6

Helicopter Transportation for Perinatal and Maternal Emergency Care in Japan

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1. Introduction

The number of obstetric and pediatric doctors has been the most insufficient in all the fields of clinical medicine even in the age of decreasing birthrate in Japan. Obstetric departments in local hospitals and private obstetric clinics have been closed and reorganized especially in the sparsely populated areas during late 10 years. The perinatal transportation system becomes more critical than ever before to maintain the quality of perinatal medicine.

The Helicopter Emergency Medical Service was started in Japan in 2001 after the civil aeronautic law was partly amended to allow the service. The so-called "doctor-helicopter law" was then enacted in 2007 to promote introduction of the Helicopter Emergency Medical Service nationwide based on governmental funding. As of June 2011, 27 helicopters are in emergency medical service in the field of emergency medicine (Japanese Society for Aeromedical Services, 2011). Since Japan is an island country and has many isolated islands, helicopters have sporadically been involved in the maternal or neonatal transportations. However, there seems to be no other hospitals like Wakayama Medical University Hospital where a helicopter routinely has taken part in the maternal and neonatal transportation that obstetric and pediatric doctors are involved in, respectively.

The objective is to study the effectiveness of helicopter transport in the perinatal medicine.

2. Methods

2.1 Helicopter emergency medical service at wakayama medical university hospital

In January 2003, Wakayama Medical University Hospital became the 7th hospital in Japan to introduce a helicopter for Emergency Medical Service. The helicopter, a Eurocopter EC135Pi, is based at the rooftop of the 13-story university hospital, and the helicopter administration office where communication center is, and medical and flight crews are standing by is on the 13th floor. Emergency room and perinatal medical center are on the

first and 6th floors of the same building, respectively. The helicopter was installed with a respirator, a cardiorespiratory monitor, a portable echo, and an automated external defibrillator. The hospital is located in northwest Wakayama prefecture. The coverage area is the whole of Wakayama prefecture (4,726.12 km^2), the southern part of Nara prefecture (1,727.52 km^2), and the southern part of Mie prefecture (991.74 km^2). The flying time is 30 minutes for 100 km. Service hours are 8:00 am to 5:00 pm (6:00 pm in summer) and the crew comprises a pilot, co-pilot, emergency medical doctor, and emergency medical nurse. The flight frequency is currently 390/year (0-5/day).

2.2 Modifications of the helicopter emergency medical service for perinatal transfer

Wakayama Medical University Perinatal Medical Center, the only one tertiary perinatal medical center in Wakayama prefecture (Section on Transport Medicine American Academy of Pediatrics, 2007), was equipped with a vehicle installed with a neonatal respirator, two incubators, and two cardiorespiratory monitors for neonatal ground transfer in 2000. Use of the helicopter emergency medical service for perinatal and maternal medical transport began in June 2003 and some modifications were needed in order to provide these services. Perinatal medical transport was for high-risk pregnant women or sick neonates, and basically limited to inter-facility transport. The crew is comprised of the 4 personnel described above, plus a neonatal intensive care doctor (NICU) for neonatal transport or an obstetric doctor for maternal transport. The NICU or obstetrics department receive the request for helicopter transport from a local medical facility and ask the helicopter administration office to set up the rendezvous point and time with the local ambulance office, which then transfer the patient from the local medical facility to the rendezvous point. The NICU doctor on departure loads a neonatal transport incubator into the helicopter. The coverage area include the whole of Wakayama prefecture and the southern part of Mie prefecture from which it takes more than 3 hours to transport a patient to the perinatal center overland. The frequency of neonatal and maternal transports has been 4-11/year each since the services were introduced.

Statistical data from 2003 indicated that south Wakayama (SW) comprised 50.4% of the area, 19.6% of the population, and 20.7% of the live births in Wakayama Prefecture; and south Mie (SM) comprised 17.2% of the area, 4.7% of the population, and 3.4% of the live births in Mie Prefecture (Fig. 1)

Perinatal helicopter transportation was started in June 2003, and therefore maternal and child health statistics were compared for the three years before (2000-2002) and after (2004-2006) this year, (Department of Health and Welfare, Mie Prefecture; Department of Health and Welfare, Wakayama Prefecture; & Ministry of Health, Labor, and Welfare) using a χ-square test and Fisher's exact test. The neonatal mortality rate was defined as number of deaths at < 28 days after birth in three years / number of live births in three years × 1,000 - and the perinatal mortality rate as perinatal deaths (fetal deaths after 22 weeks of pregnancy + early neonatal deaths) in three years / total births (live births + fetal deaths after 22 weeks of pregnancy) in three years× 1,000. The fetal death rate was defined as fetal deaths in three years / total births in three years × 1,000 (Mothers' & Children's Health & Welfare Association, 2006).

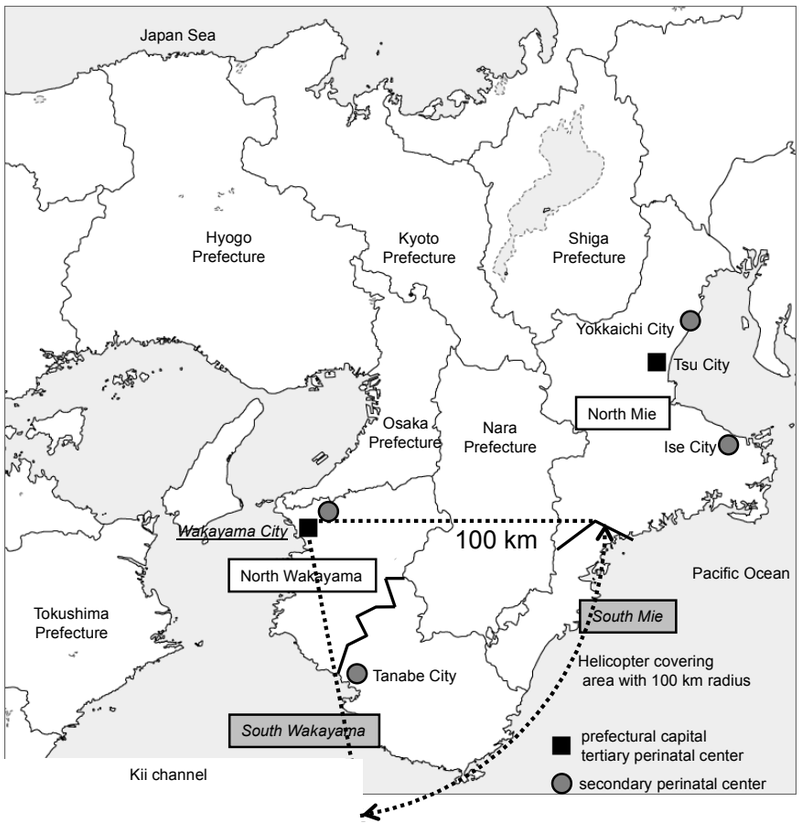

Fig. 1. Tanabe City is the central part of Wakayama prefecture. South Wakayama (SW) is Tanabe City and south of it, and north Wakayama (NW) is north of it. Perinatal Helicopter Medical Service covers area within the 100 km radius, mainly SW and south Mie (SM).

3. Results

3.1 The result of the perinatal and maternal emergency helicopter transport from June 2003 to Dec 2010 is presented

3.1.1 Neonatal helicopter transportation

There were 51 cases of neonatal transfer by helicopter (6.8 cases/year), one of which was a pair of twins, during the time period from June 2003 to December 2010. The reasons of transport were critical congenital cardiac disease (n=19), neonatal asphyxia (n=12), congenital digestive tract anomaly (n=7), low birth weight (n=5, including 3 extremely low birth weight (ELBW) infants), neonatal jaundice (n=4), respiratory distress (n=3), post-hemorrhagic hydrocephalus (n=1), and neonatal vomiting (n=1) (Table 1).

The referring facilities were located in north Wakayama (NW) (n=17) and south Wakayama (SW) (n=34) based on division of the prefecture into north and south with respect to the location of Tanabe City, which is in central Wakayama (Fig. 2). The average time from request of helicopter transport by a local hospital until take-off and return to site 13R of the university hospital was 23 ± 23 min and 1 hr, 23 ± 33 min (mean ± 1S.D), respectively.

Reasons for neonatal transports	*No.(%)*	*Reasons for maternal transports*	*No.(%)*
Critical congenital cardiac disease	19 (37.3)	Threatened premeture delivery	25(46.3)
Neonatal asphyxia	12(23.5)	Preterm PROM	13(24.1)
Congenital digestive tract anomaly	7(13.7)	Pregnancy induced hypertension	4(7.4)
Low birth weight (ELBW)	4*(7.8))	Threatened abortion	3(5.6)
Neonatal jaundice	4(7.8)	IUGR	2(3.7)
Respiratory distress	3(5.8)	Placenta previa	2(3.7)
Post-hemorrhagic hydrocephalus	1(2.0)	TTTS & IUFD	1(1.9)
Neonatal vomiting	1(2.0)	Invasive GAS infection & IUFD	1(1.9)
Total	51(100.0)	Ectopic pregnancy	1(1.9)
		Atonic bleeding	1(1.9)
		Traffic accident	1(1.9)
*: A pair of twins included		Total	54(100.0)

ELBW: extremely low birth weight <1000 g, PROM: premature rupture of the membranes, GAS: group A streptococcus, IUGR: intrauterine growth restriction, TTTS: twin-to-twin transfusion syndrome, IUFD: intrauterine fetal death.

Table 1. Reasons for neonatal and maternal transports (June 2003 – Dec 2010).

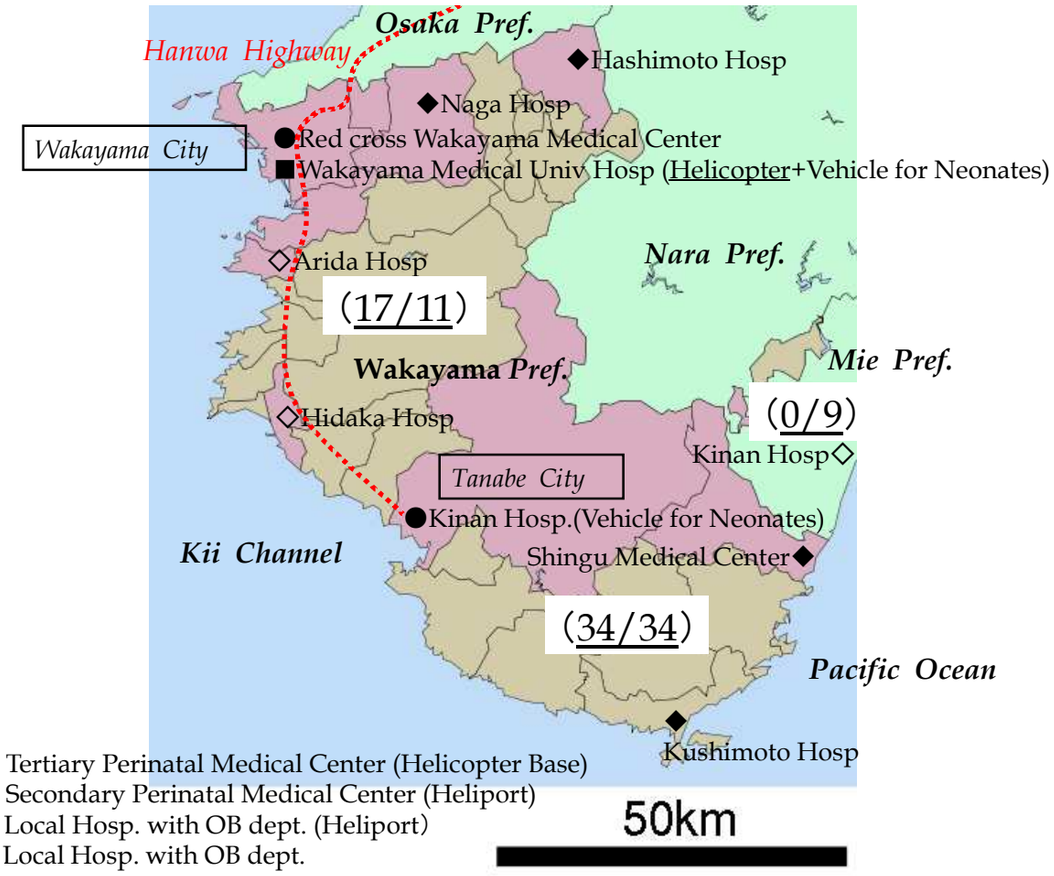

Fig. 2. Number of perinatal (neonatal/maternal) helicopter transports in Wakayama prefecture and southern Mie prefecture from June 2003 to December 2010, and the perinatal transport system in 2011.

3.2 Maternal helicopter transportation

There were 54 cases of maternal transfer (7.1 cases/year) by helicopter during the same time period. The reasons of transfer were threatened premature delivery (n=25), preterm premature rupture of membranes (PROM) (n=13), pregnancy-induced hypertension (PIH) (n=4), threatened abortion (n=3), intrauterine growth restriction (IUGR) (n=2), placenta previa (n=2), twin to twin transfusion snydrome (TTTS) & intrauterine fetal death (IUFD) (n=1), invasive group A streptococcus (GAS) infection & IUFD (n=1), ectopic pregnancy (n=1), atonic bleeding (n=1) and traffic accident (n=1) (Table 1). We transported one patient with threatened premature delivery and another with placenta previa from Shingu Medical Center in southeast Wakayama prefecture to Kinan hospital, a secondary perinatal medical center in south Wakayama with the helicopter. Two out of the 3 threatened or imminent abortions resulted in abortion. The patients with ectopic pregnancy and atonic bleeding, respectively, both survived. Six pregnant women with threatened premature delivery were back-transferred to their local hospitals overland once the condition stabilized. The other 42 patients, including four twin pregnancies, resulted in 45 live births (5.9 infants/year) in our hospital and one stillbirth due to maternal invasive GAS infection. Delivery after helicopter transfer was 42 (1.12 %) out of 3763 total deliveries in ten years. The referring facilities for all 54 patients were in north Wakayama (n=11), south Wakayama (n=34), and south Mie (n=9) (Fig. 2). The average time from receiving request of helicopter transport from a local hospital until take-off and return to site 13R was 19 ± 19 min and 1 hr, 20 ± 27 min, respectively.

An exception to the rule of inter-facility perinatal transport was made in the case of a patient at 36 weeks of pregnancy who was involved in a traffic accident. The patient had pneumothorax, femur fractures, and threatened premature delivery, and was transported from a primary school playground near the traffic accident site, based on a request by a paramedic. Caesarean section was performed soon after emergency medical treatment was completed.

3.3 Propagation of installing in-facility heliport

In-facility heliports have been installed in local hospitals since 2006 in Wakayama prefecture (Fig. 2). These are advantageous since there is no need for a local ambulance to transfer patients from a hospital to a heliport site outside the hospital. Thus, in-facility heliports simplify helicopter inter-facility transportation without using heliports outside the local hospital as a rendezvous point. Until February 2006, all neonatal (n=23) and maternal (n=19) helicopter transports occurred by way of non-hospital rendezvous points. After February 2006, in-facility heliports were used in 23 (82.1%) out of 28 cases of neonatal transports and 26 (74.3%) out of 35 cases of maternal transports (Fig. 1). Using the in–facility heliport, the time from landing at the site where patients were waiting to landing at the helicopter base on 13R of the hospital has been shortened 3 to 12 minutes compared to using the rendezvous points outside the hospital (Table 3).

4. Change in maternal and child health statistics after introduction of helicopter emergency medical service into perinatal transportation

There were 36 perinatal helicopter transports (16 maternal transports and 20 neonatal transports) in 2004-2006. The maternal transports comprised 9 from SW, 2 from NW and 5

from SM; and the neonatal transports comprised 13 from SW and 7 from NW (Table 4). Therefore, origin of perinatal helicopter transports in Wakayama Prefecture comprised of 29% from NW and 71% from SW, although SW had only 21% of the live births in Wakayama Prefecture in 2003. Live births-based frequency in perinatal helicopter was 9.3 times greater in SW than in NW. There were no accidents during transport and no requested flights were cancelled.

Time course in neonatal transport			
Heliport	*Outside the facility: n=28*	*In-facility: n=22*	
	Time from reception to lift-off		Difference
mean	0:19	0:26	0:07
median	0:11	0:22	0:11
	Time from reception to landing on the spot		Difference
mean	0:38	0:44	0:06
median	0:33	0:37	0:04
	Time from reception to landing on the base		Difference
mean	1:22	1:25	0:03
median	1:17	1:13	-0:04
Time course in maternal transport			
Heliport	*Outside the facility: n=24*	*In-facility: n=25*	
	Time from reception to lift-off		Difference
mean	0:12	0:19	0:07
median	0:10	0:17	0:07
	Time from reception to landing on the spot		Difference
mean	0:38	0:38	0:00
median	0:36	0:40	0:04
	Time from reception to landing on the base		Difference
mean	1:21	1:15	-0:06
median	1:20	1:12	-0:08

Table 3. Comparison of the transportation time course using in-facility heliport with the one using the rendezvous points outside the hospital.

Region	*South Wakayama*	*North Wakayama*	*South Mie*	*North Mie*
Area, km²	2383.2(50.4%)	2342.92(49.6%)	991.74(17.2%)	4769.66(82.8%)
Population in 2003	207,200(19.6%)	850,263(80.4%)	88,075(4.7%)	1,776,110(95.3%)
Live births in 2003	1772(20.7%)	6789(79.3%)	566(3.4%)	15,931(96.6%)
Maternal transports	9	2	5	0
Neonatal transports	13	7	0	0

Table 4. Regional differences between southern and northern parts in Wakayama and Mie prefectures, and number of perinatal helicopter transports for 3 years from 2004 to 2006 in each region.

The gestation periods in the maternal air transports from SW and SM were 19 weeks in 1 case, 22-23 weeks in 4 cases, 24-27 weeks in 7 cases, and 28-31 weeks in 2 cases (Table 5). Twelve of the 14 maternal transports (86%) were performed at less than 28 weeks of gestation. The number of twin pregnancies was 2. Eight out of 14 (57%) of the babies were delivered in less than 7 days after transport. One case ended as stillbirth at 20 weeks' gestation. All four women who were air-transported at 22-23 weeks delivered in less than 7 days after air-transportation (Table 5).

Pregnancy	*No. of transport*	*No. of Delivery*	*Span between transport and delivery: Days*	*No. of mothers*
< 22W	1	1	< 1	3
22-23W	4*	4*	1～6	5*
24-27W	7*	4	7～13	0
28-31W	2	3*	14～30	4*
32-36W	0	0	31～60	1
37-41W	0	2	60 <	1
Total	14	14	Total	14

*: included 1 twin-pregnancy

Table 5. Gestation at transport and delivery, and span between transport and delivery in the maternal helicopter transports from South Wakayam and South Mie.

No anomalies were observed in the 15 infants born alive, but 9 of the 15 infants (60%) were extremely low-birth-weight (ELBW<1000 g) and one of these (11%) died. Three of the 13 neonatal air-transports (23%) from SW died due to ELBW + rupture of the liver capsule, severe asphyxia, and congenital heart disease, respectively (Table 6). There were no maternal deaths in the women transported by helicopter.

Outcome of maternal transports			*Outcome of neonatal transports*		
South Wakayama N= 9 (1: twin)	Stillbirth	0/1	South Wakayama N=13	CHD	4/5
	ELBW	5/5		Birth asphyxia	2/3
	VLBW	3/3		Neonatal jaundice	2/2
	NBW	1/1		ELBW	0/1
South Mie N=5 (1: twin)	ELBW	3/4		Hydrocephalus	1/1
	LBW	1/1		Anal atresia	1/1
	NBW	1/1		Total	10/13
	Total	14/16			

ELBW: extremely low birth weight, VLBW: very low birth weight, NBW: normal birth weight
CHD: congenital heart disease

Table 6. Outcome of infants after perinatal transportation. Number of infants discharged alive from NICU/number of infants admitted to NICU after perinatal helicopter transportation.

The neonatal and perinatal mortality rates for the three years (2004-2006) after introduction of helicopter transportation decreased by -0.31 and -0.57 in South Wakayama (SW), -0.28 and -0.18 in North Wakayama (NW), -0.90 and -2.49 in South Mie (SM), and -0.49 and -1.48

in North Mie (NM), respectively, compared to the three years before introduction of the helicopter (2000-2002) (Table 6). The differences in neonatal and perinatal mortality rates in 2004-2006 compared to 2000-2002 were greater in SW than in NW, and in SM compared to NM. The fetal death rate decreased by -0.78 in SW, -1.19 in NW, -1.59 in SM, and -2.65 in NM in 2004-2006 compared to 2000-2002, with greater decreases in NW than in SW, and in NM compared to SM. Fetal death rate in NW ($p<0.05$) and neonatal mortality rate ($p<0.01$), perinatal mortality rate ($p<0.01$), and fetal death rate ($p<0.01$) in NM all differed significantly between 2004-2006 and 2000-2002 (Table 7). The changes in the number of maternal deaths between 2000-2002 and 2004-2006 were 0 in SW, 1 in NW, -2 in SM, and -1 in NM, with the greatest change occurring in SM (Kumagai, et al., 2011)

Neonatal mortality	***2000-2002***	***2004-2006***	***Difference***	***95%CI***
South Wakayama	2.14	1.84	-0.31	-0.362, 3.06
North Wakayama	1.44	1.16	-0.28	-0.98, 0.42
South Mie	1.5	0.597	-0.90	-3.04, 1.24
North Mie	1.78	1.29	-0.49*	-0.99, -0.01
Perinatal mortality	***2000-2002***	***2004-2006***	***Difference***	***95%CI***
South Wakayama	4.45	3.88	-0.57	-3.05, 1.90
North Wakayama	5.10	4.92	-0.18	-1.54, 1.18
South Mie	5.46	2.97	-2.49	-6.74, 1.76
North Mie	6.03	4.55	-1.48**	-2.40, -0.56
Fetal death rate	***2000-2002***	***2004-2006***	***Difference***	***95%CI***
South Wakayama	32.7	31.9	-0.78	-7.46, 5.89
North Wakayama	28.6	27.4	-1.19**	-4.34, 1.96
South Mie	30.0	28.4	-1.59	-12.36, 9.19
North Mie	28.0	25.3	-2.65**	-4.67, -0.64
No. of maternal deaths	***2000-2002***	***2004-2006***	***Difference***	
South Wakayama	1	1	0	
North Wakayama	0	1	1	
South Mie	2	0	-2	
North Mie	3	2	-1	

CI: confidence interval, *: $p<0.05$, **: $p<0.01$

Table 7. Differences in maternal and child health statistics between 3 years before (2000-2002) and after (2002-2004) introduction of perinatal helicopter transportation.

5. Discussion

Prefectural and national governments have a responsibility to maintain and improve perinatal medical care in Japan, and the efforts made at the prefectural level is reflected by the maternal and child health statistics. Maternal and child health care in Japan has reached a world-class level and is still improving year by year. In this study, a comparison of neonatal and perinatal mortalities between the three-year periods before and after introduction of helicopter transport for perinatal cases showed greater decreases in the southern parts of Wakayama and Mie Prefectures compared to the northern part of each prefecture. The southern parts of each prefecture are sparsely populated areas that are remote from each prefectural capital. The highest decrease in the number of maternal deaths

occurred in South Mie, most likely due to the introduction of perinatal helicopter transport since all 5 helicopter transports from this region were maternal transports. Overall, the data suggest that perinatal transportation using a single "doctor-helicopter" in a sparsely populated area will contribute to improvement of maternal and child health despite the fact that statistical differences were not significant, as the areas involved are sparsely populated.

In a large metropolitan area in Southern California, a helicopter transport service has been used successfully to move emergency patients from referring hospitals to a perinatal center (Elliot JP, O'Keeffe DF & Freeman RK). Cooperation among helicopter transports overlapping each coverage area is important for improving perinatal medicine, especially for handling patients during a disaster. In 2010, Wakayama prefecture has secured flight cooperation for helicopter transports with neighboring Osaka and Tokushima prefectures (Fig. 2).

Maternal helicopter transport represented 1.12% of all deliveries in our hospital and the cause of it was threatened premature delivery, preterm premature rupture of membranes, and pregnancy-induced hypertension in numerical order. This order is the same as the report from Nova Scotia that the primary reasons for maternal air transfer representing 1.3% of all deliveries were threatened preterm labor (41%), preterm premature rupture of the membranes (21%), hypertensive disease/hemolysis, elevated liver enzymes, and low platelets (16.5%) in the Women's Hospital (Jony & Baskett, 2006).

One of the effects of maternal helicopter transport was a high rate of ELBW (58%) in infants born after transport from South Wakayama and South Mie, which does not necessarily mean that helicopter transport caused high rate of ELBW infants to the mothers transported. The gestation period in the cases of maternal transport was less than 28 weeks in 12 out of 14 women, and all 4 women at 22 or 23 weeks' gestation delivered within 7 days after transport. The pregnant women who were transported from distant local hospitals tended to have earlier pregnancy and earlier delivery after transport. The both factors seemed to lead to the high rate of ELBW.

Abortion is de facto legal in Japan, with some limitations. Approved doctors can virtually practice abortion to anyone after 12 and before 22 weeks gestation if consent was given by the mother. The decision to request maternal transport for high risk pregnancy tends to have been made in local hospitals after 22 weeks and 0 days of gestation, at which time abortion is redefined as preterm birth by the maternal health protection law amended in 1996.

A helicopter flight of 100 km is completed around 30 min and is less bumpy and invasive than ground transport for more than 3 hours (Ohara et al., 2008). However, hurried and noisy helicopter transport may add stress to pregnant women and lead to triggering of earlier delivery (American Academy of Pediatrics Section on Transport Medicine, 2007).

The fetal death rates in South Wakayama and South Mie remain higher than those in North Wakayama and North Mie. Since perinatal mortality rates are already lower in the southern areas compared to those in North Wakayama and North Mie, fetal deaths before 22 weeks gestation are thought to be a cause of the high rate in fetal death after 12 weeks of pregnancy). Fetal death is divided into spontaneous and artificial. The artificial fetal death rate in Japan has been higher than the spontaneous rate since 1984, and in 2006 these rates were 15.6 and 11.9, respectively. Socioeconomic problems in sparsely populated areas, such as fewer primary

obstetric facilities, a higher maternal age (Salihu et al., 2008), and lower income (Nishi & Miyake, 2007) compared to urban areas, may be related to the higher fetal death rate.

6. Conclusion

Human resources in the fields of obstetrics and pediatrics have decreased in Japan, and patient transportation is important for maintaining the quality of perinatal medicine, especially in sparsely populated areas. The Helicopter Emergency Medical Service is of value in perinatal transportation and this approach is likely to be adopted nationally in Japan.

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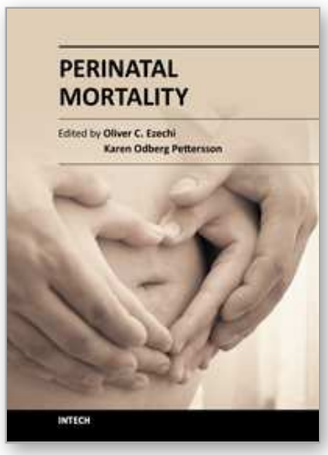

Perinatal Mortality
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This book is a compendium of important topics related to perinatal mortality. It has been written for anyone who is interested in perinatal medicine and wishes to be part of the global strategy for prevention and control of perinatal mortality. It covers variety of subjects using simple language that can easily be understood by most health workers and those interested in quality health care. Postgraduate students in midwifery, obstetrics and paediatrics will also find it a very useful companion.

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