The Use of Soft Copy to Enhance the Interpretation of Hard Copy Digital Images

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Abstract

The Department of Radiology at Brooke Army Medical Center conducted a prospective comparison analysis of the utility of soft copy versus hard copy interpretation. We digitally acquired 218 examinations, storing the information on an optical drive. The acquired images were printed on Jlm for initial hard copy interpretation. In those instances where we felt that additional clarification was warranted, we accessed the entire data set on the Picture Archiving and Communication System (PACS).

The comparison analysis involved a total of 218 radiographic examinations. On 93 studies, (43% of the total) we determined that final radiological disposition required further assessment. Further evaluation by accessing and manually manipulating the data on the computer monitor occurred. Upon reviewing the data we found that in 37% of the 93 cases, soft copy access allowed us to come to a conclusion without additional imaging.

Introduction

Computerized imaging has been in use since the mid-1970’s. The computerized tomogram, commonly known as the CT scanner, started the revolution in digitally acquiring images. Digital angiography followed, also using digitally acquired images. The use of digital acquisition for general radiography is gaining greater acceptance as technology improves. All plain film radiography at our institution is captured as a digital image and stored on an optical disc. The images are printed on film from the digital data set for access by clinicians and interpretation by the Department of Radiology.

The goal of our institution is to phase out the use of hard copy, with all radiologists interpreting plain radiographs from the PACS (Picture Archiving and Communication System) monitor. As an initial step in accomplishing the goal of a filmless department, the efficacy of the utilization of the soft copy image with the capability of manually manipulating the image was evaluated. During staff review of after hours plain films, the soft copy images were accessed only if further information was deemed necessary by the staff radiologist. The images were manipulated on a high resolution monitor in an attempt to arrive at a firm radiological interpretation of the images. This report summarizes our experience in interpreting 218 studies obtained from the Emergency Department (ED) and Acute Care Clinic(ACC) during normal operations. The studies were acquired during on-call hours, where the initial interpretation was rendered by a resident radiologist. The next
morning, the studies were reviewed by a staff radiologist, at which time selected studies were accessed from the digital data set and manually manipulated on a high-resolution monitor. This study was performed to assess whether manual manipulation of soft copy could be used to enhance the interpretation of the hard copy image. We assessed whether the soft copy assisted in the interpretation of hard copy studies. The main criterion was whether a firm radiological diagnosis could be arrived at without resorting to further imaging of the patient or delaying the interpretation of the study.

Materials and Methods

System Configuration

The digital radiology system utilized at our institution is the Medical Diagnostic Imaging Support (MDIS) system. The images are acquired on a special phosphor coated plate utilizing standard radiographic techniques. The phosphor plate is scanned by a laser, which results in an image being digitally read into the computer. The image is initially stored on a hard drive (40 hard drives, each with 40 gigabytes) for rapid access, then it is transferred to an optical disk (200 disks, each 10 gigabytes) for permanent storage. We currently have approximately four years in the database, with images dating back to 1992.

The digital image is accessed in two ways, either by copying the image to laser film or by accessing the image on a monitor. The digital image on film can be read in the conventional manner. A high-resolution 19 inch 2K monitor (1536 x 2048 pixels of resolution) is used for reviewing and reading the soft copy images. The images were formed in a matrix that varied in dimensions from 1760 x 2140 pixels with a depth of 10 bits. The depth allows latitude for manual windowing of the image for better contrast and brightness control.

Study Design

All patients, including both adult and pediatric patients, who sought assistance at the Acute Care Clinic or the Emergency Department during after-duty hours on Fridays and Saturdays were entered into this study. The only criterion for being included in the study was that they required plain radiographic evaluation. These studies included all plain film studies, to include bone, chest, abdomen, genitourinary, and gastrointestinal. The studies were initially interpreted in hard copy by the resident who was duty. The next morning, the staff reviewing the hard copy would decide if the soft copy image would be accessed on the monitor. This determination was based on the ability to interpret the study without limitation. The reasons to access soft copy include difficulty assessing the retrocardiac region on chest radiographs, overexposure of the lungs with blacking out of the pulmonary markings, overexposure of the spine, especially in the lower thoracic region on lumbosacral studies, inability to assess the soft tissues on extremities due to overexposure secondary to the algorithm required for bone evaluation, and underexposure of the abdomen that obscured small calcifications and diluted contrast in the ureters.

The 218 studies consisted of 38 pediatric studies and 180 adult studies. These studies were obtained over a 3 month period. Each case consisted of one or more images as specified by the imaging protocols. Previous studies, which were in the database system, were able to be brought up in soft copy for immediate comparison. This aspect of the digital database was helpful for chest radiographs, especially in the older patient. There were 146 skeletal, 60 chest, and 15 abdominal studies. Of the
218 studies, 43% (104 studies) of the hard copy images required access of the soft copy images. The soft copy manipulation and access to the database assisted the radiological interpretation in 34 (37%) of the 104 cases. The types of studies accessed and the types of areas being evaluated are summarized in Table 1 and Table 2.

### Results

43% of the 218 studies, a total of 104 studies, reviewed by staff warranted access to the soft copy image to manipulate the data set to clarify areas of the images. The areas that needed clarification varied according to the study. The chest studies accessed required clarification of the retrocardiac regions and the bony structures (ribs and thoracic spine). Spinal studies needed clarification of the posterior elements. Extremity soft tissues were usually burned out, requiring the extra windowing ability of the soft copy to assess for swelling and other soft tissue defects. The use of soft copy manipulation helped with evaluation of these areas. It allowed a firm radiological diagnosis to be reached without recalling the patient for further imaging. Soft copy manipulation also enabled the radiologist to render an unambiguous interpretation of the study.

Another aspect of significant value was the availability of the images in the digital database for the review of staff after the hard copy images had been removed for clinical reasons. This was probably one of the more helpful aspects of digitally acquired images. The ability to access a database spanning up to four years became useful for accessing older studies within the system for comparison, particularly for the comparison of chest radiographs in the older patient.

Selected cases in which the use of soft copy manipulation proved useful are as follows:

1. A trauma patient was noted on the images of the pelvis to have an old fracture of the superior pubic ramus and the pubic bone on the left. Due to the nature of the trauma, a new fracture was difficult to exclude. The underexposure of the film on the hard copy images obscured the bony detail. Accessing this study on the monitor
allowed windowing which enabled complete
evaluation of the area, leading to the
exclusion the possibility of a new fracture.

(2) Another patient arrived with
the complaint of a twisted ankle. Review of
the hard copy images revealed the presence
of an old well-healed fracture. The soft
tissues were not visualized well secondary
to overexposure of the image. With the
windowing capability of the monitor, the
soft tissues were found to be swollen. A
new small avulsion fracture of the distal
fibula was identified on the soft copy image.

(3) An older patient arrived with
chest pain and shortness of breath. The
chest radiograph demonstrated findings
consistent with congestive heart failure,
which included cardiomegaly, cephalization
of the vascular markings, and peribronchial
cuffing. This study also showed
parenchymal streakiness consistent with
chronic scarring or acute atelectasis. The
older studies were accessed from the digital
database for comparison. This revealed that
the streaky density was old. It was
unchanged from the prior study, which
most likely represented scarring.

(4) An older patient with low
back pain arrived at the Emergency
Department. The images obtained appeared
overexposed, obliterating much of the soft
tissue and bone detail. The images were
windowed on the monitor, which allowed
the staff to evaluate all aspects of the study.
This included the ability to visualize the
lower thoracic spine, the posterior spinal
elements, and the distal sacrum. Soft copy
manipulation allowed the review of the
images without recalling the patient to
repeat the study.

(5) A trauma victim came in
with a gunshot wound to the chest. The
portable chest radiograph was
underexposed, leading to poor visualization
of the soft tissues and the lung apices. With
soft copy manipulation, these areas were
windowed to a more optimal level of
visualization. This allowed complete
evaluation of air within the soft tissues
extending to the axilla, indicating a more
serious injury to the chest than originally
suspected.

This is a small sample of the
studies in which access to a digital database
system improved the timeliness and
accuracy of the radiological interpretation.
Without access to soft copy for
manipulation of the images, the
interpretation of the images would include
disclaimer statements, usually including
recommendations for further imaging. This
could lead to inconvenience for the patient
and the clinician. In addition it would
increase the cost of the visit in terms of time
and money. Access to a database which
included more than four years of studies
increased the accuracy of the evaluation of a
study, particularly chest radiographs in
older patients. Prior to the establishment of
the digital database, images which required
comparison with older studies to assess the
chronicity of a potential abnormality were
placed aside until the next business day, at
which time the appropriate file for the
patient would be pulled to compare with the
current study. With the digital database,
the old studies are usually available in soft
copy format, allowing immediate
comparison and clarification of the
chronicity of an abnormality.

Discussion

Prior studies in the literature
compared the reading of a digitized image
to the reading of the actual radiograph (1).
In those studies, the original image was
obtained on a standard film screen
combination. This image was digitized and
reviewed on a high resolution monitor. In
our study, the image was obtained by
creating a digital dataset based on shades of
gray, which were converted to an image for
reviewing on a high resolution monitor.
For convenience, the image was also transferred to laser printed film for hard copy review.

In prior studies, the digitized image did not have the clarity of the original image, even with soft copy manipulation. This led to several false observations, either positive or negative, when the image was read later on hard copy (1). Another problem with the accuracy of soft copy reading of a digitized study was in the detection of subtle orthopedic fractures. Utilizing a digitized image on a monitor, several fractures were missed. The cause of these missed fractures was from the resolution of the system, the monitor and the digitized image. (2)

In our system, the image was acquired digitally. The image has a greater depth, which allowed manipulation of the soft copy to accentuate certain areas of the radiograph. The digital image displayed on the monitor had a third dimension available to the radiologist for enhancement of the image. The soft copy manipulation of the image added to the information available for the interpretation of the image. This in turn led to a firm radiologic reading and diagnosis of the study.

In 34 of the 104 studies which were felt to need soft copy manipulation (34%), the use of soft copy manipulation made a difference in the radiological reading of the study. The soft copy manipulation clarified regions of the radiograph, which prior to this technology, would have required a disclaimer within the report or further imaging of the patient. These areas include the retrocardiac region, the soft tissues on a bone study, the upper lungs in a trauma victim, and over- or under-exposed studies.

In conclusion, we feel that soft copy manipulation can enhance the radiological interpretation of a study in approximately 34% of cases. By allowing the radiologist to change the contrast and brightness of an image, further information can be obtained. This information usually led to a firmer radiological interpretation of the study, thus better assisting the clinician in obtaining a diagnosis.

The opinions expressed in this article are those of the authors and should not be considered official or the views of the U.S. Army or the Department of Defense.

References
