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Daily Chest X-Rays in the Intensive Care Unit: Are They Worth the Cost?

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Abstract

Background: Although automated daily chest x-rays have minimal utility in patient care, practitioners have been slow to adopt the change towards restrictive, clinically indicated, chest x- ray ordering.

Methods: We measured the utility of daily chest x-rays versus those ordered for clinical indication. We collected data on daily chest x-rays ordered for 17 intubated patients and analyzed documentation and subsequent intervention. We then educated the critical care team and re-collected data on 26 intubated patients using a restrictive approach. Collected data included intubated days, hospital/ICU length of stay, chest x-ray read, and subsequent management. Total charge was also collected.

Results: Our study indicated the positive impact of restrictive chest x-rays. Prior to educational intervention, 83 chest x-rays ($29,631) were ordered. With restrictive ordering, that number lessened to 52 ($18,564). Under automated ordering, new chest x-ray findings occurred in 13.25% of images, leading to a change in management 10.84% of the time. With restrictive ordering, new findings were noted in 29.41% of chest x-rays, which altered management in 21.15% of cases.

Conclusion: Our study confirms that restrictive chest x-ray ordering leads to a higher percentage of new findings and changes in management, while saving valuable resources, without affecting intubated days, length of stay, and mortality.

Keywords: Chest X-Ray; Quality Improvement; Cost; Mechanical Ventilation; Critical Care

Introduction

Chest x-rays are commonly ordered on a daily basis for mechanically ventilated patients in the intensive care unit. These are often ordered under the assumption of finding a mispositioned endotracheal tube or central venous catheter, or to uncover a developing condition, such as pneumonia or effusion [1]. Although often ordered, costly automated daily chest x-rays have provided little utility in patient care. To this point, we set out to demonstrate the low yield of automated daily chest x-rays in the intensive care unit. In our study, our goal was to reduce the utilization of unnecessary daily chest x-rays ordered on intubated patients in the ICU, which has been previously possible without affecting days of mechanical ventilation, length of ICU stay, and mortality [2]. For years, the practice of our intensive care units had been to order chest x-rays for all intubated patients each morning. We hypothesized that through education and enforcing proper electronic medical record (EMR) ordering that we would be able to decrease the number of automated chest x-rays ordered and limit the costs associated with each chest x- ray, without negatively impacting patient care. To test this hypothesis, we assessed the current practice in our intensive care units, implemented education with optimization of our electronic medical record system ordering, and recollected post intervention data while ordering chest x- rays only as clinically indicated.

Methods

The hospital is a large community teaching hospital with a total of 504 beds. The hospital holds one cardiac care unit, comprised of ten beds, and two in-

tensive care units, each with an additional ten beds. Data was collected for patients across all three critical care units. The study was submitted to the Institutional Review Board and was exempt from review, as it was deemed to be a quality improvement project. Pre-intervention data was collected over a three-week span, in which we measured automated daily chest x-rays ordered on intubated patients, along with patient diagnosis, intubated days, new chest x-ray finding, alteration of management, hospital/ICU length of stay, and mortality. Alteration of management included change in fluid status (diuresis), initiation/alteration of antibiotic therapy, and endotracheal tube repositioning. Given the necessity of certain chest radiographs in the intensive care unit, we excluded those chest x-rays ordered for intubation, line placement, chest tube placement, and thoracentesis. We also determined total charge per patient per chest radiograph to be $357.00.

Data was collected over a three-week span in June 2018 prior to implementing a period of education regarding chest x-ray and EMR ordering. During July 2018, an educational PowerPoint was presented to and distributed to all intensivists, house staff, and critical care nursing, which emphasized the low utility of automated daily chest x-rays for intubated patients in the ICU. This was also re-emphasized prior to the post-intervention data collection period over a three-week span in August 2018. During this three-week period, it was enforced that ordering clinicians must designate a reason for each chest x-ray in the EMR order. Clinicians were not to order a morning chest x-ray unless clinically indicated. Examples included new finding on physical exam or change in clinical status, such as fever or hypoxia.
During the initial three-week period, we measured the number of daily chest x-rays ordered on 17 intubated patients and analyzed intensivist documentation and subsequent intervention. After this period, we educated the critical care team (nurses, residents, and intensivists), and re- collected data over a three-week period using a restrictive approach on 26 intubated patients.

Collected data included intubated days, hospital and ICU length of stay, and, most importantly, chest x-ray read and subsequent management. We also collected total charge for chest x-rays pre- and post-educational intervention, along with endotracheal tube misplacement. Data was then analyzed with paired t-tests and Fisher's exact tests using Minitab statistical software.

Results

During our investigation, 17 intubated patients were followed over the course of three weeks prior to our educational intervention. Of these patients, the average daily number of automated daily chest x-rays was 4.88, with an average charge of $1,743.00. After educating staff of the low utility of automated daily chest x-rays and re-enforcing the need to document a reason for chest x-ray order, as well as ordering only for clinical relevance, data was re-collected on 26 intubated patients (Figure 1). The average number of morning chest x-rays for these patients over a three-week period fell to 2.0 ($p = 0.03$), a total charge of $714.00 ($p = 0.03$). 83 ($29,631.00) automated chest x-rays were ordered prior to invention, and 52 ($18,564.00) post- intervention, which yielded 31 less chest x-rays with $11,067.00 less charged (Figure 2).

Figure 1: Patient Population by Diagnosis

Pre-Intervention Diagnosis	**Number of Patients**
Pneumonia	7
Septic Shock	4
Hypovolemic Shock	3
Seizure	1
Cardiac Arrest	1
Difficult Extubation Post-Operatively	1
Post-Intervention Diagnosis	**Number of Patients**
Pneumonia	7
ARDS	4
Septic Shock	4
Hypovolemic Shock	3
Seizure	3
Congestive Heart Failure	2
Cardiac Arrest	1
Ischemic Bowel	1
Hypercapnic Respiratory Failure	1

Figure 1: Patient Population by Diagnosis. Diagnoses associated with patient population in the pre intervention vs post intervention phases.

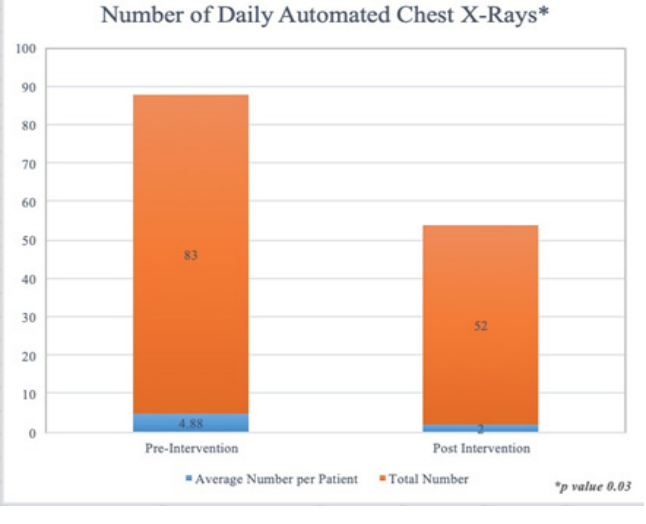

Figure 2: Number of Chest X-Rays and Associated Cost. Total number of daily automated chest x-rays.

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Prior to intervention, new chest x-ray imaging findings were noted on 13.3% of films, influencing management in 10.8% of cases. After educational intervention, new findings were noted in 29.4% of images, changing management in 21.2% of cases, although new findings and management changes were not statistically significant (p = 0.801, p = 0.658, respectively) (Figure 3). In terms of undesired outcomes, endotracheal tube re positioning occurred as a result of three chest x-rays, two in the pre-intervention group, and one in the post-intervention group.

Of 17 intubated patients prior to intervention, there was a total of 105 intubated days, compared to 163 in 26 patients post intervention. There was no significant difference in days intubated (mean = 5.5 pre-intervention, mean = 3 post-intervention, p = 0.874). Average hospital and ICU length of stay also did not statistically differ between pre-intervention patients (Hospital LOS mean = 14 days, ICU LOS mean = 6 days) and post-intervention patients (Hospital LOS mean = 17 days, ICU LOS mean = 4 days), with p-values of 0.388 and 0.524, respectively. Using Fisher's Exact Test, there was no statistically significant difference between pre- intervention in hospital mortality and post-intervention in hospital mortality (3/17 vs 10/26, p = 0.117) (Figure 4).

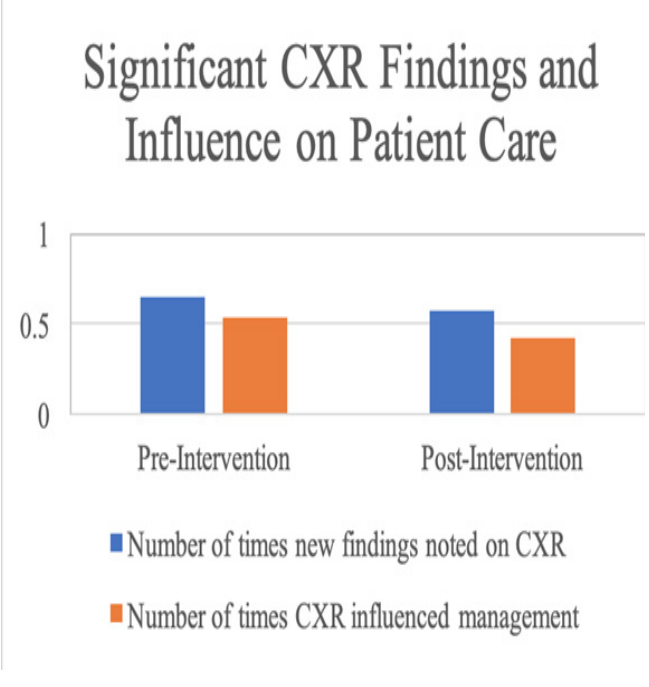

Figure 3: Significant Chest X-Ray Findings and Influence on Patient Care. Significant chest x-ray findings and influence on patient care including number of times new findings noted on chest x-ray and number of times chest x-ray influenced management.

Figure 4: Pre- and Post-Intervention Chest Radiograph Data

	Pre-Intervention n=17	Post-Intervention n=26	p-value
Number of AM CXRs			
median (min-max)	3 (1-15)	1.5 (0-7)	0.0409
mean (SD)	4.88 (4.83)	2 (1.876)	0.03
Total Charge			
median (min-max)	1071 (357-5355)	536 (0-2499)	0.0409
mean (SD)	1743 (1725)	714 (670)	0.03
Number of times new findings noted			
median (min-max)	0.647 (0.931)	0.577 (0.809)	0.8759
mean (SD)	0 (0-3)	0 (0-2)	0.801
Number of times CXR influenced management			
median (min-max)	0.529 (0.8)	0.423 (0.703)	0.7074
mean (SD)	0 (0-2)	0 (0-2)	0.658
Intubated Days			
median (min-max)	6.56 (5.12)	6.27 (6.72)	0.6383
mean (SD)	5.5 (1-16)	3 (0-28)	0.874
Hospital Length of Stay			
median (min-max)	14.41 (7.12)	17.35 (14.72)	0.7844
mean (SD)	14 (5-30)	17 (1-63)	0.388
ICU Length of Stay			
median (min-max)	9 (6.77)	7.65 (6.57)	0.4234
mean (SD)	6 (1-19)	4 (1-25)	0.524
In hospital mortality, n (%)	3/17 (17.65%)	10/26 (38.46%)	0.117

Figure 4: Pre- and Post-Intervention Chest Radiograph Data. Pre and post intervention data, showing statistical significance only in number of AM chest x-rays and total charge. No statistical significance in new findings noted, management changes, intubated number of days, hospital length of stay, ICU length of stay, or in hospital mortality.

Discussion

Daily automated chest x-rays for ventilated patients in the intensive care unit has been a common practice and was previously supported in various literature. Greenbaum and colleagues determined that 43% of 126 films showed worsening of a known, or development of a new, cardiopulmonary abnormality, or showed mispositioning of an invasive device [3]. Bekemyer and associates found new or increased abnormalities (including tube or catheter malposition) in 34.5% of 1,354 chest x-rays, prompting change after 28.5% of radiographs [4]. In one particular investigation, Horst and colleagues found that 30% of findings discovered on automated daily chest x-rays were potentially life threatening [5]. Although previously deemed to be a worthwhile practice, this routine is no longer supported by the American College of Radiology. It is now recommended to order a portable chest radiograph for clinical indication, as well as after placement of an endotracheal tube, central venous line, Swan-Ganz catheter, nasogastric tube, feeding tube, or chest tube [6].

Later literature supported the use of clinically indicated chest x-ray ordering. Silverstein and col-

leagues demonstrated an extremely low yield of clinically significant, unexpected findings on routine chest x-rays and proposed abandoning this routine [7]. Additionally, Bhagwanjee demonstrated that clinical exams were efficient in predicting significant radiographical changes and postulated that a 52% reduction in chest x-rays would have resulted if the need was determined by clinical examination [8]. In a study carried out by Graat and colleagues, only 5.8% of routine chest x-rays demonstrated unexpected findings in a combined medical and surgical ICU. Just 2.2% of the automated daily chest x-rays ordered led to any change in management [9].

Although recommendations have changed for chest x-ray ordering on intubated, mechanically ventilated patients in the intensive care unit, practitioners have been slow to adopt the change. We set out to prove our hypothesis that clinically indicated chest x-ray ordering would not significantly impact patient safety, while saving valuable resources. Through education and clinically indicated chest x-ray ordering, 31 less chest x-rays were done during the post intervention period, with a charge savings of $11,067.00 USD, a significant difference.

There was no significant difference in new chest x-ray findings and no significant change in management. Most importantly, our study did not show any significant difference in intubated days, ICU length of stay, hospital length of stay, and mortality. In just three of the 135 chest x- rays ordered in this study (2.2%) was there mispositioning of an invasive device (endotracheal tubes requiring adjustment).

By instituting effective education among intensivists, house staff, and critical care nursing, we were able to propagate a 37% decrease in the number of chest x-rays ordered, with a push towards clinically indicated ordering. Persistent reminders of the low utility of automated chest x-ray ordering as previously described in the literature and encouraging documentation of a clinical reason behind each order led to a local culture change at our institution. This system of education and EMR system requirements for orders may have potential to propagate for future quality improvement projects.

It is important to acknowledge the major limitations in our study. For one, the sample size and subsequent power of our project remains small, with just 17 pre-intervention patients followed over three weeks, and 26 post intervention patients followed over an additional three weeks. Additionally, the study took place from June – August, a short time period during summer months, when patient acuity is generally healthier than winter months. Furthermore, with frequent rotation of house staff and attending physicians, it is difficult to measure bias in automated chest x-ray ordering preference. However, although we recognize these limitations, the study remains supportive of the need to continue clinically indicated, restrictive chest x-ray ordering for mechanically ventilated patients in the intensive care unit.

Conclusion

Through this small study, we were able to reiterate the low diagnostic yield and low utility of automated daily chest radiographs ordered for intubated, mechanically ventilated patients in the intensive care unit. This was possible without affecting intubated days, ICU length of stay, hospital length of stay, and mortality. We conclude that the routine use of clinically indicated chest x-ray ordering is of greater benefit than automated chest x-ray orders and saves valuable hospital resources. To be effective, clinicians must be reminded of the low utility of automated ordering on a regular basis, in an effort to become common practice in the intensive care unit.

Summary Statement

The routine use of clinically indicated chest x-ray ordering is of greater benefit than automated chest x-ray orders.

Take Home Points

- Automated daily chest x-rays in mechanically ventilated patients are common practice, although no longer recommended by the American College of Radiology. Chest x-rays in critically ill patients should be obtained based on clinical status with a restrictive approach.
- The utility of automated chest x-rays was measured through intensivist documentation, chest x-ray interpretation, and subsequent management decisions. ICU/Hospital length of stay, intubated days, mortality, and total charge were also measured.
- Data was analyzed and compared pre- and post- educational intervention. Results showed the positive impact of restrictive chest x-ray ordering, without significantly impacting intubated days, length of stay, and mortality.
- Although a higher burden on cost, automated chest x-rays had less significant findings and led to less changes in management.
- Restrictive ordering of chest x-rays led to a significant conservation of valuable resources without affecting patient care.

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