Selective reduction in complicated monochorionic pregnancies: a systematic review and meta-analysis of different techniques

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OBJECTIVE: This systematic review and meta-analysis aimed to compare the perinatal outcomes of complicated monochorionic pregnancies after selective reduction by radiofrequency ablation, bipolar cord coagulation, and interstitial laser.

DATA SOURCES: We searched PubMed, Scopus, and Web of Science, from the inception of the database up to April 26, 2021.

STUDY ELIGIBILITY CRITERIA: Studies comparing at least 2 selective reduction techniques among complicated monochorionic pregnancies and presenting data on perinatal outcomes, including gestational age at procedure, gestational age at delivery, procedure to delivery interval, preterm premature rupture of membranes, preterm birth, survival rate, and birthweight, were eligible.

METHODS: The random-effects model was used to pool the mean differences or odds ratios and corresponding 95% confidence intervals. Heterogeneity was assessed using the I^2 value.

RESULTS: A total of 10 studies with 734 cases of fetal reduction met the inclusion criteria, of which 9 studies with 674 fetuses were eligible for quantitative synthesis. In 8 studies that compared radiofrequency ablation with bipolar cord coagulation, radiofrequency ablation was associated with increased procedure to delivery interval (days) (mean difference, 13.42; 95% confidence interval, 1.90−24.94; P=.02; I^2=0.0%), decreased preterm birth (odds ratio, 0.50; 95% confidence interval, 0.29−0.85; P=.01; I^2=3.0%), and decreased preterm premature rupture of membranes (odds ratio, 0.45; 95% confidence interval, 0.27−0.73; P=.001; I^2=0.0%). Radiofrequency ablation and bipolar cord coagulation had comparable survival rates (odds ratio, 0.85; 95% confidence interval, 0.54−1.35; P=.49; I^2=0.0%). In 3 studies that compared radiofrequency ablation with interstitial laser, there was no significant difference in gestational age at delivery (P=.07) or survival (P=.15). In 3 studies that compared bipolar cord coagulation with interstitial laser, bipolar cord coagulation was associated with a higher survival rate (odds ratio, 3.21; 95% confidence interval, 1.13−9.10; P=.03; I^2=0.0%), but the gestational age at delivery was comparable between groups (P=.16).

CONCLUSION: This study demonstrated that radiofrequency ablation has a greater procedure to delivery interval and decreased preterm premature rupture of membranes and preterm birth than bipolar cord coagulation. Although there was no difference in gestational age at delivery for either bipolar cord coagulation, radiofrequency ablation, or interstitial laser, survival was higher with bipolar cord coagulation than with interstitial laser.

Key words: bipolar cord coagulation, fetal reduction, fetoscopy, interstitial laser, laser, meta-analysis, monochorionic, radiofrequency

Introduction

Monochorionic (MC) pregnancies are at increased risk of adverse outcomes because of the vascular anastomoses in the placenta, resulting in a shared circulation between fetuses. Complications include twin-to-twin transfusion syndrome (TTTS), selective fetal growth restriction (sFGR), twin anemia polycythemia sequence, twin reversed arterial perfusion (TRAP), and discordant anomalies.

In the event of death of 1 fetus, because of these vascular anastomoses, acute intertwin transfusion may occur, resulting in hypotension and hypoxia in the co-twin. Severe neurologic damage or death of the co-twin has been reported in 12% to 26% of MC pregnancies.[1,2] The extent of the neurologic injury ranges from mild to severe and includes encephalomalacia, germinal matrix hemorrhage, parenchymal hemorrhage, and gray matter lesions.[2,3] For this reason, in cases of severe sFGR,

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AJOG at a Glance

Why was this study conducted?

This study aimed to systematically compare the perinatal outcomes of complicated monochorionic (MC) pregnancies after selective reduction by radiofrequency ablation (RFA), bipolar cord coagulation (BCC), and interstitial laser (IL).

Key findings

Selective fetal reduction in complicated MC pregnancies was associated with a shorter procedure to delivery interval and a higher rate of preterm birth with BCC than RFA. IL was associated with lower survival than BCC.

What does this add to what is known?

The decision to undergo selective fetal reduction can be challenging to parents, and determining the ideal technique for this intervention is important. This systematic review and meta-analysis demonstrated a decreased risk of preterm birth with RFA.

advanced TTTS, or discordant anomalies that could result in the death of the affected fetus, selective reduction (SR) may be an option to protect the co-twin and increase the rate of intact survival.

In dichorionic twins, intracardiac injection of potassium chloride or lidocaine is possible; however, in MC twins, because of the risk of diffusion of these toxic agents to the co-twin through the placental anastomoses, a method to rapidly cause cessation of flow in the cord of the affected fetus is necessary to avoid risks to the co-twin. Some of the methods described for MC twins are radiofrequency ablation (RFA), bipolar cord coagulation (BCC), and ultrasound-guided interstitial laser (IL) or fetoscopic FL.[1]

Although the SR techniques have been compared previously, the method, which results in the best pregnancy outcome, is still conflicting. This may be because of the relatively small number of patients presented in each study, variation in procedure choice in different centers, variation in operator experience, and preference. By performing this systematic review and meta-analysis study, we sought to determine the optimal method of SR and assess risks of adverse perinatal outcomes.

Material and Methods

This systematic review and meta-analysis was conducted according to the Preferred Reporting Items for Systematic Reviews and Meta-Analyses checklist.[4] The study protocol for this systematic review was registered in the International Prospective Register of Systematic Reviews (registration number CRD42021251961).

Information sources and search strategy

A systematic literature search was performed by 2 independent authors (K.H. and A.A.N.) on PubMed, Web of Science, and Scopus from the inception of the database up to April 26, 2021. The search was conducted using the following keywords: "radiofrequency" OR "radio-frequency" OR "radio frequency" OR "cord coagulation" OR "cord-coagulation" OR "interstitial laser" OR "fetoscopic laser" AND "fetal reduction" OR "pregnant" OR "pregnancy" OR "fetal" OR "fetus". References of relevant articles were manually reviewed, and eligible studies were added to the results of the electronic literature search.

Eligibility criteria

We reviewed the studies on complicated MC multiple pregnancies that (1) underwent SR by one of the following techniques, RFA, BCC, IL, and FL; (2) evaluated the outcome of interest, including gestational age (GA) at intervention, incidence of preterm premature rupture of membranes (PPROM), preterm birth (PTB) (<37 weeks of gestation), GA at delivery, mode of delivery, and procedure to delivery interval; and (3) compared at least 2 SR techniques and designed as case-control, cohort, or case series with at least 20 patients.[5] We excluded studies designed as a case report or case series with <20 participants, where the full text was not in English, abstract papers, and editorial letters. If the underlying reason for SR was not noted, or the technique itself was not described in detail, the study was excluded.

Data extraction

Data extraction was performed by 2 independent authors (K.H. and A.A.N.) using a standardized Excel spreadsheet. The following data were abstracted: author's name, publication year, study design, sample size, number of twins and triplets, techniques of fetal reduction, indications for SR, survival (defined as live birth), GA at procedure, incidence of PPROM, procedure to delivery interval, PTB, GA at delivery, and birthweight.

Outcome measure

The primary outcome of this systematic review and meta-analysis was the survival rate. The secondary outcomes included GA at procedure, procedure to delivery interval, incidence of PPROM, PTB at <37 weeks of gestation, GA at delivery, and birthweight.

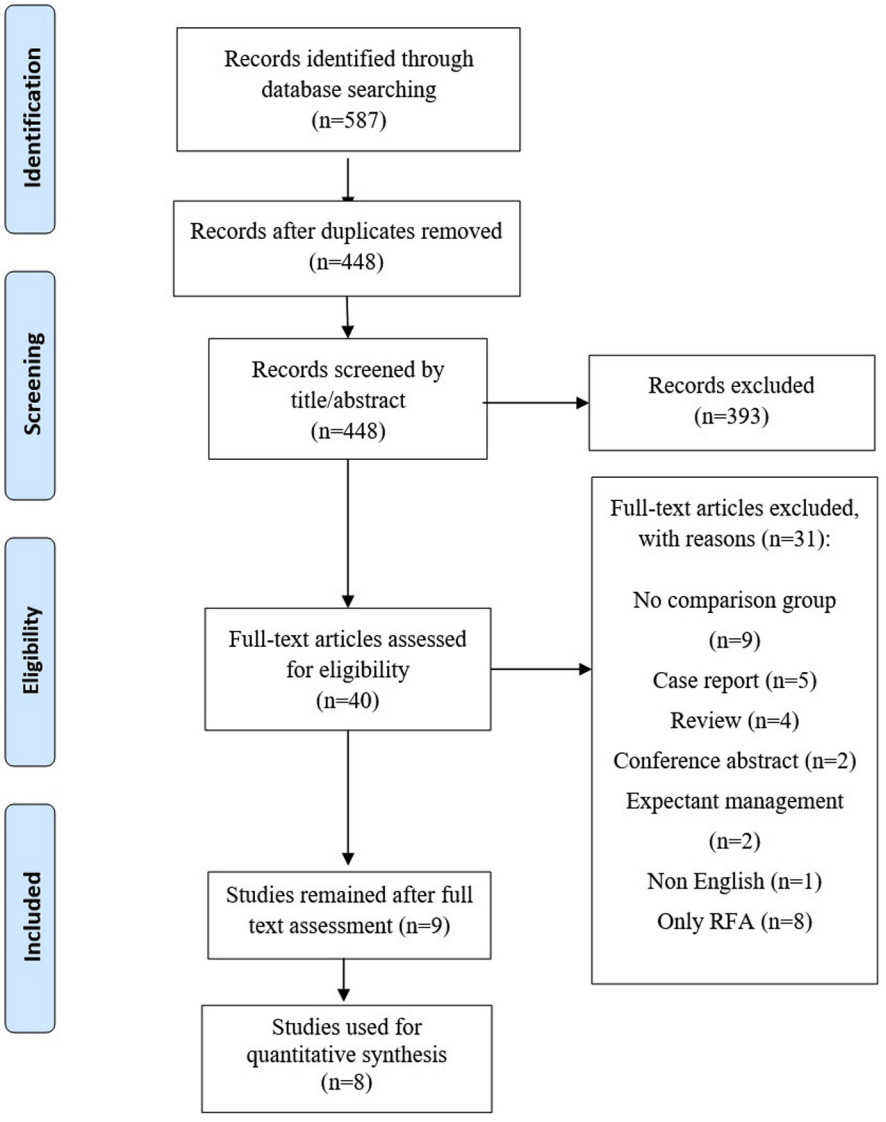
Assessment of risk of bias

The Newcastle-Ottawa Scale (NOS) was used to evaluate the quality of the included studies and risk of bias. The NOS is comprised "participant selection," "comparability of study groups," and "assessment of outcome or exposure." A score >7 is considered high quality.[5]

Data synthesis

Statistical analysis was performed using the Review Manager (version 5.4; The Nordic Cochrane Centre, The Cochrane Collaboration, Copenhagen). If data were presented as median (range) or median (interquartile range), data were converted to mean and standard deviation using the Hozo formula.[6] Pooled effect sizes were presented using mean

FIGURE 1
PRISMA flowchart



PRISMA, Preferred Reporting Items for Systematic Reviews and Meta-Analyses; *RFA*, radiofrequency ablation.

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difference or odds ratio (OR), using the Mantel-Haenszel test, with 95% confidence interval (CI) for continuous and categorical variables, respectively. The 95% prediction interval (PI) was presented if the number of eligible studies for each outcome of interest was >5. Only outcomes that were reported in at least 3 studies were analyzed. I square tests (I^2) were used to examine heterogeneity across the included studies; $I^2 \geq 50\%$ and $P < .05$ indicate heterogeneity. Moreover, network meta-analysis was performed using an online interactive web application (available at https://crsu.shinyapps.io/metainsightc) to identify the best SR technique in terms of fetal survival. A random-effects model was used owing to the anticipated heterogeneity of included studies.

Results

Search strategy and study characteristics

As shown in Figure 1, a total of 587 articles were retrieved. Of those articles, 139 were excluded for duplication. The remaining 448 studies were screened for eligibility, of which the titles of 408 studies were not related to SR of MC pregnancies. Title and abstract screening resulted in 40 potentially eligible studies. After a full-text assessment was performed, 9 studies met the inclusion criteria defined previously in our methods. RFA was compared with BCC in 8 studies, RFA vs IL in 3 studies, and BCC vs IL in 3 studies.

The study characteristics are presented in Tables 1 and 2. Included studies were published between 2010 and 2021. Of note, 3 studies were conducted in the United States,[7,8,13] 1 in the Netherlands,[9] 1 in Canada,[15] 1 in China,[12] 1 in India,[14] 1 in Israel,[11] and 1 in the United Kingdom.[10] All studies had a retrospective design,[7–13,15] except for 1.[14] A total of 734 cases of fetal reduction were eligible for meta-analysis, of which 302 underwent RFA, 269 had BCC, and 35 performed IL. Furthermore, 11 cases underwent FL, and 17 cases had laser intervention without a description of the precise method used (either IL or FL). The most common reason for fetal reduction was discordant anomaly (n=229) followed by TRAP (n=219), TTTS (n=184), sFGR (n=98), and others (n=4).

Radiofrequency ablation vs bipolar cord coagulation.

The survival rates were 81.6% (235/288) for RFA and 80.8% (219/271) for BCC, which were not significantly different (OR, 0.85; 95% CI, 0.54−1.35; 95% PI, 0.48−1.52; $P=.49$; $I^2=0.0\%$) (Figure 2, A). The mean GAs at the time of the procedure were 20.34 weeks (95% CI, 19.16−21.52; 95% PI, 16.20−24.47) for RFA and 21.39 weeks (95% CI, 20.69−22.08; 95% PI, 19.19−23.59) for BCC, which were not significantly different (mean difference, −1.09 weeks; 95% CI, −2.25 to 0.08; 95% PI, −4.92 to 2.74; $P=.07$; $I^2=79.0\%$) (Figure 2, B). The mean GAs at delivery were 34.04 weeks (95% CI, 32.73−35.36; 95% PI, 29.86−38.22) for RFA and 33.61 weeks (95% CI, 32.23−35.00; 95% PI, 29.16−38.07) for BCC, which were not significantly different (mean difference, 0.43 weeks; 95% CI, −0.52 to 1.38; 95% PI, −0.75 to 1.62; $P=.52$; $I^2=0.0\%$) (Figure 2, C).

TABLE 1
Characteristics of included studies

First author (y), country	Study design	Sample size	Twin/ triplet	Techniques (number of cases)	Indication for procedure (number of cases)
Roman et al,[7] 2010, United States	Retrospective	60	54/6	RFA (20)	TTTS (4), sFGR (2), TRAP (6), anomaly (8)
				BCC (40)	TTTS (8), sFGR (4), TRAP (12), anomaly (16)
Bebbington,[8] 2012, United States	Retrospective	146	130/16	RFA (58)	TTTS (15), sFGR (19), TRAP (18), anomaly (6)
				BCC (88)	TTTS (28), sFGR (5), TRAP (35), anomaly (20)
Van Den Bos et al,[9] 2013, The Netherlands	Retrospective	131	All twins	RFA (11)	TTTS (1), sFGR (2), TRAP (5), anomaly (2), other (1)
				BCC (36)	TTTS (16), sFGR (5), TRAP (0), anomaly (14), other (1)
				IL (15)	TTTS (1), sFGR (1), TRAP (11), anomaly (2)
				FL (69)	TTTS (22), sFGR (3), TRAP (23), anomaly (20), other (1)
Nobili et al,[10] 2013, United Kingdom	Retrospective	56	All twins	RFA (26)	TRAP (7), anomaly (49)
				BCC (22)	
				IL (8)	
Yinon et al,[11] 2015, Israel	Retrospective	53	All twins	RFA (36)	TTTS (6), sFGR (19), TRAP (4), anomaly (7)
				BCC (17)	TTTS (8), sFGR (4), TRAP (0), anomaly (5)
Peng et al,[12] 2016, China	Retrospective	93	All twins	RFA (45)	TTTS (15), sFGR (10), TRAP (12), anomaly (8)
				BCC (48)	TTTS (32), sFGR (6), TRAP (2), anomaly (7), TAPS (1)
Abdel-Sattar et al,[13] 2018, United States	Retrospective	60	54/6	RFA (18)	TTTS (0), sFGR (2), TRAP (10), anomaly (6)
				FL (42)	TTTS (2), sFGR (1), TRAP (30), anomaly (9)
Dadhwal et al,[14] 2019, India	Prospective	30	All twins	RFA (14)	TTTS (9), sFGR (3), TRAP (4), anomaly (14)
				BCC (4)	
				IL (12)	
Shinar et al,[15] 2021, Canada	Retrospective	105	All twins	RFA (74)	TTTS (6), sFGR (9), TRAP (35), anomaly (24)
				BCC (14)	TTTS (3), sFGR (1), TRAP (0), anomaly (10)
				IL and FL (17)	TTTS (8), sFGR (2), TRAP (5), anomaly (2)

BCC, bipolar cord coagulation; *FL*, fetoscopic laser; *IL*, interstitial laser; *RFA*, radiofrequency ablation; *sFGR*, selective intrauterine growth restriction; *TAPS*, twin anemia polycythemia sequence; *TRAP*, twin reversed arterial perfusion; *TTTS*, twin-to-twin transfusion syndrome.

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The overall incidence rates of PTB (<37 weeks of gestation) and PPROM were 50.7% (102/201) and 17.6% (43/244) for RFA and 66.7% (94/141) and 28.4% (69/243) for BCC, respectively. There was a significantly decreased OR of PTB and PPROM after RFA than BCC (PTB: OR, 0.50; 95% CI, 0.29−0.85; P=.01; I^2=3.0%; PPROM: OR, 0.45; 95% CI, 0.27−0.73; P=.001; I^2=0.0%) (Figure 2, D and E). Furthermore, birthweight was not significantly different between RFA and BCC (Figure 2, F). The 95% PI for PPROM ranged from 0.22 to 0.91, but PI for PTB was not applicable because of the small number of studies.

Radiofrequency ablation vs interstitial laser.

The survival rates were 80.4% (41/51) for RFA and 57.1% (20/35) for IL, which were not significantly different (OR, 2.14; 95% CI, 0.76−1.35; P=.15; I^2=0.0%) (Figure 3, A). The mean GAs at delivery were 34.04 (95% CI, 32.73−35.36) for RFA and 33.06 (95% CI, 30.20−35.92) for IL, which was not significantly different (Figure 3, B).

Bipolar cord coagulation vs interstitial laser.

The survival rates were 82.3% (51/62) for BCC and 57.1% (20/35) for IL (OR, 3.21; 95% CI, 1.13−9.10; P=.03;

TABLE 2
Continued characteristics of included studies

First author (y), country	Techniques (number of cases)	GA at procedure	GA at delivery	PPROM	Survival
Roman et al,[7] 2010, United States	RFA (20)	20.3 (17.0–29.0)	36.0 (26.0–41.0)	5.0	87.0
	BCC (40)	21.5 (15.0–26.0)	39.0 (19.0–40.0)	22.5	88.0
Bebbington,[8] 2012, United States	RFA (58)	20.2±2.2	33.0 (23.4–38.9)	13.7	70.7
	BCC (88)	20.9±2.7	34.7 (29.2–38.6)	27.3	85.2
Van Den Bos et al,[9] 2013, The Netherlands	RFA (11)	15.0 (14.0–18.0)	34.0 (20.0–39.0)	9.1	63.6
	BCC (36)	20.5 (18.0–22.0)	35.5 (29.0–38.8)	13.9	77.8
	IL (15)	16.0 (15.0–18.0)	26.0 (18.0–35.0)	13.3	46.7
	FL (69)	16.0 (15.0–19.0)	33.0 (20.5–38.0)	26.1	66.7
Nobili et al,[10] 2013, United Kingdom	RFA (26)	18.0 (13.0–27.0)	36.4 (27.0–41.0)	NR	92.3
	BCC (22)	20.0 (17.0–32.0)	35.0 (28.0–41.0)	NR	90.0
	IL (8)	14.0 (12.0–21.0)	36.0 (26.0–40.0)	NR	87.5
Yinon et al,[11] 2015, Israel	RFA (36)	21.3 (17.7–24.3)	35.0 (29.8–38.0)	13.9	88.9
	BCC (17)	20.2 (19.4–22.5)	31.3 (26.7–36.6)	11.8	76.5
Peng et al,[12] 2016, China	RFA (45)	19.6 (18.1–26.5)	31.4 (22.2–40.6)	33.3	71.1
	BCC (48)	23.1 (17.2–27.5)	31 (20.2–40.0)	41.5	62.5
Abdel-Sattar et al,[13] 2018, United States	RFA (18)	19.1 (16.9–25.4)	34.6 (17.4–40.1)	11.1	66.7
	FL (42)	20.1 (17.3–27.1)	35.8 (24.3–40.3)	23.8	97.6
Dadhwal et al,[14] 2019, India	RFA (14)	24.3 (16.0–26.4)	36 (28.0–38.0)	NR	71.4
	BCC (4)	22.5 (20.0–26.0)	36 (28.0–37.0)	NR	75.0
	IL (12)	23.4 (18.0–26.4)	34 (26.0–39.0)	NR	50.0
Shinar et al,[15] 2021, Canada	RFA (74)	19.3±4	34.5±6.5	18.9	91.9
	BCC (14)	21.1±3.6	32.2±6.6	42.9	92.9
	IL and FL (17)	20.6±3.8	30.1±6.9	41.2	82.4

BCC, bipolar cord coagulation; *FL*, fetoscopic laser; *GA*, gestational age; *IL*, interstitial laser; *NR*, not reported; *PPROM*, preterm premature rupture of membranes; *RFA*, radiofrequency ablation.

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I^2=0.0%) (Figure 4, A). The mean GAs at delivery were 33.61 (95% CI, 32.23–35.00) for BCC and 33.06 (95% CI, 30.20–35.92) for IL, which were not significantly different (Figure 4, B).

Survival after radiofrequency ablation vs bipolar cord coagulation vs interstitial laser

Figure 5 shows a matrix of survival comparisons according to SR techniques in a network meta-analysis. SR techniques were ranked from worst to best (in terms of fetal survival) along the leading diagonal. The SR technique comparisons obtained from pairwise meta-analyses only are above the leading diagonal line, in the upper triangle. These are calculated as the SR technique in the row vs the SR technique in the column. For example, the pooled OR from pairwise analysis of RFA (row) vs BCC (column) is 0.85 (95% CI, 0.54–1.35). The SR technique comparisons obtained from the network meta-analysis are below the leading diagonal line, in the lower triangle. These are calculated as the treatment in the column vs the treatment in the row. Both pairwise and network estimates were presented as point estimates and corresponding 95% CIs.

Quality assessment

The quality assessment showed that all included studies have high quality with NOS scores for 2 studies being 9[7,15] and for 1 study being 8,[9] whereas the rest of the studies had a score of 7.[8,11,12,14] The details of the quality assessment are reported in the Supplemental Table.

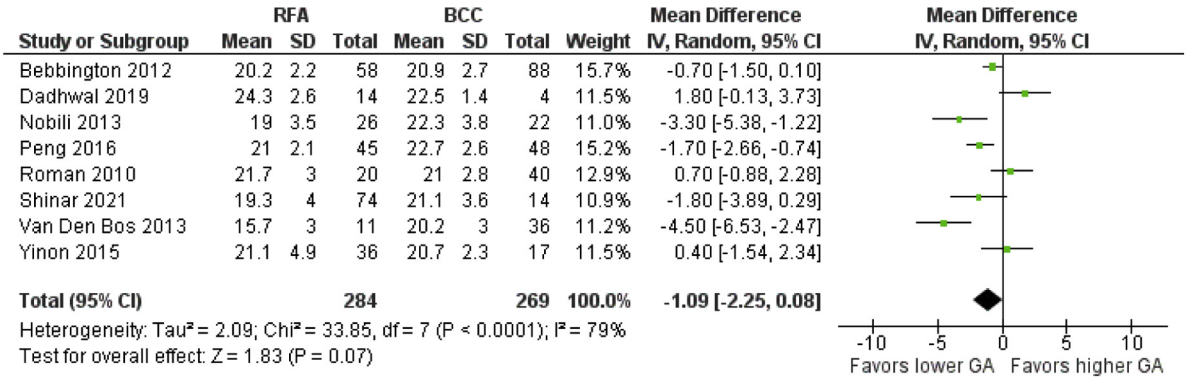
Discussion

Principal findings

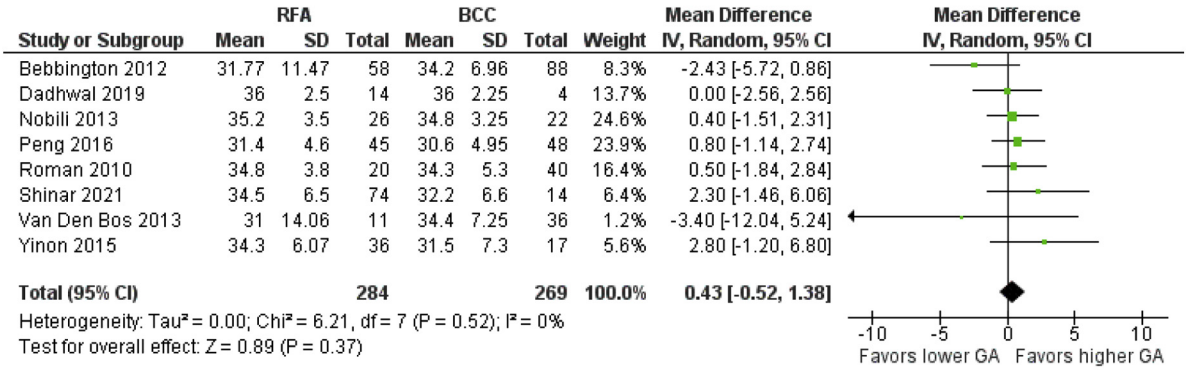
The principal findings of our systematic review and meta-analysis for SR in MC pregnancies were that RFA was found to have a higher interval from procedure to delivery, and lower rates of PPROM and PTB than BCC. There was no survival difference between IL ablation and RFA, but we did find a lower survival rate when IL ablation was compared with BCC.

FIGURE 2
Meta-analysis of pregnancy outcomes after RFA vs BCC

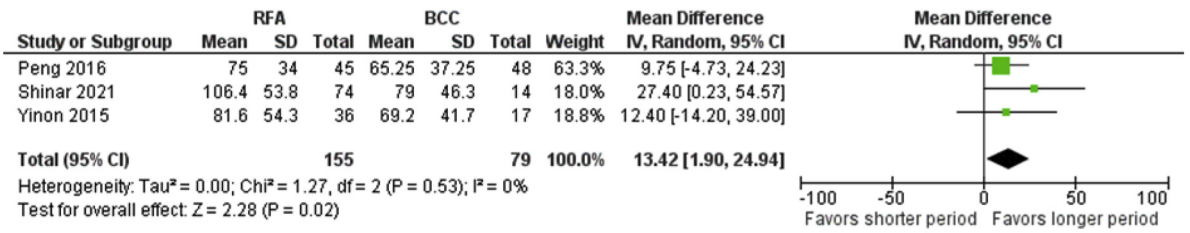
A GA at procedure



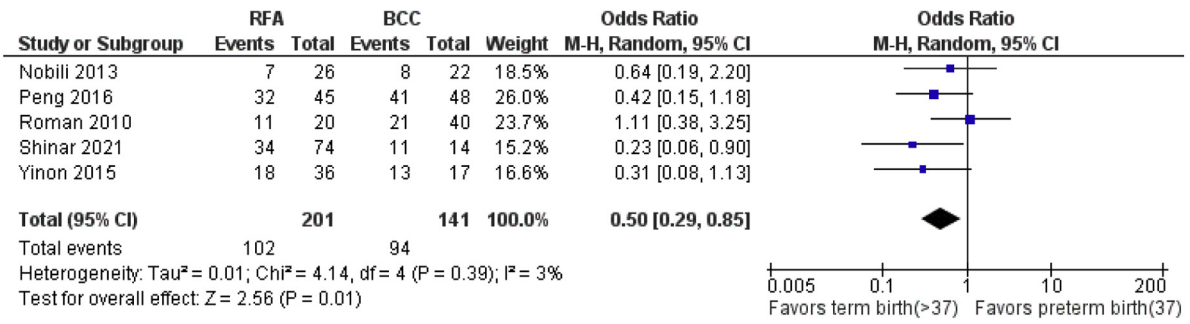
B GA at delivery



C Procedure to delivery interval (days)



D PTB < 37 weeks



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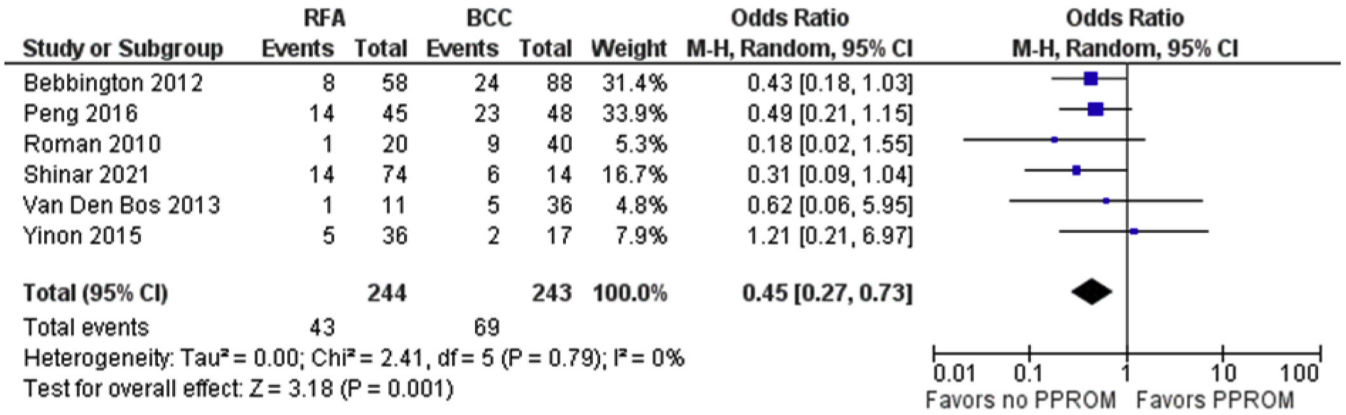
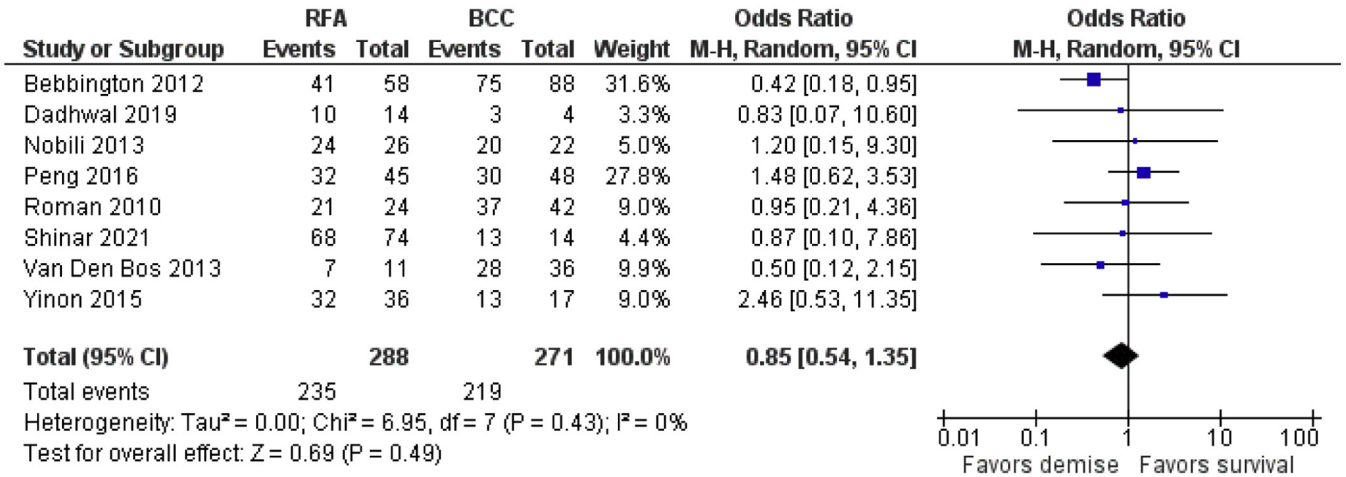
(continued)

FIGURE 2
Continued

E PPROM



F Survival



G Birthweight

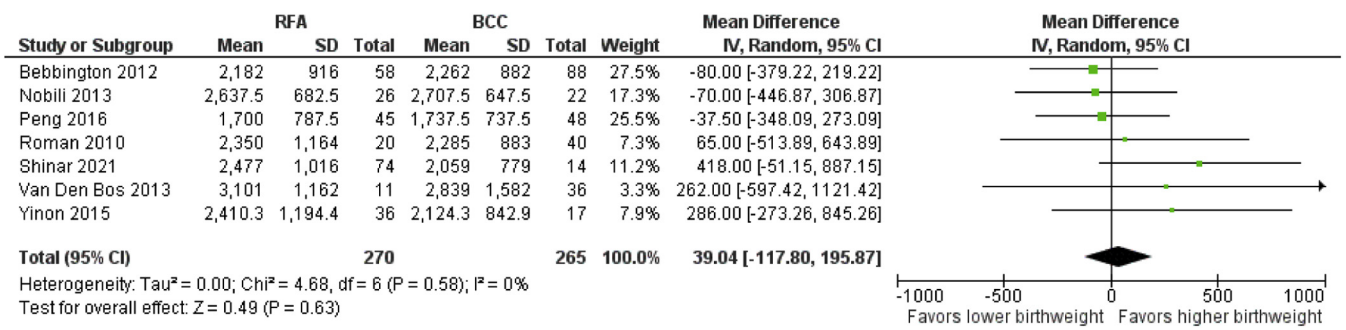
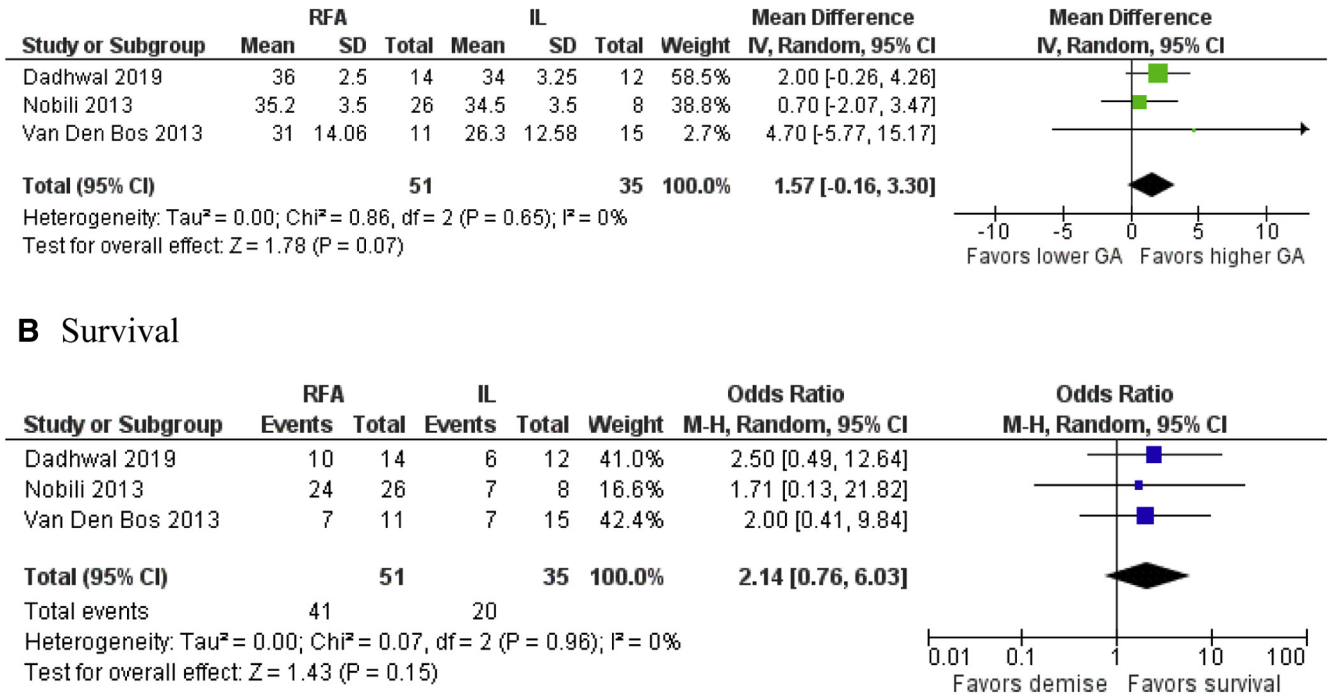


FIGURE 3
Meta-analysis of pregnancy outcomes after RFA vs IL



Meta-analysis of pregnancy outcomes after RFA vs IL in terms of (**A**) GA at delivery and (**B**) survival.

CI, confidence interval; *IL*, interstitial laser; *IV*, weighted mean difference; *M-H*, Mantel-Haenszel; *RFA*, radiofrequency ablation; *SD*, standard deviation.

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This study suggested that RFA may have better outcomes in terms of PPROM and PTB than BCC. This may be related to the size of the instruments used for uterine entry. RFA is performed using a 17-gauge needle (1.4 mm), whereas BCC requires a 10F to 12F cannula (3.3−4 mm) through which the bipolar forceps can be introduced into the uterus for cord coagulation.

Comparison with existing literature

Some may advocate for the use of IL ablation because of the smaller size of the needle used[16]; however, in the study by Ting et al,[17] there was no difference in outcomes between RFA and IL even at earlier GAs. IL ablation, which is performed by introducing a laser fiber through an 18-gauge needle, is typically used in earlier pregnancies. IL has been reported to have higher failure rates at advanced pregnancies.[18] This may be because of the inability to adequately coagulate the larger vessels present in a controlled manner with laser energy.[19,20]

Robyr et al[21] found that BCC was associated with worse outcomes when performed before 18 weeks of gestation. Most centers prefer this option for late second-trimester cases after 18 weeks of gestation. We did not find any differences between RFA and BCC concerning the GA at intervention.

Another important question was whether the outcomes are different based on the indication for the SR. The studies suggested that SR performed for sFGR is associated with a higher survival rate than in TTTS.[11] It has been hypothesized that, in TTTS, both the donor and recipient are potentially affected and that, despite targeting the sicker twin, the co-twin may be too sick to recover. The associated polyhydramnios in TTTS increases the risk of PPROM[22] and PTB. The rates of co-twin death in cases of SR for TTTS have been reported to be as high as 22% to 25%.[23,24] In the systematic review by Rossi et al,[25] the authors suggested that the indication for SR may

Meta-analysis of pregnancy outcomes after RFA vs BCC in terms of (**A**) GA at procedure, (**B**) GA at delivery, (**C**) procedure to delivery interval, (**D**) PTB at <37 weeks of gestation, (**E**) PPROM, (**F**) survival, and (**G**) birthweight.

BCC, bipolar cord coagulation; *CI*, confidence interval; *IV*, weighted mean difference; *M-H*, Mantel-Haenszel; *GA*, gestational age; *PPROM*, preterm premature rupture of membranes; *PTB*, preterm birth; *RFA*, radiofrequency ablation; *SD*, standard deviation.

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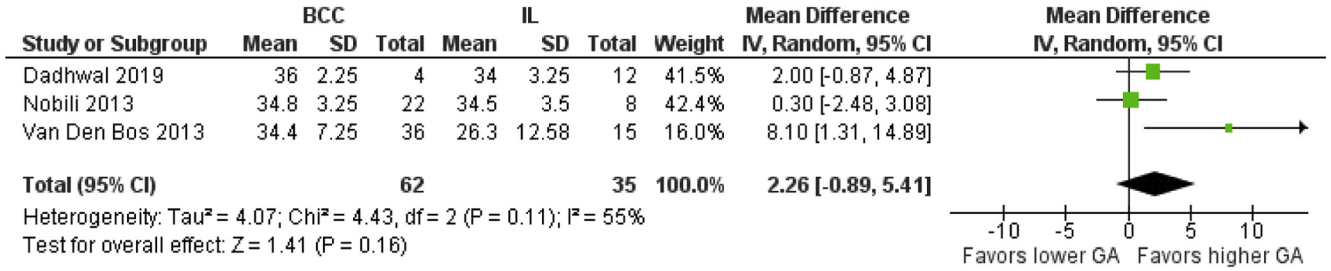
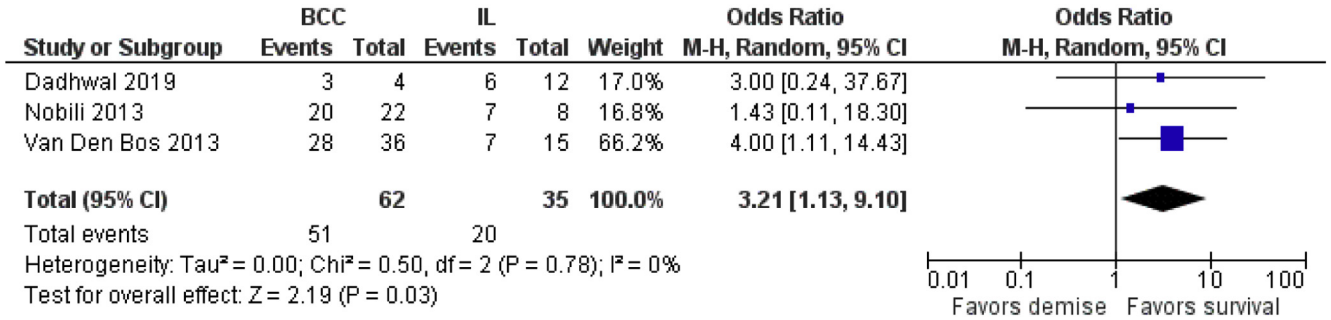
FIGURE 4
Meta-analysis of pregnancy outcomes after BCC vs IL

A GA at delivery



B Survival



Meta-analysis of pregnancy outcomes after BCC vs IL in terms of (**A**) GA at delivery and (**B**) survival.

BCC, bipolar cord coagulation; *IL*, interstitial laser; *IV*, weighted mean difference; *M-H*, Mantel-Haenszel.

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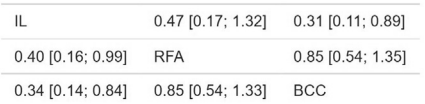
determine the type of procedure used and that the underlying pathology may not have any effect on outcomes. BCC is more likely to be selected in TTTS, whereas RFA is preferred for TRAP because of the shorter available cord segment.

A meta-analysis reviewing SR techniques in 2015[26] analyzed 3 studies and compared the outcomes between RFA and BCC. Our meta-analysis included a total of 8 studies with analyses of RFA vs BCC, RFA vs IL, and BCC vs IL. Our study supported the findings of the previous study showing higher PPROM and PTB rates with BCC. In terms of survival and live birth rates when BCC was compared with RFA, we did not show a higher rate for BCC, and we found lower PPROM and PTB rates with RFA. Thus, our meta-analysis suggested a potential benefit with RFA. These different results may be because of the inclusion of a larger number of patients. Moreover, it may be because of increased experience with RFA over the intervening years resulting in better contemporary outcomes than those originally reported.

FIGURE 5
Network meta-analysis of fetal survival after RFA vs BCC vs IL



BCC, bipolar cord coagulation; *IL*, interstitial laser; *RFA*, radiofrequency ablation.

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Strengths and limitations

This review was limited by the small number of eligible studies included in the analysis and selection bias based on the clinician's preferences and each centers' policies. Most studies were case series with a small sample size potentially resulting in the data having no statistical significance. There was limited information on crucial preprocedure risk factors, such as cervical length, maternal history of PTB, and other factors that may affect outcomes. Another limitation was the lack of data on FL, which prevented the meta-analysis to compare this technique with other techniques. However, having stated this, our study did represent the largest number of combined cases to date.

Conclusions and implications

There was no difference in survival rate between RFA and BCC, but RFA was associated with lower PPROM and PTB. When technically feasible, RFA may be a reasonable option to minimize risks. Although survival rates were similar between RFA and BCC, long-term studies are needed to assess the effects of PTB on the surviving fetus. Further well-designed prospective studies comparing RFA and BCC with IL and FL are required. ■

REFERENCES

1. Bebbington M. Selective reduction in complex monochorionic gestations. Am J Perinatol 2014;31(Suppl1):S51–8.

2. Ong SS, Zamora J, Khan KS, Kilby MD. Prognosis for the co-twin following single-twin death: a systematic review. BJOG 2006;113:992–8.

3. Quarello E, Molho M, Ville Y. Incidence, mechanisms, and patterns of fetal cerebral lesions in twin-to-twin transfusion syndrome. J Matern Fetal Neonatal Med 2007;20:589–97.

4. Moher D, Liberati A, Tetzlaff J, Altman DG; PRISMA Group. Preferred reporting items for systematic reviews and meta-analyses: the PRISMA statement. PLoS Med 2009;6:e1000097.

5. Stang A. Critical evaluation of the Newcastle-Ottawa scale for the assessment of the quality of nonrandomized studies in meta-analyses. Eur J Epidemiol 2010;25:603–5.

6. Hozo SP, Djulbegovic B, Hozo I. Estimating the mean and variance from the median, range, and the size of a sample. BMC Med Res Methodol 2005;5:13.

7. 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.

8. Bebbington MW, Danzer E, Moldenhauer J, Khalek N, Johnson MP. Radiofrequency ablation vs bipolar umbilical cord coagulation in the management of complicated monochorionic pregnancies. Ultrasound Obstet Gynecol 2012;40:319–24.

9. van den Bos EM, van Klink JM, Middeldorp JM, Klumper FJ, Oepkes D, Lopriore E. Perinatal outcome after selective feticide in monochorionic twin pregnancies. Ultrasound Obstet Gynecol 2013;41:653–8.

10. Nobili E, Paramasivam G, Kumar S. Outcome following selective fetal reduction in monochorionic and dichorionic twin pregnancies discordant for structural, chromosomal and genetic disorders. Aust N Z J Obstet Gynaecol 2013;53:114–8.

11. Yinon Y, Ashwal E, Weisz B, Chayen B, Schiff E, Lipitz S. Selective reduction in complicated monochorionic twins: prediction of obstetric outcome and comparison of techniques. Ultrasound Obstet Gynecol 2015;46:670–7.

12. 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 Investig 2016;81:552–8.

13. Abdel-Sattar M, Chon AH, Llanes A, Korst LM, Ouzounian JG, Chmait RH. Comparison of umbilical cord occlusion methods: radiofrequency ablation versus laser photocoagulation. Prenat Diagn 2018;38:110–6.

14. Dadhwal V, Sharma AK, Deka D, Chawla L, Agarwal N. Selective fetal reduction in monochorionic twins: preliminary experience. J Turk Ger Gynecol Assoc 2019;20:79–83.

15. Shinar S, Agrawal S, El-Chaâr D, et al. Selective fetal reduction in complicated monochorionic twin pregnancies: a comparison of techniques. Prenat Diagn 2021;41:52–60.

16. Lewi L, Gratacos E, Ortibus E, et al. Pregnancy and infant outcome of 80 consecutive cord coagulations in complicated monochorionic multiple pregnancies. Am J Obstet Gynecol 2006;194:782–9.

17. Ting YH, Poon LCY, Tse WT, et al. Outcome of radiofrequency ablation for selective fetal reduction before vs at or after 16 gestational weeks in complicated monochorionic pregnancy. Ultrasound Obstet Gynecol 2021;58:214–20.

18. Paramasivam G, Wimalasundera R, Wiechec M, Zhang E, Saeed F, Kumar S. Radiofrequency ablation for selective reduction in complex monochorionic pregnancies. BJOG 2010;117:1294–8.

19. Hecher K, Lewi L, Gratacos E, Huber A, Ville Y, Deprest J. Twin reversed arterial perfusion: fetoscopic laser coagulation of placental anastomoses or the umbilical cord. Ultrasound Obstet Gynecol 2006;28:688–91.

20. Ville Y, Hyett JA, Vandenbussche FPHA, Nicolaides KH. Endoscopic laser coagulation of umbilical cord vessels in twin reversed arterial perfusion sequence. Ultrasound Obstet Gynecol 1994;4:396–8.

21. Robyr R, Yamamoto M, Ville Y. Selective feticide in complicated monochorionic twin pregnancies using ultrasound-guided bipolar cord coagulation. BJOG 2005;112:1344–8.

22. Hoffman M, Habli M, Donepudi R, et al. Perinatal outcomes of single fetal survivor after fetal intervention for complicated monochorionic twins. Prenat Diagn 2018;38:511–6.

23. Kumar S, Paramasivam G, Zhang E, et al. Perinatal- and procedure-related outcomes following radiofrequency ablation in monochorionic pregnancy. Am J Obstet Gynecol 2014;210:454.e1–6.

24. Lanna MM, Rustico MA, Dell'Avanzo M, et al. Bipolar cord coagulation for selective feticide in complicated monochorionic twin pregnancies: 118 consecutive cases at a single center. Ultrasound Obstet Gynecol 2012;39:407–13.

25. Rossi AC, D'Addario V. Umbilical cord occlusion for selective feticide in complicated monochorionic twins: a systematic review of literature. Am J Obstet Gynecol 2009;200:123–9.

26. Gaerty K, Greer RM, Kumar S. Systematic review and metaanalysis of perinatal outcomes after radiofrequency ablation and bipolar cord occlusion in monochorionic pregnancies. Am J Obstet Gynecol 2015;213:637–43.

SUPPLEMENTAL TABLE

Newcastle-Ottawa scale (NOS) quality assessment for included studies

	Selection				Comparability	Outcome			
Study	1	2	3	4	5	6	7	8	NOS
Roman et al,[7] 2010	*	*	*	*	**	*	*	*	9
Bebbington,[8] 2012	*	*	*	*		*	*	*	7
Van Den Bos et al,[9] 2013	*	*	*	*	*	*	*	*	8
Nobili et al,[10] 2013	*	*	*	*		*	*	*	7
Yinon et al,[11] 2015	*	*	*	*		*	*	*	7
Peng et al,[12] 2016	*	*	*	*		*	*	*	7
Dadhwal et al,[14] 2019	*	*	*	*		*	*	*	7
Shinar et al,[15] 2021	*	*	*	*	**	*	*	*	9

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PRISMA 2020 Checklist

Section and Topic	Item #	Checklist item	Location where item is reported
TITLE			
Title	1	Identify the report as a systematic review.	Page 1
ABSTRACT			
Abstract	2	See the PRISMA 2020 for Abstracts checklist.	Pages 5-6
INTRODUCTION			
Rationale	3	Describe the rationale for the review in the context of existing knowledge.	Page 7-8
Objectives	4	Provide an explicit statement of the objective(s) or question(s) the review addresses.	Page 7-8
METHODS			
Eligibility criteria	5	Specify the inclusion and exclusion criteria for the review and how studies were grouped for the syntheses.	Pages 8- 9
Information sources	6	Specify all databases, registers, websites, organisations, reference lists and other sources searched or consulted to identify studies. Specify the date when each source was last searched or consulted.	Page 8
Search strategy	7	Present the full search strategies for all databases, registers and websites, including any filters and limits used.	Page 8
Selection process	8	Specify the methods used to decide whether a study met the inclusion criteria of the review, including how many reviewers screened each record and each report retrieved, whether they worked independently, and if applicable, details of automation tools used in the process.	Page 9
Data collection process	9	Specify the methods used to collect data from reports, including how many reviewers collected data from each report, whether they worked independently, any processes for obtaining or confirming data from study investigators, and if applicable, details of automation tools used in the process.	Page 9
Data items	10a	List and define all outcomes for which data were sought. Specify whether all results that were compatible with each outcome domain in each study were sought (e.g. for all measures, time points, analyses), and if not, the methods used to decide which results to collect.	Page 9

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PRISMA 2020 Checklist *(continued)*

Section and Topic	Item #	Checklist item	Location where item is reported
	10b	List and define all other variables for which data were sought (e.g. participant and intervention characteristics, funding sources). Describe any assumptions made about any missing or unclear information.	Page 9
Study risk of bias assessment	11	Specify the methods used to assess risk of bias in the included studies, including details of the tool(s) used, how many reviewers assessed each study and whether they worked independently, and if applicable, details of automation tools used in the process.	Page 9
Effect measures	12	Specify for each outcome the effect measure(s) (e.g. risk ratio, mean difference) used in the synthesis or presentation of results.	Pages 9-10
Synthesis methods	13a	Describe the processes used to decide which studies were eligible for each synthesis (e.g. tabulating the study intervention characteristics and comparing against the planned groups for each synthesis (item #5)).	Page 10
	13b	Describe any methods required to prepare the data for presentation or synthesis, such as handling of missing summary statistics, or data conversions.	N/A
	13c	Describe any methods used to tabulate or visually display results of individual studies and syntheses.	N/A
	13d	Describe any methods used to synthesize results and provide a rationale for the choice(s). If meta-analysis was performed, describe the model(s), method(s) to identify the presence and extent of statistical heterogeneity, and software package(s) used.	Page 10
	13e	Describe any methods used to explore possible causes of heterogeneity among study results (e.g. subgroup analysis, meta-regression).	Pages 10
	13f	Describe any sensitivity analyses conducted to assess robustness of the synthesized results.	Pages 10
Reporting bias assessment	14	Describe any methods used to assess risk of bias due to missing results in a synthesis (arising from reporting biases).	Page 11-12
Certainty assessment	15	Describe any methods used to assess certainty (or confidence) in the body of evidence for an outcome.	N/A
RESULTS			
Study selection	16a	Describe the results of the search and selection process, from the number of records identified in the search to the number of studies included in the review, ideally using a flow diagram.	Page 10-11
	16b	Cite studies that might appear to meet the inclusion criteria, but which were excluded, and explain why they were excluded.	Page 10-11
Study characteristics	17	Cite each included study and present its characteristics.	Page 10-11 and table 1
Risk of bias in studies	18	Present assessments of risk of bias for each included study.	Table 1 and supplementary
Results of individual studies	19	For all outcomes, present, for each study: (a) summary statistics for each group (where appropriate) and (b) an effect estimate and its precision (e.g. confidence/credible interval), ideally using structured tables or plots.	Page 10-11
Results of syntheses	20a	For each synthesis, briefly summarise the characteristics and risk of bias among contributing studies.	page 11-12

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PRISMA 2020 Checklist *(continued)*

Section and Topic	Item #	Checklist item	Location where item is reported
	20b	Present results of all statistical syntheses conducted. If meta-analysis was done, present for each the summary estimate and its precision (e.g. confidence/credible interval) and measures of statistical heterogeneity. If comparing groups, describe the direction of the effect.	Pages 11-12
	20c	Present results of all investigations of possible causes of heterogeneity among study results.	Pages 11-12
	20d	Present results of all sensitivity analyses conducted to assess the robustness of the synthesized results.	Pages 11-12
Reporting biases	21	Present assessments of risk of bias due to missing results (arising from reporting biases) for each synthesis assessed.	N/A
Certainty of evidence	22	Present assessments of certainty (or confidence) in the body of evidence for each outcome assessed.	N/A
DISCUSSION			
Discussion	23a	Provide a general interpretation of the results in the context of other evidence.	Page 13-14
	23b	Discuss any limitations of the evidence included in the review.	page 14-15
	23c	Discuss any limitations of the review processes used.	page 14-15
	23d	Discuss implications of the results for practice, policy, and future research.	pages 14-15
OTHER INFORMATION			
Registration and protocol	24a	Provide registration information for the review, including register name and registration number, or state that the review was not registered.	page 8
	24b	Indicate where the review protocol can be accessed, or state that a protocol was not prepared.	NA
	24c	Describe and explain any amendments to information provided at registration or in the protocol.	NA
Support	25	Describe sources of financial or non-financial support for the review, and the role of the funders or sponsors in the review.	page 15
Competing interests	26	Declare any competing interests of review authors.	page 15
Availability of data, code and other materials	27	Report which of the following are publicly available and where they can be found: template data collection forms; data extracted from included studies; data used for all analyses; analytic code; any other materials used in the review.	NA

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