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Analysis of High-Risk Infant Births and Their Mortality: Ten Years' Data from Chonnam National University Hospital

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Prematurity and low birth weight are major factors associated with neonatal morbidity and mortality, and their incidence is not decreasing despite an annual decrease in the total number of live births in Korea. The objective of this study was to establish a strategy to reduce neonatal mortality by analyzing the clinical characteristics of high-risk infant births along with their mortality and causes of death. We retrospectively surveyed the medical records of infants born at Chonnam National University Hospital and of patients admitted to the neonatal intensive care unit (NICU) for 10 years from October 1999 to December 2008. Premature and low birth weight infants were almost half of the live births, and their NICU admission rate increased with increases in the numbers of outborns and multiples. Also, their mortality decreased dramatically over the past 10 years. About 60% of deaths occurred within 1 week of life, and the causes of death were mostly related to prematurity. Perinatal asphyxia was the major cause of death in infants less than 1 week old, whereas sepsis was the major cause after 4 weeks of age. The major cause of death was sepsis in premature or low birth weight infants and perinatal asphyxia in term or normal weight infants. The major cause of death was sepsis in inborns and perinatal asphyxia in outborns. Our results suggest that medical personnel training for immediate postnatal care including neonatal resuscitation, infection control, and a systematic team approach to regionalization are all needed to reduce the mortality rate.

Key Words: *Premature birth; Cause of death; Low birth weight; Mortality*

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INTRODUCTION

Recently, the number of live births in Korea has begun to decrease, giving Korea the lowest total fertility rate (TFR) in the world. However, the numbers of premature and low birth weight infants have been increasing because of the increasing numbers of high-risk pregnancies. With the development of improved perinatal medicine, infant survival rates are increasing, and the birth weight and gestational week survival limits have gradually become lower and shorter, respectively. Since the introduction of a pulmonary surfactant for treating respiratory distress syndrome and the development of mechanical ventilation in the 1990s, the survival rate for extremely low birth weight infants (ELBWIs) weighing less than 1,000 g has increased from 32.7% in the 1990s[1] to 60% to 80% in the 2000s.[2-4] Despite this improvement in the survival rate, however, preventing the deaths of high-risk infants in the neonatal intensive care unit (NICU) remains difficult.

The objective of this study was to establish a strategy for reducing the neonatal mortality rate by analyzing data gathered in a tertiary hospital for 10 years regarding characteristics and mortality rates of high-risk infants, such as premature and low birth weight infants.

MATERIALS AND METHODS

We retrospectively surveyed the medical records of infants born at Chonnam National University Hospital (CNUH) and of patients admitted to the NICU for the 10 years from October 1999 to December 2008. First, we investigated the annual numbers of live births (inborn), along with their distributions of gestational weeks and birth weights and admission rates to the NICU. We also examined the annual

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numbers of NICU patients, including outborn babies who were transferred from outside the hospital; the proportion of NICU patients among the total live births in the Gwangju-Chonnam area; and each infant's clinical characteristics, such as delivery site and method, gender, plurality, gestational week, and birth weight. We compared the admission rate of inborns, the proportion of outborns among NICU patients, and the birth rates of premature and low birth weight infants between first 5 years (1999 to 2003) and the latter 5 years (2004 to 2008).

Our definitions of terms were as follows. *Premature* infant referred to a live birth at less than 37 completed weeks of gestation, *term* was defined as 37 to 41 6/7 weeks, and *post-term* was defined as 42 weeks or more. An *extremely low birth weight infant* (ELBWI) was an infant weighing less than 1,000 g, a *very low birth weight infant* (VLBWI) was one weighing less than 1,500 g, a low birth weight infant (LBWI) was one weighing less than 2,500 g, a *normal birth weight infant* was one weighing 2,500 to 3,999 g, and a *large baby* was one weighing more than 4,000 g at birth. The patients discharged against medical advice and almost certain to die at home were included in the data on deaths. We also compared the mortality rate according to the birthplace, delivery mode, gender, and plurality between the two periods. Finally, we analyzed the annual mortality rates and major causes of death according to gestational week, birth weight, and postnatal days of life.

The SPSS ver. 18.0 (SPSS Inc., Chicago, IL, USA), was used for analysis. Comparison was conducted by chi-square statistics. A p value < 0.05 was considered statistically significant.

RESULTS

1. Inborn babies

1) Number of live births and admission rate to NICU: The total number of live births at CNUH from January 1999 to December 2008 was 9,535 (average, 953.5 per year). The number of live births decreased 25% over the 10 years, from 1,206 in 1,999 to 899 in 2008. The number of infants admitted to the NICU was 6,000 for these 10 years (average, 600 per year). Thus, almost two-thirds (62.9%) of inborn infants were at high risk of requiring NICU admission. The admission rate increased significantly over the 10 years, from 51.1% in 1999 to 63.5% in 2008 ($p < 0.001$) (Table 1).

2) Rates of premature and LBWIs: Among inborn infants, 40.3% were premature, 58.9% were term, and 0.8% were post-term. In particular, 6.3% of inborn infants were premature infants of less than 30 weeks of gestation. LBWIs accounted for 39.0% of inborns, VLBWIs made up 10.0%, ELBWIs made up 3.0%, normal birth weight infants were 58.2%, and large babies of over 4,000 g accounted for 2.8%. Thus, premature and low birth weight infants accounted for about 40% of inborns. The rate of premature infants increased significantly from 35.0% in 1999 to 44.0% in 2008 ($p < 0.001$). Rates of ELBWIs and of VLBWIs showed little change, but the rate of LBWIs increased significantly from 33.0% in 1999 to 40.0% in 2008 ($p < 0.001$) (Tables 2, 3). When we compared the rate of premature and LBWI infants between the two periods (1999 to 2003 vs. 2004 to 2008), both were increased significantly (36.9% vs. 44.4%, $p < 0.001$, for premature infants, and 37.3% vs. 41.1%, $p < 0.001$, for LBWIs) (Fig. 1A).

2. NICU patients

1) Proportion of NICU patients among total live births in the Gwangju-Chonnam area: Total live births in the Gwangju-Chonnam area over the 10 years were 353,907 (average, 35,391 per year), with a decrease of 32.9%, from 45,075 in 1999 to 30,253 in 2008. Total NICU patients for 10 years were 8286 (average, 828.6 per year), with a decrease of 2.5%, from 810 in 1999 to 790 in 2008, which was

TABLE 1. Live births, NICU admissions, and mortality at Chonnam University Hospital

Year	Live births in GC area, n	CUH, Inborn, n	NICU, CUH		
			Inborn, n (admission rate, %)	Outborn, n (outborn rate, %)	Total, n (%)†
1999	45,075	1,206	616 (51.1)	194 (24.0)	810 (1.8)
2000	46,711	1,158	681 (58.8)	148 (17.9)	829 (1.8)
2001	40,390	978	668 (68.3)	185 (21.7)	853 (2.1)
2002	34,944	973	697 (71.6)	159 (18.6)	856 (2.4)
2003	33,984	931	637 (68.4)	259 (28.9)	896 (2.6)
2004	31,735	872	567 (65.0)	269 (32.2)	836 (2.6)
2005	28,945	797	481 (60.4)	308 (39.0)	789 (2.7)
2006	29,389	800	534 (66.8)	262 (32.9)	796 (2.7)
2007	32,481	921	548 (59.5)	283 (34.1)	831 (2.6)
2008	30,253	899	571 (63.5)*	219 (27.7)	790 (2.6)*
Total	353,907	9,535	6,000 (62.9)	2,286 (27.6)	8,286 (2.3)
Mortality, n (%)			188 (3.1)	98 (4.3)	286 (3.5)

*$p < 0.001$ between 1999 and 2008. †The proportion (%) of NICU patients among live births in the Gwangju-Chonnam area. GC: Gwangju Chonnam, CUH: Chonnam University Hospital, NICU: neonatal intensive care unit.

TABLE 2. Gestational age-specific live births at Chonnam National University Hospital

Year	Live births, n	<30 w, n (%)	<37 w, n (%)	37-41w, n (%)	≧42 w, n (%)
1999	1,206	71 (6.0)	418 (35.0)	782 (64.8)	6 (0.5)
2000	1,158	76 (7.0)	369 (32.0)	786 (67.9)	3 (0.3)
2001	978	69 (7.0)	360 (37.0)	602 (61.6)	16 (1.6)
2002	973	61 (6.0)	374 (38.0)	571 (58.7)	28 (2.9)
2003	931	48 (5.0)	415 (45.0)	512 (55.0)	4 (0.4)
2004	872	55 (6.0)	381 (44.0)	487 (55.8)	4 (0.5)
2005	797	56 (7.0)	345 (43.0)	444 (55.7)	8 (1.0)
2006	800	67 (8.0)	389 (49.0)	411 (51.4)	-
2007	921	54 (6.0)	394 (43.0)	523 (56.8)	4 (0.4)
2008	899	46 (5.0)	397 (44.0)*	501 (55.7)	1 (0.1)
Total	9,535	603 (6.3)	3,842 (40.3)	5,619 (58.9)	74 (0.8)

*$p < 0.001$ between 1999 and 2008.

TABLE 3. Birth weight-specific live births at Chonnam National University Hospital

Year	Live births, n	<1,000 g, n (%)	<1,500 g, n (%)	<2,500 g, n (%)	2,500-3,999 g, n (%)	≧4,000 g, n (%)
1999	1,206	19 (2.0)	108 (9.0)	399 (33.0)	779 (64.6)	28 (2.3)
2000	1,158	22 (2.0)	105 (9.0)	415 (36.0)	703 (60.7)	40 (3.5)
2001	978	30 (3.0)	116 (12.0)	382 (39.0)	565 (57.8)	31 (3.2)
2002	973	25 (3.0)	100 (10.0)	379 (39.0)	554 (56.9)	40 (4.1)
2003	931	18 (2.0)	84 (9.0)	380 (41.0)	528 (56.7)	23 (2.5)
2004	872	21 (2.0)	81 (9.0)	349 (40.0)	491 (56.3)	32 (3.7)
2005	797	26 (3.0)	87 (11.0)	330 (41.0)	459 (57.6)	8 (1.0)
2006	800	29 (4.0)	95 (12.0)	351 (44.0)	436 (54.5)	13 (1.6)
2007	921	31 (3.0)	96 (10.0)	373 (40.0)	518 (56.2)	30 (3.3)
2008	899	21 (2.0)	69 (8.0)	361 (40.0)*	515 (57.3)	23 (2.6)
Total	9,535	242 (3.0)	941 (10.0)	3,719 (39.0)	5,548 (58.2)	268 (2.8)

*$p < 0.001$ between 1999 and 2008.

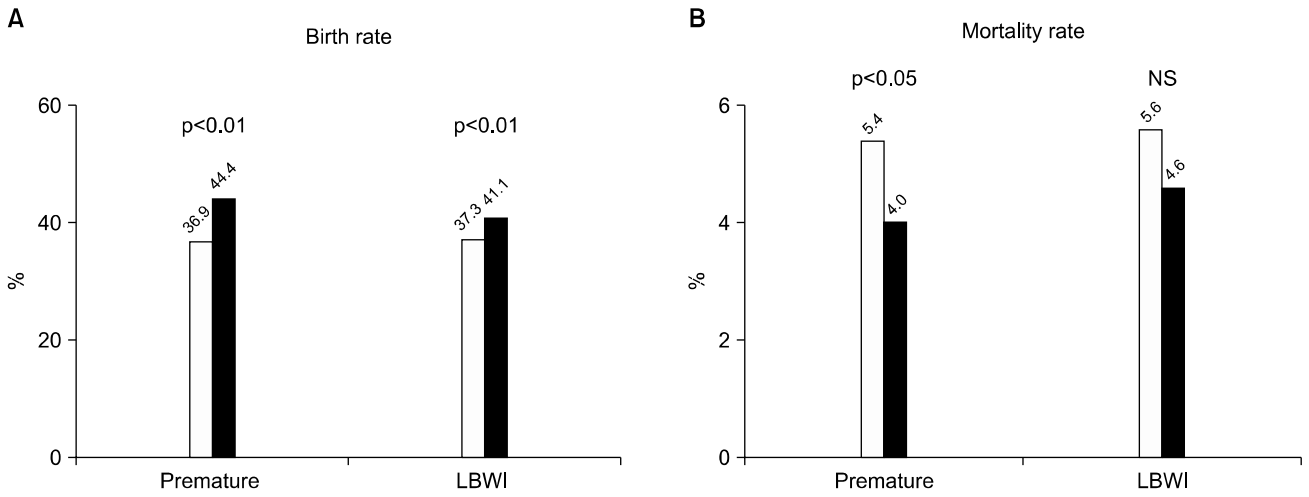

FIG. 1. The comparison of rates for premature and LBWI births among inborns (A), and of mortality rates for premature and LBWIs among NICU patients (B) between 1999 to 2003 (white bar) and 2004 to 2009 (black bar). LBWI: low birth weight infant, NS: not significant.

negligible compared with the decreasing rate of live births. The proportion of NICU patients among live births in the Gwangju-Chonnam area increased significantly from 1.8% in 1999 to 2.6% in 2008 ($p < 0.001$) (Table 1).

2) Transfer rate, delivery methods, gender, and plurality: The patients born outside our hospital among NICU pa-

tients accounted for more than a quarter (27.6%), and the proportion of outborns among NICU patients increased some, but not significantly so (24.0% vs. 27.7%, p=0.085) (Table 1). The rate of C-section delivery exceeded half (54.0%), although the rate differed somewhat annually. On average, males outnumbered females (56% vs. 44%), and singletons outnumbered multiples (86.2% vs. 13.8%). The rate of multiples increased some, but not significantly so (11.0% vs. 13.3%, p=0.158) (Table 4).

3) Gestational week and birth weight distribution: Among NICU infants, 52.4% were premature, 47.3% were term, and 0.3% were post-term; in particular, 8.5% were premature infants of less than 30 weeks of gestation. Although the proportion of premature infants varied annually, it tended to increase, going from 52.5% in 1999 to 55.6% in 2008. The proportion of LBWIs was 48.5%, that of normal weight infants was 48.2%, that of large babies was 3.4%, and that of ELBWIs was 12.9%. Although the annual num-

TABLE 4. Distribution of delivery mode, gender, and plurality in NICU patients

Year	Delivery mode		Gender		Plurality		Total, n
	Vaginal, n	C-section, n (%)	Female, n	Male, n (%)	Singleton, n	Multiplets, n (%)	
1999	349	461 (56.9)	346	464 (57.3)	721	89 (11.0)	810
2000	412	417 (50.3)	358	471 (56.8)	738	91 (11.0)	829
2001	432	421 (49.4)	403	450 (52.8)	719	134 (15.7)	853
2002	393	463 (54.1)	396	460 (53.7)	723	133 (15.5)	856
2003	416	480 (53.6)	371	525 (58.6)	752	144 (16.1)	896
2004	375	461 (55.1)	330	506 (60.5)	719	117 (14.0)	836
2005	370	419 (53.1)	327	462 (58.6)	676	113 (14.3)	789
2006	340	456 (57.3)	387	409 (51.4)	688	108 (13.6)	796
2007	333	498 (59.9)	379	452 (54.4)	722	109 (13.1)	831
2008	393	397 (50.3)	346	444 (56.2)	685	105 (13.3)	790
Total	3,813	4,473 (54.0)	3,643	4,643 (56.0)	7,143	1,143 (13.8)	8,286
Death, n (%)	119 (3.1)	167 (3.7)	133 (3.7)	153 (3.3)	222 (3.1)	64 (5.6)	286 (3.5)

NICU: neonatal intensive care unit.

TABLE 5. Distribution of gestational age and birth weight, with mortality rates, in NICU patients

Year	Total		<30 w		<37 w		<1,000 g		<1,500 g		<2,500 g	
	Admission, n	Death n (%)	Admission, n	Death, n (%)	Admission, n	Death n (%)	Admission, n	Death n (%)	Admission, n	Death n (%)	Admission, n	Death n (%)
1999	810	38 (4.7)	83	17 (20.5)	425 (52.5)	28 (6.6)	24 (3.0)	7 (29.2)	122 (15.1)	19 (15.6)	424 (52.3)	30 (7.1)
2000	829	28 (3.4)	84 (10.1)	13 (15.5)	433 (52.2)	20 (4.6)	25 (3.0)	10 (40.0)	116 (14.0)	17 (14.7)	442 (53.3)	23 (5.2)
2001	853	42 (4.9)	85 (10.0)	21 (24.7)	438 (51.3)	29 (6.6)	33 (3.9)	15 (45.5)	126 (14.8)	23 (18.3)	428 (50.2)	30 (7.0)
2002	856	28 (3.3)	74 (8.6)	12 (16.2)	443 (51.8)	21 (4.7)	26 (3.0)	10 (38.5)	108 (12.6)	14 (13.0)	413 (48.2)	20 (4.8)
2003	896	30 (3.3)	57 (6.4)	9 (15.8)	459 (51.2)	20 (4.4)	22 (2.5)	9 (40.9)	97 (10.8)	11 (11.3)	429 (47.9)	21 (4.9)
2004	836	22 (2.6)	61 (7.3)	13 (21.3)	426 (51.0)	17 (4.0)	24 (2.9)	9 (37.5)	95 (11.4)	15 (15.8)	390 (46.7)	17 (4.4)
2005	789	25 (3.2)	68 (8.6)	11 (16.2)	391 (49.6)	14 (3.6)	39 (4.9)	10 (25.6)	110 (13.9)	13 (13.1)	350 (44.4)	15 (4.3)
2006	796	22 (2.8)	76 (9.5)	14 (18.4)	441 (55.4)	16 (3.6)	33 (4.1)	10 (30.3)	107 (13.4)	14 (13.1)	373 (46.9)	16 (4.3)
2007	831	28 (3.4)	64 (7.7)	16 (25.0)	444 (53.4)	22 (5.0)	35 (4.2)	14 (40.0)	107 (12.9)	17 (15.9)	397 (47.8)	22 (5.5)
2008	790	23 (2.9)	53 (6.7)	12 (22.6)	439 (55.6)	17 (3.9)	24 (3.0)	9 (37.5)	80 (10.1)	12 (15.0)	372 (47.1)	16 (4.3)
Total	8,286	286 (3.5)	705 (8.5)	138 (19.6)	4,339 (52.4)	204 (4.7)	285 (3.4)	103 (36.1)	1,068 (12.9)	155 (14.5)	4,088 (49.3)	210 (5.2)

NICU: neonatal intensive care unit.

ber of ELBWIs showed no change or an increase, the proportion of LBWIs and VLBWIs decreased slightly during the study period (Table 5).

3. Mortality of NICU patients

1) Mortality rates: The NICU patients' overall mortality rate for the 10 years was 3.5%. Although it varied depending on the year, the rate decreased from 4.7% in 1999 to 2.9% in 2008 (p=0.063). The mortality rate for premature infants decreased from 6.6% to 3.9% (p=0.063) and the rate for LBWIs also decreased from 7.1% to 4.3% (p=0.063) during the study period (Table 5). When we compared the mortality rate between the two periods (1999 to 2003 vs. 2004 to 2008), the rate for premature infants decreased significantly in the latter 5 years compared with the first 5 years (4.0% vs. 5.4%, p=0.035); however, the rate for LBWIs showed no significant difference (4.6% vs. 5.6%, p=0.129) (Fig. 1B).

Regarding gestational age, the mortality of premature infants was 4.7%, that of term infants was 2.0%, and that of post-term infants was 8.3%. Specifically, the mortality rate at 23 weeks of gestation was 100%, that at 24 weeks was 78.6%, that at 25 weeks was 66.7%, and that at 26 weeks was 37.5%, but it dropped sharply at 27 weeks and increased again after 42 weeks. Regarding birth weight,

TABLE 6. Gestational age-specific mortality rates in NICU patients

Gestational week	No. of patients	No. of death	%
23	4	4	100.0
24	14	11	78.6
25	48	32	66.7
26	88	33	37.5
27	157	31	19.7
28	194	20	10.3
29	200	7	3.5
30	271	11	4.1
31	310	12	3.9
32	387	9	2.3
33	520	6	1.2
34	741	12	1.6
35	705	7	1.0
36	700	9	1.3
37	919	17	1.8
38	1,115	25	2.2
39	872	15	1.7
40	750	14	1.9
41	267	9	3.4
42	21	2	9.5
43	3	0	0.0
Total	8,286	286	3.5

TABLE 7. Birth weight-specific mortality rates in NICU patients

Birth weight (g)	No. of patients	No. of death	%
-499	2	2	100.0
500-749	58	36	62.1
750-999	225	65	28.9
1,000-1,249	336	33	9.8
1,250-1,499	447	19	4.3
1,500-1,749	545	14	2.6
1,750-1,999	669	12	1.8
2,000-2,249	864	13	1.5
2,250-2,499	872	16	1.8
2,500-2,749	705	14	2.0
2,750-2,999	744	16	2.2
3,000-3,249	860	16	1.9
3,250-3,499	748	8	1.1
3,500-3,749	613	13	2.1
3,750-3,999	320	5	1.6
4,000-4,249	169	3	1.8
4,250-4,499	56	0	0.0
4,500-	53	1	1.9
Total	8,286	286	3.5

NICU: neonatal intensive care unit.

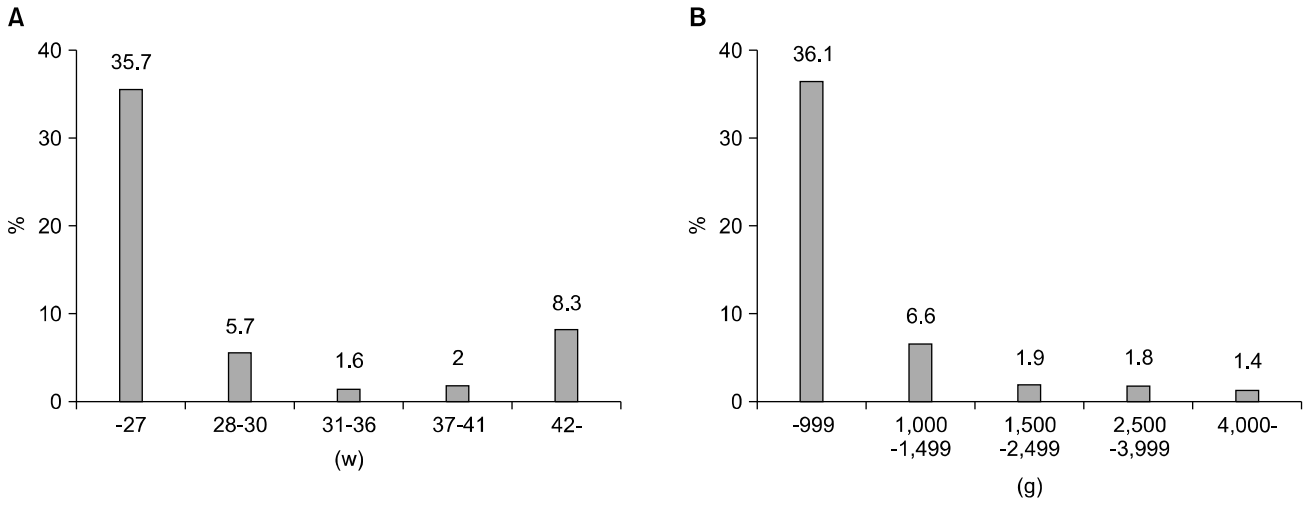

FIG. 2. Gestational age- (A) and birth weight-specific mortality rates (B) in NICU patients.

the mortality rate of ELBWIs was 36.1%, that of VLBWIs was 14.5%, that of LBWIs was 5.2%, that of normal weight infants was 1.8%, and that of large babies was 1.4%. Specifically, the mortality rate for infants weighing 500-749 g was the highest (62.1%), whereas it was 28.9% for infants weighing 750-999 g, 9.8% for infants weighing 1,000-1,249 g, 4.3% for infants weighing 1,250-1,499 g, and less than 2% for infants weighing more than 1,500 g (Tables 6, 7). The mortality rates according to gestational age and birth weight group are shown in Fig. 2.

The gestational age distribution of the 286 dead patients was 71.3% (n=204) premature infants, 28.0% (n=80) term infants, and 0.7% (n=2) post-term infants. Premature infants of less than 30 weeks of gestation accounted for almost half (48.3%, n=138) of the total deaths. The birth weight distribution of the dead patients was 73.4% (n=210) LBWIs, 25.2% (n=72) normal weight infants, and 1.4% (n=4) large babies. The VLBWIs accounted for more than half of the deaths (54.2%, n=155) (Table 5).

The mortality rate was higher in outborns than in inborns (4.3% vs. 3.1%, p=0.01) and in multiples than in singletons (5.6% vs. 3.1%, $p<0.01$). No statistically significant differences were found according to delivery mode or gender, however.

2) Cause of death according to patient characteristics: The most common cause of death among the 286 dead infants was sepsis with disseminated intravascular coagulation (DIC; 22.4%). The other causes were perinatal asphyxia (18.9%), respiratory distress syndrome (RDS; 9.1%), severe intraventricular hemorrhage (IVH; 8.0%), congenital heart disease (8.0%), acute renal failure with hyperkalemia (7.7%), massive pulmonary hemorrhage (7.3%), tension pneumothorax (7.0%), respiratory failure related to congenital myotonic dystrophy (3.5%), and severe bronchopulmonary dysplasia (BPD; 2.1%). Among the premature infants' deaths, sepsis with DIC was the most common (24.0%), followed by RDS (11.3%), and massive pulmonary hemorrhage (10.8%). Cause of death in term infants was most often perinatal asphyxia (31.3%), and then congenital heart disease (20.0%) and sepsis with DIC (16.3%). Among the post-term infants, only two died, one of congenital heart disease and one of sepsis.

In LBWIs, sepsis with DIC (22.3%) was the most common cause of death, and then RDS (14.6%). In normal weight infants, perinatal asphyxia (31.9%) was the most common, followed by sepsis with DIC (19.4%) and congenital heart disease (15.3%). Four large babies died: two of perinatal asphyxia, one of congenial heart disease, and one of anencephaly. Among 188 inborn patients who died, 22.9% died from sepsis with DIC, 12.2% died of perinatal asphyxia, and 11.2% died of RDS, whereas among 98 outborns, 31.6% died from perinatal asphyxia, 21.4% died of sepsis with DIC, and 13.7% died of congenital heart disease.

3) Cause of death according to postnatal days of life: The average postnatal age at death was 13.1 days (range, 1 to 199 days). There were 34 infants (11.9%) who died within 1 day, 131 (45.8%) who died within 2 to 7 days, 89 (31.1%) who died within 1 to 4 weeks, and 32 (11.2%) who died within 4 weeks. Regarding causes of death according to days of life, perinatal asphyxia was the most common (38.2%), and then RDS (29.4%), septic shock (5.9%), and severe IVH (2.9%), in the first day of life. During the first week of life, perinatal asphyxia was the most common (24.2%), then sepsis with DIC (14.5%), RDS (12.7%), and severe IVH (9.7%). Of infants dying later than 4 weeks of life, 34.4% died of sepsis with DIC, 18.8% died of severe BDP, and 9.4% died of congenital heart disease.

DISCUSSION

Along with the significant economic growth from the 1960s to 1980s, the other criterion signifying successful modernization was family planning. As a result, the TFR dropped from 4.5 in the 1970s to 2.8 in the 1980s and to 1.6 in the 1990s. Despite the pronatal policies of the Korean government, the TFR in 2009 was 1.15, which was the lowest in the world, and this became a serious social issue. Despite the fact that the annual number of live births is decreasing, the numbers of high-risk infants, such as premature and LBWIs, are increasing as the result of later marital ages leading to pregnancies at older ages and the higher rates of multiple pregnancies associated with infertility procedures. Increased survival rates of premature infants and LBWIs, owing to developments in neonatal medicine, play an important role in increasing the population in an era of lower fertility rates.

Similar to the decline in live births in the Gwangju-Chonnam area, from 45,075 in 1999 to 30,253 in 2008,[5] the number of inborn live births at Chonnam National University Hospital decreased from 1206 to 899. However, the number of NICU patients decreased slightly, from 616 to 571, in the same period. Moreover, the birth rate for high-risk infants apparently increased due to the increased admission rate for inborn infants, from 51.1% in 1999 to 63.5% in 2008; the increased proportion of outborn infants in the NICU, from 24.0% to 27.7%; and the increased proportion of NICU patients among the live births in the Gwangju-Chonnam area, from 1.8% to 2.6%.

Park et al[6] compared the nationwide neonatal statistics of 62 general hospitals in 2002 with those of 64 hospitals reviewed by Bae et al[7] in 1996. They showed that the rate of premature infants increased from 11.1% to 17.5%, whereas the rate of LBWIs increased from 9.8% to 15.3%. In our study, the rate of premature infants among inborns was 40.3% and the rate of LBWIs was 39.0%, which were thus much higher than the rates reported in those two studies.[6,7] Furthermore, the rate of VLBWIs (10.0%) was also higher than previous data in our hospital between 1996 and 2001 (6.0%).[8] This suggests that the high-risk pregnancy rate is increasing faster than before and is higher than in other tertiary hospitals. The proportions of premature (52.4%) and LBWIs (48.5%) among NICU patients were around half, which was close to the proportions reported by Bae et al[9] in 2009.

In our hospital, the overall C-section rate was 54.0%, with no large differences for any years compared with the increasing rates for the premature infants, LBWIs, and multiples. The male to female ratio was 1.27:1, and it was greatest in 2004 (1.5:1). The rate of multiples increased from 11.0% to 13.3% in the same period (average 13.8%), with a peak in 2003 (16.1%), when the number of NICU patients was greatest. When comparing our data of 2008, which was the last year of this study, to the national statistics of 2008,[10,11] we found that we had more high-risk pregnancies and higher rates of C-section (50.3% vs. 36.3%) and multiples (13.3% vs. 5.4%).

Among NICU patients, the increased proportion of premature infants less than 37 weeks of gestation, from 52.5% in 1999 to 55.6% in 2008, seemed to be an increased proportion of infants born at 30 to 37 weeks, because the proportion of premature infants born at less than 30 weeks decreased, from 10.2% to 6.7%, in the same period. The proportions of LBWIs and VLBWIs decreased, from 52.3% to 47.1%, and from 15.1% to 10.1%, respectively. However, the proportion of ELBWIs increased, which we consider to be because of an increase in small for gestational age infants, due in turn to increases in high-risk pregnancies, such as pregnancies with preeclampsia or eclampsia, multiple pregnancies, and so on. In NICU patients, 58% to 59% of term or normal birth weight infants were inborn, whereas more than 80% of premature or LBWIs were outborn.

Bae et al[6] reported that the mortality rate for premature infants dropped from 7.8% in 1999 to 5.5% in 2008, and the rate for LBWIs likewise dropped from 8.4% to 6.1%. However, we have to make a constant effort to improve, because this rate is similar to that in the United States but still higher than that of Japan. In our study, the mortality rates for premature infants (4.7%) and LBWIs (5.2%) were lower than those reported by Bae et al.[6] The mortality rate for VLBWIs (15.0%) was also much lower than a previous report of our hospital (28.2%) by Kim et al in 2003.[8]

There is recent and rising interest in ELBWI survival. In our study, the ELBWI mortality rate (36.1%) was higher than that reported by Park et al (25%).[12] Likewise, the mortality rate of infants less than 500 g (100%) was higher than that reported by Chang et al (56%).[13] This could be due to whether a report did or did not include in the death count the cases discharged against medical advice and whom physicians regarded as likely to die. Additionally, this rate depends on the number of congenital anomalies, clinical conditions at the time of maternal or infant transport, and the level of the medical facility and medical personnel. In our study, we included in the deaths the cases who were discharged against medical advice and whom physicians regarded as likely to die. The outborns were more than one quarter of NICU patients, and, even in the case of the inborns, they were close to outborns because they were born soon after the maternal transport.

The mortality of NICU patients decreased from 4.7% in 1999 to 2.9% in 2008, and it decreased similarly, from 6.6% to 3.9%, for premature infants. It decreased from 7.1% to 4.3% for LBWIs in the same period, but no decrease occurred for the infants at less than 1,000 g or at 30 weeks' gestation. Therefore, the decrease in the mortality rate seemed to be due to the decrease for infants between 30 and 37 weeks or between 1,000 and 2,500 g. To reduce the mortality rate further, we must focus our attention on saving the infants weighing less than 1,000 g or at less than 30 weeks' gestation. According to the mortality rates by gestational week or birth weight, premature infants accounted for 4.7% of the average overall rate, 2.0% of the term infants, 8.3% of the post-term infants, 36.1% of the ELBWIs, 14.5% of the VLBWIs, 5.2% of the LBWIs, 1.8% of the normal weight infants, and 1.4% of the large babies.

Of the 286 dead infants, more than half were premature infants of less than 30 weeks of gestation or were VLBWIs, and more than 70% were either premature infants or LBWIs. The mortality at less than 23 weeks' gestation was 100%; that at less than 24 weeks, 78.6%; that at birth weights less than 500 g, 100%; and that at weights from 500 to 749 g, 62.1%. This suggests that gestational week and birth weight are critical to survival, and the lower limits for survival are 24 weeks and 500 g. The mortality rate of outborn patients was higher (4.3%) than that of inborns (3.1%; p=0.01), which emphasizes the importance of maternal transport. Also, the mortality rate for multiples was higher (5.6%) than that for singletons (3.1%; $p < 0.01$). This suggests that being outborns and multiples were also risk factors for death.

The patients dying within 1 day accounted for 12% of deaths, whereas 58% died within 1 week. Regarding the causes of death, identifying the main cause of death is often difficult, because in most cases several events occur suddenly and simultaneously, or at least during a short time, and the medical record is sometimes inadequate, especially for transferred patients. In this study, the major causes of death related to prematurity, such as sepsis with DIC (22.4%), perinatal asphyxia (18.9%), RDS (9.1%), and severe IVH (8.0%). By clinical characteristics, the most common causes of death were sepsis with DIC for premature or LBWIs, perinatal asphyxia for term or normal weight infants, sepsis with DIC for inborns, and perinatal asphyxia for outborn infants. According to the postnatal age, the most common causes of death were perinatal asphyxia for those dying within 1 week and sepsis with DIC for those dying after 4 weeks of life.

In conclusion, educating medical personnel about immediate postnatal care (including neonatal resuscitation in the delivery room) and about the prevention and control of hospital infections is very important. Additionally, a systematic team approach to regionalization and medical training for safe and effective transport of high-risk mothers and infants seems to be necessary.

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REFERENCES

1. Kim BI, Choi JH, Yun CK, Park JD, Choi CW, Choi JW, et al. Statistical study of extremely low birth weight (ELBW) infants. Korean J Perinatol 1998;9:3-12.
2. Kim JT, Park HK, Jun NL, Lim JW, Kim EA, Kim KS, et al. Recent outcome of extremely low birth weight infants at Asan Medical Center. J Korean Soc Neonatol 2003;10:133-42.
3. Kook JH, Kim SH, Kim MJ, Song ES, Choi YY. The changes of rate and mortality of low birth weight infants andIts relating factors-past 25 years in Chonnam University Hospital. Chonnam Med J 2007;43:181-90.
4. Park MR, Lee BS, Kim EA, Kim KS, Pi SY. Outcomes of extremely low birth weight infants at the Asan Medical Center between 2003 and 2006. J Korean Soc Neonatol 2008;15:123-33.
5. Statistics Korea. http://kostat.go.kr/portal/korea/index.action.
6. Park DK, Kil CH, Bae CW. Neonatal statistics of Korea in 2002: collective results of live-births, and neonatal mortality rates from 62 Hospitals. J Korean Soc Neonatol 2004;11:122-9.
7. Bae CW, Kim MH, Chun CS, Lee C, Moon SJ, Yoo BH, et al. Neonatal statistics of Korea in 1996: collective results of live-births , neonatal mortality , and incidence of dischage against medical advice at 64 hospitals. J Korean Soc Neonatol 1997;4: 153-69.
8. Kim YO, Kim SH, Cho CY, Choi YY, Kook JH, Hwang TJ. Changes in incidence, survival rate and morbidity of very low birth weight infants. J Korean Pediatr Soc 2003;46:769-76.
9. Bae CW, Kim KS, Kim BI, Shin SM, Lee SL, Lim BK, et al. Patient distribution and hospital admission costs in neonatal intensive care units: collective study of 7 hospitals in Korea during 2006. J Korean Soc Neonatol 2009;16:25-35.
10. Health Insurance Review & Assessment Service 2008. http://www.hira.or.kr/intro.jsp.
11. Korean Statistical Information Service 2008. http://www.kosis.kr.
12. Park SE, Jeon GW, Choi CW, Hwang JH, Koo SH, Kim YJ, et al. Evaluation of perinatal and management factors associated with improved survival in extremely low birth weight infants. Korean J Pediatr 2005;48:1324-9.
13. Chang YS, Kim YJ, Koo SH, Lee JH, Hwang JH, Choi CW, et al. Outcomes and management of fetal infants with birth weight below 500 g at a tertiary center. Korean J Pediatr 2005;48:939-45.