Original Article

Impact of pre-procedural check list in improving the quality of chest radiography in a teaching hospital

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Abstract

To assess whether using a pre-procedural checklist and implementing it before performing chest radiography will result in an improvement in the quality of chest radiography, thus aiding in better diagnosis, reduction in the radiation exposure, reduction in the repetition of chest radiographs and thus reducing the cost incurred due to wastage of films and manpower. **Aims and Objectives**: To improve the quality of the chest radiographs. To evaluate the effectiveness of usage of pre procedural check list by the radiographers in improving the technical adequacy of the chest radiographs. To help the radiologists and the clinicians in better diagnosis and treatment. **Materials and Methods:** One hundred and seventy eight chest radiographs done during a period of 10 days from 10th-20th of September 2015 were selected before implementing the check list. After giving instructions to the radiographers and getting their consent, the chest radiographs were performed implementing the check list, and a total of 157 chest radiographs were done during the period of September 21st-30th 2015. Improvement in the technical adequacy in terms of optimal penetration, rotation, inspiration and angulations was assessed after the introduction of the check list. **Results:** The percentage of optimal i.e. technically adequate chest radiographs significantly increased (P<0.01) from 23 to 38.9% after the introduction of the pre-procedural check list; The percentage of over penetrated/ rotated radiographs significantly reduced from 14 to 5.7% (P<0.01) showing remarkable improvement. The percentage of rotated, over penetrated and expiratory/rotated films was found to decrease after the introduction of the check list, though it did not show any statistically significant difference. The other parameters like angulation and under penetration did not show any significant difference between the two groups. **Conclusion:** The use of a pre-procedural check list significantly increased the technically adequate optimal chest radiographs.

Keywords: chest radiographs, checklist, pre-procedural, radiographers, technical adequacy.

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INTRODUCTION

Even with the advent of advanced imaging technologies like Computed Tomography (CT) and Magnetic Resonance Imaging (MRI), plain chest radiography still remains the initial investigation of choice in the teaching hospitals, since it is easily accessible and available to the patients. Since the chest radiography is the frequently performed radiological study, less attention is given to the techniques and thus the quality of the chest radiographs. Many a times, chest radiography is the only imaging investigation based on which the patient is treated. Apart from the basic facilities such as good X-ray room, cassettes and the films which determine the quality of a radiograph, optimization of many factors like deep inspiration, proper patient positioning with horizontally placed X-ray tube without any angulations are mandatory for quality chest radiographs. Technically adequate chest radiographs are

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inevitable for correct interpretation by radiologist helping clinical diagnosis and treatment.

MATERIALS AND METHODS

The chest radiographs were performed using a Siemens 500 mA X-ray machine in Sri Muthukumaran Medical College Hospital and Research Institute by two qualified radiographers before and after implementing the pre-procedural check list. One hundred and seventy eight chest radiographs done during a period of 10 days from 10-20th of September 2015(before implementing the pre procedural check list) were evaluated for technical adequacy, rotation, exposure and angulation. After giving the instructions to the radiographers and getting their consent, the chest radiographs were performed by implementing the pre-procedural check list. A total of 157 cases done during the period of September 21st-30th 2015 were selected. Improvement in the technical adequacy in terms of optimal penetration, rotation, inspiration and angulation, after the introduction of the pre-procedural check list was assessed.

Institutional Ethics Committee approval was obtained. Informed consent from the concerned radiographers was obtained. The entire chest radiographs were done following the CAR standards for General (plain) Radiography [1, 2].

Posteroanterior view of the chest radiographs performed with patient standing erect facing the film with central ray directed posteriorly at T7 or inferior angle of the scapula and the Source to Image receptor Distance (SID) of 72 inches(180cm).

The check list and the evaluation criteria are as follows:

1. Confirming proper positioning of the patient and centering of the X-ray beam to prevent rotation: For ensuring this, the patient was made to stand evenly on both feet with the chest stand placed on a level ground. The chest radiograph is said to be properly centered if the medial ends of the clavicles are equidistant from the spinous processes at T4/5 level.

2. Properly instructing the patient on the importance of deep inspiration to prevent expiratory films. The patient is asked to take a deep breath and then hold it to fully aerate the lungs. The exposure is done when the patient is taking a second full inspiration which allowed for deeper inspiration.

The film is said to be inspiratory, if posterior 9-10 ribs are seen or anterior 6th rib is seen at the level of mid dome of the diaphragm.

3. Adequate penetration: 120-150 kVp and 4-6 mAs were used while adjusting the current(mA) according to the patient thickness.(For every 4-5cm increase in the thickness , mA is increased by factor of two).In a normally penetrated film the thoracic spine is just visible through the cardiac shadow. If not seen, it is underexposed and if they are too easily seen they are overexposed.

4. Angulation: X-ray tube was placed horizontally, directing the X-ray beam at T7 or inferior angle of the scapula in which the clavicles are projected at the level of 3rd rib. If the beam is angulated towards the head, the clavicles will be projected in a higher level with abnormal shape of the heart and non visualization of the sharp outline of the left hemidiaphraghm.

The chest X-rays of both the groups were analyzed for technical adequacy by two experienced radiologists and if any controversy, the images were rechecked by both the radiologists.

Statistical analysis

Percentages of the optimal/technically adequate, rotated, over penetrated, over penetrated/rotated, expiratory, expiratory/rotated chest radiographs calculated in both the groups and the data analyzed using 'Z' test of proportion. The P values less than or equal to 0.05 were considered as statistically significant (P≤0.05).

RESULTS

Table 1: X-rays taken by radiographers before and after checklist

Quality of the chest x-rays	X-rays				'Z' value	Significance
	Before check list (n=178)		After check list (n=157)			
	No	%	No	%		
Technically adequate chest x-rays	41	23	61	38.9	3.174	P<0.01
Rotated	51	28.7	37	23.6	1.063	P>0.05
Over penetrated	21	11.8	13	8.3	1.07	P>0.05
Over penetrated and rotated	25	14	9	5.7	2.600	P<0.01
Expiratory	11	6.2	14	8.9	0.929	P>0.05
Expiratory and rotated	17	3.9	11	7	1.239	P>0.05
Others	12	6.7	12	7.6	0.319	P>0.05

In this study, the percentage of optimal technically adequate chest radiographs significantly increased from 23% to 38.9%. The improvement was statistically highly significant (P< 0.01) after the

introduction of pre- procedural check list. The percentage of over penetrated/ rotated radiographs significantly reduced from 14 to 5.7 % ($P < 0.01$) showing remarkable improvement. The percentage of rotated, overpenetrated and expiratory/rotated was found to decrease after the introduction of the check list, though it did not show any statistically significant improvement or difference. The other parameters like angulation, under penetration, rotation/over penetration/expiration, over penetration/expiration, expiration/angulations and under penetration /rotation did not show any significant difference between the two groups.

DISCUSSION

Even though the new imaging modalities like Multidetector Computed Tomography (MDCT), High Resolution Computed Tomography(HRCT) and Magnetic Resonance Imaging (MRI) are overtaking the conventional imaging methods, chest radiography still is the most frequently performed imaging[3] .It is the initial and primary investigation for the lung, mediastinal diseases and to evaluate cardiac diseases and pulmonary circulation. Thus, it remains the most frequently performed imaging examination accounting for more than half of the total workload in any radiology department.[4] The patient body habitus, latitude dynamic range of X-ray transmission through chest, scattered radiation, overlap of anatomic structures and perceptual limitations are some factors not limited to the image area affecting the image quality. These challenges to a lesser extent have been reduced with technical development.[5] When there is more workload especially in the teaching hospitals, the technical problems like rotation, expiratory status, angulations and under or over penetration are bound to happen limiting better diagnosis leading to more repetition. Hence the above mentioned parameters need special attention to improve the image quality of the chest X-rays. The stringent technical aspects and guidelines for conventional chest radiography have been given by Canadian Association of Radiologists and American College of Radiology [1,2]. However these guidelines and technical factors are not strictly followed resulting in technically inadequate chest radiographs. A better imaging technique with more stress on proper instructions to the patients by the radiographers is essential for better clinical diagnosis and treatment [6,7]. In this study, there is significant improvement in the quality of the chest X-rays after implementing the check list with the percentage of optimal, technically adequate films **(Figure-1)** increasing from 23% to 38% (**$P < 0.01$)** after the introduction of the pre- procedural check list.

Figure 1

Figure 2

Figure 3

Figure 4

Figure 5

Legend

Fig- 1: Technically adequate chest radiograph Postero Anterior (PA) view

Fig -2: Rotated chest radiograph

Fig-3: Over penetrated chest radiograph

Fig -4: Under penetrated chest radiograph

Fig -5: Expiratory Chest radiograph

Figure 1 shows a technically adequate chest radiograph with deep inspiration (horizontal black arrow denoting 9th posterior rib), optimal exposure and centralization with medial ends of clavicles (upward pointing black arrow) equidistant from the spinous process (downward pointing black arrow) at T5 level. Positioning the patient adequately is mandatory for correct interpretation of the chest radiograph. Even a small degree of rotation disturbs the mediastinal outlines, and the lung nearest to the film will appear less translucent mimicking pathologies like consolidation or pneumonitis**.** In a rotated chest radiograph, definite comment on the mediastinal pathology and mediastinal widening is not possible [8, 9, 10]. **Figure 2** shows a rotated chest radiograph with medial end of left clavicle (downward pointing black arrow) away from the central line (upward pointing black arrow). The right mediastinal border (black arrow head) is not seen with the right lower zone (horizontal black arrow) being more white or less translucent than the left side. Over penetration or overexposure (**Figure 3**) increases the visibility of the thoracic spine with darkening of the lung fields which will result in missing out of the small subtle radio-opaque lesions like nodules. Probability of missing out lung nodules or a solitary pulmonary nodule is more in an over penetrated chest radiograph leading to legal and ethical challenges. In this study, the incidence of rotated /over penetrated chest radiographs significantly reduced (**P<0.01**) after the introduction of the pre-procedural check list. Underexposure **(Figure 4)** of chest radiograph, where there is more opacity resulting in absent visibility of thoracic spine and increased opacity in the lower lung zones may result in fallacious diagnosis of lower zone consolidation or pneumonitis.[6,8] In this study, there was no significant difference in the incidence of underpenetrated chest radiographs in the two groups. Taking chest radiographs in deep inspiration is essential to better outline the cardiac and diaphragmatic borders, to prevent false positive findings due to crowding of lung markings and to correctly measure the cardiac size [11, 12]. In this study, the percentage of expiratory /rotated, rotated and over penetrated was found to decrease after the introduction of the check list , though it did not show any statistically significant difference. The other combination of technical inadequacies like under penetration, over penetration, angulations, rotation and expiration did not show any significant difference between the two groups. **Figure 5** shows an expiratory chest radiograph with the posterior aspect of 4th rib(upward pointing black arrow) at the level of the middome of the diaphragm with crowding of the vessels and the ribs(horizontal black arrow) leading to more opacity. The number of expiratory chest radiographs (**Figure 5**) did not show any improvement after the implementation of the checklist. Apart from the radiographers' competence, taking chest radiographs in deep inspiration also needs patients' co-operation. The socioeconomic status and literacy level of the patients could have been different in both the groups which may be one of the reasons for lack of improvement in the expiratory status. The chest radiographs being the most frequently performed imaging , the radiographers tend to pay less attention on the technical factors like proper positioning, adequate inspiration and exposure factors. This should be avoided because many a times, chest radiographs play a vital role in diagnosis and treatment.

CONCLUSION

The radiologist cannot interpret a chest radiograph which is not technically adequate. Chest radiography is the initial investigation of choice not only in the respiratory and cardiovascular disorders but also in many systemic diseases. It accounts for approximately 50% of the workload in the radiology department. A good quality chest radiograph is very essential for correctly interpreting the findings. Apart from correctly operating the X-ray machine and maintaining the X-ray room, the radiographers are responsible for providing technically adequate radiographs[13]. The use of a pre- procedural check list by the radiographers was found to significantly increase the quality of the chest radiographs, thus making the interpretation easy with reduction in the repetition, wastage of the films and radiation dose to the patient.

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