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Original Article

Clinical Outcome of Monochorionic Diamniotic Twins with Intrauterine Growth Restriction

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Abstract

Objective This study investigated the clinical outcome of monochorionic diamniotic (MCDA) twins with selective intrauterine growth restriction (sIUGR).

Study Design International Peace Maternal and Child Health Hospital of Shanghai ultrasound database was investigated to identify all MCDA delivered from January 2013 to December 2017. After identifying 43 pairs of MCDA twins with sIUGR and 282 pairs of normal MCDA twins, we compared clinical outcomes between the two groups.

Results Compared with normal twins, sIUGR fetuses had significantly shorter gestational age at delivery, smaller average birth weight of both twins, more significant intertwin difference in birth weight, lower Apgar scores, and higher intrauterine fetal demise (IUFD) rate, and smaller placental weight. The rate of abnormal umbilical cord insertions and abnormal blood flow in the ductus venosus (DV) and middle cerebral artery (MCA) is significantly higher in the sIUGR group. In addition, the subtype analysis of sIUGR groups indicated the poorest outcomes in type II with no significant difference between type I and III.

Conclusion MCDA twins with sIUGR generally exhibited limited clinical outcomes than normal MCDA twins. These limitations are mainly associated with abnormal umbilical cord insertions and blood flow in the DV and MCA. Clinical outcomes differed among the three types of sIUGR, with type II having the worst prognosis and the highest IUFD rate.

Keywords
- clinical outcome
- intrauterine fetal death
- monochorionic diamniotic
- perinatal outcome
- selective intrauterine growth restriction

Key Points

- sIUGR generally exhibited limited clinical outcomes than normal MCDA twins.
- These limitations are mainly associated with blood flow of the DV and MCA.
- sIUGR with type II has the worst prognosis and the highest IUFD rate.

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During the last decade, the reduction of infant mortality has been among the critical long-term public health priorities according to the World Health Organization.[1] With an occurrence rate of 10 to 25%, selective intrauterine growth restriction (sIUGR) represents one of the most severe abnormalities of monochorionic diamniotic (MCDA) twins. It also engenders higher risks of adverse pregnancy and postpartum outcomes for both the mother and infant than the singleton intrauterine growth restriction.[2,3]

MCDA twins define a twin gestation resulting from a single fertilized egg that generates two genetically identical offspring. They share the same placenta with different amniotic sacs. MCDA twins occur at a rate of 3 to 4 in 1,000 live births in China. The perinatal nervous system morbidity of the affected fetus is high; for instance, ~15% of the growth-restricted fetuses end up with intrauterine fetal death (IUFD), while the other survived fetuses often suffer cardiovascular complications and neurological sequelae in ~20% of the cases.[4–6]

In clinical practice, the estimated fetal weight (EFW) constitutes the base for diagnosis of sIUGR: For example, an EFW <10th percentile in one twin and the intertwin EFW discordance >25% are the prominent predictors of growth discordant.[7,8] The Doppler ultrasound represents the most efficient approach for monitoring and diagnosing sIUGR.[9] It offers a timely diagnosis, proper classification, and improved management of the prognosis of sIUGR. Notably, the umbilical arterial (UA) Doppler flow pattern can fluctuate throughout gestation, increasing the risk of fetal mortality.[10,11] Most diagnoses and decisions are mainly based on clinical experience and relatively simple rules due to a lack of systematic study on the clinical parameters associated with different outcomes. However, our current understanding of ultrasound indicators and other predictors of growth discordant remains limited.

The objective of this study was to analyze and compare the various ultrasound indicators that may characterize adverse postnatal outcomes concerning pregnancy outcomes in a retrospective cohort of MCDA twins. Our results highlighted the potential of ultrasound surveillance to assist in treating sIUGR.

Materials and Methods

Human Subjects

The MCDA twins inspected and delivered at the International Peace Maternal and Child Health Hospital of Shanghai from January 2013 to December 2017 were selected to perform this study. All clinical data were obtained with informed consent as outlined by the Institutional Review Board at the International Peace Maternity and Child Health Hospital. Strict criteria like the birth weight of one fetus below the 10th percentile represented the normal twins, while the other fetus's birth weight was considered normal range. Other anomalies such as twin-to-twin transfusion syndrome (TTTS), twin anemia–erythrocytosis sequence, twin fetal artery reverse perfusion sequence, growth restriction in both twin fetuses, structural abnormalities, chromosomal abnormalities, or one or two fetuses were excluded from this query. This investigation was approved by the Ethics Committee of the International Peace Maternity and Child Health Hospital.

Diagnostic Criteria and Classification of MCDA and sIUGR

Women pregnant with twins were placed under outpatient prenatal monitoring; however, in need of cesarean intervention, they will be shifted to inpatient prenatal monitoring for cesarean surgery.[12,13] Previous studies reported that the diagnosis of MCDA cases was confirmed through two significant measures. The first measure referred the single placenta (**T**-shaped uterus) with twins separated by the amniotic membrane which can be seen in early pregnancy B-mode ultrasound and the second measure referred a single placenta or amniotic membrane with no chorion between the two amniotic sacs.[8] On the contrary, the B-mode ultrasound diagnosis of sIUGR patients was based on two principal criteria. First, in the presence of any single chorionic sac, the EFW of the smaller fetus should be less than the 10th percentile of the corresponding gestational age, while the EFW of the larger fetus should be normal. Second, the difference should be more than 25% in EFW between the twins; it is calculated as follows: (largest fetus EFW − smallest fetus EFW)/larger fetus EFW × 100%. Among 650 fetuses, 86 were diagnosed with sIUGR and 564 were uncomplicated MCDA fetuses (control). Assessed by color Doppler ultrasound, sIUGR cases were divided into three types based on diastolic flow in the umbilical artery of the smaller fetuses. Type I was with normal blood flow (23 patients); type II had absented or reversed end-diastolic flow (14 cases); and type III had intermittent or reversed end-diastolic flow (6 patients).

Clinical Care and Observation Indicators

All pregnant women underwent Doppler ultrasound examination to monitor fetal growth and development. sIUGR fetuses were closely monitored at a higher frequency for proper and timely medication or even termination of pregnancy based on the conditions of the fetuses and the pregnant woman. For those who had abnormal blood flow of umbilical arteries, dexamethasone was given at 28 to 32 weeks of pregnancy to promote the maturation of fetal lungs. If conditions deteriorated, such as continuous α-wave inversion of the ductus venosus (DV), edema, and oligohydramnios, pregnancy was terminated after consent was obtained. The following data were also collected: gestational age of delivery, birth weight, the intertwin difference in birth weight, neonatal Apgar score, IUFD, stillbirth and neonatal mortality, placental weight, and umbilical cord insertion.

Ultrasound Test Indicators

Based on the ultrasound tests, the following parameters were used to examine the chronicity in the early pregnancy stage. The fetal growth and mid-to-late pregnancy, end-diastolic phase of the umbilical artery, blood flow spectrum of DV and middle cerebral artery (MCA), maximum anteroposterior diameter of the amniotic fluid, and umbilical cord attachment.

Statistical Analysis

Statistical analysis was performed using SPSS Statistics 21 (IBM Corp., Armonk, NY). The Student's *t*-test or chi-square test was used for comparison as appropriate.

Results

Perinatal Outcome and Prognosis of Pregnant Women and Fetus in the sIUGR Group and the Control Group

There was no significant difference between the sIUGR group and the control group in gestational age, gravidity and parity, and percentage of receiving in vitro fertilization and embryo transfer (IVF-ET). However, fetuses in the sIUGR group had a significantly shorter gestational age than those in the control group (33.5 ± 2.7 vs. 35.6 ± 1.9; $p < 0.01$). The average birth weight of the smaller fetuses (i.e., the growth-restricted fetuses) in the sIUGR group was significantly lower than that in the control group (1,458.0 ± 499.5 vs. 2,309.0 ± 398.9; $p < 0.01$); the difference in intertwin birth weight in the sIUGR group was significantly higher than that of the control group (33.6 ± 12.7 vs. 8.6 ± 6.2; $p < 0.01$). The Apgar score of both fetuses was significantly lower in the sIUGR than that in the control group (larger fetuses: 9.0 ± 1.9 vs. 9.8 ± 0.8; smaller fetuses: 7.6 ± 3.7 vs. 9.7 ± 0.9; $p < 0.01$). IUFD was significantly higher in the sIUGR group than the control group: six cases of single-fetus death (14.0%) and one case of twin-fetus death in the sIUGR group (2.3%) versus no death in the control group (►**Table 1**).

Perinatal Outcomes and Prognosis among sIUGR Types

After 32 weeks of pregnancy, NST examination was conducted once a week on outpatient. There were no significant differences in age, gravidity and parity, and percentage of IVF-ET among the three types of sIUGR. Gestational age was shorter in type II (31.2 ± 2.8) than that in type I (34.7 ± 1.9) and type III (34.5 ± 2.2; $p < 0.01$ and $p < 0.05$, respectively), but no significant difference between type I and type III. The average birth weight of the larger fetuses in type II (7.7 ± 2.8) was lower than those in type I (9.7 ± 0.5) and III (9.3 ± 1.0; $p < 0.01$ and $p < 0.05$, respectively), but no significant difference between types II and III. The average birth weight of the smaller fetuses in type II (4.2 ± 4.3) was significantly lower than that in type I (9.2 ± 2.2) and type III (9.3 ± 0.8; both $p < 0.01$), but no significant difference between types II and III. The difference in intertwin birth weight in type II (40.0 ± 20.2) was larger than that in type I (30.3 ± 4.0) and type III (31.6 ± 8.0; both $p < 0.05$), but no significant difference between types II and III.

The Apgar scores of the larger fetuses in type II (7.7 ± 2.8) were lower than those of type I (9.7 ± 0.5) and type III (9.3 ± 1.0; $p < 0.01$ and $p < 0.05$, respectively), but no significant difference between types I and III. The Apgar scores of the smaller fetuses in type II (4.2 ± 4.3) were significantly lower than those of type I (9.2 ± 2.2) and type III (9.3 ± 0.8; both $p < 0.01$), but no significant difference between types II and III. Intrauterine mortality was significantly higher in type II than that in types I and III (p <0.01; ►**Table 2**). One case (4.4%) of single-fetal death was found in type I; five cases

Table 1 Outcomes in pregnant women and fetuses in the sIUGR group and the control group

Group	*n*	Gestational age (weeks)	Gravidity	Parity	IVF-ET cases[a]	Delivery gestational weeks	Neonatal birth weight (g)		Difference in birth weight (%)	Newborn Apgar		IUFD[a]					
												Larger fetus		Both fetuses		Total	
							Larger	Smaller		Larger	Smaller	*n*	%	*n*	%	*n*	%
sIUGR	43	29.7 ± 4.3	1.8 ± 1.4	0.4 ± 0.5	5	33.5 ± 2.7	2,206.5 ± 595.1	1,458.0 ± 499.5	33.6 ± 12.7	9.0 ± 1.9	7.6 ± 3.7	6	14.0	1	2.3	7	16.3
Control	282	30.5 ± 4.0	1.8 ± 1.0	0.3 ± 0.6	38	35.6 ± 1.9	2,526.94 ± 406.10	2,309.0 ± 398.9	8.6 ± 6.2	9.8 ± 0.8	9.7 ± 0.9	0	0	0	0		
p		0.250	0.863	0.580	0.739	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001					

Abbreviations: EFW, estimated fetal weight; IVF-ET, in vitro fertilization and embryo transfer; IUFD, intrauterine fetal death; sIUGR, selective intrauterine growth restriction.
Notes: The difference in birth weight was calculated by (larger fetus EFW - smaller fetus EFW)/larger fetus EFW × 100%.
Independent two-sample *t*-test was used for statistical comparisons unless otherwise stated.
[a]Chi-square test.

Table 2 Outcomes in pregnant women and fetuses among three sIUGR types

Type	*n*	Gestational age (weeks)	Gravidity	Parity	IVF-ET cases[a]	Delivery gestational weeks	Neonatal birth weight (g)		Difference in birth weight (%)	Newborn Apgar		IUFD[a]					
												Larger fetus		Both fetuses		Total	
							Larger	Smaller		Larger	Smaller	*n*	%	*n*	%	*N*	%
I	23	30.6 ± 4.1	2.0 ± 1.6	0.4 ± 0.5	3	34.7 ± 1.9	2,445.4 ± 416.4	1,706.7 ± 317.7	30.3 ± 4.0	9.7 ± 0.5	9.2 ± 2.2	1	4.4	0	0		
II	14	28.3 ± 4.8	1.7 ± 1.1	0.3 ± 0.5	1	31.2 ± 2.8	1,725.0 ± 646.8	965.7 ± 441.1	40.0 ± 20.2	7.7 ± 2.8	4.2 ± 4.3	5	35.7	1	7.1	6	42.9
III	6	29.8 ± 4.1	1.2 ± 0.4	0.5 ± 0.6	1	34.5 ± 2.2	2,414.2 ± 400.6	1,653.3 ± 369.6	31.6 ± 8.0	9.3 ± 1.0	9.3 ± 0.8	0	0	0	0		
p		I vs. II: 0.131, I vs. III: 0.698, II vs. III: 0.498	I vs. II: 0.508, I vs. III: 0.202, II vs. III: 0.272	I vs. II: 0.379, I vs. III: 0.784, II vs. III: 0.384	0.912	I vs. II: <0.0001, I vs. III: 0.865, II vs. III: 0.019	I vs. II: <0.0001, I versus III: 0.870, II versus III: 0.027	I vs. II: <0.0001, I vs. III: 0.725, II vs. III: 0.004	I vs. II: 0.030, I vs. III: 0.605, II vs. III: 0.035	I vs. II: 0.002, I vs. III: 0.191, II vs. III: 0.033	I vs. II: <0.0001, I vs. III: 0.862, II vs. III: 0.010	< 0.0001					

Abbreviations: EFW, estimated fetal weight; IVF-ET, in vitro fertilization and embryo transfer; IUFD, intrauterine fetal death; sIUGR, selective intrauterine growth restriction.
Notes: Difference in birth weight was calculated by (larger fetus EFW – smaller fetus EFW)/larger fetus EFW × 100%.
Independent two-sample *t*-test was used for statistical comparisons unless otherwise stated.
[a]Chi-square test.

(35.7%) of single-fetal death and one case (7.1%) of twin death occurred in type II; and no stillbirths and neonatal deaths occurred in type III.

Placental Weight and Abnormal Umbilical Cord Insertion

The placental weight of the sIUGR group is significantly lower than that of the control group (834.2 ± 211.3 vs. 973.4 ± 216.9; $p < 0.01$). There was no significant difference in placental weight among the three types of sIUGR. The incidence of abnormal umbilical cord insertion was significantly higher in the sIUGR group (15 cases [34.9%]) than that in the control (15 cases [5.3%]; $p < 0.01$). There were six cases (26.1%) of abnormal insertion of the umbilical cord in type I, 7 (50.0%) in type II, and 2 (33.3%) in type III (►**Table 3** and **4**).

Abnormal Blood Flow in Ductus Venosus and Middle Cerebral Artery

The incidence of abnormal blood flow in the DV and the MCA was significantly higher in the sIUGR group than in the control group ($p < 0.01$). There were 22 cases of abnormal blood flow (7.8%) in the control group: 9 cases of α-wave reverse blood flow in DV, 11 cases of diastolic blood flow loss in the MCA, and 1 case with both abnormalities (►**Table 5**). Ten cases (23.3%) were diagnosed with abnormal blood flow in the sIUGR group: 5 cases with α-wave reverse blood flow in DV, 4 cases of diastolic blood flow loss in MCA, and 1 case with both abnormalities.

Moreover, in the IUGR group (type I), one case was diagnosed with α-wave reverse blood flow in DV and 2 cases displayed a diastolic blood flow loss in the MCA. At the same time, type II exhibited three patients with α-wave reverse blood flow in DV, two cases of diastolic blood flow loss in a MCA, and one case with both abnormalities. Finally, only one case of α-wave reverse blood flow in DV was diagnosed in type III (►**Table 6**).

Gestational Diabetes

The incidence of gestational diabetes in pregnant women in the sIUGR group (2 cases [4.7%]) was lower than that in the control group (60 cases [21.3%]; $p < 0.05$). There was no significant difference in preeclampsia, gestational hypertension, intrahepatic cholestasis of pregnancy (ICP), and postpartum hemorrhage between the sIUGR group and the control group (►**Table 7**).

Discussion

In this study of 325 MCDA twins, including 43 pairs of MCDA twins with sIUGR and 282 pairs of normal MCDA twins, the gestational age of sIUGR at delivery was significantly lower than that of uncomplicated MCDA twins, consistent with previous findings.[14] In addition, no significant age difference was found in a prior pregnancy, and no significant IVF-ET ratio between the sIUGR and control groups, but neonatal complications were significantly elevated in noncomplicated MCDA twins.[15]

Table 3 Placental weight and abnormal umbilical cord insertions in the sIUGR group and the control group

Group	*N*	Placental weight (g)[a]	Abnormal umbilical cord insertions (*n*)[b]
sIUGR	43	834.2 ± 211.3	15 (34.9%) (sail-shaped placenta: 7, racket-shaped placenta: 8)
Control	282	973.4 ± 216.9	15 (5.3%) (sail-shaped placenta: 6, racket-shaped placenta: 7, mixed: 2)
p		< 0.0001	< 0.0001

Abbreviation: sIUGR, selective intrauterine growth restriction.
[a]Independent two-sample *t*-test.
[b]Chi-square test.

Table 4 Placental weight and abnormal umbilical cord insertions among three sIUGR types

Type	*N*	Placental weight (g)[a]	Abnormal umbilical cord insertions (*n* [%])
I	23	875.5 ± 234.4	6 (26.1) (sail-shaped placenta: 2, racket-shaped placenta: 4)
II	14	781.5 ± 173.6	7 (50.0) (sail-shaped placenta: 4, racket-shaped placenta: 3)
III	6	806.2 ± 207.9	2 (33.3) (sail-shaped placenta: 1, racket-shaped placenta: 1)
p		I vs. II: 0.224, I vs. III: 0.553, II vs. III: 0.800	[a]

Abbreviation: sIUGR, selective intrauterine growth restriction.
Note: Independent two-sample *t*-test was used for statistical comparisons.
[a]No statistical analysis performed due to small sample number.

Table 5 Abnormal blood flow in PIVCs and middle cerebral artery revealed by Doppler ultrasound in the sIUGR group and the control group

Group	*N*	α-Wave reverse blood flow in ductus venous	Middle cerebral artery diastolic blood flow loss	Combined	Total *n* (%)
sIUGR	43	5	4	1	10 (23.3)
Control	282	9	11	1	22 (7.8)
p					0.002

Abbreviations: PIVCs, peripheral intravenous catheters; sIUGR, selective intrauterine growth restriction.
Note: Chi-square test was applied for statistical comparisons.

Table 6 Abnormal blood flow in PIVCs and middle cerebral artery revealed by Doppler ultrasound among the three sIUGR types

Type	*N*	α-Wave reverse blood flow in ductus venous	Middle cerebral artery diastolic blood flow loss	Combined	Total, *n* (%)
I	23	1	2	0	3 (13.0)
II	14	3	2	1	6 (42.9)
III	6	1	0	0	1 (16.7)

Abbreviations: PIVCs, peripheral intravenous catheters; sIUGR, selective intrauterine growth restriction.
Note: No statistical analysis performed due to small sample size.

The gestational age at delivery in the sIUGR group was significantly earlier than that in the control group. Birth weight and Apgar score of the small fetuses in the sIUGR group were significantly lower than those in the control group, and the intertwin difference in birth weight was significantly higher in the sIUGR group than that in the control group (33.6 ± 12.7% vs. 8.6 ± 6.2%). These findings confirmed that sIUGR fetuses require ultrasound examination on both fetuses' body mass index and intertwin differences in body mass index. In addition, the death of the smaller fetus induced hypotension, which resulted in acute blood loss of the surviving fetus through the anastomotic blood vessel and eventually caused damage to the nervous system or even death of the surviving fetus.[16] Prognosis of perinatal infants is mainly related to sIUGR types, with type I having the best clinical outcome, minimal perinatal death, and complications.[17–19] A previous study reported that in 39 cases of sIUGR, type I sIUGR represented an average gestational age of 35.4 weeks, less than 3% of intrauterine mortality, and 90% of perinatal survival rate.[18,20]

Herein, on the one hand, the sIUGR patients had the highest intrauterine death rate (16.3% vs. 0), which was

Table 7 Gestational complications in the sIUGR group and the control group

Group	*N*	Preeclampsia, *n* (%)		Gestational hypertension, *n* (%)	Gestational diabetes, *n* (%)	ICP, *n* (%)	Postpartum hemorrhage, *n* (%)
		Mild	Severe				
sIUGR	43	0 (0)	2 (4.7)	3 (7.0)	2 (4.7)	2 (4.7)	0 (0)
Control	282	18 (6.4)	12 (4.3)	12 (4.3)	60 (21.3)	10 (3.6)	8 (2.8)
p		0.234	0.234	0.428	0.010	0.720	0.263

Abbreviations: ICP, intrahepatic cholestasis of pregnancy; sIUGR, selective intrauterine growth restriction.
Note: Chi-square test was applied for statistical comparisons.

linked to the smallest fraction of the tiniest placenta. On the other hand, the improved diameter of the arteriolar anastomosis supported the necessity of close monitoring of sIUGR to prevent intrauterine mortality. In addition, type I had the best prognosis, the highest Apgar score, the longest gestational age at delivery, and the highest birth weight of both fetuses. The Apgar score of the smaller fetuses was slightly lower in type I than in type III but significantly higher than in type II ($p < 0.01$). Intrauterine death of the smaller fetus occurred in only one case (4.4%), with no twin death in type I.

Good pregnancy outcome in type I has been associated with a slight difference in placental share and similar anastomosis to that of normal twins.[19,21] It is well known that the anastomotic vessels allow two-way blood flow carrying higher oxygen to the smaller fetus without causing TTTS, thereby reducing fetal weight differences caused by an uneven distribution of the placenta.[6,19] Thus, the placental share difference in type I sIUGR was smaller than that in the other two types but similar to normal MCDA twins (1.8 vs. 1.3).[8] Previous research suggested that type II possessed the largest placental share difference among the three types of sIUGR. The nutritional imbalance between the fetuses cannot be fully compensated by placental anastomotic vessels.[8,19,21] In this study, type II sIUGR has the worst prognosis, with an average gestational age of 31.2 ± 2.8 weeks, significantly lower birth weight of the two fetuses, a more significant difference in birth weight ($40.0\% \pm 20.2\%$), lower Apgar score of the two fetuses, and much higher intrauterine mortality rate (42.9 vs. 4.4% in type I and 0% in type III). In type III, the placenta exhibited a relatively large diameter of arterio-arterial anastomosis (diameter >2 mm in 98.0% of cases). It facilitated the bidirectional blood flow between the fetuses, increasing blood supply to the smaller fetus and reducing the difference in fetal weight.[19,22–28] Gratacós et al reported intrauterine mortality of 15.4% in the smaller fetuses and an incidence of brain damage of 19.7% in the larger fetuses in type III.[8,16,18] Our results showed that type III patients presented no intrauterine death and better prognosis compared with type II but no statistically significant difference between type I and type III regarding average gestational age, birth weight of both fetuses, birth weight between the two fetuses, and Apgar scores.

sIUGR is mainly characterized by the unbalanced distribution of the placenta and abnormal umbilical cord insertion, which often occurs with an edge or velamentous insertion. The large difference in placental share is correlated with a larger difference in fetal weight of the twins.[8,19,29] In our study, the placental weight of the sIUGR group was significantly lower than that of the control group ($p < 0.01$). Still, there was no significant difference in placental weight among the three types. The incidence of abnormal umbilical cord insertion in the sIUGR group was significantly higher than in the control group (34.9 vs. 5.3%; $p < 0.01$). There were six cases with abnormal insertion of the umbilical cord in type I (26.1%), seven cases in type II (50.0%), and two cases in type III (33.3%), indicating a higher incidence trend of abnormal umbilical cord insertion in type II than that in types I and III. Ultrasound represents the most important monitoring method during pregnancy; the blood flow spectrum of UA and DV is the earliest and the most sensitive indicator of vascular resistance and the commonly used indicator of fetal heart function, respectively.[8,30] In this study, 10 patients (23.3%) had abnormalities such as α-wave reverse blood flow in DV and/or diastolic blood flow loss in the MCA in the sIUGR group, compared with 22 patients (7.8%) in the control group. The incidence of abnormal MCA blood flow was significantly higher in the sIUGR group than that in the control group ($p < 0.01$). In the sIUGR group, the rate of abnormalities was the highest in type II compared with type I and type III. Three cases (12.0%) were found with α-wave reverse blood flow in DV and/or diastolic blood loss in MCA in type I, six patients (42.9%) in type II, and one case (25.0%) in type III. The α-wave reverse flow in DV occurred in one of the seven intrauterine death cases (14.3%), lower than those without intrauterine death in sIUGR (9/36, 25.0%). The abnormal blood flow in the DV and the MCA was missed in the four cases of intrauterine death due to a lack of regular records of color Doppler ultrasound. These results reaffirmed the importance of MCA monitoring in sIUGR patients with abnormal blood flow in the umbilical arterial.

In single-fetus pregnancy, the perinatal mortality rate of oligohydramnios fetuses is 13 to 47 times higher than that of fetuses with normal amniotic fluid. Oligohydramnios with a maximal vertical pocket depth less than 10 mm was significantly correlated with IUFD and high perinatal death risk.[9,31] Our results indicated that the amniotic fluid was missing around the smaller fetus in the type I group assessed by B-mode ultrasound at 33 weeks of gestation. Because the gestational periods of pregnant women with fetal complications exceeded 28 weeks, the fetus could survive without leaving the uterus, and the mothers did not want to give up on their "abnormal" fetus. So, instead of performing the selective fetal reduction to eliminate the "abnormal" fetus, we performed a cesarean section to rescue and treat the two fetuses with the hope of saving both fetuses. The pregnancy was terminated by cesarean section in the emergency department in certain cases. In addition, the incidence of gestational diabetes was significantly lower in the sIUGR group than in the control group, while the incidence of other complications was similar, including preeclampsia, gestational hypertension, ICP, and postpartum hemorrhage. Thus, there was no correlation between pregnancy complications and sIUGR.

Conclusion

In summary, sIUGR is mainly caused by an imbalance of placental share and abnormal umbilical cord insertion. The prognosis of sIUGR depends on the type of sIUGR. The perinatal outcome of type I is good with enough gestational age and a smaller difference in birth weight between two fetuses. Type II has a poor prognosis and is prone to fetal death, and, therefore, needs close monitoring of fetal conditions to take timely action, including termination of pregnancy.

Availability of Data and Material

The datasets used and/or analyzed during the study are available from the corresponding author on reasonable request.

Authors' Contributions

T.Q. and W.C. conceived and designed this research and the tables, and approved the final draft. Y.C., Y.G., and H.S. reviewed drafts of the paper, and approved the final draft. L.X. analyzed the data, wrote or reviewed drafts of the article, and approved the final draft.

Ethical Approval

This investigation was approved by the Ethics Committee of the International Peace Maternity and Child Health Hospital.

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None.

Conflict of Interest

None declared.

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