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Current Status of Computed Radiography in Emergency Departments

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This study reports the findings of a computed radiography (CR) imaging experience questionnaire sent to 35 emergency departments (ED) in North America. A total of 25 responses to the questionnaire were received corresponding to a return rate of 71%. The median daily workload was 71 patient examinations and the average number of films per patient examination for the 21 facilities was 3.0 ± 0.8. A total of 91% of respondents printed to film all ED trauma images obtained with CR with only one ED claiming to be filmless. CR in the ED was easy to use and had significant benefits of reducing examination repeat rates, permitting a prompt availability of radiographic images, improving image quality, providing improved operational efficiency, and eliminating lost films. Major limitations of CR were deemed to be limited viewing stations, CR costs, and inefficient patient ID entry. Radiology departments were very happy with the introduction of CR into the ED setting with approximately half being highly satisfied and half somewhat satisfied. The degree of satisfaction by ED personnel was similar with about half being highly satisfied, 40% somewhat satisfied, and the remainder neutral. The fact that not a single respondent was in any way dissatisfied shows that CR can play a useful role in the ED setting.

KEY WORDS: PACS, emergency department, computed radiography, digital imaging

PHOTOSTIMULABLE phosphor computed radiography (CR) systems have a wide linear response over four orders of magnitude that permits films to be obtained with the required film density independent of the radiation exposure incident at the imaging plate and allows image processing to enhance the visibility of selected features. CR is therefore very attractive for performing portable chest examinations where the absence of phototiming often results in suboptimal film density in screen-film systems.[1-4] CR systems have also been introduced into Radiology departments as a means of obtaining a digital output. Replacing conventional screen-film systems with CR permits the Radiology department to take advantage of a picture archiving and communication system (PACS). Major benefits of PACS include the ability to digitally enhance radiographic images, digital image archival that eliminates lost films, and the ability to send images to remote locations (ie, teleradiology) such as intensive care units or to radiologists removed from the site of image production.[5-7]

CR has several advantages compared to conventional screen-film technology including the elimination of chemical processing, reduction of film-based costs, and the availability of a digital output for PACS and teleradiology applications. CR has been introduced in many settings including the emergency department (ED), but to date there have been no studies performed to investigate the use of CR in the ED setting. Common imaging problems in the ED relate to the need for rapid imaging, timely provision of radiographs to the ED medical staff, improved image quality for difficult examinations with potentially uncooperative patients (eg, cross-table lateral C-spines), and the problem of lost films.[8-10] In this study, we sent a CR questionnaire to 35 EDs in North America to summarize their experiences with CR, identify advantages of using CR in the ED setting, and to document problem areas.

METHOD

Appendix 1 shows the questionnaire sent out to the Chiefs of Radiology who serviced 35 EDs that were identified by manufacturers as current users of CR imaging equipment to radiograph

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Table 1. Computed Radiography Questionnaire Respondent Category Summary (N = 26)*

Respondent	No. of Responses	%
Radiologist	8	31
Technologist	4	15
Administrator	10	38
Physicist	3	12
Other	1	4

*One form was completed by a technologist and a physicist.

trauma patients. The questionnaire was distributed in November 1996, and responses were received over the following three months. A total 25 responses to the questionnaire were received, corresponding to a return rate of 71%. The data provided below represents a total of 31 CR systems in EDs across the continental United States. Distribution of the responses were as follows: 11 (44%) in the East, 8 (32%) in the Midwest, 3 (12%) in the West, and 3 (12%) in the South.

RESULTS AND DISCUSSION

Hospital Information

Table 1 summarizes the category of respondents who completed the CR questionnaires. Administrators and radiologists accounted for 69% of the respondents. Table 2 summarizes information on the trauma center classification of the EDs participating in this study. Most identifiable trauma centers were equally divided between levels I and II. Table 3 summarizes the information on the size of hospitals housing the EDs participating in this study. Approximately half of the identified hospitals were midsized (200-500 beds) and a third were large institutions with more than 500 beds.

ED Data

Data on the size of the ED in terms of rooms and beds were ambiguous, with some answers relating to the number of rooms and others to the number of separate beds (bays) within the available rooms. The EDs are therefore better described in terms of installed (ie, fixed) x-ray tubes as well as the number of daily examinations performed in each ED. Table 4 shows the distribution of fixed x-ray tubes as reported on the CR questionnaire. Several EDs supplement their fixed x-ray tube capacity with portables, which may be permanently located in the ED and/or brought in as required.

Table 2. Summary of the Trauma Level Classification for Emergency Departments (N = 25)

Trauma Level	No. of Responses	%
I	10	40
II	6	24
III	2	8
Other	7	28

Table 3. Summary of Hospitals Size Institution Housing the Emergency Department (N = 25)

Bed Size	No. of Responses	%
<100	1	4
100-200	2	8
200-500	13	52
>500	9	36

The median daily workload (N = 21) was 71 patient examinations with a 25 percentile value of 62 patient examinations and a 75 percentile value of 77.5 patient examinations. The minimum number of daily patient examinations reported was 23 and the maximum was 800. The average number of films per patient examination for the 23 facilities was 3.0 ± 0.8.

In 76% (N = 25) of the responses, the ED and Radiology department were in the same building, whereas in 68% (N = 25) of the responses the ED and Radiology department were on the same floor. A total of 11 out of 18 respondents had ED departments located within 50 yards of the Radiology department. The remaining 7 Radiology departments were located at distances ranging from 100 yards to 1,000 yards from the ED. The median time taken to travel between the ED and Radiology was 90 seconds with a 25 percentile value of 60 seconds and a 75 percentile value of 180 seconds. The minimum time taken to travel between the ED and Radiology was 0 seconds (departments were located adjacent to one another) and the maximum was 720 seconds.

CR Specifications

Table 5 summarizes the CR systems installed in the EDs participating in this survey. The total number of installed CR systems was 31. This

Table 4. Frequency of Number of Installed X-ray Tubes (N = 22)

No. of Tubes	Frequency
0*	4
1	7
2	5
3	3
>3	3

*These Emergency Departments use portable x-ray units.

Table 5. Summary of Installed Computed Radiography Systems in Emergency Departments

Manufacturer	Model	No. of Units	%
Fuji*	AC-1	2	61%
	AC-3	8	
	9000	6	
	Not specified	2	
AGFA	ADC-70	7	23%
Kodak	Ektascan	1	16%
	KESPR	4	

Note: Fuji, Stamford, CT; AGFA, Richfield Park, NJ; Kodak, Rochester, NY.

number of CR units in EDs, compared with the estimated 650 CR systems that are in current use in North America, shows the limited penetration of the ED market by this digital technology. Only 16% of respondents (N = 23) reported that their CR system in the ED was interfaced with their radiological information system (RIS). A total of 68% of respondents (N = 22) performed *all* of their ED radiographic examinations using CR with a further 23% performing between 90% and 98%, one 80% and one 50%.

A total of 91% of respondents (N = 23) printed all ED trauma images obtained with CR to film; only one ED reported being totally filmless. In the one other facility, 10% of images were printed to film. In 73% of facilities (N = 23), clinicians had the ability to review ED images on a workstation and 27% of facilities reported having no clinician workstations. In 70% of institutions (N = 23), digital images were also sent to display stations within Radiology, whereas the remaining institutions had no significant capacity for reviewing CR radiographs generated within the ED by means of a softcopy display in Radiology.

Benefits and Limitations of CR

The data presented in Tables 6 and 7 provide a summary of the identified benefits and limitations of using CR in the ED setting, with the first value being the number of responses for that category, and the number in parentheses the corresponding percentage of responses for that category. The three most important benefits of CR in the ED setting, taken as the number of responses in the major and minor categories in Table 6, were the ease of CR use (25), a reduction in the examination repeat rate (25), and the prompt availability of the radiographic image (24). Additional benefits of CR included the improved image quality (22), image processing (22), improved ED/MD efficiency (21), improved image delivery (20), and elimination of lost films (20). The large number of positive responses in most of the categories listed in Table 6 is a clear indication that CR has been well received when used in an ED setting.

The three most important limitations of CR, taken as the combined responses in the major and moderate categories in Table 7, were deemed to be the patient ID entry process (18), cost of CR (17), and limited viewing stations (16). Additional factors that were identified as a limitation of CR included image orientation (9), the lack of a Digital Imaging and Communications in Medicine (DICOM) output (8), reduced throughput (7), and limited cassette sizes (7), which were mentioned relatively infrequently as being moderate/major

Table 6. Summary of Reported Benefits of Computed Radiography in the Emergency Department Setting

	Minor		Moderate		Major		Not Applicable	
	No.	(%)	No.	(%)	No.	(%)	No.	(%)
Ease of use:	0	(0)	11	(44)	14	(56)	0	(0)
Reduces repeat rate:	0	(0)	6	(24)	19	(76)	0	(0)
Eliminates film chemistry:	4	(16)	3	(12)	7	(28)	11	(44)
Reduces patient doses:	6	(24)	8	(32)	5	(20)	6	(24)
Improves image quality:	3	(12)	5	(20)	17	(68)	0	(0)
Eliminates lost films:	4	(16)	2	(8)	18	(72)	1	(4)
Image processing:	2	(8)	6	(24)	16	(64)	1	(4)
Prompt image availability:	1	(4)	4	(16)	20	(80)	0	(0)
Teleradiology access:	3	(12)	5	(20)	10	(40)	7	(28)
Improves patient flow:	5	(20)	12	(48)	7	(28)	1	(4)
Improves image delivery:	1	(4)	7	(28)	13	(52)	4	(16)
Improves technologist efficiency:	4	(16)	6	(24)	12	(48)	3	(12)
Improves ED/physician efficiency:	2	(8)	9	(36)	12	(48)	2	(8)

Abbreviation: ED, emergency department.

Table 7. Summary of Reported Limitations of Computed Radiography in the Emergency Department Setting

	Minor		Moderate		Major		Not Applicable	
	No.	(%)	No.	(%)	No.	(%)	No.	(%)
Expense:	3	(12)	12	(48)	5	(20)	5	(20)
Difficult to use:	17	(68)	2	(8)	0	(0)	6	(24)
Reliability:	14	(56)	4	(16)	2	(8)	4	(16)
Lack of suitable backup:	11	(44)	2	(8)	3	(12)	9	(36)
Increases patient dose:	9	(36)	3	(12)	2	(8)	11	(44)
Reduces throughput:	7	(28)	5	(20)	2	(8)	10	(40)
Lack of DICOM:	3	(12)	3	(12)	5	(20)	12	(48)
Limited cassette sizes:	7	(28)	5	(20)	2	(8)	11	(44)
ID entry process:	4	(16)	11	(44)	7	(28)	3	(12)
Limited viewing stations:	5	(20)	6	(24)	10	(40)	3	(12)
Image re-orientation:	14	(56)	6	(24)	3	(12)	2	(8)

Abbreviations: DICOM, Digital Imaging and Communications in Medicine; ID, identification.

limitations. In general, these results reinforce the finding that CR is perceived to play a positive role in the ED setting, although there are a few areas where improvements are clearly desirable. Access to Hospital Information Systems (HIS) or RIS is clearly important to guarantee accurate patient information and improve overall technologist efficiency by elimination of duplicate data entry. The problem of limited viewing stations will increase as hospitals move away from hard-copy films, but may be mitigated by increasing use of microcomputers by referring physicians to access images or by the use of inexpensive paper printers. Furthermore, CR costs are likely to decrease in the near future with an increasing number of manufacturers entering this growing market.

CR Performance

About 54% of respondents (N = 22) reported a CR downtime of between 0% and 1%, while 25% reported a downtime of between 2% and 5%. A further 17% reported a downtime in the range of 6% to 10% with only one facility reporting a downtime of 15%. Of the 17 respondents who provided reasons for the downtime, 24% of the responses were attributed to imaging plate jams, 18% related to preventive maintenance, and 18% of the problems related to the laser printer. Only 12% of the responses attributed downtime as a result of CR system mechanical failure. An analysis of the downtime data did not show any noticeable differences between the three manufacturers, although the limited data size is too small to make definitive conclusions.

Table 8 provides a summary of the backup that EDs use in the event of the CR system not being available (ie, system redundancy). Percentages do not total 100% because some institutions have multiple backup systems. Backup systems used are another CR system in the hospital (44%), screen-film in the ED (40%) or screen-film within Radiology (48%). Only 16% of the survey sites had duplicate CR capacity within the ED as a backup option. The downtime recorded in this survey, with over 20% reporting downtimes in excess of 50%, is not negligible and shows the importance of having a backup capability in any ED department if continuous patient coverage is to be available. This need for a reliable back up for CR in the ED setting may be one of the most important reasons for the limited use of CR in EDs as demonstrated by the small number of users (35) we were able to identify

Table 8. Back Up System Summary (N = 37)

Type of Back Up	No. Responses	%
Other CR in ED	4	16
Other CR in Hospital	11	44
S-F in ED	10	40
S-F in Radiology	12	48

Abbreviations: CR, computed radiography; ED, emergency department; S-F, screen-film.

Table 9. Satisfaction with Computed Radiography by Radiology Personnel (N = 25)

Rank	No. Responding	%
Highly satisfied	13	52
Somewhat satisfied	12	48
Neutral	0	0
Somewhat dissatisfied	0	0
Highly dissatisfied	0	0

Table 10. Satisfaction with Computed Radiography by Emergency Department Personnel (N = 25)

Rank	No. Responding	%
Highly satisfied	12	48
Somewhat satisfied	10	40
Neutral	3	12
Somewhat dissatisfied	0	0
Highly dissatisfied	0	0

through contacts with all the major vendors, advertising on the Internet, and personal contacts.

Tables 9 and 10 summarize the overall satisfaction with the CR systems within EDs by Radiology personnel and ED personnel, respectively. Radiology departments are very happy with the introduction of CR into the ED setting with approximately half reporting to be highly satisfied and half reporting to be somewhat satisfied. The degree of satisfaction by ED personnel was similar with about half reporting to be highly satisfied, 40% somewhat satisfied, and the remainder being neutral.

CONCLUSIONS

Radiology departments were very happy with the performance of CR in the ED setting with approximately half being highly satisfied and half somewhat satisfied. The degree of satisfaction by ED personnel was similar to that of radiologists with about half being highly satisfied, 40% somewhat satisfied, and the remainder neutral. Not a single respondent was in any way dissatisfied with the performance of CR in the ED, thereby showing that this technology can play a valuable role within the ED setting.

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APPENDIX 1
Computed Radiography in the Emergency Department (ED) Questionnaire

Name of respondent (optional) _____

Phone number (optional) _____

Hospital name (optional) _____

Questionnaire Respondent:
- Radiologist ( )
- Technologist ( )
- Administrator ( )
- Physicist/Engineer ( )
- Other ( ) _____

Number of hospital beds:
- <100 ( )
- 100-200 ( )
- 200-500 ( )
- >500 ( )

Trauma Center:
- Level I ( )
- Level II ( )
- Level III ( )
- Other ( ) _____

Emergency Department specifics:
No. of rooms _____ : No. of x-ray tubes _____

APPENDIX 1
Computed Radiography in the Emergency Department (ED) Questionnaire (Continued)

Patients who need x-rays in Emergency Department each day:
Average no. of x-ray examinations: _____

Average no. of radiographs taken: _____

Comments (e.g. maximum throughput required): _____

Distance from ED to the Radiology department:
Same building? Yes ( ) No ( ) Same floor Yes ( ) No ( )
ED to Radiology: Distance _____ Yards: Time _____ minutes

Type of CR used in Emergency Department:
CR #1 Manufacturer/Model: _____

Type of imaging plates in use: _____

Installation date (mm/yr): _____

CR #2 Manufacturer/Model: _____

Type of imaging plates in use: _____

Installation date (mm/yr): _____

Is the CR interfaced to your Radiology Information System (RIS)? _____

If so, please specify RIS system and demographic data input into the CR: _____

What % of ED radiographs are currently performed with CR? _____

Comments: _____

Specify (any) type(s) of radiographic examination(s) in your ED setting that you elect NOT to perform using CR and why: _____

What % of CR images are printed to film? _____

Where are CR images printed? _____

Comment: _____

What % of CR images are sent to clinician (non-radiologist) workstation? _____

Specify type/number/location of (any) clinician (non-radiologist) workstations: _____

What % of CR images are sent to radiologists workstations? _____

Specify the type/number/location of (any) radiologist's workstations: _____

APPENDIX 1

Computed Radiography in the Emergency Department (ED) Questionnaire (Continued)

Benefits of CR in Emergency Department:	Minor	Moderate	Major	Not Applicable
Ease of use:	( )	( )	( )	( )
Reduces repeat rate:	( )	( )	( )	( )
Eliminates film chemistry:	( )	( )	( )	( )
Reduces patient doses:	( )	( )	( )	( )
Improves image quality:	( )	( )	( )	( )
Eliminates lost films:	( )	( )	( )	( )
Image processing:	( )	( )	( )	( )
Prompt image availability:	( )	( )	( )	( )
Teleradiology access:	( )	( )	( )	( )
Improves patient flow:	( )	( )	( )	( )
Improves image delivery:	( )	( )	( )	( )
Improves RT efficiency:	( )	( )	( )	( )
Improves ED/MD efficiency:	( )	( )	( )	( )
Other (specify):				
_____:	( )	( )	( )	( )
_____:	( )	( )	( )	( )
_____:	( )	( )	( )	( )

Limitations of CR in Emergency Department:	Minor	Moderate	Major	Not Applicable:
Expense:	( )	( )	( )	( )
Difficult to use:	( )	( )	( )	( )
Reliability:	( )	( )	( )	( )
Lack of suitable backup:	( )	( )	( )	( )
Increases patient dose:	( )	( )	( )	( )
Reduces throughput:	( )	( )	( )	( )
Lack of DICOM:	( )	( )	( )	( )
Limited cassette sizes:	( )	( )	( )	( )
ID entry process:	( )	( )	( )	( )
Limited viewing stations:	( )	( )	( )	( )
Image re-orientation:	( )	( )	( )	( )
Other (specify):				
_____:	( )	( )	( )	( )
_____:	( )	( )	( )	( )
_____:	( )	( )	( )	( )

Estimate the % downtime with your CR: _____

Comments (give reasons for downtime): _____

_____

Backup for CR:

Other CR system in ED	( )
Other CR in hospital	( )
Screen-film in ED	( )
Screen-film in Radiology	( )
Other (please specify)	( )

APPENDIX 1
Computed Radiography in the Emergency Department (ED) Questionnaire (Continued)

Overall degree of satisfaction of CR in an ED setting:

I. Radiology		II. Emergency Department	
Highly satisfied	( )	Highly satisfied	( )
Somewhat satisfied	( )	Somewhat satisfied	( )
Neutral	( )	Neutral	( )
Somewhat dissatisfied	( )	Somewhat dissatisfied	( )
Highly dissatisfied	( )	Highly dissatisfied	( )

Comment: _____

Miscellaneous comments:

Please return completed questionnaire to:

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