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Safety, speed, and effectiveness of air transportation for neonates

Short running title: Air transportation for neonates

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Abstract

Background

In Japan, 44.3% of neonates are delivered in private clinics without an attending pediatrician. Obstetricians must resuscitate asphyxiated neonates in unstable condition, such as respiratory failure, and they are frequently transferred to tertiary perinatal medical centers. There have been no studies comparing physiological status and prognosis between neonates transported by ambulance and helicopter.

Methods

Medical and transport records were used to compare physiological status between neonates transported to Kagoshima City Hospital by ground and air transport between January 1, 2013, and December 31, 2017.

Results

Data from 425 cases transferred by ground and 143 by air were analyzed. There were no significant differences between the two groups in mean gestational age, mean birth weight, fetal blood pH, Apgar score, or SNAPPE-II on arrival to the tertiary center (16.3 ± 15.4[95% CI; 13.2, 17.7] vs. 16.4 ± 15.4[95% CI; 13.9, 19.0], respectively; $P = 0.999$); both groups had SNAPPE-II score 10 – 19, indicating no difference in mortality risk. The times to starting first aid and to admission to the intensive care unit were significantly reduced in neonates transported by air than by ground. In subgroup analysis of patients gestational age ≤ 28 weeks, all cases of severe intraventricular hemorrhage (IVH) were observed in the ground transportation group.

Conclusions

Neonatal transportation by air is as safe as ground transportation, and time to first aid and intensive care are significantly reduced by transportation by air than by ground. Air transport could also contribute to prevention of IVH in neonatal transportation.

Key words: resuscitation, obstetrics clinic, neonatal air transportation, SNAPPE-II, Rapid Response Team

In Japan, 55.1% of births are at hospitals with a pediatrician on staff, while 44.3% of births are at private clinics without a pediatrician and 0.5% are in private homes with midwives.[1] In cases of obstetric emergencies, non-experts in neonatology have to resuscitate asphyxiated neonates at private clinics. Furthermore, in such emergency cases, cesarean sections are mostly performed without an anesthesiologist and attending pediatrician. Therefore, newborn infants in unstable condition, such as respiratory failure, frequently need to be transported to a tertiary perinatal medical center located far from the clinic either by ground or by air transport. In Japan, hospitals taking care of neonates are divided into level 1, 2, and 3. Level 1 hospitals have at least one pediatrician on staff but do not have to be a neonatologist. Level 2 hospitals are called as “regional perinatal medical center”, and have pediatricians holding the concurrent post of neonates and pediatrics for 24 hours in the hospital. Level 3 hospitals are called as “tertiary perinatal medical center” responsible for regional perinatal medicine. Level 3 hospitals must have neonatologists working exclusively in neonatal intensive care unit (NICU) and an anesthesiologist in order to emergency operations in the hospital. This study was performed to examine the safety, speed, and effectiveness of air transportation of neonates in unstable condition from local clinics to tertiary perinatal medical centers.

The study area has a population of 1.6 million living in an area of 9187 km^2 composed of 26 inhabited islands and is covered by a level 3 tertiary center, Kagoshima City Hospital (KCH). There were 13209 deliveries in the study area in 2016. The KCH perinatal center is responsible for arrangement and management of all neonatal transportation requests by local health facilities in the area. It provides resource-intensive treatments, including therapeutic hypothermia, inhaled nitric oxide (iNO), extracorporeal membrane oxygenation (ECMO), continuous renal replacement therapy (CRRT), and resuscitation for neonates born from a gestational age of 22 weeks. There are 42 facilities where pregnant women can deliver a baby in the study area. Three health institutions have neonatologists and pediatricians on staff, four institutions have pediatricians, and the others do not have neither neonatologists nor pediatricians. In 2016, 6864 (52%) infants were born at private local clinics in the study area. In obstetric emergencies, private clinics requested neonatal transportation to the tertiary center. In 2012, air transportation of unstable neonates was introduced to reduce the time from receiving the request by a clinic to first aid on arrival at local clinics and admission to the NICU of KCH.

The current perinatal medical system is designed to ensure that maternal patients are smoothly referred and transported to advanced medical facilities when necessary. However, in some cases, emergency caesarean section must be conducted at local clinics due to the time necessary for maternal transportation to the tertiary center. To reduce the time to commencement of interventions, a perinatal rapid response team (Perinatal-RRT) service was started in 2012 composed of four health care providers specializing in trauma, obstetrics, and neonatology dispatched to local clinics by air transportation.

To date, there have been no physiological evaluations of neonatal air transportation and Perinatal-RRT. This study was performed to examine the safety and speed of neonatal air transportation, the effectiveness of early intervention at private clinics for improving prognosis, and its cost effectiveness.

Methods

This was a retrospective cohort study using medical and transport records of patients admitted to the NICU of KCH to compare neonatal physiological status between ground and air transportation. Eligible patients were those admitted to KCH by ground or by air transportation between January 1, 2013, and December 31, 2017. Exclusion criteria were ground transportation by a method other than ambulance and air transportation by a method other than emergency medical service (EMS) helicopter. A specialized ambulance for neonatal patients equipped with a neonatal transport capsule, ventilator, intravenous drip pumps specialized for neonates, and air and oxygen gas cylinders were used for ground transportation of neonates. The area covered by the transportation system was divided to five groups according to ground and air transportation times. (Figure 1) Neonatal transportation by air was conducted by the EMS team consisting of medical doctors and nurses. The EMS helicopter was equipped with the same neonatal medical devices as the ambulance used for neonatal ground transportation. This study was approved by the Ethics Committee of KCH (Approval No. 2017-40).

The Score for Neonatal Acute Physiology with Perinatal Extension-II (SNAPPE-II), a scoring system designed to predict neonatal prognosis using gestational age, vital signs, and blood gas analysis data,[2,3] was used to evaluate neonatal physiological status on arrival at the NICU of KCH. The SNAPPE-II has a range from 0 to 162, and mortality risk increases with every 10 points. Transportation time was divided in two sections, i.e., Time to First Aid (TFA) defined is the time from receiving an emergency call to contacting the patient at the clinic, and Time to Intensive Care (TIC) defined as the time from receiving an emergency call to arriving at the tertiary center (i.e., KCH).

The effectiveness of early interventions at the clinic was evaluated in subgroup analysis. Patients who were born preterm with gestational age ≤ 28 weeks (Preterm-28) were included in the analysis. The incidence of intraventricular hemorrhage (IVH) diagnosed within 72 hours was used to predict prognosis. Patients without IVH or with IVH grades 1 and 2 were considered to have good prognosis, while those with IVH grades 3 and 4 were considered to have poor prognosis.[4] Ground transportation cost was estimated to be $561 per single dispatch based on introduction costs, depreciation expenses and operating cost, on the other hand air transportation cost was estimated to be $2,861 per single dispatch at Kagoshima. (Table 1) A subvention in helicopter EMS for a year was almost same in Japan regardless of dispatch times, therefore air transportation cost was calculated based on dispatch times. The currency exchange rate used in the calculations was 110 Japanese Yen/US$.

Results

Of 838 cases of neonatal transportation in the study period, 630 were by ground and 162 were by air. (Figure 2) 46 cases were transported by the Self-Defense Force, bullet train, or taxi. 425 of the 630 cases of ground transportation and 155 of 162 cases of air transportation were emergency cases. Of the 425 emergency cases by ground transportation, 264 were requested by local clinics in the city district where air transportation was not an option and 161 were transferred from clinics outside the city where both air and ground transfer services were available. 12 of the 155 emergency air transportation cases were requested by clinics on remote islands or in suburban areas. 425 ground transfer cases and 143 air transfer cases were included in the analysis. These cases had gestational ages (GA) of 37.3 ± 3.2 weeks and 37.3 ± 4.2 weeks, respectively (P = 0.694), birth weights (BW) of 2666 ± 641 g and 2564 ± 690 g, respectively (P = 0.1570), umbilical artery (UA) -pH 7.23 ± 0.14 and 7.24 ± 0.15, respectively (P = 0.808), Apgar scores (5 min) of 8.1 ± 2.0 and 8.1 ± 2.1, respectively ($P = 0.877$), and SNAPPE-II scores on arrival at the tertiary center of 16.3 ± 15.4[95% CI; 13.2, 17.7] and 16.4 ± 15.4[95% CI; 13.9, 19.0], respectively ($P = 0.999$). There were no significant differences in background data between the patients transported by ground and by air.

TFA and TIC were analyzed according to areas A – E in the study area (Table 2). TFA: Area A 91.1 ± 18.7 min ($n = 21$), 16.4 ± 7.9 min ($n = 26$) ($P < 0.001$); Area B 103.0 ± 17.0 min ($n = 2$), 19.7 ± 8.0 min ($n = 12$) (*$P = 0.028$); Area C 60.3 ± 5.4 min ($n = 10$), 19.5 ± 10.9 min ($n = 17$) ($P < 0.001$); Area D 46.9 ± 12.0 min ($n = 80$), 11.9 ± 7.7 min ($n = 55$) ($P < 0.001$); Area E 27.9 ± 9.0 min ($n = 43$), 14.3 ± 9.3 ($n = 33$)($P < 0.001$). TIC: Area A 236.3 ± 45.1 min, 69.4 ± 29.0 min ($P < 0.001$); Area B 219.0 ± 15.6 min, 95.2 ± 29.6 min (*$P = 0.029$); Area C 187.4 ± 61.6 min, 79.0 ± 29.5 min ($P < 0.001$); Area D 123.0 ± 27.8 min, 63.0 ± 21.7 ($P < 0.001$); Area E 85.9 ± 21.0 min, 63.9 ± 24.4 min ($P < 0.001$). In all areas, air transportation significantly reduced both TFA and TIC.

Twenty cases were designated as Preterm-28. Twelve of these 20 case were transported by ambulance, while the others were transported by helicopter. Background data of the patients according to ground and air transport in this group are shown in Table 3: GA 25.4 ± 2.2 weeks and 25.4 ± 1.2 week, respectively ($P = 0.640$); BW 800 ± 303 g and 767 ± 180 g ($P = 0.908$), respectively. All of the patients with poor prognosis in this group were transferred by ambulance. There were significant differences in TFA, TIC, and prognosis between the patients transported by ambulance and helicopter.

Discussion

The level of medical treatment is dependent on the level of health facilities where they are provided. For example, treatments provided in prehospital stages are different from those provided in hospital wards and intensive care units. While EMS provides adequate medical care of patients from children to adults and meets the current demands, perinatal EMS is unique due to its highly specialized service. Half of all births occur at private clinics in Japan, and neonates with complications are not always resuscitated by trained health care providers. In addition, these private clinics are often located far from the NICU of the tertiary perinatal medical center. Private clinics can be regarded as prehospital locations in perinatal medicine. For adult EMS, a single call to the operator both activates the medical rescue team and sends an ambulance simultaneously. In contrast, in the perinatal emergency transport system, there is no single operator in charge of arranging transportation, and therefore a number of complicated steps are required to arrange neonatal transportation. An obstetrician at a clinic first needs to make a request to the tertiary center to accommodate the sick neonate, then calls EMS and explains the situation, and attends the transport as the EMS team is not familiar with perinatal medicine. Transportation by a non-expert team should be avoided because the condition of the patients often deteriorates during transportation, leading to poor prognosis.[5] We implemented a system for rapid activation of perinatal EMS in 2000. One request call to KCH activates perinatal EMS, which sends a neonatal transportation team to the clinic. Generally, a neonatal transportation team is composed of a neonatal doctor/physician's assistant, nurse/nurse practitioner, and respiratory therapist trained for transportation with the medical devices necessary for neonatal resuscitation. In KCH, the neonatal transportation team has a neonatal doctor and a nurse, and an ambulance specially designed for neonatal intensive care during transportation. Therefore, as soon as the team arrives at the clinic, they can begin treatment equivalent to the NICU at KCH. Therefore, the time required for first contact on the ground is the time required to start intensive care for neonates. Shorter TFA is associated with better prognosis of the neonates. In adult patients, it was reported that reducing TFA by air EMS improved the number of days of hospital admission as well as morbidity and mortality rates.[6,7] However, there have been few reports regarding the effects of air transportation on neonatal outcomes.

In this study, there were no differences in the backgrounds of the patients transferred by ground and by air, and the results of SNAPPE-II on arrival were not different between the two groups. The 95% CI of SNAPPE-II scores in both groups were within 10 – 19, indicating no difference in mortality risk. While air transportation could aggravate the respiratory state of the neonates due to the decreased oxygen concentration and changes in atmospheric pressure, no unfavorable effects on the results of blood gas analysis were observed on arrival. In the KCH neonatal transport team, two neonatal doctors and one nurse are dispatched for ground transportation, while the EMS team for air transportation is composed of one emergency doctor and nurse, and two neonatal doctors. Neonatal doctors are selected from attending, fellow, and resident doctors depending on the severity of the neonate's condition. Therefore, interventions on arrival at the private clinics are the same as those provided in the tertiary center regardless of the means of transportation.

In the Preterm-28 group ($n = 20$), all cases of severe IVH ($n = 5$) were among the neonates transported by ground (58%). While there were no significant differences in body weight, gestational age, or SNAPPE-II score between the neonates transported by ground and by air, the mean TFA and TIC were significantly different between the two groups. Multiple factors are related to IVH, including prematurity, antenatal glucocorticoid therapy, respiratory distress, fluctuations in blood pressure, cardiopulmonary resuscitation, off-peak delivery, and hypotension. IVH generally occurs in preterm neonates. Smaller and younger neonates have higher risk of IVH.[8,9,10] In addition to prematurity, neonatal transport was also reported as a risk factor for IVH.[11] The incidence of IVH in infants born outside of tertiary centers was reported to be 25.7% while that of infants at tertiary centers was 14.7%.[12] To our knowledge, there has been no previous clinical research regarding the effects of transportation methods on outcomes of neonates. We found that air transportation of out-born infants did not increase the risk of IVH and could be conducted safely with trained neonatologists. Helicopter transportation has been reported to have fewer effects on neonates associated with movement of the vehicle during transportation than an ambulance.[13] Although there were no differences in SNAPPE-II scores on arrival between the two groups, the incidence of severe IVH was significantly higher in the neonates transported by ambulance than by helicopter. It may be better to transport premature neonates by helicopter than by ambulance in terms of preventing IVH.

Delivery at a private clinic has been reported as a risk factor of poor prognosis in cases showing hypoxic ischemic encephalopathy (HIE), and inadequate resuscitation was also shown to be a risk of IVH.[14,15] HIE, which is frequently caused by placental abruption, is the most common cause of developmental delays in neonates. Placental abruption is unpredictable, and therefore seamless interventions of initial neonatal resuscitation, specialized treatments for respiratory failure, and immediate transportation to the NICU are needed. The incidence rate of HIE is 0.1%, and prognosis is poor in 60% of cases with HIE without timely and adequate medical interventions.[16] Although xenon gas inhalation, embryonic stem cell transfusion, and erythropoietin have been reported to improve prognosis, therapeutic hypothermia is the only established therapy for patients with moderate to severe HIE. Therapeutic hypothermia (TH) should be induced within the initial 6 hours after delivery to achieve the maximum effect, and prehospital cooling has recently been recommended. However, prehospital passive cooling may also be a risk factor for poor prognosis due to a lack of appropriate medical equipment to safely manage the body temperature of the neonate.[17,18] The results of a case-control study in the cohort are shown in Table 4. FTA was reduced and prehospital cooling was initiated in all HIE patients enrolled in the study, and there were no negative effects of prehospital cooling. Even though the cohort was small, the results of TH for HIE was comparable to a previous study. [16] Therefore, the neonatal transport team with specialized medical equipment could safely initiate TH in asphyxiated neonates.

In Japan, delivery at a private clinic is a risk factor for poor prognosis. One reason for this is the maternal transportation time.[14,19] At least two doctors and a nurse are required to safely perform an emergency cesarean section, especially in cases of placental abruption. In most such cases, the mother is hemodynamically unstable and the neonate is likely to be asphyxiated. Immediate delivery after diagnosis is desirable, but maternal transfer to a higher-tier medical institution would delay emergency cesarean section. Perinatal-RRT using EMS with a helicopter as a means of transportation has been in operation at KCH since 2012. The Perinatal-RRT is composed of an emergency doctor, an obstetrician, and a neonatologist allow the team to cope with perinatal emergencies at private clinics, which can be fatal to both the mother and infant without timely and adequate medical interventions. The Perinatal-RRT is equipped with packs of blood products, such as red blood cells, fresh frozen plasma, and platelets, if needed. Perinatal-RRT can be dispatched within 8 minutes after receiving a request. In the present study period, Perinatal-RRT was requested for eight cases, five of which (63%) had good outcomes despite expected fatality of the fetus on arrival of the team. (Table 5) While a rapid response system (RRS) has been shown to contribute to improved outcomes in cases of in-hospital,[20] The Perinatal-RRT at KCH is unique in that it responds to cases in private clinics. There have been no reports regarding RRS specializing in perinatal medicine, and further studies are needed to establish the effects of Perinatal-RRT.

Medical expenses of hospitalization in the NICU were also estimated in Preterm-28 according to prognosis. In the case of preterm neonates weighing < 1000 g, total expenses at 120 days of hospitalization were evaluated, while those at 90 days were evaluated for neonates weighing 1000 – 1500 g regardless of transportation method. The difference in cumulative medical expenses until 1 year of age between the good and poor prognosis groups was $189800. (Figure 3) With regard to medical expenses associated with home care, there have been few reports examining quality adjusted life year (QALY) and incremental cost-effectiveness ratio (ICER) in infants with poor prognosis.[21] The costs per QALY for neonatal care in 1990 were $6101, $1290, $3833, and $955 for infants weighting < 1000 g, 1000 – 1500 g, 1501 – 2500, and > 2500 g, respectively. In a study performed in 2010, for children born at < 32 weeks of gestation, the average cost per QALY at 4 years old was $28290, ranging from $17381 to $79856, and more than doubled for children with two or more morbidities at the age of 4 years.[22] One study in Japan estimated that the costs of medical care and treatments for these newborn infants would be $35000 per month in the acute phase, $15000 per month in the stable phase, and $4000 per month at home.[23] Neonates with HIE treated with TH in the acute phase were discharged with good outcomes within 30 days after admission. However, those with poor outcomes needed to stay in the hospital longer and required ongoing medical care at home after discharge. We estimated that the total costs would amount to $122000 in the first year, and annual medical expenses of $45000 thereafter.

The results of this study did not demonstrate the cost-effectiveness of air transportation of neonates. However, in premature neonates, air transportation could save $189800 until 1 year of age to have a possibility of preventing severe IVH. Further, introduction of Perinatal-RRT could have averted costs of $122000 in HIE patients receiving TH.

Limitations

First, while there are many risk factors for IVH in premature neonates, ranging from maternal factors to clinical procedures, multivariate analysis was not performed in the present study. Second, in study area B, only small numbers of infants in both groups were included in the analysis, especially in the ground transportation group, and therefore statistical analysis was not possible. QALY and ICER are commonly used in cost-effectiveness evaluations. However, we did not perform analysis in terms of QALY and ICER due to the paucity of previous reports in neonates. Insurance systems and medical care provided for neonates are also different between countries. There is also the discrepancy in single dispatch cost between the previous report and our data.[24] The reason will be labor costs of medical staff and the difference in estimated dispatch times. Further studies are needed to investigate the cost-effectiveness of air transportation.

Conclusions

Neonatal air transportation after birth was safe and significantly reduced the time required to start first aid and for intake of the patient in the neonatal intensive care unit. In premature neonatal transportation, air transportation could contribute to the prevention of IVH, and medical costs could be reduced with the introduction of air transportation and Perinatal-RRT.

Author contributions

E.H., S.I., H.Y., M.K., and Y.K. contributed to the study design and writing the manuscript.

M.K participated in the statistical analysis.

C.I., Y.N., T.Y., M.Y., T.T., T.K., Y.M., and H.O. participated in data collection.

All authors have seen and approved the final version of this manuscript.

The authors declare no conflict of interest.

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Table 1. Estimated single dispatch cost in air and ground transportation.

Air transportation, Helicopter.

	Subvention per year	Actual dispatch times (2018)	Single dispatch cost	Estimated single dispatch cost in neonates
Kagoshima	$1,941,181	1,114	$1,743	$2,861
Average in Japan	$1,954,545	559	$3,497	N/A

*Introduction cost of neonatal equipment specialized for helicopter were $286,363. Useful life is estimated as 8 years. Estimated neonatal equipment cost in single dispatch was $1,118.

Ground transportation, Ambulance for neonates.

	Depreciation expenses per year	Average dispatch times per year	Single dispatch cost	Estimated single dispatch cost in neonates
Kagoshima	$43,182	126	$343	$561**
Japan [24]	N/A	4,649	N/A	$1,182

*Introduction cost of the ambulance and neonatal equipment for ambulance were $345,454. Useful life is estimated as 8 years. The cost every dispatch was $218 calculated based on driver`s fee and operating cost for 2 hours.

**This calculation does not include labor costs for doctor and nurse.

Table 2. Comparison of patient background characteristics between ground and air emergency transportation groups.

Transportation	Ground	Air	*P*-value
No. of neonates	425	143	
Background			
Gestational week at delivery	37.3 ± 3.2	37.3 ± 4.2	0.694
Birth weight (g)	2666 ± 641	2564 ± 690	0.157
Umbilical cord pH	7.23 ± 0.14	7.24 ± 0.15	0.808
Apgar score at 5 min	8.1 ± 2.0	8.1 ± 2.1	0.877
SNAPPE-II score	16.3 ± 15.4	16.4 ± 15.4	0.999
95% CI	[14.8, 17.7]	[13.9, 19.0]	
Area A			
No. of neonates	21	26	
Background			
Gestational week at delivery	35.3 ± 5.2	35.3 ± 5.2	0.889
Birth weight (g)	2458 ± 913	2389 ± 826	0.740
Umbilical cord pH	7.27 ± 0.12	7.23 ± 0.24	0.528
Apgar score at 5 min	7.5 ± 2.1	7.4 ± 1.9	0.625
Time to first aid (min)	91.1 ± 18.7	16.4 ± 7.9	< 0.001
Time to intensive care (min)	236.3 ± 45.1	69.4 ± 29.0	< 0.001

Area B			
No. of neonates	2	12	
Background			
Gestational week at delivery	34.4 ± 1.1	37.2 ± 6.2	
Birth weight (g)	2294 ± 263	2624 ± 971	
Umbilical cord pH	7.33 ± 0.04	7.22 ± 0.12	
Apgar score at 5 min	9 ± 0	7.4 ± 1.4	
Time to first aid (min)	103.0 ± 17.0	19.7 ± 8.0	
Time to intensive care (min)	219.0 ± 15.6	95.2 ± 29.6	
Area C			
No. of neonates	10	17	
Background			
Gestational week at delivery	37.3 ± 4.2	38.3 ± 2.2	0.760
Birth weight (g)	2641 ± 696	2706 ± 681	0.960
Umbilical cord pH	7.26 ± 0.16	7.24 ± 0.11	0.501
Apgar score at 5 min	8.0 ± 1.7	7.7 ± 2.5	0.788
Time to first aid (min)	60.3 ± 5.4	19.5 ± 10.9	<0.001
Time to intensive care (min)	187.4 ± 61.6	79.0 ± 29.5	<0.001
Area D			

No. of neonates	80	55	
Background			
Gestational week at delivery	37.3 ± 4.2	37.3 ± 3.2	0.679
Birth weight (g)	2611 ± 698	2635 ± 576	0.742
Umbilical cord pH	7.26 ± 0.12	7.25 ± 0.10	0.431
Apgar score at 5 min	8.1 ± 1.8	8.6 ± 1.7	0.031
Time to first aid (min)	46.9 ± 12.0	11.9 ± 7.7	<0.001
Time to intensive care (min)	123.0 ± 27.8	63.0 ± 21.7	<0.001
Area E			
No. of neonates	43	33	
Background			
Gestational week at delivery	37.2 ± 3.2	37.3 ± 3.2	0.937
Birth weight (g)	2697 ± 617	2490 ± 643	0.379
Umbilical cord pH	7.24 ± 0.12	7.22 ± 0.15	0.173
Apgar score at 5 min	8.4 ± 1.7	8.1 ± 2.6	0.637
Time to first aid (min)	27.9 ± 9.0	14.3 ± 9.3	<0.001
Time to intensive care (min)	85.9 ± 21.0	63.9 ± 24.4	<0.001

Table 3. Patient background characteristics in Preterm-28 subgroup.

Transportation	Ground	Air	*P*-value
No. of neonates	12	8	
Background			
Gestational week at delivery	25.4 ± 2.2	25.4 ± 1.2	0.640
Birth weight (g)	800 ± 303	767 ± 180	0.908
Umbilical cord pH	7.28 ± 0.19	7.35 ± 0.05	0.763
Apgar score at 5 min	6.1 ± 2.6	6.4 ± 2.6	0.731
SNAPPE-II score	46.4 ± 30.9	39.3 ± 20.5	0.939
95% CI	[26.8, 66.0]	[22.1, 56.4]	
Time to first aid (min)	64.4 ± 56.4	19.4 ± 10.1	0.015
Time to intensive care (min)	183.0 ± 75.7	90.2 ± 22.6	0.023
Good prognosis	7 (58%)	8 (100%)	0.035

Table 4. Patient background characteristics in HIE receiving TH subgroup.

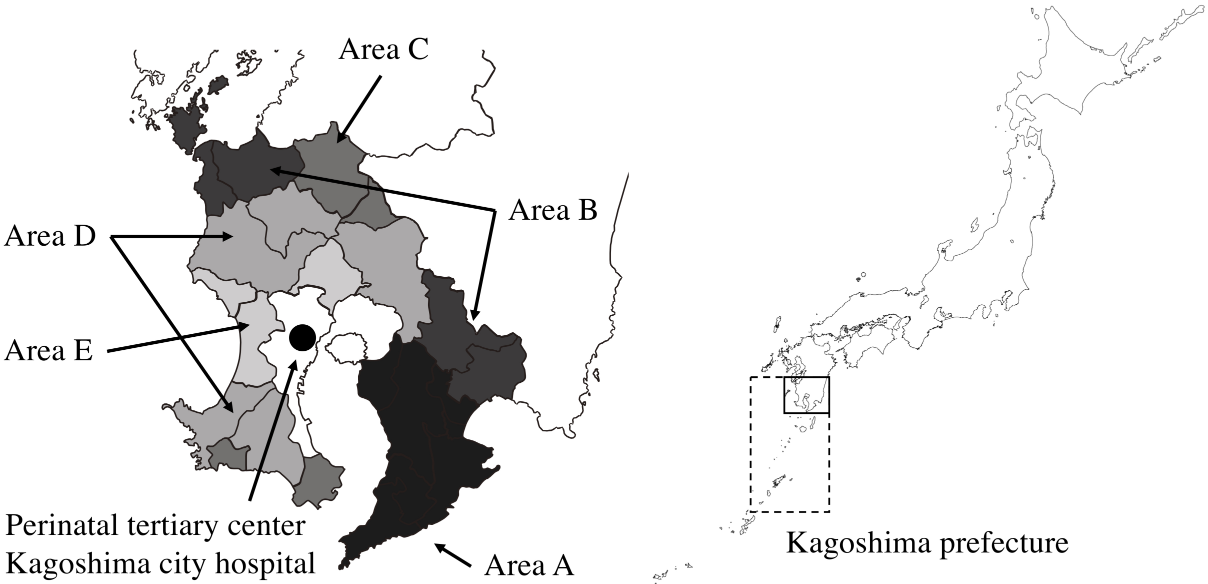
Prognosis(HIE receiving TH)	Good	Poor	*P*-value
No. of neonates	18 (72%)	7 (28%)	
Air Transportation	5/18 (28%)	2/7 (29%)	
Time to first aid (min)	17.7 ± 16.8	27.7 ± 34.9	0.904
Time to intensive care (min)	63.2 ± 40.5	111.4 ± 82.4	0.115
Background			
Gestational week at delivery	38.4 ± 2.2	38.3 ± 2.2	0.976
Birth weight (g)	2928 ± 519	3027 ± 665	0.586
UA-pH	6.89 ± 0.17	7.00 ± 0.11	0.133
Apgar score at 5 min	4.3 ± 2.9	3.0 ± 2.9	0.377
SNAPPE-II score	40.2 ± 15.0	49.4 ± 23.8	0.327

Table. 5 Cases with Perinatal-RRT response.

Case	Area	Diagnosis	FTA (min)	GA (week)	Outcome
1	B	NRFS	26	33	Good
2	B	NRFS	19	38	Good
3	A	PTL	37	33	Good
4	D	PTL	43	24	Still birth
5	C	PTL	20	23	Good
6	D	PTL	17	24	Poor (w/o IVH)
7	B	NRFS	23	39	Still birth
8	I	PTL	31	29	Good

*I, Islands; NRFS, Non-reassuring fetal status; PTL, Preterm labor.

Figure 1. Map showing Areas A, B, C, D, and E.



Area A: Ground 90 min, Air 15 min; Area B: Ground 100 min, Air 20 min; Area C: Ground 60 min, Air 20 min; Area D: Ground 50 min, Air 15 min; Area E: Ground 30 min, Air 15 min (times are TFA).

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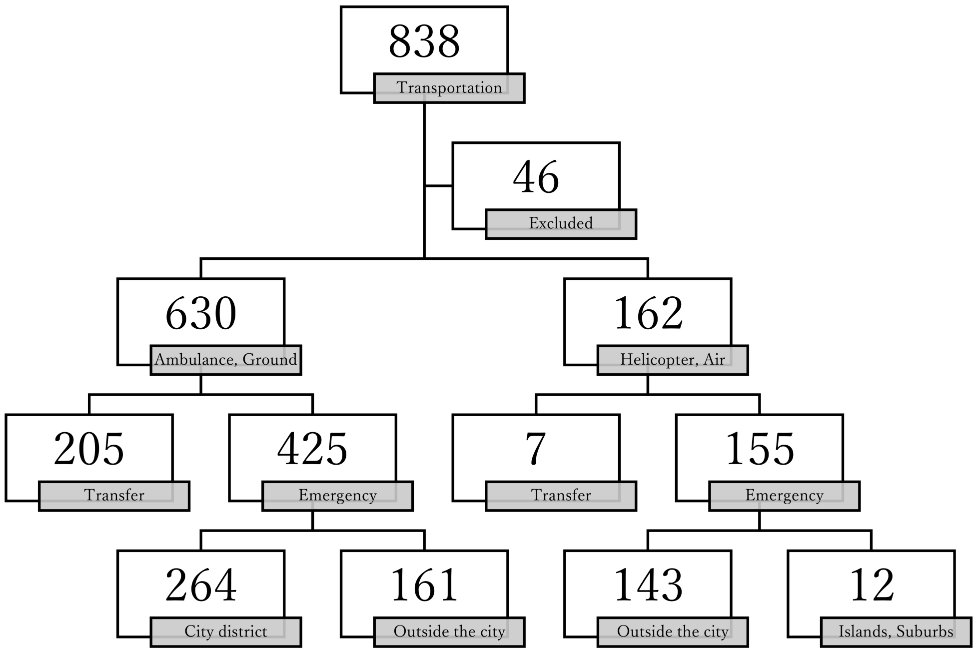
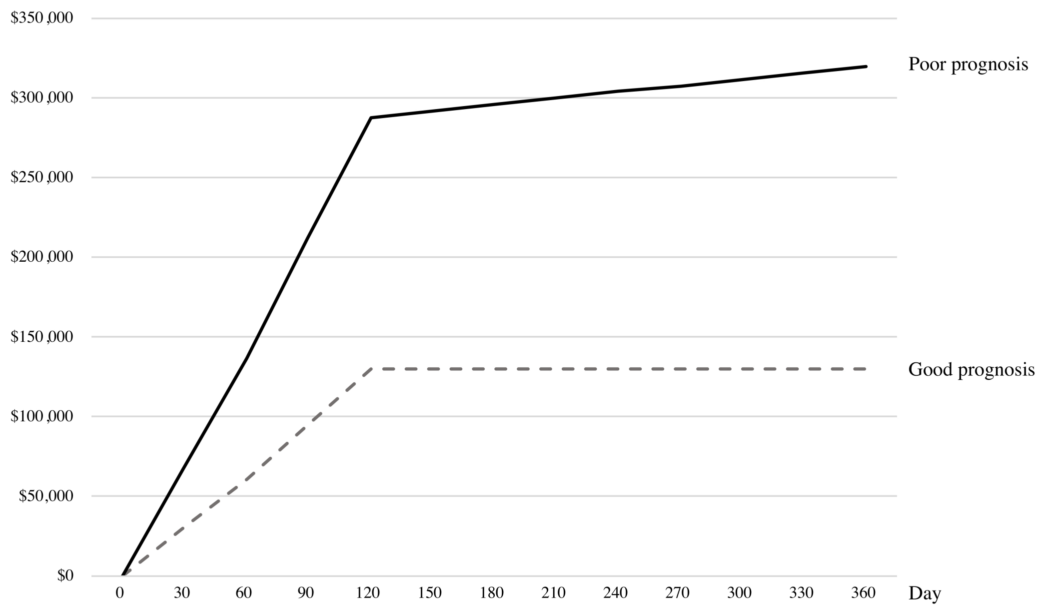
Figure 2. Neonatal transportation.



ped_14401_f2.jpg

Figure 3. Mean accumulated medical expenses in Preterm-28.



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