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Original Research Article

Cost benefit analysis of computerized radiography system in a tertiary care hospital

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ABSTRACT

Background: Computed radiography (CR) has presently proven to be both efficient and cost effective as against conventional radiography. Cost benefit and cost effectiveness analysis of a newly installed computerized radiography system in comparison with Conventional radiography set-up in a tertiary care hospital.
Methods: Costs incurred under major heads were calculated and compared for both Computerized and Conventional radiography systems. A brief survey regarding the overall clinician and patients response towards the newly installed CR system was carried out and results were calculated.
Results: CR system proves to be highly efficient tool in the department of radiology to provide not only better quality images and faster means of image acquisition and archiving but also higher rates of satisfaction amongst radiology staff, clinicians and patients. Overall cost-effectiveness as well as the consumer satisfaction of the new technology is good as compared to conventional radiography. CR reduces repetition of images due to artifacts caused by dark room procedures and due to the provision of multiple images on a single film an average reduction in film expenditure. It reduces waiting period for patients and increases level of satisfaction in clinicians working in critical care dept. and A&E dept. due to early processing of urgent films.
Conclusions: cost benefit analysis of CR over conventional radiography proved overall running costs are comparable to the conventional system with a breakeven point achievement in a couple of years since installation especially in a high turnover tertiary care health setup.

Keywords: Cost benefit analysis, Cost effectiveness analysis, Computerized radiography

INTRODUCTION

Computed radiography (CR) is an imaging system which utilizes the similar image capturing technique as the conventional radiography set-up however differs considerably in post exposure film processing. CR imaging is a five step process:

- X-ray image received on phosphor plate
- Image extracted from phosphor plate by Laser (Raw image)
- Raw image processed for quality improvement
- Final image in DICOM format
- DICOM image can be printed, burned on CD, or sent to PACS.[1-4]

The hospital where the study had been carried out is a 780 bed tertiary care hospital of armed forces where the

average workload averages around 45,000 patients in conventional radiology alone. CR system was formally introduced into the month of July 2015 in the department of radiodiagnosis. Since then it was observed that the patient as well clinician's satisfaction rates improved drastically.

This study was done statistically record and calculate the overall cost-effectiveness of the new technology as well as the rise in consumer satisfaction therein. Comparison was drawn between the overall major expenses incurred to the department in the six months of CR usage as against the use of conventional radiography in the previous six months period.

METHODS

The Radiology Department at the hospital is equipped with a Care View CR system which comes with two optical cassette readers, two post processing systems, and two computers for the storage of image and data and one film printer. A major benefit in the use of flexible phosphor plates is that the exposure source that is used with conventional x-ray films is also used with the advanced CR system. The phosphor imaging plates utilized in CR system function as a direct substitute for films used in conventional system. The transition from conventional film radiography to CR is relatively an uncomplicated proposition. Another most important feature of imaging plates is their reusability. The functional life of any imaging plate runs into thousands of times. However, for practical purposes, the life of the imaging plate largely depends upon its handling and usage. The ability to reuse the imaging plates thus drastically reduce the recurring cost, not to forget the reduction in cost of chemicals like developer and fixer that are used in conventional film radiography. For the year 2015 data of total conventional workload was collected and there were a total of 43,657 cases that utilized radiography as a diagnostic technique. Out of these from Jan-Jun 2015 (pre CR installation) the total number of cases were 22,320 and the latter half of the year (post CR installation) were 21,337. A cost benefit analysis was performed to ascertain the consumer response and the financial impact of this system. Performing a cost benefit analysis involves the following steps i.e. identifying the costs and benefits. For the study the following costs for conventional and computed radiography systems were identified.

- Film
- Processing Chemicals costs
- Cost of imaging plates: Rs 60,000/- per plate (10 plates were provided free of cost with the CR system)
- Cost of CR system: Rs 10,00,000/-

Though the total functional life of any CR system is difficult to predict however for the ease of calculation an arbitrary period of 10 years can easily be affixed as the total functional lifespan of the system, hence the total cost of the machine is to be divided 120 times so as to reach an average value of additional cost incurred in up gradation of the diagnostic radiography in the department.

Since the merits and demerits of installation of a technically advanced system cannot be entirely based on terms of cost, a small survey pertaining to the usefulness, efficiency and levels of satisfaction among the users was conducted within the hospital.

The questionnaire was simple, easy to understand and was based on the issues or problems faced by referring clinicians in the previous setting.

The questions are as follows

After introduction of the CR system in this hospital

- Are you happier with the quality of the films/clarity of the image? Y/N
- Do you find it more convenient to view all the images of patient on a single film? Y/N
- Has the waiting period for urgent films reduced? Y/N.

40 clinicians were interviewed comprising a balanced mix of general physicians, specialists and super specialists. The data was collected either personally or telephonically.

RESULTS

Out of the 40 clinicians interviewed, 34 were extremely happy about the film quality whereas 6 rated it satisfactory or above average. 22 clinicians said that it was far more convenient to have more than 1 image on a single film rather than a patient carrying multiple films while visiting for consultation. 13 clinicians were equivocal, whereas 5 preferred the single image, single film system. There was a 100 % positive response pertaining to the reduction of the waiting time. Clinicians mostly involved in critical care reported an increased level of satisfaction due to early processing of urgent films as the time is the most limited resource in the accident and emergency as well as critical care departments.

A limited survey was also carried out amongst the 5 radiologists and 6 residents present in the department. The feedback was largely positive with better film quality, wider latitude and the option of post processing being the most important advantages cited. The residents emphasized the fact that though the measurement of angles and ratios had become slightly more time consuming than conventional system, yet the CR system being more user friendly, working on console and calculating the angles and ratios was more accurate. The radiologists were happy about the improved quality of

images as well as the efficiency of the film processing and the overall increased diagnostic accuracy; however, it was also brought out that the spatial resolution of CR images is slightly inferior than that of conventional images which leads to missing out on the details like subtle bone erosions.

Table 1: Cost of items.

Item	Cost
X-ray film 17" x 14"	65/- per film
X-ray film 15" x 12"	49/- per film
X-ray film 12" x 10"	33/- per film
X-ray film 10" x 8"	22/- per film
Laser film 12' x 10"	61/- per film
Auto developer	610/- per kit
Auto fixer	1365/- per kit

Cost-benefit analysis (CBA), sometimes called benefit–cost analysis (BCA), is a systematic approach which calculates as well as compares the cost with the overall benefits and profits from the project. This technique is adopted to determine factors that provides a well laid out road map for planning and execution of policies for benefit in labor, time and cost savings etc.[2,3]

Cost benefit analysis has two major purposes

- To find out the feasibility of a new project tin relation to an institute or organization and also provide a systematic justification of the feasibility.
- To compare a new project or policy with the traditional one already in use, which requires comparison of total benefits against the additional cost incurred.

During the analysis the cost effectiveness of the CR system, the one-time cost of the setup and as well as the imaging plates was treated as a separate group since the initial expenditure of setting up the dark room with its supportive equipment was not available.

Moreover, the cost comparison between an already existing conventional set-up and a technically advanced, efficient, quality driven set-up can get skewed due to inclusion of its initial cost to the department.

The major cost analysis was carried out between the running costs of both systems with the additional cost burden incurred due to the wastages that are common with a conventional system.

It was noted that the film expenditure values alone were a benchmark as far as the usefulness of the CR system is concerned. The big difference between the 2 values can be attributed to the following 2 factors:

- The repetition of imaging due to faulty factors or other artifacts caused by dark room procedures were almost reduced to near 0%.
- Due to the provision of multiple images on a single film, an average reduction in film expenditure of almost 20-30% was seen.

Another major factor contributing to the cost-effectiveness of the CR system was the significant reduction in the expenditure of processing chemicals used in conventional radiography.

Table 2: Costs incurred in a conventional system in 6 months.

Items	Total expenditure of items in 6 months	Cost incurred
X-ray film 17" x 14"	65 x 2973	1,93,245/-
X-ray film 15" x 12"	49 x 6248	3,06,152/-
X-ray film 12" x 10"	33 x 20,014	6,60,462/-
X-ray film 10" x 8"	22 x 7892	1,73,624/-
Auto developer	610 x 12 (2 kits/month x 6)	7320/-
Auto fixer	1365 x 12 (2 kits/month x 6)	16,380/-
Total expenditure in conventional		13,57,183/-

A factor though not adequately worked upon in our study yet has a major contribution is reduction in the minimum manpower required to operate the whole setup. Once installed the whole system can be handled by a single operator effectively trained in CR. Training of the radiographers on the newly installed system can be considered another addition to the overall system installation cost, however the same could not be incorporated in the costing owing to the fact that hospital being a central government institution, the total cost of man hours spent on training a batch of radiographers was extremely difficult.

Table 3: Costs incurred in CR system in 6 months.

Items	Total expenditure of items in 6 months	Cost incurred
Installation cost factor	6 month x 8334/month	50,004
Laser film 12' x 10"	61 x 21830	13,31,630
Total expenditure in CR system		13,81,634/-

The minor cost advantage factor arising due to resale of used fixer solution was calculated to be approximately Rs 22800/- as 1 packet of fixer is used to make 19 liters of solution which is sold at around Rs 100/- per liter of used solution (19 x 2 (2 pkts/month) x 100 x 6 (months)). This cost was not included in the calculations keeping in mind the nuisance of collection, storage and auction process for the sale of used fixer solution, not to miss the valuable man-hours wasted in the process. The negative ecological

impact of the harmful chemical waste was an important reason too for not including the same in cost calculations.

From the above figures, the total difference between the 6 monthly expenditures on both systems can easily be calculated which stands at 24,451/-. Hence it can easily be summarized that right after the installation the CR system proves to be profitable as far as cost reduction is concerned; however, it is to be noted that the study was not merely working out the cost difference but to calculate cost effectiveness, hence with the added advantages that CR system brings with it are more than worth the additional cost incurred to the organization. It must be noted that the reduction in the number of total films printed during the latter half of 2015 is not due to less footfalls or lesser requisitions but due to enormous savings on films made possible by having multiple images on a single film as well as due to dramatic reduction in the film wastages prime reason of which remains the sub-optimal quality of the image.

DISCUSSION

Computed radiography (CR) has provided an easy entry point to PACS with much easier transition from screen film to digital radiography. An enhanced image and flexibility of post-exposure image improvement are well-known benefits of CR, which overall lead to reduced rates of repeated exposures to the same patient.[2] In conventional radiography, the radiographer has to choose between good contrast and good latitude, the image thus taken once cannot be readjusted for further changes. This drawback is apart from the other inevitable requirements for a dark room setup, provision for storage and disposal of the toxic chemicals like developer and fixer with additional burden of inflation affecting the price of both films as well as chemicals. In India, the price of films has seen a steady rise of almost 4-10% (depending on the manufacturer) over past few years. Another drawback that is well known to radiologists is the need to show different tissues in a single film for example high attenuation bones versus soft tissues of a body part. In the conventional system this would require several exposures increasing the total radiation dose to the patient thus blurring the risk-benefit edge of imaging. The ability of computerized radiography to image structures of different attenuation values has done away the need of repeat exposures for different tissues. Further adding up to the abovementioned advantage is ability to process the image with factors like brightness, contrast, sharpness enhancement and zooming etc. giving a wide dynamic range of image enhancement and a better processed film. The measurements to be taken over the films previously has been simplified by the instant result giving digital scale and angle marker.

A point worth noting is that even when the total difference between the numbers of patients in pre CR period is only marginally higher than that in post CR period (22320-21337=983), the difference in the total number of films expended in pre CR period far exceeds the number of films used in CR period. This difference owes to a simple advantage of CR system over conventional of accommodating multiple images on a single film.

Another benefit that comes with CR is PACS which enables the users to retrieve the images from the archive with simple ease. In the past many of the cases of lost images either at the patients or hospitals end not only caused inflated cost per patient due to repetition of study but also diagnostician's dilemma in inability to compare with previous images. Due to the fact that CR system requires only a standardized film in comparison to the convention, led to better inventory management. Storage and maintenance of the films was relatively more convenient in the latter half of the year.

Computed radiography's spatial resolution is considered inferior to conventional radiography and some of the senior clinicians as well as radiologists focused that getting used to resolution provided by the CR/DR system will take some time; however, for most of the clinicians and residents this limitation is considered clinically insignificant taking into account the benefits it provides. Another major advantage that was well appreciated after CR introduction was that it is more tolerant of under/over exposure (wide latitude).[5-10]

In a study done by Johnson Et al8,9,10, dose reductions between 50% to 95% were recorded scientifically at the centers that underwent transformation from traditional film to photostimulable phosphor plate systems. This study focused on skeletal radiography and showed significant reduction of about 20% to 50% patient dose, primarily noted during peripheral skeletal imaging.

An advantage not directly concerning the cost benefit is reduction the toxic waste generated by the radiology dept. as previously disposal of the used fixer and developer solutions was a significant task as the toxic elements present in the solution can cause serious ecological problems.

CONCLUSION

To conclude, CR system proves to be highly efficient tool in the department of radiology to provide not only better quality images and faster means of image acquisition and archiving but also higher rates of satisfaction amongst radiology staff, clinicians and patients.

Overall running costs are comparable to the conventional system with a breakeven point achievement in a couple of years since installation especially in a high turnover tertiary care health setup.

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