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Comparison of interhospital pediatric intensive care transport accompanied by a referring specialist or a specialist retrieval team

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Abstract *Objective:* Interhospital transfers of critically ill pediatric patients in The Netherlands are accompanied by referring specialists or by specialist retrieval teams. We compared the interventions before and directly after transports and the complications and the equipment available during transports in the two groups. *Design and setting:* Prospective observational clinical study in pediatric intensive care units of Dutch university hospitals. *Patients:* 249 pediatric patients requiring interhospital intensive care transport. *Methods:* Data were collected on interhospital pediatric intensive care transports. We compared patient characteristics, interventions before and directly after transport, complications and equipment available during transport (137 accompanied by referring specialists, 112 by specialist retrieval teams). *Results:* Interhospital transports accompanied by referring specialists had a longer average transport time (74.6 vs. 60.2 min), higher incidence of respiratory insufficiency (56.9% vs. 41.1%), and lower incidence of circulatory insufficiency (27.0% vs. 41.1%) than primary admission diagnoses. These transports had a lower percentage of ventilatory support (47.4% vs. 72.3%), higher need for acute interventions directly upon arrival on the pediatric ICU, and higher incidence of critical and serious complications. In 75% of the transfers accompanied by retrieval teams interventions before the transport were deemed to be necessary. During the transports accompanied by referring specialists the equipment and materials available proved rather limited. *Conclusions:* During pediatric intensive care transports accompanied by nontrained referring specialists there appears to be a higher incidence of complications, specialized equipment is more often not available, and more acute interventions are required upon arrival in the pediatric ICU.

Keywords Interhospital intensive care transport · Equipment and materials · Complications · Interventions · Retrieval team · Children

Introduction

Recent developments in providing intensive care for infants and children have led worldwide to centralization in tertiary centers. The reason for centralization is that critically ill children show a better clinical outcome when treated in tertiary pediatric intensive care units (PICUs) than when treated in nontertiary pediatric centers [1, 2, 3, 4, 5]. Also, interhospital transport of critically ill children by specialist pediatric retrieval teams tends to be associated with a lower incidence of major complications than transport by nontrained personnel [6,

7, 8, 9]. Specialist retrieval teams are able to produce a higher degree of stabilization of the patient prior to and during transport [7, 8, 10]. Two of the eight tertiary PICUs in The Netherlands have well-organized and almost continuously accessible transport facilities. The other six centers perform transports only in specific cases, depending on the severity of the patient's condition and the availability of personnel in the PICU. This has resulted in a situation in which specialist retrieval teams do accompany about one-third of the pediatric intensive care transports. The referring specialists, who are not trained in pediatric intensive care and pediatric intensive care transport, accompany the other two-thirds. Assuming that both the level of pediatric advanced life support in the community hospitals in The Netherlands and the level of care in the PICUs in the tertiary centers are basically uniform, we undertook a study to assess differences between both groups of accompanying specialists. We compared the incidence of interventions before and directly after the transfer and the complications and the availability of equipment and materials during transfer.

Patients and methods

Patient data

Six out of the eight PICUs in The Netherlands actively participated in this study; one did not participate, and one provided data on only 2 of 46 transfers and was therefore excluded. These two centers are comparable to the six other centers included in this study in terms of patient population.

The study cohort consisted of patients (neonates excluded) below 16 years of age referred from a community hospital to one of the tertiary PICUs in The Netherlands over a 7-month period from 1 November 2000 to 31 May 2001. The referring hospitals were all Dutch community hospitals. The patients were referred directly from the emergency room, pediatric ward, or general intensive care unit of these hospitals. During the interhospital transport the patients were accompanied by either a physician (generally a pediatrician, sometimes an anesthetist) from the referring hospital (further referred to as referring specialist) or a specialist retrieval team from the PICU to which the patient was referred. The retrieval team consists of the team of the ground ambulance (a paramedic trained in intensive care and a driver), a pediatric intensivist or an anesthetist participating in the on-call of the PICU and occasionally a nurse of the PICU.

During the study period there were 381 interhospital pediatric intensive care transfers to one of the six participating centers. We received data from 268 (75.1%) transports, of which 249 (65.4%) were complete. Of these complete data 137 (55%) transports were accompanied by the referring specialists and 112 (45%) by a specialist retrieval teams of the PICU. The referring specialists were mainly pediatricians (86.9%), and in the other transports anesthetists (13.1%). The physicians in the retrieval team were mainly pediatric intensivists (91.1%), in the other transports by the retrieval teams it was an anesthetist participating in the on-call for the PICU. The numbers of transfers according to the tertiary centers are presented in Table 1. There were no statistical differences in the patient characteristics between the two groups (Table 2).

On admission to the PICU the attending intensive care specialist collected the clinical characteristics including age, Pediatric Risk of Mortality (PRISM) score, Pediatric Index of Mortality (PIM) score, acute physiology parameters, and primary admission

Table 1 Number of transfers and predicted mortality rates (PRIM and PIM) according to the tertiary centers

Tertiary center no.	Number of transfers		PRISM upon admission on PICU				PIM upon admission on PICU			
	Referring specialist	Retrieval team	Referring specialist		Retrieval team		Referring specialist		Retrieva team	
			Median	Range	Median	Range	Median	Range	Median	Range
1	3	25	0.83	0.4/3.3	1.68	0.3/93.4	0.53	0.3/1.97	1.97	0.2/83.8
2	39	12	1.87	0.3/86.3	2.35	0.5/73.3	1.87	0.2/12.8	1.43	0.3/47.5
3	15	32	2.01	0.6/28.6	2.41	0.5/28.3	1.80	0.2/7.1	1.77	0.2/17.8
4	1	26	97.2	–	1.33	0.6/83.1	91.6	–	2.38	0.3/44.9
5	44	12	1.77	0.3/21.8	2.79	0.3/39.3	1.12	0.2/9.1	3.00	0.3/14.4
6	35	5	3.42	0.4/98.4	1.48	0.8/1.9	1.97	0.4/83.1	1.16	0.2/3.3
Total	137	112	2.01	0.3/98.4	1.86	0.3/93.4	1.75	0.2/91.6	1.97	0.2/83.8

Table 2 Patient demographics on admission in the pediatric intensive care unit

	Referring specialist (n =137)	Retrieval team (n =112)	p
Age (years)	3.8±5.1	2.9±4.2	0.139
PH	7.34±0.14	7.36±.12	0.906
FIO_2	0.55±0.28	0.62±0.28	0.095
PaO_2 (mmHg)	127±80	151±100	0.198
PaO_2/FIO_2	272±172	274±170	0.801
$PaCO_2$ (mmHg)	43±19	43±27	0.149
Base excess (mmol/l)	−2.2±8.2	−2.8±6.7	0.246
Blood pressure systolic (mmHg)	96±26	91±23	0.118
Glasgow Coma Scale score	9.5±4.0	8.3±4.0	0.181

diagnosis. There were insufficient data to allow calculation of predicted mortality before the transfer. The same specialist and the accompanying specialist collected the data of the transport, including interventions before and directly after the transfer, and the complications and the availability of equipment during the transport.

Definitions of complications during the transport were as follows. Critical complications are endotracheal tube obstruction or dislocation, cyanosis (central cyanosis observed by the physician), bradycardia (heart rate below 60 beats per minute or reduction of the heart rate more than 30% of the baseline), circulatory arrest (asystoly, ventricular fibrillation, or loss of palpable central pulses), and hypotension (reduction in blood pressure by more than 10% of the baseline and under 10th percentile). Serious complications are neurological deterioration (reduction in Glasgow Coma Score by 2 or more points), desaturation (reduction in pulse oxymetry by more than 5% for longer than 15 s), hypothermia (reduction in temperature by more than 2°C and under 36.0°C), hyperthermia (elevation in the temperature by more than 2°C and over 39.0°C), loss of venous access, tachycardia (elevation in heart rate by more than 30% of the baseline) and hypertension (elevation in blood pressure by more than 10% of the baseline and over 90th percentile).

The duration of the transport is the time from departure in the referring hospital until the arrival on the PICU. All the data were rechecked by a telephone call with the referring specialist, the transporting specialist and the attending intensivist by one of the authors and stored in a database.

Statistical analysis

Statistical analysis was performed using SPSS PC 11.0 for Windows (SPSS, Chicago, Ill., USA). Where the appropriate χ^2 test, independent-groups Student's t test or nonparametric tests were used to compare the characteristics, complications, and interventions of the two groups of transport, i.e., by referring specialist or by specialist retrieval team. Results from metric data are presented as means ±standard deviation. For PRISM and PIM scores a logarithmic transformation was used before the independent Student's t test. These results are presented as median with their ranges. A p value of less than 0.05 was considered to be statistically significant.

Results

Table 1 presents the predicted mortality rates (PRISM and PIM) upon admission on the PICU. There was no significant difference for PRISM (p=0.952) or PIM (p=0.070) between the transports performed by the referring specialists and the retrieval teams. The duration of the transport proved significantly longer in the group accompanied by the referring specialist than those accompanied by a specialist retrieval team (73.8±35.4 vs. 61.7±32.4 min, p=0.022). Table 3 shows frequencies and percentages of primary admission diagnosis (χ^2=8.56 by 3 df, p=0.036). In the group with respiratory illness respiratory syncytial virus was seen in 35.5%, upper airway obstruction in 16.1%, pneumonia in 14.5%, status asthmaticus in 8.1%, and central apnea in 8.1%. Circulatory illness was by far most due to sepsis (75.9%), mainly meningococcal septic shock (68.3% of the sepsis group). Congenital heart disease was reported in the circulatory illness group in 12%. In the group with neurological disturbances these were mainly related to meningitis (29.6%), status epilepticus (22.2%), and intracranial hemorrhage (14.8%). A higher percentage of respiratory illness (56.9% vs. 41.1%) is observed in the group accompanied by the referring specialist and a higher percentage of circulatory illness (27.0% vs. 41.1%) in the group accompanied by a specialist retrieval team. The group of patients accompanied by the referring specialist showed a significantly lower incidence of mechanical ventilation before and during the transport (47.2% vs. 72.3%, p=0.001).

There was a high incidence of interventions before the transport in the group of patients accompanied by a specialist retrieval team. In 25.0% of these transports there was no intervention performed by the retrieval teams, in 23.2% there was one intervention, in 8.9% there were two interventions, and in 42.9% there were three or more interventions deemed necessary. The most commonly performed interventions were on the respiratory area change in ventilatory settings (36.6%) and start of mechanical ventilation (16.1%), endotracheal intubation (16.1%), and repositioning of endotracheal tubes (12.5%). On the circulation area these interventions were mainly fluid resuscitation (36.6%), start or change in vasoactive drugs (24.1%) and the introduction of central venous lines (17.0%). In 2.7% of the transports by retrieval teams cardiopulmonary resuscitation was started immediately upon arrival of the team in the referring hospital.

Table 3 Primary admission diagnoses

	Referring specialist (n =137)		Retrieval team (n =112)	
	n	%	n	%
Respiratory insufficiency	78	56.9	46	41.1
Circulatory insufficiency	37	27.0	46	41.1
Postoperative	2	1.5	1	0.9
Trauma	1	0.7	3	2.7
Neurological disturbance	16	11.7	11	9.8
Metabolic disturbance	1	0.7	2	1.8
Other	2	1.5	3	2.7
Total	137	100.0	112	100.0

Table 4 Frequencies of interventions directly after admission in the PICU

	Referring specialist (*n*=137)		Retrieval team (*n*=112)		p (χ^2)
	n	%	*n*	%	
Major					
Changing ventilator settings	33	23.7	15	10.8	0.033
Central venous line	30	21.6	11	7.9	0.011
Fluid resuscitation	29	20.9	13	9.4	0.045
Additional oxygen	27	19.4	5	3.6	0.001
Start or change cardiotonics	21	15.1	13	9.4	0.395
Endotracheal intubation	20	14.4	4	2.9	0.003
Start mechanical ventilation	16	11.5	2	1.4	0.003
Repositioning endotracheal tube	12	8.6	2	1.4	0.017
Start cardiopulmonary resuscitation	2	1.4	0	0.0	0.199
Minor					
Arterial line	68	48.9	31	22.3	0.001
Start or change sedation	35	25.2	9	6.5	0.001
Nasogastric tube	30	21.6	5	3.6	0.001
Venous access	8	5.8	0	0.0	0.009

Table 5 Complications during pediatric interhospital intensive care transport

	Referring specialist (*n*=137)		Retrieval team (*n*=112)		p (χ^2)
	n	%	*n*	%	
Critical					
Hypotension	16	19.0[c]	7	6.3	0.015
Cyanosis	6	4.4	0	0.0	0.025
Bradycardia	4	2.9	0	0.0	0.068
Circulatory arrest	4	2.9	0	0.0	0.068
Endotracheal tube obstruction	1	0.7	0	0.0	0.365
Endotracheal tube dislocation	1	0.7	0	0.0	0.365
Serious					
Desaturation	17	12.6[b]	2	1.8	0.002
Tachycardia	10	7.3	2	1.7	0.043
Neurological deterioration	9	6.6	1	0.9	0.023
Hyperthermia	2	7.7[a]	0	0.0	0.199
Loss of venous access	2	1.5	1	0.9	0.683
Hypothermia	1	3.8[a]	0	0.0	0.365
Hypertension	1	1.2[c]	2	1.7	0.447

[a] Percentage of 26 due to temperature measurement not available during transport in 113 cases
[b] Percentage of 135 due to pulse oxymetry not available during transport in 4 cases
[c] Percentage of 84 due to noninvasive blood pressure or invasive blood pressure not available during transport in 55 cases

The difference in the incidence of interventions directly upon admission to the PICU between the transfers accompanied by the referring specialist and those accompanied by specialist retrieval teams is summarized in Table 4. There was an overall higher incidence of interventions directly after admission on the PICU in the patients transferred by the referring specialists. The incidence of complications during the transfers is summarized in Table 5. Severe impairment of the circulation (bradycardia and circulatory arrest) was significantly higher in the group of patients accompanied by referring specialists (8 vs. 0, p=0.009). The incidence of hypotension was also significantly higher in the group of patients accompanied by referring specialists (16 vs. 7, p=0.015). Of the 37 patients in the group with a primary admission diagnosis of circulatory insufficiency and accompanied by the referring specialist 12 were transferred without any monitoring of blood pressure, while all the patients with circulatory insufficiency accompanied by specialist retrieval teams were closely monitored by invasive blood pressure measurement. Recalculation of the complications in relation to the longer transport time in the group accompanied by the referring specialist did not change the significance.

The data on the equipment and the materials not available during transport are given in Table 6. The availability of all equipment and materials (except electrocardiography and pulse oxymetry) was significantly lower in the group of patients accompanied by the referring specialists. In 26 (19.0%) transports accompanied by the referring specialists there was no ventilator reported to be available, and in 80 (58.3%) transports a

Table 6 Equipment and materials **not** available during pediatric interhospital intensive care transport

	Referring specialist (n=137)		Retrieval team (n=112)		p (χ^2)
	n	%	n	%	
Electrocardiography	0	0.0	0	0.0	
Respiration	5	3.6	0	0.0	0.041
Oxygen saturation	4	2.9	0	0.0	0.068
Noninvasive blood pressure	58	42.3	0	0.0	0.001
Invasive blood pressure	128	93.4	0	0.0	0.001
Temperature	113	82.5	25	22.3	0.001
End tidal CO_2	123	89.8	37	33.0	0.001
Suction	26	19.0	0	0.0	0.001
Resuscitation bag	19	13.9	0	0.0	0.001
Laryngoscope	41	29.9	0	0.0	0.001
Endotracheal tube	40	29.2	0	0.0	0.001
Suction catheters	49	35.8	0	0.0	0.001
Thorax drain	90	65.7	9	8.0	0.001
Infusion needle	26	19.0	0	0.0	0.001
Intraosseous needle	99	72.3	15	13.4	0.001
Intravenous fluid	30	21.9	0	0.0	0.001
Medication for cardiopulmonary resuscitation	63	46.0	0	0.0	0.001
Medication for intubation	67	48.9	0	0.0	0.001
Medication for sedation	61	44.5	0	0.0	0.001
Medication for circulation	78	56.9	5	4.5	0.001
Medication for convulsions	74	54.0	0	0.0	0.001
Resuscitation chart	86	62.8	21	18.8	0.001

ventilator of the ambulance was available. A suitable ventilator for children with a body weight below 15 kg was available in only 17 (12.4%) transports accompanied by the referring specialist. Specialist retrieval teams had suitable ventilators in 82 (73.2%) transports. The difference in availability of ventilators was highly significant (p<0.001).

Discussion

The characteristics of pediatric patients referred from a community hospital to a tertiary pediatric intensive care unit accompanied by the referring specialist or by a specialist retrieval team of one of the PICUs were not significantly different except for duration of transport and primary admission diagnosis. Although the differences in primary diagnosis could be a potential bias, it is our opinion that it is not a significant bias because the PRISM and PIM scores in the group of patients with respiratory insufficiency and circulatory insufficiency did not show a significant difference. The percentages of the transports accompanied by the referring specialist and the specialist retrieval team in this study was 55% vs. 45%, which is different from the distribution of all pediatric intensive care transports in The Netherlands (2/3 vs. 1/3). This difference is mainly due to the exclusion of the two PICUs that do not have a retrieval team to their disposal.

The PRISM and PIM scores tend to be low with a median of 1.9 and 1.8 both showing a wide range. Because in a high number of transports data were missing, full calculation was impossible in these transports, and therefore PRISM and PIM scores are probably underscored. A recent publication of the comparison of three scoring systems for mortality risk among retrieved pediatric intensive care patients also shows the difficulty in collecting data on mortality risk. In this publication PIM score resulted in more complete data collection (88%) than pre-ICU PRISM (24%) and PRISM (60%) [11].

Stabilization of the patient prior to the transport by retrieval teams and the greater number of interventions by these teams compared to the transports by the referring specialists could have led to a lower predicted mortality upon admission on the PICU and probably the predicted mortality scores were higher before the transfer in this group as is shown by the group of the PICU in St. Mary's Hospital in London [7, 9]. In particular, interventions to secure the airway and to start mechanical ventilation were performed frequently by these teams [7]. Our finding that there was a higher percentage of mechanical ventilation of patients accompanied by a specialist retrieval team tends to support this. The high incidence of endotracheal intubations directly upon admission on the PICU and the high incidence of respiratory related complications during the transport in the group of patients accompanied by the referring specialists suggests that these interventions should have been done prior to transport. In our personal communications with these specialists by far the most common reason to decide not to intubate the patient prior to the transport was the lack of

skills to handle intubation and mechanical ventilation related complications and the lack of specialized equipment and materials during transport. Since in all referring hospitals anesthetists are permanently available, there is no lack of support of the endotracheal intubation during the initial treatment.

Our findings of a high incidence of interventions by a specialist retrieval team before the transport is in agreement with reports in the literature [7]. The high incidence of interventions directly after admission to the PICU in the group of patients accompanied by the referring specialist has been previously reported [7]. The expert opinion of PICU specialists was that in a high percentage of the transports accompanied by the referring specialists interventions should have been performed before the transfer.

The high incidence of complications during transport in the group of patients accompanied by referring specialists is comparable to reports in the literature [6]. However, as a percentage of the number of transfers it is lower in our study. This might be due to our criteria for defining complications or by an underestimation by the referring specialists. The incidence of hypotension in the group of patients accompanied by the referring specialists may be underestimated due to the absence of continuous blood pressure monitoring in the majority of these transfers. Another possible explanation for the fewer complications in this study than in other studies is that the referral specialists in this study were better trained than those in the other studies. However, the difference in complications between the referral specialists and the retrieval teams is still high. The materials and medication necessary for intensive care transport were often reported to be lacking in transports accompanied by referring specialists.

During the transports of infants and small children (weighing less than 15 kg) accompanied by the referring specialists artificial ventilation was carried out mostly by hand-bagging, because in 88.5% of these transfers there was no ventilator available suitable for these patients. In older children accompanied by these specialists artificial ventilation was also by hand-bagging in most transports. Manual ventilation during transport results in greater fluctuation in ventilatory parameters, such as tidal volumes and peak inspiratory pressures, from an established baseline than occurs with the use of a transport ventilator [12]. Given this, and since in most cases no PEEP valve was used, most patients accompanied by referring specialists were not ventilated with sufficient PEEP and controlled tidal volumes and were exposed to a high potential risk of ventilator induced lung injury.

The high incidence of complications reported in the group of patients accompanied by the referring specialists may be related not only to the lack of experience and know-how of the accompanying specialists but also to the lack of pretransport interventions and to the absence or insufficiency of specialized equipment, materials, and medication available during transport. On the other hand, specialist retrieval teams bring their expertise and equipment to the patient in the referring hospital, and thereby the intensive care of the patient begins even before the transfer.

In our opinion, the necessity for specialist retrieval teams to accompany interhospital pediatric intensive care transport is evident from the insufficient level of care during transports accompanied by nontrained referring specialists, which leads to a higher incidence of complications during transport. Professional, fully equipped retrieval teams should be organized on a permanent, 24-h per day basis, staffed by specialists trained in pediatric intensive care and pediatric intensive care transport. Only then can the level of care during transport approach the level of care on the pediatric intensive care unit itself.

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