

ACR Appropriateness Criteria® Intensive Care Unit Patients

*Expert Panel on Thoracic Imaging: Robert D. Suh, MD,***Scott J. Genshaft, MD,* Jacobo Kirsch, MD,†**Jeffrey P. Kanne, MD,‡ Jonathan H. Chung, MD,§ Edwin F. Donnelly, MD, PhD,||**Mark E. Ginsburg, MD,¶ Darel E. Heitkamp, MD,##**Travis S. Henry, MD,** Ella A. Kazerooni, MD,†† Loren H. Ketaj, MD,‡‡**Barbara L. McComb, MD,§§ James G. Ravenel, MD,|||**Anthony G. Saleh, MD,¶¶ Rakesh D. Shah, MD,###**Robert M. Steiner, MD,*** and Tan-Lucien H. Mohammed, MD†††*

Abstract: Portable chest radiography is a fundamental and frequently utilized examination in the critically ill patient population. The chest radiograph often represents a timely investigation of new or rapidly evolving clinical findings and an evaluation of proper positioning of support tubes and catheters. Thoughtful consideration of the use of this simple yet valuable resource is crucial as medical cost containment becomes even more mandatory. This review addresses the role of chest radiography in the intensive care unit on the basis of the existing literature and as formed by a consensus of an expert panel on thoracic imaging through the American College of Radiology. The American College of Radiology Appropriateness Criteria are evidence-based guidelines for specific clinical conditions that are reviewed every 3 years by a multidisciplinary expert panel. The guideline development and review include an extensive analysis of current medical literature from peer-reviewed journals and the application of a well-

established consensus methodology (modified Delphi) to rate the appropriateness of imaging and treatment procedures by the panel. In those instances in which evidence is lacking or not definitive, expert opinion may be used to recommend imaging or treatment.

Key Words: appropriateness criteria, chest radiographs, chest x-rays, intensive care unit, tubes, catheters

(*J Thorac Imaging* 2015;30:W63–W65)

SUMMARY OF LITERATURE REVIEW

Introduction/Background

Portable chest radiographs can be categorized as one of the following:

- (1) Daily or routine chest radiographs for patient monitoring.
- (2) Chest radiographs obtained after specific procedures.
- (3) Chest radiographs documenting the presence or course of disease.

This narrative concerns daily routine chest radiographs in the intensive care unit (ICU). The role of chest radiographs after insertion of endotracheal, nasogastric (orogastric), and chest tubes, placement of pulmonary artery (Swan-Ganz) and central venous catheters (CVC), and chest tube removal is addressed (Table 1).

Discussion of Imaging Modalities by Variant

Variants 1, 2, and 3: Routine Versus Clinically Indicated Chest Radiographs

Long-standing controversy exists regarding the role of routine portable chest radiographs in critically ill patients in

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From the *Ronald Reagan UCLA Medical Center, Los Angeles, CA;

†Cleveland Clinic, Weston; §§Mayo Clinic, Jacksonville; †††University of Florida College of Medicine, Gainesville, FL;

‡Department of Radiology, University of Wisconsin School of Medicine and Public Health, Madison, WI; §National Jewish Health, Denver, CO; ||Department of Radiology, Vanderbilt University Medical Center, Nashville, TN; ¶Society of Thoracic Surgeons, Columbia University, New York; ¶¶The American College of Chest Physicians, New York Methodist Hospital, Brooklyn;

##North Shore University Hospital, Manhasset, NY; #Department of Radiology and Imaging Services, Indiana University, Indianapolis, IN; **Emory University Hospital, Atlanta, GA; ††University of Michigan Medical Center, Ann Arbor, MI; ‡‡Department of Radiology, University of New Mexico, Albuquerque, NM;

|||Department of Radiology, Medical University of South Carolina, Charleston, SC; and ***Temple University Hospital, Philadelphia, PA.

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Jeffrey P. Kanne is a consultant at Parexcel Informatics. Robert M. Steiner is a consultant and course director at Education Symposium Inc. and a consultant at John and Johnson. The remaining authors declare no conflicts of interest.

Correspondence to: Robert D. Suh, MD, Department of Radiology, Ronald Reagan UCLA Med Ctr, 757 Westwood Plaza Ste 1638, Los Angeles, CA 90095-7437 (e-mail: rsuh@mednet.ucla.edu).

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TABLE 1. Table Ratings

Variants	Radiologic Procedure X-Ray Chest Portable
Variant 1: Admission or transfer to ICU	7
Variant 2: Stable patient. No change in clinical status	3
Variant 3: Patient with clinical worsening	9
Variant 4: Post-insertion of tube or catheter	9
Variant 5: Post-chest tube removal	5

Rating scale: 1, 2, 3—Usually not appropriate; 4, 5, 6—May be appropriate; 7, 8, 9—Usually appropriate.

the ICU, particularly in the mechanically ventilated patient. Traditionally, routine daily chest radiographs have been performed for these patients, largely on the basis of data from the 1980s, which showed a high incidence of new or unexpected findings.

More recent data suggest that this solidly entrenched philosophy in ICU management of patients is of low yield in the absence of a clear indication, such as new device placement or clinical change. Oba and Zaza¹ performed a meta-analysis of 8 trials comprising 7078 ICU patients, half of whom received daily chest radiographs and the other half of whom received chest radiographs for specific clinical indications. The study examined primary endpoints such as hospital or ICU mortality, length of mechanical ventilation, hospital stay, or adverse event rate. Eliminating routine daily chest radiographs did not affect mortality, length of stay in the hospital or ICU, or ventilator days.

Hejblum et al² assessed the efficiency and effectiveness of routine daily versus clinically indicated chest radiographs for mechanically ventilated patients in the ICU. In the first period, 11 ICUs were randomly allocated to use daily chest radiographs and 10 ICUs to use an indication-driven strategy. A total of 424 patients had 4607 routine chest radiographs, and 425 patients had 3148 indication-driven chest radiographs, which represents a statistically significant 32% reduction in use of chest radiographs without sacrificing quality of care or safety. Lakhal et al³ have likewise found decreased resource utilization in ICUs using indication-driven chest radiograph ordering, and Leong et al⁴ concluded that the timing of portable chest radiographs in overall management guidelines should be based on clinical evaluations.

Graat et al⁵ prospectively evaluated the clinical value of 2457 routine chest radiographs in a combined surgical/medical ICU (MICU). In their study, 5.8% of daily routine chest radiographs showed new or unexpected findings, but only 2.2% warranted a change in therapy. No difference was found between the medical and surgical patients.

A prospective randomized control study of MICU patients by Krivopal et al⁶ found a greater percentage of radiographs with significant findings (requiring intervention) in the indication-driven group (26.5%) than in the routine group (13.3%). Significant interventions included diuresis, antibiotic administration, or invasive procedures. Patients in the indication-driven group received significantly fewer radiographs than those in the routine group (4.4 vs. 6.8) and experienced no significant difference in outcomes, length of intubation, ICU stay, hospital stay, or mortality.

Clec'h et al⁷ also showed increased diagnostic yield of indication-driven versus routine chest radiographs. When the clinical indication of a radiograph is acute hypoxia, Walker et al⁸ reported a relatively high rate of actionable findings, with 24.3% of radiographs showing major changes and 20.3% of radiographs showing minor changes. Hendrikse et al⁹ concluded that the diagnostic and therapeutic value of routine chest radiograph is low, recommending abandoning routine chest radiographs in the ICU. Although reporting the lowest rate of significant abnormal chest radiograph findings at 3% of all chest radiographs in 18% of the MICU patients, Hall et al¹⁰ still recommended daily routine studies on all critically ill patients. Strain et al¹¹ found a high diagnostic yield in MICU patients with acute cardiopulmonary disease but very low in patients with stable cardiac disease (usually myocardial infarction) and in ICU patients who had only extrathoracic disease.

For cardiothoracic ICU patients, 2 prospective non-randomized studies^{12,13} support the recommendation to obtain chest radiographs in cardiothoracic ICU for clinical findings but not for routine follow-up with a low incidence of significant findings on routine radiographs (4.5% in both studies) and consequently a minimal impact on patient management. The role of chest radiographs for evaluation of intra-aortic balloon pumps and ventricular-assist devices has not been specifically addressed in the literature.

Recommendation. Routine daily chest radiographs are not indicated for patients admitted to the ICU. In stable patients admitted for cardiac monitoring, or in stable patients admitted for only extrathoracic disease, an initial ICU admission radiograph is recommended; follow-up radiographs should be obtained only for specific clinical indications, including clinical worsening and tube or line insertion.

Variant 4: Post-insertion of Tube or Catheter

Endotracheal Tubes. Nine studies appear in the literature since 1980^{11,13-20} that evaluate the significance of the chest radiograph in assessing endotracheal tube placement after insertion. Five of these studies demonstrate that between 12% and 15% of endotracheal tubes are malpositioned, many requiring repositioning. Two studies found 28% and 46% of tubes malpositioned upon insertion, and the single dissenting paper found 2% malpositioned. Two studies comparing physical examination with radiographs^{14,21} found that physical examination predicted malpositioned tubes in 3% of patients, whereas the radiographs showed malpositioning in 14% of patients in 1 study and 28% in the other, the vast majority discovered in the first 3 days.²²

Recommendation. Very few malpositioned tubes are detected by physical examination. Radiographs immediately after intubation are indicated to ensure proper positioning.

CVCs and Swan-Ganz Catheters. Eight studies evaluating CVCs and Swan-Ganz catheters^{11,14-18,20,22,23} derived the same conclusion: chest radiographs are useful after catheter insertion, detecting approximately 10% malpositioned. The majority of complications, occurring in approximately 10% of catheter insertions, are minor; pneumothorax occurred in approximately 2% of patients.^{15,23} Complications were twice as common with subclavian compared with jugular catheters (17% vs. 8%),¹⁴ although unsuspected complications were infrequent.

Recommendation. A chest radiograph after insertion of a CVC and/or Swan-Ganz catheter is recommended to demonstrate proper placement and to detect complications. Beyond initial insertion, follow-up chest radiographs have a low yield for revealing complications and are only suggested when complications are clinically suspected.

Nasogastric (Orogastric) Tubes. There are no large prospective studies that consider the utility of obtaining a chest radiograph immediately after the insertion of a nasogastric suction tube or a small-bore feeding tube. Chest radiographs revealed important tube malpositioning in 1% of cases.^{11,15,17}

On the basis of limited evidence, small-bore feeding tubes may, in a small but significant number of patients, be inadvertently placed in the bronchi or lungs. This error is not always detected clinically and may lead to injection of feeding material into the lung or tube penetration of the pleura, with subsequent pneumothorax.

Recommendation. A chest radiograph is warranted after initial nasogastric tube insertion and before the first feeding. Beyond the initial chest radiograph, follow-up

chest radiographs are not required for managing stable tubes.

Chest Tube Insertion. Few studies evaluate the efficacy of the initial chest radiograph after the insertion of a chest tube. The 3 available studies show that approximately 10% of tubes are malpositioned.^{11,16,20} Many of the radiographic abnormalities detected are minor and do not lead to tube repositioning.

Recommendation. After insertion of a chest tube, a chest radiograph is recommended to show the position of the tube, any success in drainage, and possible complications from insertion. Further evaluation of tube position and function is warranted on the basis of management of the pleural space and clinical indications.

Variant 5: Post-chest Tube Removal

A total of 6 prospective observational and retrospective cohort studies and 1 meta-analysis^{7,24–29} found a low rate of complications, most notably pneumothorax, after chest tube removal, the majority of which were predicted clinically^{25,27} and with a low rate of tube reinsertion of between 0.25% and 4%.^{24,29}

Recommendation. A routine chest radiograph is not recommended after chest tube removal, unless indicated by clinical presentation.

SUMMARY OF RECOMMENDATIONS

- Placement of endotracheal or nasogastric (orogastric) tubes, CVC, Swan-Ganz catheters, or any other life-support item is an indication for a chest radiograph.
- Change in the clinical condition of the patient is an indication for a chest radiograph.
- Routine daily chest radiographs in the ICU are not indicated.

SUMMARY OF EVIDENCE

Of the 29 references cited in the *ACR Appropriateness Criteria Intensive Care Unit Patients* document, all of them are categorized as diagnostic references, including 5 good-quality studies and 12 quality studies that may have design limitations. There are 12 references that may not be useful as primary evidence.

The 29 references cited in the *ACR Appropriateness Criteria Intensive Care Unit Patients* document were published between 1981 and 2012.

Although there are references that report on studies with design limitations, 5 good-quality studies provide good evidence.

REFERENCES

1. Oba Y, Zaza T. Abandoning daily routine chest radiography in the intensive care unit: meta-analysis. *Radiology*. 2010;255:386–395.
2. Hejblum G, Chalumeau-Lemoine L, Ioos V, et al. Comparison of routine and on-demand prescription of chest radiographs in mechanically ventilated adults: a multicentre, cluster-randomised, two-period crossover study. *Lancet*. 2009;374:1687–1693.
3. Lakhal K, Serveaux-Delous M, Lefrant JY, et al. Chest radiographs in 104 French ICUs: current prescription strategies and clinical value (the RadioDay study). *Intensive Care Med*. 2012;23:1787–1799.
4. Leong CS, Cascade PN, Kazerooni EA, et al. Bedside chest radiography as part of a postcardiac surgery critical care pathway: a means of decreasing utilization without adverse clinical impact. *Crit Care Med*. 2000;28:383–388.
5. Graat ME, Choi G, Wolthuis EK, et al. The clinical value of daily routine chest radiographs in a mixed medical-surgical intensive care unit is low. *Crit Care*. 2006;10:R11.
6. Krivopal M, Shlobin OA, Schwartzstein RM. Utility of daily routine portable chest radiographs in mechanically ventilated patients in the medical ICU. *Chest*. 2003;123:1607–1614.
7. Clec'h C, Simon P, Hamdi A, et al. Are daily routine chest radiographs useful in critically ill, mechanically ventilated patients? A randomized study. *Intensive Care Med*. 2008;34:264–270.
8. Walker CM, Tang J, Richardson ML, et al. On-demand chest radiographs for hypoxia: impact on clinical care. *J Thorac Imaging*. 2012;27:152–155.
9. Hendrikse KA, Gratama JW, Hove W, et al. Low value of routine chest radiographs in a mixed medical-surgical ICU. *Chest*. 2007;132:823–828.
10. Hall JB, White SR, Karrison T. Efficacy of daily routine chest radiographs in intubated, mechanically ventilated patients. *Crit Care Med*. 1991;19:689–693.
11. Strain DS, Kinasewitz GT, Vereen LE, et al. Value of routine daily chest x-rays in the medical intensive care unit. *Crit Care Med*. 1985;13:534–536.
12. Graham RJ, Meziane MA, Rice TW, et al. Postoperative portable chest radiographs: optimum use in thoracic surgery. *J Thorac Cardiovasc Surg*. 1998;115:45–50; discussion 50–42.
13. O'Brien W, Karski JM, Cheng D, et al. Routine chest roentgenography on admission to intensive care unit after heart operations: is it of any value? *J Thorac Cardiovasc Surg*. 1997;113:130–133.
14. Gray P, Sullivan G, Ostrowski P, et al. Value of postprocedural chest radiographs in the adult intensive care unit. *Crit Care Med*. 1992;20:1513–1518.
15. Silverstein DS, Livingston DH, Elcavage J, et al. The utility of routine daily chest radiography in the surgical intensive care unit. *J Trauma*. 1993;35:643–646.
16. Henschke CI, Pasternack GS, Schroeder S, et al. Bedside chest radiography: diagnostic efficacy. *Radiology*. 1983;149:23–26.
17. Horst HM, Fagan B, Beute GH. Chest radiographs in surgical intensive care patients: a valuable “routine”. *Henry Ford Hosp Med J*. 1986;34:84–86.
18. Brunel W, Coleman DL, Schwartz DE, et al. Assessment of routine chest roentgenograms and the physical examination to confirm endotracheal tube position. *Chest*. 1989;96:1043–1045.
19. Marik PE, Janower ML. The impact of routine chest radiography on ICU management decisions: an observational study. *Am J Crit Care*. 1997;6:95–98.
20. Bekemeyer WB, Crapo RO, Calhoon S, et al. Efficacy of chest radiography in a respiratory intensive care unit. A prospective study. *Chest*. 1985;88:691–696.
21. Bhagwanjee S, Muckart DJ. Routine daily chest radiography is not indicated for ventilated patients in a surgical ICU. *Intensive Care Med*. 1996;22:1335–1338.
22. Kollef MH, Legare EJ, Damiano M. Endotracheal tube misplacement: incidence, risk factors, and impact of a quality improvement program. *South Med J*. 1994;87:248–254.
23. Sise MJ, Hollingsworth P, Brimm JE, et al. Complications of the flow-directed pulmonary artery catheter: a prospective analysis in 219 patients. *Crit Care Med*. 1981;9:315–318.
24. Eisenberg RL, Khabbaz KR. Are chest radiographs routinely indicated after chest tube removal following cardiac surgery? *Am J Roentgenol*. 2011;197:122–124.
25. Khan T, Chawla G, Daniel R, et al. Is routine chest X-ray following mediastinal drain removal after cardiac surgery useful? *Eur J Cardiothorac Surg*. 2008;34:542–544.
26. McCormick JT, O'Mara MS, Papasavas PK, et al. The use of routine chest X-ray films after chest tube removal in postoperative cardiac patients. *Ann Thorac Surg*. 2002;74:2161–2164.
27. Pacharn P, Heller DN, Kammen BF, et al. Are chest radiographs routinely necessary following thoracostomy tube removal? *Pediatr Radiol*. 2002;32:138–142.
28. Sepehrpour AH, Farid S, Shah R. Is routine chest radiography indicated following chest drain removal after cardiothoracic surgery? *Interact Cardiovasc Thorac Surg*. 2012;14:834–838.
29. Whitehouse MR, Patel A, Morgan JA. The necessity of routine post-thoracostomy tube chest radiographs in post-operative thoracic surgery patients. *Surgeon*. 2009;7:79–81.