Interhospital transfer of pediatric neurosurgical patients

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OBJECTIVE The purpose of this study was to describe patterns of transfer, resource utilization, and clinical outcomes associated with the interhospital transfer of pediatric neurosurgical patients.

METHODS All consecutive, prospectively collected requests for interhospital patient transfer to the pediatric neurosurgical service at Texas Children's Hospital were retrospectively analyzed from October 2013 to September 2014. Demographic patient information, resource utilization, and outcomes were recorded and compared across predefined strata (low [$< 5\%$], moderate [$5\%–30\%$], and high [$> 30\%$]) of predicted probability of mortality using the Pediatric Risk of Mortality score.

RESULTS Requests for pediatric neurosurgical care comprised 400 (3.7%) of a total of 10,833 calls. Of 400 transfer admissions, 96.5%, 2.8%, and 0.8% were in the low, moderate, and high mortality risk groups, respectively. The median age was 54 months, and 45% were female. The median transit time was 125 minutes. The majority of transfers were after-hours (69.8%); nearly a third occurred during the weekend (32.3%). The median intensive care unit stay for 103 patients was 3 days (range 1–269 days). Median length of hospital stay was 2 days (range 1–269 days). Ninety patients (22.5%) were discharged from the emergency room after transfer. Seventy-seven patients (19.3%) required neurosurgical intervention after transfer, with the majority requiring a cranial procedure (66.2%); 87.3% of patients were discharged home.

CONCLUSIONS This study highlights patient characteristics, resource utilization, and outcomes among pediatric neurosurgical patients. Opportunities for quality improvement were identified in diagnosing and managing isolated skull fractures and neck pain after trauma.

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KEY WORDS interhospital transfer; health resources; trauma; outcome assessment

NEUROSURGICAL care may be a common reason for interhospital transfer.^{4,21,36,37} The impetus to transfer children for specialized pediatric services is no different.^{9,34} The primary indication for transfer is the need for urgent or emergency neurosurgical evaluation and intervention. Often, transferred patients have acute life-threatening conditions such as intracranial hemorrhage or hydrocephalus. Many hospitals lack full-time neurosurgical coverage,^{21,28} and the demand for interhospital transfer will increase as surgical subspecialists consolidate into larger regional pediatric surgical centers of excellence as designated by the American College of Surgeons.³²

Previous studies^{9,34} of the transfer of critically ill children in the general pediatric patient population have demonstrated significant differences in patient characteristics, resource utilization, and outcomes across mortality risk-

stratified groups. Costly length of intensive care unit (ICU) stay and incidence of invasive procedures were greater in the high-risk admissions, as compared with the low- and moderate-risk admissions. In addition, these same studies^{9,34} showed a higher mortality rate in the high-risk admissions, compared with low- and moderate-risk admissions.

To the best of our knowledge, the criteria for the transfer of pediatric neurosurgical patients, the resource utilization involved, and the characteristics of transferred patients have not been previously studied. Furthermore, there is a lack of data regarding outcomes for pediatric neurosurgical patients who undergo transfer. Our study aimed to examine the characteristics, resource utilization, and outcomes of transfer admissions to the pediatric neurosurgical service at a large tertiary/quaternary children's hospital.

ABBREVIATIONS ICU = intensive care unit; PRISM = Pediatric Risk of Mortality.

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Methods

Study Population

All consecutive prospectively documented requests for interhospital patient transfer to the pediatric neurosurgical service at Texas Children's Hospital from October 1, 2013, to September 30, 2014, were retrospectively identified from a centralized transfer center database. Texas Children's Hospital is a 495-bed freestanding children's hospital, which attained Level I trauma designation in October 2010. The local Institutional Review Board approved this study with a waiver of informed consent.

Data Collection

Details of each patient transfer request were extracted from the transfer center database, including time of transfer request, duration of transit, time of arrival at our institution, reason for transfer, and reported diagnosis at the time of transfer request. The distance traveled for transfer was calculated using the shortest distance between the referring facility and our hospital on Google Maps. Electronic medical records of these patients were then reviewed for diagnostic, laboratory, physiological, and demographic information collected on all patients within 24 hours of admission. Therapeutic interventions, duration of use, and length of overall hospital stay and ICU stay were noted. Data on clinical outcomes were also collected at the time of discharge.

Pediatric Risk of Mortality

The Pediatric Risk of Mortality (PRISM) score was developed to assess pediatric ICU and surgical risk of mortality.²⁵ Data for computation of the PRISM score were obtained within the first 24 hours of admission, and the PRISM score was calculated using the formula published by Pollack et al.²⁸

Analysis of Resource Utilization

Resource utilization was assessed using information regarding receipt of neurosurgical procedures, length of stay in the ICU, and duration of hospital stay. Clinical outcomes were analyzed, including hospital and ICU length of stay and survival status at hospital discharge. For survivors, the discharge destination was determined, including home, rehabilitation, hospice, long-term skilled nursing facility, or transfer back to the referring hospital.

Data Analysis

Descriptive statistics, including means, standard deviations, standard errors, and confidence intervals, were computed as necessary. Bivariate analyses compared patient characteristics, resource utilization, and outcomes across predefined strata (low [$< 5\%$], moderate [$5\%–30\%$], and high [$> 30\%$]) of predicted probability of mortality using the PRISM algorithm.²⁵ Bivariate comparisons of categorical and nonparametric continuous data across the 3 mortality risk strata were performed using the chi-square and Kruskal-Wallis tests, respectively. Analysis was performed using SPSS statistical package (version 21, IBM Corp.). All p values < 0.05 were considered significant.

Results

Patient Transfer Requests

There were a total of 10,833 requests for transfer of pediatric patients during the study period. Requests for transfer to the pediatric neurosurgical service constituted 400 (3.7%) of the total requests. The majority of the transfers were via ground transport (85.8%; Table 1). Air transport (helicopter or airplane) was used in 14.2% of cases. Transfers from our affiliated West Campus, approximately 25 miles away, accounted for 17.5% of the transfers. Overall, there were 118 unique referring facilities for the study group. The median driving distance between the referring facility and our hospital was 37.7 miles (range 0.2–750 miles).

The overall median transit time (i.e., time interval between accepting the transfer and arrival of the transfer) was 125 minutes for pediatric neurosurgical transfers. However, the overall median time interval between receiving the transfer request and patient arrival was 139.5 minutes. This time interval includes the time required for the physician to review the transfer request and communicate acceptance to the referring facility. The majority of transfers (69.8%, Fig. 1 upper) were admitted to our facility after-hours (from 6 PM to 6 AM), and nearly a third of the transfers were admitted on the weekend (32.3%, Fig. 1 lower).

Patient Characteristics

Of 400 transfer admissions, 96.5%, 2.8%, and 0.8%

TABLE 1. Patient demographics and transfer characteristics for patients transferred for pediatric neurosurgical evaluation

Variable	No. of Patients	%
Age (yrs)		
<1	104	26
1–6	134	33.5
6–12	79	19.8
12–18	79	19.8
>18	4	1
Sex		
Male	220	55
Female	180	45
Mortality risk cohorts		
Low	386	96.5
Moderate	11	2.8
High	3	0.8
Method of transport		
Ambulance	340	85
Private car	3	0.8
Helicopter	56	14
Plane	1	0.3
Transit time (mins)		
<60	115	28.7
60–120	77	19.3
120–180	80	20
180–240	56	14
>240	72	18

FIG. 1. Graphs of time of admission (**upper**) and day of admission (**lower**) for pediatric patients transferred for neurosurgical evaluation.

were in the low, moderate, and high mortality risk cohorts, respectively. The median patient age was 54 months (range 0.4–264 months), and 45% of the study population was female (Table 1). Demographic data were similar among the different mortality risk groups (Table 2). The most frequent diagnoses at the time of request for transfer were skull fracture (24.8%), subdural hematoma (8%), and head injury (5.8%). Traumatic brain injury, with or without intracranial hemorrhage, was the most common actual diagnosis for transferred patients (Fig. 2). Isolated skull fracture, noted in 84 patients (21%), was the most common single diagnosis at discharge. Incorrect diagnoses were noted in 35 patients. The most common transfer request with an incorrect diagnosis was spine fracture. Five patients were transferred with the diagnosis of spine fracture but had a negative clinical and radiographic workup at our facility.

Resource Utilization

One hundred three patients were admitted to the ICU after transfer, with a median of 3 days (range 1–269 days) spent in the ICU. The mean length of stay in the hospital

TABLE 2. Patient demographics, resource utilization, and outcomes based on predicted mortality risk calculated from the PRISM score

Variable	Predicted Mortality Risk			p Value
	<5%	5%–30%	>30%	
No. of patients	386	11	3	
Median age (yrs)	5.5	1.9	2	0.11
% females	44.8	45.5	66.7	0.75
Median transit time (mins)	129	131	109	0.92
Median total transfer time (mins)	155	144	131	0.91
Neurosurgery (yes)	71	5	1	0.06
Median length of stay in hospital (days)	8	5.5	2	0.001
Median length of ICU stay (days)	2	5.5	2	0.12
Actual diagnosis				
VPS/HCP	22	0	0	
Tumor	30	0	0	
Traumatic brain injury	219	6	2	
Vascular	15	0	0	
Infection	5	0	0	
Spinal	40	1	0	
Seizures/AMS/vomiting	35	0	0	
Other	20	4	1	
Disposition				
Home	345	3	1	
CPS	18	3	0	
Rehabilitation facility	18	1	0	
Hospice	3	0	0	
Transfer to another hospital	0	2	0	
Death	2	2	2	

AMS = altered mental status; CPS = child protective services; VPS/HCP = ventriculoperitoneal shunt/hydrocephalus.

was 2 days (range 1–269 days) for 400 patients. Ninety patients (22.5%) were discharged directly from the emergency room after transfer. Most of these discharges-on-transfer had a diagnosis of isolated skull fracture (53.3%). Seventy-seven patients (19.3%) required neurosurgical intervention after transfer, with the majority requiring a cranial procedure (66.2%). The types of surgical procedures performed are shown in Table 3.

Outcomes

Table 3 describes the discharge disposition for patients in this study. The majority of patients were discharged home (87.3%). Six patients (1.5%) died in the entire study population. Four patients deemed low- or moderate-risk at the time of transfer died for the following reasons: C1–2 dislocation with traumatic brain injury, cerebellar hemorrhage, hydrocephalus with sepsis, and brain tumor with hydrocephalus.

Discussion

In this first study to describe interhospital transfer of

FIG. 2. Bar graph showing actual diagnosis categories for 400 pediatric patients transferred for neurosurgical evaluation. HCP = hydrocephalus; VPS = ventriculoperitoneal shunt.

pediatric neurosurgical patients, reasons for transfer, hospital course, and discharge disposition have been described for a large tertiary/quaternary children's hospital over the course of 12 months. Pediatric neurosurgical transfers were relatively uncommon at our facility, comprising only 3.7% of all transfer requests. Nonetheless, the absence of neurosurgical coverage is a common indication for interhospital transfer.²¹ Many outlying community hospitals do not have pediatric neurosurgeons on staff, whereas others

do not provide full-time pediatric neurosurgical coverage. The American College of Surgeons has recognized that higher-volume pediatric surgical centers may achieve better outcomes.³² Furthermore, other data indicate that high-volume centers may achieve better outcomes for certain neurosurgical conditions,¹³ which has further stimulated regionalization of care and the trend toward transfer of patients to specialized centers.^{6,14,22,24} The management of some pediatric neurosurgical conditions requires dedicated teams, such as neurointensivists, that may not be available at other facilities; in the adult neurosurgical patient population, this has been shown to improve outcomes.^{2,13} Patients or family members may request transfers on the basis of outside recommendations or the reputation of a particular center.²¹ Unfortunately, there are other reasons for transfer, such as concerns over professional liability or a patient's insurance status. On the basis of recent trends in the delivery of health care sparked by national health care reform, including hospital system consolidation, subspecialization, and regionalization,⁵ we expect that interhospital transfers in pediatric neurosurgery will become increasingly more common.

Opportunities for Quality Improvement

Telemedicine—and in particular teleradiology—technology has existed for quite a long period of time.⁸ However, its implementation in the interhospital transfer process has not been consistently applied. Prior research has shown that teleradiology increased the intervention rate in transferred patients, decreased transfer time, reduced unnecessary transfers, and even reduced the number of adverse events during transfer itself.¹ Specifically, patients with isolated skull fractures, and those with isolated neck pain without evidence of fractures on CT imaging, may be examined remotely by the neurosurgeon using an audio-video interface. Isolated skull fractures without evidence of intracranial hemorrhage, which composed the majority

TABLE 3. Resource utilization and outcomes of care for 400 patients transferred for neurosurgical evaluation

Variable	No. of Patients	%
Neurosurgical intervention		
Craniotomy for tumor	24	6.0
Craniotomy for hematoma*	19	4.8
Ventriculoperitoneal shunt insertion or revision	12	3.0
Spine surgery	11	2.8
Ventricular drain/tap	7	1.8
Others†	4	1.1
Median length of hospital stay in days (range)	2 (1–269)	—
Median length of ICU stay in days (range)	3 (1–269)	—
Disposition		
Home	349	87.3
CPS	21	5.3
Rehabilitation facility	19	4.8
Hospice	3	0.8
Transfer to another hospital	2	0.5
Death	6	1.5

* Includes cranioplasty.

† Includes vagus nerve stimulation (n = 2), transsphenoidal resection (n = 1), baclofen pump revision (n = 1).

of patients discharged from our emergency room soon after transfer (53.3%), is a relatively benign diagnosis given the low likelihood for neurological deterioration or intervention.^{3,29,30} The presence of neck pain without neurological deficits and a normal CT scan of the neck, in an older child, is another condition in which a clinical decision rule¹ for transfer should be used. The neurosurgeon would be more confident of the patient's clinical examination and could potentially avoid transferring those patients who would be discharged home from the emergency room after transfer. In the present study, although we could review radiological images from our affiliate hospital (17.5% of transfers), we could not clinically evaluate the patient, and this limited our ability to reduce unnecessary transfers. In addition to the introduction of telemedicine, the implementation of frequent educational workshops on common neurosurgical conditions for emergency room teams, as well as general pediatricians at major community hospitals, is needed. The creation and distribution of well-defined clinical protocols for common neurosurgical cases among our referring centers is essential to change transfer practices.

This study also highlighted the large number of patients arriving after-hours or on the weekends. A proportion of these transfers may be attributed to working parents unable to take their children to the hospital during regular working hours on weekdays. However, delays in establishing a diagnosis and initiating a transfer request at the referring facility also contribute to these patterns. The potential impact of transfer delays is underscored by several studies reporting that pediatric patients who undergo surgery at night or on the weekend have higher complications rates,^{3,7,10–12,15–20,23,26,29,31,33,35,38,39} including an analysis of our own practice patterns in pediatric neurosurgery.³⁰ Our results indicate the need for early transfer requests to reduce delays in care and after-hour transfers.

PRISM in Pediatric Neurosurgery

We stratified our study population into groups of predicted mortality based on PRISM score. These scores and their associated strata of risk were not associated with a shorter or longer transit time, expedited or prolonged ICU stay, or absence or need for neurosurgical intervention. Hence, the PRISM score may not be as valuable for pediatric neurosurgical patients undergoing interhospital transfer as it is for children cared for by other pediatric subspecialists. The use of the updated PRISM III score, which has revised the list of variables and ranges, may have improved the mortality prediction in our patient population.²⁷ However, many of the neurosurgical patients did not have significant systemic physiological derangements at the time of transfer. These measures of systemic physiological variables, such as blood pressure, heart rate, respiratory rate, partial pressure of oxygen, and partial pressure of carbon dioxide, prothrombin time/partial thromboplastin time, total bilirubin, and serum electrolytes, are required by the PRISM formula.

Limitations of the Study

Certain limitations of this study need to be highlighted. Our study involved only 1 academic children's medical

center; therefore, the results may not be generalizable to other children's hospitals in the US. Moreover, the case mix of patients and illness severity noted in our study population may not reflect those at other children's hospitals. Neurosurgery does not exist in isolation, and children with multisystem injury, who often require neurosurgical evaluation in addition to input from other services, will need to be transferred to a higher level of care. Many of these patients are brought directly to our facility by emergency services, and this may be the reason why the high mortality risk group was particularly small in our study.

In addition, we were unable to show that resource utilization varied according to the severity of illness of the patients. That is, greater risk of mortality was associated with higher utilization of resources. Unfortunately, only 3 high-risk patients were included in our study cohort, which limits meaningful comparisons between low-, moderate-, and high-risk groups. However, our methodological approach of describing the study cohort across strata of predicted mortality risk could be easily applied to other children's hospitals in the setting of future multicenter collaborations.

Conclusions

An appropriate and timely transfer process may improve care and safety for pediatric neurosurgical patients. This study serves as a first step in the identification and characterization of pediatric neurosurgical patients at the time of interhospital transfer. Future larger multiinstitutional studies based on our present work may demonstrate that resource consumption needs vary from primarily rehabilitative for lower-risk admissions, to aggressive surgical interventions for high-risk admissions. Multiple aspects of the transfer process of pediatric neurosurgical patients may be improved upon.

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Disclosures

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Conception and design: Jea, Hansen, Briceño, Moreno, Ryan. Acquisition of data: Vedantam, Hansen, Briceño, Moreno, Ryan. Analysis and interpretation of data: Vedantam, Hansen, Briceño, Moreno, Ryan. Drafting the article: all authors. Critically revising the article: Jea, Hansen, Briceño, Moreno, Ryan. Reviewed submitted version of manuscript: all authors. Approved the final version of the manuscript on behalf of all authors: Jea. Study supervision: Jea.

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