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Original Article

A Comparison of Perinatal and Neonatal Outcomes between Complicated Monochorionic Triamniotic and Dichorionic Triamniotic Pregnancies after Selective Fetal Reduction by Radiofrequency Ablation

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ABSTRACT

Background: Triplet pregnancies are associated with significant perinatal and neonatal morbidity and mortality, often necessitating selective fetal reduction (SFR) to improve outcomes. This study compares perinatal and neonatal outcomes between complicated monochorionic triamniotic (MC-TA) and dichorionic triamniotic (DC-TA) triplet pregnancies undergoing selective fetal reduction using radiofrequency ablation (RFA).

Methods: This retrospective cohort study, conducted at Yas Hospital, Tehran, Iran, from March 2017 to March 2024, included all complicated MC-TA and DC-TA triplet pregnancies undergoing RFA between 16 and 26 weeks' gestation. Outcomes included live birth rate, miscarriage rate, gestational age at delivery, and neonatal metrics (birth weight, Apgar scores, and neonatal intensive care unit [NICU] admission). Data were analyzed using SPSS version 24.0, with statistical significance set at $p < 0.05$.

Results: Of 32 triplet pregnancies (20 DC-TA and 12 MC-TA), the mean gestational age at RFA was significantly lower in MC-TA (19.58 ± 1.8 weeks) than in DC-TA (22.3 ± 2.1 weeks; $p = 0.005$). Twin-to-twin transfusion syndrome (TTTS) was the primary indication for MC-TA (50%), while selective fetal growth restriction (FGR) predominated in DC-TA (45%). The overall pregnancy survival rate was 78.1%, with live birth rates of 70% in MC-TA and 74.3% in DC-TA ($p = 0.72$). Miscarriage rates were 25% in MC-TA and 20% in DC-TA ($p = 0.68$). Mean gestational age at delivery (MC-TA: 35.1 ± 2.3 weeks; DC-TA: 34.4 ± 3.0 weeks; $p = 0.51$) and neonatal outcomes (birth weight, Apgar scores, and NICU admission) were comparable.

Conclusion: RFA is an effective intervention for selective fetal reduction in complicated triplet pregnancies, yielding a 78.1% pregnancy survival rate with no significant differences in perinatal or neonatal outcomes between MC-TA and DC-TA groups. RFA is recommended as a safe, minimally invasive option, with post-procedure ultrasound monitoring advised to mitigate complications.

Keywords: Dichorionic triamniotic, Monochorionic triamniotic, Neonatal outcomes, Perinatal outcomes, Radiofrequency ablation, Selective fetal reduction

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Introduction

The incidence of triplet pregnancies has increased significantly in recent decades, driven by assisted reproductive technologies (ART) and rising maternal age (1, 2). In 2020, the United States reported a triplet pregnancy rate of 1 in 1,300, reflecting a persistent upward trend (3). Despite advancements in neonatal care, triplet pregnancies are associated with substantial maternal and fetal complications, including gestational diabetes, preeclampsia, preterm labor (PTL), miscarriage, fetal growth restriction (FGR), and neurodevelopmental issues (4–6). Monochorionic triamniotic (MC-TA) pregnancies, characterized by a shared placenta, face unique risks such as twin-to-twin transfusion syndrome (TTTS) and selective FGR due to vascular anastomoses, which exacerbate adverse outcomes compared to dichorionic triamniotic (DC-TA) pregnancies with at least one separate placenta (7, 8).

Selective fetal reduction (SFR) is a critical intervention to mitigate these complications, aiming to improve perinatal and neonatal outcomes for the remaining fetuses (9). Methods such as bipolar cord coagulation, fetoscopic laser occlusion, potassium chloride (KCl) injection, and radiofrequency ablation (RFA) have been described, with RFA gaining attention as a minimally invasive technique that uses ultrasound-guided thermal energy to occlude fetal blood flow (10–12). While RFA is associated with high success rates, it carries risks such as preterm premature rupture of membranes (PROM) and intrauterine fetal death (IUFD) (13, 14).

Despite the growing use of RFA, there is a significant gap in the literature regarding its comparative efficacy in MC-TA versus DC-TA triplet pregnancies. Most studies focus on twin pregnancies or combine twins and triplets, limiting specific insights into triplet-specific outcomes (13, 15, 16). Furthermore, the impact of chorionicity on RFA outcomes remains underexplored, particularly in complicated triplet pregnancies where differences in placental sharing may influence complication rates and survival (7, 17). This study addresses this gap by comparing perinatal and neonatal outcomes following RFA in MC-TA and DC-TA triplet pregnancies, hypothesizing that MC-TA pregnancies, due to shared placental circulation, may exhibit higher complication rates (e.g., miscarriage or IUFD) compared to DC-TA pregnancies. The findings aim to inform clinical decision-making and optimize SFR strategies for these high-risk pregnancies.

Methods

Study Design and Population This retrospective cohort study was conducted at Yas Hospital, a tertiary referral center for fetal medicine affiliated with Tehran University of Medical Sciences, Tehran, Iran, from March 2017 to March 2024. The study included all complicated MC-TA and DC-TA triplet pregnancies undergoing selective fetal reduction via RFA between 16 and 26 weeks' gestation. Complicated triplet pregnancies were defined as those with indications for SFR, including TTTS, selective FGR, fetal anomalies, or acardiac fetus. Exclusion criteria included incomplete medical records, non-triplet pregnancies, or RFA performed outside the specified gestational window. The study was approved by the Ethics Committee of Tehran University of Medical Sciences (IR.TUMS.MEDICINE.REC.1403.195) and adhered to the Declaration of Helsinki.

Indications and Diagnostic Criteria Indications for SFR included TTTS (staged per Quintero et al. (15)), selective FGR (estimated fetal weight (EFW) <3rd percentile or intertwin/triplet EFW discordance ≥20% (16)), fetal anomalies, acardiac fetus, or maternal request. For MC-TA or monochorionic twins within DC-TA, selective FGR was confirmed using at least two of four Delphi criteria: EFW <10th centile, abdominal circumference <10th centile, EFW discordance ≥25%, or umbilical artery pulsatility index >95th centile (17). Gestational age was determined by first-trimester ultrasound (crown-rump length), with last menstrual period used if ultrasound was unavailable. All patients underwent aneuploidy screening, with amniocentesis for high-risk cases, and detailed anatomic surveys and fetal echocardiography. Amnioreduction was perfor-med for polyhydramnios when indicated.

RFA Procedure RFA was performed under local anesthesia (5 cc subcutaneous lidocaine) and intramuscular sedation (50 mg pethidine, 25 mg promethazine). A 17-gauge radiofrequency needle (RF Medical MYGEN, South Korea) was inserted percutaneously under continuous ultrasound guidance into the umbilical vein at the abdominal cord insertion site of the target fetus (typically the smallest or most compromised). Radiofrequency energy was applied to achieve 100°C for 2 minutes, with up to three cycles if blood flow persisted. Prophylactic amoxicillin (1000 mg) and

indomethacin (50 mg rectal suppository) were administered 30 minutes prior and repeated after 6 hours. Patients were hospitalized for 24 hours, with follow-up ultrasound and Doppler examination of the middle cerebral artery the next day. Follow-up occurred one week post-procedure and continued until delivery.

Statistical Analysis Data were analyzed using SPSS version 24.0 (IBM Corp., Armonk, NY). Normality was assessed using the Shapiro-Wilk test and Q-Q plots. For continuous variables, comparisons between MC-TA and DC-TA groups used independent t-tests for normally distributed data or Mann-Whitney U tests for non-normally distributed data. Categorical variables were analyzed using Chi-square tests or Fisher's exact test when expected cell counts were <5. Effect measures (e.g., odds ratios, mean differences) with 95% confidence intervals (CIs) were reported alongside p-values. Statistical significance was set at $p < 0.05$.

Ethical approval

This study was approved by the Ethics Committee of Tehran University of Medical Sciences (IR.TUMS.MEDICINE.REC.1403.195) and conducted in accordance with the Declaration of Helsinki.

Results

Baseline Characteristics Of 32 triplet pregnancies undergoing RFA (20 DC-TA, 12 MC-TA), 75% of MC-TA pregnancies were spontaneous, while 70% of DC-TA pregnancies were ART-induced (p = 0.047, Fisher's exact test). Maternal age (MC-TA: 32.1 ± 4.2 years; DC-TA: 33.4 ± 3.9 years; p = 0.39), gravidity (p = 0.62), and body mass index (p = 0.55) were comparable. The mean gestational age at RFA was significantly lower in MC-TA (19.58 ± 1.8 weeks) than in DC-TA (22.3 ± 2.1 weeks; 95% CI of difference: -3.88 to -0.76; p = 0.005, t-test). TTTS stage 3 was the primary indication in MC-TA (50%), while selective FGR predominated in DC-TA (45%; p = 0.32, Fisher's exact test). Baseline characteristics are summarized in Table 1.

Perinatal and Neonatal Outcomes The overall pregnancy survival rate was 78.1% (25/32), with no significant difference between groups (MC-TA: 75%, DC-TA: 80%; p = 0.68, Fisher's exact test; odds ratio [OR] 0.75, 95% CI 0.15-3.76). Live birth rates were 70% in the MC-TA group and 74.3% in the DC-TA group (p = 0.72, OR 0.82, 95% CI 0.21-3.15). Miscarriage rates were higher in MC-TA (25%) than in DC-TA (20%), but the difference was not statistically significant (p = 0.68, OR 1.33, 95% CI 0.27-6.61). Three intrauterine fetal deaths (IUFDs) occurred: two in MC-TA (shared chorionic sac) and one in DC-TA (separate sac). Mean gestational age at delivery was 35.1 ± 2.3 weeks in MC-TA and 34.4 ± 3.0 weeks in DC-TA (p = 0.51, 95% CI -1.45 to 2.85). Cesarean delivery was performed in 96% of cases (31/32). Common maternal comorbidities included hypothyroidism (25%), gestational diabetes (20%), and gestational hypertension (5%).

Neonatal outcomes showed no significant differences between groups. Mean birth weight was 2327 ± 412 g in MC-TA versus 2012 ± 389 g in DC-TA (p = 0.22, 95% CI -171 to 801). Apgar scores at 1 and 5 minutes were comparable (p = 0.67 and p = 0.81, respectively). NICU admission occurred in 62.5% (25/40 live-born neonates), with three neonatal deaths (7.5%). Surviving neonates exhibited normal neurodevelopment at one-year follow-up. Outcomes are summarized in Table 2.

Table 1. Baseline Characteristics of MC-TA and DC-TA Pregnancies Undergoing RFA

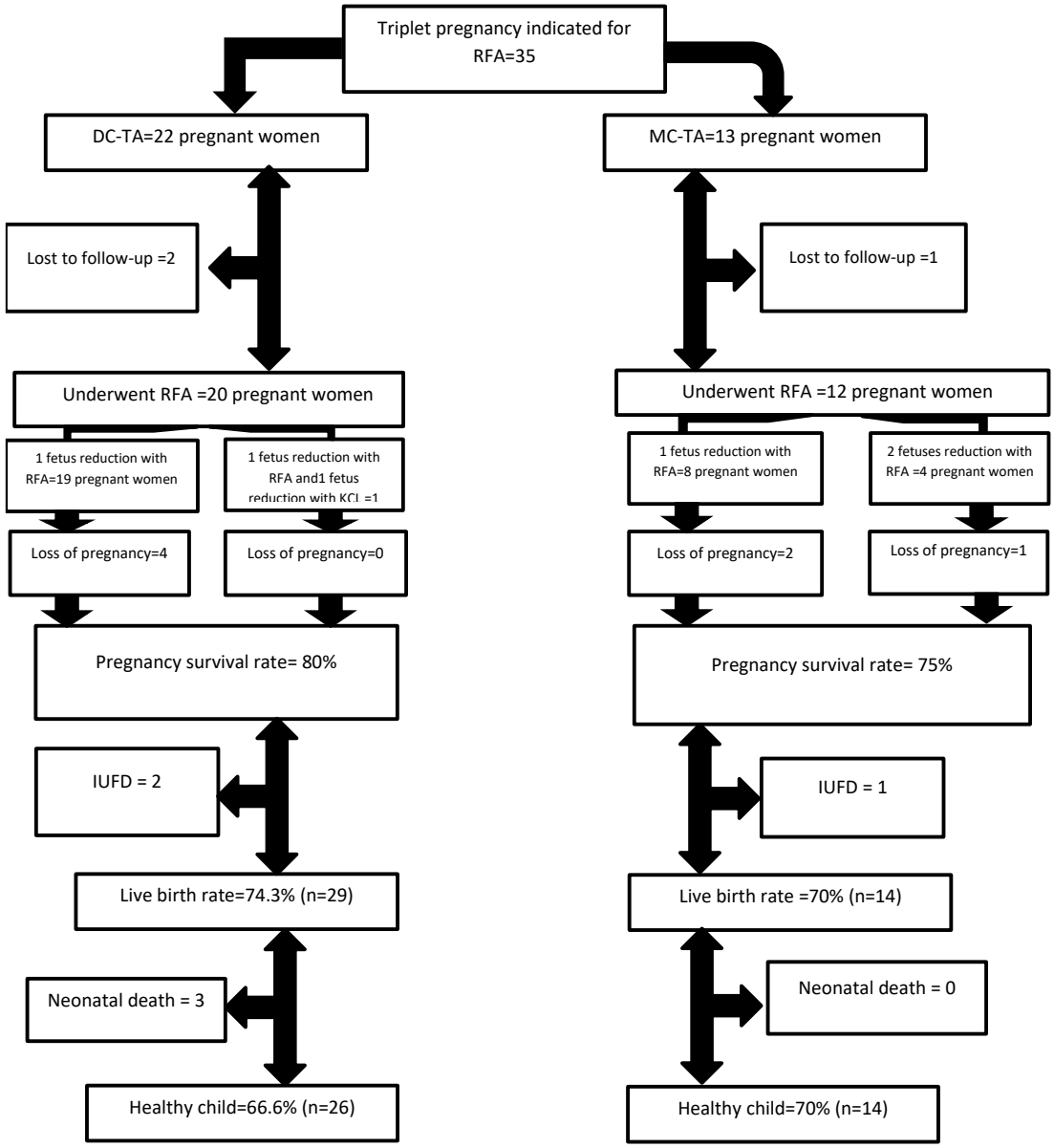
Variable	MC-TA (n=12)	DC-TA (n=20)	p-value (95% CI)
Maternal age (years, mean ± SD)	32.1 ± 4.2	33.4 ± 3.9	0.39 (-4.37, 1.77)
Gravidity (median, IQR)	2 (1-3)	2 (1-3)	0.62
BMI (kg/m^2, mean ± SD)	26.8 ± 3.1	27.4 ± 2.9	0.55 (-2.74, 1.54)
ART-induced pregnancy (%)	25% (3/12)	70% (14/20)	0.047*
Gestational age at RFA (weeks, mean ± SD)	19.58 ± 1.8	22.3 ± 2.1	0.005*
Indication for RFA (%)			0.32
- TTTS	50% (6/12)	20% (4/20)	
- Selective FGR	25% (3/12)	45% (9/20)	
- Fetal anomaly	17% (2/12)	25% (5/20)	
- Acardiac fetus	8% (1/12)	5% (1/20)	
- Maternal request	0%	5% (1/20)	

*Statistically significant (p < 0.05). BMI: body mass index; ART: assisted reproductive technologies; RFA: radiofrequency ablation; TTTS: twin-to-twin transfusion syndrome; FGR: fetal growth restriction.

Table 2. Perinatal and Neonatal Outcomes After RFA

Outcome	MC-TA (n=12)	DC-TA (n=20)	p-value (95% CI or OR)
Pregnancy survival rate (%)	75% (9/12)	80% (16/20)	0.68 (OR 0.75, 0.15-3.76)
Live birth rate (%)	70% (14/20 fetuses)	74.3% (26/35 fetuses)	0.72 (OR 0.82, 0.21-3.15)
Miscarriage rate (%)	25% (3/12)	20% (4/20)	0.68 (OR 1.33, 0.27-6.61)
Gestational age at delivery (weeks, mean ± SD)	35.1 ± 2.3	34.4 ± 3.0	0.51 (-1.45, 2.85)
Birth weight (g, mean ± SD)	2327 ± 412	2012 ± 389	0.22 (-171, 801)
Apgar score at 1 min (median, IQR)	8 (7-9)	8 (7-9)	0.67
Apgar score at 5 min (median, IQR)	9 (8-10)	9 (8-10)	0.81
NICU admission (%)	64.3% (9/14)	61.5% (16/26)	0.85 (OR 1.13, 0.30-4.27)
Neonatal mortality (%)	7.1% (1/14)	7.7% (2/26)	0.94 (OR 0.92, 0.08-10.72)

OR: odds ratio; CI: confidence interval; NICU: neonatal intensive care unit



RFA: Radiofrequency ablation, MC-TA: Monochorionic triamniotic, DC-TA: Dichorionic triamniotic, IUFD: Intrauterine fetal death

Flowchart 1. A summary of our results

Description: Flowchart 1 illustrates the patient selection process and outcomes. It begins with 32 triplet pregnancies (20 DC-TA, 12 MC-TA) undergoing RFA. For DC-TA, 16 pregnancies survived (80%), with 26 live births (74.3%) and 4 miscarriages (20%). For MC-TA, 9 pregnancies survived (75%), with 14 live births (70%) and 3 miscarriages (25%). Three IUFDs are noted (2 MC-TA, 1 DC-TA). The flowchart uses standardized shapes (rectangles for processes, diamonds for decision points) and will be professionally formatted using software (e.g., Microsoft Visio or Adobe Illustrator) for submission.

Discussion

This retrospective cohort study of 32 complicated triplet pregnancies (20 DC-TA and 12 MC-TA) undergoing RFA for selective fetal reduction demonstrated a pregnancy survival rate of 78.1% and a live birth rate of 72.8%, with no significant differences in perinatal or neonatal outcomes between the MC-TA and DC-TA groups. The mean gestational age at RFA was significantly lower in MC-TA (19.58 ± 1.8 weeks) than in DC-TA (22.3 ± 2.1 weeks; p = 0.005), likely reflecting earlier referral for TTTS, the predominant indication in MC-TA (50%). Miscarriage rates (25% in MC-TA vs. 20% in DC-TA; p = 0.68) and neonatal outcomes (birth weight, Apgar scores, and NICU admission) were comparable, suggesting that RFA is effective across different chorionicity types.

Our live birth rate of 72.8% aligns closely with prior studies, such as Gaerty et al.'s 2015 meta-analysis (76.8% survival rate across 320 monochorionic pregnancies) (18) and Zhang et al.'s 2024 study (75.7% live birth rate in 132 cases, including twins and triplets) (15). Similarly, Rahimi-Sharbaf et al. (2021) reported a 71.3% live birth rate in monochorionic twins undergoing RFA, consistent with our findings despite their focus on twins (13). These aligned results support RFA as a reliable method for selective fetal reduction, particularly in complicated multifetal pregnancies. However, our miscarriage rate (22%) was higher than that reported by Zhang et al. (6.81%) (15) but lower than the 22.2% reported by Moise et al. in a smaller cohort (n = 9) (19). This discrepancy may reflect our exclusive focus on triplets, which carry higher baseline risks than twins (6), or differences in operator experience and sample size. In contrast, a 2023 study by Sileo et al. reported a lower survival rate (65%) in MC-TA triplets managed conservatively without SFR, highlighting the benefit of RFA in improving outcomes (7). Conversely, Hessami et al. (2022) found higher survival rates (85%) in triplets reduced to singletons compared to twins, suggesting that the number of remaining fetuses impacts prognosis—a factor not directly assessed in our study (4).

The lack of significant differences in outcomes between MC-TA and DC-TA groups suggests that RFA's efficacy is not substantially influenced by chorionicity, possibly due to the standardized technique targeting the umbilical vein under ultrasound guidance. The higher (though non-significant) miscarriage rate in MC-TA may relate to shared placental circulation, which increases the risk of vascular complications following RFA (8, 23). Complications such as PROM (9.3%) and IUFD (3 cases) underscore the importance of close post-procedure monitoring within 1–2 weeks to detect issues such as chorioamnionitis. The high cesarean section rate (96%) is consistent with national trends in Iran and obstetric indications for preterm deliveries (20). Clinically, RFA appears to be a safe and minimally invasive option for selective fetal reduction, particularly when performed by experienced operators in tertiary centers. These findings support its use in complicated triplet pregnancies and have implications for counseling patients on expected outcomes regardless of chorionicity.

Limitations

The retrospective design, small sample size (n = 32), and lack of randomization limit the generalizability of the findings. Referral bias, inherent to a tertiary center, may have skewed the cohort toward more severe cases. Long-term neurodevelopmental outcomes beyond one year were not assessed, and the study did not compare RFA with other SFR methods (e.g., bipolar cord coagulation). Future multicenter studies or meta-analyses could address these limitations by increasing sample size and incorporating comparative effectiveness data.

Clinical and Research Implications RFA is a viable method for selective fetal reduction in complicated MC-TA and DC-TA triplet pregnancies, offering comparable outcomes across chorionicity types. Clinicians should prioritize post-RFA ultrasound and Doppler monitoring to mitigate complications, particularly in cases with selective FGR, which may increase the risk of associated anomalies (23). Future research should focus on long-term neonatal outcomes, head-to-head comparisons of different SFR techniques, and larger cohorts to confirm these findings. Systematic reviews combining triplet-specific data could further elucidate optimal management strategies.

Conclusion

RFA for selective fetal reduction in complicated MC-TA and DC-TA triplet pregnancies achieved a 78.1% pregnancy survival rate, with no significant differences in live birth rate (70% vs. 74.3%), miscarriage rate (25% vs. 20%), or neonatal outcomes (birth weight, Apgar scores, NICU admission) between groups. RFA is a safe and

effective intervention, but post-procedure monitoring is essential. Delivery in centers with specialized staff and facilities is recommended to optimize outcomes.

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Conflicts of interest

The authors declare no conflict of interest related to this study.

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