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Original Article

Cerebral Palsy and Intellectual Disability in the Children of Women With Chronic Kidney Disease

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ABSTRACT

BACKGROUND: This study examined the risk of adverse maternal and neonatal outcomes, especially cerebral palsy and intellectual disability, in pregnant women with and without chronic kidney disease and their children. **METHOD:** In total, 156 pregnancies involving 139 women with chronic kidney disease who were treated at our center between 2001 and 2010 were identified. We also selected 3067 women without chronic kidney disease who delivered their infants without suffering any medical complications during the same period as control groups. Long-term neonatal prognosis was assessed based on the frequencies of cerebral palsy and/or intellectual disability. **RESULTS:** The pregnant women had the following types of chronic kidney disease: immunoglobulin A nephropathy (n = 54), glomerulonephritis (n = 17), chronic renal failure (n = 16), nephrotic syndrome (n = 12), nephritis (n = 11), diabetic nephropathy (n = 10), congenital malformations and deformations (n = 10), purpura nephritis (n = 7), and others (n = 19). Of the children who were born to mothers with chronic kidney disease, one developed cerebral palsy, and another developed cerebral palsy with intellectual disability. Seven of the children who were born to mothers without chronic kidney disease developed cerebral palsy. The posterior probability of these conditions was 0.01900 and 0.002610 in the children born to mothers with and without chronic kidney disease, respectively. A primiparous mother (odds ratio [OR]: 4.07, 95% confidence interval [CI]): 2.78 to 5.95), preeclampsia (OR: 6.44, 95% CI: 3.92 to 10.59), grade 1 to 4 intraventricular hemorrhaging (OR: 7.71, 95% CI: 2.05 to 28.92), and an Apgar score of less than 7 at five minutes (OR: 0.51, 95% CI: 0.27 to 0.96) were found to influence the risk of cerebral palsy and/or intellectual disability in children born to women with chronic kidney disease. **CONCLUSION:** We found that the incidence of cerebral palsy and/or intellectual disability is 7.2-fold higher in children born to women with chronic kidney disease than in those born to women without chronic kidney disease.

Keywords: cerebral palsy, chronic kidney disease, intellectual disability, preeclampsia, small for gestational age

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Introduction

Pregnant women with chronic kidney disease are at greater risk of maternal and fetal complications.[1-6] For example, Kendrick et al.[1] concluded that infants born to women with kidney disease are at a 71% greater risk of being admitted to the neonatal intensive care unit or death than infants born to women without kidney disease (odds ratio [OR]: 1.71; 95% confidence interval [CI]: 1.17 to 2.51) and that women with chronic kidney disease are at a two-fold higher risk of delivering low birth weight infants (OR: 2.38; 95% CI: 1.64 to 3.44). Moreover, Fink et al.[4] concluded that women with renal disease were also at increased risk of delivering infants that were small for their gestational age (SGA; OR: 5.3, 95% CI: 2.8 to 10.0) and/or had five-minute Apgar scores of less than 7 (OR: 3.9, 95% CI: 1.1 to 14.6). Although several reports have indicated that pregnant

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women with chronic kidney disease are at increased risk of adverse maternal and fetal outcomes, the long-term prognosis of neonates born to such women including their risk of cerebral palsy and intellectual disability is unclear.[1-6]

We performed a retrospective cohort study examining the risk of adverse maternal and neonatal outcomes, especially cerebral palsy and intellectual disability, in pregnant women with and without chronic kidney disease and their children.

Materials and Methods

This study was approved by the ethics committee of Tokyo Women's Medical University. The medical records of the mothers and infants were reviewed. In this study, 156 singleton pregnancies involving 139 women with chronic kidney disease whose infants were delivered between 22 and 41 weeks of gestation at the Maternal and Perinatal Center, Maternal-Fetal Division, Tokyo Women's Medical University Hospital, between January 1, 2001, and December 31, 2010, were examined. Chronic kidney disease was diagnosed based on the Kidney Disease Outcomes Quality Initiative definition of chronic kidney disease (the presence of kidney lesions or a glomerular filtration rate of less than 90 mL/min/1.73 m^2).[7] We also randomly selected 3067 women without chronic kidney disease who delivered their infants without suffering any medical complications during the same period as control groups. All pregnancies involving multiple pregnancies, fetal anomalies, intrauterine fetal death, or preconception dialysis were excluded from this study.

Gestational age was determined based on the last menstrual period and standard obstetric ultrasound examinations. All the patients had been permitted to continue their pregnancies by obstetricians and were managed in collaboration with nephrologists.

Threatened preterm labor was defined as progressive dilatation of the cervix combined with regular uterine contractions that occurred between 22 and 36 weeks of gestation.[8] Premature rupture of membranes (PROM) was defined as the observation of amniotic fluid pooling in the vagina, ferning, or a reduction in the volume of amniotic fluid on ultrasound,[8] or a positive result during testing with Check PROM (an insulin-like growth factor binding protein-1 reagent). According to the criteria of the National High Blood Pressure Education Program, hypertensive disorders in pregnancy can be classified into chronic hypertension, pregnancy-induced hypertension, preeclampsia, and superimposed preeclampsia.[9] Women whose blood pressure reached 140/90 mm Hg or more after the 20th week of gestation, but who did not exhibit proteinuria, were diagnosed with pregnancy-induced hypertension.[10]

Preeclampsia was defined as systemic hypertension exceeding 140/90 mm Hg accompanied by proteinuria after the 20th week of gestation.[11] Proteinuria was defined as a 24-hour urinary protein level of $\geq$300 mg or a score of $\geq$1 during dipstick tests of random urine samples.[11] Chorioamnionitis was clinically diagnosed based on the patients' medical records. The clinical findings of chorioamnionitis were considered to include maternal fever (greater than 100.4°F) and at least one of uterine fundal tenderness, maternal tachycardia (greater than 100 beats/min), maternal leukocytosis, and foul-smelling amniotic fluid.[12,13]

Hospitalization was considered necessary for hypertension, pregnancy-induced hypertension, worsening renal dysfunction, new onset proteinuria, markedly worsening proteinuria, threatened preterm labor, PROM, and intrauterine growth restriction (IUGR).

Regarding the fetal assessments performed during the patients' hospitalization, the initial ultrasound scan was used to estimate fetal weight and amniotic fluid volume, and then further ultrasound evaluations were performed every seven days and used to evaluate fetal growth. Nonstress testing was performed daily, and biophysical profiles were obtained when necessary.

Delivery was allowed to occur after the onset of active labor in the presence of maternal indications, such as significant renal dysfunction, the onset of pregnancy-induced hypertension, or clinical chorioamnionitis, and fetal indications such as growth arrest, a nonreassuring fetal status, and a gestational age greater than 37 weeks. Caesarean sections were performed in patients who had previously undergone Caesarean sections and patients who did not respond to induction, a nonreassuring fetal status, fetal malpresentation, or maternal indications. Short-term neonatal prognosis was evaluated based on the following conditions: premature birth (less than 37 weeks of gestation), SGA (below the tenth birth weight percentile for the infant's gestational age), neonatal death (within 28 days of birth), and infantile death after discharge. Long-term neonatal prognosis was assessed based on the incidence of cerebral palsy and/or intellectual disability (an intelligence quotient or development quotient of less than 70).[14] Cerebral palsy was defined as a nonprogressive, nontransient central nervous system disorder that is characterized by abnormal muscle tone in at least one extremity and abnormal control of movement and posture.[15] In addition to meeting the above criteria, the infants had to be aged at least 2 years at the most recent diagnosis to be definitively diagnosed with cerebral palsy. In patients with suspected cerebral palsy, the infants' physical findings were reviewed by a developmental pediatrician. In addition, a developmental quotient of less than 70 was interpreted as representing significantly delayed performance (intellectual disability).[15]

The infants were assessed for periventricular echodensity, intraventricular hemorrhaging (IVH), and periventricular leukomalacia (PVL). Periventricular echodensity was defined as confluent areas of increased echogenicity compared with the echogenicity of the choroid plexus. IVH was detected using cranial ultrasonography and was graded from 1 to 4 according to the classification developed by Papile et al.[16] PVL was diagnosed based on the presence of echodense or echolucent areas in the periventricular regions on coronal and sagittal views.[17]

Statistical analysis

The results are expressed as mean ± standard deviation values. Statistical analyses were performed using the chi-square test, Fisher exact probability test, the Mann–Whitney *U* test, the Student *t* test, or multiple regression analysis (SAS software, version 9.13, SAS Institute Inc). The significance of the differences between the with chronic kidney disease and without chronic kidney disease groups were assessed using the Student *t* test or Mann–Whitney *U* test for continuous variables and the chi-square test or Fisher exact probability test for categorical variables. *P* values of <0.05 were considered to be significant. OR and 95% CI were calculated to estimate how each factor influenced the relative risk of cerebral palsy and/or intellectual disability in the children of women with chronic kidney disease. The results were compared using both univariate and multivariate analyses, whereas logistic regression models were used to assess the influence of confounding factors. Posterior probabilities and highest probability densities were calculated to estimate the frequency of cerebral palsy and/or intellectual disability in the children of women with chronic kidney disease and the children of women without chronic kidney disease.

Results

The pregnant women exhibited the following types of chronic kidney disease: immunoglobulin A nephropathy (n = 54), glomerulonephritis (n = 17), chronic renal failure (n = 16), nephrotic syndrome (n = 12), nephritis (n = 11), diabetic nephropathy (n = 10), congenital malformations and deformations (n = 10), purpura nephritis (n = 7), and others (n = 19).

The maternal and neonatal outcomes involving pregnant women with and without chronic kidney disease are described in Table 1. The pregnant women with chronic kidney disease exhibited significantly higher frequencies of primipara (74.3%), preeclampsia (17.9%), preterm delivery (34.6%), and Caesarean sections (46.1%) than the pregnant women without chronic kidney disease ($P < 0.001$). There was no difference in the frequency of abruptio placentae, placenta previa, PROM, or chorioamnionitis between the two groups. The mean gestational age at delivery of the

TABLE 1.
Maternal and Neonatal Outcomes of Pregnancies Involving Women With and Without Chronic Kidney Disease (CKD)

Variables	CKD (n = 156)	No CKD (n = 3,067)	*P* Value
Primipara (n)	116	1885	<0.001
Maternal age (yr)	32.5 ± 4.8	32.3 ± 4.8	0.614
Obstetric complications (n)			
Threatened premature labor (n)	28	555	0.963
Preeclampsia (n)	28	90	<0.001
Abruptio placentae (n)	0	7	0.55
Placenta previa (n)	2	35	0.872
Preterm premature rupture of membranes (n)	5	146	0.482
Chorioamnionitis (n)	0	11	0.934
Mean gestational age at delivery (wk)	36.3 ± 4.0	37.6 ± 3.3	<0.001
Preterm delivery (<37 wk ; n)	54	597	<0.001
Nonreassuring fetal status (n)	16	259	0.52
Mode of delivery: Caesarean section (n)	72	908	<0.001
Maternal death (n)	0	0	1
Neonatal outcomes			
pH of umbilical artery <7.0 (n)	0	7	0.55
Mean birth weight (g)	2459.7 ± 777.7	2765.0 ± 656.1	<0.001
Apgar score <7 at 1 min (n)	18	246	0.158
Apgar score <7 at 5 min (n)	7	79	0.234
Small for gestational age (n)	15	139	0.027
Male sex (n)	92	1582	0.085
Neonatal outcomes			
Periventricular leukomalacia	2	8	0.134
Grade 1-4 intraventricular hemorrhaging	4	13	0.002
Neonatal death (n)	1	0	0.035
Cerebral palsy and/or intellectual disability (n)	2	7	0.098

infants born to the women with and without chronic kidney disease exhibited was 36.3 ± 4.0 weeks (range: 23 to 41) and 37.6 ± 3.3 weeks (range: 22 to 42), respectively ($P < 0.001$).

Regarding neonatal outcomes, the mean birth weights of the children delivered by the women with and without chronic kidney disease were 2459.7 ± 777.7 g and 2765.0 ± 656.1 g, respectively ($P < 0.001$). SGA (9.6%) was more common among the children born to the women with chronic kidney disease than in those delivered by the women without chronic kidney disease ($P = 0.027$). IVH (2.5%) occurred more frequently in the infants born to the women with chronic kidney disease than in those born to the women without chronic kidney disease ($P = 0.002$). Among the 156 children born to women with chronic kidney disease, one child was subsequently diagnosed with cerebral palsy, and another was diagnosed with cerebral palsy and intellectual disability (Table 2). On the other hand, seven of the children that were born to women without chronic kidney disease subsequently developed cerebral palsy alone, and none of the children that were born to women without chronic kidney disease were diagnosed with intellectual disability (Table 2). There was no difference in the incidence of cerebral palsy and/or intellectual disability between the two groups. There was one neonatal death (0.6%) among the pregnancies involving women with chronic kidney disease. The latter neonate was born at 30 weeks' gestation and exhibited a birth weight of 1284 g and Apgar scores of 4 and 7 at one and five minutes, respectively. She subsequently died of neonatal toxic shock syndrome-like exanthematous disease on the 14th day after birth.

The clinical characteristics of the infants that developed cerebral palsy and/or intellectual disability are described in Table 2. Two of the women whose children developed cerebral palsy and/or intellectual disability had chronic kidney disease, one had chronic glomerulonephritis, and the other had immunoglobulin A nephropathy. In the former case, a 1,050 g appropriate for gestational age male was born at 28 weeks of gestation to a 32-year-old primiparous female who had experienced a single episode of PROM on the day of delivery. The infant's Apgar score was 7 at one minute and 8 at five minutes. An ultrasound examination of the infant's brain performed on the 29th day of life detected cystic PVL. He was diagnosed with bilateral spastic paralysis and intellectual disability at age of three years.

In the latter case, a 1,156 g appropriate for gestational age male was born at 28 weeks of gestation to a 38-year-old multiparous woman who had experienced a single episode of severe preeclampsia on the day of delivery. An ultrasound examination of the infant's brain performed on the day after birth detected grade 4 IVH, and the infant manifested seizures on the second day after delivery. He was diagnosed with cerebral palsy at age three years and is now seven years old.

In patient number 7, which involved a woman without chronic kidney disease, labor and delivery were monitored closely, and there were no signs of intrapartum asphyxia. The infant exhibited signs of apnea at five hours after delivery and was admitted to the neonatal intensive care unit. An ultrasound examination of his brain performed on the second day after birth detected grade 2 periventricular echogenicity, and he subsequently manifested seizures. He is now six years old and has developed cerebral palsy.

The posterior probabilities and highest probability densities of cerebral palsy and/or intellectual disability in the children of women with and without chronic kidney disease

TABLE 2.
Cases of CP/Intellectual Disability Involving the Children of Pregnant Women With and Without CKD

Number	Variables	Renal Disease	Obstetric Complications and Reason for Termination	Delivery Mode	Gestational Age at Delivery (wk)	Birth Weight (g)	SGA	Sex	Apgar Score 1 and 5 min	pH of Umbilical Artery	Diagnosis and Prognosis
With CKD											
1	CP + ID	Chronic glomerulonephritis	Preterm PROM Renal dysfunction	Vaginal delivery	28	1050	(-)	Male	7 and 8	7.363	Cystic PVL
2	CP	Immunoglobulin A nephropathy	Severe PIH	CS	28	1156	(-)	Male	7 and 8	7.225	Grade 4 IVH Neonatal seizures
Without CKD											
1	CP	None	Prolapsed fetal membranes Threatened premature labor	Vaginal delivery	23	553	(-)	Female	5 and 6	Unknown	Grade 3 IVH
2	CP	None	Prolapsed fetal membranes Threatened premature labor	CS	24	803	(-)	Male	2 and 5	7.407	IVH Retinopathy of prematurity
3	CP	None	Threatened premature labor	CS	25	668	(-)	Female	9 and 9	7.361	IVH
4	CP	None	Placenta previa Preterm PROM	CS	28	1412	(-)	Female	6 and 8	7.234	Grade 3 PVE
5	CP	None	Placenta previa	CS	30	1472	(-)	Male	5 and 9	7.317	Cystic PVL
6	CP	None	Placenta previa	CS	30	1542	(-)	Male	2 and 5	7.34	PVL
7	CP	None	Onset of labor	Vaginal delivery	39	2998	(-)	Male	8 and 9	7.339	Grade 2 PVE Neonatal seizures

Abbreviations:
CKD = chronic kidney disease
CP = cerebral palsy
CS = Caesarean section
ID = intellectual disability
IVH = intraventricular hemorrhaging
PIH = pregnancy-induced hypertension
preterm PROM = preterm premature rupture of membranes
PVE = periventricular echodensity
PVL = periventricular leukomalacia
SGA = small for gestational age

are described in Table 3. Of the children who developed cerebral palsy and/or intellectual disability, two and seven were born to women with and without chronic kidney disease, respectively. Thus, the posterior probability of children that are born to women with and without chronic kidney disease developing cerebral palsy and/or intellectual disability was found to be 0.01900 and 0.002610, respectively. Consequently, this study revealed that the incidence

TABLE 3.
Posterior Probability and Highest Probability Density of CP and/or ID in the Children of Pregnant Women With and Without CKD

Variables	Likelihood	n	Mean	SD	95% HPD Interval
CP (with CKD)	1/156	20,000	0.012600	0.008910	0.000245-0.029800
CP (without CKD)	6/3067	20,000	0.002280	0.000864	0.000801-0.004050
CP and/or ID (with CKD)	2/156	20,000	0.019000	0.010900	0.001940-0.040300
CP and/or ID (without CKD)	7/3067	20,000	0.002610	0.000923	0.000973-0.004450

Abbreviations:
CKD = chronic kidney disease
CP = cerebral palsy
ID = intellectual disability
SD = standard deviation
HPD = highest probability density

of cerebral palsy and/or intellectual disability was 7.2-fold higher in children born to women with chronic kidney disease than in those born to women without chronic kidney disease.

The prenatal events and factors that influence the risk of cerebral palsy and/or intellectual disability in children born to women with chronic kidney disease are described in Table 4. A primiparous mother (OR: 4.07, 95% CI: 2.78 to 5.95), preeclampsia (OR: 6.44, 95% CI: 3.92 to 10.59), grade 1 to 4 IVH (OR: 7.71, 95% CI: 2.05 to 28.92), and an Apgar score of less than 7 at five minutes (OR: 0.51, 95% CI: 0.27 to 0.96) were found to affect the risk of cerebral palsy and/or intellectual disability in such children.

Discussion

Several studies have examined the pregnancy outcomes of women with chronic kidney disease. These studies found that 17% to 60% of cases involved preterm deliveries, 30% to 59% of cases involved Caesarean sections, and preeclampsia occurred in 13% to 64% of pregnancies.[1-6] Fink et al.[4] suggested that women with renal disease are at increased risk of preeclampsia (OR: 7.2, 95% CI: 4.2 to 12.5), preterm labor (OR: 7.9, 95% CI: 1.9 to 32.6), dysfunctional labor (OR: 3.6, 95% CI: 1.1 to 11.5), and Caesarean section (OR: 3.1, 95% CI: 2.0 to 4.8). Our findings regarding the maternal outcomes of pregnant women with chronic kidney disease were consistent with those of previous case reports, i.e., the incidences of preeclampsia, preterm delivery, and Caesarean section were 17.9%, 34.6%, and 46.1%, respectively.

Recently, Nevis et al.[2] reviewed pregnancies involving women with kidney disease and revealed that the overall risk of adverse fetal events was two-fold higher in such women than in women without kidney disease.[2] Alsuwaida et al.[5] also suggested that women with estimated glomerular filtration rate of 60 to 89 mL/min/1.73 m^2 are at significantly greater risk of preterm births (31.2%) and of delivering children that manifest IUGR (38.5%) or intrauterine fetal death (15.8%). In studies involving at least 25 pregnancies, the prevalence rates of stillbirths and neonatal/perinatal deaths ranged from 8% to 15%.[18] There have been several reports about perinatal mortality in pregnant women with chronic kidney disease[1,3,6,18-20]; however, our study was first to examine the frequency of cerebral palsy and/or intellectual disability among the children born to such women.

With regard to the developmental delays experienced by children born to women with chronic kidney disease, Kerstjens et al.[21] found that among moderately preterm-born (between 32 0/7 and 35 6/7 weeks of gestation) children the incidence of developmental delays was 14.2% higher in those that were SGA (a proxy for IUGR; SGA: 21.9%, no SGA: 7.7%, $P < 0.05$, adjusted OR: 2.75, CI: 1.25 to 6.08), 10.5% higher in cases involving preexisting maternal obesity (obesity: 18.0%, no obesity: 7.5%, $P < 0.01$, adjusted OR: 2.73, CI: 1.35 to 5.52), 4.2% higher in cases involving multiple pregnancies (multiple: 12.0%, singleton: 7.8%, $P < 0.05$, adjusted OR: 1.86, CI: 1.02 to 3.42), and 9.2% higher in males (males: 13.0%, females: 3.8%, $P < 0.001$, adjusted OR: 4.20, CI: 2.09 to 8.46). The abovementioned relationship between SGA and the risk of developmental delays was in line with the findings of other reports about term or early-preterm children.[22,23] Our study also detected an association between SGA and the risk of cerebral palsy and/or intellectual disability in the children born to women with chronic kidney disease, although cases involving multiple pregnancies were excluded, and no association was detected between the risk of cerebral palsy and/or intellectual disability and male sex.

Trønnes et al.[24] assessed the risk of cerebral palsy in relation to various pregnancy-related disorders in a study of all the live births that took place in Norway from 1967 through 2001. In total, 1,764,509 children that were delivered between 23 and 43 weeks' gestation were included.[24] In the latter study, the prevalence of cerebral palsy was 1.8 per 1000 births, and placental abruption, chorioamnionitis, PROM, IUGR, preeclampsia, multiple births, placenta previa, bleeding, cervical conization, and congenital malformations were all found to be associated with cerebral palsy.[24] In our study, preeclampsia was more common in the pregnant women with chronic kidney disease (28 of 156 versus 90 of 3067 cases, respectively; $P < 0.001$). As for other pregnancy-related disorders, Shatrov et al.[25] examined the relationship between clinical or histologic chorioamnionitis and cerebral palsy in a meta-analysis. As a result, they detected significant associations between clinical chorioamnionitis or histologic chorioamnionitis and cerebral palsy. Specifically, pooled OR for cerebral palsy of 2.42 (95% CI: 1.52 to 3.84) and 1.83 (95% CI: 1.17 to 2.89) were obtained for clinical chorioamnionitis (chi1 = 13.91; $P < 0.001$) and histologic chorioamnionitis (chi1 = 6.86; $P = 0.009$), respectively.[25] These findings suggest that neonates that are exposed to clinical chorioamnionitis or histologic chorioamnionitis are

TABLE 4.
Prenatal Events and the Factors That Influence the Risk of Cerebral Palsy and/or Intellectual Disability in the Children of Pregnant Women With CKD

Variables	Multiple Regression Analysis			
	Case (n = 156)	Control Group (n = 3,067)	OR (95% CI)	*P* Value
Primipara	116	1885	4.07 (2.78-5.95)	<0.001
Preeclampsia	28	90	6.44 (3.92-10.59)	<0.001
Grade 1-4 intraventricular hemorrhaging	4	13	7.71 (2.05-28.92)	<0.001
Apgar score <7 at five min	7	79	0.51 (0.27-0.96)	0.037

Abbreviations:
95% CI = 95% confidence interval
CKD = chronic kidney disease
OR = odds ratio
Data are presented as n values.

at 140% and 80% greater risk of cerebral palsy, respectively.[25] However, in our study, none of the pregnant women with chronic kidney disease had chorioamnionitis, and thus it was presumed that our study was limited by its retrospective nature and relatively small sample size.

IVH is the most common type of intracranial hemorrhaging observed in preterm neonates, and it has been demonstrated to be a precursor of poor neurocognitive development, cerebral palsy, and death.[26] Recently, Calisici et al.[26] determined the neurodevelopmental outcomes (at corrected ages of 18 to 24 months) of 138 preterm infants who were born prior to 37 weeks' gestation and had grade 3 to 4 IVH. Although they demonstrated that the long-term outcomes (at age two years) of preterm infants do not differ according to birth weight, they concluded that severe IVH is a significant risk factor for poor neurodevelopmental outcomes in this already high-risk population.[26] On the other hand, Brumbaugh et al.[8] found that the rates of neonatal morbidities and cerebral palsy among preterm neonates that were delivered by Caesarean section due a non-reassuring fetal heart rate pattern were not affected by the presence of grade 3 or 4 IVH. In our study, we revealed that the frequency of grade 1 to 4 IVH was significantly higher among the pregnant women with chronic kidney disease, and it was presumed that this was due to the fact that our study population was not solely composed of infants that underwent preterm or Caesarean deliveries.

Finally, many studies have revealed that pregnant women with chronic kidney disease tend to have sicker infants.[1,3,6,18-20] Thus our finding that neurological disorders, such as cerebral palsy or intellectual disability, are more common in children born to women with chronic kidney disease is not surprising. In this study, two of the children (2 of 156, or 1.28%) born to women with chronic kidney disease manifested severe neurological damage (one had IVH, and the other had PVL). These two children were both born at 28 weeks' gestation. Preterm birth can increase a child's risk of cerebral palsy by up to 100-fold.[27] However, preterm and very preterm births contribute to the development of cerebral palsy in fewer than half of the patients.[27] On the other hand, Himpens et al.[28] reported that the prevalence of cerebral palsy decreases significantly with increasing gestational age category: 14.6% at 22 to 27 weeks' gestation, 6.2% at 28 to 31 weeks' gestation, 0.7% at 32 to 36 weeks' gestation, and 0.1% in term infants. For this reason, we speculate that prematurity contributed to the occurrence of cerebral palsy or intellectual disability in the children born to women with chronic kidney disease in this study.

Limitations of the study

Several limitations should be considered when interpreting the results of our study. First, there were several minor limitations such as the small sample size, which led to inadequate assessments; the short duration of therapy; and the fact that the study involved a heterogeneous group of patients with chronic kidney disease. Second, our data were collected retrospectively, and so prospective studies are required to confirm our results.

Conclusion

Our study indicated that a primiparous mother, preeclampsia, grade 1 to 4 IVH, and an Apgar score of less than 7 at five minutes influence the risk of cerebral palsy and/or intellectual disability in children born to women with chronic kidney disease. Moreover, this study revealed that compared with children born to women without chronic kidney disease, those born to women with chronic kidney disease exhibited a 7.2-fold higher incidence rate of cerebral palsy and/or intellectual disability.

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The biggest disease today is not leprosy or tuberculosis, but rather the feeling of being unwanted.

Mother Theresa