in the ED. *Am J Emerg Med*. 1999;17:248-51.
7. Goarin JP, Catoire P, Jacquens Y, et al. Use of transesophageal echocardiography for diagnosis of traumatic aortic injury. *Chest*. 1997;112:71-80.
8. Kearney PA, Smith DW, Johnson SB, Barker DE, Smith MD, Sapin PM. Use of transesophageal echocardiography in the evaluation of traumatic aortic injury. *J Trauma*. 1993;34:696-701; discussion 701-3.
9. Laissy JP, Blanc F, Soyer P, et al. Thoracic aortic dissection: diagnosis with transesophageal echocardiography versus MR imaging. *Radiology*. 1995;194:331-6.
10. Minard G, Schurr MJ, Croce MA, et al. A prospective analysis of transesophageal echocardiography in the diagnosis of traumatic disruption of the aorta. *J Trauma*. 1996;40:225-30.
11. Nienaber CA, Spielmann RP, von Kodolitsch Y, et al. Diagnosis of thoracic aortic dissection. Magnetic resonance imaging versus transesophageal echocardiography. *Circulation*. 1992;85:434-47.
12. Nienaber CA, von Kodolitsch Y, Brockhoff CJ, Koschyk DH, Spielmann RP. Comparison of conventional and

transesophageal echocardiography with magnetic resonance imaging for anatomical mapping of thoracic aortic dissection. A dual noninvasive imaging study with anatomical and/or angiographic validation. *Int J Card Imaging*. 1994;10:1-14.
13. Saletta S, Lederman E, Fein S, Singh A, Kuehler DH, Fortune JB. Transesophageal echocardiography for the initial evaluation of the widened mediastinum in trauma patients. *J Trauma*. 1995;39:137-41; discussion 141-2.
14. Sarasin FP, Louis-Simonet M, Gaspoz JM, Junod AF. Detecting acute thoracic aortic dissection in the emergency department: time constraints and choice of the optimal diagnostic test. *Ann Emerg Med*. 1996;28:278-88.
15. Smith MD, Cassidy JM, Souther S, et al. Transesophageal echocardiography in the diagnosis of traumatic rupture of the aorta. *N Engl J Med*. 1995;332:356-62.
16. Sommer T, Fehske W, Holzknecht N, et al. Aortic dissection: a comparative study of diagnosis with spiral CT, multiplanar transesophageal echocardiography, and MR imaging. *Radiology*. 1996;199:347-52.
17. Vignon P, Gueret P, Vedrinne JM, et al. Role of transesophageal echocardiography in the diagnosis and management of traumatic aortic disruption. *Circulation*. 1995;92:2959-68.

Fluoroscopy

1. Cohen DM, Garcia CT, Dietrich AM, Hickey RW, Jr. Miniature C-arm imaging: an in vitro study of detecting foreign bodies in the emergency department. *Pediatr Emerg Care*. 1997;13:247-9.
2. Garcia CT, Cohen DM. Intraosseous needle: use of the miniature C-arm imaging device to confirm placement. *Pediatr Emerg Care*. 1996;12:94-7.
3. Jones J, McDonald JH, Smith M, Holt SP. Bedside fluoroscopy to screen for simple extremity trauma in the ED. *American Journal of Emergency Medicine*. 1995;13:545-7.
4. Lee SM, Orlinsky M, Chan LS. Safety and effectiveness of portable fluoroscopy in the emergency department for the management of distal extremity fractures. *Annals of Emergency Medicine*. 1994;24:725-30.
5. Mitchell K, Jones J, McNiich D. Portable fluoroscopy as a rapid method to establish intraosseous infusion (abstract). *Annals of Emergency Medicine*. 1997;30:407.
6. Wyn T, Jones J, McNinch D, Heacox R. Bedside fluoroscopy for the detection of foreign bodies. *Academic Emergency Medicine*. 1995;2:979-82.