Does Use of a PACS Increase the Number of Images Per Study? A Case Study in Ultrasound

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The purpose of this study was to determine if the use of a picture archiving and communications system (PACS) in ultrasonography increased the number of images acquired per examination. The hypothesis that such an increase does occur was based on anecdotal information; this study sought to test the hypothesis. A random sample of all ultrasound examination types was drawn from the period 1998 through 1999. The ultrasound PACS in use (ACCESS; Kodak Health Information Systems, Dallas, TX) records the number of grayscale and color images saved as part of each study. Each examination in the sample was checked in the ultrasound PACS database, and the number of grayscale and color images was recorded. The comparison film-based sample was drawn from the period 1994 through 1995. The number of examinations of each type selected was based on the overall statistics of the section; that is, the sample was designed to represent the approximate frequency with which the various examination types are done. For film-based image counts, the jackets were retrieved, and the number of grayscale and color images were counted. The number of images obtained per examination (for most examinations) in ultrasound increased with PACS use. This was more evident with some examination types (e.g., pelvis). This result, however, has to be examined for possible systematic biases because ultrasound practice has changed over time since the authors stopped using film routinely. The use of PACS in ultrasonography was not associated with an increase in the number of images per examination based solely on the use of PACS, with the exception of neonatal head studies. Increases in the number of images per study was otherwise associated with examinations for which changes in protocols resulted in the increased image counts.

KEY WORDS: PACS, ultrasound, workflow, archiving

The Ultrasound Section of the Department of Radiology of the University of Pennsylvania Medical Center (UPMC) provides diagnostic ultrasound examinations for inpatients and outpatients. Exceptions to examination types performed are breast and carotid studies. The patient population is chiefly adult because the Children’s Hospital of Philadelphia is immediately adjacent to UPMC and serves the pediatric population. UPMC does have a neonatal intensive care unit, so the Ultrasound Section performs examinations in that unit. In addition to the section in UPMC, the department also provides faculty for the Ultrasound Section at Presbyterian Hospital, a UPMC affiliate approximately 1.5 km from UPMC. The Ultrasound Section at UPMC performs approximately 17,000 examinations per year with an additional 5,000 examinations at Presbyterian. The section staff consists of 11 technologists, an aide, and 9 radiologists (some of whom cover clinical areas in addition to ultrasound). Three radiologists of the group have primary responsibility at Presbyterian Hospital, but all staff rotate through both facilities.

In the section at UPMC, the Department has 8 ultrasound machines with a ninth machine used for portables. There are 4 Phillips/ATL Ultramark 9 HDI, 2 HDI 3000 systems, and 2 HDI 5000 machines (Phillips/ATL; Bothell, WA). Portable studies are done with one of the ATL HDI 3000 machines. The Section also has

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a General Electric Logiq 700 (General Electric Medical Systems; Milwaukee, WI) machine in the Emergency Department (ED) that is dedicated to doing ED examinations. A Medison VoluSon (Kretztechnik, Austria) machine used for three-dimensional ultrasound rounds out the department machine complement. At Presbyterian Hospital, the Section has an ATL HDI 5000 and an HDI 3000.

The core of the ultrasound PACS is a Kodak (Kodak Health Imaging Systems, Dallas, TX) ultrasound image management system. This system is no longer manufactured by Kodak; however, it is still in full operation at UPMC and Presbyterian Hospital. The system consists of a DICOM-conformant network (IEEE 802.3; 100BaseT), 6 Model 100 workstations, 9 cine loop-capable image acquisition modules (ACCESS acquisition modules; ANFS), a file server/database (ACCESS Network File Server; TANES), and a Hewlett-Packard 144-platter magneto-optical disk jukebox. Also connected to the network are a Kodak 2180 laser imager with processor and Printer Interface Unit (Kodak Health Imaging Systems, Dallas, TX), and a Codonics color paper printer (Codonics Inc, Middleburg Heights, OH). The ATL HDI 5000 machines at UPMC and the Medison VoluSon have direct connections to the PACS network via built-in DICOM interfaces. An earlier report describes some of the history and development of the system and film cost savings resulting from its use.

In previous work, the investigators described the time savings for technologists based on eliminating the handling of film. The background for the hypothesis of this study, that picture archiving communications system (PACS) use in itself might increase the number of images per examination, was based on the much-reduced labor associated with recording images. Instead of having to remove and exchange film cassettes during the examination, both the move to laser-printed film and PACS eliminated the task. However, centralized laser printing did not eliminate the task of the technologist having to go to the printer to pick up the films. Use of the PACS eliminated this additional task. In effect, acquiring images when using PACS required much less effort for the technologist. This led to the speculation that the technologists might, therefore, take more images per case. The ready applicability of PACS to ultrasonography also has been well documented by Choplin et al., Wolman et al., and Mattheus et al. in the early 1990s.

MATERIALS AND METHODS

As part of a study of activity-based costing done in the ultrasound section, detailed information about the cost of all aspects of performing an examination were accumulated. Among these were a set of data about the number of sheets of film (multiformat camera and laser printed) and number of color prints made per examination. The section had standardized on the number of images per sheet of film and paper (6 on 1 for multiformat films, 15 on 1 for laser-printed film, and 6 on 1 for paper color prints). These data were stratified by the type of examination performed and were accumulated prospectively during the 1994 through 1995 period. The ultrasound PACS was installed in late 1995, but was only interfaced to 3 machines at the time. By November 1996, the system was connected to all but one machine, and the section decided to reduce film usage. At first, a single sheet of film was printed per case, but the studies were read from the workstations. Shortly thereafter (December 1996), the system had proven reliable enough to discontinue printing film. On moving from a temporary location (necessary by Departmental construction) to a new area in the department, the laser printer that had been dedicated to ultrasonography was dropped from the installation plan. Since December 1996, the ultrasound section has been “filmless” for diagnosis. Films still are printed for patients referred to outside institutions, for medicolegal reasons, and for some teaching conferences.

The data on the number of films per examination from the cost study were used as the film “baseline.” For the PACS images, the system database keeps a count of the number of black and white and color images in each examination. To obtain a sample of examinations for the PACS part of the study, examinations were selected at random from section log books. To obtain a sample that reflected the practice of the section, however, there were approximate target numbers for each of 12 examination types that corresponded to those of the film baseline. PACS data were accumulated retrospectively for the 1998 through 1999 period. This period was chosen because it was after the system had been in full use for a year, reducing the “learning curve” bias. Also, the system had been very stable and reliable over this period, so the technologists and radiologists had few concerns about images being “lost.”

The film data consisted of lists of the number of sheets of film (8" × 10-inch multiformat and 14" × 17-inch laser print) and color paper used per examination. To translate these into numbers of images, the number of sheets of each type of medium was multiplied by the number of images usually recorded per sheet. By the time the data were accumulated, the printing formats were standardized within the section. The potential error introduced by this method (from partially exposed sheets of film or paper) is discussed subsequently.