

# A cohort study of the perinatal outcome of radiofrequency ablation in complicated monochorionic multiple pregnancies based on a different needle insert angle

Qian Liu, Xiaomei Shi, Liyuan Fang,  
Tengzi Rao, Lishuang Shi and Jing Wu 

## Abstract

**Objective:** To compare the pregnancy outcomes of radiofrequency ablation (RFA) for complicated multiple pregnancies between fetal abdominal and dorsal needle insertion angles.

**Methods:** We performed a historical cohort study of patients who underwent selective reduction using RFA through different needle insertion angles from 2015 to 2018 at a local hospital. Dorsal needle insertion cases were consecutively selected and abdominal needle insertion cases were selectively enrolled. The Cox proportional hazards model was constructed to identify predictors of fetal survival time with different needle insertion angles.

**Results:** The RFA procedure was performed in 28 women through an abdominal insertion angle and in 28 women through a dorsal insertion angle. There were no significant differences in perinatal outcomes between the two groups. The overall live birth rate after RFA in the two groups was 73.5% and the mean gestation was  $31.6 \pm 6.5$  weeks. The Cox model showed that gestational age at RFA was a predictor of the duration of the period between RFA and delivery.

**Conclusion:** RFA conducted through the dorsal insertion angle is technically feasible for selective reduction in complex monochorionic multiple pregnancies. Gestational age at this procedure is an independent risk factor for the duration of pregnancy post-RFA.

---

Department of Medical Genetics Centre, Guangdong Women's and Children's Hospital, Guangzhou City, China

---

## Corresponding author:

Jing Wu, Department of Medical Genetics Centre, Guangdong Women's and Children's Hospital, No. 521 Xingnan Road, Guangzhou 51000, China.  
Email: [wujing020@126.com](mailto:wujing020@126.com)



**Keywords**

Radiofrequency ablation, pregnancy outcome, multiple pregnancy, selective reduction, risk factor, needle insertion angle

Date received: 15 January 2021; accepted: 26 April 2021

**Introduction**

Monochorionic (MC) multiple pregnancies, especially twin pregnancies, may be complicated by specific and serious complications owing to placental sharing and vascular anastomoses. These complications include selective intrauterine growth restriction, twin–twin transfusion syndrome, twin reversed arterial perfusion, discordance for structural anomalies, and twin anemia–polycythemia sequence. Untreated complicated MC multiple pregnancies may result in higher perinatal morbidity and mortality.<sup>1</sup> A single twin’s death may result in death or major insult to the brain and other organs of the surviving co-twin. This is because of sudden exsanguination through vascular anastomoses towards the dead twin owing to a blood gradient.<sup>2</sup> Therefore, selective reduction is an option for minimizing potential injuries and improving the chances of survival of the co-twin in complex MC multiple pregnancies.<sup>3</sup>

Previous studies have reported the treatment effect and perinatal outcomes<sup>3,4</sup> of radiofrequency ablation (RFA). However, little is known about the effect of the needle entry angle on perinatal outcomes<sup>3</sup>. The RFA needle is usually percutaneously inserted through the maternal abdominal wall into the intrauterine fetal abdomen at the level of the cord insertion site of the complicated twin.<sup>4–6</sup> However, the fetus sometimes maintains a prone position or suddenly changes position after the needle enters the uterine cavity. Whether this

procedure should then be interrupted or a different needle insertion angle chosen remains unclear. A fetal dorsal insertion angle may increase the complexity of the operation owing to factors, including spinal obstruction, more fetal tissue to pass through, and opposite directions between the umbrella end of the ablation needle and the umbilical artery and vein.

Whether the needle insertion angle affects the treatment effect and perinatal outcomes of RFA is unclear. Therefore, this study aimed to compare the effect of fetal abdominal and dorsal needle insertion angles on pregnancy outcomes of selective reduction in RFA for complicated multiple pregnancies.

**Materials and methods*****Study population***

Reporting of this study conforms to the STROCSS statement.<sup>7</sup> We conducted a historical cohort study of patients with complicated MC multiple pregnancies who underwent selective reduction by RFA in single fetal therapy center between January 2015 and December 2018. Patients who underwent dorsal needle insertion were consecutively enrolled in the dorsal insertion angle group if the fetus was in a prone position continuously or the fetal position suddenly changed after the needle entered the uterine cavity in the procedure. Depending on the indication for the operation, gestational age, and cervical

length before the procedure, patients who received RFA via ventral puncture in the same year were selectively enrolled into the ventral (abdominal) insertion group and compared with the dorsal insertion angle group at a ratio of 1:1.

Before the procedure, a comprehensive ultrasound examination was performed to confirm the gestational age and chorionicity, and also to confirm the diagnosis and staging of complicated MC multiple pregnancies. All patients were counseled in detail about the possible complications for MC multiple pregnancies and the options for treatment, such as RFA, expectant management, and fetoscopic laser surgery, including their inherent risks. Informed consent for treatment was obtained from each patient.

Postoperation, all surviving fetuses underwent a head magnetic resonance imaging scan after 28 weeks of gestation to assess fetal neurological development and to determine if there was brain injury.

### *Ethics/review board approval*

This study was conducted in accordance with the principles of the Helsinki Declaration. Ethical approval to perform the study was obtained from the Research Ethics Committee of Guangdong Women's and Children's Hospital, Guangzhou, China (No. 201701048). All patient details have been de-identified. Patients participating in the study did not need to sign an informed content form because of the retrospective nature of the study.

### *RFA*

All patients were admitted to the hospital before the day of RFA after undergoing a comprehensive assessment before this procedure. All procedures were conducted by the combination of one fetology specialist and one interventional ultrasound specialist

in the intrauterine therapeutic room of the Medical Genetics Center.

All patients were treated using the RF-1500 RFA system (MedSphere International Co., Ltd., Shanghai, China). For the RFA protocol,<sup>8</sup> local anesthesia was provided at the planned puncture site on the maternal abdomen (2% lidocaine hydrochloride administered subcutaneously). Under continuous sonographic guidance, a 15-cm or 20-cm 17-gauge RFA electrode needle was inserted from the fetal abdominal or dorsal side to adjacent to the area of umbilical cord insertion. After confirmation of the location, an umbrella electrode was deployed. RFA energy was applied starting from 20 W, with increases of 10 W per minute. The impedance feedback system of the ablation generator automatically turned off the power output when the impedance of the target tissue became too high after it was completely desiccated (impedance "roll-off").<sup>9</sup> If there was no impedance roll-off, ablation was maintained for 2 to 3 minutes after reaching a target temperature of 100°C. The procedure was repeated for an additional one or two cycles using the same heating algorithm, until cessation of cord blood flow was confirmed using color and power Doppler velocimetry (EPIQ5; Philips Ultrasound, Bothell, WA, USA).

### *Follow-up*

Pregnancy and neonatal outcome data were obtained from the clinical notes or from referring physicians. Missing data were collected by telephone interview with the patients to determine postoperative outcomes. Follow-up was performed locally through multiple contact methods, such as telephone and some internet contact. All patients were followed up for at least two times. Follow-up was within 1 month after RFA for determining the health of the infant and pregnant woman, and at

1 month after delivery for determining information regarding delivery and neonatal health from the medical records and a phone interview with the parents. Special events were recorded by a nurse in the follow-up form at any time.

### **Data collection**

Data on perinatal characteristics were collected, including maternal age, cervical length at RFA, indications for RFA, gestational weeks at RFA, cycles of RFA deployed, total ablation time, and pregnancy outcomes.

### **Definitions**

Using the fetal midaxillary line as the boundary, the needle entry position in the front of the midaxillary line was defined as the abdominal needle insertion angle. The needle entry position in the back of the midaxillary line was defined as the dorsal needle insertion angle.

Postprocedural complications, included events that occurred within 2 weeks following the procedure. These included intrauterine fetal death of the co-twin, miscarriage, and termination of pregnancy owing to abnormal ultrasound findings, such as hydrops of the co-twin. Adverse perinatal outcomes included any of the following: intrauterine fetal death or miscarriage 2 weeks following the procedure, termination of pregnancy, and preterm delivery before 28 weeks of gestation. Selective intrauterine growth restriction was defined as an estimated fetal weight <10th percentile in one twin and estimated fetal weight discordance  $\geq 25\%$ . Cases were classified into one of three types in relation to Doppler flow of the umbilical artery.<sup>10</sup>

The survival rate was defined as survival beyond the first 28 days of postnatal life.<sup>3</sup>

### **Statistical analysis**

Data analysis was performed with IBM SPSS Statistics for Windows version 21.0 software (IBM Corp., Armonk, NY, USA). The Student's *t*-test and Mann–Whitney *U*-test were used to compare continuous variables with and without a normal distribution, respectively, between the two groups. The chi-square and Fisher's exact tests were used for analysis of categorical variables. Cox survival regression was conducted to compare the proportion of pregnant women who underwent RFA and did not deliver after the procedure between the two groups. Differences were considered significant when *P* was <0.05.

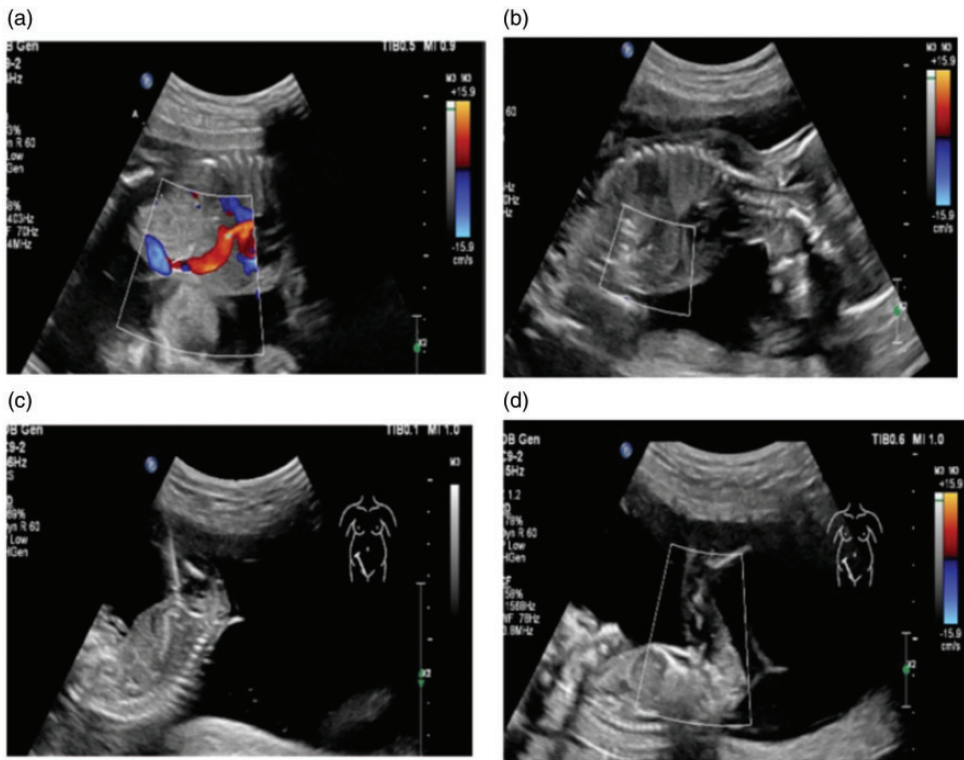
## **Results**

### **Characteristics of the study groups**

Fifty-six ( $n = 28$  in each group) selective fetocides of complicated MC multiple pregnancies were successfully performed. Color Doppler ultrasound images of umbilical blood flow in the fetus before and after RFA at two different insertion angles are shown in Figure 1. The obstetric characteristics of the pregnant women in the two groups are shown in Table 1. Maternal age, gestational age, cervical length before RFA, and indications of RFA were similar between the two groups.

### **Operative characteristics and pregnancy outcome**

The mean ( $\pm$ standard deviation) gestational age at the procedure of RFA was  $20.5 \pm 3.3$  weeks, the rate of at least one fetus being born alive was 73.5%, the mean gestational age of delivery was  $31.6 \pm 6.5$  weeks, and the mean duration of pregnancy after RFA was  $77.7 \pm 46.4$  days. The operative characteristics and pregnancy outcomes of the two groups are shown



**Figure 1.** Intraoperative and postoperative ultrasound images of two needle insertion angles. (a) Intraoperative image of the dorsal insertion angle; (b) postoperative image of the dorsal insertion angle; (c) intraoperative image of the abdominal insertion angle; (d) postoperative image of the abdominal insertion angle.

**Table 1.** Characteristics of the study population of pregnant women with complicated monochorionic multiple pregnancies undergoing selective reduction in relation to the needle insertion angle.

Characteristics	Abdominal needle insertion (n = 28)	Dorsal needle insertion (n = 28)	P
MA (years)	28.6 ± 3.6	27.7 ± 5.6	0.51
GA (weeks)	20.3 ± 3.2	20.8 ± 3.4	0.60
CL before RFA (mm)	32.1 ± 3.8	30.4 ± 6.3	0.22
Indication for procedure			
TTTS	13 (46.4)	13 (46.4)	1.00
TRAP	3 (10.7)	1 (3.6)	0.30
sIUGR	5 (17.9)	6 (21.4)	0.74
sIUGR+TTTS	1 (3.6)	1 (3.6)	1.00
Anomalous co-twin	4 (14.3)	5 (17.9)	0.72
Excessive number of fetuses	2 (7.1)	2 (7.1)	1.00

Data are shown as mean ± standard deviation or n (%).

MA, maternal age; GA, gestational age; CL, cervical length; RFA, radiofrequency ablation; TTTS, twin-to-twin transfusion syndrome; TRAP, twin reversed arterial perfusion sequence; TAPS, twin anemia-polycythemia sequence; sIUGR, selective intrauterine growth restriction.

**Table 2.** Procedural characteristic and pregnancy outcomes in women with complicated monochorionic multiple pregnancies undergoing RFA in relation to different insertion needle angles.

Characteristics	Abdominal needle insertion (n = 28)	Dorsal needle insertion (n = 28)	P
Total ablation time (s)	329.4±141.4	336.7±144.5	0.69
Post-procedural complications	5 (17.9)	4 (14.3)	0.72
TOP	2 (7.1)	3 (10.7)	0.64
GA at delivery (weeks)	31.0±7.5	32.2±5.5	0.64
Interval of RFA to delivery (days)	75.5±48.8	80.1±44.7	0.71
Preterm delivery:			
<37 weeks	18 (64.3)	22 (78.6)	0.24
<34 weeks	14 (50.0)	14 (50.0)	1.00
<32 weeks	12 (42.9)	10 (35.7)	0.58
<30 weeks	9 (32.1)	8 (28.6)	0.77
<28 weeks	9 (32.1)	5 (17.9)	0.22
Survival rate	19 (67.9)	22 (78.6)	0.37
Cesarean section	4 (14.3)	8 (28.6)	0.19
Adverse perinatal outcome	2 (7.1)	3 (10.7)	0.64

Data are shown as mean ± standard deviation or n (%).

RFA, radiofrequency ablation; TOP, termination of pregnancy; GA, gestational age.

in Table 2. There were no significant differences in the operative characteristics between the two groups. Cervical length before RFA and the total ablation time were not significantly different between the groups. The rates of preterm birth before 37, 34, 32, 30, and 28 weeks' gestation were similar between the two groups. Complications after the procedure were not significantly different between the groups, including post-procedural and perinatal complications. The rate of termination of pregnancy due to fetal serious oligohydramnios or structural anomalies of the co-twin was also not significantly different between the groups. The characteristics of delivery, including neonatal gestational age and the rate of cesarean section, were not significantly different between the two groups.

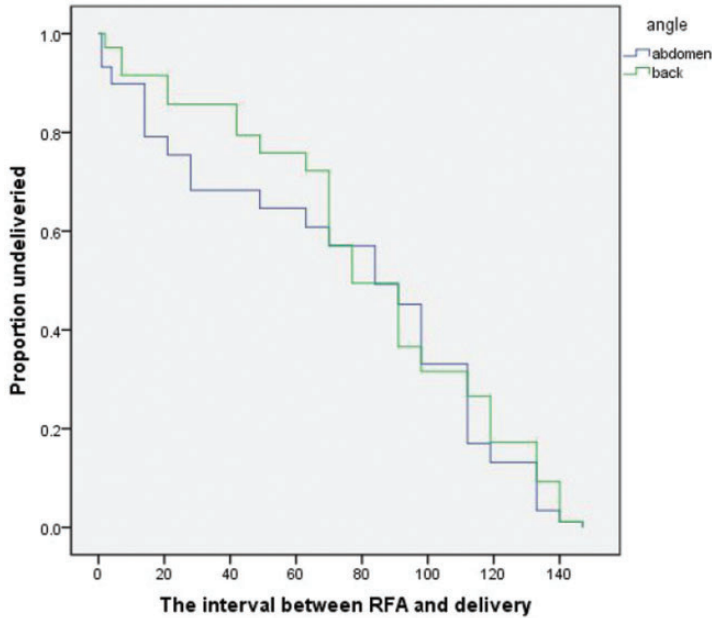
The relationship of the RFA technique and survival time after the procedure was assessed by survival analysis. Multivariate Cox regression analysis showed that the survival curve of fetal survival time was

slightly longer in the dorsal insertion group than in the abdominal insertion group, while taking into account covariates, including maternal age, gestational age, indications, ablation time, ablation cycles, and cervical length at the procedure (Figure 2). We found that gestational age at RFA was a significant predictor for the duration of the period between RFA and delivery ( $P < 0.005$ , Table 3).

## Discussion

This study compared the effect of abdominal and dorsal insertion angles in selective reduction in RFA on pregnancy outcomes for complex multiple pregnancies. Our study suggested that the dorsal needle insertion angle was an acceptable technique of RFA for fetal reduction in complicated MC multiple pregnancies with a similar success rate as the abdominal needle insertion angle. The total ablation time and pregnancy outcomes were similar between the two groups.





**Figure 2.** Survival analysis shows the proportion of women with monochorionic multiple pregnancies who did not deliver after the RFA procedure in the two needle insertion angle groups in relation to the fetal survival time after RFA.

RFA, radiofrequency ablation.

**Table 3.** Multivariable analysis of the relation of procedural risk factors with an adverse perinatal outcome.

Variable	OR (95% CI)	P
Maternal age	1.022 (0.965–1.082)	0.458
Indication	1.006 (0.813–1.246)	0.956
Gestational age at RFA	1.161 (1.045–1.288)	0.005
Cervical length	0.958 (0.902–1.017)	0.162
Total ablation time	1.000 (0.998–1.003)	0.741
Ablation cycles	0.956 (0.486–1.880)	0.896

OR, odds ratio; CI, confidence interval; RFA, radiofrequency ablation.

To cease umbilical blood flow, the total ablation time in the dorsal insertion angle group was slightly longer than that in the abdominal needle insertion angle group, but this was non-significant. The total ablation time in the dorsal insertion angle group

was not longer than that found in previous studies.<sup>3,6</sup> This indicated that after dorsal needle insertion in RFA, although the direction of the umbrella end of the ablation needle was opposite to that of the fetal umbilical artery and umbilical vein, the ablation time might not need to be extended to cease umbilical flow.

There were no significant differences in the pregnancy outcomes between the two groups, including the rates of post-procedural complications, termination of pregnancy after RFA, preterm birth, and live birth. In our study, the overall live birth rate was 73.5%, which is similar to the live birth rate reported by previous<sup>3,9,11</sup> studies. The mean gestational age at delivery was  $31.0 \pm 7.5$  weeks in the abdominal needle insertion group and  $32.2 \pm 5.5$  weeks in the dorsal needle insertion group, which are earlier than those in previous

studies.<sup>3,4,9</sup> The reason for this finding may be because the mean gestational weeks at RFA was later than 16 weeks reported in these previous studies (mean gestational age at RFA:  $20.3 \pm 3.2$  and  $20.8 \pm 3.4$  weeks, respectively). A previous study reported that gestational age at delivery was earlier if RFA was performed after 16 weeks.<sup>9</sup> Additionally, Cox regression analysis in this study showed that gestational age at RFA was an independent risk factor of the duration of pregnancy after RFA.

With regard to application of RFA for treating complicated MC multiple pregnancies, previous studies examined the efficacy and pregnancy outcome on the basis of indications and gestational age at this procedure.<sup>9,12-15</sup> Our study investigated the pregnancy outcomes of RFA in relation to different needle insertion angles. We found that, although dorsal injection increased the complexity of the operation of RFA, it may not increase the incidence of adverse pregnancy outcomes. Therefore, if the fetus remains in a prone position or the fetal position suddenly changes after the ablation needle enters the uterine cavity, RFA may not need to be interrupted during selective reduction for complex multiple pregnancies.

The main limitations of this study are its non-randomized study design and small sample size. Therefore, our observations cannot be used to draw a definite conclusion. Additionally, we did not have long-term outcome data for neurodevelopment of surviving fetuses. Therefore, a prospective study is required to determine the long-term neurodevelopment outcomes of surviving fetuses with RFA using two needle insertion angles.

Previous studies<sup>3</sup> have reported that severe impairment of neurodevelopment occurs in 2% to 5% of children, which indicates that RFA is a relatively safe technique for selective reduction in complex MC multiple twins. In conclusion, electrode

needle dorsal insertion is a practical characteristic of RFA. The number of gestational weeks at the procedure is an independent risk factor for the duration of pregnancy after RFA.

### Acknowledgments

The authors thank all colleagues in the Department of Ultrasound and Medical Genetics Center, staff members of Guangdong Women's and Children's Hospital, and the parents and neonates who participated.

### Declaration of conflicting interest

The authors declare that there is no conflict of interest.

### Funding

The author(s) disclosed receipt of the following financial support for the research, authorship, and/or publication of this article: This study received funding from the Traditional Chinese Medicine Bureau of Guangdong Province (20211051).


### Author contributions

Jing Wu conceived the idea of the study. Jing Wu, Qian Liu, and Xiaomei Shi wrote the proposal and prepared the initial manuscript. Lishuang Shi was responsible for follow-up. Liyuan Fang and Tengzi Rao contributed to data collection and analysis. Jing Wu made intellectual contributions to the final manuscript. All authors read and approved the final manuscript.

### Availability of data and materials

The data used and analyzed during this study are available from the corresponding author on reasonable request.

### ORCID iD

Jing Wu  <https://orcid.org/0000-0003-4213-4106>

### References

1. Prefumo F and Jauniaux E. Twin-to-twin-transfusion syndrome: from amniodrainage



- to laser. *BJOG* 2018; 125: 1163. 10.1111/1471-0528.15253
2. Lewi L, Jani J, Blickstein I, et al. The outcome of monochorionic diamniotic twin gestations in the era of invasive fetal therapy: a prospective cohort study. *Am J Obstet Gynecol* 2008; 199: 514.e1-8. 10.1016/j.ajog.2008.03.050
  3. Sun L, Zou G, Yang Y, et al. Risk factors for fetal death after radiofrequency ablation for complicated monochorionic twin pregnancies. *Prenat Diagn* 2018; 38: 499–503. 10.1002/pd.5269
  4. Rahimi-Sharbat F, Ghaemi M, Nassr AA, et al. Radiofrequency ablation for selective fetal reduction in complicated Monochorionic twins; comparing the outcomes according to the indications. *BMC Pregnancy Childbirth* 2021; 21: 189. 10.1186/s12884-021-03656-1
  5. Tsao K, Feldstein VA, Albanese CT, et al. Selective reduction of acardiac twin by radiofrequency ablation. *Am J Obstet Gynecol* 2002; 187: 635–640.
  6. Cabassa P, Fichera A, Prefumo F, et al. The use of radiofrequency in the treatment of twin reversed arterial perfusion sequence: a case series and review of the literature. *Eur J Obstet Gynecol Reprod Biol* 2013; 166: 127–132. 10.1016/j.ejogrb.2012.10.009
  7. Agha R, Abdall-Razak A, Crossley E, et al. STROCSS 2019 Guideline: Strengthening the reporting of cohort studies in surgery. *Int J Surg* 2019; 72: 156–165. 10.1016/j.ijssu.2019.11.002
  8. Moise KJ, Johnson A, Moise KY, et al. Radiofrequency ablation for selective reduction in the complicated monochorionic gestation. *Am J Obstet Gynecol* 2008; 198: 191–198. 10.1016/j.ajog.2007.07.043
  9. Ting YH, Poon LCY, Tse WT, et al. Outcomes of radiofrequency ablation for selective fetal reduction in complicated monochorionic pregnancies performed before 16 gestational weeks and thereafter. *Ultrasound Obstet Gynecol* 2020. 10.1002/uog.22160
  10. Gratacos E, Lewi L, Munoz B, et al. A classification system for selective intrauterine growth restriction in monochorionic pregnancies according to umbilical artery Doppler flow in the smaller twin. *Ultrasound Obstet Gynecol* 2007; 30: 28–34. 10.1002/uog.4046
  11. Peng R, Xie HN, Lin MF, et al. Clinical Outcomes after Selective Fetal Reduction of Complicated Monochorionic Twins with Radiofrequency Ablation and Bipolar Cord Coagulation. *Gynecol Obstet Invest* 2016; 81: 552–558. 10.1159/000445291
  12. Yinon Y, Ashwal E, Weisz B, et al. Selective reduction in complicated monochorionic twins: prediction of obstetric outcome and comparison of techniques. *Ultrasound Obstet Gynecol* 2015; 46: 670–677. 10.1002/uog.14879
  13. Bebbington MW, Danzer E, Moldenhauer J, et al. Radiofrequency ablation vs bipolar umbilical cord coagulation in the management of complicated monochorionic pregnancies. *Ultrasound Obstet Gynecol* 2012; 40: 319–324. 10.1002/uog.11122
  14. Roman A, Papanna R, Johnson A, et al. Selective reduction in complicated monochorionic pregnancies: radiofrequency ablation vs. bipolar cord coagulation. *Ultrasound Obstet Gynecol* 2010; 36: 37–41. 10.1002/uog.7567
  15. Lu J, Ting YH, Law KM, et al. Radiofrequency Ablation for Selective Reduction in Complicated Monochorionic Multiple Pregnancies. *Fetal Diagn Ther* 2013; 34: 211–216. 10.1159/000355406