Telemedicine in Pediatric Transport: A Feasibility Study

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ABSTRACT. ***Objective.*** **Investigate the hypothesis that telemedicine, in the form of real-time audiovisual transmission, would permit accurate assessment of illness severity and allow improved triage for transport.**

Methods. **A prospective study comparing assessments of patients examined conventionally (in person) and remotely by a telemedicine link. Fifteen patients (3 months to 14 years of age) admitted to our emergency department were evaluated as if for transport. Patients were evaluated simultaneously by a physically present pediatric emergency room physician and by a pediatric critical care physician linked to the examining room by a broadband audiovisual link. Each physician completed a patient assessment questionnaire independently. The sensitivity and specificity of the patient assessment by the audiovisually linked physician were calculated.**

Results. **Sensitivity, ie, the ability of the remote, audiovisually connected telemedicine physician to detect abnormal findings, is 87.5%. Specificity, the ability of the remote physician to detect normal findings, is 93%. It is likely that sensitivity would be markedly improved with addition of an electronic stethoscope.**

Conclusion. **This study demonstrates that pediatric patients may be assessed accurately with a broadcast-quality real-time audiovisual system. Such a system may have dramatic implications for providing pediatric specialty and subspecialty care in underserved areas.** ***Pediatrics*** **1998;102(5). URL: http://www.pediatrics.org/cgi/content/full/102/5/e58;** ***telemedicine, pediatric, pediatric telemedicine, transport.***

Telemedicine, broadly defined, is the use of telecommunication technology to provide medical information and services. In the past, telephone and radio were the primary tools available. Recent advances permit much more sophisticated audio/visual/data linkage using broad-band telephonic communication, fiber, and satellite. Despite telemedicine's rapid evolution and growing use, many physicians still are unfamiliar with the technology available and its potential.[1]

Specialized pediatric services are limited outside of major medical centers, especially in rural areas. The past decade has seen the consolidation of many large hospitals and closure of many rural hospitals. The trend is to transfer patients to tertiary/quaternary medical centers for complex problems, while keeping patients in community hospitals or at home for less serious problems. This approach requires evaluation and triage of children by physicians with limited pediatric training and experience who often seek expert consultation.[2]

Assessing patients by telephone is often a difficult and frustrating experience for transport physicians. The referring physician may have inadequate experience assessing children to provide adequate and complete information. The accepting physician may be inexperienced in telephone triage. Different clinical training may make communication difficult and time-consuming. Practitioner anxiety, on either end, may interfere with assessment. The desire to transfer children urgently from community hospital emergency departments may lead to unnecessary transport for misperceived minor problems on the one hand or transport without appropriate stabilization for critical illness on the other. Limited data make decisions regarding the mode of transport (ground, rotary, or fixed-wing) difficult. A shared, effective assessment system would permit more rapid access to specialized care, better resource utilization, and potential cost savings.[3,4]

We hypothesized that using telemedicine in the form of real-time audiovisual transmission would permit accurate assessment of severity of illness and minimize problems related to patient assessment, improving triage for transport.

METHODS

We set up a mock transport triage system within our own institution. One room in our emergency department was designated the remote site and was equipped with a remote-controlled ceiling camera, monitor (to allow the patient and parent to see the distant physician), and a two-way audio system. A room in our pediatric intensive care unit was designated the telemedicine room and was equipped with a monitor, audio system, and controls (Fig 1). By using a real-time, broadcast-quality link with no compression or decompression of transmission (see "Appendix"), a pediatric intensivist observed the patient being examined in person by a pediatric emergency medicine room physician. Limited funding prevented the use of an electronic stethoscope in this study.

Children being evaluated in the Children's Hospital of Pittsburgh's emergency department were eligible for participation in the study. Patients triaged to an outpatient clinic were excluded. Patients requiring critical care also were excluded to avoid any possibility of interfering with timely treatment during this pilot study. After obtaining parental consent, the emergency room physician obtained a patient history without the pediatric intensivist listening, maximizing the remote intensive care physician's dependence on the visual system to determine physical findings. The emergency room physician then examined the patient with the remote intensive care physician observing, controlling the cameras and being able to hear and communicate with the physician, patient, and parent. The intensive care physician did not obtain a

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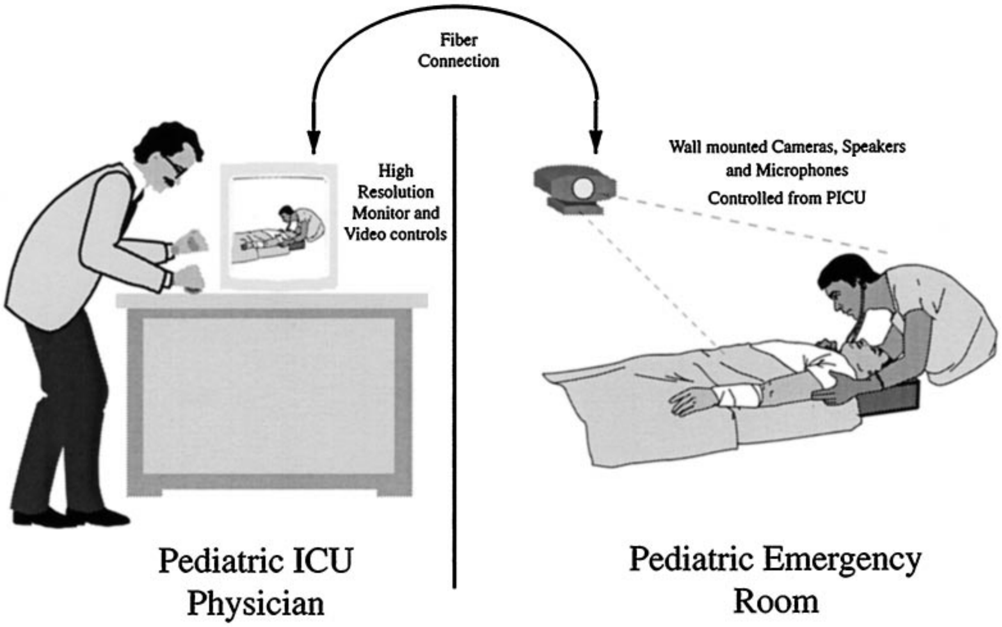

Fig 1. Pediatric emergency room–ICU link.

history, but rather listened to the reaction of the child to the examination. The intensive care physician was able to ask for repeat examinations. After the examination, each physician completed an assessment sheet independently.

Data collected (Table 1) included physical examination, modified Asthma score,[5] Croup Score,[6] or Glasgow Coma scale[7] for children when appropriate, preliminary diagnosis (Table 2), recommended interventions, and disposition.

The data then were divided into normal and abnormal findings. The assessments of the pediatric emergency room physician were considered the standard to calculate sensitivity and specificity.

RESULTS

A total of 15 patients (mean age, 4.8 years; range, 3 months to 12 years) were examined with this telemedicine system, and 510 assessments were made. The pediatric emergency room physician observed 489 normal findings (96% of the 510 assessments). Cardiac, lung, and abdominal auscultatory findings were counted only if they were abnormal because the remote physician did not have access to an electronic stethoscope. The remote pediatric intensive care unit physician's observations agreed with the emergency room's findings 472 of 489 (97%) times. The emergency room physician observed 21 abnormal findings. The remote pediatric intensive care physician identified 18 of 21 of these abnormal findings. The sensitivity, ie, the ability of the remote telemedicine physician to detect abnormal findings, was 87.5%. The specificity, the ability to detect normal findings, was 93%.

Evaluation of the findings by the two physicians in this study indicated that assessment of neurologic status, perfusion, and skin findings agreed in all cases. The differences could be accounted for by the inability to assess cardiac and breath sounds by the remote pediatric intensive care physician.

In 14 of 15 patients, the two examining physicians agreed on the diagnosis. The physicians disagreed about a 7-year-old child with facial petechiae and dehydration. Physical findings were identical, but physician diagnosis differed. In this case, not knowing the history of vomiting probably influenced the diagnosis made by the remote physician.

Five of the 15 patients were admitted from the

TABLE 1. Patient Assessment Criteria

Physical Assessment:
General assessment: level of distress/irritability
HEENT, nuchal rigidity, extraocular movements, pupillary reactions, scleral assessment
*Heart: assessment of heart sounds, murmurs, gallops, pulses
*Lungs: wheezing, retractions
*Abdomen: distension, palpation, organomegaly, sounds
Skin: edema, petechiae, erythroderma
Modified Asthma Score
Silverman Croup Score
Glasgow Coma Scale
Preliminary Diagnosis: included general categories such as neurologic, respiratory, cardiac, sepsis, gastrointestinal
Interventions: included fluid bolus, aerosols, intravenous antibiotics, etc
Patient Assessment Criteria: all findings were categorized as normal, abnormal, mild, moderate, or severe

* Cardiac and lung auscultation were performed by the physically present emergency room physician only.

TABLE 2. Patient Diagnoses

Age	Diagnosis
5 y	Cellulitis
12 y	Upper respiratory infection
18 mo	Upper respiratory infection
19 mo	Upper respiratory infection
10 y	Seizures
4 mo	Hernia
9 y	Ankle sprain
4 y	Burn
4 y	Dehydration
2 y	Reactive airway disease
15 mo	Upper respiratory infection
13 mo	Croup
7 y	Vomiting and dehydration
9 mo	Reactive airway disease
14 mo	Reactive airway disease

emergency room. The remote intensive care physician would have admitted 4 of these 5. Diagnoses included a 5-year-old with cellulitis, a 3-year-old with an upper respiratory tract infection, a 2-year-old and a 14-month-old with reactive airway disease, and a 15-month-old with hydrocephalus. The remote intensive care physician would not have admitted the last patient.

DISCUSSION

This is the first study to assess the diagnostic capability of a visual telemedicine system in children for determining physical findings. The study indicates that infants and children may be assessed accurately with a broadcast-quality real-time audiovisual system. We demonstrated that with broadcast-quality transmission, assessment could be made as if the child were being treated in person. Our system permitted accurate assessment of pupillary reaction, sclera color, flaring, retractions, capillary refill, and erythroderma.

In our study, the remote physician's assessment was limited by lack of an electronic stethoscope. The addition of this equipment very likely would have improved his ability to assess the cardiopulmonary systems and might have influenced his decision not to admit the 14-month-old child with reactive airways. Alternatively, this may have been an example of diverging evaluation of severity. The remote physician's assessment also was limited by not having the history of vomiting and may have led to a different diagnosis in the 7-year-old child with facial petechiae and dehydration.

It is recognized that interobserver differences may exist even with two skilled physicians at the same location. For the purposes of this study, the assumption was made that the physician in physical contact with the patient represented the standard. This study method provides a reasonable, cost-effective way of assessing a telemedicine system without the prohibitive cost of a randomized, blinded study.

Our study may have been biased by cues taken by the remote physician from the actions of the emergency room physician, resulting in a false concordance. However, we believe that this is, and will be, a factor in the study of any remote situation. Patient history was not given to the remote physician in an attempt to minimize this bias. The ability to obtain a history would likely improve the remote physician's diagnostic capability.

For the purpose of this study, the highest quality transmission was chosen to demonstrate that accurate assessment was feasible with real-time transmission. Lower bandwidth systems, which cost less, are more widely available and require compression and decompression of signals, may also be considered for use. Image fidelity, however, may suffer. At present, only the field of radiology has established image quality standards. The issue of standards is particularly important in children because special characteristics may be necessary to achieve diagnostic accuracy. For example, whereas adults will often sit still, follow commands, and repeat tasks, permitting accurate assessment with lower resolution systems, this is unlikely with children and should be taken into consideration by those building such systems. The challenge will be to determine the lowest bandwidth needed to accurately assess patients and thus provide maximum benefit at minimum cost.

The use of such a system in the pediatric transport environment has the potential to improve patient care by improving access to specialized pediatric care. Expert assessment and recommendations may be brought into communities where little pediatric input is available. Telemedicine may allow reduction of transport costs by optimizing transport triage. For example, a transport initially judged to necessitate a helicopter by a remote physician may be converted into an ambulance transport because of expert assessment and suggested interventions. Additionally, telemedicine may provide a greater interaction between outlying facilities and tertiary care centers, improving education and awareness for all involved.[8]

The potential of telemedicine is exciting and attractive. This small study provides encouraging data for te use of telemedicine in evaluating acutely ill infants and children and supports the need for larger studies. Many questions need to be answered with regard to patient outcomes, legal issues, social issues, standards, costs, and reimbursement as pediatric telemedicine develops into its own field.[9,10]

APPENDIX

Telemedicine Definitions[a]

Bandwidth—capacity of an electronic transmission medium to transmit data per unit to time. Higher bandwidths mean more data can be transmitted.

Broadcast—transmission of information, usually unilateral, such as television, not requiring any compression or decompression of the signal.

Compression/decompression—hardware and/or software used with interactive video system that converts an analog signal to a digital signal.

Real time—sends and receives audio/video/data simultaneously with no more than a fraction of a second delay.

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