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Comparison of Observer Performance between Emergency Physicians at Different Level of Experience Using Digital Imaging for Detecting Pneumothorax in the Emergency Department

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Abstract

Objectives: Digital radiology is relatively new technology that allows the examiner a number of advantages. The objective of this study is to evaluate the efficacy of digital chest radiography using plain expiratory and inspiratory images to detect Pneumothorax and comparison of observer performance between residents and experienced Emergency Department (ED) physicians.

Methods: Plain digital images of chest radiographs containing expiratory and inspiratory views, requested to exclude Pneumothorax from January 2000 to December 2003 were included. All images were reviewed independently by three experienced ED physician and three ED residents. The physicians were asked to decide on the presence or absence of a Pneumothorax, its site, size and its percentage of occupying area. The physician's reports were recorded and compared with reports of consultant radiologists as a standard.

Results: A total of 252 sets of inspiratory and expiratory films were ordered. Of the 118 pairs that met the inclusion and exclusion criteria, 76 pairs (64.4%) were positive for Pneumothorax using the standard consultant radiologist's reports. Overall sensitivity was 72.6% (CI ± 4.2) for inspiratory and 80.0% (CI ± 3.7) for expiratory films (*P*=0.001), with a specificity of 69.4% (CI ± 4.6) for inspiratory and 73.1% (CI ± 4.8) for expiratory films (*P*=0.12). The kappa for agreement was 0.65, 0.52, and 0.32 for the presence of Pneumothoraces, their size (small, medium, or large), and their percentage of occupying the area of pleural cavity respectively.

Conclusion: Expiratory images on a digital viewer are more sensitive than inspiratory images for detecting Pneumothoraces, and this difference is decreased with expert physician's review. The agreement was poor when a percentage is used to describe the size of the Pneumothorax occupying Pleural cavity.

Keywords: Pneumothorax; Inspiratory image; Expiratory image; Digital plain image; Emergency department

Introduction

Over the last decade there have been remarkable advances in the technology applied to radiological imaging. Digital radiography has replaced film based conventional radiography. This is particularly true for western countries, the impetus for these changes can be largely attributed to the advantages inherent in digital imaging [1,2]. Many attempts have been made in the past to compare observer performance using digital versus conventional radiography and results have been encouraging in favor of digital imaging [3,4].

Digital radiology is relatively a new technology that allows the examiner a number of advantages. These include the ability to adjust the view density, focus on or magnify an area of interest on a film and so on. Many have proposed that this technology improves the ability of emergency medicine physicians to diagnose a Pneumothorax from a single inspiratory view because it allows for better assessment of the lung and bony thorax.

This study was undertaken to assess the value of expiratory chest images using digital viewers in the emergency department when a Pneumothorax is suspected. The study was also designed to evaluate the sensitivity of Pneumothorax detection for staff and residents and to determine the inter observer agreement between ED physicians at different level of experience while evaluating the presence, size (small, medium, or large), site and percentage of occupying pleural cavity by the Pneumothorax.

Methodology

This study was done in the McGill University Health Centre Emergency Department Canada and the study was approved by the institutional review board of the university and the director of professional services of the health centre.

From the digital radiology system record chest images that contained an inspiratory and expiratory antero-posterior or postero-anterior views from January 2000 to December 2003 were taken. The inclusion criteria included both inspiratory and expiratory images taken an erect posture for the subject who presented in ED suspected for Pneumothorax. The images were excluded if a chest tube was present. When multiple images were found in a digital radiological record for a given patient within one day duration then only one from both inspiratory and expiratory view were included, preferably the views that were done closest together in time.

Three emergency medicine staff and three emergency medicine residents (each at a different level of training) were given a short clinical history for each film and then were asked to evaluate the films. The inspiratory and expiratory views were arranged randomly on several

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compact discs with no patient identification so that each view would be evaluated independently. No lateral films were included for evaluation. Although the films were randomly assorted on several compact discs and not directly viewed from a dedicated digital viewing computer, each physician had the ability to control the viewing computer as if he or she were using the dedicated digital viewer (i.e., control the film density, focus on a selected area, etc.). For each view, the physicians were asked to decide the following: (1) if a Pneumothorax was present (yes or no), and if so, (2) on which side the Pneumothorax was present, (3) the size of the Pneumothorax either small, medium, or large using definitions as "small": defined as a "small rim of air around the lung"; "moderate": defined as lung "collapsed halfway towards the heart border"; and "complete": defined as "airless lung, separate from the diaphragm" [5] and (4) the percentage of Pneumothorax which was done by calculating the ratio of the transverse radius of the Pneumothorax (cubed) to the transverse radius of the hemi thorax (cubed) and to express the Pneumothorax size as a percentage, multiply the fractional size by 100 [6].

Radiology reports of the plain radiographs of the same images reported by consultant radiologists were taken as a standard to compare with that of the ED physicians reports for the absence or presence of Pneumothorax, site, size and area occupied by air in percentage within in pleural cavity. Automated software SPSS was used to calculate the statistical data. Agreement was calculated using the Cohen kappa, in which the agreement is poor when $\kappa<0.2$, is fair when $0.2<\kappa<0.4$, is moderate when $0.4<\kappa<0.6$, is good when $0.6<\kappa<0.8$, and is very good when $\kappa>0.8$.

Results

A total of 252 sets of inspiratory and expiratory images were ordered between January 2000 and December 2003 using the digital radiology system. Of the 252 sets, 118 sets of films met the inclusion criteria, and all were of adequate diagnostic quality, with 76 pairs positive (64.4%) for Pneumothoraces. Thirty-seven of the 76 pairs had small Pneumothoraces (48.7%), 25 pairs had medium Pneumothoraces (32.9%) and 14 pairs had large Pneumothoraces (18.4%).

	INSPIRATRY	EXPIRATORY	P
Sensitivity	77.1%, CI ± 5.6	81.3%, CI ± 5.1	0.17
Specificity	98.6%, CI ± 2.0	96.2%, CI ± 3.3	0.0
+LR	53.97, CI ± 1.38	21.13, CI ± 0.86	
−LR	0.23, CI ± 1.38	0.20, CI ± 0.86	
PPV	98.8%, CI ± 1.6	97.3%, CI ± 2.3	0.15
NPV	73.8%, CI ± 6.3	.9%, CI ± 6.6	0.75
Accuracy	86%	87%	0.69

+LR = positive likelihood ratio; −LR = negative likelihood ratio; PPV = positive predictive value; NPP = negative predictive value.

Table 1: Detection of pneumothorax by the staff physician.

	INSPIRATRY	EXPIRATORY	P
Sensitivity	68.1%, CI ±6.2	78.7%, CI ±5.4	0.001
Specificity	93.5%, CI ±4.1	92.2%, CI ±4.6	0.5
+LR	10.4, CI ±0.64	10.5, CI ±0.6	
−LR	0.34, CI ±0.64	0.23, CI ±0.6	
PPV	94.2%, CI ±3.7	94.7%, CI ±3.2	0.77
NPV	61.0%, CI ±6.6	71.3%, CI ±6.9	0.004
Accuracy	78%	84%	0.04

+LR = positive likelihood ratio; −LR = negative likelihood ratio; PPV = positive predictive value; NPP = negative predictive value.

Table 2: Detection of pneumothorax by the residents.

The staff physicians had sensitivity of 77.1% (CI ±5.6) for inspiratory and 81.3% (CI ± 5.1) for expiratory films (P=0.17 for the differences) and a specificity of 98.6% (CI ± 2.0) for inspiratory and 96.2% (CI ± 3.3) for expiratory films (P=0.04 for the differences; Table 1). The resident physicians had a sensitivity of 68.1% (CI ± 6.2) for inspiratory and 78.7% (CI ± 5.4) for expiratory films (P=0.001 for the differences) and a specificity of 93.5% (CI ± 4.1) for inspiratory and 92.2% (CI ± 4.6) for expiratory films (P=0.5 for the differences; Table 2). When the results of the staff and resident physicians were pooled together, the sensitivity was 72.6% (CI ± 4.2) for inspiratory and 80.0% (CI ± 3.7) for expiratory films (P=0.001 for the differences), and specificity was 96.0% (CI ± 2.3) for inspiratory and 94.2% (CI ± 2.8) for expiratory films (P=0.12 for the differences; Table 3).

The kappa for agreement of the staff, residents, and the two groups together on the presence of Pneumothorax was 0.79, 0.51, and 0.65, respectively. The kappa for agreement of the staff, residents, and the combined group on the size of Pneumothoraces as small, medium, or large was 0.57, 0.42, and 0.52, respectively, and the kappa for agreement of the staff, residents, and combined group on the size of Pneumothoraces as a percentage was 0.38, 0.23, and 0.32, respectively (Table 4).

Discussion

There have been many remarkable advances in conventional thoracic imaging over the past 10-15 years. Perhaps, the most remarkable is the rapid conversion from film based to digital radiographic system. An exciting aspect of these changes is due to ability of digital radiographic application to enhance the diagnostic capabilities. It is common clinical practice to request both inspiratory and expiratory films of the chest when a Pneumothorax is clinically suspected. This is done in an effort to increase sensitivity, even though this practice increases costs and radiation exposure to the patients [7-9].

Historically, it is evident that expiratory views make a Pneumothorax more obvious to the viewer, [10,11] possibly due to the volume of air in the pleural cavity is greater in relation to the lung volume of an inspiratory view. The greater volume of air in the pleural space in an expiratory view is thought to make the lung denser with clearer margins, allowing easier detection of a pneumothorax.[7,10,11] However despite the different views in literature for ordering both inspiratory and expiratory images, in practice it is still being used.

	INSPIRATRY	EXPIRATORY	P
Sensitivity	72.6%, CI ±4.2	80.0%, CI ±3.7	0.001
Specificity	96.0%, CI ±2.3	94.2%, CI ±2.8	0.12
+LR	18.34, CI ±0.58	13.81, CI ±0.49	
−LR	0.29, CI ±0.58	0.21, CI ±0.49	
PPV	96.6%, CI ±2.0	96.0%, CI ±2.0	0.55
NPV	69.4, CI ±4.6	73.1%, CI ±4.8	0.12
Accuracy	82%	85%	0.13

+LR = positive likelihood ratio; −LR = negative likelihood ratio; PPV = positive predictive value; NPP = negative predictive value.

Table 3: Detection of pneumothorax by all physicians.

	STAFF	RESIDENTS	ALL
Presence of pneumothorax	0.79	0.51	0.65
Size as small, medium, large	0.57	0.42	0.52
Size as percentage	0.38	0.23	0.32

Table 4: Kappa values for agreement on the findings.

Although, it has been reported in studies that expiratory film only may not be very sensitive to detect pneumothorax expiratory views still considered to be good tool for diagnosing Pneumothorax. [9,12]

Radiological imaging has little value without expert reader's interpretation using their perceptual and cognitive processes giving clinical utility and effectiveness [1]. In a study [10] combined inspiratory and expiratory film both for conventional film ED physicians performances was found to be 12.5% less than with that of standard radiologist's report. Whereas, in our study expiratory and inspiratory digital images were evaluated in contrast to this study expiratory digital images appear to be more sensitive than inspiratory views when pooling all emergency physicians together (P=0.001). There appears to be no statistical difference, however, when these inspiratory and expiratory films are interpreted by more experienced ED physicians (P=0.17). The less experienced ED resident physicians were more likely to detect a Pneumothorax when viewing the expiratory digital film as compared to the inspiratory digital film (P =0.001).

The sensitivity of both views was lower than might be expected or assumed in the clinical setting, in our study it may be due to the large proportion of small Pneumothoraces (48.7%) in the 76 pairs of films with Pneumothoraces. The reason could be fact that ED physicians were given only a short clinical history, without any description related to findings of clinical exams. In addition, the physicians were allowed to view the compact discs on their own computers at their own convenience. It is likely that their home computer monitors were not as large or as high resolution as the viewers used by the radiologists for final interpretation.

Agreement on the size of Pneumothorax was moderate to good when small, medium, or large was used to report the size, but only fair to poor agreement was found when percentage was used.

Conclusion

It appears that expiratory antero-posterior digital chest images in comparison to inspiratory digital images are more sensitive in detecting Pneumothoraces by less experienced or resident ED physicians. No statistical difference emerges in the detection of Pneumothoraces when the same inspiratory and expiratory films are viewed by more experienced or staff ED physicians.

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