A LOW-COST WEB-BASED TOOL FOR PEDIATRIC ECHOCARDIOGRAPHIC CONSULTATION

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SUMMARY

Objective

This pilot project explored the effectiveness of using a web-based tool to provide a clinically relevant, secure, low-cost and low-bandwidth means of pediatric echocardiographic consultation.

Methods

Thirty-four clinically relevant segments (3-4 segments per tape, n = 10) were captured as Audio Video Interleave (AVI) files and compressed to Moving Picture Expert Group I (MPEG I) files. A prospective study comparing the interpretation of original echocardiograms and echocardiograms viewed as MPEG I files either locally or on the web was undertaken.

Results

There was 100% agreement in the overall clinical diagnoses among all physicians, independent of whether they interpreted the original tapes or the MPEG I files on the web. There was agreement with the interpretation from the original echocardiogram segments 91% of the time by at least one of the two pediatric cardiologists viewing the MPEG I files. Both pediatric cardiologists viewing the MPEG I files agreed with the original videotape 71% of the time; they disagreed with each other's interpretation of the MPEG I files 21% of the time, regardless if they agreed with the original tapes or not. The quality of the original echocardiographic segments was rated as "good" 79% of the time.

Conclusion

Echocardiograms captured as MPEG I files agreed with the clinical diagnosis and the original echocardiogram. This may be a low-cost alternative in pediatric care and needs to be considered in clinical use.

INTRODUCTION

Echocardiography provides important information for physicians in diagnosing heart disease. Due to issues of cost, personnel and availability of qualified individuals, this 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 [3, 5]. Real-time echocardiography is limited in the number of telemedicine rural sites. A store-and-forward (SAF) 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 equipment and was very labor intensive for the purpose of their study [2]. Echocardiograms have also been transmitted over regular telephone lines at 14 kband (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 [6]. With the availability of web-based systems, physicians who do not have access to a pediatric cardiologist could be adapted to a low-cost web-based tool for consultation.

MATERIALS AND METHODS

A pediatric cardiologist randomly selected ten 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 chosen. 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 (VCR) 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, both, 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 webserver. 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 six months for the purpose of this study. The files were viewed on the physicians' own personal computers. The two physicians were asked to 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 – 4: 1 being very poor quality and 4 being excellent. 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 $\pm$ 11.4 sec (Mean $\pm$ SD). The initial capture resulted in the average file size being 19954 kb $\pm$ 9976. After compression, the file size

decreased to 2359 kb $\pm$ 1470. 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 three physicians viewing these images, regardless of whether they were viewed as the original echocardiogram videotapes or as a MPEG file. An example of the comparison of one segment is shown in Table 1. With regard to diagnosis of the individual segments, there was agreement with interpretation by at least one of the two pediatric cardiologists viewing the MPEG files 91% of the time. There was agreement 71% of the time with regards to the pediatric cardiologist agreeing with the original videotapes diagnoses. 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. [Table II]

DISCUSSION

This pilot project demonstrates that echocardiograms captured as MPEG I files can be sent by file transfer to an encrypted website for review by consultants. Also, if need be, these files could be directly e-mailed 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 [4]. 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 studies [1]) due to limited experience. Since 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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TABLE I: Comparison of the Diagnosis and Agreement/Disagreement

TAPE #	ORIGINAL DIAGNOSIS	PHYSICIAN 1	PHYSICIAN 2	PHYSICIAN 3	AGREE
1a	Intracardiac anatomy	TV, RV, PA	HLHS, ASD poor RV	ASD, L-R	YES
1b	Intracardiac anatomy	ASD	Same but color	RVH	YES
1c	Intracardiac anatomy	ASD	Mitral hypoplasia	Bovey interference	YES
1d	Intracardiac anatomy	Frozen Picture	ASD, bovey interference	Bovey interference	YES
2a	Coronary arteries, arch	Overriding aorta, VSD, ?RVH	VSD, aorta, no PA	VSD, aorta	YES
2b	Branching detail	TOF, PA, VSD	RV to aorta color	R-L flow	YES
2c	Branching detail	VSD, PA, good function	L-R flow PFO	PFO, ventricle size	YES
2d	Branching detail	VSD	Large VSD	Large VSD	YES
2e	Branching detail	L aortic arch	1st branch aorta	L aortic arch	YES
3a	PFO with aneurysm	PFO, foramen flap	PFO, aneurysm	PFO, aneurysm	YES
3b	Intracardiac detail	ASD, foramen	PS, no MR	RVH, stretched	NO
4a	Coronaries, LV function	LSA, circ	LAD coronary	LAD coronary	YES
4b	Aortic valve detail	LCA, LAD	LM coronary	LM coronary	YES
4c	Aortic valve detail	AoV 3 leaflets	L coronary	L coronary	YES
4d	Aortic valve detail	Function m-mode	LV function	LV function	YES

4e	Aortic valve detail	RCA	R coronary	R coronary	YES
5a	Aortic coarctation	R aortic arch	Coarc, PDA	Coarc, PDA	YES
6a	Intracardia thrombus	LA thrombus	Thrombus	Echogenic spot	YES
6b	Vegetation	VSD, thrombus	Irregular mass	Thrombus	YES
6c	Vegetation	Mobile LA thromus	VSD, mass	VSD, mass	YES
7a	Prosthetic aortic	S/P Ao valve	Prosthetic valve	Abnormal Ao valve	YES
7b	Prosthetic aortic	S/P Ao valve	Abnormal valve	Abnormal valve	YES
8a	Tiny musc VSD	PDA	Flow MPA	Flow MPA	YES
8b	Aortic arch detail	Musc VSD, PFO	LA/LV dilated	LA/LV dilated	YES
8c	Aortic arch detail	PDA	Large PDA	Large PDA	YES
9a	Intracardiac anatomy	PFO L-R flow	PFO, L-R flow	PFO	YES
9b	Aortic arch details	Normal ventricle	Normal anatomy	Large RV	NO
9c	Aortic arch details	ASD/PFO L-R flow	Normal anatomy	RVH	YES
9d	Aortic arch details	?ASD/?PDA	Aortic valve	Pul valve	NO
9e	Aortic arch details	Ao innv superiorly	L aortic arch	L aortic arch	YES
9f	Aortic arch details	PDA	Major arterial branch	Flow arterial vessel	YES
10a	Hypertrophic cardiomyopathy	IHSS MR	Hypertrophic cardiomyopathy	Hypertrophic cardiomyopathy	YES
10b	Hypertrophic cardiomyopathy	Severe IHSS	Septal hypertrophy	LVOT	YES

10c	Hypertrophic cardiomyopathy	Thick IV septum	Septal hypertrophy	Septal hypertrophy	YES

TABLE II: Quality of Echocardiograms

TAPE #	PHYSICIAN 1	PHYSICIAN 2	PHYSICIAN 3	AGREE
1a	1	2	2	YES
1b	1	2	2	YES
1c	1	1	2	YES
1d	1	1	2	YES
2a	4	4	4	YES
2b	4	4	4	YES
2c	4	4	3	YES
2d	4	4	4	YES
2e	3	4	5	YES
3a	4	4	4	YES
3b	5	5	4	YES
4a	4	5	5	YES
4b	4	3	5	NO
4c	4	4	5	YES
4d	3	4	5	YES
4e	3	4	5	YES
5a	3	3	3	YES
6a	3	4	4	YES
6b	4	4	4	YES
6c	3	5	4	YES
7a	2	2	2	YES

7b	2	1	2	YES
8a	2	2	4	NO
8b	2	3	4	YES
8c	3	3	4	YES
9a	4	4	4	YES
9b	4	4	4	YES
9c	4	4	4	YES
9d	4	4	4	YES
9e	3	5	4	YES
9f	3	5	4	YES
10a	4	4	4	YES
10b	4	4	3	YES
10c	4	4	4	YES

KEY: 1 = VERY POOR QUALITY

2 = POOR QUALITY

3 = FAIR QUALITY

4 = GOOD QUALITY

5 = EXCELLENT QUALITY