Impact of Telemedicine on Hospital Transport, Length of Stay, and Medical Outcomes in Infants with Suspected Heart Disease: A Multicenter Study

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Background: Previous single-center studies have shown that telemedicine improves care in newborns with suspected heart disease. The aim of this study was to test the hypothesis that telemedicine would shorten time to diagnosis, prevent unnecessary transports, reduce length of stay, and decrease exposure to invasive treatments.

Methods: Nine pediatric cardiology centers entered data prospectively on patients aged <6 weeks, matched by gestational age, weight, and diagnosis. Subjects born at hospitals with and without access to telemedicine constituted the study group and control groups, respectively. Data from patients with mild or no heart disease were analyzed.

Results: Data were obtained for 337 matched pairs with mild or no heart disease. Transport to a tertiary care center (4% [$n = 15$] vs 10% [$n = 32$], $P = .01$), mean time to diagnosis (100 vs 147 min, $P < .001$), mean length of stay (1.0 vs 26 days, $P = .005$) and length of intensive care unit stay (0.96 vs 2.5 days, $P = .024$) were significantly less in the telemedicine group. Telemedicine patients were significantly farther from tertiary care hospitals than control subjects. The use of inotropic support and indomethacin was significantly less in the telemedicine group. By multivariate analysis, telemedicine patients were less likely to be transported (odds ratio, 0.44; 95% confidence interval, 0.23–0.83) and less likely to be placed on inotropic support (odds ratio, 0.16; 95% confidence interval, 0.10–0.28).

Conclusions: Telemedicine shortened the time to diagnosis and significantly decreased the need for transport of infants with mild or no heart disease. The length of hospitalization and intensive care stay and use of indomethacin and inotropic support were less in telemedicine patients. (J Am Soc Echocardiogr 2013;26:1090-8.)

Keywords: Telemedicine, Congenital heart disease

One percent of all children are born with congenital heart disease.[1] Echocardiography is used for definitive diagnosis or exclusion of congenital heart disease in newborns,[2,3] and the management of neonates with sepsis, pulmonary hypertension, and prematurity is also greatly enhanced by echocardiography. However, many neonates in rural areas or smaller cities do not have immediate access to local pediatric sonographers or echocardiographic interpretation by pediatric cardiologists. This can result in suboptimal echocardiogram quality,[4] delay in the initiation of medical intervention, unnecessary patient transport, and increased medical expenditures.

Telemedicine has been used with increased frequency to improve the efficiency of pediatric cardiology care in hospitals not served by pediatric cardiologists. Several reports from single institutions suggest that telecardiology is accurate, improves patient care, is cost-effective, and enhances echocardiographic quality in locations not served by pediatric cardiologists.[5-16] Telemedicine has also been shown to prevent unnecessary transport of neonates with suspect heart disease by ruling out congenital heart defects or diagnosing lesions without immediate hemodynamic consequences that require only basic medical intervention or outpatient follow-up.

We report the first multicenter (nine institutions) study assessing the impact of telemedicine on the delivery of care to infants undergoing echocardiography. Time to diagnosis, rates of transport, hospital length of stay (LOS), and exposure to invasive treatments were compared between telemedicine and control patients (matched by gestational age, weight, and diagnosis) without significant heart disease. We hypothesized that telemedicine would shorten time to diagnosis,

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Abbreviations

ANOVA = Analysis of variance

ICU = Intensive care unit

LOS = Length of stay

prevent unnecessary transports, reduce LOS, and decrease exposure to invasive treatments.

METHODS

Patients and Institutions

In this 36-month, prospective, multicenter cohort study (July 1, 1999, to December 31, 2001), all infants aged ≤ 6 weeks who were referred to one of the participating tertiary care institutions with the diagnosis of "heart murmur" or "rule out congenital heart disease" were enrolled by a pediatrician or neonatologist, who evaluated the patients and made all management decisions. Sonographers employed by community hospitals who scanned adult and pediatric patients performed all echocardiographic studies. Each participating tertiary care center interpreted echocardiograms obtained at delivery hospitals that had access to telemedicine and those that did not have access to telemedicine. Subjects born at hospitals with access to telemedicine constituted the study group, and those without telemedicine constituted the population from which the control group was drawn. Institutional review board approval was obtained at each participating institution (tertiary care and referral delivery hospitals).

A brief description of telemedicine co-investigators, facilities, technologies used, and number of transmissions per month per site is provided in Appendix A. In this study, no attempt was made to compare results by technology used. Each site co-investigator was responsible for study and control group patient identification and for data entry at that individual site.

Each participating tertiary care center provided both urgent and elective consultative services to both the telemedicine outreach sites and the control outreach sites. Participants fell into three general groups: (1) those needing immediate stabilization and referral for significant cardiac disease, (2) those who could be referred to an outpatient clinic at a later date for stable or asymptomatic cardiac disease (e.g., small ventricular septal defect, atrial septal defect, mild valvular stenosis), and (3) those with no heart disease. One control patient was matched to each study group patient within the referral population of each participating center by weight, gestational age, and diagnosis. For a large percentage of cases, it was not feasible to match on distance, and hence this aspect of matching was not successful in eliminating differences between groups on this variable. Every effort was made to ensure control group recruitment prospectively. However, in some cases, when the incidence of a specific diagnosis was very rare, a control patient was recruited retrospectively from infants referred in the 1-year time period before the start of the study. In addition to this stratified matching, we controlled for any residual influence of these variables by including weight and gestational age as covariates in all tests of between-subjects and within-subject effects.

Obtaining data from and matching control infants with mild or no heart disease, and matching them with infants in the telemedicine arm of the study, was more difficult compared with the infants with serious heart disease, who were always referred to the tertiary care institution for inpatient admission. We dealt with this problem by ensuring that co-investigators at each participating tertiary care center identified a collaborator at each of their referring institutions who worked with the co-investigator to facilitate data collection.

Participating physicians from nine institutions entered 1,057 patients into the database between September 1999 and December 2001. Of these, 581 (55.0%) received telemedicine services, and 476 (45.0%) were control patients. Control and experimental data were satisfactory from six of the nine institutions (see Appendix A); the other three institutions did not enter control data, and hence their patients were not included in this analysis. For the remaining six sites, all telemedicine patients were matched with control subjects on diagnosis and disease severity. This yielded 37 matched telemedicine-control pairs with significant heart disease and 337 matched pairs with mild or no heart disease (Table 1) from the six institutions with complete data. The length of time of telemedicine practice ranged from 3 to 8 years at these six hospitals. Because the nature of the questions we could address varied by severity of disease (e.g., the effects of telemedicine on avoidance of more intense and invasive treatment than necessary), we did not include the children with significant disease. Hence, the 337 matched pairs of infants with mild or no heart disease comprise the study sample for this report.

Table 1 Study population: underlying cardiac findings (all mild in degree)

Diagnosis	*n*	%
Patent ductus arteriosus	222	33
Ventricular septal defect (all types)	132	20
Muscular	96	
Membranous	34	
Other	2	
Atrial septal defect: secundum/patent foramen ovale	120	18
No cardiac disease identified	120	18
Pulmonary artery branch stenosis	32	4.7
Pulmonary hypertension	22	3.3
Atrioventricular septal defect	16	2.4
Pulmonary valve stenosis	6	0.9
Tricuspid valve regurgitation	2	0.3
Right ventricular hypertrophy	2	0.3

Data Collection

Data were collected at three separate time points for each study and control group patient. A single data entry Web site provided easy access for all participating centers to centralize electronic data entry. Data were entered for the study and control groups using questionnaires provided in the electronic database (Appendices B–E). Input from participating centers regarding refinement of these questionnaires was solicited at the beginning the study.

A master database received input from the participating centers, and aggregate data were provided to all principal and co-investigators every 3 months. In addition, each participating center received data specific to its own institution as requested. Aggregate data were presented at meetings of the investigators, which were held three times per year at national pediatric cardiology meetings (American Society of Echocardiography, American Heart Association, and American College of Cardiology). The data were masked to maintain confidentiality. A study code and key were maintained securely.

At the beginning of the study, each tertiary care center completed a detailed questionnaire (Appendix B) to ascertain the type of telemedicine technology at each site, the type of traditional cardiac care delivery, other demographic referral characteristics such as population served, and the volume of cardiac referrals at each participating tertiary care center. Data collected included patient identification number at both referring and tertiary care institutions, birth weight, gender, gestational age, and date of study entry.