

The Contribution of Telemedicine in the Management of Childhood Heart Disease and its Impact on Continuing Education: Experience of Mohamed VI University Hospital of Marrakech and Children's National Heart Institute of Washington

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Abstract

The telemedicine is a form of remote medical practice using information and communication technologies. Our study is a retrospective, descriptive study of the epidemiological, clinical and para-clinical parameters of 140 patients followed in the department of childhood diseases of the Mother-Child Hospital of Mohammed VI Medical Center in Marrakech, who benefited from Telemedicine (TM) staff with the cardio-pediatric team of the Children's National Heart Institute of Washington during a period of 5 years. The aim of our study is to present our academic experience in TM in the field of pediatric cardiology as a first Moroccan experience, to study the contribution of this technology in the management of pediatric patients with congenital or acquired cardiac diseases, and to report its impact on education and continuing training. The average age of our patients was 2.5 years, the sex ratio was 1.028. The mainly symptoms that led to the consultation included a heart murmur, cyanosis, respiratory distress, or dyspnea at feeding. On the physical examination 56.43% had a saturation lower than 92%, the patients' weight was lower than the 10th percentile in 63.57% of the cases. The initial diagnoses of heart disease retained by echocardiography in our department were cyanogenic Congenital Heart Disease (CHD) in 54% of cases, non-cyanogenic CHD in 37.3% of cases, and acquired heart disease in 7.6% of patients. After TM staff, surgical treatment was recommended for 69.29%. At the end of videoconferencing, it was found that the diagnosis was confirmed in 49.29% of cases, completed in 28.57% and adjusted in 19.29%. A later assessment of the patients' condition found that 19.3% recovered, 24.3% remained stable under treatment, 12.9% are waiting for surgery; however 35% of our patients died and 5.7% were lost to follow-up. We noted that the TM staffs promoted access to hyperspecialized advice and international expertise, it has also improved educational and learning curve as well as ultrasound techniques, thus contributing to the enhancement of patients' care in the field of pediatric cardiology.

Keywords: Telemedicine; Pediatric cardiology; Education; Teaching; Marrakech; Washington

Abbreviations: CHD: Congenital Heart Disease; TM: Telemedicine; CVS: Cardiovascular Surgery; CNMC: Children's National Medical Center of Washington; WHO: World Health Organization; FTP: File Transfer Protocol

Introduction

Advances in technology and high-speed Internet access have revolutionized the practice of medicine, including pediatric cardiology. The need for rapid diagnosis and the use of cardiac imaging to identify children with life-threatening cardiovascular diseases, especially in developing countries where pediatric cardiology is an emerging specialty, has brought in

expert advice from developed countries through Telemedicine (TM) [1,2]. The latter is the application of information and communication technologies to the practice of medicine, contributing to equitable access to care. Echocardiography and non-invasive cardiovascular imaging allows a firm diagnosis as well as the exclusion of congenital heart disease [3,4]. Tele-echocardiography can be described as a process in which a technician obtains ultrasound images of a given patient, which are then transmitted to an off-site location where a cardiologist can provide further analysis and interpretation, allowing expert interpretation and rapid consultation, with quick and accurate decision making. We report the experience of TM by satellite between the department of childhood diseases, the Department of Cardiovascular Surgery (CVS) of Mohamed VI University Hospital of Marrakech and the Children's National Medical Center of Washington (CNMC), which is part of an academic and clinical collaboration agreement between Morocco and the United States of America.

Material and Methods

We conducted a retrospective and descriptive study of 140 clinical cases of congenital and acquired heart diseases, who were seen in consultation, or hospitalized in the pediatric units of the mother-child hospital of Mohammed VI University Hospital Center of Marrakech, and who benefited from TM from March 2011 to December 2016. The data were collected through the registry of recommendations taken in the TM staffs dealing with different parameters. The location of TM staff is the telemedicine laboratory of Marrakech medical school, the participants are the team of the Mohammed VI University Hospital of Marrakech including professors, residents and interns of pediatrics (particularly neonatology department) and CVS departments. As well as Prof. Craig Sable, Professor of Pediatrics, Director of the Cardiology and Echocardiography Teaching Program, Director of the Telemedicine Program at the CNMC, and his team as needed. The staff lasts one hour with an average of 3 patients' discussion per session. The meeting is held weekly: every Tuesday or Thursday at 3:00 pm, depending on the availability of the teams. The session begins with a brief presentation of heart disease clinical cases, visualizing previously recorded echo-cardiographic data and possibly cardiac catheterization, cardiac MRI or cardiac CT angiography. The diagnosis is discussed in detail on each echo-heart video, the therapeutic strategy is adapted according to the selected diagnosis, and recommendations for each patient are recorded in a register and in the patient's file.

Result

The average age of the discussed patients was 2.5 years with extremes of 3 days to 16 years. Among 140 patients 50.7% were female, 49.3% were male, and the sex ratio was 1.028, 101 cases (72.14%) were hospitalized and 39 (27.86%) were seen at the consultation. Concerning the reasons of consultation, a heart murmur on auscultation was found in 40.29%, followed by cyanosis

(25.85%), respiratory distress (21.43%), down syndrome in 14.57%, fatigue during feeding in 12.86% and growth retardation in 10.86%, while 10.71% of patients experienced pallor, edematous syndrome, confusion or profuse sweating. At the physical examination Saturation was $\geq 92\%$ in 61 patients (43.57%), between $[\geq 85\% \leq 92\%]$ in 24 patients (17.14%), between $[\geq 70\% \leq 85\%]$ in 32 children (16.43%) and $< 70\%$ in 23 patients. We noted that 63.7% of the patients had a weight below the 10th percentile, most of the children were symptomatic with more or less serious signs; it showed a heart murmur in more than half of the patients (55.71%), a dyspnea (30%), a cyanosis (24.28%), a tachycardia (37.86%) and a chest deformity (2.14%). Through echocardiography we have been able to objectify a multitude of paediatric heart-diseases, which are essentially dominated by ventricular septal defect (14.1%), atrial septal defect (10%), double outlet right ventricle and transposition of the great vessels (8%), atrioventricular canal (7.6%), pulmonary stenosis (5.6%), Persistence of the ductus arteriosus and Tetralogie of Fallot (5.2%), Pulmonary Atresia and Tricuspid Atresia (4%), Cardiomyopathy (2.8%), Unique ventricle and Coarctation of the Aorta (2.4%), Pulmonary Hypertension (2%), Common Arterial Trunk and Pericarditis (1.6%), Aortic stenosis and persistence of the left superior vena cava (1.2%), as well as other cardiac diseases: Kawasaki syndrome, Abnormal Pulmonary Venous return, Mucopolysaccharidose, Coronary artery fistula, Rheumatic fever, Major aortopulmonary collateral arteries, Coronary artery defect, Noncompaction of Ventricular Myocardium in 0.8%, and Hypoplasia of the left ventricle, Ebstein anomaly, Mitral regurgitation, Hypoplasia of the right ventricle, Cor triatriatum, Myocardial fusion, Pulmonary embolism, Shone syndrome, Situs inversus, Aortic aneurysm, Pulmonary artery aneurysm, Thrombosis of the pulmonary artery, Mitral atresia, Aorto-pulmonary window, Hypoplasia of the pulmonary artery, Endocarditis in 0.4%.

Thus congenital heart diseases represent 91.7% (121) out of all heart diseases discussed, of which 54% are cyanogenic and 37.3% non-cyanogenic. Acquired heart disease represents 7.6% (19).

After TM staff, a surgical treatment was recommended in 69.29% of cases, a medical treatment in 30.71%, and interventional catheterization in 25.71% of cases. At the end of the videoconference, the diagnosis was confirmed in 49.29%, completed in 28.57% and rectified in 19.29%. Finally, 4 patients (2.86%) were summoned to complete the investigations. Recovery was observed in 19.3%, 24.3% of patients were stable under treatment, 12.9% of cases were awaiting surgery. 35% passed away, and 5.7% were lost to follow-up. TM had a major impact on the continuing professional development of professors on several levels: It allowed discussion with experts on the different approaches to medical treatment, surgery, catheterization and therapeutic abstention. The discussion centred on the patient's clinical symptoms, the analysis of echo-cardiographic data, and other supplement examinations (EKG, CT angio-scan or MRI...). In some cases, the analysis of the patient's

dysmorphic features could be used to direct the patient towards certain genetic diseases associated with cardiac diseases. This teaching contributed to the improvement of the learning curve and ultrasound techniques that became aligned with international guidelines. In addition, TM has enabled professors to receive publications and online courses as additional information on the presented cases. It also allows them to attend cardiac catheterization classes scheduled on Friday at 11:00 AM GMT. TM had also a direct impact on the training of young doctors, since they acquired skills in pediatric cardiology by attending the debriefing of meetings. The use of this innovative teaching tool was a real motivation for their training, while benefiting from international expertise. For the students, the TM helped to arouse their interest in the field of pediatric cardiology and encouraged them to use medical English in their practice. By creating bonds of fellowship, TM has allowed us to benefit from internships in Washington, at least four professional internships have been scheduled, including a six-week pediatric cardiology internship for a pediatric professor at the CNMC. In addition, 5 missions of surgery, catheterization and ultrasound consultations were carried out in Marrakech every two years. These missions made it possible to examine more than a hundred children, to operate and to catheterize some of them. At the end of the internship at the CNMC, a few meetings were held with certain departments at Washington Hospital, including pediatric neurology, genetics and pediatric dermatology, they all approved the idea of connecting us by telemedicine for an exchange of expertise. The planning of other internships and other missions in the future is currently being considered.

Discussion

According to the American Telemedicine Association TM is the use of medical information exchanged from one site to another, through electronic communication, to improve a patient's clinical condition [5]. The World Health Organization WHO adopted the following description: "TM is that part of medicine that uses the transmission of medical information (images, reports, recordings, etc.) by telecommunication, in order to obtain remote diagnosis, specialized advice, continuous monitoring of a patient, therapeutic decisions, for continuing education of health care providers, all with the aim of advancing the health of individuals and their communities" [6]. Congenital heart diseases can be defined as malformations of the heart and/or vessels, present at birth, related to a developmental abnormality [7]. In emerging countries, there is a shortage of professional specialists in paediatric cardiology, who are often concentrated in large urban centres, which delays the management of the paediatric population and requires constant transfer of patients from isolated areas to referral health centres [8]. As in Morocco, congenital heart disease accounts for 7.8% of all children hospitalized over a 4 years period in Rabat hospital [9]. A study carried out in the neonatology department of Mohamed VI University Hospital of Marrakech, on 143 congenital heart disease files collected over a period of 3 years, found a hospital prevalence

of 7.77% [10], another study carried out on the pediatric centre of the mother-child hospital of the Mohammed VI University Hospital of Marrakech over a period of 5 years found a hospital prevalence of congenital heart disease of 1.86% [11]. This high rate makes it difficult for pediatricians to properly care for, hence the need for specialized advice in paediatric cardiology.

Since 2002, Marrakech medical school has set up a videoconferencing system using Integrated Services Digital Networks providing end-to-end digital connectivity, enabling remote conferences to discuss medical cases and educational topics. In 2007, a satellite videoconferencing system was donated by Washington Children's Hospital. A satellite connection was made for the first time, in the presence of members of the board of the Marrakech medical school and Washington Children's Hospital. The Cardiovascular Surgery Department has taken the initiative to start multidisciplinary staff conferences for the discussion of heart diseases clinical cases in children. The staff was made up of the pediatrics, cardiovascular surgery, and adult cardiology teams. The first session was held in 2009, since then the staff has become a regular part of the teleconsultation, tele-expertise and continuing education. Since 2010, the TM department of the CNMC has provided us with an FTP server (File Transfer Protocol), on which we have started to transfer the echo-cardiographic data before each staff to be consulted by the different participants, thanks to FTP client software (Filezilla). Consequently, there are two ways of consultation using echocardiography in TM:

a) Real-time or interactive (live) echocardiography which is the most recommended mode [12,13], the advantage of this approach is that the sonographer, following the instructions of the pediatric cardiologist, can produce additional real-time images [12,14,15], this approach is richer in terms of the amount of information obtained, but it may take longer time.

b) Tele-ecardiography consulted off-line through a "store-and-forward" system by recording and transferring of echocardiographic images before the TM session, so that they can be consulted beforehand, this is the alternative and most commonly used model [16], and it is the model used until now in our faculty. It also offers advantages in comparison to live TM, allowing the acquisition of high quality images [17].

Consequently, pediatric cardiology is suitable for TM since it is a highly specialized field with few professionals. Care is concentrated in a few regional centers. As a result, distance separates the patient from expert advice. Children with significant heart disease should report to a hospital with a pediatric cardiologist on site, so he can approve a definitive diagnosis or a specific treatment. Fortunately, all forms of heart disease can be diagnosed by a specialist using a combination of tests, including auscultation, EKG, chest X-ray and echo-cardiography, which are suitable for electronic transmission and thus will be shared by TM [18]. In England, only 13 of 184 outlying hospitals provide paediatric cardiac intensive care, most of which will present postnatal services without on-site expertise [19].

A study conducted by Geoffroy et al. [20], evaluated for the first time in France the contribution of TM in the management of children heart disease; five consultation sessions by videoconference were organized, 22 patients were seen. Heart disease was congenital in 20 patients and acquired in 2 patients. The purpose of the TM consultation was to specify medical therapy in 7 patients and indication for surgery or interventional catheterization in 15 patients. There were no significant diagnostic changes, but in 2 patients with complex heart disease anatomical details were made. In 3 patients, discussion by videoconference was essential to get the very reluctant family to accept the indication for surgery. Webb et al. [21] conducted a multicentre study of 9 centers across the United States that evaluated 338 pairs of babies (with and without access to telemedicine). This study showed a statistically significant reduction in the telemedicine group in the percentage of babies transferred to a tertiary care hospital (10% versus 5%) and in the total length of stay in the ICU. Hence, TM seems to be the ideal tool to support specialists, promoting access to hyperspecialized advice and improving patient care in the field of pediatric cardiology.

The first continuing education initiatives in TM have been made for physicians in rural areas to keep them in touch with the new recommendations, such as the study done in the USA [22] in 14 remote sites using videoconferencing for 3 years. Of the participants in this study, 73% of the respondents found it was as effective as having the presenter in the room, 23% found it less effective and 4% found it more effective. Another study in Brazil [23], evaluating the educational impact of online pediatric cardiology learning, included 62 health professionals from 20 hospitals connected by a TM network, and where the evaluation of the educational impact of TM used a pre- and post-test approach, the questionnaire results indicated high satisfaction values (average of 87%), course compliance was high (79%), however knowledge gain revealed significant differences according to profession and specialty. In our experience, as part of training and development, cardiovascular surgeons, and pediatricians met weekly with American experts by videoconference: "tele-expertise" on complex cases of patients with heart disease. These sessions were attended by professors, residents and interns, providing an opportunity for them to engage in continuous clinical learning at several levels: Improvement of knowledge in echocardiographic techniques, follow-up of complex heart disease and participation with Americans in surgical procedures especially in the field of cardiac catheterization.

Conclusion

Our work has shown that, as in developed countries, the applications of telemedicine in pediatric cardiology in a developing country are multiple. It mainly includes initial and continuing training and expertise in diagnosis and/or therapeutic management. The interest of telemedicine in our context is essentially linked to the lack of expert practitioners in the field of pediatric cardiology, which is an emerging specialty worldwide. It has helped to forge partnerships between surgeons and pediatricians, and between different centers creating a sense of community. However its

development in our training always faces material and institutional challenges.

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