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Original Article

Association between combinations of pathological conditions causing cerebral palsy among mothers and infants and associated characteristics including umbilical arterial pH and parity

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Abstract

This study sought to identify combinations of pathological conditions that cause cerebral palsy (CP) among mothers and infants and their relationship to five associated characteristics, including umbilical arterial pH (UApH). Cases were retrieved from the cause analysis reports produced by the Japan Obstetric Compensation System for Cerebral Palsy. Only singleton births for whom UApH data were available, gestational age at birth ≥ 32 weeks of gestation and birth weight ≥ 1,400 g were included; therefore, 349 of the 421 CP cases to receive compensation in 2018 were included in this study. The relationship between the pathological conditions and the associated characteristics, which were UApH, 1-minute Apgar score, gestational age at birth, birth weight, and parity, were analyzed. The parity was significantly higher among mothers with placental abruption (PA) than in those without these conditions whose infants were eligible, even if these values were higher (adjusted odds ratio [aOR], 2.845; p = 0.004). Additionally, umbilical cord blood flow obstruction (UCBFO) was associated with a significantly lower parity (aOR, 0.406; p = 0.001). It was suggested that parity is a useful indicator of the risk of PA and UCBFO as well as for elucidating the numerical value of the characteristics at birth.

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Introduction

Cerebral palsy (CP) was initially thought to be primarily caused by a lack of oxygen during birth. However, it has been reported that this cause is responsible for only a few CP cases. For most CP cases (85% – 90%), the cause occurs before or during birth, and in many cases, the specific cause is not known. Some of the risk factors for CP are low birth weight, premature birth, multiple births, assisted reproductive technology infertility treatments, infections during pregnancy, jaundice and kernicterus, maternal medical conditions, and birth complications (Cerebral Palsy. Centers for Disease Control and Prevention. (Available from: https://www.cdc.gov/ncbddd/cp/facts.html. Accessed Jan. 4, 2020)).[1-3]

The Japan Obstetric Compensation System for Cerebral Palsy (JOCSC) of the Japan Council for Quality Health Care (JQ) was reported in the 8th Recurrence Prevention Report published in March 2018 (The Japan Obstetric Compensation System for Cerebral Palsy – Looking back over 10 years after System was launched. JQ (Available from: http://www.sanka-hp.jcqhc.or.jp/documents/english/pdf/looking_back_over10years_after_system_was_launched201906.pdf. Accessed Jan. 4, 2020)) that 968 of the 1,606 analyzed cases (60.3%) stated pathological conditions as the main cause of CP onset.[4] Among these cases, 773 (48.1%) had a single pathological condition and 195 (12.1%) had multiple pathological conditions. However, no cause was identified for 638 cases (39.7%).

The singular pathological conditions noted in 773 cases (48.1%) were placental separation or bleeding from the placenta (272 cases, 16.9%), umbilical factors

(214 cases, 13.3%), infections (57 cases, 3.5%), uterine rupture (34 cases, 2.1%), feto-maternal transfusion syndrome (31 cases, 1.9%), and others (165 cases, 10.3%). The JOCSC also provides a cause analysis report every year, with a summary version posted on the system website, revealing any fetal pathological conditions causing CP. For example, fetal hypoxia/acidemia (FH/A) was reported in 142 of the 421 cases in their cause analysis reports in 2018.

Earlier studies, including a meta-analysis carried out on predefined groups, revealed that a low arterial cord pH was associated with neonatal mortality, hypoxic ischemic encephalopathy, intraventricular hemorrhage or periventricular leukomalacia, and CP.[5] Sabol and Caughey reported that for neonates with an umbilical artery ≥ 7.1 with a 5-min Apgar score ≥ 7, outcomes included respiratory distress syndrome and admission to the neonatal intensive care unit.[6]

In our study, we used the reports analyzed in the JOCSC to conduct a retrospective study of cases with pathological conditions related to the placenta, umbilical cord, gestational hypertension, intrauterine infections and fetal acidemia as the causes of CP. These pathological conditions were reported to be the most common maternal and fetal causes of CP. The purpose of our study was to clarify the relationship between these causes and the following associated characteristics: umbilical artery pH (UApH), Apgar score, gestational age at birth, birth weight, and parity. These characteristics are useful for assessing infant risk factors for CP.[7,8] The relationship between the presence or absence of multiple maternal and infant pathological conditions was clarified, as well as their association with UApH, Apgar score, gestational age at birth, birth weight, and parity. By analyzing the variables within the scope of the summary version of the cause analysis report published on the JQ website, it is intended that the results could be utilized to study about causing CP. These characteristic variables were limited, but we chose to determine the characteristics depending on the presence or absence of the maternal pathological conditions like as hypertensive disorder of pregnancy.

No previous studies have analyzed the combinations of these pathological conditions.[9,10] Therefore, the identification of a significant relationship between combinations of maternal and infant pathological conditions causing CP and these five associated characteristics, especially including a comparison of cases with no pathological causes, is novel. Any change in these relationships was also assessed based on whether the values of the five associated characteristics were above or below the median of our study cases.

Materials and Methods

JOCSC reports

The JOCSC, which is operated by the JQ, was launched in 2009 to provide prompt, no-fault compensation for children with severe disability due to CP associated with obstetric factors and their respective families. This compensation does not cover congenital causes or factors that occurred during or after the neonatal period. The system also aims to prevent cerebral palsy by achieving early medical conflict resolution and improving obstetric care. The review committee performs a case review for compensation, and after a child is declared eligible to receive compensation, the cause of CP is individually analyzed by the Cause Analysis Committee. Once collected, the Recurrence Prevention Committee analyzes these individual cases from an epidemiological standpoint. In order to ensure the transparency of this system, as well as to prevent the recurrence of similar cases and improve the quality of obstetric care, these reports are sent to the delivery facilities and the families.[11]

There are two versions of the cause analysis reports. One is the full-text version (with masked [blackened] information so that the individuals and childbirth facilities cannot be identified), which is written based on specified procedures for research purposes. The other is the summary version (without identifying information regarding the individuals or childbirth facilities), which is posted on the system website after obtaining consent from the childbirth facilities and the parents (The "summary version" of the Cause Analysis Reports. The Japan Council for Quality Health Care. (Available from: http://www.sanka-hp.jcqhc.or.jp/documents/analysis/archive/2020/index.html. Accessed Jan. 4, 2020)).

Ethics

This study was conducted with the approval of the Medical Research Committee of the School of Medicine at the Tokyo Medical and Dental University (approval no. M2019-082-01) according to the ethical principles of the Declaration of Helsinki.

Participants

From 2009 to 2019, 2,951 cases were declared eligible for compensation and 1,643 had summary versions of their reports posted on the system website.[12] Eligible children mainly met the following criteria: gestational age at birth ≥ 32 weeks and birth weight ≥ 1,400 g or gestational age at birth ≥ 28 weeks. These criteria were formally defined for children born on or after January 1, 2015 as a result of the review. For our study, 421 reports

from 2018 were included, when it was assumed that there were sufficient cases corresponding to the new criteria. There are two eligibility categories declared by the general compensation target standard and the individual judgment standard. The cases of the general standard include not only hypoxia-ischemia but also fetal infection, anemia-hypovolemia and others (including unknown causes), which are gestational age at birth ≥ 32 weeks of gestation and birth weight ≥ 1,400 g (Available from: http://www.sanka-hp.jcqhc.or.jp/application/sphere.html. Accessed Oct. 14, 2020)). Among the declared cases by JOCSC, this study judged that the diversity of results could be identified by analyzing the cases with high characteristic values, and the caess for the general subjects are targeted for research.

We excluded 72 cases that were not singleton births and did not have umbilical arterial pH (UApH) data available, since this was necessary to assess the associated characteristics for CP in this study. We also excluded 41 cases declared eligible by the individual judgment standard, because there are limitations to the declared cases (Figure 1). We therefore retrospectively analyzed the pathological conditions and associated characteristics of 349 cases.

The pathological conditions related to the placental dysfunction cases, placental abruption cases, umbilical cord blood flow disturbance cases, maternal disease cases and fetus acidemia cases that were studied here, placental abruption (PA), placental dysfunction (PD), umbilical cord blood flow obstruction (UCBFO), hypertensive disorder of pregnancy (HDP), intrauterine infections (II), fetal hypoxia/acidemia (FH/A) and hypoxic-ischemic (HI). No maternal pathological conditions were distinguished and no maternal or fetal pathological conditions were noted to be the causative agent for CP. We analyzed the relationship of these pathological conditions with the following associated characteristics: UApH, 1-minute Apgar score, gestational age at birth, birth weight, and parity. These characteristics were grasped by the numerical parameters noted in the summary version of the cause analysis report, and this report includes no description such as physical characteristics or medical history. As for the Apgar score, the 1-minute after birth, which has numerous values of variables, was adopted in consideration of the relationship with UApH.

Various combinations, including the presence or absence, of these pathological conditions and their relationship with the five associated characteristics were analyzed.

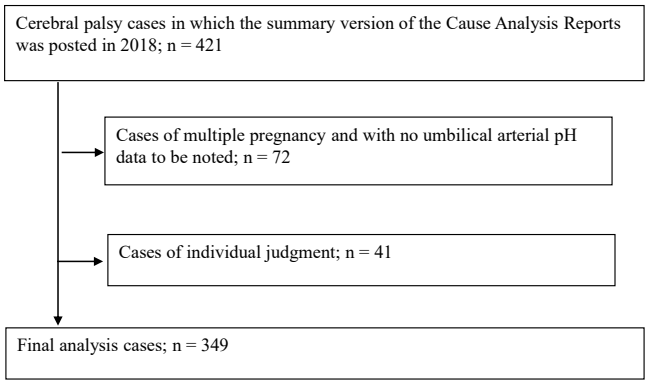

Figure 1. Flow diagram showing the number of eligible cases

Statistical analysis

A two-sided P value < 0.050 was considered statistically significant. All analyses were conducted using IBM SPSS version 26.0 (IBM, Tokyo, Japan). Continuous variables were summarized as the median (interquartile range [IQR]). The distributions of these variables were compared between groups using the Mann–Whitney U test. The relationship between various combinations of the pathological conditions and the five associated characteristics were evaluated using univariate and multivariate logistic regression analyses. The adjusted odds ratio (aOR) or OR and its 95% confidence interval (CI) were estimated. The five associated characteristics were grouped into two subcategories above and below their median values for the univariate and multivariate logistic regression analyses. By comparing two groups of the cause pathological conditions grouped by the median values of each five characteristics, the difference of risk depending on the values was obtained.

Results

For the 349 cases included, data on the five associated characteristics are shown in Table 1.

Data concerning the five associated characteristics and their relationship to the pathological conditions causing CP are shown in Table 2. Various combinations of these pathological conditions were included to fully evaluate the associated characteristics. All the continuous variables are described using the IQR.

The UApH was significantly lower when pathological conditions causing CP were present than when they were absent. For example, the UApH was lower among mothers with PA and HDP than in those without these conditions (6.710 [6.616, 6.907] vs. 7.244 [7.022,

Table 1. Data on the five cerebral palsy-associated characteristics studied and judgment case

Variables	Judgment	n	Median (Interquartile range)
Mothers			
Parity	Total	349	0 [0, 1]
	General judgment cases	308	0 [0, 1]
	Individual Judgment cases	41	1 [0, 2]
Infants			
Gestational weeks	Total	349	38 [35, 39]
	General judgment cases	308	38 [36, 40]
	Individual Judgment cases	41	30.0 [28.5, 30.5]
Birth weight (g)	Total	349	2,656 [2,067, 3,079]
	General judgment cases	308	2,752.0 [2,291.0, 3,123.5]
	Individual Judgment cases	41	1,310.0 [1,158.5, 1,471.0]
Umbilical artery pH	Total	349	7.211 [6.880, 7.320]
	General judgment cases	308	7.212 [6.865, 7.320]
	Individual Judgment cases	41	7.210 [6.938, 7.312]
1-minute Apger score	Total	349	3 [1, 8]
	General judgment cases	308	3 [1, 8]
	Individual Judgment cases	41	4.0 [1.0, 6.8]

Table 2. Mann-Whitney U test results concerning the relationship between pathological conditions causing CP and the five associated characteristics studied about general judgement cases

Pathological conditions causing CP	Umbilical artery pH					1-minute Apgar score					Gestational age at birth (weeks)					Birth weight (g)					Parity				
	n		Median [interquartile range]		p value	n		Median [interquartile range]		p value	n		Median [interquartile range]		p value	n		Median [interquartile range]		p value	n		Median [interquartile range]		p value
	Yes	No	Yes	No		Yes	No	Yes	No		Yes	No	Yes	No		Yes	No	Yes	No		Yes	No	Yes	No	
Mother-related																									
PD	28	244	7.137 [6.980, 7.252]	7.184 [6.788, 7.312]	0.887	28	241	2 [1, 5]	2 [1, 7]	0.363	28	244	39 [37, 40]	38 [36, 39]	**0.040**	28	244	2,468 [1,924, 2,770]	2,768 [2,272, 3,133]	**0.013**	28	244	0 [0, 1]	0 [0, 1]	**0.042**
PA	65	207	6.710 [6.616, 6.907]	7.244 [7.022, 7.335]	**< 0.001**	65	204	0 [0, 1]	4 [1, 8]	**< 0.001**	65	207	37 [35, 39]	38 [36, 40]	**0.007**	65	207	2,640 [2,092, 3,082]	2,760 [2,294, 3,122]	0.184	65	207	1 [0, 1]	0 [0, 1]	**0.006**
UCBFO	123	149	7.187 [6.881, 7.317]	7.156 [6.744, 7.310]	0.129	120	149	2 [1, 7]	2 [1, 8]	0.606	123	149	39 [36, 40]	38 [36, 39]	**0.005**	123	149	2,746 [2,294, 3,092]	2,732 [2,218, 3,112]	0.648	123	149	0 [0, 1]	1 [0, 1]	**< 0.001**
Umbilical cord compression	51	221	7.091 [6.771, 7.329]	7.198 [6.829, 7.311]	0.708	50	219	2 [1, 7]	2 [1, 7]	0.599	51	221	39 [35, 40]	38 [36, 39]	0.101	51	221	2,704 [2,300, 3,066]	2,750 [2,218, 3,122]	0.967	51	221	0 [0, 1]	0 [0, 1]	**0.009**
HDP	16	256	6.805 [6.728, 6.926]	7.198 [6.845, 7.318]	**0.001**	16	253	0 [0, 1]	2 [1, 7]	**< 0.001**	16	256	36 [35, 38]	38 [36, 40]	**0.025**	16	256	2,430 [1,924, 2,886]	2,749 [2,272, 3,128]	0.057	16	256	0 [0, 1]	0 [0, 1]	0.434
II	33	239	7.041 [6.901, 7.244]	7.187 [6.806, 7.320]	0.314	33	236	1 [1, 4]	2 [1, 8]	0.161	33	239	39 [36, 40]	38 [36, 39]	0.227	33	239	2,916 [2,438, 3,210]	2,704 [2,228, 3,080]	0.141	33	239	0 [0, 1]	0 [0, 1]	**0.044**
Cause unknown	59	213	7.298 [7.248, 7.351]	7.025 [6.750, 7.270]	**< 0.001**	59	210	8 [6, 9]	1 [1, 4]	**< 0.001**	59	213	38 [37, 39]	38 [35, 40]	0.459	59	213	2,815 [2,312, 3,140]	2,660 [2,182, 3,088]	0.232	59	213	1 [0, 1]	0 [0, 1]	0.093
Infant-related																									
FH/A	129	179	6.802 [6.671, 7.000]	7.307 [7.238, 7.350]	**< 0.001**	128	177	1 [0, 2]	8 [4, 9]	**< 0.001**	129	179	38 [36, 40]	38 [36, 39]	0.251	129	179	2,754 [2,283, 3,122]	2,748 [2,294, 3,124]	0.910	129	179	0 [0, 1]	0 [0, 1]	0.288
Hypoxic ischemic encephalopathy	20	252	7.044 [6.699, 7.281]	7.179 [6.826, 7.311]	0.334	20	249	2 [1, 4]	2 [1, 7]	0.508	20	252	38 [37, 40]	38 [36, 40]	0.356	20	252	2,902 [2,514, 3,440]	2,727 [2,200, 3,085]	0.090	20	252	0 [0, 1]	0 [0, 1]	0.657
Mother- and infant-related																									
Cause unknown	36	272	7.309 [7.269, 7.359]	7.173 [6.817, 7.311]	**< 0.001**	36	269	8 [8, 9]	2 [1, 7]	**< 0.001**	36	272	39 [38, 40]	38 [36, 40]	**0.004**	36	272	2,946 [2,603, 3,353]	2,739 [2,231, 3,102]	**0.011**	36	272	0 [0, 1]	0 [0, 1]	0.322

PD, placental dysfunction; PA, placental abruption; HDP, hypertensive disorder of pregnancy; II, intrauterine infections; UCBFO, umbilical cord blood flow obstruction; FH/A, fetal hypoxia/acidemia

Table 3. Univariate and multivariate logistic regression analyses for the pathological conditions causing CP and both umbilical artery pH and gestational age at birth categorized into two groups using the median values about general judgement cases

Pathological conditions causing CP	n	Umbilical artery pH				Gestational weeks				1-minute Apgar score			
		Univariate analyses for variables categorized into two groups (≤7.2115 vs. >7.2115)		Multivariate analyses for variables categorized into two groups (≤7.2115 vs. >7.2115)		Univariate analyses for variables categorized into two groups (≤38 vs. >38)		Multivariate analyses for variables categorized into two groups (≤38 vs. >38)		Univariate analyses for variables categorized into two groups (≤ 3 vs. > 3)		Multivariate analyses for variables categorized into two groups (≤ 3 vs. > 3)	
		OR (95% CI)	p value	aOR (95% CI)	p value	OR (95% CI)	p value	aOR (95% CI)	p value	OR (95% CI)	p value	aOR (95% CI)	p value
Mother-related													
PD	28	0.456 (0.193–1.075)	0.073	0.676 (0.226–2.023)	0.484	0.456 (0.193–1.075)	0.073	0.069 (0.019–0.248)	**<0.001**	0.540 (0.229–1.274)	0.159	0.113 (0.017–0.747)	**0.024**
PA	65	0.049 (0.017–0.141)	**<0.001**	0.113 (0.036–0.355)	**<0.001**	1.747 (0.996–3.063)	0.052	1.757 (0.625–4.939)	0.285	0.028 (0.007–0.117)	**<0.001**	0.082 (0.013–0.525)	**0.008**
UCBFO	123	1.116 (0.691–1.804)	0.654	1.743 (0.919–3.307)	0.089	0.732 (0.452–1.187)	0.206	0.819 (0.428–1.567)	0.547	0.844 (0.517–1.375)	0.495	0.722 (0.275–1.895)	0.508
HDP	16	0.074 (0.010–0.571)	**0.012**	0.134 (0.015–1.214)	0.074	2.874 (0.970–8.511)	0.057	3.562 (0.748–16.969)	0.111	0.087 (0.011–0.671)	**0.019**	0.371 (0.020–6.953)	0.507
II	33	0.577 (0.268–1.242)	0.159	0.771 (0.296–1.992)	0.591	0.670 (0.315–1.424)	0.296	0.929 (0.341–2.529)	0.885	0.685 (0.318–1.477)	0.334	2.401 (0.636–9.061)	0.196
Mother- and infant-related													
Cause unknown	36	7.623 (2.877–20.196)	**<0.001**	1.959 (0.615–6.237)	0.256	0.410 (0.186–0.904)	**0.027**	0.420 (0.161–1.091)	0.075	15.757 (4.715–52.656)	**<0.001**	1.580 (0.253–9.862)	0.625

PD, placental dysfunction; PA, placental abruption; HDP, hypertensive disorder of pregnancy; II, intrauterine infections; UCBFO, umbilical cord blood flow obstruction

7.335] and 6.805 [6.728, 6.926] vs. 7.198 [6.845, 7.318], respectively; $p < 0.001$), among infants with FH/A compared to those without FH/A (6.805 [6.728, 6.926] vs. 7.198 [6.845, 7.318], respectively; $p = 0.001$). Mothers without these pathological conditions and both mothers and infants in combination without these conditions had significantly higher UApH than those with these pathological conditions (7.298 [7.248, 7.351] vs. 7.025 [6.750, 7.270] and 7.309 [7.269, 7.350] vs. 7.173 [6.817, 7.311], respectively; $p < 0.001$).

The 1-minute Apgar score was lower for infants whose mothers had PA and HDP than for infants whose mothers did not have these pathological conditions (0 [0, 1] vs. 4 [1, 8] and 0 [0, 1] vs. 2 [1, 7], respectively; $p < 0.001$), for infants with FH/A compared to those without FH/A (1 [0, 2] vs. 8 [4, 9], respectively; $p < 0.001$). Similarly, the 1-minute Apgar score was higher in mothers and mothers in combination with infants with no pathological condition compared to those with combination having those conditions (8 [6, 9] vs. 1 [1, 4] and 8 [6, 9] vs. 2 [1, 7], respectively; $p < 0.001$).

For mothers with PA and HDP, the gestational age of infants at birth was significantly lower than for those without these pathological conditions (37 weeks [35, 39] vs. 38 weeks [36, 40]; $p = 0.007$ and 36 weeks [35, 38] vs. 38 weeks [36, 40]; $p = 0.025$, respectively). Alternatively, for mothers with UCBFO and PD, the gestational age at birth was significantly higher than for those without these conditions (39 weeks [37, 40] vs. 38 weeks [36, 39]; $p = 0.040$ and 39 weeks [36, 40] vs. 38 weeks [36, 39]; $p = 0.005$, respectively). Both mothers and infants in combination without pathological conditions had a significantly higher gestational age at birth than those with these conditions (39 weeks [38, 40] vs. 38 weeks [36, 40]; $p = 0.004$, respectively).

The birth weight of infants whose mothers had PD was significantly lower than that of infants whose mothers did not have these conditions (2,468 g [1,924, 2,770] vs. 2,768 g [2,272, 3,133]; $p = 0.013$, respectively). Alternatively, the birth weight of infants whose mothers had no pathological condition was significantly higher than the birth weight when these pathological conditions were present (2,946 g [2,603, 3,353] vs. 2,739 g [2,231, 3,102], respectively; $p = 0.011$).

The parity of mothers with PA was significantly higher than that of mothers without PA (1 [0, 1] vs. 0 [0,1]; $p = 0.006$). Finally, mothers with UCBFO had a significantly lower parity than those without UCBFO (0 [0, 1] vs. 1 [0,1], respectively; $p < 0.001$) (Table 2).

The logistic regression analyses were performed about the cause pathological conditions that revealed a significantly higher or lower using the Man-Whitney U test.

Results of the univariate and multivariate logistic regression analyses of the five associated characteristics among mothers and infants with pathological conditions causing CP compared to these pathological conditions having high or low characteristics values, are shown in Tables 3 and 4. Each of the five associated characteristics (UApH, 1-minute Apgar score, gestational age at birth, birth weight, and parity) were categorized into two

Table 4. Univariate and multivariate logistic regression analyses for the pathological conditions causing CP and both birth weight and parity categorized into two groups using the median values about general judgement cases

Pathological conditions causing CP	n	Birth weight (g)				Parity			
		Univariate analyses for variables categorized into two groups (≤2,656 vs. >2,656)		Multivariate analyses for variables categorized into two groups (≤2,656 vs. >2,656)		Univariate analyses for variables categorized into two groups (0 vs. ≥1)		Multivariate analyses for variables categorized into two groups (0 vs. ≥1)	
		OR (95% CI)	p value	aOR (95% CI)	p value	OR (95% CI)	p value	aOR (95% CI)	p value
Mother-related									
PD	28	0.307 (0.130–0.725)	**0.007**	0.055 (0.016–0.191)	**<0.001**	0.427 (0.175–1.041)	0.061	0.372 (0.126–1.101)	0.074
PA	65	0.729 (0.417–1.275)	0.268	0.756 (0.267–2.140)	0.599	2.053 (1.168–3.609)	**0.012**	2.845 (1.391–5.820)	**0.004**
UCBFO	123	1.195 (0.740–1.930)	0.467	0.960 (0.506–1.820)	0.899	0.402 (0.244–0.664)	**<0.001**	0.406 (0.241–0.684)	**0.001**
HDP	16	0.497 (0.175–1.409)	0.188	0.878 (0.194–3.978)	0.866	0.613 (0.207–1.816)	0.377	0.492 (0.153–1.576)	0.232
II	33	1.380 (0.656–2.901)	0.396	1.138 (0.427–3.033)	0.796	0.479 (0.213–1.073)	0.074	0.536 (0.233–1.230)	0.141
Mother- and infant-related									
Cause unknown	36	2.244 (1.042–4.833)	**0.039**	1.744 (0.692–4.392)	0.238	1.240 (0.617–2.490)	0.545	1.096 (0.496–2.421)	0.821

PD, placental dysfunction; PA, placental abruption; HDP, hypertensive disorder of pregnancy; II, intrauterine infections; UCBFO, umbilical cord blood flow obstruction

groups using the median value (i.e., UApH ≤ 7.212 vs. > 7.212, 1-minute Apgar score ≤ 3 vs. > 3, gestational age at birth ≤ 38 weeks vs. > 38 weeks, birth weight ≤ 2,752 g vs. > 2,752 g, and parity 0 vs. ≥ 1) in the univariate and multivariate logistic regression analyses. In the logistic regression analysis, the presence or absence groups of the causal pathological conditions were used as the dependent variable, and the variables related to the five characteristics were classified into two categories, high and low relative to the median, and used as independent variables. In the univariate analyses, each the variables related to the five characteristics was used.

The resulting statistically significant results were confirmed by the aforementioned statistical analysis method. The results were described using the numerical values of the multivariate analysis when both the univariate and multivariate analyses showed significant results.

The analysis for UApH revealed statistically significant decreases among mothers with PA compared to those with high characteristic values (aOR, 0.113; 95% CI, [0.036 – 0.355]; $p < 0.001$, respectively). The 1-minute Apgar scores were significantly decreases for mothers with PA compared to those with high characteristic values (aOR, 0.082; 95% CI, [0.013 – 0.525]; $p = 0.008$, respectively; Table 3).

The analysis for parity showed statistically significant increases in mothers with PA (aOR, 2.845; 95% CI, [1.391 – 5.820]; $p = 0.004$). Alternatively, in mothers with UCBFO, parity was significantly lower compared to those with high values (aOR, 0.406; 95% CI, [0.241 – 0.684]; $p = 0.001$; Table 4).

Discussion

In our study, among the cases eligible to receive compensation, statistically significant results according to the circumstances of five associated characteristics in which the pathological conditions causing CP occurred in mothers and infants were confirmed. Furthermore, the univariate and multivariate logistic regression analyses results according to high or low of characteristics values by grouping at the median demonstrated statistically significant increases or decreases when the cause pathological conditions did or did not occur. For UApH and the 1-minute Apgar score, cases of mothers with PA displayed the median of UApH and the 1-minute Apgar score was 6.710 and 0, both of which were lower than these values in the cases without these pathological causes. Conversely, for UApH and the 1-minute Apgar score, the cases of mothers with PA demonstrated the statistically significant decreases compared to the higher characteristic values. These statistical results were expected, given that PA occurs as an event before parturition.

In cases of mothers with HDP, UApH, 1-minute Apgar score, and gestational age were significantly lower than in the absence of those cases. Alternatively, in the same

cases there were no statistically significant decreases or increases compared to the higher values of these three characteristics.

Previous studies have demonstrated that even moderate degrees of fetal acidemia (pH threshold of ≤ 7.10) may place neonates at risk for adverse outcomes.[13-14] Our study population included many infants with UApH > 7.10; however, there were also cases in which the association between the pathological conditions and UApH data were observed during the obstetric care period.

There have been previous studies concerning the possibility of using the Doppler examination of the umbilical vein during the perinatal period to determine normal and abnormal fetal growth.[15-19] The UApH could be numerically confirmed at birth, and measuring umbilical artery has been performed for identifying maternal and fetal conditions.[20-22]

For mothers with PA, there were significant increases in parity compared to those without PA, even when the values were higher. On the other hand, the cases of mothers with UCBFO displayed significant decreases in parity compared to those without UCBFO, even when the values were higher. In parity, PA as the prepartum events and UCBFO as intrapartum events were divided into significant increases and decreases. This is the result of logistic regression by grouping parity according to whether it was the first birth or not.

For infants born after 32 weeks who are covered by JOCSC and have a birth weight of 1,400 g or more, it is suggested that it is necessary to pay attention to PA for those who have experienced childbirth, and to UCBFO for primiparas.

Regarding birth weight, there were statistically significant decreases among children with mothers with PD compared to those with mothers without PD, even when the values were higher. This result was expected given that for the PD is a factor that inhibits fetal growth.

It was discovered, therefore, that the risk for CP can be assessed according to the relationships between the pathological conditions and associated characteristics assessed in this study.

However, there were limitations to this study. First, this research was conducted with infants who had been diagnosed with CP. If any signs were observed during the perinatal period, typically the pathological conditions causing CP could not be easily identified by the associated characteristics. Secondly, by analyzing the variables within the scope of the summary version of the cause analysis report published on the JQ website, it is intended that the results can be easily utilized to study about causing CP. Alternatively, it is suggested that the usefulness of the analysis results will increase by including additional variables during pregnancy.

Conflict of Interest

The authors declare that there are no conflicts of interest to disclose.

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