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ORIGINAL ARTICLE

Telemedicine in Congenital Heart Disease

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ABSTRACT

BACKGROUND: The primary rationale for the development of telemedicine has been to serve populations that have limited access to traditional, high quality medical services. These include those living in rural areas or other underserved areas, like islands, or even urban areas when a rare medical subspecialty, such as pediatric cardiology is not available.

OBJECTIVE: The aim of the present study was to present our results with use of telemedicine during the European project TELEREMEDY over a period of 26 months when adult cardiologists and pediatricians of our hospital communicated with pediatric cardiologists at the tertiary Children's Hospital "Agia Sofia" in Athens and at the Royal Brompton Hospital in London, as well as with physicians at the "Venizelio" Hospital in Crete.

METHODS AND RESULTS: Over 26 months, 31 teleconference sessions were organized. During this period, 155 children with suspected congenital heart disease (CHD) underwent echocardiographic examination, which confirmed CHD in 83 (54%), acquired heart disease in 13 (8%) and normal anatomy in 59 (38%). Ventricular septal defect was diagnosed in 26/83 (31%), complex CHD in 20 (24%), atrial septal defect in 12 (14%) and patent ductus arteriosus in 8 (10%) children. Our hospital with the adult electrophysiology team was the expertise center for diagnosis and treatment of 30 children with arrhythmia.

During 23 sessions with the tertiary Children's Hospital "Agia Sofia" in Athens, an immediate transfer to the pediatric intensive care unit of the tertiary center was decided for 27 cases (17%). During 3 sessions with one participating hospital we provided consultation for 10 cases with arrhythmias. During 6 sessions with the Royal Brompton Hospital in London, rare cases of CHD, both adult and pediatric, were discussed. Two multilane conferences were organized among all participants and the systems capabilities in each hospital were discussed.

CONCLUSION: Telemedicine systems, like the one used herein in the context of the TELEREMEDY program, facilitate a timely diagnosis and management of children with CHD in hospitals lacking pediatric cardiology service. In the present series, use of this program obviated unnecessary and costly transfers in 83% of cases Thus, immediate access to specialists can guide patient management and thus may alter the morbidity and mortality in this patient population.

KEY WORDS: *pediatric cardiology; telemedicine; congenital heart disease; cardiac arrhythmias*

ABBREVIATIONS
CHD = congenital heart disease

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INTRODUCTION

Telemedicine involves the use of telecommunication technologies as a medium for providing medical information and services to consumers located at sites that are at a distance from the provider.[1-7] The concept encompasses everything from plain old telephone systems, to high speed, wide bandwidth transmission using fiber optics, satellites or a combination of terrestrial and satellite communication technologies. The peripheral software could be as simple as a typewriter used to type a letter seeking for an opinion, to high capacity parallel processing computers and imaging devices. Although the definition includes telephone, facsimile and distance learning, telemedicine is being used in a generic format for remote diagnosis and consultation at this time.

Pediatric Cardiology is a subspecialty that is lacking from many peripheral hospitals, and certainly from rural areas. Congenital heart diseases (CHD) are the most frequent congenital diseases. It is estimated that about 1% of live births have some form of congenital heart disease. Correct diagnosis is of critical value for proper management especially when it comes to critically ill neonates. Most of the regional hospitals in Greece lack pediatric cardiology teams and the pediatrician (sometimes with the aid of the adult cardiologist), is the first who deals with the neonate that is suspected to have or has congenital heart disease. Quick diagnosis and transportation of the critically ill neonate could be life saving, and avoiding unnecessary transportations could save a lot of money for the health care system on the other hand.

Echocardiography is one of the imaging modalities that can quickly and safely diagnose all forms of congenital heart disease, when conducted by experienced in the field physicians. Telemedicine has the ability to transmit echocardiographic images from one location to another either as video, digitized images, or digital data, even in real time with acceptable resolution. It is an invaluable tool for the inexperienced adult cardiologist and the pediatricians of the peripheral hospital who are caring for a neonate or a child with possible CHD and can communicate through the link with the experts in a tertiary center.

This was the idea of the project called TELEREMEDY (TELEmedicine for REmote diagnosis Management and EDucation in CHD) funded by the European Community (EC) and 6 regional hospitals in Europe. Our hospital participated in this project and we are herein presenting our data.

PATIENTS AND METHODS

For the duration of 26 months, adult cardiologists and pediatricians of our hospital, as part of the TELEREMEDY project, communicated with pediatric cardiologists at the tertiary Children's Hospital "Agia Sofia" in Athens and at the Royal Brompton Hospital in London, as well as with physicians at the "Venizelio" Hospital in Crete, using the TELEREMEDY program. Six hospitals (Santa Cruz and Red Cross in Spain in addition to the above mentioned) in Europe communicated through Euro-ISDN (Integrated System Digital Network) lines. The high speed of data transmission (64 Kbps per channel) permits on-line, real-time teleconference, transmission of ECG, x-rays and echocardiograms between the connected hospitals.

Our equipment included a) two personal computers, b) a video camera for transmission of picture and sound, c) two television sets for projection of picture and sound transmission among connected sites with the capability to transmit echocardiograms in real time as well as echocardiographic studies recorded on a video player, d) a document camera, for transmission of ECGs, x-rays and other printed material, e) two monitors and a sound transmission set for communication with the echocardiography and catheterization laboratories. We connected the videoconference room with our echocardiography laboratory, the neonatal intensive care unit and the catheterization laboratory through Hospitals Local Area Network. We also connected the hospital amphitheatre with these sites. Through these connections we were able to transmit moving and still images to the referral hospitals.

RESULTS

Over 26 months, 155 children with suspected congenital heart disease (CHD) were examined. The echocardiogram confirmed congenital heart disease in 83 (54%) children, acquired heart disease in 13 (8%) and normal anatomy in 59 (38%). Ventricular septal defect was diagnosed in 26/83 (31%), complex congenital heart disease in 20 (24%), atrial septal defect in 12 (14%) and patent ductus arteriosus in 8 (10%) of the children (Table 1). Our hospital with the adult electrophysiology team was the expertise center for diagnosis and treatment of 30 children with arrhythmia. Totally 31 teleconference sessions were organized.

During 23 sessions with the tertiary Children's Hospital "Agia Sofia" in Athens, decisions were taken about the optimal treatment plan of children with newly diagnosed congenital heart disease, whereas an immediate transfer to the pediatric intensive care unit of the tertiary center was decided for 27 cases (17%). During 3 sessions with one of the participating hospitals we provided consultation for 10 cases with arrhythmias. During 6 sessions with the Royal Brompton Hospital in London, rare cases of congenital heart disease, both adult and paediatric were discussed. Two multilane conferences were organized among all participants and the systems capabilities in each hospital were discussed.

We continued using the system beyond the 18-month pe-

TABLE 1. Results of the TELEREMEDY Program.

Duration (months)	26	
Sessions	31	
Patients	155	
Diagnoses		
Congenital heart disease (%)	83	(54%)
Acquired heart disease (%)	13	(8%)
Normal cardiac anatomy (%)	59	(38%)
Congenital heart disease	83	
VSD (%)	26	(31%)
Complex CHD (%)	20	(24%)
ASD (%)	12	(14%)
PDA (%)	8	(10%)
Immediate transfer (%)	27	(17%)
Consultations rendered (cardiac arrhythmias)	30	

ASD = atrial septal defect; CHD = congenital heart disease; PDA = patent ductus arteriosus; VSD = ventricular septal defect

riod and had an additional 5 sessions of teleconference with the other hospitals of our network. One of the project's aims was the development of a European registry of patients with CHD for facilitating management as well as for research reasons.

DISCUSSION

Our experience using the TELEREMEDY system was very favorable. We found that the medical community accepted this novel mode of communication with great interest because of the obvious advantages it had in facilitating diagnosis and treatment. Physicians in our hospital very soon became acquainted and fully accustomed with it. It was a great relief for pediatricians of our hospital to have access to expert pediatric cardiology consultation and service through collaboration with a team of adult cardiologists. Pediatric patients' parents were also very pleased to have a way to communicate with the experts "locally". They were also relieved to know that their critically ill neonate was managed in collaboration with a specialist through the telemedicine link getting stabilized and transferred under controlled conditions to the referral center, which is 240 km away from the city of Patras. It is also significant to mention that apart from the physicians who were using the system, technical support was always needed, and was provided by a specialized technician in our hospital.

Telemedicine is not a medical subspecialty, but a facilitator of all medical and surgical specialties. Although telemedicine dates back to1950s, it is a phenomenon that is currently being embraced enthusiastically by telecommunication providers, hardware and software manufacturers, medical care providers, policy makers and politicians alike.[2-7] The main purpose of such systems is to provide rapid access to the experts when a remote medical advice could be life saving. The proponents of distance health believe that in addition to providing specialty care for isolated communities, distance health can provide universal access to high quality medical care at an affordable cost.

Existing distance health applications can be grouped into three categories: 1) Remote diagnosis and consultation, primarily between a specialist and another health provider such as primary care physician, nurse practitioner or other allied health care provider, but can also occur between the health care provider and the patient, 2) Distance learning for continuing education, and 3) Research purposes, when a physician can have access to remote medical records, or exchange data with colleagues in a remote location.

The primary rationale for the development of telemedicine has been to serve those populations that, for one reason or another, have limited access to traditional, high quality medical services.[1-5,7] These include those living in rural areas or other underserved areas, like islands, or even urban areas when a rare medical subspecialty (i.e. pediatric cardiology) is not available. The geographic distribution of health care providers, driven largely by economic and cultural factors further compounds the problems faced by the rural and underserved residents. It is the combination of all of these factors that makes telemedicine an attractive alternative to complement whatever health care services may be available in these areas. The question is whether telemedicine is safe and medically effective and what legal and economic implications will arise as the field is expanding. As it is expected several studies have appeared in the literature and guidelines are being formed about these issues.[2-7]

Future applications would include administering therapeutics remotely such as telesurgery. Extensive use of powerful computers, virtual reality and high speed, reliable communications network using protocols such as ATM (asynchronous transfer mode), would make this a reality!

CONCLUSION

Telemedicine systems like the one we have used in the context of the TELEREMEDY program facilitate a timely diagnosis and management of children with congenital heart disease in hospitals lacking pediatric cardiology service. The immediate access to specialists can guide patient management and thus may alter the morbidity and mortality in this patient population. Furthermore, in the present series use of this program obviated unnecessary and costly transfers in 83% of cases (Table 1). Potential problems to be solved, will be

defining the population needs in certain rural communities, constructing an electronic environment (patient records, etc.) for rapid communication, defining legal and economical issues of remote consultation, and defining standards for telecommunication, data transmission and computing in medicine, just to mention a few. It should be made perfectly clear that telemedicine should not replace existing health services but supplement or complement what is already available. On the other hand, the critical success of telemedicine will depend ultimately, not on legal, ethical or economical issues, but on the acceptance of this modality by health care providers and patients and demonstration of improved patient outcomes and cost savings by the use of this mode of health care delivery.

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