

Research article

Utility of routine chest radiographs in a medical–surgical intensive care unit: a quality assurance survey

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Abstract

Objective To determine the utility of routine chest radiographs (CXR) in clinical decision-making in the intensive care unit (ICU).

Design A prospective evaluation of CXRs performed in the ICU for a period of 6 months. A questionnaire was completed for each CXR performed, addressing the indication for the radiograph, whether it changed the patient's management, and how it did so.

Setting A 14-bed medical–surgical ICU in a university-affiliated, tertiary care hospital.

Patients A total of 645 CXRs were analyzed in 97 medical patients and 205 CXRs were analyzed in 101 surgical patients.

Results Of the 645 CXRs performed in the medical patients, 127 (19.7%) led to one or more management changes. In the 66 surgical patients with an ICU stay < 48 hours, 15.4% of routine CXRs changed management. In 35 surgical patients with an ICU stay ≥ 48 hours, 26% of the 100 routine films changed management. In both the medical and surgical patients, the majority of changes were related to an adjustment of a medical device.

Conclusions Routine CXRs have some value in guiding management decisions in the ICU. Daily CXRs may not, however, be necessary for all patients.

Keywords chest radiograph, intensive care unit, quality assurance, routine radiography

Introduction

It is not clear whether the performance of routine CXRs alters management in patients admitted to the ICU. Studies evaluating the use of routine CXRs have mainly been in the form of prospective observational studies, with contradictory results. Fong *et al* found that 48% of CXRs performed in a surgical ICU were routine studies, and only 17% had an impact on clinical management [1]. In a pediatric ICU, Price *et al* found that 37% of CXRs could be avoided by establishing specific indications, thereby resulting in significant cost savings [2]. In a prospective study, Hall *et al* compared bedside clinical diagno-

sis with the diagnosis made from the routine CXR [3]. Of 538 routine CXRs, 8% presented new 'major' findings; however, 58% of these were anticipated by the clinical examination, and only 3.4% of all routine CXRs presented findings not clinically anticipated. Conversely, several studies have concluded that routine CXRs are beneficial to patient care. Brainsky *et al* observed that 20% of routine CXRs performed in a medical ICU had 'major important' findings, and 8% prompted a change in management [4]. The majority of changes related to diuretic use, antibiotic coverage, initiation of a diagnostic test, or decisions regarding ventilator weaning. Similarly, Bekemeyer

et al found that 27% of both routine and non-routine CXRs revealed clinically unsuspected abnormalities, but that non-routine films were more likely to change investigative or therapeutic management [5].

Although there may be benefits related to the performance of routine CXRs, there are also significant associated economic and clinical costs. Adverse consequences associated with patient repositioning for the performance of CXRs can include patient discomfort, hypotension, oxyhemoglobin desaturation, and displaced endotracheal tubes (ETTs), nasogastric tubes (NGTs), or vascular catheters.

The financial costs, potential adverse clinical consequences, and the uncertainty surrounding the value of routine CXRs in previously published studies prompted us to prospectively evaluate their utility in our medical-surgical ICU as part of a quality assurance survey. The goals of this study were to determine the percentage of routine and non-routine radiographs that change management in our medical-surgical ICU, and to determine the specific resultant management changes.

Materials and methods

All medical and surgical patients admitted to the ICU at Mount Sinai Hospital, a university-affiliated hospital, over a 6-month period were enrolled and prospectively evaluated. Because this was an observational study, no attempt was made to alter the performance of routine CXRs. Informed consent was not obtained from patients because this study was part of an ICU quality assurance program.

For each CXR performed (routine and non-routine), the clinical fellow completed a data sheet documenting the patient's ICU admission diagnosis, the indication for the CXR, and any resulting changes in management.

The ICU team, consisting of the attending physician, a clinical fellow, and a group of housestaff, interpreted the daily CXRs.

CXRs were defined as routine if they were performed first thing in the morning or at ICU admission. In our ICU, the on-call resident decides which patients should have routine CXRs. CXRs performed for a specific indication (e.g. desaturation, fever) were defined as non-routine.

Changes in patient management were categorized as ETT placement or change in position, central line placement or change in position, thoracostomy tube placement or change in position, ventilator setting change, antibiotics started, congestive heart failure (CHF) treated, lung or pleural biopsy, thoracentesis, or other.

Analysis

Given that medical and surgical patients often have different complications and varying lengths of stay, the data for each were analyzed separately. Surgical patients were divided into

two groups retrospectively by ICU length of stay ≥ 48 hours or < 48 hours. Medical patients were defined as non-surgical patients admitted from a medical ward, the emergency department, or another hospital.

The hospital's computerized radiographic database (eFilm workstation 1.5.2, © 2000; eFilm Medical Inc. Toronto, Ont., Canada) was reviewed to determine whether there were additional radiographs not documented on a daily datasheet. Indications for these non-routine CXRs were not determined retrospectively. All data were entered into a computerized database (Excel 97; Microsoft Corp., Redmond, Washington, USA).

Results

Over a 6-month period, 850 CXRs were performed in 198 patients: 645 CXRs in 97 medical patients and 205 CXRs in 101 surgical patients. Major admitting diagnoses for the medical and surgical patients are presented in Tables 1 and 2, respectively.

Table 3 presents the various indications for the CXRs in the medical and surgical patients. The two most common indications for non-routine CXRs were following a procedure to verify the position of a medical device and exclude complications, and for evaluation of a suspected new medical condition. Table 4 presents the management changes resulting from the CXRs in each of the patient groups.

Medical patients

Of 645 CXRs performed in medical patients, 463 (71.8%) were routine radiographs. Of 182 non-routine CXRs, 60 data sheets were completed (37 following a procedure, 21 for a suspected change in condition, and two for other reasons). In addition, almost one-half of the patients (45/97) had at least one CXR performed per day in addition to the morning CXR.

Of the 645 CXRs, 127 (19.7%) led to a change in management, with some CXRs prompting more than one change. Of 463 routine films, 103 (22.2%) resulted in 107 changes in management. The majority of these changes (58.0%) related to the adjustment of a medical device, most commonly the ETT, the central line, the chest tube, or the NGT. The balance of these changes (42.0%) led to a change in clinical management, specifically the treatment of CHF, the addition of antibiotics, the performance of bronchoscopy, or a change in ventilator settings.

Of the 60 non-routine films with completed data sheets, 24 (40%) resulted in 27 changes in management (15 adjustments of a medical device, and 12 changes in clinical management).

Surgical patients with an ICU stay < 48 hours

There were 66 patients in this group, with a total of 78 CXRs recorded. Seventy-one (91.0%) of these CXRs were routine.

Table 1

| Major admitting diagnoses in medical patients (n = 97) | |
|--|----|
| Diagnosis | n |
| Respiratory | 45 |
| Pneumonia | 13 |
| Acute respiratory distress syndrome | 9 |
| Acute COPD exacerbation | 8 |
| Alveolar hemorrhage | 7 |
| Other* | 8 |
| Sepsis | 12 |
| Cardiovascular | 15 |
| Congestive heart failure | 6 |
| Myocardial infarction | 5 |
| Cardiac arrest | 2 |
| Other | 2 |
| Gastrointestinal | 10 |
| Gastrointestinal bleeding | 6 |
| Liver failure/cirrhosis | 3 |
| Other | 1 |
| Drug overdose | 7 |
| Other† | 8 |

COPD, chronic obstructive pulmonary disease. * Pneumonitis, central alveolar hypoventilation, pulmonary embolus. † Febrile neutropenia, myasthenic crisis, idiopathic thrombocytopenic purpura.

Of the 78 CXRs, 12 (15.4%) changed management, all of which were routine; one CXR prompted two changes.

Surgical patients with an ICU stay ≥ 48 hours

There were 127 CXRs recorded in 35 patients in this group, and 100 (78.7%) were routine films. Nine of 35 (25.7%) patients had an average of 1.6 additional films over a period

Table 2

| Diagnosis | Intensive care unit stay | |
|---|--------------------------|--------------------------|
| | < 48 hours (n = 66) | ≥ 48 hours (n = 35) |
| Post-operative monitoring | 56 | 19 |
| Gastrointestinal | 36 | 13 |
| Ear, nose and throat | 9 | 1 |
| Orthopedic | 3 | 1 |
| Thoracic | 1 | 1 |
| Vascular | 1 | 1 |
| Other | 6 | 2 |
| Respiratory failure | 2 | 3 |
| Sepsis | 2 | 3 |
| Post-partum complications | 2 | 0 |
| Cardiovascular (congestive heart failure, cardiac arrest) | 1 | 2 |
| Gastrointestinal complications* | 1 | 5 |
| Other | 2 | 3 |

* Gastrointestinal complications include common bile duct repair, small bowel obstruction, perforated viscus and peritonitis.

of 16 days. Thirty (23.6%) of the 127 CXRs changed management. There were 29 management changes in 26 routine CXRs (12 changes in position of a medical device, and 17 changes in clinical management). There were also four non-routine CXRs, which resulted in five changes in clinical management and one change in position of a medical device.

Discussion

In this quality assurance survey, we observed in our medical patients that 22% of all routine CXRs, and 40% of non-routine CXRs, led to a change in management. Similarly, in

Table 3

Indication for chest radiograph (CXR)

| | Medical patients (n = 97) | Surgical patients | |
|--------------------------------|---------------------------|---------------------|--------------------------|
| | | < 48 hours (n = 66) | ≥ 48 hours (n = 35) |
| Total number of CXRs performed | 645 | 78 | 127 |
| Routine CXRs (n) (% total) | 463 (72%) | 71 (91%) | 100 (79%) |
| Non-routine CXRs (n) (% total) | 182 (28%) | 7 (9%) | 27 (21%) |
| Data sheet completed (n) | 60 | 1 | 10 |
| Post-procedure | 37 (62%) | 0 | 4 (40%) |
| Clinical change | 21 (35%) | 1 (100%) | 6 (60%) |
| Other | 2 (3%) | 0 | 0 |

Table 4

Management changes resulting from chest radiographs (CXR)

| | Medical patients | | Surgical patients | | |
|---|----------------------|-------------------------|-----------------------|---------------------|------------------------|
| | Routine (n = 103) | Non-routine (n = 24) | < 48 hours | ≥ 48 hours | |
| | | | | Routine (n = 26) | Non-routine (n = 4) |
| CXR that changed management (n) (% total) | 127 (20%) | | 12 (15%) [†] | 30 (24%) | |
| Total number of management changes* | 107 | 27 | 13 | 29 | 6 |
| Adjustment/insertion of medical device | 62 (58%) | 15 (56%) | 5 (38%) | 12 (41%) | 1 (17%) |
| Ventilator setting changes | 1 (1%) | 0 | 0 | 0 | 0 |
| Antibiotic treatment | 3 (3%) | 4 (15%) | 0 | 0 | 0 |
| Treatment of congestive heart failure | 8 (8%) | 1 (4%) | 4 (31%) | 8 (28%) | 1 (17%) |
| Thoracentesis | 7 (6%) | 1 (4%) | 0 | 3 (10%) | 1 (17%) |
| Bronchoscopy | 11 (10%) | 3 (11%) | 0 | 0 | 1 (17%) |
| Other | 15 (14%) | 3 (11%) | 4 (31%) | 6 (21%) | 2 (33%) |

Percentages may not add up to 100% because of rounding. * Some CXRs resulted in more than one management change. † Only routine CXRs changed management.

surgical patients with ICU stays longer than 48 hours, 26% of routine and 40% of non-routine films changed management. In surgical patients with ICU stays shorter than 48 hours, a smaller percentage of routine CXRs (17%) resulted in a change in management. In both the medical and surgical patients, the two most common changes resulting from the CXR were adjustment of a medical device, and the diagnosis and treatment of CHF. Furthermore, 46% of the medical patients and 26% of the surgical patients with an ICU stay ≥48 hours had one or more CXRs performed, in addition to the routine CXR, on a given day.

Our study probably overestimates the utility of routine CXRs owing to the introduction of selection bias, since the house-staff decide which patients have morning CXRs. In contrast, the percentage of non-routine CXRs that alter therapy may have been underestimated, as 63–68% of these radiographs had no data sheets completed.

Our results are very similar to those of Fong *et al*, who observed that only 17% of routine CXRs prompted a change in clinical management in a surgical ICU [1]. Other studies have yielded varied results, most probably due to the heterogeneous patient population in the ICU setting, as well as large differences in study design and terminology [3,4,6,7]. For instance, Silverstein *et al* found that 27% of routine CXRs performed in a surgical ICU presented worse or new findings; however, only 1.4% of these required immediate action [6].

Our study evaluated the impact of routine CXRs without having recorded the information yielded by the bedside physical examination. Thus, given that no clinical correlation was made, the impact of CXRs on clinical management was most

likely overestimated. This is supported by Hall *et al*, who reported that the incorporation of information from the clinical examination reduces the utility of routine CXRs, with only 3.4% leading to a change in management. The majority of the changes (78%) were related to repositioning of an ETT or a NGT [3]. Similarly, another prospective study reported that general physical examination had a sensitivity greater than 90% in predicting clinical change, which led to a 52% reduction in the number of CXRs performed [7].

Numerous studies have concluded that only selected patients should have routine CXRs performed [1,2,6–10]. Several investigators have evaluated the need for CXRs to check placement of a medical device. Palesty *et al* concluded that CXRs are not necessary following the placement of a central line over a guide wire, as they observed no complications in 380 such changes [10]. Gray *et al* found that clinicians were fairly accurate in determining the placement of subclavian or internal jugular (IJ) vein pulmonary artery (PA) catheter introducer sheaths, but the clinicians were not accurate for clinical determination of ETT or PA catheter position [9]. In contrast, Gladwin *et al* found that the sensitivity of a clinical decision protocol for detecting complications and malpositions of IJ catheter insertion was only 44%. They concluded that routine CXRs are necessary following IJ catheter insertion [11]. The major difference in these opposing studies is that Gray *et al* evaluated mostly IJ cannulations with a PA catheter introducer sheath, whereas Gladwin *et al* inserted longer central venous catheters, which have a higher likelihood of being placed in the right atrium.

Daily CXRs are often performed in ICUs to assess the placement of medical devices. However, there are currently several

ways to clinically judge the position of these devices. Once it has been established that the devices are in the correct position, clinical evaluation including ETT position at the lips could potentially eliminate a large number of CXRs, resulting in significant cost savings.

Conclusion

The authors conclude that although routine CXRs prove to have some value in the management of critically ill patients, they may not be warranted for all patients, specifically surgical patients admitted for post-operative monitoring. Moreover, the use of clinical decision protocols may reduce the number of CXRs performed following placement of a medical device.

Competing interests

None declared.

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