Investigation of the status of interhospital transport of critically ill pediatric patients

Jun Qiu, Xiao-Li Wu, Zheng-Hui Xiao, Xian Hu, Xue-Li Quan, Yi-Min Zhu
Changsha, China

Background: **With the unequal distribution of medical resources in developing countries, critically ill children need to be transferred to tertiary hospitals from primary hospitals with limited resources. Although a large number of critically ill children are transferred each day in China, the standard process of inter-hospital transport is not formulated.**

Methods: **We retrospectively analyzed the data collected during transport. A total number of 9231 patients (≤14 years) who had been transferred to the Hunan Children's Hospital by a specialized team from primary hospitals from January 1, 2009 to June 30, 2012 were included in the study.**

Results: **Nearly half of the critically ill children were neonates (48.72%) and two thirds of the children were suffering from respiratory, neurological and cardiac diseases. Multivariate adjusted odds ratios (OR) and 95% confidence intervals (CI) were calculated using unconditional logistic regression. Mobilization time in non-working hours was longer than the working hours (OR=1.186, 95% CI=1.059-1.329). Our study showed that mobilization time for neonates was shorter than that for older children (OR=0.801, 95% CI=0.692-0.928). The mobilization time of referral cases was shorter in areas within a radius of 50 km than in those within a radius of over 250 km (OR=0.427, 95% CI=0.350-0.521). Referred patients in summer needed a significantly shorter mobilization time than in winter (OR=0.705, 95% CI=0.616-0.806).**

Conclusion: **Standardized processes and guidelines for inter-hospital transport would be essential to ensure effective transport of patients and reduce the mobilization activation time.**

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Key words: **critically ill pediatric patients; inter-hospital transport; specialist retrieval teams**

Original article

Introduction

Pediatric intensive care is a unique area of medicine that requires caregivers not only with knowledge of pediatric illness, but also with the critical issues of pediatric care.[1] Critically ill patients who require more concise diagnosis or care beyond the capabilities of the non-tertiary hospital need to be transferred to a nearest tertiary hospital in order to receive higher quality care. In some western countries, the intensive care services for children have undergone substantial centralization in the past few decades.[2,3] However, in China, the medical technologies in referral hospitals are limited. The purpose of inter-hospital transport of critically ill children is to improve clinical outcomes and reduce the mortality of these patients.[4,5] Furthermore, studies have demonstrated that a specialized pediatric retrieval team might reduce the occurrence of serious adverse clinical events and complications compared with a referring specialist team.[2,6-9] Despite of the rapid development of the techniques in pediatric care, the transport of critically ill pediatric patients remains a challenge. Because transport of critically ill pediatric patients is subjected to a high risk environment with limited resources and and few monitoring capabilities.[10] Furthermore, the deterioration of illness is influenced by transport-related factors, namely, response time, stabilization time, the mode of transport, the professionalism of the retrieval team and diagnostic category.[2,3,7,11,12] Therefore, it is important to identity the factors that are associated with effective transport.

There are 222 million children (≤14 years) according to data from the sixth census released by the National Bureau of Statistics of China. Hunan

Author Affiliations: Department of Children's Intensive Research Center, Hunan Children's Hospital, Changsha 410007, China (Qiu J, Xiao ZH, Hu X, Quan XL, Zhu YM); Department of Obstetrics and Gynecology, Maternal And Child Health Hospital Of Hunan Province, Changsha 410007, China (Wu XL)

Corresponding Author: Yi-Min Zhu, PhD, Department of Children's Intensive Research Center, Hunan Children's Hospital, Changsha 410007, China (Tel: +8613907315063; Fax: +8673085600902; Email: cszhuyimin@126.com)

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Children's Hospital receives 3000 inter-hospital referral children from primary hospitals, community hospitals and partial tertiary hospitals annually. Children often present to primary hospitals that lack of pediatric expertise, and with limited technologies and medical resources. Hence, critically ill children should be transferred to tertiary hospitals in order to improve their outcome. Although a large number of critical ill children are transferred each day, the standard process of inter-hospital transport is not formulated. This study was undertaken to offer a scientific basis for the standardization process of inter-hospital transport by investigating the current status of inter-hospital transport and examining the risk factors of mobilization time in China.

Methods

Ethics statement

The study was approved by Public Health Ethics Committee of Hunan Children's Hospital. Informed written consent was also obtained from a legal guardian of each child involved in our study before data collection. All data collected from participants were fully anonymous.

Patients and study design

Hunan Children's Hospital is the largest tertiary hospital which serves for a population of 71 million, and with a land area of 211 800 km^2 in China. The hospital has 1800 beds, including 80 beds in pediatric intensive care unit (PICU). The transport center carries out a total of 3000 retrievals to pediatric/neonate intensive care units each year. A standardized data set consisted of patients that were transported to our hospital by a specialized retrieval team from primary hospitals. The patients were under 14 years old and transported between January 1, 2009 and June 30, 2012.

Data quality was controlled by normative training of staff members, who were responsible for transporting critically ill patients. The information of age, sex, main reasons for transport, source of admission (tertiary hospitals or non-tertiary hospitals), diagnostic category, admitting diagnosis, admission department (e.g., pediatric ward), referral radius, seasonal variation, time of referral telephone call (working hours, 8 a.m.-6 p.m.; out of working hours, 6 p.m.-8 a.m.) and mobilization time (from reception of referral telephone calls to the departure of specialist retrieval team from recipient hospital) were collected. Missing values were excluded. Because the majority of inter-hospital transport patients were neonates and infants, age was categorized into neonate (<30 days), infant (1-12 months), and older children (1-14 years). Each year was divided into spring (from March to May), summer (from June to August), autumn (from September to November), and winter (from December to the next February).

Transport center

The specialized retrieval team was composed of pediatricians, registered nurses and ambulance technicians. They were trained for at least one year in PICU, and were able to undertake interventions such as endotracheal intubation, invasive hemodynamic monitoring, mechanical ventilation, and use of vasoactive drugs. The task of the specialist team was to provide a safe, effective continuation of critical care for the entire process from receiving referral telephone call until the arrival of patients to recipient hospital. One pediatrician and one nurse were responsible for urgent resuscitation, and they were on duty for 24 hours. Six specialized retrieval teams were provided for referral patients at any time in transport center. If the referral task was approved, the retrival teams will be active in working hours. For the security of the retrieval teams, if the referral distance exceeded 150 km in non-working hours, the transport was delayed until the next day. The retrieval team guided physicians at the referring hospital on continuing management and appropriate treatments for delayed patients.

Mobilization time

In this study, we defined mobilization time as the interval time from reception of referral telephone call to the departure of specialist retrieval team from recipient hospital. The time interval between referral acceptance and the team arrival at patient's bedside was defined as response time in most of the literature.[3,11-13] In other words, the mobilization time and journey time were included in response time. However, all inter-hospital transports were transferred by ground ambulances in China, and the journey time was subjected to many factors including weather, geographical distances and the condition of traffic.[14] The purpose of this study was to find out the risk factors of mobilization time, and to establish standardized transport processes and guidelines for inter-hospital transport. It would be essential to ensure effective patient transport and minimize mobilization active time.

Statistical analysis

The results were presented as percentages. Differences between the groups were assessed by the Chi-square test for categorical data. Multivariate logistic regression was used to estimate odd ratios (OR) and 95% confidence intervals (CI) for the relationship between demographic characteristics and mobilization time.

Multivariate logistic regression model was used

to find the association between the risk factors and the mobilization time. Computerized analysis was performed using the SPSS for Windows version 18.0. The histogram was plotted by Microsoft Excel 2007. All statistical tests were two-sided. A *P* value less than 0.05 was considered statistically significant. This study was registered and approved by the research ethics committee of the hospital.

Results

During this study period, 10 087 referral telephone calls were answered in the transport center, 532 (5.27%) calls were canceled (the physiological parameters of 378 children had improved, 45 children died and 109 called for other reasons), and 324 (3.21%) cases had missing values. Finally, 9231 (91.51%) patients from 273 hospitals in Hunan and Jiangxi provinces were transported to Hunan Children's Hospital by ground ambulances. The ratio of male to female was 2.24:1. The majority of patients were neonates (48.72%), nearly two-fifths of the patients were infants and 1164 (12.61%) were older children. Two thirds of transported patients suffered from respiratory, neurological and cardiac diseases. Among the patients, 67.24% were admitted from non-tertiary hospitals, while the remainder were from tertiary hospitals. A large proportion (82.69%) of the patients was from departments of pediatrics, neonatal, gynecology and obstetrics, PICU, emergency department, and neonatal intensive care unit in referring hospitals. A total of 1598 (17.31%) patients had no detailed documentation on the source of referral. Among the patients, 81.52% were transported within a 250 km radius. Table 1 shows the baseline characteristics of the transports.

The majority of referral telephone calls were received during working hours (80.31%, 7413/9231). Referral telephone calls increased from 8 a.m., peaked at 10 a.m., and then gradually decreased (Fig.). Seasonal variation of inter-hospital pediatric transport revealed that the highest prevalence occured in spring (26.82%, 2476/9231) and winter (28.07%, 2591/9231) during the study period (Table 2).

The median retrieval mobilization time was 30 minutes (interquartile range, 20-50 minutes). Despite the mobilization time being a continuous variable, the data were divided into two groups (mobilization time ≥75th percentile and <75th percentile) as a dichotomous categorical. By statistical analysis, the two groups were similar in gender ratio (χ^2=1.04, P>0.05). The two groups were statistically significant in age categories (χ^2=39.22, P<0.001), referral time (χ^2=16.19, P<0.001), seasons (χ^2=88.60, P<0.001), and referral radius (χ^2=94.94, P<0.001) (Table 2). The

Table 1. Baseline characteristics of interhospital transport of critically ill patients

Variables	*n*	%
Sex		
Male	6381	69.13
Female	2850	30.87
Age		
Neonate (<30 d)	4497	48.72
Infant (1-12 mon)	3570	38.67
Older children (1-18 y)	1164	12.61
Diagnostic category		
Respiratory disease	3124	33.84
Neurological disease	1727	18.71
Cardiac disease	1358	14.71
Injury	428	4.64
Others	2219	24.04
Post operation	375	4.06
Source of admission		
Tertiary hospitals	3024	32.76
Non-tertiary hospitals	6207	67.24
Different departments from referring hospitals		
Department of Pediatrics	3428	37.14
Department of Neonatology	2759	29.88
Department of Gynaecology and Obstetrics	659	7.14
Pediatric Intensive Care Unit	585	6.34
Emergency Department	97	1.05
Neonatal (newborn) Intensive Care Unit	34	0.37
Infection Department	34	0.37
Surgery Department	32	0.35
Out-patient Clinic	5	0.05
Unknown	1598	17.31
Referral radius		
≤50 km	1124	12.18
50-150 km	2856	30.94
150-250 km	3545	38.40
>250 km	1706	18.48

Table 2. Effect of patients transport related factor on mobilization time

Variables	Mobilization time		χ^2	*P*
	≤P75 (50 min)	>P75 (50 min)		
Sex				
Male	4707 (73.77%)	1674 (26.23%)	1.04	>0.05
Female	2131 (74.77%)	719 (25.20%)		
Age				
Neonate (<30 d)	3463 (77.01%)	1034 (22.99%)		
Infant (1-12 mon)	2544 (71.26%)	1026 (28.74%)	39.22	<0.001
Older children (1-14 y)	831 (71.39%)	333 (28.61%)		
Referral time				
Working hours	5085 (73.03%)	1878 (26.97%)	16.19	<0.001
Non-working hours	1753 (77.29%)	515 (22.71%)		
Seasons				
Spring	1745 (70.48%)	731 (29.52%)		
Summer	1698 (77.39%)	496 (22.61%)	88.60	<0.001
Autumn	1579 (80.15%)	391 (19.85%)		
Winter	1816 (70.09%)	775 (29.91%)		
Referral radius				
≤50 km	962 (85.59%)	162 (14.41%)		
50-150 km	2114 (74.02%)	742 (25.98%)	94.94	<0.001
150-250 km	2556 (72.10%)	989 (27.90%)		
>250 km	1206 (70.69%)	500 (29.31%)		

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Table 3. Multivariable unconditional logistic regression analysis of the risk factors of mobilization time

Factors	β	SE	χ^2	df	*P* value	Odds ratio	95% confidence intervals	
							Lower	Upper
Referral time	0.171	0.058	8.726	1	0.003	1.186	1.059	1.329
Age			10.233	2	0.006			
Neonate	-0.222	0.075	8.791	1	0.003	0.801	0.692	0.928
Infant	-0.108	0.077	1.994	1	0.158	0.897	0.772	1.043
Referral radius			79.319	3	0.000			
<50 km	-0.851	0.101	70.345	1	0.000	0.427	0.350	0.521
50-150 km	-0.167	0.069	5.893	1	0.015	0.846	0.740	0.968
150-250 km	-0.066	0.066	1.022	1	0.312	0.936	0.823	1.064
Seasons			72.535	3	0.000			
Spring	-0.003	0.062	0.002	1	0.965	0.997	0.883	1.126
Summer	-0.350	0.068	26.276	1	0.000	0.705	0.616	0.806
Autumn	-0.515	0.073	49.635	1	0.000	0.598	0.518	0.690
Constant	-0.688	0.101	46.620	1	0.000	0.502		

SE: standard error.

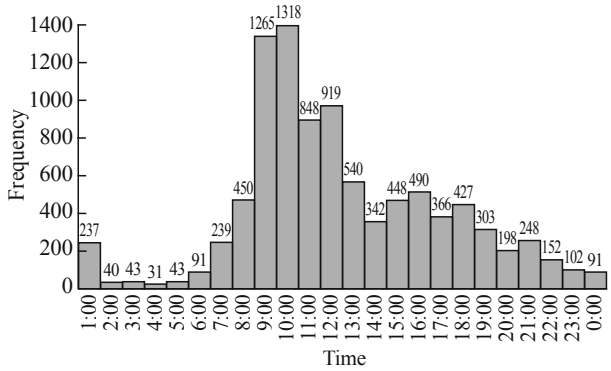

Fig. The distribution of referral calls in 24 hours each day.

median mobilization time of referred infants was longer than that of referred neonates [32 minutes (IQR: 20-55 minutes) *vs.* 30 minutes (IQR: 20-50 minutes)]. The median mobilization time varied significantly, based on referral time [working hours: 30 minutes (IQR: 20-50 minutes) *vs.* non-working hours: 30 minutes (IQR: 20-55 minutes)]; seasonal variation (spring: 35 minutes *vs.* summer: 30 minutes); referral radius (≤50 km: 25 minutes *vs.* 150-250 km: 32 minutes). These results are not included in the tables.

Sex, age categories, referral time, seasons, and referral radius were used as explanatory variables. The association between these factors and mobilization time was found by using Chi-square test. Age categories, referral time, seasons and referral radius were entered into a step multivariate logistic regression model for further analysis. In multivariate analysis, referral time, age categories, referral radius and seasons were associated with mobilization time ($P<0.05$). Mobilization time in non-working hours was longer than in working hours (OR=1.186, 95% CI=1.059-1.329). Mobilization time for neonates was shorter than that of the infants and older children (OR=0.801, 95% CI=0.692-0.928). Referral radius of 50 km required shorter mobilization time than that of over 250 km (OR=0.427, 95% CI=0.350-0.521). Referral of patients in summer required a significantly shorter mobilization time than in winter (OR=0.705, 95% CI=0.616-0.806).

Discussion

Pediatric diseases, with a high mortality, are often characterized by rapid change and development. Thus, the features of inter-hospital transport were the trend of being time-critical, managing difficult situation, and providing high-quality care. Despite numerous advances in pediatrics, transport of critically ill patients remains a challenge,[7] due to lack of pediatricians to provide initial care for these patients in outlying districts.[15] In addition, referral patients are subjected to limited medical resources and limited monitoring capability. It is necessary that critically ill children are transferred to a tertiary care facility in order to get high-quality care, to improve the clinical outcome, and to reduce the morbidity and mortality rates.[16-18]

In this study, we analyzed the characteristics of inter-hospital transport of critically ill children attended by ground ambulances. Nearly half of the critically ill children were neonates (48.72%) and the male-female birth ratio was 2.24:1. The respiratory, neurological and cardiac diseases comprised more than 70% of all cases. Furthermore, the minority of inter-hospital referred patients were derived from tertiary hospitals and the majority of patients were from the Department of General Pediatric Ward and Department of Obstetrics and Gynecology in 250 km radius. The current emergency inter-hospital transport system in China was largely related to our social health status. First of all, the developments of obstetrics and gynecology and neonatology were unequal in non-tertiary hospitals. Furthermore, the diseases of neonates were complicated, so many neonates needed to be treated by

experienced doctors. Another challenge was that there was no standardized inter-hospital transport system.

In this study, the median mobilization time was 30 minutes when the referral center needed to notify the specialist retrieval team and vehicles prepare transport. Abdel-Latif et al[11] reported that the median of mobilization time was 26 minutes (team activation, team mobilization and vehicle mobilization). Ramnarayan et al[12] reported that the median of team mobilization time was 25 minutes. In 1995, a study showed that the median mobilization time was 65 minutes (IQR: 32-155 min), and Britto et al[13] defined the mobilization time between receiving referral call and departure of the team from the tertiary center. The median mobilization time of neonates was less than that of the infants in this study, which was different from findings of a study by Abdel-Latif.[11] Kempley et al[19] found that the median response time was 87 minutes for newborn infants transferred in London and southeast England. Beddingfield et al[20] reported that the mean stabilization time for infants was more than that of the adolescents (46 min *vs*. 28 min). These differences are more likely to reflect differences between multiple interventions and the severity of illness. The department of neonatology is inferior to the department pediatrics in primary hospitals. Thus, the conditions of infants were more critical than those of the neonates in inter-hospital transport of pediatric patients, and required more interventions. Borrows et al[3] demonstrated that the mean stabilization time increased the number of major interventions. Referral radius of 50 km took shorter mobilization time than that of over 250 km (OR=0.427, 95% CI=0.350-0.521). The reason for the longer mobilization time is that the specialist retrieval team needed to take more time to advise physicians at the referring hospital on continued management, appropriate treatment and communication with the families, particularly when the referral radius was over 50 km. This study showed that mobilization time in non-working hours was longer than that of the working hours (OR=1.186, 95% CI=1.059-1.329) and referral patients in summer needed a significantly shorter mobilization time than in the winter (OR=0.705, 95% CI=0.616-0.806). In working hours, the six retrieval teams were available all the time, while only one team was available in non-working hours. In winter, the number of hospitalized patients was nearly twice that in the other seasons. The retrieval teams were busy in the entire winter period. The majority of pediatric patients were transported in spring and winter. The reasons are as follows: first, childhood pneumonia and influenza have seasonal variation; second, some bacteria and viruses may be more selective in terms of their action to the temperature in spring and winter.

Therefore, the following measures should be made to minimize mobilization time. First, regardless of seasons or referral time, the specialized retrieval team and vehicles should station at the referral center and should respond within the stipulated time after accepting a request for transport. Second, the retrieval team should be trained to bring the awareness of "time is life", and to ensure that the critically ill patients be transferred in a timely and effectively manner. Third, a reward and punishment system should be established to ensure a timely and effectively inter-hospital transport. Finally, the referring hospital, the referral center and the ward of the recipient hospital should establish a sound channel of communication.

To our knowledge, no study has shown "the standard time" may improve outcomes and decrease the mortality or morbidity rates of critically ill patients. However, the literature has demonstrated that stabilization time is related to the number of interventions, referral category, the operational efficiency of the transport team and the severity of illness.[3,11,12,19] According to the feature of "golden hour" in emergency medical services,[21,22] a mistaken assumption is that expeditious inter-hospital transports are effective transports. Therefore, many inter-hospital transports should practice a "scoop and run" approach because of better outcomes and the decrease of mortality which can be achieved by rapid and safe transfer to tertiary centers.[23] However, recent evidence has suggested that the outcome can be improved by early goal-directed therapy for septic and head trauma patients.[24-26] There was a motorized transport by which critically ill pediatric patients were transported only with cardiac monitoring, peripheral venous access, oxygen therapy and ventilation by hand-bagging. The retrieval teams should guide the caregivers in the referring hospital to perform vital interventions and goal-directed treatment before the team reaches the patient, and therapy should be continued until arrival at the referring hospitals.

It is important that some supporting measures should be taken to improve the effectiveness of retrieval teams. Furthermore, the hospital management can organize strategies and training systems for retrieval teams. On the other hand, the standardization process of inter-hospital transport and the guidelines of inter-hospital transport should be initialized.

The following limitations might have affected the results of our study. First, 324 children were excluded because of lack of variations, so it might have led to selective bias. A second potential limitation is that all inter-hospital transport of critically ill patients did not use Pediatric Risk of Mortality score (PRISM)[27,28] or Pediatric Risk of Mortality (PIM)[29,30] to evaluate

the severity of illness. Some physiological parameters cannot be collected by PRISM or PIM in partial tertiary hospitals in China, let alone in primary hospitals. Third, interventions were not recorded in the process of inter-hospital transport. Finally, this single-center study may not be adapted to other systems. Therefore, a large sample and a multicentre evaluation would be helpful in further studies.

In conclusion, mobilization time is commonly used as a performance measure for effective management. The mobilization time is a result of multiple factors, such as referral time, age categories, referral radius and seasons. The standardization process and guidelines of inter-hospital transport should be created to minimize mobilization time.

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Competing interest: The authors have declared that no competing interests are related to this study.

Contributors: QJ, ZYM, and XZH conceived and designed the experiments. QJ, WXL, HX, and QXL performed the experiments. WXL, QJ, and HX analyzed the data. QJ, XZH, and ZYM contributed reagents/materials/analysis tools. QJ wrote the draft of the paper.

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