

## American College of Radiology ACR Appropriateness Criteria®

**Clinical Condition:** Intensive Care Unit Patients

**Variant 1:** Admission or transfer to ICU.

Radiologic Procedure	Rating	Comments	RRL*
X-ray chest portable	7		☼
<b>Rating Scale:</b> 1,2,3 Usually not appropriate; 4,5,6 May be appropriate; 7,8,9 Usually appropriate			*Relative Radiation Level

**Variant 2:** Stable patient. No change in clinical status.

Radiologic Procedure	Rating	Comments	RRL*
X-ray chest portable	3		☼
<b>Rating Scale:</b> 1,2,3 Usually not appropriate; 4,5,6 May be appropriate; 7,8,9 Usually appropriate			*Relative Radiation Level

**Variant 3:** Patient with clinical worsening.

Radiologic Procedure	Rating	Comments	RRL*
X-ray chest portable	9		☼
<b>Rating Scale:</b> 1,2,3 Usually not appropriate; 4,5,6 May be appropriate; 7,8,9 Usually appropriate			*Relative Radiation Level

**Variant 4:** Post-insertion of tube or catheter.

Radiologic Procedure	Rating	Comments	RRL*
X-ray chest portable	9		☼
<b>Rating Scale:</b> 1,2,3 Usually not appropriate; 4,5,6 May be appropriate; 7,8,9 Usually appropriate			*Relative Radiation Level

**Variant 5:** Post-chest tube removal.

Radiologic Procedure	Rating	Comments	RRL*
X-ray chest portable	5	Data are largely based on studies of patients following cardiothoracic surgery. This may not be generalizable to all indications for chest tube removal.	☼
<b>Rating Scale:</b> 1,2,3 Usually not appropriate; 4,5,6 May be appropriate; 7,8,9 Usually appropriate			*Relative Radiation Level

## INTENSIVE CARE UNIT PATIENTS

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### **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 following insertion of endotracheal, nasogastric (orogastric), and chest tubes, placement of pulmonary artery and central venous catheters (CVC), and chest tube removal is addressed.

#### **Discussion of Imaging Modalities by Variant**

*Variants 1, 2, and 3: Routine versus clinically indicated chest radiographs*

There has been long-standing controversy regarding the role of routine portable chest radiographs in critically ill patients in the ICU, particularly in the mechanically ventilated patient. Traditionally, routine daily chest radiographs have been performed for these patients, largely based on 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 Zaza [1] performed a meta-analysis of 8 trials comprising 7,078 ICU patients, half of whom received daily chest radiographs and the other half of whom received chest radiographs for 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.

Hejblum et al [2] performed a large multicenter prospective trial with a cluster-randomized, crossover design, to assess 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 4,607 routine chest radiographs, and 425 patients had 3,148 indication-driven chest radiographs, which represents a statistically significant 32% reduction in use of chest radiographs without sacrificing quality of care or safety. Lakhali et al [3] have likewise found decreased resource utilization in ICUs employing an indication-driven chest radiograph ordering pattern.

Leong et al [4] 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.

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Several studies evaluated the clinical utility of routine daily versus nonroutine clinically indicated chest radiographs. Graat et al [5] prospectively evaluated the clinical value of 2,457 routine chest radiographs in a combined surgical/medical intensive care unit (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 [6] prospectively divided them into those who received daily routine chest radiographs and those who only received clinically indicated chest radiographs. They 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 also received significantly fewer radiographs than those in 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. A prospective randomized study by Clec'h et al [7] showed similar findings of increased diagnostic yield of indication-driven versus routine chest radiographs. Walker et al [8] also reported a relatively high rate of actionable findings when the clinical indication of a radiograph is acute hypoxia, with 24.3% of radiographs showing major changes and 20.3% of radiographs showing minor changes.

Another prospective observational study [9] 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 [10] 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 [11] 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 [12,13] 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. 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 extrathoracic disease only, 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**

There are 9 studies described in the literature since 1980 [11,13-20] that evaluate the significance of the chest radiograph in assessing endotracheal tube placement following insertion. In 5 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 [14,21]. 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 [22] 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.

### **Central Venous Catheters**

Eight studies were reviewed regarding CVC [11,14-18,20,22]. The majority came to the same conclusion: chest radiographs following catheter insertion are useful, with approximately 10% of the chest radiographs demonstrated malpositioned catheters. Pneumothoraces were present in only a small percentage of patients. Gray

et al [14] 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 CVC is recommended to demonstrate proper placement and detect any complications. Beyond the initial insertion, follow-up chest radiographs have a low yield for revealing complications. Follow-up chest radiographs are suggested only when complications are suspected clinically.

### **Swan-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 [14,15,17,23]. The pneumothorax rate was approximately 2% [15,23].

#### *Recommendation*

Chest radiographs are suggested after catheter insertion. Once 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 [11,15,17]. 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 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. 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 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 [11,16,20]. 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.

#### *Variant 5: Post-chest tube removal*

Sepeheripour et al [24] performed a meta-analysis of studies evaluating the utility of standard chest radiographs following chest tube removal. A total of 6 prospective observational and retrospective cohort studies evaluating routine and indication-directed chest radiographs following chest tube removal were reviewed [7,25-29]. These studies found a low rate of complications, most notably pneumothorax, following chest tube removal, the majority of which were predicted clinically [26,28] and with a low rate of tube re-insertion of between 0.25% and 4% [25,29].

#### *Recommendation*

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

### **Summary of Recommendations**

- Placement of endotracheal or nasogastric (orogastric) tubes, Swan-Ganz catheters, CVC, 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 1981–2012.

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

## Relative Radiation Level Information

Potential adverse health effects associated with radiation exposure are an important factor 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 below). Additional information regarding radiation dose assessment for imaging examinations can be found in the *ACR Appropriateness Criteria® Radiation Dose Assessment Introduction* document.

Relative Radiation Level Designations		
Relative Radiation Level*	Adult Effective Dose Estimate Range	Pediatric Effective Dose Estimate Range
○	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

\*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”.

## Supporting Documents

For additional information on the Appropriateness Criteria methodology and other supporting documents go to [www.acr.org/ac](http://www.acr.org/ac).

## References

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The ACR Committee on Appropriateness Criteria and its expert panels have developed criteria for determining appropriate imaging examinations for diagnosis and treatment of specified medical condition(s). These criteria are intended to guide radiologists, radiation oncologists and referring physicians in making decisions regarding radiologic imaging and treatment. Generally, the complexity and severity of a patient's clinical condition should dictate the selection of appropriate imaging procedures or treatments. Only those examinations generally used for evaluation of the patient's condition are ranked. Other imaging studies necessary to evaluate other co-existent diseases or other medical consequences of this condition are not considered in this document. The availability of equipment or personnel may influence the selection of appropriate imaging procedures or treatments. Imaging techniques classified as investigational by the FDA have not been considered in developing these criteria; however, study of new equipment and applications should be encouraged. The ultimate decision regarding the appropriateness of any specific radiologic examination or treatment must be made by the referring physician and radiologist in light of all the circumstances presented in an individual examination.