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Case Report

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The feasibility of telemedicine in pediatric cardiology

Abstract

Context: Lack of affordable and timely access to specialty medical care is a major contributor to Health disparities in the United States, but telemedicine are a promising solution to this problem. We looked specifically at the feasibility of using telemedicine in the general pediatrician's office to connect patients with a pediatric cardiologist.

Aims: To evaluate the convenience and feasibility of using commercial digital stethoscopes and portable electrocardiograms to connect a general pediatrician with a pediatric cardiologist.

Settings and design: General pediatricians (n=16) in Orange County, CA were provided smart phone compatible electronic stethoscopes and electrocardiograms.

Methods and material: General pediatricians made digital referrals to a pediatric cardiologist by obtaining and forwarding digital recordings of abnormal heart sounds as well as electrocardiogram strips to a remote pediatric cardiologist. Data collected included number of recordings as well as the outcome of the telemedicine referral. The general pediatricians involved in the study were then surveyed to determine its convenience.

Statistical analysis used: Each survey response was scaled between 1-10, and the responses were averaged for statistical analysis.

Results: The majority (78%) of telemedicine consultations did not require a referral for a face-to-face consultation and echocardiogram. Pediatricians reported moderate difficulty using the smart phone compatible stethoscope and EKG (6.3/10, 6.8/10 respectively). However, 78% were willing to use the technology if it were shown to improve access to medical care for their patients.

Conclusion: Telemedicine can potentially serve as a convenient, cost effective means to provide Patients with greater access to specialty medical care.

Keywords: telemedicine, pediatric cardiology, heart murmurs, arrhythmias, health disparities

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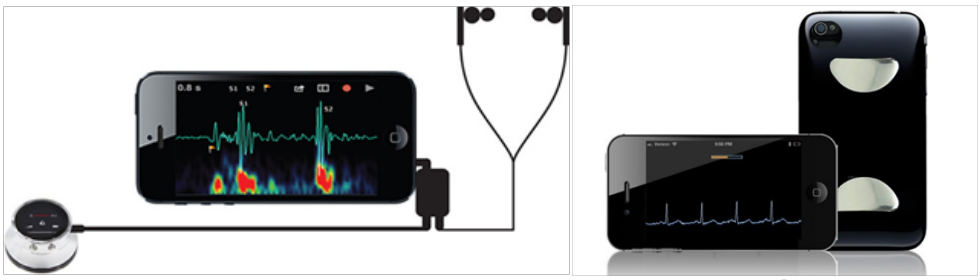
Introduction

Telemedicine is the delivery of health-related services and information via telecommunications technologies.[1,2] The two primary modes of telemedicine practice are "store and forward" and "real-time" videoconferencing.[3,4] In store-and-forward, tele health digital images, video, and audio recordings are captured and "stored" on the client computer or mobile device. At a later time, "stored" data is transmitted securely ("forwarded") and studied by relevant specialists who then responds with their opinion and recommendations.[1,4] Prior studies have demonstrated how this method increases patient access to tertiary care centers by overcoming geographical barriers.[5] There are currently several applications of telemedicine within the field of pediatric cardiology focused on discriminating between pathologic and benign murmurs and arrhythmias in children.[6,7] Studies have estimated that 80% of children will develop a murmur in their lifetime and less than 1% of these murmurs being pathologic.[8] Several electronic stethoscopes can accurately detect the difference between a benign and pathologic murmur with great sensitivity and specificity (95%, 96%, respectively), but the feasibility of it in practice remains in question.[8,9] However, it is unknown if general practitioners would be willing to use this new form of communication. In this feasibility study, we investigate the agreeability of general practitioners to use the technology as well as its convenience for the general practitioners.

Methods

The digital stethoscope (Figure 1A) allows for the recording and transmission of heart sounds via email (Thinklabs, Centennial, and Colorado).[10] The portable electrocardiogram consists of sensors connected to a smart phone via Bluetooth technology (Figure 1B) that record and transmit a single lead electrocardiogram (Lead I) in the form of a 30 second rhythm strip (Cardiac Designs, Round Rock, Texas).[11] General practitioners (N=16) were provided the portable electrocardiogram, digital stethoscope, and free corresponding smart phone apps ('ECG check' and 'Thinklabs Stethoscope App'). They were instructed on how to record heart sounds, record an electrocardiogram, insert basic history, and transmit that information via email to a board certified pediatric cardiologist. Practitioners were asked to send any suspicious heart murmur that may warrant a consultation to a board certified pediatric cardiologist. Heart sound recordings were sent from the position of the best sound quality. Rhythms were assessed by placing a patient's thumb on each sensor of the digital monitor. The patient population included neonates through 21 years of age and was a convenience sample. Patients with obvious



a. **b.**

Thinklabs 'One' Stethoscope and Cardiac Designs ECG Check Hardware

Figure 1A Image of the Think labs 'One' Stethoscope with digital recording capability and phonogram display shown.

Figure 1B ECG Check iPhone Case with ECG Recording Capability and Display shown.

signs and symptoms requiring a cardiology consult or those with preexisting cardiac conditions were excluded from the study. Informed consent was obtained from the parent and/or patient. No names were used in the data transmission. The University of California - Irvine Research Ethics Review Board approved the study. Outcome measures included the number of remote consults performed as well as satisfaction scores from the general pediatricians using a short survey approximately two months after they received the recording devices. The survey included 5 questions and reported scores on a scale of 1-10. Any score between 8-10 was classified as none to minimally difficult, between 4-7 as moderately difficult, and between 1-3 as very difficult.

Results

There were a total of 27 patients that the general physicians felt unsure as to whether a cardiology consult or further cardiac workup was warranted and submitted for a telemedicine consult. Of the 27 telemedicine consultations, 21 were determined to be benign or insignificant by the pediatric cardiology specialist not warranting an in person cardiology consult. From the consults, 5/27 was for arrhythmias and all were determined to be benign. Of these arrhythmias, 4/5 was due to sinus arrhythmia, and one rhythm tracing showed ventricular bigeminy. As a result, no arrhythmia consults required a referral for in person consultation. The 6/27 patients who had suspicious or indeterminate stethoscope findings were sent for an in-person cardiology consultation. The specialist considered the data quality unacceptable for interpretation (N=4) or a significant finding was found that warranted further workup (N=2). All 4 patients with unacceptable data quality were found to have benign findings on cardiology evaluation and the 2 patients with significant findings had small ventricular septal defects. Physician survey responses showed that on average, primary care physicians reported moderate difficulty (score of 6.4/10) in differentiating benign from pathologic murmurs (Table 1). Physicians in our pilot study showed only mild difficulty in obtaining a cardiology consult for their patients in a timely manner (average score of 9.2/10), which may be due to our study being limited to a large metropolitan area. Most of the physicians were willing to use new technology at the bedside if shown to improve the timeliness and ease of obtaining a consult (score of 7.8/10). However, 10/16 (63%) physicians did not send any consults. The two pieces of hardware including the stethoscope and electrocardiogram monitors had moderate user-friendly scores of 6.3/10 and 6.8/10 respectively.

Table 1 This table shows the average of the scores reported in the survey on a scale of 1-10 for each question. Scores 1-3 were rated was 'very difficult,' 'the worst,'' or 'unwilling' based on how the question was phrased. Scores 4-7 are considered 'moderately difficult,' 'considerable thought,' or 'mediocre.' Scores 8-10 were considered 'very easy,' 'very willing,' or 'excellent'

Averaged Reviews/Feedback from Participating Pediatricians

Question	Averaged Response (#/10)
"Using any number from 1 to 10, where 1 is 'very difficult and 10 is 'with ease,' how comfortable do you feel differentiating between a benign and pathologic murmur?"	6.4
"Using any number from 1 to 10, where 1 is 'very difficult' and 10 is 'with ease,' what number would you use to rate the ease with which you can get a cardiology consult for your patients in a timely manner?"	9.2
Using any number from 1 to 10, where 1 is 'not willing' and 10 is 'will use,' how willing are you to use any new technology at the patient's bedside if it were shown to improve the timeliness and ease of obtaining consults for patients?"	7.8
Using any number from 1 to 10, where 1 is the worst and 10 is the best, how would you rate the Thinklabs stethoscope as a user friendly item?"	6.3
"Using any number from 1 to 10, where 1 is the worst and 10 is the best, how would you rate the ECG check hardware as a user friendly item?"	6.8

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Discussion

Distinguishing benign versus pathologic etiologies of murmurs and arrhythmias is imperative to rule out congenital heart disease and life-threatening conditions.[12] General practitioners often come across cases that may or may not warrant additional workup. Immediate input from a specialist is usually not available and, therefore, these patients are referred for an in-person cardiology consultation, often at great expense to the families and the health care system.[13,14] As demonstrated by our study, many of these appointments and associated costs are unnecessary and inappropriate.[8,15] If the referral stems from ambiguity, early communication with a specialist may alleviate this concern. As a result, there has been health care models suggested that focus on enhancing communication between specialists and primary care physicians. A pilot started in Los Angeles, California (eConsult)[16] looked at the results of enhancing communication between specialists and primary care physicians.[16] The platform provided a medical messaging service in a secure and compliant manner, connecting general practitioners with specialists.

This 18-month pilot demonstrated a 60% reduction in wait times, 46% reduction in face-to-face visits, and rapid responses to clinical questions in under 3 days.[16] Our study went one step further in incorporating some of the now easily available digital applications that allow transmission of single lead ECG and digital heart sounds for review by a pediatric cardiologist. In comparison, our study utilized the enhanced digital recording tools for electrocardiograms and heart sounds and showed a 78% reduction in face time and rapid response within minutes. This study has shown that telemedicine has the potential to answer many clinical questions in the primary care setting using some of the commercially available tools for telemedicine. Several prior studies including Finley et al.[17] have shown these digital devices can have very high sensitivities and specificities.[8,9,17] Although the specific manufacturers and capabilities of each digital stethoscope used in these studies are different, the sensitivities and specificities reported in the studies were roughly equivalent. These devices may allow distant cardiologists to distinguish benign and pathologic murmurs or arrhythmias remotely providing effective cost savings and increased access to health care for the patient. Most general practitioners in this study reported moderate difficulty at baseline in distinguishing a benign versus pathologic murmur. We believe this model can assist these practitioners on a day-to-day basis when heart sounds are ambiguous. To our surprise, only 48% of physicians used the technology despite the reported 78% interest in using the technology. This disparity may reflect the comfort level using the technology as well as the pace of a busy practice. Data was not collected in regard to physician age and relative use, but it was qualitatively evident by report that the older physicians had greater difficulty using the technology. We believe that the level of use will approach reported interest levels with a better app user interface and further technical education.[18]

After all, by having additional tools that connect the general practitioner with the specialist, the primary care setting can provide an expanded scope of service to their patient population. Although our study was limited to the pediatric cardiology specialty with digital tools for recording heart rhythm and heart sounds, there is clearly the potential to expand its application to other fields of medicine as well as incorporate other digital tools such as ultrasound. Our pilot project was done in a metropolitan area where pediatric cardiology services are easily available. We predict that such tools can have an even greater impact in rural areas or the developing world where subspecialty services are not easily available. With this technology, doctors can make consults over long distances. Volunteers can be trained to use the technology, travel around the world and relay information over the internet to a specialist anywhere in the world.[1] As with any technology and telemetry service, we understand that there are limitations. There is the risk of false negatives where a significant finding could be missed. This is why we limited our study only to patients where the primary care physician felt somewhat unsure and excluded patients that had a clear indication for further workup. Future studies on outcomes will be paramount for risk stratification and development of these applications. We also acknowledge that data quality can be poor at times and not eliminate all unwarranted in-person consults. However, with advancements in technology, these abilities will only improve.

Conclusion

Telemedicine can provide greater access to specialized pediatric cardiology services in a primary care setting. Many patients were shown to have benign findings that were diagnosed using digital technology in an expedited manner. Ongoing advances in technology will make it easier to use this technology and also increase the accuracy of the data collection, especially with less compliant, younger children. The benefits of this technology include enhancing access to care for patients across the world, controlling health care costs, and providing direct support for general practitioners.

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Conflict of interest

The authors declared there is no conflict of interest.

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