Original Article

Feasibility study of first-year medical students identifying cardiac anatomy using ultrasound in rural Panama

Brianna Miner¹, Amanda Purdy¹, Laura Curtis¹, Kevin Simonson¹, Caleb Shumway¹, Jessa Baker¹, Jessica Vaughan¹, Kara Percival¹, Olivia Sanchez¹, Shadi Lahham², Linda Joseph², J Christian Fox²

¹ School of Medicine, University of California Irvine, Orange, CA 92868, USA

² Department of Emergency Medicine, University of California Irvine, Orange, CA 92868, USA

Corresponding Author: Lahham Shadi, Email: slahham8@gmail.com

BACKGROUND: There are over 15 million children who have cardiac anomalies around the world, resulting in a significant morbidity and mortality. Early recognition and treatment can improve the outcomes and lengthen life-expectancy of these patients. The NIH and WHO have promoted guidelines for screening for congenital cardiac anomalies using ultrasound in rural environments.

METHODS: Our study took place in Bocas Del Toro, Panama where a mobile clinic was established for community healthcare screening and ultrasonographic evaluation by medical student volunteers and volunteer clinical faculty. This was a non-blinded, investigational study utilizing a convenience sample of pediatric patients presenting for voluntary evaluation. Seven first-year medical students were recruited for the study. These students underwent a training program for advanced cardiac ultrasound instruction, termed "Pediatric Echocardiography Cardiac Screening (PECS)".

RESULTS: Ten patients were enrolled in the study. Nine patients had adequate images as defined by the PECS criteria and were all classified as normal cardiac pathology by the medical students, resulting in a sensitivity and specificity of 100%. A single patient was identified by medical students as having a pathologic pulmonic stenosis. This was confirmed as correct by a blinded ultrasonographer.

CONCLUSIONS: In this pilot study, the first-year medical students were able to correctly identify pediatric cardiac anatomy and pathology in rural Panama after undergoing a 12-hour ultrasound PECS training session. We believe that with this knowledge, minimally trained practitioners can be used to screen for cardiac anomalies in rural Panama using ultrasound.

KEY WORDS: Ultrasound; Panama; Rural medicine; Medical education

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INTRODUCTION

In the developing world, over 15 million children are affected by cardiac anomalies, resulting in a significant morbidity and premature death.^[1] This imposes a substantial burden on health care systems, especially those with limited resources. Early recognition and treatment can significantly improve outcomes and lengthen life-expectancy of these patients.^[2] With advanced imaging often financially out of reach for many in these populations, ultrasound has emerged as

a convenient and portable method of imaging in rural communities and austere environments.^[3–6] Furthermore, for the diagnosis of congenital heart disease, echocardiography has become a first-line imaging modality.^[7]

Since 2006, both the National Institutes of Health (NIH) and WHO have promoted guidelines for both screening and diagnosis of congenital cardiac anomalies. With rheumatic heart disease and congenital heart defects now being the most common cardiovascular ailment in

patients under 25, there has been a renewed focus on clinical screening programs in developing nations.^[1,8] In Latin America, a significant proportion of Panamanians live below the poverty line in rural communities resulting in a bimodal lifetime age distribution.^[9,10] This discrepancy results in disproportionately affected populations which can be attributed to the fact that many patients live in rural communities with unsanitary conditions and poor access to healthcare.^[11] With multiple recent international studies in Mexico and Africa using point of care ultrasound to screen patients for cardiac anomalies, there is hope that similar projects can have promising results in rural Panama.^[12,13]

In this project, a group of first year medical students traveled to Bocas Del Toro, Panama to visualize basic cardiac anatomy on pediatric patients. Combining the explosiveness of ultrasound in medical education and the need for pediatric cardiac screenings in rural settings, our aim was to determine if minimally trained first-year medical students were able to successfully identify pediatric cardiac anatomy and cardiac pathology in rural Panama.

METHODS

Study design and setting

This was a non-blinded, investigational study utilizing a convenience sample of pediatric patients presenting for voluntary evaluation between June 16, 2014 and August 10, 2014. The study was approved by the Institutional Review Board. Written consent was obtained by each subject's parent or legal guardian prior to enrollment. The study took place in Bocas Del Toro, Panama where a mobile clinic was established for community healthcare screening and ultrasonographic evaluation by medical student volunteers and an American-trained, board certified emergency medicine physician who completed emergency ultrasound fellowship. Ultrasound screening took place on selected

days throughout this time period. Any patient under 18 years of age was eligible for enrollment in the study. All patients were asymptomatic volunteers without any financial compensation.

Seven American-trained first-year medical students were recruited and consented for study enrollment. All students had completed an entire first year of medical education which included human physiology, human anatomy, cardiac anatomy and basic cardiac ultrasound. In addition, all seven students also received twelve additional hours of advanced cardiac ultrasound instruction, termed "Pediatric Echocardiography Cardiac Screening" (PECS), by the emergency ultrasound director at our institution. PECS included identification of cardiac pathology and structural abnormalities including interventricular septal defects, atrial septal defects, mitral regurgitation, mitral stenosis, tricuspid valve regurgitation, aortic regurgitation, aortic stenosis, and pulmonary stenosis (Table 1). To be considered qualified for cardiac screening, each student needed to demonstrate the ability to obtain the required cardiac views including parasternal long, parasternal short, apical 4 chamber, and apical 5 chamber and to perform the required techniques including color doppler and pulse wave or continuous wave doppler.

Intervention

Enrolled patients underwent cardiac ultrasonography done by trained medical students. For a patient to be considered for data analysis, all 4 cardiac views must be visualized and recorded. A sonosite M-turbo and Sonosite Edge (FUJIFILM Sonosite Inc) using a P21 5-1Mhz probe were used to enroll all patients. Per the PECS protocol, patients had parasternal long, parasternal short, apical 4 chamber, and apical 5 chamber views saved for review. Images were documented by the students as "normal" or "pathologic". A blinded board certified ultrasonographer then reviewed all images to determine adequacy of image quality and attempted

Table 1. Echocardiography views and values used to evaluate for structural abnormalities

Structural abnormality	PECS exam methods of evaluation
Interventricular septal defects	Color Doppler in parasternal long, parasternal short, and apical 4 chamber
Atrial septal defects	Color Doppler in parasternal short and apical 4 chamber
Mitral valve regurgitation	Color Doppler in parasternal long and apical 4 chamber
Aortic valve regurgitation	Color Doppler in parasternal long and apical 5 chamber
Tricuspid valve regurgitation	Color Doppler in apical 4 chamber
Mitral valve stenosis	Parasternal long, parasternal short, and measurement of peak diastolic velocity in apical 4 chamber
Aortic valve stenosis	Parasternal long and measurement of peak systolic velocity in apical 5 chamber
Pulmonic valve stenosis	Measurement of peak systolic velocity in great vessel view of parasternal short

Table 2. Age distribution of the patients included in this study

Age distribution	Number	%
0–5 years	2	20
6–10 years	4	40
10–15 years	3	30
16–18 years	1	10
Total	10	100

to identify pathology. All images and video clips were considered adequate if they obtained necessary views of cardiac anatomy. Saved video clips were then reviewed a second time by the ultrasound director at our institution.

Methods of measurement and outcome measures

The primary outcome of the study was to determine if first-year medical students were able to obtain adequate quality images to assess for cardiac anomalies in pediatric patients as determined by our board certified ultrasonographer. This outcome was defined by obtaining all adequate images required of the PECS criteria. A secondary outcome was to determine if minimally trained first-year medical students were able to identify any cardiac pathology that could be validated by review of a blinded ultrasonographer. All recorded video clips were reviewed by the blinded ultrasonographer to determine adequacy of image quality.

RESULTS

A total of ten patients were enrolled in this study. Their ages ranged between 3 and 17 years (Table 2). There was an equal number of males and females. A total of nine patients had all adequate images as defined by the PECS criteria and were all classified as normal cardiac pathology by the medical students. These video clips were reviewed by the on-site, blinded ultrasonographer and the ultrasound director of our department, resulting in a sensitivity and specificity of 100%. The ultrasound director was a board certified emergency medicine physician who underwent emergency ultrasound fellowship. A single patient was identified by medical students as having a pathologic pulmonic stenosis. This was identified on site by the blinded ultrasonographer and confirmed as correct by ultrasound director at our institution.

DISCUSSION

Given the prevalence of congenital heart disease in rural populations, multiple international studies

are evaluating the efficacy and utility of screening programs. Until recently, low-income countries and rural environments have relied on auscultation as the criterion standard to identify cardiac anomalies. This unfortunately has a variable and low detection rate. More recently, international trials in Europe, India and most recently sub-Saharan Africa have shown favorable outcomes of echocardiography as a screening tool.^[8,11,13,14] Beaton et al^[14,15] compared auscultation with protocolized echocardiography in sub-Saharan Africa. This study showed a significantly higher burden of disease than expected which was attributed to the poor sensitivity of auscultation for identification of such pathology. The study concluded that widespread ultrasound screening followed by comprehensive follow up for positive scans is key to successful programs. Although such screening programs can be promising, their screening is performed by residency trained physicians who may not always be available in rural communities.

Despite a thorough literature review, no clinical studies have been done in rural Panama to assess the ability of screening echocardiography to identify cardiac anomalies. Additionally, the ability of minimally trained medical students to identify cardiac pathology is not well understood.^[6,11] Our aim was to determine if minimally trained first-year medical students were able to identify basic cardiac anatomy. The development of basic ultrasound curriculum initiated early in medical education allows minimally trained practitioners early exposure to ultrasonography. This bodes well for rural communities where healthcare facilities are sparse. We hypothesized that if first-year medical students were able to accurately provide cardiac screening in such a rural environment, then local practitioners may be able to do so following a protocolized PECS training course.

Our study was unique in two ways. First, no previous studies have evaluated ultrasonography in rural Panama. Second, few studies have evaluated minimally trained practitioners ability to correctly identify normal versus pathologic cardiac anatomy in rural settings. Although our sample size was small ($n=10$), the high sensitivity and specificity suggests that the amount of training time and resources required for effective screening is low. Given the morbidity and mortality of congenital heart disease, greater access to cardiac screening would be a substantial health benefit to rural communities such as Bocas Del Toro, Panama, especially if minimally trained local practitioners could take part. Furthermore, the development of more portable and affordable ultrasound technology has allowed echocardiography screening to

enter even the most austere environments.^[16–18]

Interestingly, during the course of data collection, a single patient was found to have pulmonary stenosis during the screening event. This was reviewed and correctly identified by the on-site ultrasonographer during review of images. Based on these ultrasound findings, the patient had arrangements made for transportation to the nearest pediatric cardiac center. There, a radiology performed echocardiogram was done that again identified pulmonary stenosis and this patient underwent successful surgical repair. This success story brings into question the true prevalence of congenital heart defects in pediatric patients in rural Panama. Without adequate medical care and screening, the true prevalence of such disease is unknown. In our project, the total number of screened patients is low; however, further studies would need to be done to justify the use of resources for cardiac screening. Additionally, practitioners without advanced anatomy and physiology may need a modified training program to help screen for these pathologies.

While there needs to be larger-scale clinical trials to confirm out promising conclusions, future studies may include wireless transmission of images to be reviewed off-site and determine which patients can benefit from further testing. This would be instrumental in patients in remote locations. Additionally, for communities with limited financial resources and lack of access to primary care physicians, point of care ultrasound may prove useful for basic screening to help determine if patients even need advanced medical care. The increased access to low-cost ultrasound screening could prove beneficial in rural communities. Simplified training courses would also increase the number and type of personnel who can be involved in screening patients. Ultimately, additional studies are needed to adequately assess the efficacy of point of care ultrasound in the hands of minimally trained practitioners.

Limitations

Although the results of the study are promising, the total number of enrolled patients is low. Additionally, the study was done at a single site. Medical students were also exposed to additional ultrasound training during their first-year of medical school. Images were recorded and reviewed by on-site board certified physician. Future studies may have pre-defined definitions of abnormal findings. The PECS protocol may not be useful for practitioners who do not have advanced cardiac anatomy training. Decreasing the number of views required in

the PECS protocol may increase the number of patients willing to be screened. Having a cardiologist available to interpret all ultrasounds may be useful to help differentiate between pathology and normal variants although the findings listed in the PECS protocol can be identified by appropriately trained emergency medicine physicians

In conclusion, in this pilot study, first-year medical students were able to correctly identify pediatric cardiac anatomy and pathology in rural Panama after undergoing a 12-hour ultrasound PECS training session. We believe that with this knowledge, minimally trained practitioners can be used to screen for cardiac anomalies in rural Panama using ultrasound.

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Conflicts of interest: The authors declare that they have no competing interests.

Contributors: All authors have read and approved the final manuscript.

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