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Utilization Effect of Integrating a Chest Radiography Room into a Thoracic Surgery Ward

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Abstract

PURPOSE—Bedside chest radiography (bCXR) represents a substantial fraction of the volume of medical imaging for inpatient healthcare facilities. However, its image quality is limited compared to posterior-anterior/lateral (PA/LAT) acquisitions taken radiographic rooms. We evaluated utilization of bCXR and other chest imaging modalities before and after placing a radiography room within our thoracic surgical inpatient ward.

METHODS—Institutional review board approval was obtained for this HIPAA-compliant. We retrospectively identified all patient admissions (3,852) to the thoracic surgical units between April 1, 2007 and December 31, 2010. All chest imaging tests performed for these patients including computed tomography (CT) scans, magnetic resonance imaging (MRI), ultrasound (US), bedside and PA/LAT radiographs were counted. Our primary outcome measure was chest imaging utilization, defined as the number of chest examinations per admission, pre- and post-establishment of the digital radiography room on January, 10th 2010. Statistical analysis was performed using an independent-samples t-test to evaluate changes in chest imaging utilization.

RESULTS—We observed a 2.61 fold increase in the number of PA/LAT CXR per admission ($p < 0.01$) and a 1.96 fold decrease in the number of bCXR per admission ($p < 0.01$) post radiography room implementation. The number of chest CT, MRI and US per admission did not change significantly.

CONCLUSION—Establishing a radiography room physically within thoracic surgery units or in close proximity can significantly shift CXR utilization from bedside to PA/LAT acquisitions, which may enable opportunities for improvement in efficiency, quality, and safety in patient care.

Keywords

Chest imaging; workflow improvement; imaging utilization; radiography room; radiology resource optimization

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INTRODUCTION

Large upsurges in radiology utilization over the past decade [1,2] have contributed significantly to concern about potential inappropriate use and associated health care costs [3–7]. Conventional projection radiography remains the most frequently utilized imaging modality during acute hospitalization. It is rapidly available, relatively inexpensive and administers less patient radiation than other modalities while providing information required for diagnosis and treatment during hospitalization.

Conventional chest radiography (CXR) acquired in posterior-anterior (PA) and lateral (LAT) positions and bedside anterior-posterior (AP) acquisitions have been extensively studied and improved over the years. Techniques including modern screen-film technology, beam equalization, and digitization (Computed Radiography and Digital Radiography (DR)) have improved image quality, efficiency and diagnostic accuracy [8–15]. However, transportation of patients to the radiology department has not been similarly improved. As a result, physicians frequently request bedside chest radiography (bCXR) in order to decrease the delay between CXR order and results receipt. Bedside radiography is more labor intensive and therefore more expensive to provide. In addition, bCXRs produce poorer quality images than do standard radiographs. Bedside AP acquisitions have variability in exposure and scattered radiation effects, which can decrease image contrast [16–18]. They also have poorer visualization of the basilar segments of the lungs and magnification of the heart silhouette when compared to PA/LAT acquisitions. In addition, although radiation exposure to healthcare workers from bedside radiography is minimal, it is still two to three times higher than exposure from background radiation [19–20]. Standard PA/LAT acquisition is performed in a shielded room, limiting worker radiation exposure. Despite these limitations, as pressures on length of stay have increased, bCXR have been increasingly used at our institution, even as discharge radiographs.

Several early studies of computed and digital radiography versus analog screen-film in emergency department, intensive care unit and outpatient care environments have been studied with regard to impact, utilization, workflow, productivity, and cost assessment [21–24]. But studies comparing the utilization of portable versus standard digital chest radiography based on location of the radiography room have not been performed. Therefore, the aim of this study was to evaluate chest imaging utilization pre- and post-implementation of a digital radiography room within the thoracic surgery wards.

METHODS

Study Setting

Our facility is a 793-bed university-affiliated, tertiary care hospital in an urban area with 46,000 inpatient admissions, 3.5 million ambulatory visits, and 59,000 emergency department (ED) visits annually. Institutional review board approval was obtained for this retrospective Health Insurance Portability and Accountability Act (HIPAA)-compliant study; informed consent requirements were waived. The institution's thoracic surgery wards, comprising an intensive care unit (ICU), intermediate care unit and the standard non-critical ward, are located on the building's 11th floor.

Intervention

A complete radiography room with a General Electric DR X-Ray device, model Revolution Digital XR/d (GE Healthcare, Waukesha, WI) was implemented on the institution's thoracic surgery ward (11th floor), starting operations in January 10, 2010. Prior to that, patients would have to be transported to the radiography room serving these patients located on the ground floor.

Study Population and Data Source

We identified all patients admitted through thoracic and pulmonary services to the 11th floor wards using our electronic research patient data registry (RPDR). The pre-intervention group underwent imaging examinations between April 1, 2007 and January 09, 2010 and the post-intervention group between January 10, 2010 and December 31, 2010. The patients' entire admission on the 11th floor was captured.

All chest imaging studies performed for these patients were considered in our metrics, including chest computed tomography (CT), magnetic resonance imaging (MRI), ultrasound (US), PA/LAT CXR, and bCXR. These data were collected using the hospital's radiology information system (RIS) (IDX Rad, version 9.2; GE Healthcare, Milwaukee, WI) and the hospital's patient data repository (Research Patient Data Registry [RPDR]). Only imaging examination orders placed during the patient admission on the floor were considered in the study. We did not include imaging test orders placed for the patient if they were transferred to other floors or institutions. The RPDR does not have capability to provide information about transfer dates and location. The RIS, however, enables capture of the total chest imaging examinations ordered for patients on the thoracic wards which include ICU, intermediate and non-critical units.

Outcome Measure

The primary outcome measure was utilization of chest imaging, defined as the number of chest examinations per admission, pre- and post-establishment of the digital radiography room on January, 10th 2010.

Statistical Analysis

Statistical analysis was performed to assess the intensity of utilization for each chest imaging modality pre- and post-intervention by using an independent samples t test. Our study was powered to detect statistical differences with 99% confidence level. All statistical evaluation was performed with a commercial available statistical tool JMP (SAS Institute Inc., Cary, NC).

RESULTS

Study Cohort and Characteristics

During the pre-intervention period, 3,572 patients (1,807 [50.6%] female; age range: 14–96 years old; median age 62 years old) were admitted to the thoracic wards floor. A total of 1,367 patients (673 [49.2%] female; age range: 14–92 years old; median age 61 years old) were admitted during the post-period. No significant difference in gender was identified between the groups ($p=.40$). Due to our large sample size, a slight difference in the median age (1 year difference) between the groups was found to be significantly different ($p=.01$). However, in clinical practice this difference likely does not affect management or imaging intensity for the patients. Moreover, our study was powered to detect statistical differences with 99% confidence level (p values under 0.01 were considered as significant). Therefore, we considered this difference negligible.

Chest Imaging Examinations and Modalities

A total 34,292 chest imaging examinations including chest CT (1032 [3%]), MRI (19 [0.1%]), US (173 [0.5%]), bCXR (20241 [59%]), and PA/LAT CXR (12827 [37.4%]) were performed on patients from the 11th floor during the study period, the majority of which (96.4%) were PA/LAT CXR and bCXR. A total of 24,226 (70.6%) of the imaging

examinations were during the longer pre-intervention period. The distribution of imaging modality per admission pre- and post-intervention is shown in Figure 1.

Comparative Analysis

Figure 2 shows the number of chest imaging examinations per admission for each modality quarterly. The radiography room started services on January, 10 2010. We observed a high demand for PA/LAT CXR per admission in the first quarter of 2010 and a decrease of the bCXR per patient in the same period. The total number of admissions, bedside and PA/LAT CXR per quarter is shown in Fig. 3.

We observed a 1.96 fold decrease from 4.7 to 2.4 examinations per admission in the use of bedside CXR ($p=.004$) and 2.61 fold increase from 1.8 to 4.7 examinations per admission ($p=.001$) in CXR PA/LAT utilization after the implementation of the radiography room. However, no significant change in the total number of CXRs including PA/LAT and bedside was observed after the intervention ($p=.53$). Moreover, no statistical difference was observed on the pre- and post-state of CT, MRI and US utilization ($p=.96$; $p=.72$; $p=.62$, respectively).

Figure 4 shows the total count of CXRs ordered from the 11th floor ICU (upper chart). It is shown that the majority of patients underwent bedside CXRs compared to PA/LAT acquisitions due to the criticality of these patients. No significant difference in utilization was observed after the intervention for PA/LAT ($p=.715$) or for bedside CXR ($p=.111$). The middle and bottom charts show the total count of chest imaging ordered from the intermediate and noncritical units, respectively. These charts show a significant shift pre- and post-intervention in the intermediate unit for PA/LAT ($p=.002$) and bedside ($p<.001$), and in the non-critical unit [PA/LAT ($p<.001$); bedside ($p<.001$)].

DISCUSSION

We are not aware of any prior investigations assessing the impact on chest imaging utilization of implementing a radiography room near a patient ward. We observed significant changes in the type of CXR ordered pre- and post-intervention. Specifically we saw a significant increase in the total number of CXR PA/LAT per admission and a concomitant decrease in bedside CXRs per admission after implementation of a radiography room near our thoracic surgery units; while there was no significant change in the total number of CXR including PA/LAT and bedside, or total number of other chest imaging modalities per admission throughout our study period. Moreover, comparing the effects of placing a radiography room on the thoracic floor on ICU, intermediate and non-critical units, we observed that the impact in utilization is significant when considering intermediate and non-critical units. There was no significant difference in CXR utilization for patients located in the ICU.

The significant decrease in number of bedside CXR per admission supports the assumption that prior to the intervention, bedside CXRs were being performed for patients that could potentially have undergone standard PA/LAT CXR for patients located in intermediate and non-critical units. Providing a more conveniently located radiography room facilitated a shift to PA/LAT CXRs for these patients, provided access to a better quality chest imaging examination, and reduced staff exposure to ionizing radiation.

Our study has several limitations. First, data are from only one tertiary care institution, and our results may not be generalizable to other settings. Second, although we observed a significant decrease in the bCXR utilization after the implementation of the radiography room, a progressive decrease can be observed beginning the first quarter of 2009. In 2008

the American College of Radiology published a guideline regarding appropriateness of daily routine bCXR in several different clinical scenarios [25–29]. In general, daily routine bCXR for follow up and monitoring were considered inappropriate based on several studies including randomized clinical trials. This publication could have had some impact in the bCXR utilization observed in our study. Third, this investigation focused only on chest imaging, and intensity of imaging utilization may be different when considering other body part diagnostic imaging tests. However, chest imaging examinations are the most requested diagnostic imaging test and therefore, the impact in its optimization may have repercussions for patient care.

Further, we did not do a cost analysis to see if implementation of a radiography room is cost-effective, examining the balance between the costs of the room, reduction in transport labor costs, any decrease in length of stay, etc. Nor did we measure the impact on the quality of imaging examination interpretation or patient outcome. We did not examine the appropriateness of testing.

In conclusion, the implementation of the radiography room on a patient care floor resulted in significant changes in the pattern of CXRs performed for the study units at our institution, which may enable opportunities for improvement in efficiency, quality and safety in patient care. Future work will focus on benefit analysis of quality, safety and efficiency of care.

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List of Abbreviations

bCXR	Bedside chest radiography
PA/LAT	Posterior-anterior/lateral
CT	Computed tomography
MRI	Magnetic resonance imaging
US	Ultrasound
CXR	Conventional chest radiography
LAT	Lateral
ED	Emergency department
ICU	Intensive care unit
HIPAA	Health Insurance Portability and Accountability Act

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Figure 1.
Pre- and Post-intervention chest imaging per admission for each modality.

Figure 2.
Chest imaging per admission by quarter for each modality.

Figure 3.
Total count of admissions, portable and PA/LAT CXR in the thoracic surgery wards.

Figure 4. (upper chart) shows the total chest imaging count by quarter for bedside CXR and PA/LAT CXR in ICU patients, the middle chart in intermediate unit patients and the bottom chart in non-critical unit.