BMC Pregnancy and Childbirth

CASE REPORT

Open Access

Individualized intervention and growth dynamics assessment in TRAP sequence with conjoined twins based on radiofrequency ablation

Hua Lai[1,2†], Huiting Zhu[1†], Jinliang Zhang[1], Juhua Xiao[3], Mengjiao Liu[4], Danping Liu[5], Zengming Li[2*] and Xin Zhou[3*]

Abstract

Background Twin reversed arterial perfusion (TRAP) sequence with conjoined twins (CTs) represents an exceedingly rare and critical complication in monochorionic monoamniotic (MCMA) twin pregnancies. High mortality rates are associated with this condition, making early diagnosis and management crucial for improving survival outcomes, particularly for the pump twin.

Case presentation This case report focuses on a unique instance of TRAP-associated CTs, diagnosed at 13 weeks and 1 day of gestation. Management involved detailed ultrasonography and radiofrequency ablation (RFA) at 18 weeks and 5 days to interrupt the blood supply to the non-viable acardiac twin. This intervention allowed the pump twin to continue normal development, culminating in a cesarean delivery at 35 weeks and 1 day. The newborn showed a healthy postnatal outcome with no significant neurodevelopmental deficits noted at follow-up.

Conclusions Early identification and tailored intervention are essential in cases of TRAP sequence associated with conjoined twins. This case exemplifies the potential of integrated multidisciplinary approaches and timely use of RFA, which significantly enhance the prognosis for the viable twin. These strategies are vital for managing complex MCMA pregnancies and can inform future clinical practices.

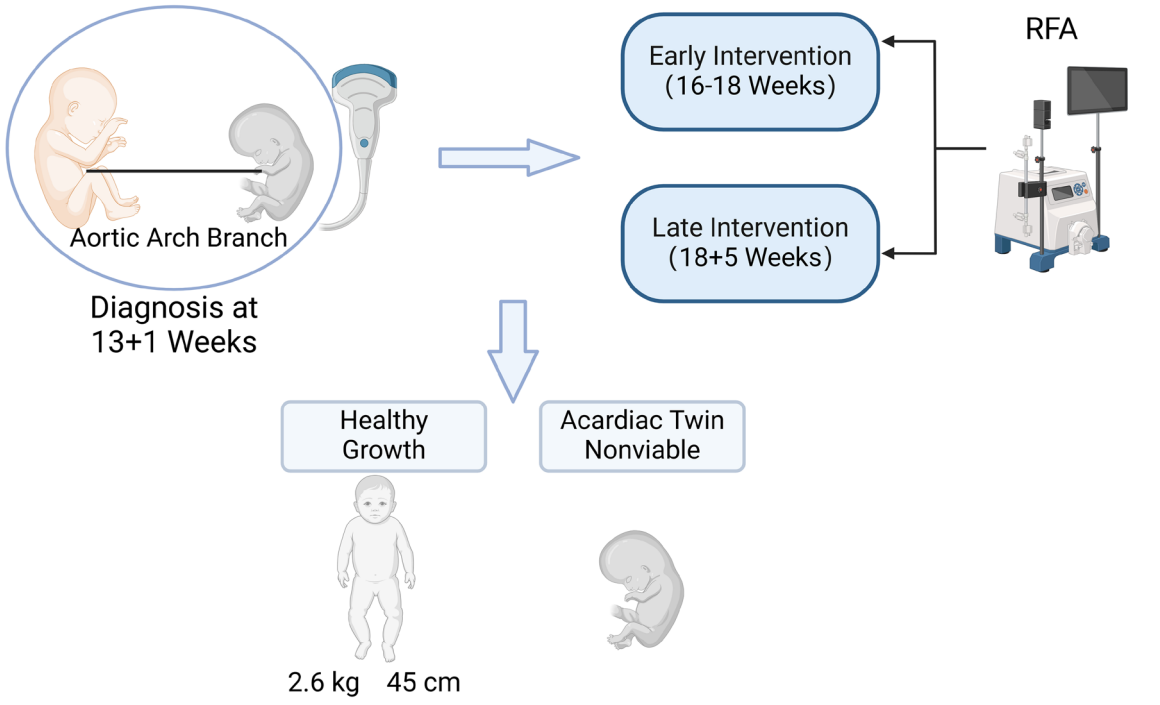
Keywords Twin reversed arterial perfusion, Conjoined twins, Monochorionic monoamniotic, Radiofrequency ablation, Fetal growth curve, Perinatal management

†Hua Lai and Huiting Zhu regarded as co-first authors.

*Correspondence:
Zengming Li
lizengming0707@163.com
Xin Zhou
jxsfbcsk@163.com

Full list of author information is available at the end of the article

Graphical abstract



Background

Twin Reversed Arterial Perfusion (TRAP) sequence is a rare complication unique to monochorionic (MC) twin pregnancies, with a traditionally reported incidence of approximately 1% among MC twins and 1 in 35,000 pregnancies overall. However, with the widespread application of early pregnancy ultrasonography and assisted reproductive technologies (ART), the actual incidence may be higher, estimated at 1 in 40 MC twin pregnancies and 1 in 15,000 overall pregnancies [1–3]. Recent meta-analyses suggest that this increase may largely reflect enhanced ultrasound sensitivity [4], while ART may contribute to a shift in baseline incidence by inducing multifetal gestations [5]. Approximately 30% of TRAP cases occur in monochorionic monoamniotic (MCMA) twin pregnancies [6, 7]. Conjoined twins (CTs), a rare subtype of MCMA twins, result from incomplete embryonic division during early development and have an extremely low incidence, ranging from 1 in 50,000 to 1 in 250,000 live births.

The hallmark of TRAP is that the acardiac twin entirely depends on the pump twin's arterial blood supply. This perfusion occurs through placental vascular anastomoses, typically via artery-to-artery connections, or through atypical anatomical routes such as direct branches from the pump twin's aortic arch [8–10]. These abnormal flow patterns are often visualized on prenatal ultrasound [11, 12]. Atypical shunting, particularly involving direct cardiac branches, may impose greater cardiovascular strain on the pump twin, increasing the risk of adverse outcomes. The spontaneous miscarriage rate in TRAP pregnancies is reported to be 35–50% [11, 13, 14], and without intervention, the pump twin has a mortality risk of approximately 30% by 18 weeks of gestation [2, 15, 16]. Therefore, clinical management aims to prolong gestation and prevent complications such as heart failure and fetal hydrops.

Management options include expectant monitoring, radiofrequency ablation (RFA), and laser coagulation. RFA has been widely adopted due to its minimally invasive nature and favorable success rates [2, 17], though the optimal timing of intervention, often between 14 and 18 weeks of gestation, remains debated [1, 11]. Recent advances, such as artificial intelligence combined with Doppler ultrasound for quantifying blood flow, have shown promise for guiding individualized treatment decisions [18, 19].

This study presents a rare case of TRAP sequence associated with conjoined twins, in which the acardiac twin received blood supply from a direct branch of the pump

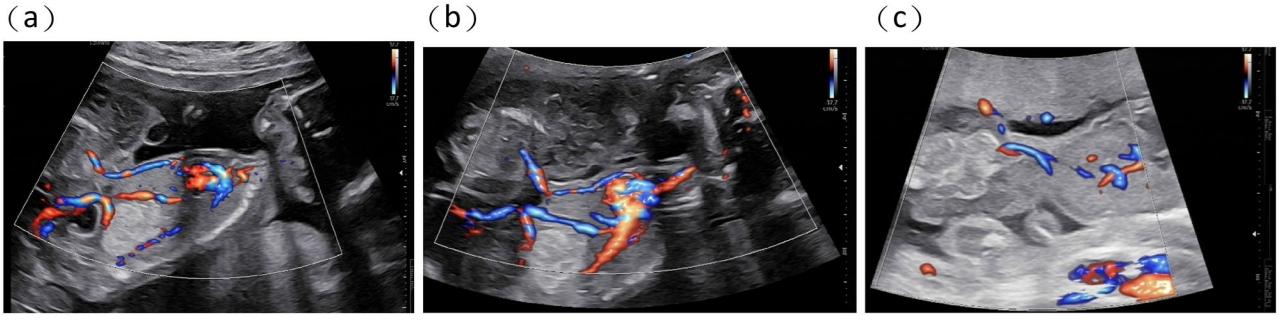


Fig. 1 Blood supply to the acardiac twin and conjoined area. Note: (**a**) The blood supply to the acardiac twin originates from a branch of the pump twin's aortic arch; (**b**) Vessels near the attachment site of the pump twin's umbilical cord; (**c**) The conjoined area between the acardiac twin and the pump twin, with the connection area highlighted. The images were obtained using two-dimensional ultrasound, showing the vascular anastomosis and the conjoined fetal structures

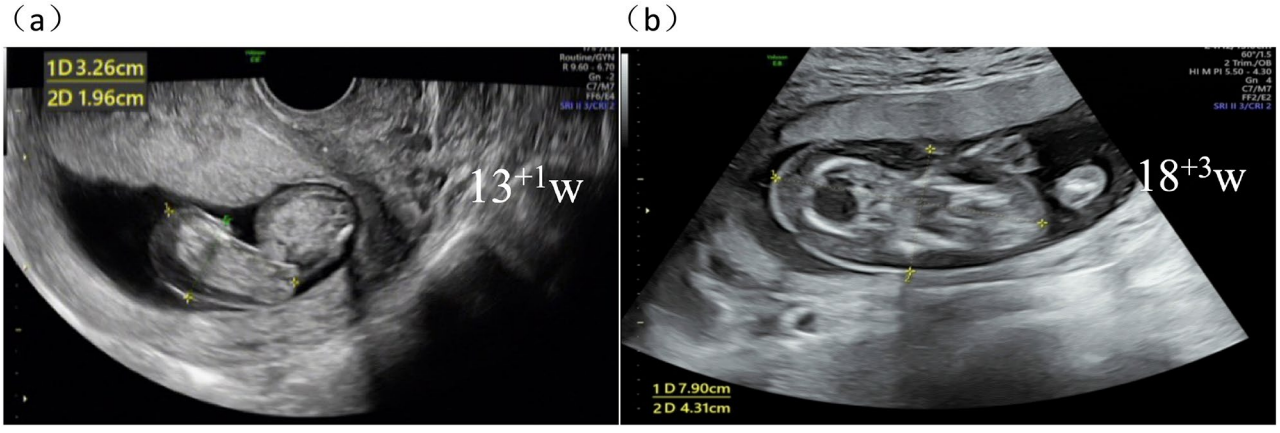


Fig. 2 Ultrasound images of the acardiac twin. Note: (**a**) Ultrasound image of the acardiac twin at 13 weeks and 1 day of gestation, with the fetal size measuring 3.3 × 1.9 cm (**b**) Ultrasound image of the acardiac twin at 18 weeks and 3 days of gestation, with the fetal size measuring 7.9 × 4.3 cm. The images were obtained using standard two-dimensional ultrasound with abdominal scanning, displaying the morphology and growth of the acardiac twin

twin's aortic arch. Through a detailed evaluation of the vascular anatomy and outcomes following RFA, this case highlights the clinical value of individualized management strategies and contributes to optimizing care for complex monochorionic pregnancies.

Case presentation

A 32-year-old Asian woman (G3P1Ab1) was referred after first-trimester ultrasonography and identified a monochorionic monoamniotic (MCMA) twin pregnancy complicated by TRAP sequence. The last menstrual period was recorded as August 12, 2023. Obstetric history included a cesarean delivery of healthy twin daughters in 2014 and a spontaneous miscarriage at 8 weeks of gestation, managed by dilation and curettage. No family history of genetic disorders or congenital anomalies was reported. The partner was healthy.

Pre-pregnancy, mild hypothyroidism was diagnosed and managed with oral levothyroxine (25 μg/day), with TSH levels maintained between 1.2 and 2.5 mIU/L during pregnancy. Pre-pregnancy body mass index (BMI) was 23.4 kg/m^2. There was no history of smoking, alcohol use, radiation exposure, or teratogenic medication exposure. Ultrasound using a Voluson E10 system (GE Healthcare) revealed abnormal arterial flow from a branch of the pump twin's aortic arch, instead of typical placental umbilical vessel anastomoses. The vessel coursed along the pump twin's anterior abdominal wall and entered the acardiac twin through a 6.0-mm-wide conjoined region (Fig. 1a-c), indicating a shared cardiac circulation. At 13 + 1 weeks, MCMA twin pregnancy was confirmed. One fetus was diagnosed as an acardiac twin measuring 3.3 × 1.9 cm, with absent cardiac structures and severely underdeveloped head and torso (Fig. 2a). At 17 + 2 weeks, the acardiac twin showed significant edema and grew to 5.1 × 3.2 cm, while the pump twin had a normal heart rate and umbilical artery Doppler without cardiac dysfunction. By 18 + 3 weeks, the acardiac twin had rapidly enlarged to 7.9 × 4.3 cm (Fig. 2b), growing faster than typically reported in TRAP cases [20, 21]. A multidisciplinary team (obstetrics, fetal medicine, ultrasonography, genetics, pediatrics) determined that continued growth

of the acardiac twin posed a high risk of pump twin cardiac failure and recommended immediate intervention.

At 18 + 5 weeks, ultrasound-guided radiofrequency ablation (RFA) was performed. Under sterile conditions and local anesthesia, transabdominal ultrasound identified the feeding vessel from the pump twin's aortic arch. A 17G needle was inserted obliquely through the abdominal wall, avoiding the pump twin and placenta, and advanced to the proximal segment of the vessel. Ablation was delivered at an initial power of 25 W, increasing to 35 W, with two cycles lasting 4 min 30 s and 1 min 50 s, respectively (total 6 min 20 s). Color Doppler confirmed complete vessel occlusion and cessation of blood flow to the acardiac twin (Fig. 3a-b). Postoperative monitoring showed a pump twin heart rate of 138 bpm and umbilical artery resistance index (RI) of 0.61 without complications. By day 12, the conjoined region had thinned from 6.0 mm to 4.7 mm, and the acardiac twin had detached.

Mid- to late-gestation ultrasound monitoring showed that the pump twin's growth followed the INTERGROWTH-21st standard, with an estimated fetal weight (EFW) of 2.3 kg (P45) at 34 weeks. The acardiac twin gradually regressed in size to 5.8 × 1.5 cm. At 34 + 5 weeks, preterm premature rupture of membranes (PPROM) occurred, and antenatal corticosteroids (dexamethasone) were administered for fetal lung maturation. At 35 + 1 weeks, an emergency cesarean section was performed, delivering a male infant (Fig. 4a) weighing 2.6 kg, measuring 45 cm in length, with an Apgar score of 9. Postnatal echocardiography revealed a 3.1 mm atrial septal defect, a 1.2 mm patent foramen ovale, and a 1.9 mm patent ductus arteriosus. The cranial ultrasound was unremarkable. At a 6-week follow-up, cardiac defects had closed spontaneously, and neurodevelopment was normal.

Placental pathology identified a 1.2 mm-diameter artery extending from a branch of the pump twin's aortic arch to the acardiac twin. The vessel wall showed intact smooth muscle and no intimal hyperplasia (Fig. 4b). The acardiac twin, measuring 6.0 cm in length and 6.0 × 3.0 × 1.5 cm in volume (Fig. 4c), received its entire blood supply from this direct arterial connection. Fibrotic and necrotic tissue was observed in the conjoined region. Growth curve analysis showed that the acardiac twin's weight increased from 7.5 g at 13 + 1 weeks to 92.7 g at 18 + 3 weeks, significantly lower than expected for gestational age (Table 1). The pump twin's weight consistently remained within the normal range (P10-P90), with a birth weight of 2.6 kg (Fig. 5a-b). Notably, from 15 + 2 to 18 + 3 weeks, the acardiac twin exhibited accelerated growth, with an average daily weight gain of 3.2 g, possibly due to the direct cardiac arterial supply [22].

This case features an acardiac twin supplied by a cardiac branch of the pump twin, an uncommon anatomy that may accelerate acardiac growth and increase the hemodynamic burden. In TRAP cases with conjoined twins, miscarriage rates can reach 50%, and pump twin survival with conservative management is 50–70% [2, 11]. RFA may raise survival to 85–90% [17]. Although intervention at 18 + 5 weeks was effective, treatment at 12 to 14 weeks may further reduce risk [23, 24]. This case lacked a third-trimester fetal brain MRI. Ongoing neurodevelopmental follow-up is warranted.

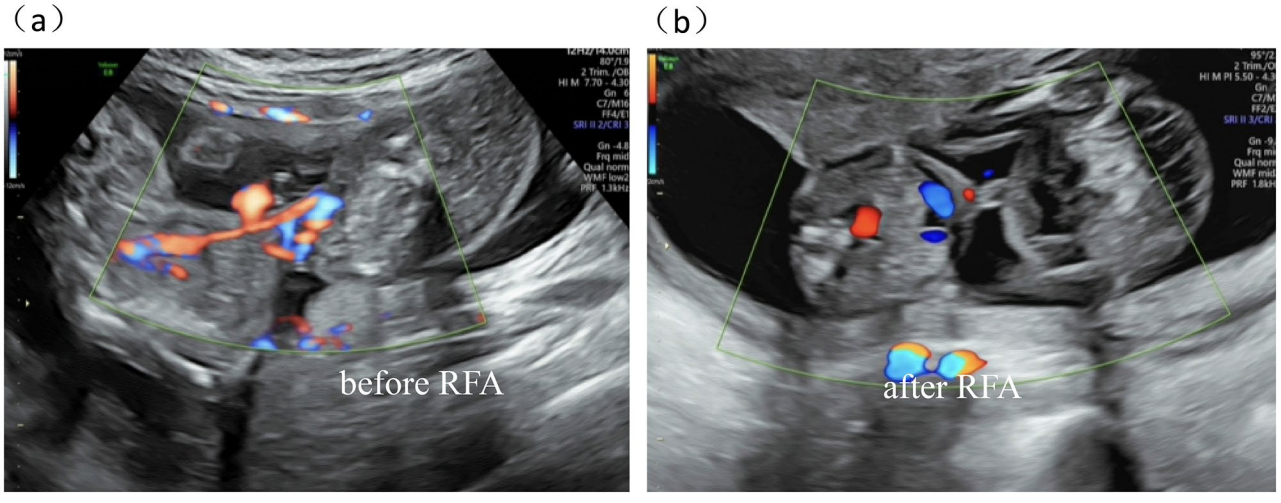


Fig. 3 Comparison of blood supply vessels before and after RFA. Note: (**a**) Color Doppler ultrasound image of the acardiac twin's blood supply vessels before RFA, with the green box indicating the location of the blood supply vessels; (**b**) Color Doppler ultrasound image after RFA showing the occlusion of the blood supply vessels, with the green box marking the area where the vessels have disappeared. The images were obtained using standard two-dimensional ultrasound and color Doppler techniques, showing the changes in blood flow before and after RFA

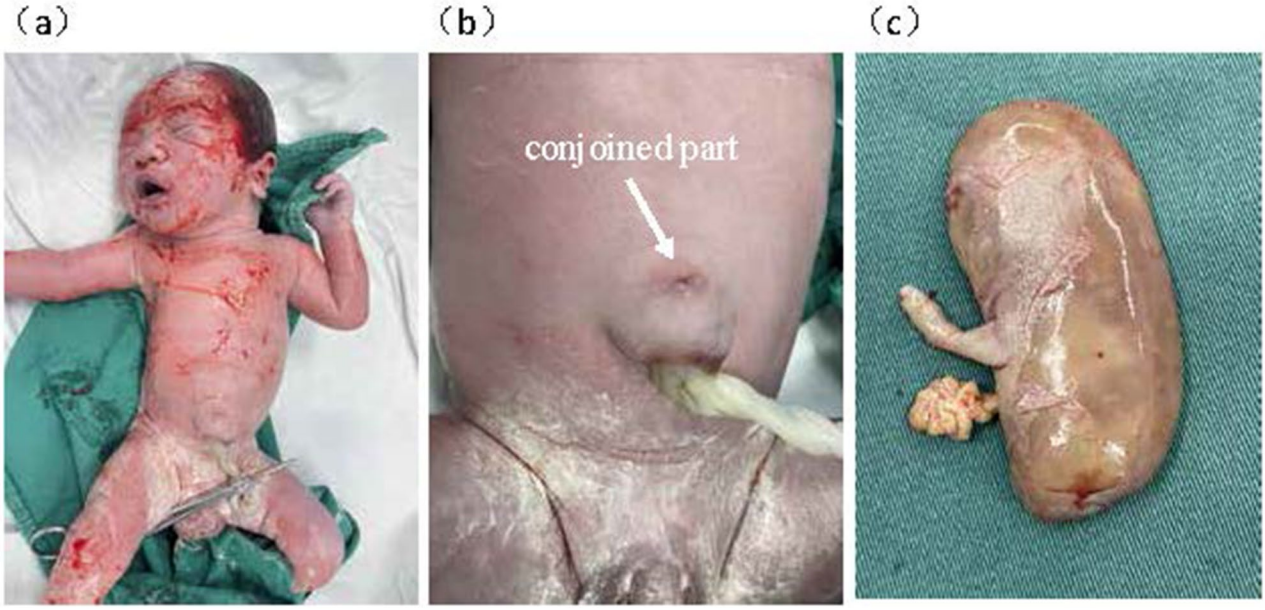


Fig. 4 Surviving pump twin and acardiac twin. Note: (**a**) The surviving male infant after delivery; (**b**) The white arrow indicates the conjoined area between the pump twin and the acardiac twin, showing the location of the connection; (**c**) The acardiac twin, displaying its morphology

Table 1 Biometrical measurement results of the acardiac twin and the pump twin

Examine date	GW (w)	The Acardiac Twin		The Pump Twin				
		size (cm)	EW (g)	BPD (mm)	HC (mm)	AC (mm)	FL (mm)	EFW[a] (g)
Nov. 12th, 2023	13 + 1	3.3 × 1.9	7.5	-	-	-	-	-
Nov. 27th, 2023	15 + 2	4.4 × 2.1	15.8	32	-	-	18	-
Dec. 11th, 2023	17 + 2	7.3 × 3.8	51.5	39	-	-	24	-
Dec. 19th, 2023	18 + 3	7.9 × 4.3	61.5	43	-	-	26	-
Dec. 23rd, 2023	19	8.0 × 4.0	-	43	-	-	27	-
Jan. 2nd, 2024	20 + 3	7.9 × 3.6	-	47	183	160	32	364.2
Jan. 9th, 2024	21 + 3	6.9 × 3.5	-	50	185	172	35	430.6
Jan. 22nd, 2024	23 + 2	6.0 × 3.6	-	56	210	185	40	564.6
Feb. 19th, 2024	27 + 2	5.7 × 1.5	-	69	253	233	51	1085.6
Mar. 4th, 2024	29 + 2	5.8 × 1.5	-	74	267	254	55	1373.4
Mar. 18th, 2024	31 + 2	6.0 × 2.3	-	77	279	277	59	1726.7
Apr. 8th, 2024	34 + 2	5.9 × 2.0	-	84	296	290	65	2115.5

Note: GW: gestation weeks; EW: estimated weight; HC: head circumference; AC: abdominal circumference; FL: femur length; EFW: estimated fetal weight. a: EFW was calculated by the INTERGROWTH-21st standards. -: none

Discussion

TRAP sequence with conjoined twins is an extremely rare and high-risk complication of MCMA twin pregnancies [25]. Its core pathology involves the acardiac twin surviving entirely on arterial blood supplied by the pump twin. Due to the absence of cardiac structures, the acardiac twin has a near 100% mortality rate, while the pump twin mortality rate ranges from 50 to 55% [1, 26]. In MCMA twin pregnancies, only about 70% of fetuses survive, and approximately half of the losses are associated with TRAP or conjoined twins. A comprehensive PubMed search identified 17 relevant studies (Table 2), including 5 case reports, 1 guideline, 2 retrospective studies, 3 systematic reviews or meta-analyses, 3 narrative reviews on ultrasound and fetal assessment, 1 prospective study, and 2 case series. These studies consistently emphasize that early diagnosis and individualized intervention are key to improving outcomes.

This case is the first to report an anatomical variation in the TRAP sequence with conjoined twins, in which the acardiac twin received blood directly from a branch of the pump twin's aortic arch. As of 2023, none of the five previously reported cases of TRAP with conjoined twins in the PubMed database [27–31] described this vascular pattern. Unlike typical placental vascular anastomoses, a direct cardiac arterial supply may create a shared cardiac output system, accelerating metabolic activity in the acardiac twin and increasing hemodynamic load on the

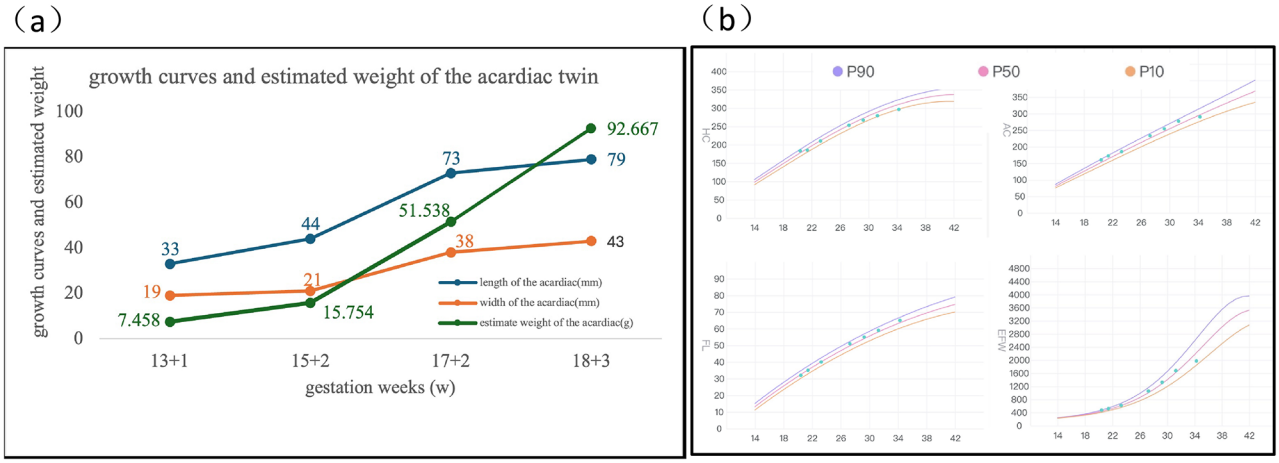


Fig. 5 Comparison of growth curves between the acardiac twin and pump twin. Note: (**a**) Growth curve of the acardiac twin, with weight estimated using the formula: Weight (g) = 1.2 × (maximum length in cm)^2 - (1.7 × maximum length in cm) (Moore TR, 1990); (**b**) Growth curve of the pump twin, with weight estimated based on the INTERGROWTH-21st standards

pump twin. In this case, the acardiac twin gained an average of 3.2 g daily from 15 + 2 to 18 + 3 weeks. These findings suggest that the hemodynamic mechanism of TRAP may vary significantly due to abnormal embryonic vascular development. High-resolution ultrasound combined with genetic analysis may help clarify the etiology. Identifying such atypical vascular pathways highlights the importance of advanced imaging techniques, particularly color Doppler ultrasound, in detecting abnormal flow early. Without a timely diagnosis, misclassification as placental teratoma or vanishing twin syndrome may occur [32, 33]. Diagnosis in this case was made at 13 + 1 weeks, enabling timely intervention planning and emphasizing the essential role of first-trimester ultrasound in TRAP management.

Management of the TRAP sequence with conjoined twins requires careful consideration of anatomical features and procedural risks. Although RFA successfully interrupted abnormal blood flow in this case, laser coagulation has also been used in cases with clearly defined placental anastomoses. Literature suggests that laser techniques can precisely occlude vascular connections [34], but the procedure is technically demanding and poses a higher risk of collateral damage, particularly in conjoined twins with complex anatomy. In this case, the acardiac twin received blood from a deep-seated branch of the pump twin's aortic arch. Given this vascular configuration, RFA under real-time ultrasound guidance was considered a safer approach [17]. Systematic reviews have shown that RFA offers a higher success rate (92%) and lower complication rate (8%) compared to laser coagulation [35]. Compared with conservative management, which carries a 30% mortality rate for the pump twin, RFA significantly improves survival to over 90%, particularly in cases with rapid acardiac twin growth [2].

Clinical management of the TRAP sequence with conjoined twins relies heavily on the timing of intervention. In this case, RFA was successfully performed at 18 + 5 weeks. Postoperative hemodynamics of the pump twin remained stable, and a healthy delivery was achieved, with a birth weight of 2.6 kg and an Apgar score of 9. Although the optimal timing remains debated, literature generally supports the window of 16 to 18 weeks as a balance between procedural safety and fetal outcome [36, 37]. Earlier intervention between 12 and 14 weeks may reduce the risk of preterm premature rupture of membranes [23] but must be weighed against technical challenges and increased risk of fetal injury at earlier gestational ages. This case demonstrates that mid-gestation RFA can effectively occlude abnormal blood flow in TRAP with atypical vascular anatomy without major complications, providing a clinical reference for similar cases. Real-time ultrasound guidance enabled precise targeting of the feeding vessel. Intraoperative monitoring of the pump twin's cardiac function, including umbilical artery resistance index and ductus venosus waveform, contributed to procedural safety and efficacy.

Multidisciplinary collaboration was essential in this case. Teams in obstetrics, imaging, genetics, and neonatology jointly assessed acardiac twin growth and pump twin development, leading to timely intervention. After the procedure, the conjoined region reduced from 6.0 mm to 4.7 mm within 12 days, and the acardiac twin detached. This outcome supports the value of coordinated care in reducing complications such as preterm birth and infection, while improving procedural success [19].

This study has limitations. Fetal brain MRI was not performed in late gestation, limiting neurodevelopment assessment. In addition, the single-center retrospective

Table 2 Summary of literature on TRAP syndrome and conjoined twins

PMID	Study Type	Study Design/Sample Characteristics	Key Findings and Conclusions	Support and Implications for This Study
37,835,852	Case Report & Review	Two MCMA twin TRAP cases; includes literature review.	Transvaginal and 3D ultrasound are critical for early diagnosis; early intervention improves outcomes.	Supports the importance of early ultrasound diagnosis in this case, emphasizing anatomical variation identification.
35,466,064	Review	Literature review on TRAP pathophysiology and treatments (RFA, laser).	RFA is the primary intervention, but optimal timing remains unclear; comparative studies are needed.	Provides theoretical basis for selecting RFA in this case; highlights the need for optimized timing.
23,122,031	Retrospective Study	11 TRAP cases (7 underwent RFA); median intervention at 17 weeks.	RFA is safe and effective (85% neonatal survival), but optimal timing requires further research.	Supports feasibility of RFA at 18 + 5 weeks in this case, aligning with mid-gestation intervention.
39,705,119	Retrospective Cohort	107 MC twins (12 TRAP cases); RFA learning curve analysis.	Increased procedural proficiency prolongs delivery intervals (2019–2023 vs. 2013–2018).	Highlights the role of multidisciplinary expertise, consistent with this case's workflow.
33,757,441	Case Report	One MCDA triplet pregnancy (two acardiac twins) treated with laser at 15 weeks.	Early individualized intervention (laser) improves outcomes (healthy delivery at 37 weeks).	Suggests alternatives (e.g., laser) for complex cases, though RFA was prioritized here.
39,626,652	Systematic Review	757 TRAP cases from 120 studies.	RFA has the highest technical success; prospective studies are needed to define optimal timing.	Validates RFA effectiveness in this case; aligns with the need for larger cohort studies.
34,728,404	Review	Literature review on MCMA complications (TRAP, conjoined twins).	Early anatomical screening and close monitoring reduce fetal loss risks.	Reinforces the 13 + 1-week diagnostic strategy and imaging's central role in this case.
36,123,247	Review	Monitoring and management of MCMA twins (including TRAP and conjoined twins).	Prenatal surveillance and timely delivery improve outcomes.	Aligns with this case's multidisciplinary monitoring and perinatal management.
32,890,327	Review	Early evaluation of MC twin complications (TRAP, conjoined twins).	Early ultrasound is critical for diagnosis and management.	Strengthens the rationale for early ultrasound in identifying anatomical variations.
30,479,634	Review	Ultrasound protocols for twin pregnancies (including TRAP and conjoined twins).	Standardized ultrasound protocols enhance complication detection.	Supports the standardized INTERGROWTH-21st protocol used in this case.
34,540,478	Review	Congenital heart defects (CHD) in MC twins and TRAP association.	TRAP may increase CHD risk in pump twins; fetal echocardiography is essential.	Explains the postnatal ASD in this case; underscores long-term cardiac follow-up needs.
33,017,845	Guidelines & Recommendations	Diagnostic and management guidelines for twin pregnancies (including TRAP).	Recommends early diagnosis, multidisciplinary collaboration, and individualized intervention.	Validates the multidisciplinary approach and framework used in this case.
20,069,540	Review	Umbilical cord entanglement in 32 monoamniotic twins.	Close monitoring after 20 weeks improves outcomes despite cord entanglement.	Supports the safety of mid-gestation intervention in this case.
24,355,992	Review	Early ultrasound for chorionicity determination and twin management.	Early ultrasound improves complication identification and management.	Reinforces the timeliness of diagnosis at 13 + 1 weeks in this case.
16,284,762	Review	MRI and ultrasound in complex twin pregnancies (32 cases).	MRI complements ultrasound for assessing conjoined structures and hemodynamics.	Highlights the limitation of missing MRI data in this case; suggests multimodal imaging for future studies.
11,093,987	Case Series	Fetoscopic surgery for TRAP/TTTS in three cases (anesthetic management).	Anesthetic strategies must balance maternal-fetal safety; individualized decisions are key.	Indirectly supports the local anesthesia strategy and multidisciplinary collaboration in this case.

design and small sample size may not reflect the full range of TRAP presentations. Larger multicenter studies with long-term follow-up are needed to explore the pathophysiology of atypical vascular patterns and to optimize RFA timing. Ultrasound radiomics and machine learning may enhance individualized treatment planning by predicting acardiac twin growth and pump twin cardiac adaptation.

In conclusion, early diagnosis, timely intervention, and multidisciplinary care are key to improving outcomes in TRAP with conjoined twins. This case shows that mid-gestation RFA targeting a cardiac branch supply can be effective. Further validation through larger studies and improved imaging methods is needed to guide management in similar high-risk pregnancies.

Conclusion

This study reports the first TRAP case with conjoined twins where the acardiac twin was perfused via a cardiac branch of the pump twin. Mid-gestation RFA effectively blocked the abnormal supply and improved the outcome. Early diagnosis at 13 + 1 weeks, individualized monitoring, and multidisciplinary care led to a healthy delivery at 35 + 1 weeks, with a birth weight of 2.6 kg and normal postnatal development (Graphic abstract). The case highlights a rare vascular variant, supports RFA safety, and introduces a monitoring approach. Despite limitations such as single-center data and lack of fetal brain MRI, the findings offer a basis for refined TRAP management. Future studies should combine multicenter data with AI-based tools to improve decision-making.

Abbreviations

AC	Abdominal Circumference
BMI	Body Mass Index
EFW	Estimated Fetal Weight
LMP	Last Menstrual Period
MC	Monochorionic
MCMA	Monochorionic Monoamniotic
RFA	Radiofrequency Ablation
TRAP	Twin Reversed Arterial Perfusion
CTs	Conjoined Twins

Acknowledgements
None.

Author contributions
Hua Lai and Huiting Zhu contributed equally to this work and share first authorship. Hua Lai, Huiting Zhu, and Jinliang Zhang were responsible for clinical data collection, case monitoring, and manuscript drafting. Juhua Xiao and Xin Zhou performed and interpreted the ultrasound examinations. Mengjiao Liu and Danping Liu contributed to data analysis and literature review. Zengming Li and Xin Zhou supervised the clinical management and critically revised the manuscript. All authors read and approved the final manuscript.

Funding
This work was financially supported by the Science and Technology Project of Jiangxi Province (No: 20212BAG70006 and 20242BAB25447), the Science and Technology Plan of Jiangxi Provincial Health Commission (No: 202110093) and Funded by Jiangxi Provincial Key Clinical Specialty Construction Project.

Data availability
Data used for analysis are available from the corresponding author upon reasonable request.

Declarations

Ethics approval and consent to participate
All data were obtained with the patient's consent, and we have received formal approval from the Institutional Review Board and Ethics Committee of our hospital to publish this report (Ethics Approval Number: EC-JS-202101).

Consent for publication
Written informed consent was obtained from the patient for the publication of this case report and any accompanying images.

Competing interests
The authors declare no competing interests.

Author details
[1]Department of Obstetrics, Jiangxi Maternal and Child Health Hospital, Nanchang 330006, China
[2]Jiangxi Key Laboratory of Reproductive Health, 508 Xizhan Avenue, Nanchang, Jiangxi 330006, China
[3]Department of Ultrasound, Jiangxi Maternal and Child Health Hospital, 508 Xizhan Avenue, Nanchang, Jiangxi 330006, China
[4]Jiangxi Provincial Key Laboratory of Preventive Medicine, Nanchang University, Jiangxi, China
[5]Department of Genetics, Jiangxi Maternal and Child Health Hospital, Nanchang 330006, China

Received: 8 February 2025 / Accepted: 25 April 2025
Published online: 17 May 2025

References

1. Shettikeri A, Acharya V, Sahana VS, Radhakrishnan R. Outcome of pregnancies diagnosed with TRAP sequence prenatally: A Single-Centre experience. Fetal Diagn Ther. 2019;47:301–6.
2. Brock CO, Johnson A. Twin reverse arterial perfusion: timing of intervention. Best Pract Res Clin Obstet Gynecol. 2022;84:127–42.
3. Yıldırım E. Spontaneous triplet pregnancy and trap sequence, case report. BMC Pregnancy Childbirth. 2019;19.
4. Magnusson Å, Laivuori H, Loft A, Oldereid NB, Pinborg A, Petzold M et al. The association between high birth weight and Long-Term Outcomes—Implications for assisted reproductive technologies: A systematic review and Meta-Analysis. Front Pead. 2021;9.
5. Chen M, Heilbronn LK. The health outcomes of human offspring conceived by assisted reproductive technologies (ART). J Dev Origins Health Disease. 2017;8:388–402.
6. Khairudin D, Khalil A. Monochorionic monoamniotic twin pregnancies. Best Pract Res Clin Obstet Gynecol. 2022;84:96–103.
7. Kozinszky Z, Surányi A. The High-Risk profile of selective growth restriction in monochorionic twin pregnancies. Medicina. 2023;59:648.
8. Zhang L, Liu H, Huang S, Tong C, Wang Z, Qi H et al. Alterations in fetal doppler parameters before and Twenty-Four hours after radiofrequency ablation for twin reversed arterial perfusion sequence. Front Med. 2022;9.
9. Nicolì P, Damiani GR, Gaetani M, Dellino M, Vitagliano A, Malvasi A et al. The Strange Case of Dr Pump and Mr Acardiac: The Twin Reversed Arterial Perfusion (TRAP) Sequence in Two Monochorionic Monoamniotic (MCMA) Twin Pregnancies—Diagnosis, Prognosis and Management: Review of Literature. Diagnostics. 2023;13:3109.
10. Steffensen TS, Gilbert-Barness E, Spellacy W, Quintero RA. PLACENTAL PATHOLOGY IN TRAP SEQUENCE: CLINICAL AND PATHOGENETIC IMPLICATIONS. Fetal Pediatr Pathol. 2008;27:13–29.
11. Vitucci A, Fichera A, Fratelli N, Sartori E, Prefumo F. Twin Reversed Arterial Perfusion Sequence: Current Treatment Options International Journal of Women's Health. 2020;Volume 12:435–43.
12. Amer Sa, Abdulmalik, Alshoabi SA, Qurashi AA, Alhazmi FH, Al-Rudini RY. Ultrasound doppler findings of a twin reversed arterial perfusion sequence (TRAP). Pakistan J Med Sci. 2023;40.
13. Weber MA, Sebire NJ. Genetics and developmental pathology of twinning. Seminars Fetal Neonatal Med. 2010;15:313–8.
14. Weber EC, Recker F, Gottschalk I, Strizek B, Geipel A, Gembruch U, et al. Outcome of monochorionic monoamniotic twin reversed arterial perfusion sequence diagnosed in the first trimester. Fetal Diagn Ther. 2021;48:778–84.
15. Lewi L, Valencia C, Gonzalez E, Deprest J, Nicolaides KH. The outcome of twin reversed arterial perfusion sequence diagnosed in the first trimester. Am J Obstet Gynecol. 2010;203:e2131–4.
16. Mone F, Devaseelan P, Ong S. Intervention versus a Conservative approach in the management of TRAP sequence: a systematic review. J Perinat Med. 2016;44.
17. Komatsu EJ, Hamzeh C, Hamadeh G, Llanes A, Korst LM, Chmait RH. Cord occlusion in twin reversed arterial perfusion sequence: A retrospective study of laser photocoagulation versus radiofrequency ablation. Fetal Diagn Ther. 2024;:1–8.
18. Burtan D, Burn JF, Spehar B, Leonards U. The effect of image fractal properties and its interaction with visual discomfort on gait kinematics. Sci Rep. 2023;13.
19. Stellon MA, Joshi DS, Beninati M, Antony KM, Bohrer J, Hinshaw JL, et al. Management of twin reversed arterial perfusion (TRAP) sequence with

microwave ablation: A case report and review of the literature. J Clin Ultrasound. 2024;52:1208–13.
20. Papageorghiou AT, Ohuma EO, Altman DG, Todros T, Ismail LC, Lambert A, et al. International standards for fetal growth based on serial ultrasound measurements: the fetal growth longitudinal study of the INTERGROWTH-21st project. Lancet. 2014;384:869–79.
21. Hadlock FP, Harrist RB, Martinez-Poyer J. In utero analysis of fetal growth: a sonographic weight standard. Radiology. 1991;181:129–33.
22. Wong AE, Sepulveda W. Acardiac anomaly: current issues in prenatal assessment and treatment. Prenat Diagn. 2005;25:796–806.
23. Tan TYT, Sepulveda W. Acardiac twin: a systematic review of minimally invasive treatment modalities. Ultrasound Obstet Gynecol. 2003;22:409–19.
24. Cabassa P, Fichera A, Prefumo F, Taddei F, Gandolfi S, Maroldi R, 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 Reproductive Biology. 2013;166:127–32.
25. Van Mieghem T, Abbasi N, Shinar S, Keunen J, Seaward G, Windrim R, et al. Monochorionic monoamniotic twin pregnancies. Am J Obstet Gynecol MFM. 2022;4:100520.
26. Glinianaia SV, Rankin J, Khalil A, Binder J, Waring G, Sturgiss SN, et al. Prevalence, antenatal management and perinatal outcome of monochorionic monoamniotic twin pregnancy: a collaborative multicenter study in England, 2000–2013. Ultrasound Obstet Gynecol. 2018;53:184–92.
27. Sanjaghsaz H, Bayram MO, Qureshi F. Twin reversed arterial perfusion sequence in conjoined, acardiac, acephalic twins associated with a normal triplet. A case report. J Reprod Med. 1998;43:1046–50.
28. Yuan H, Zhou Q, Li J, Zeng S. Triplet pregnancy from the transfer of two blastocysts demonstrating a twin reversed arterial perfusion sequence with a conjoined-twins pump fetus. Int J Gynecol Obstet. 2017;137:196–7.
29. Galinkin JL, Gaiser RR, Cohen DE, Crombleholme TM, Johnson M, Kurth CD. Anesthesia for fetoscopic fetal surgery: twin reverse arterial perfusion sequence and twin-Twin transfusions syndrome. Anesth Analgesia. 2000;91:1394–7.
30. Fishman SJ, Puder M, Geva T, Jenkins K, Ziegler MM, Shamberger RC. Cardiac relocation and chest wall reconstruction after separation of thoracopagus conjoined twins with a single heart. J Pediatr Surg. 2002;37:515–7.
31. MacKenzie AP, Stephenson CD, Funai EF, Lee M-J, Timor-Tritsch I. Three-dimensional ultrasound to differentiate epigastric heteropagus conjoined twins from a TRAP sequence. Am J Obstet Gynecol. 2004;191:1736–9.
32. Dhanju G, Breddam A. Twin reversed arterial perfusion (TRAP) sequence: A case report and a brief literature review. Radiol Case Rep. 2022;17:1682–91.
33. Ruiz-Cordero R, Birusingh RJ, Pelaez L, Azouz M, Rodriguez MM. Twin reversed arterial perfusion sequence (TRAPS): an illustrative series of 13 cases. Fetal Pediatr Pathol. 2016;35:63–80.
34. Berg C, Holst D, Mallmann MR, Gottschalk I, Gembruch U, Geipel A. Earlyvslate intervention in twin reversed arterial perfusion sequence. Ultrasound Obstet Gynecol. 2014;43:60–4.
35. Stellon MA, Joshi DS, Beninati MJ, Leverson G, Yang Q, Antony KM et al. Management of twin-reversed arterial perfusion (TRAP) sequence: a systematic review and meta-analysis. Fetal Diagn Ther. 2024;:1–26.
36. Moreno Escobar JJ, Morales Matamoros O, Aguilar del Villar EY, Quintana Espinosa H, Chanona Hernández L. DS-CNN: deep convolutional neural networks for facial emotion detection in children with down syndrome during Dolphin-Assisted therapy. Healthcare. 2023;11:2295.
37. Ozawa K, Wada S, Muromoto J, Sugibayashi R, Wada YS, Ito Y, et al. Long-term neurodevelopmental outcomes of the pump twin in twin reversed arterial perfusion sequence treated by radiofrequency ablation. Prenat Diagn. 2021;41:1575–81.

Publisher's note