ORIGINAL ARTICLE

Comparison of Conventional Radiography and Digital Computerized Radiography in Patients Presenting to Emergency Department

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SUMMARY

Objectives

To compare the differences between conventional radiography and digital computerized radiography (CR) in patients presenting to the emergency department.

Methods

The study enrolled consecutive patients presenting to the emergency department who needed chest radiography. Quality score of the radiogram was assessed with visual analogue score (VAS-100 mm), measured in terms of millimeters and recorded at the end of study. Examination time, interpretation time, total time, and cost of radiograms were calculated.

Results

There were significant differences between conventional radiography and digital CR groups in terms of location unit (Care Unit, Trauma, Resuscitation), hour of presentation, diagnosis group, examination time, interpretation time, and examination quality. Examination times for conventional radiography and digital CR were 45.2 and 34.2 minutes, respectively. İnterpretation times for conventional radiography and digital CR were 25.2 and 39.7 minutes, respectively. Mean radiography quality scores for conventional radiography and digital CR were 69.1 mm and 82.0 mm. Digital CR had a 1.05 TL cheaper cost per radiogram compared to conventional radiography.

Conclusions

Since interpretation of digital radiograms is performed via terminals inside the emergency department, the patient has to be left in order to interpret the digital radiograms, which prolongs interpretation times. We think that interpretation of digital radiograms with the help of a mobile device would eliminate these difficulties. Although the initial cost of setup of digital CR and PACS service is high at the emergency department, we think that Digital CR is more cost-effective than conventional radiography for emergency departments in the long-term.

Key words: Conventional radiography; digital CR; emergency department.

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Introduction

Digital radiography (Digital CR) was first introduced in the 80s[1] when the first radiograms were recorded on phosphorus-coated digital cassettes.[2] The advantages of digital radiograms include manipulation of digital data at various stages between image acquisition and final interpretation. A wide dynamic range is obtained.

There are multiple advantages of digital CR to conventional radiography. Spatial resolution is higher and images can be recorded electronically. It allows Teleradiology and Picture Archiving and Communication System (PACS) applications. It does not require image re-acquisition. It mitigates workload by virtue of absence of stages such as dark-room and developing process.[3,4]

The aim of our study was to compare the difference between conventional radiography and digital Computerized Radiography (CR) in patients presenting to the emergency department.

Materials and Methods

University Faculty of Medicine is a tertiary emergency department with nearly 65000 annual patient admissions. Patients are examined and treated at a total of 3 sites of care (emergency care unit, resuscitation, and trauma). Our study was conducted between January 2010 and June 2010.

All consecutive patients who presented to the emergency department and had a chest radiogram for any reason were included in this study, following permission from the University Faculty of Medicine Local Committee of Ethics. Hemodynamically unstable patients, those undergoing emergency operations, and those in need of a necessary intervention (ex. tension pneumothorax, evisceration, traumatic cardiac arrest outside the hospital) were excluded from the study. Only patients who consented were included in the study. To form a more homogeneous group, only chest radiograms were included. Chest radiograms were only obtained in patients who demonstrated need for the imaging by virtue of indication, diagnosis, comparison, and higher frequency of use.[5] Three research assistants were involved in the study, each with 2 years experience. Research assistants were instructed in filling of the patient enrollment forms prior to study onset, but had no instruction on evaluating the quality of radiographs. VAS scores were determined based on personal perceptions of overall quality of the radiograms. The emergency department had a conventional radiography device before installing the Digital CR device. The conventional chest radiography group was therefore formed first, followed by digital CR. Digital CR was performed using the Kodak CR 975 digital radiography device. Emergency service assistants evaluated the radiographs at terminals in the emergency department (emergency care unit, resuscitation, and trauma), and filled the appropriate scores. Ege University Faculty of Medicine Department of Emergency Medicine performs a mean of 175 radiographic examinations each day. A total of 621 chest radiographies, 301 conventional and 320 digital CR, were included in the study.

The quality score of the radiography was measured using visual analog scale (VAS-100 mm) in millimeters and recorded at the end of the study. The examination time was calculated by subtracting the radiographic examination time from the examination request time and recorded in minutes, and the interpretation time was calculated by subtracting radiographic examination time from the radiographic interpretation time and recorded in minutes.

All data from this cross-sectional study were transferred to digital medium and analyzed by SPSS 11.0 statistical software.

As a basic statistical analytical method, descriptive statistics, mean, standard deviation, and frequency tables were used. Continuous variables were presented as mean±standard deviation; categorical variables were presented as frequency and percentage. Advanced statistical analyses included Chi Square analysis to test the significance of the difference between the paired groups and Student's t-test to test the significance of the difference between the means.

Results

The mean age was 55.9±19.9 for conventional radiography and 57.3±18.6 for digital CR. No significant difference in age was detected between both groups (T:1.092, p=0.375).

Gender of the study population was distributed evenly, with 342 (53.3%) male patients and 279 (46.7%) female patients. The conventional radiography group was composed of 159 (25.6%) males and 142 (22.8%) females, whereas the Digital CR group consisted of 183 (29.4%) males and 137 (22.0%) females. Gender distribution was not different in both groups.

There was a significant difference between conventional radiography and Digital CR groups in terms of units (Care Unit, Trauma, Resuscitation) at which they were cared (Table 1).

There was a significant difference between conventional radiography and Digital CR groups in terms of the distribution of the hour of presentation (Chi Square: 25,068, p≤0,0001) (Figure 1).

Mean examination time and Interpretation time for conventional radiography and digital CR show a statistically significant difference.

Table 1. Patient distribution in terms of type of radiographic examination

Patient care unit	Type of radiographic examination					
	Conventional		Digital CR		Total	
	Number	%	Number	%	Number	%
Care Unit	232	37.4	275	44.2	507	81.6
Trauma	36	5.8	24	3.9	60	9.7
Resuscitation	33	5.3	21	3.4	54	8.7
Total	301	48.5	320	51.5	621	100

Chi Square: 8.140, p=0.017.

Total times for conventional radiography and Digital CR difference were statistical insignificant (Table 2).

The mean radiography perceived quality scores were 69.1±15.9 mm and 82.0±8.4 mm for conventional radiography and digital CR, respectively. This difference was statistically significant (t:-12.757, p≤0.0001).

Digital CR has advantages to conventional radiography. The patient's was blocked loss of data. Old and new X-ray radiographs can be compared. In addition, the radiographs do not need additional space for archiving.

Cost

Mean cost of a conventional radiogram is $0.70, which equals 1.05 TL according to the exchange rate on 8 April 2011.

Mean cost of a 35x43 cm Digital cassette is $1000, and nearly 30000 examinations can be performed per cassette. A single radiography costs a mean of $0.033, which equals to 0.0495 TL. As a result, 1.005 TL is saved per a single radiogram by using digital CR. A mean of 175 radiograms are taken each day at emergency departments, bringing a savings of 175.08 TL.

Kodak directview CR 975 system, PACS system, and Kodak directview CR PQ cassettes (24x30 cm, 35x43 cm) cost approximately 100.000 TL. The device would pay off itself after approximately 571 days.

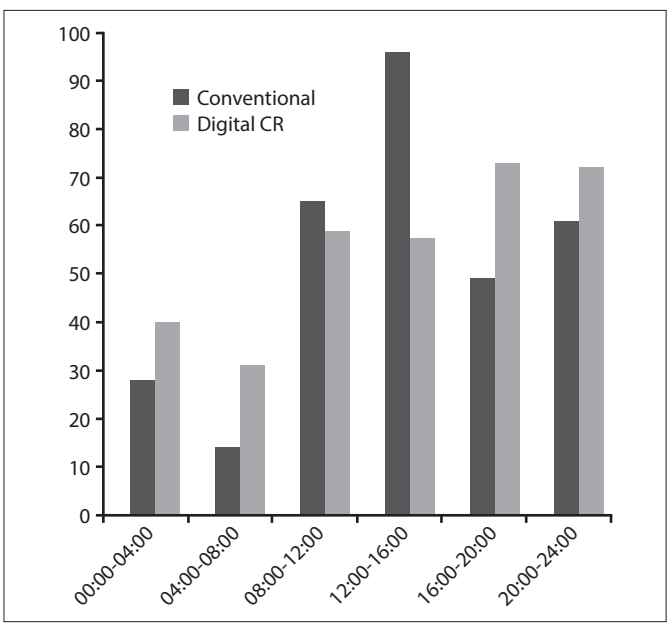

Figure 1. Distribution in terms of type of radiography and presentation hour groups of the patients.

Discussion

Many studies have been performed so far to compare digital CR and conventional method. In these studies, parameters such as examination time for digital radiography, manipulation of data at the post-examination period, graphic quality, and number of hourly examinations were investigated.[6-9]

Trauma and resuscitation patients were more commonly in the conventional radiography group, and care unit patients were more commonly in the digital CR group. A greater number of care unit patients in digital CR group may have prolonged the interpretation time, since patient crowding in care unit is greater than resuscitation and trauma units at our emergency department. Interpretation time is influenced by patient crowding. While conventional radiographies are interpreted at bedside, Digital CR radiograms are interpreted via the terminals at the care unit, which delays interpretation in conjunction with patient crowd. In addition, radiographic interpretation time may have been affected during the running-in-period following the onset of Digital CR use at the emergency department.

Most common presentations in conventional radiography and Digital CR groups occur between 08:00-16:00 and 16:00-24:00, respectively. The mean patient density between 16:00-24:00 is greater than that between 08:00-16:00 at our emergency department. Crowded hours are characterized by delayed interpretation process.

Table 2. Distribution of the examination times of both radiographic examination types

Variable	Examination type	Mean±SD (Min)	t	p
Examination time	Conventional	45.2±41.1	3.333	0.001*
	Digital CR	34.2±41.3		
Interpretation time	Conventional	25.2±21.2	-6.545	<0.0001*
	Digital CR	39.7±32.3		
Total time	Conventional	70.5±49.4	-0.849	0.396
	Digital CR	74.0±52.2		

In conventional radiography group, additional time is required after the examination for dark-room, development, and image printing. In addition, a radiology technician is needed at the emergency department to perform the development process. In the case of digital CR, a radiology technician automatically sends patient radiogram directly from the digital cassette with the software of Picture Archiving and Communication System (PACS) to the provider. Therefore, conventional radiography examination time is prolonged.

One study has reported that Digital radiography increased mean number of examinations by 12% compared to conventional radiography. The same study has found that the time for the radiogram to get ready for interpretation shortened by 77% in Digital CR compared to conventional CR.[10]

A shorter interpretation time in conventional radiography is an unexpected finding in our study. The emergency department; including emergency care unit 2, resuscitation and trauma unit 2 are total number of 4 staff. Patient relatives cannot enter the emergency service. This phenomenon may be explained as follows: in conventional radiography group, personnel brought the printed radiogram to the physician or patient bed after the examination. Thus, bed-side radiographic interpretation could be made. In case of Digital CR group, radiogram was transmitted to the terminals found at the emergency department, where the radiograms were interpreted. Presentation of the patients in the Digital CR group took place between 16:00-24:00 when the emergency department was most crowded and majority of the patients in the digital CR group consisted of care unit patients. Therefore, we think that radiography interpretation times were prolonged in the digital CR group. We also think that difficulties in usage due to newly implemented digital CR technology contributed to prolongation of interpretation time.

We think that the reason why we could not detect any significant difference between conventional radiography and digital CR groups in terms of the mean total time stems from the differences in mean examination times and mean interpretation times.

We expected to find a higher radiographic quality score in digital CR group owing to the ability of the manipulation of the digital data, acquisition of a wide dynamic range, and a higher spatial resolution compared to conventional radiography.[11,12] Two studies reported that Digital CR (phosphorus cassette) radiograms assess mediastinal structures and peripheral lung fields with a higher score compared with conventional radiograms.[5,13] Van Soldt et al. reported a better image quality with Digital CR compared to conventional radiography.[14]

The mean cost of conventional radiography and Digital CR has been calculated. According to this calculation, Digital CR is 1.005 TL cheaper per radiogram. Digital CR has a lower cost and it is more profitable for an emergency department in the long term compared to conventional radiography. The device would pay off itself after approximately 571 days.

One study has reported that the cost of the setup of Digital CR is higher than conventional radiography, whereas cost per radiogram is lower with the former.[15]

Limitations

It took time to be accustomed to an evaluation system via radiography terminals since patient admission began shortly after the digital CR system setup was completed at the emergency department. This may be the reason for a prolonged digital CR interpretation time in our study. Difference between enrolled patients in terms of care units and initial diagnoses may have altered study findings. Interpretation time of the radiograms may have been affected by many reasons such as ED crowding and severity of the patient symptoms and status.

Conclusions and Recommendations

Radiography examination and interpretation times may vary based on crowding and the care unit the patient presents. We think that interpretation of digital radiograms with the help of a mobile device would eliminate these difficulties.

Digital CR provides better image quality by conventional radiography. The patient's was blocked loss of data. The Digital

CR does not need additional space for archiving.

Although the initial cost of setup of digital CR and PACS service is high at the emergency department, we think that Digital CR is more cost-effective than conventional radiography for emergency departments long-term.

Conflict of Interest

The authors declare that there is no potential conflicts of interest.

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