www.jpnim.com Open Access eISSN: 2281-0692
Journal of Pediatric and Neonatal Individualized Medicine 2024;13(1):e130116
doi: 10.7363/130116
Received: 2022 Jul 14; revised: 2023 Mar 31; rerevised: 2023 May 09; accepted: 2023 May 21; published online: 2024 Apr 30

Original article

Neonatal outcome of second-born twins: a 15-year retrospective study

Filipa Miranda[1], Andreia Teixeira[2,3,4], Luísa Castro[2,3,5], Carmen Carvalho[1], Luísa Lopes[1]

[1]Neonatal Intensive Care Unit, Centro Materno-Infantil do Norte, Centro Hospitalar e Universitário de Santo António, Porto, Portugal

[2]MEDCIDS Department of Community Medicine, Information and Decision in Health, Faculty of Medicine, University of Porto, Porto, Portugal

[3]CINTESIS@RISE – Center for Health Technology and Services Research, Faculty of Medicine, University of Porto, Porto, Portugal

[4]ADiT-LAB, Polytechnic Institute of Viana do Castelo, Viana do Castelo, Portugal

[5]ESS-IPP School of Health, Polytechnic Institute of Porto, Porto, Portugal

Abstract

Objective: The aim of this study is to identify perinatal factors influencing the condition of the second-born twin.

Methods: A retrospective study of 15 years in a level 3 maternity center was conducted.

Results: The study included 1,176 twin pairs. The birth was eutocic in 26.4% of first-born and 27.8% of second-born twins, but cesarean section was more frequent in second-born twins. The average weight of the first-born twin was 2,097 g and that of the second-born 2,060 g, and this difference was influenced by maternal age and conception mode; 14.5% of first-born twins and 20.1% of second-born twins were small for gestational age (GA). There was a statistically significant difference in the 1st and 5th minutes Apgar scores between twins and the score in the 5th minute was influenced by chorionicity. There was no statistically significant difference in the number of admissions to the Neonatal Intensive Care Unit, length of stay or number of neonatal deaths. There was a statistically significant difference in the number of disorders, influenced by maternal age. We also found a significant difference in hyperbilirubinemia, glycemic status and apnea, but not in other disorders. The number of patients who underwent at least 1 procedure was higher in second-born twins (27.7% vs 25.2%) and was influenced by chorionicity.

There was a difference in surfactant administration, but not in other procedures.

Conclusions: We found more cesarean sections in second-born twins, but more assisted vaginal deliveries in first-born twins. We also found statistically significant differences in relation to weight, size for GA, weight discordance, Apgar scores, and total number of disorders and procedures to which the twins were submitted. Chorionicity, conception mode and maternal age were of the most influence in these differences.

Keywords

Twin, diseases in twins, twin pregnancy, neonatology, newborn, pregnancy.

Corresponding author

Filipa Miranda, Neonatal Intensive Care Unit, Centro Materno-Infantil do Norte, Centro Hospitalar e Universitário de Santo António, Porto, Portugal; email: filiparmiranda@gmail.com.

How to cite

Miranda F, Teixeira A, Castro L, Carvalho C, Lopes L. Neonatal outcome of second-born twins: a 15-year retrospective study. J Pediatr Neonat Individual Med. 2024;13(1):e130116. doi: 10.7363/130116.

Introduction

The incidence of twin pregnancy has increased during the last decades. In 2009, around 1 in 30 newborns in the United States was a twin, compared with 1 in 53 babies in 1980 [1]. Nowadays, twin pregnancies account for approximately 2.6% of all newborns (2.8% in Portugal) [2, 3]. They are associated with an increased risk of morbidity and mortality of both children [4-6].

Compared to the first-born twin, studies have shown that the second-born twin has lower Apgar scores, lower birth weight and higher incidence of early neonatal death, admission to the Neonatal Intensive Care Unit (NICU) and adverse perinatal outcome [6-12]. The aim of this study is to identify mortality and morbidity and other perinatal factors influencing the second-born twin in a Portuguese hospital.

Materials and methods

We performed a retrospective descriptive study, and all twin pregnancies delivered at Centro Materno Infantil do Porto between January 2003 and December 2018 were reviewed. Gestations with intrauterine fetal death in either or both twins and triplets were excluded.

Maternal charts were reviewed for maternal age, parity, conception method, chorionicity, complications of pregnancy (gestational diabetes, hypertension, infections, threatened preterm labor, fetal growth restriction and other complications), gestational age (GA), time of membrane rupture and mode of delivery. It was not possible to quantify smoking habits due to insufficient data. Chorionicity was confirmed by pathologic examination of the placenta and zygosity was not evaluated.

Newborn charts were reviewed for gender, birth weight, weight for GA, birth weight discordance (we considered the weight discordant twin to be the one that presented a weight reduction of more than 20% in relation to the sibling), Apgar score in the 1st and 5th minutes, admission to NICU, length of stay, death, disorders (growth restriction, asphyxia, intraventricular hemorrhage, patent ductus arteriosus, other heart diseases, transient tachypnea of the newborn, hyaline membrane disease, bronchopulmonary dysplasia, necrotizing enterocolitis, hyperbilirubinemia, changes in glycemic status, acidosis, other metabolic disorders, non-TORCH infections, renal failure or hypertension, retinopathy of prematurity, and surgical diseases) and procedures (mechanical ventilation, non-invasive ventilation, administration of surfactant, blood and platelet transfusion, parenteral nutrition and central venous catheter). In the cesarean sections, the second-born twin was considered the one born later.

Cord gases, 10th minute Apgar score and time interval between births were not available for the majority of the newborns and, therefore, were not included as variables.

Categorical variables were described using the absolute and relative frequencies, n (%). Normally distributed quantitative variables were summarized by the mean and standard deviation. Non-normally distributed quantitative variables were summarized by the median and interquartile interval. The normality of the variables was verified by observation of the respective histograms. The comparison between the first-born and second-born twins was made using two-sided sample tests: McNemar test (for dichotomous variables); marginal homogeneity test (for categorical variables with more than 2 categories); paired t-test (for normally distributed variables); or Wilcoxon test (for ordinal or non-normally distributed variables). For variables where significant differences were found between twins, some adjustments to other variables were analyzed using multiple logistic or linear regressions. To assess which independent variables to include in each multiple linear/logistic regression model, simple regressions were performed for each variable of interest, including socio-demographic and clinical variables. Independent variables correlated at $p < 0.2$ in the simple linear/logistic regressions were included in the initial multiple models. Only the significant variables were maintained in the final multiple models. The results of linear regression models are presented as unstandardized coefficient values (β), their 95% confidence interval and the respective p-values. To evaluate the model, the determination coefficient (r^2) was assessed. Assumptions of the linear regression models were verified as follows: (1) visual analysis of histograms to assess the normality of residuals and (2) plotting residuals versus the fitted predictive values for checking homoscedasticity. The results of logistic regression models were presented by odds ratios, their 95% confidence interval and the respective p-values. Fitting of data to the logistic models was assessed by Hosmer and Lemeshow goodness-of-fit test. Data analysis was performed using SPSS® (version 28.0) statistical software (IBM®, Armonk, NY, USA) and Jamovi (version 1.2) (Computer Software, Sydney, Australia). Values of $p \leq 0.05$ were considered significant.

Results

The total number of twin pairs delivered during the study was 1,195. After excluding 19 pregnancies with intrauterine fetal death, 1,176 twin pairs were entered for analysis.

Time of rupture was lower for the second-born twin (87% vs 91.2% had a time of membrane rupture of less than 12 hours; $p < 0.001$). No significant difference between first-born and second-born twins was found regarding sex.

The birth was eutocic in 26.4% of first-born and 27.8% of second-born twins, but cesarean section was more frequent for the second-born twin (64.3% vs 66.8%, $p < 0.001$; **Tab. 1**). This statistically significant difference was analyzed using simple logistic regression and was not influenced by GA, maternal age, parity, conception method or complications of pregnancy.

Although the median Apgar score was 8 and 9 in the 1st and 5th minutes, respectively, for both twins, there was a statistically significant difference between twins ($p < 0.001$; **Tab. 1**).

This difference was adjusted for GA, maternal age, parity, conception method, chorionicity and complications of pregnancy. Chorionicity influenced the 5th minute Apgar score, but it had no influence on the 1st minute score (a simple linear regression was used). In monochorionic diamniotic (MCDA) twins, the average reduction in the difference of 5th minute Apgar score was 0.7 ($p = 0.013$) and in dichorionic diamniotic (DCDA) twins it was 0.6 ($p = 0.033$), relative to the reference category monochorionic monoamniotic (MCMA).

Medium weight was 2,097 g for the first-born and 2,060 g for the second-born twin (**Tab. 1**). The difference between weights was most evident in women under the age of 18 (154 g). This weight difference was adjusted for GA, maternal age, parity, conception method, chorionicity and complications of pregnancy using linear regression and was influenced by maternal age ($\beta = 4.2$, $p = 0.025$) and conception mode. For women of the same age, the difference in weight at birth of the newborns was 96 g greater following ovarian stimulation ($p = 0.045$) and 68 g greater following intracytoplasmic sperm injection (ICSI) ($p = 0.039$) than for spontaneous conception.

Regarding weight for GA, 20.1% of the second-born twins and only 14.5% of the first-born twins were small for GA ($p = 0.002$; **Tab. 1**).

Birth weight discordance was 6% for the first-born twin and 11.6% for the second-born twin ($p < 0.001$). It is a small sample, but analyzing with simple logistic regression this difference was influenced by GA ($\beta = 0.9$, $p < 0.001$), hypertension ($\beta = 1.9$, $p = 0.004$) and conception method (other: $\beta = 2.8$, $p = 0.027$; reference: spontaneous conception).

Concerning NICU treatment, 59.9% of the first-born and 61.1% of the second-born twins were admitted. There was no statistically significant difference in the number of admissions, length of stay (medium of 14 days) or neonatal death (2.5% for the first-born vs 3.1% for the second-born twin) (**Tab. 2**).

Both groups had a median of 3 disorders, but we found that there was a significant difference between the first-born and the second-born ($p = 0.001$; **Tab. 2**). This difference between the number of disorders was associated with maternal age ($\beta = -0.004$, $p = 0.002$). It was more significant

Table 1. Comparison between the first-born and second-born twins by type of birth, hours of membrane rupture, gender, weight, weight for gestational age (GA), weight discordance and Apgar scores (1,176 pairs of twins).

		First-born twin	Second-born twin	p-value
Type of birth, n (%)	**Cesarean section**	756 (64.3%)	786 (66.8%)	**< 0.001**[a]
	Eutocic	311 (26.4%)	327 (27.8%)	
	Vacuum-assisted delivery	63 (4.5%)	43 (3.7%)	
	Forceps	46 (3.9%)	20 (1.7%)	
Hours of membrane rupture, n (%)	**< 12 h**	1,023 (87%)	1,073 (91.2%)	**< 0.001**[b]
	12-24 h	100 (8.5%)	64 (5.4%)	
	> 24 h	53 (4.5%)	39 (3.3%)	
Sex, n (%)	**Male**	595 (50.6%)	614 (52.2%)	0.339[b]
	Female	581 (49.4%)	562 (47.8%)	
Weight (g), M ± SD		2,097 ± 567	2,060 ± 572	**< 0.001**[c]
Weight, n (%)	**< 1,000 g**	51 (4.3%)	62 (5.3%)	**0.002**[b]
	1,000-1,500 g	137 (11.6%)	134 (11.4%)	
	1,500-2,500 g	691 (58.8%)	719 (61.1%)	
	2,500-4,000 g	297 (25.3%)	261 (22.2%)	
Weight for GA, n (%)	**Small**	171 (14.5%)	236 (20.1%)	**0.002**[a]
	Adequate	999 (85%)	939 (79.8%)	
	Large	6 (0.5%)	1 (0.1%)	
Weight discordance, n (%)		70 (6%)	137 (11.6%)	**< 0.001**[d]
Apgar score in the 1st minute, Med [Q1; Q3]		8 [7; 9]	8 [7; 9]	**< 0.001**[b]
Apgar score in the 5th minute, Med [Q1; Q3]		9 [9; 10]	9 [8; 10]	**< 0.001**[b]

Bold: $p < 0.05$.
GA: gestational age; M: mean; Med: median; SD: standard deviation; [Q1; Q3]: interquartile interval.
[a] Marginal homogeneity test; [b] Wilcoxon test; [c] Paired t-test; [d] McNemar test.

Table 2. Comparison between the first-born and second-born twins by admission to the Neonatal Intensive Care Unit (NICU), length of stay, neonatal death, total number of disorders and specific disorders, total number of procedures and specific procedures (1,176 pairs of twins).

		First-born twin	Second-born twin	p-value
Admission to NICU, n (%)		704 (59.9%)	718 (61.1%)	0.124[a]
Length of stay (days), Med [Q1; Q3]		14 [7; 26]	14 [7; 26]	0.618[b]
Neonatal death, n (%)		29 (2.5%)	37 (3.1%)	0.186[b]
Number of disorders, Med [P20; P80]		3 [1; 5]	3 [2; 6]	**0.001**[b]
Disorders, n (%)	**Fetal growth restriction**	158 (13.4%)	189 (15.9%)	0.069[a]
	Asphyxia	11 (0.9%)	19 (1.6%)	0.152[a]
	Intraventricular hemorrhage	57 (4.8%)	57 (4.8%)	1.000[a]
	Patent ductus arteriosus	66 (5.6%)	67 (5.7%)	1.000[a]
	Other heart diseases	76 (6.5%)	78 (6.6%)	0.922[a]
	Transient tachypnea of the newborn	76 (6.5%)	89 (7.6%)	0.250[a]
	Hyaline membrane disease	232 (19.7%)	252 (21.4%)	0.065[a]
	Bronchopulmonary dysplasia	32 (2.7%)	35 (3%)	0.719[a]
	Necrotizing enterocolitis	8 (0.7%)	16 (1.4%)	0.134[a]
	Hyperbilirubinemia	595 (50.6%)	546 (46.4%)	**0.003**[a]
	Changes in glycemic status	86 (7.3%)	112 (9.5%)	**0.020**[a]
	Acidosis	48 (4.1%)	52 (4.4%)	0.651[a]
	Other metabolic disorders	23 (2%)	35 (3%)	0.097[a]
	Infections (non-TORCH)	159 (13.5%)	172 (14.6%)	0.294[a]
	Renal failure or hypertension	6 (0.5%)	6 (0.5%)	1.000[a]
	Retinopathy of prematurity	62 (5.3%)	59 (5%)	0.749[a]
	Surgical diseases	60 (5.1%)	47 (4.7%)	0.193[a]
	Apnea	16 (1.4%)	7 (0.6%)	**0.049**[a]
	Jaundice	595 (50.6%)	546 (46.4%)	**0.003**[a]
Number of procedures, n (%)	**0**	880 (74.8%)	850 (72.3%)	**0.005**[b]
	≥ 1	296 (25.2%)	326 (27.7%)	
Procedures, n (%)	**Mechanical ventilation**	112 (9.5%)	125 (10.6%)	0.177[a]
	Non-invasive ventilation	193 (16.4%)	209 (17.8%)	0.164[a]
	Administration of surfactant	102 (8.7%)	123 (10.5%)	**0.018**[a]
	Blood transfusion	37 (3.1%)	31 (2.6%)	0.440[a]
	Platelet transfusion	13 (1.1%)	16 (1.4%)	0.678[a]
	Parenteral nutrition	209 (17.8%)	227 (19.3%)	0.089[a]
	Central venous catheter	139 (11.8%)	148 (12.6%)	0.342[a]

Bold: $p < 0.05$.
Med: median; NICU: Neonatal Intensive Care Unit; [P20; P80]: percentile interval; [Q1; Q3]: interquartile interval.
[a] McNemar test; [b] Wilcoxon test.

in women under the age of 18 (1.4 disorders difference).

We also found a significant difference in hyperbilirubinemia and apnea that was more frequent in the first-born twin (50.6% vs 46.4%, p = 0.003, for hyperbilirubinemia, and 1.4% vs 0.6%, p = 0.049, for apnea; **Tab. 2**). Furthermore, changes in glycemic status and the need for surfactant were more frequent in second-born twins (7.3% vs 9.5%, p = 0.020, for changes in glycemia, and 8.7% vs 10.5%, p = 0.018, for need for surfactant; **Tab. 2**).

The number of patients who underwent at least 1 procedure was higher in second-born twins (25.2% vs 27.7%, p = 0.005; **Tab. 2**). The difference in the number of patients who underwent at least 1 procedure between the first-born and the second-born twins was associated to chorionicity. In MCDA twins, the average increase in the difference in the number of procedures was 0.6 (p = 0.011) and in DCDA twins it was 0.5 (p = 0.026), relative to the reference category MCMA.

Discussion

Several studies have shown that second-born twins have a worse outcome than first-born twins [6-12].

The fact that the time of rupture of membranes was shorter for the second-born twin is consistent with the large number of diamniotic pregnancies.

Large trials have been conducted which did not show the superiority of cesarean vs vaginal delivery in terms of complications in perinatal outcome [8, 9, 13]. In our study, although eutocic deliveries were more frequent in the second-born twin, the number of cesarean sections was also higher for the second-born twin. We hypothesize that changes in fetal well-being may have justified the higher number of cesarean sections.

A lower Apgar score in second-born twins has been described in the literature in relation to twin-to-twin delivery time interval and to the type of birth [14-16]. We also found lower Apgar scores in the 1st and 5th minutes for second-born twins. Using simple logistic regression, there was no influence of GA, maternal age, parity, conception method, chorionicity or complications of pregnancy in the 1st minute Apgar score. The 5th minute Apgar score was influenced by chorionicity: DCDA and MCDA showed smaller differences in score than MCMA. Onditsova et al. [17] also stated this difference but other authors did not [7, 16].

We found differences in the weight of the second-born twin as published in previous studies [7, 11, 12]. Maternal age influenced this difference, but we did not find studies that show this difference in the second-born twin. This difference was also more evident for ovarian stimulation and ICSI. There are data published associating ovarian stimulation to the risk of low birth weight, but we did not find studies in twins [18, 19].

Second-born twins were more often small for GA and this is also consistent with the results of other authors [7, 10, 12]. Van Baal and Boomsma found lower variability of birth weight and a lower association of birth weight with GA in twins whose mothers smoked during pregnancy but we couldn´t quantify the smoking habits of the mother during pregnancy [20].

Birth weight discordance was 6% for the first-born twin and 11.6% for the second-born twin. Some authors have studied birth discordance in twins and its association with higher morbidity [21, 22]. We verified that this difference was influenced by GA, hypertension and conception method although we had a relatively small sample.

In our study there was no significant difference regarding the number of admissions to the NICU, the length of stay or number of neonatal deaths, which differs from some of the previous studies [7-9, 16]. The description of increased perinatal mortality in the second-born twin in previous studies is due to intrapartum anoxia and there was no difference in asphyxia between twins in our study.

We obtained a statistically significant difference between the number of disorders presented by each newborn, and this was influenced by maternal age. It was more significant in teenage mothers. We hypothesize that advanced maternal age is associated with perinatal complications that can be similar in both twins [23].

Esteves-Pereira et al. related the second-born infant to an elevated likelihood of jaundice, antibiotic use and oxygen therapy [6]. We found a significant difference in changes in glycemic status, number of patients who underwent at least 1 procedure and the need for surfactant but not in jaundice, oxygen therapy or antibiotic use. We also found jaundice and apnea to be more frequent in the first-born twin [6].

The number of patients who underwent at least 1 procedure was higher for the second-born twin and this was influenced by chorionicity: it was higher in MCDA pregnancies, followed by DCDA and lowest in MCMA pregnancies. Perinatal morbidity and mortality remain high among monochorionic twins according to the literature [24].

The strength of our study is that it was conducted over 15 years in a level 3 maternity center, involved 1,176 twin pairs and many data were reviewed.

As our study is retrospective, it has the limitation that there is no record of the time interval between births and cord gases that can be associated with morbidity of the second-born twin. We also have the limitation that the number of MCMA pregnancies is very low when compared with the number of DCDA and MCDA pregnancies (this is fully in line with expectations, because the number of MCMA in the literature is also low when compared with diamniotic gestations).

Our study emphasizes the greater morbidity of the second-born twin and further studies are needed to better understand what factors influence this difference.

Declaration of interest

The Authors declare that there is no conflict of interest.

References

1. Martin JA, Hamilton BE, Osterman MJ. Three decades of twin births in the United States, 1980-2009. NCHS Data Brief. 2012;80:1-8.
2. Vayssiere C, Benoist G, Blondel B, Deruelle P, Favre R, Gallot D, Jabert P, Lemery D, Picone O, Pons JC, Puech F, Quarello E, Salomon L, Schmitz T, Senat MV, Sentilhes L, Simon A, Stirneman J, Vendittelli F, Winer N, Ville Y; French College of Gynaecologists and Obstetricians. Twin pregnancies: guidelines for clinical practice from the French College of Gynaecologists and Obstetricians (CNGOF). Eur J Obstet Gynecol Reprod Biol. 2011;156:12-7.
3. Monden C, Pison G, Smits J. Twin Peaks: more twinning in humans than ever before. Hum Reprod. 2021;36(6):1666-73.
4. Armson BA, O'Connell C, Persad V, Joseph KS, Young DC, Baskett TF. Determinants of perinatal mortality and serious neonatal morbidity in the second twin. Obstet Gynecol. 2006;108:556-64.
5. D'Alton M, Breslin N. Management of multiple gestations. Int J Gynaecol Obstet. 2020;150(1):3-9.
6. Esteves-Pereira AP, da Cunha AJLA, Nakamura-Pereira M, Moreira ME, Domingues RMSM, Viellas EF, Leal MDC, Granado Nogueira da Gama S. Twin pregnancy and perinatal outcomes: data from 'Birth in Brazil Study'. PLoS One. 2021;16(1):e0245152.
7. Santana DS, Silveira C, Costa ML, Souza RT, Surita FG, Souza JP, Mazhar SB, Jayaratne K, Qureshi Z, Sousa MH, Vogel JP, Cecatti JG; WHO Multi-Country Survey on Maternal and Newborn Health Research Network. Perinatal outcomes in twin pregnancies complicated by maternal morbidity: evidence from the WHO Multicountry Survey on Maternal and Newborn Health. BMC Pregnancy Childbirth. 2018;18(1):449.
8. Rossi AC, Mullin PM, Chmait RH. Neonatal outcomes of twins according to birth order, presentation and mode of delivery: a systematic review and meta-analysis. BJOG. 2011;118(5): 523-32.
9. Smith GC, Shah I, White IR, Pell JP, Dobbie R. Mode of delivery and the risk of delivery-related perinatal death among twins at term: a retrospective cohort study of 8073 births. BJOG. 2005;112(8):1139-44.
10. Wen SW, Tan H, Yang O, Walker M. Prediction of small for gestational age by logistic regression in twins. Aust N Z J Obstet Gynaecol. 2005;45(5):399-404.
11. Assunção RA, Liao AW, Brizot ML, Krebs VL, Zugaib M. Perinatal outcome of twin pregnancies delivered in a teaching hospital. Rev Assoc Med Bras. 2010;56(4):447-51.
12. Robillard PY, Bonsante F, Croce-Spinelli M, Boumahni B, Gouyon JB, Boukerrou M, Iacobelli S. The burden to be second twin: a population-based study of 2686 twins (2124 dichorionic). Proposal of the concept of mobility. J Matern Fetal Neonatal Med. 2020;33(17):2950-4.
13. Barrett JF, Hannah ME, Hutton EK, Willan AR, Allen AC, Armson BA, Gafni A, Joseph KS, Mason D, Ohlsson A, Ross S, Sanchez JJ, Asztalos EV; Twin Birth Study Collaborative Group. A randomized trial of planned cesarean or vaginal delivery for twin pregnancy. N Engl J Med. 2013;369(14):1295-305.
14. Swanson K, Grobman WA, Miller ES. The association between the intertwin interval and adverse neonatal outcomes. Am J Perinatol. 2017;34(1):70-3.
15. Schmitz T, Korb D, Battie C, Cordier AG, de Carne Carnavalet C, Chauleur C, Equy V, Haddad B, Lemercier D, Poncelet C, Rigonnot L, Goffinet F; Jumeaux Mode d'Accouchement study group; Groupe de Recherche en Obstétrique et Gynécologie. Neonatal morbidity associated with vaginal delivery of noncephalic second twins. Am J Obstet Gynecol. 2018;218(4):449.
16. Hjorto S, Nickelsen C, Petersen J, Secher NJ. The effect of chorionicity and twin-to-twin delivery time interval on short-term outcome of the second twin. J Matern Fetal Neonatal Med. 2014;27(1):42-7.
17. Odintsova VV, Dolan CV, van Beijsterveldt CEM, de Zeeuw EL, van Dongen J, Boomsma DI. Pre- and perinatal characteristics associated with Apgar scores in a review and in a new study of Dutch twins. Twin Res Hum Genet. 2019;22(3):164-76.
18. Kalra SK, Ratcliffe SJ, Coutifaris C, Molinaro T, Barnhart KT. Ovarian stimulation and low birth weight in newborns conceived through in vitro fertilization. Obstet Gynecol. 2011;118(4):863-71.
19. Jwa SC, Nakashima A, Kuwahara A, Saito K, Irahara M, Sakumoto T, Ishihara O, Saito H. Neonatal outcomes following different ovarian stimulation protocols in fresh single embryo transfer. Sci Rep. 2019;9(1):3076.

20. Van Baal CG, Boomsma DI. Etiology of individual differences in birth weight of twins as a function of maternal smoking during pregnancy. Twin Res. 1998;1(3):123-30.
21. Puccio G, Giuffré M, Piccione M, Piro E, Malerba V, Corsello G. Intrauterine growth pattern and birthweight discordance in twin pregnancies: a retrospective study. Ital J Pediatr. 2014;40:43.
22. Wen SW, Fung KF, Huang L, Demissie K, Joseph KS, Allen AC, Kramer MS; Fetal and Infant Health Group of the Canadian Perinatal Surveillance System. Fetal and neonatal mortality among twin gestations in a Canadian population: the effect of intrapair birthweight discordance. Am J Perinatol. 2005;22(5):279-86.
23. Vandekerckhove M, Guignard M, Civadier MS, Benachi A, Bouyer J. Impact of maternal age on obstetric and neonatal morbidity: a retrospective cohort study. BMC Pregnancy Childbirth. 2021;21(1):732.
24. Al Riyami N, Al-Rusheidi A, Al-Khabori M. Perinatal outcome of monochorionic in comparison to dichorionic twin pregnancies. Oman Med J. 2013;28(3):173-7.