ACR Appropriateness Criteria Routine Chest Radiographs in Intensive Care Unit Patients

Judith K. Amorosa, MD[a], Mark Paul Bramwit, MD[a], Tan-Lucien H. Mohammed, MD[b], Gautham P. Reddy, MD, MPH[c], Kathleen Brown, MD[d], Debra Sue Dyer, MD[e], Mark E. Ginsburg, MD[f], Darel E. Heitkamp, MD[g], Jean Jeudy, MD[h], Jacobo Kirsch, MD[i], Heber MacMahon, MB, BCh[j], James G. Ravenel, MD[k], Anthony G. Saleh, MD[l], Rakesh D. Shah, MD[m]

Daily routine chest radiographs in the intensive care unit (ICU) have been a tradition for many years. Anecdotal reports of misplacement of life support items, acute lung processes, and extra pulmonary air collections in a small number of patients served as a justification for routine chest radiographs in the ICU.

Having analyzed this practice, the ACR Appropriateness Criteria Expert Panel on Thoracic Imaging has made the following recommendations:

- When monitoring a stable patient or a patient on mechanical ventilation in the ICU, a portable chest radiograph is appropriate for clinical indications only.
- It is appropriate to obtain a chest radiograph after placement of an endotracheal tube, central venous line, Swan-Ganz catheter, nasogastric tube, feeding tube, or chest tube.

The ACR Appropriateness Criteria are evidence-based guidelines for specific clinical conditions that are reviewed every 2 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 where evidence is lacking or not definitive, expert opinion may be used to recommend imaging or treatment.

The strongest data contributing to these recommendations were derived from a meta-analysis of 8 trials comprising 7,078 ICU patients by Oba and Zaza [1].

Key Words: Appropriateness criteria, chest radiograph, ICU

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[a]Robert Wood Johnson Medical School, New Brunswick, New Jersey.
[b]Cleveland Clinic Foundation, Cleveland, Ohio.
[c]University of Washington School of Medicine, Seattle, Washington.
[d]David Geffen School of Medicine at UCLA, Los Angeles, California.
[e]National Jewish Health, Denver, Colorado.
[f]Columbia University, New York, New York, Society of Thoracic Surgeons.
[g]Indiana University, Indianapolis, Indiana.
[h]University of Maryland Medical Center, Baltimore, Maryland.
[i]Cleveland Clinic, Weston, Florida.
[j]University of Chicago Medical Center, Chicago, Illinois.
[k]Medical University of South Carolina, Charleston, South Carolina.
[l]New York Methodist Hospital, Brooklyn, New York, The American College of Chest Physicians.
[m]North Shore University Hospital, Manhasset, New York.

The ACR seeks and encourages collaboration with other organizations on the development of the ACR Appropriateness Criteria through society representation on expert panels. Participation by representatives from collaborating societies on the expert panel does not necessarily imply individual or society endorsement of the final document.

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Corresponding author and reprints: Judith K. Amorosa, MD, American College of Radiology, 1891 Preston White Drive, Reston, VA 20191; e-mail: amorosa@umdnj.edu

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Variant 1. Monitoring stable patient

Radiologic Procedure	Rating	Comments	RRL
X-ray chest portable admission and/or transfer with specified indication	9		☢
X-ray chest portable clinical indications only	9	Clinical worsening only	☢
X-ray chest portable routine monitoring	1		☢

Rating Scale: 1,2,3 = Usually not appropriate; 4,5,6 = May be appropriate; 7,8,9 = Usually appropriate
RRL = relative radiation level.

SUMMARY OF LITERATURE REVIEW

Portable Chest Radiographs in the Intensive Care Unit Setting

Portable chest radiographs can be categorized as the following:

- Daily or routine chest radiographs for patient monitoring
- Chest radiographs obtained after specific procedures
- Chest radiographs documenting the presence or course of disease

This narrative concerns daily routine chest radiographs in the intensive care unit (ICU) and chest radiographs following placement of endotracheal, nasogastric (orogastric), Swan-Ganz catheter, central venous pressure catheter (CVP), and chest tube insertion. (See Variants 1-8.)

There has been emerging controversy regarding the role of routine portable chest radiographs in critically ill patients in the ICU, especially in the mechanically ventilated patient. Traditionally, routine daily chest radiographs have been done especially on these patients. This tradition has been based on data from the 1980s, which showed a high incidence of new or unexpected findings.

New data have begun to confront this solidly entrenched philosophy in ICU management of patients. Oba and Zaza [1] performed a meta-analysis of 8 trials comprising 7,078 ICU patients; half received daily chest radiographs and the other half received chest radiographs for a specific clinical indication. 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 in either group.

Hejblum et al [2] performed a large multicenter prospective trial to assess the efficiency and effectiveness of routine daily versus clinically indicated (on-demand) chest radiographs for mechanically ventilated patients in the ICU over a two-period cluster randomized design. In the first period, 11 ICUs were randomly allocated to use daily chest radiographs and 10 ICUs to use an on-demand strategy based on specific clinical indications. Four hundred twenty-four patients had 4,607 routine chest radiographs, and 425 patients had 3,148 chest radiographs on demand, which represents a statistically significant 32% reduction in use of chest radiographs without a reduction in patients' quality of care or safety.

Leong et al [3] concluded from a cohort observational study that the timing of portable chest radiographs needs to be included in the overall management guidelines based on clinical evaluations.

Two other studies evaluated the clinically relevant use of daily routine versus nonroutine clinically indicated (on-demand) chest radiographs. A large study by Graat et al [4] prospectively evaluated the clinical value of 2,457 routine chest radiographs in a combined surgical/medical intensive care unit (SICU/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 randomized control study of MICU patients by Krivopal et al [5] prospectively divided them into those who received daily routine chest radiographs and those who only received nonroutine (clinically indicated) chest radiographs. They found a greater percentage of radiographs with significant findings (requiring intervention) in the nonroutine group (26.5%) than in the routine group (13.3%). Significant

Variant 2. Respiratory failure. Patient receiving mechanical ventilation

Radiologic Procedure	Rating	Comments	RRL
X-ray chest portable clinical indications only	9		☢
X-ray chest portable routine daily	3	Some subgroups may benefit from a daily chest radiograph.	☢

Rating Scale: 1,2,3 = Usually not appropriate; 4,5,6 = May be appropriate; 7,8,9 = Usually appropriate
RRL = relative radiation level.

Variant 3. Compromised respiratory function. Patient with endotracheal tubes

Radiologic Procedure	Rating	Comments	RRL
X-ray chest portable after catheter/tube insertion	9		☢
X-ray chest portable clinical indications only	9		☢
X-ray chest portable follow-up	1		☢

Rating Scale: 1,2,3 = Usually not appropriate; 4,5,6 = May be appropriate; 7,8,9 = Usually appropriate
RRL = relative radiation level.

Variant 5. Cardiopulmonary compromise. Swan-Ganz catheter insertion

Radiologic Procedure	Rating	Comments	RRL
X-ray chest portable after catheter/tube insertion	9		☢
X-ray chest portable clinical indications only	9		☢
X-ray chest portable follow-up	1		☢

Rating Scale: 1,2,3 = Usually not appropriate; 4,5,6 = May be appropriate; 7,8,9 = Usually appropriate
RRL = relative radiation level.

interventions included diuresis, antibiotic administration, or invasive procedures. The nonroutine group also received significantly fewer radiographs per person than the routine group (4.4 versus 6.8). There was no significant difference in outcome between the groups in length of intubation, ICU stay, hospital stay, or mortality.

Another recent prospective observational study [6] analyzed 1,780 routine chest radiographs in 559 hospital ICU admissions. It concluded that the diagnostic and therapeutic value of routine chest radiograph is low, and the authors recommended abandoning routine chest radiographs in the ICU.

Hall et al [7] reported the lowest rate of significant abnormal chest radiograph findings at 3% of all chest radiographs in 18% of the MICU patients. They still recommended daily routine studies on all critically ill patients. In a study by Strain et al [8] a high yield was found in MICU patients who had acute cardiopulmonary disease, but the yield was very low in patients with stable cardiac disease (usually myocardial infarction) and in ICU patients who had extrathoracic disease only.

For cardiothoracic ICU patients, 2 prospective nonrandomized studies [9,10] showed a low incidence of significant findings on routine radiographs (4.5% in both studies) and consequently a minimal impact on patient management. The results support the recommendation to obtain chest radiographs in cardiothoracic ICU for clinical findings but not for routine follow-up.

Variant 4. Central venous pressure catheter (CVP) insertion

Radiologic Procedure	Rating	Comments	RRL
X-ray chest portable after catheter/tube insertion	9		☢
X-ray chest portable clinical indications only	9		☢
X-ray chest portable follow-up	1		☢

Rating Scale: 1,2,3 = Usually not appropriate; 4,5,6 = May be appropriate; 7,8,9 = Usually appropriate
RRL = relative radiation level.

Recommendation. Routine daily chest radiographs are not indicated for patients with acute cardiopulmonary problems. In stable patients admitted for cardiac monitoring, or in stable patients admitted for extrathoracic disease only, an initial ICU admission radiograph is not recommended; follow-up radiographs should be obtained only for specific clinical indications.

Endotracheal Tubes

There are 9 studies described in the literature since 1980 [8,10-17] that evaluate the significance of the chest radiograph in assessing endotracheal tube placement after insertion. In 5 of the studies, between 12% and 15% of patients had malpositioned endotracheal tubes, many of which required repositioning. Two studies found 28% and 46% of tubes malpositioned upon insertion, and the single dissenting paper found 2% malpositioned. Two studies compared radiographs with physical examination [11,18]. In both studies, physical examination predicted malpositioned tubes in 3% of patients, whereas the radiographs showed malpositioning in 14% of patients in one study and 28% in the other. Kollef et al [19] found that the vast majority of malpositioned tubes were discovered in the first 3 days.

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

CVP Catheters

Eight studies were reviewed regarding CVP catheters [8,11-15,17,19]. The vast majority came to the same conclusion. Approximately 10% of the chest radiographs demonstrated malpositioned catheters. Pneumothoraces were present in only a small percentage of patients. Gray et al [11] separated jugular and subclavian catheters. Complications were twice as common with subclavian catheters (17% versus 8%), although unsuspected complications were infrequent.

Recommendation. A chest radiograph after insertion of a CVP catheter is recommended to demonstrate proper placement and detect any complications. Beyond the initial insertion, follow-up chest radiographs have a low

Variant 6. Potential cardiopulmonary compromise. Nasogastric (NG) feeding tube insertion

Radiologic Procedure	Rating	Comments	RRL
X-ray chest portable after catheter/tube insertion	9	If physical examination is uncertain	☢
X-ray chest portable clinical indications only	9		☢
X-ray chest portable follow-up	1		☢

Rating Scale: 1,2,3 = Usually not appropriate; 4,5,6 = May be appropriate; 7,8,9 = Usually appropriate
RRL = relative radiation level.

yield for revealing complications. Follow-up chest radiographs are suggested only when complications are suspected clinically.

Swanz-Ganz Catheters

Previously mentioned studies incorporated the position and potential complications of Swan-Ganz catheter placements shown on chest radiographs obtained immediately postprocedure. The majority of complications, which occur in approximately 10% of catheter insertions, are minor and require catheter repositioning [11,12,14,20]. The pneumothorax rate was approximately 2% [12,20].

Recommendation. Chest radiographs are suggested after catheter insertion. After pneumothorax has been excluded and proper positioning has been assured, follow-up radiographs are not required except for specific clinical indications.

Nasogastric 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 [8,12,14]. Clearly, a patient with a functioning nasogastric tube that has already been documented to be in satisfactory position needs no imaging unless a clinical problem arises.

Recommendation. Based on limited evidence, small-bore feeding tubes may, in a small but significant number of patients, be inadvertently placed in the 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. 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 Tubes

Few studies have been performed to 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 [8,13,17]. Many of the radiographic abnormalities detected are minor and do not result in changes of tube positions.

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. Beyond this point, evaluation of tube position and function is warranted based on management of the pleural space and clinical indications.

TAKE-HOME POINTS

- Placement of endotracheal or nasogastric (orogastric) tubes, Swan-Ganz catheters, central venous pressure 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 radiograph in the ICU is not indicated.

Variant 7. Potential cardiopulmonary compromise. Nasogastric (NG) suction tube (nonfeeding) insertion

Radiologic Procedure	Rating	Comments	RRL
X-ray chest portable after catheter/tube insertion	9		☢
X-ray chest portable clinical indications only	9		☢
X-ray chest portable follow-up	1		☢

Rating Scale: 1,2,3 = Usually not appropriate; 4,5,6 = May be appropriate; 7,8,9 = Usually appropriate
RRL = relative radiation level.

Variant 8. Respiratory compromise. Chest tube insertion

Radiologic Procedure	Rating	Comments	RRL
X-ray chest portable after catheter/tube insertion	9		☢
X-ray chest portable clinical indications only	9		☢
X-ray chest portable follow-up	1		☢

Rating Scale: 1,2,3 = Usually not appropriate; 4,5,6 = May be appropriate; 7,8,9 = Usually appropriate
RRL = relative radiation level.

Table 1. Relative Radiation Level Information

Relative Radiation Level*	Adult Effective Dose Estimate Range	Pediatric Effective Dose Estimate Range
O	0 mSv	0 mSv
☢	<0.1 mSv	<0.03 mSv
☢☢	0.1-1 mSv	0.03-0.3 mSv
☢☢☢	1-10 mSv	0.3-3 mSv
☢☢☢☢	10-30 mSv	3-10 mSv
☢☢☢☢☢	30-100 mSv	10-30 mSv

mSv = millisievert.
*RRL assignments for some of the examinations cannot be made, because the actual patient doses in these procedures vary as a function of a number of factors (eg, region of the body exposed to ionizing radiation, the imaging guidance that is used). The RRLs for these examinations are designated as "Varies".

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RELATIVE RADIATION LEVEL INFORMATION

Potential adverse health effects associated with radiation exposure are important to consider when selecting the appropriate imaging procedure. Because there is a wide range of radiation exposures associated with different diagnostic procedures, a relative radiation level (RRL) indication has been included for each imaging examination. The RRLs are based on effective dose, which is a radiation dose quantity that is used to estimate population total radiation risk associated with an imaging procedure. Patients in the pediatric age group are at inherently higher risk from exposure, both because of organ sensitivity and longer life expectancy (relevant to the long latency that appears to accompany radiation exposure). For these reasons, the RRL dose estimate ranges for pediatric examinations are lower as compared to those specified for adults (see Table 1). Additional information regarding radiation dose assessment for imaging examinations can be found in the ACR Appropriateness Criteria® Radiation Dose Assessment Introduction document [21].

For additional information on ACR Appropriateness Criteria, refer to www.acr.org/ac.

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