

A Low-Cost Web-Based Tool for Pediatric Echocardiographic Consultation

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Introduction

Echocardiography provides important information for physicians in diagnosing heart disease. Due to issues of cost, personnel, and availability of qualified individuals, echocardiography has not been used to its full potential, especially in rural areas. Telemedicine applications linking physicians to underserved areas are increasing in number, especially in the area of radiology.^{1,2} Real-time echocardiography is limited in the number of telemedicine rural sites. A store-and-forward system collects electronic information and stores it on a telemedicine system for viewing by a physician at a later date. This method of consultation of echocardiograms has been studied previously. However, the equipment used was not adequately integrated or interchangeable with other diagnostic equip-

ment and was very labor-intensive for the purpose of their study.³ Echocardiograms have also been transmitted over regular telephone lines at 14 kbs (thousand bits per second). However, this resulted in large file transfers and required the technician to choose the selected segments to be studied by the consulting physician.⁴ With the availability of web-based systems, physicians who do not have access to a pediatric cardiologist could use a low-cost web-based tool for consultation.

Materials and Methods

A pediatric cardiologist randomly selected 10 analog echocardiographic videotapes. Each tape had approximately 3 to 4 segments. The videotapes were reviewed by one of the cardiologists involved in this study, and 34 clinically relevant segments were cho-

sen. Next, specific diagnoses of the overall disease found in the study were given to each tape and individual segment. The clinically relevant segments were captured as Audio Video Interleave (AVI) files and compressed using a standard videocassette recorder and a Pentium II-based computer, having a low-cost Broadway 2.0 videocapture card. After capturing the segments into AVI files, they were then compressed to MPEG I files to reduce the size of the file to be transferred. The size of each file was recorded, before and after compression, along with the length of the original segment. These files were randomized, coded, and transferred via file transfer, using an ISDN line to an encrypted web server. A prospective study was undertaken comparing the interpretation of the original tapes and of the MPEG I files. The MPEG I files were then viewed by two cardiologists, one of whom originally selected the clinically relevant segments and the other physician blinded to the study. The cardiologist who originally selected these segments reviewed them again after 6 months for the purpose of this study. The files were viewed on the physicians' own personal computers. The 2 physicians were asked to

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give their interpretation of each segment and the overall diagnosis or interpretation of the patient's disease. They were also asked to judge the quality of the tapes using a scale of 1 to 4: 1 being very poor quality and 4 being excellent quality. A third physician, a senior fellow in pediatric cardiology who was also blinded to the study, viewed the original segments on the original videotapes. He was then asked to give his interpretation of each segment, along with his overall impression, and grade of the quality of the tapes using the same scale as the previous physicians. Finally, a fourth physician subjectively judged 'agreement' or 'disagreement' of all individual segments, overall impressions, and quality of the tapes and MPEG I files.

Results

The average length of each segment was 16.7 ± 11.4 sec (mean \pm SD). The initial capture resulted in the average file size as $19,954$ kb \pm 9976 . After compression, the file size decreased to $2,359$ kb \pm $1,470$. The segments of the echocardiograms involved were atrial septal defect, right ventricular hypertrophy, patent foramen ovale, ventricular septal defect, aortic arch anatomy, coronary arteries, coarctation of the aorta, cardiac thrombus, valve vegetations, and hypertrophic cardiomyopathy.

There was 100% agreement in the overall diagnosis among the 3 physicians viewing these images, regardless of whether they were viewed as the original echocardiogram videotapes, or as a MPEG file. With regard to diagnosis of the individual segments, there was agreement with interpretation by at least 1 of the 2 pediatric cardiologists viewing the MPEG files 91% of the time. There was agreement 71% of the time with re-

gards to the pediatric cardiologist agreeing with the original diagnoses on videotape. There was disagreement of the other's segments of the MPEG I files 21% of the time. The quality of the original videotape segments was rated as 'poor' or 'very poor' 24% of the time. The quality of the MPEG I files was rated as 'good' or 'Very good' 79% of the time. It was also observed that regardless of the quality, there was no direct relation to agreement or disagreement between the pediatric cardiologists and the senior pediatric cardiology fellow.

Discussion

This pilot project demonstrates that echocardiograms captured as MPEG I files can be sent by file transfer to an encrypted web site for review by consultants. Also, if need be, these files could be directly sent via email message to a pediatric consultant, although not shown through this study. In this project the quality was equal to that of the original tapes and had no impact on the overall clinical diagnoses. This has not been the case in previous studies, where transmitting pediatric echocardiograms over ISDN lines decreased the quality in the transmission, along with leaving undetected defects.⁵ However, with the advancement of present day technology, the loss in quality no longer occurs. This study supported our hypothesis that there was agreement in the interpretation of the original files and of the encrypted files. This agreement was present 100% of the time. However, the echocardiographer may need to have real-time guidance in obtaining appropriate images (noted in previous studies⁶) due to limited experience. Because the quality of the images is crucial, a preset protocol of the

images being recorded/transmitted could prove beneficial to the cardiologist and echocardiographer. This mode of consultation could assist in both cost and initial screening of cardiac disease when a patient is at a distance. Other factors that need to be considered are billing and medico-legal issues, as this is an ever-expanding mode of technology. Also, due to the rapid advancement in technology, the current MPEG has advanced from MPEG I to MPEG IV since the origin of this study. This mode of clinical consultation could be applied to all forms of medical technology today, including teleradiology, especially in the form of ultrasound images. At present, equipment is available for the viewing of real-time echocardiograms over analog telephone lines. Further outcome-based studies are needed to confirm our initial hypothesis.

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