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ORIGINAL RESEARCH

Ultrasound guided internal jugular vein cannulation in pediatric patients: a randomized controlled trial

Shun Wang[1,2,3,4], Yue Sun[1,2,3,4], Xin Chen[1,2,3,4], Wangquan Chen[1,2,3,4], Ping Wu[1,2,3,4], Jingwen Cao[1,2,3,4], Yanzhe Tan[1,2,3,4], Yihui Li[1,2,3,4], Lifei Liu[1,2,3,4,*]

[1]Department of Anesthesiology, Children's Hospital of Chongqing Medical University, 400014 Chongqing, China
[2]National Clinical Research Center for Child Health and Disorders, 400014 Chongqing, China
[3]Ministry of Education Key Laboratory of Child Development and Disorders, 400014 Chongqing, China
[4]Chongqing Key Laboratory of Pediatric Metabolism and Inflammatory Diseases, 400014 Chongqing, China

***Correspondence**
lifeiliu@hospital.cqmu.edu.cn
(Lifei Liu)

Abstract

Background: Central venous catheterization is essential for hemodynamic monitoring and rapid fluid administration during pediatric surgeries, with the internal jugular vein (IJV) being a preferred site for access. However, ultrasound-guided IJV cannulation in pediatric patients remains technically challenging. This study aimed to compare the efficacy and safety of the modified dynamic needle tip positioning (MDNTP) technique with the real-time biplane technique in pediatric patients. **Methods**: This prospective randomized controlled trial enrolled 88 children aged 0–6 years undergoing thoracic or cardiac surgery and requiring IJV cannulation at Chongqing Children's Hospital (November 2023 to April 2024). Eleven anesthesiology residents received standardized simulator-based training in both techniques. The patients were randomized in a 1:1 ratio to either the MDNTP group (using a linear probe) or the real-time biplane group (using a biplane probe). The primary outcomes were the first-attempt success rate and cannulation time. Secondary outcomes included overall success rate, number of puncture attempts, and incidence of complications. The operators, outcome assessors, and statisticians were blinded to group assignments. Statistical analyses were performed using the Mann-Whitney U test and chi-square test. **Results**: The MDNTP group demonstrated a higher first-attempt success rate (79.5% *vs.* 54.5%; $p = 0.022$) and shorter cannulation time (82.50 (55.50–115.50) *vs.* 108.00 (71.80–174.00) s; $p = 0.023$) compared to the real-time biplane group, with fewer required puncture attempts ($p = 0.015$). Both groups achieved similar overall success rates (97.7%) and demonstrated comparable safety profiles, with one minor hematoma in the MDNTP group and none in the biplane group ($p = 1.000$). **Conclusions**: Residents performing ultrasound-guided IJV cannulation in pediatric patients using the MDNTP technique had a significantly higher first-attempt success rate and faster cannulation compared to the real-time biplane technique, without compromising safety. **Clinical Trial Registration**: ChiCTR2300077334.

Keywords

Ultrasound; Real-time biplane imaging; Internal jugular vein; Pediatric patients

1. Introduction

Central venous catheters are essential for precise hemodynamic monitoring and rapid fluid administration during complex surgical procedures, particularly in facilitating timely interventions and improving clinical outcomes in pediatric patients undergoing surgery [1, 2]. Among the available central venous access routes, the internal jugular vein (IJV) is frequently used for cervicothoracic venous access in children. Given the clinical importance of IJV cannulation, efforts to improve the success rate while minimizing complications are of particular relevance in pediatric practice [2–4]. However, the anatomical and physiological characteristics of pediatric patients, such as smaller vessel diameter, shorter neck length, and limited operative space, significantly increase the technical difficulty of venous cannulation [3]. The adoption of ultrasound-guided techniques has markedly enhanced both the success rate and safety of IJV puncture. This modality has been shown to reduce the incidence of complications, including hematoma, thrombosis, infection, carotid artery puncture, pneumothorax, hemothorax, and nerve injury, thereby contributing to safer and more effective procedures [5–8]. Despite these advancements, ultrasound-guided IJV cannulation in pediatric patients remains challenging, particularly for resident physicians. Therefore, identifying an optimal technique that enhances procedural success while remaining feasible for less experienced operators is needed.

Conventional ultrasound-guided IJV cannulation includes the short-axis out-of-plane (SAX-OOP) and long-axis in-plane (LAX-IP) approaches. Although both methods are commonly used, the optimal approach remains a matter of debate [9–13], particularly regarding their applicability for novice users, such as residents. There are currently two modified ultrasound-guided techniques in clinical use: the modified dynamic needle tip positioning (MDNTP) technique and the real-time biplane technique. The MDNTP method enhances needle tip visibility and enables precise localization of the IJV relative to the adjacent common carotid artery, thereby improving puncture accuracy [14]. The real-time biplane technique, a proven method for IJV cannulation in critically ill patients [15], simplifies the puncture procedure and improves needle visibility, offering clear advantages and potentially increased safety for patients [15, 16]. However, its application in pediatric populations has not yet been documented.

Hence, the present study aimed to compare the MDNTP technique with the real-time biplane technique to identify the more suitable approach for ultrasound-guided IJV cannulation performed by resident physicians in pediatric patients.

2. Materials and methods

This study was approved by the Institutional Review Board of the Children's Hospital of Chongqing Medical University (Approval No. 440/2023). Written informed consent was obtained from the parents or legal guardians of all participating children. The trial was registered at the Chinese Clinical Trial Registry (ChiCTR2300077334; principal investigator: LL; registration date: 06 November 2023) before patient enrollment and conducted in the operating rooms of the Department of Anesthesiology at the Children's Hospital of Chongqing Medical University.

From 01 November 2023, to 10 April 2024, pediatric patients aged 0–6 years scheduled for thoracic or cardiac surgery were consecutively screened for inclusion. Eligibility was determined by two attending anesthesiologists based on the clinical requirement for central venous access to facilitate continuous hemodynamic monitoring. Children were excluded if they had local skin infections, vascular malformations at the puncture site as identified by ultrasound, or if parental consent was not obtained. All included patients met the criteria for central venous access device (CVAD) placement as outlined in the Italian Group of Venous Access Devices (GAVeCeLT) consensus guidelines, such as severe cases requiring continuous infusion of hypertonic solution and hemodynamic monitoring [17].

The intervention measures for all patients were performed by 11 residents from our department who had no prior experience in pediatric IJV cannulation but were proficient in performing the procedure in adult patients. Before the start of the study, all residents underwent comprehensive theoretical training, which included detailed instruction and live demonstrations of both the MDNTP and real-time biplane techniques. To ensure familiarity and technical competence, each resident practiced both techniques seven times using an internal jugular puncture simulator. A senior physician with over eight years of experience in ultrasound-guided procedures supervised and documented all puncture attempts conducted by the residents.

The participants, outcome evaluators, and data managers were blinded to group allocation. A total of 88 pediatric patients were randomly assigned to either the MDNTP group or the real-time biplane group, with 44 patients in each group. Eleven residents were each allocated eight random numbers, corresponding to four patients in the MDNTP group and four in the real-time biplane group. The outcome trial effect evaluators were not involved in recording or managing any trial-related data. Informed consent was obtained for all the 88 patients (Fig. 1).

Upon entering the operating room, standard vital sign monitoring was performed, including three-lead electrocardiography (ECG), peripheral oxygen saturation, heart rate (HR), respiratory rate, and non-invasive blood pressure (BP) measurements. All patients were intubated and received general anesthesia via intravenous and inhalational routes. Anesthesia was induced using routine intravenous midazolam (0.05–0.1 mg/kg), propofol (2–3 mg/kg), sufentanil (0.5–1 μg/kg), and cisatracurium (0.15 mg/kg).

The patients were carefully positioned in the Trendelenburg position with a shoulder roll, and the head was gently rotated 30–40 degrees toward the side opposite the planned IJV cannulation site to optimize venous distension and procedural access. Before each procedure, the ultrasound probe was covered with a sterile sleeve, and sterile ultrasound gel was applied inside the sleeve to ensure aseptic technique. A 22-G, 25 mm puncture needle and a 0.018″ nitinol guidewire were used together with a central venous catheter (Arrow International, Inc., USA). The MDNTP technique was performed using the EPIQ 7C ultrasound system (Philips Ultrasound, Inc., Cambridge, MA, USA) equipped with a high-frequency linear array probe (eL18-4). The real-time biplane technique also utilized the EPIQ 7C system but required a biplane probe (XL14-3) (Fig. 2). Both ultrasound-guided techniques for pediatric IJV cannulation followed the seven-step strategy outlined in the Standardized Institutional Central (SIC) protocol, which aims to reduce complications associated with central venous catheter (CICC) placement through standardized procedures [18].

2.1 Modified dynamic needle tip positioning group

In the MDNTP group, the ultrasound probe was placed perpendicular to the long axis of the IJV for precise localization. An appropriate puncture site was selected by adjusting the probe's position such that the IJV was centered in the ultrasound image and located beneath the midpoint of the probe's long axis. The puncture site corresponded to the intersection between the probe's long-axis midpoint and the skin surface. The needle was inserted in the direction of the center of the vein. The detailed steps of the puncture procedure are illustrated in Fig. 3. Successful IJV cannulation was confirmed by removing the inner stylet, advancing the catheter smoothly into the vessel, attaching a syringe, and confirming free aspiration of venous blood. Then, a guidewire was inserted, and an ultrasound was performed to verify its correct placement within the vessel lumen. The MDNTP technique uses single-plane imaging in the SAX-OOP view to enhance needle tip visualization through

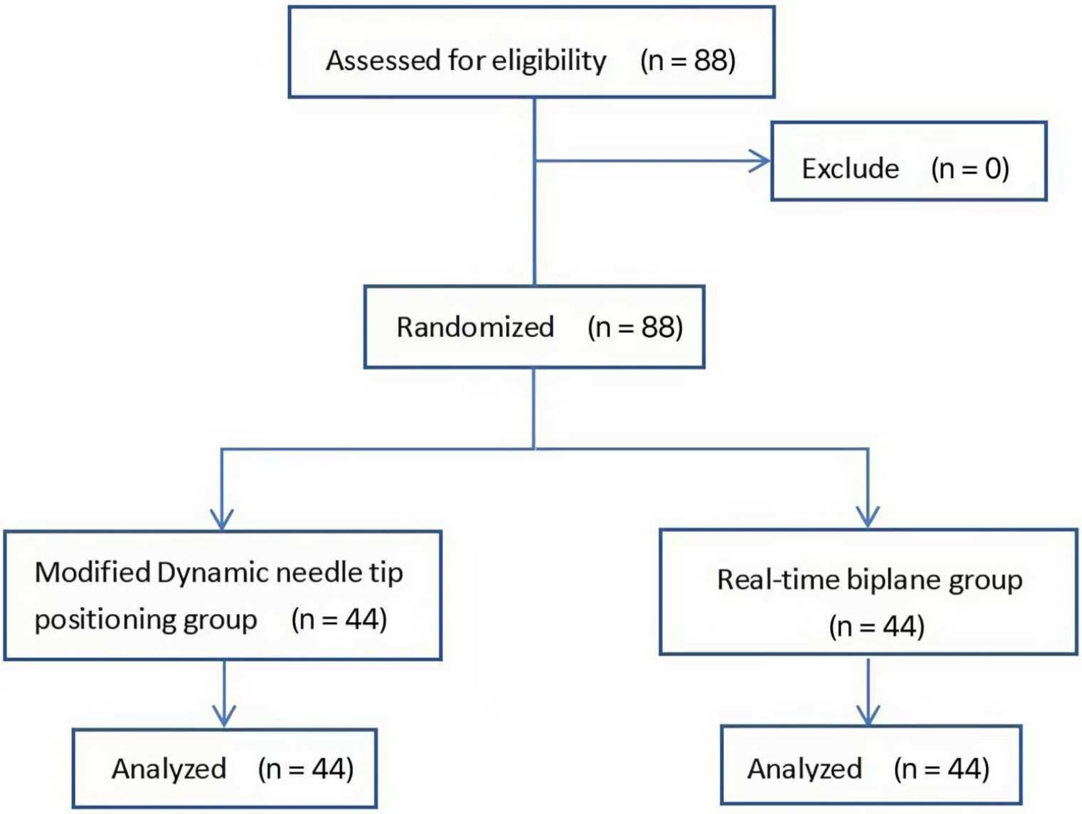

FIGURE 1. Flowchart of patient enrollment.

FIGURE 2. Real-time biplane ultrasound probe.

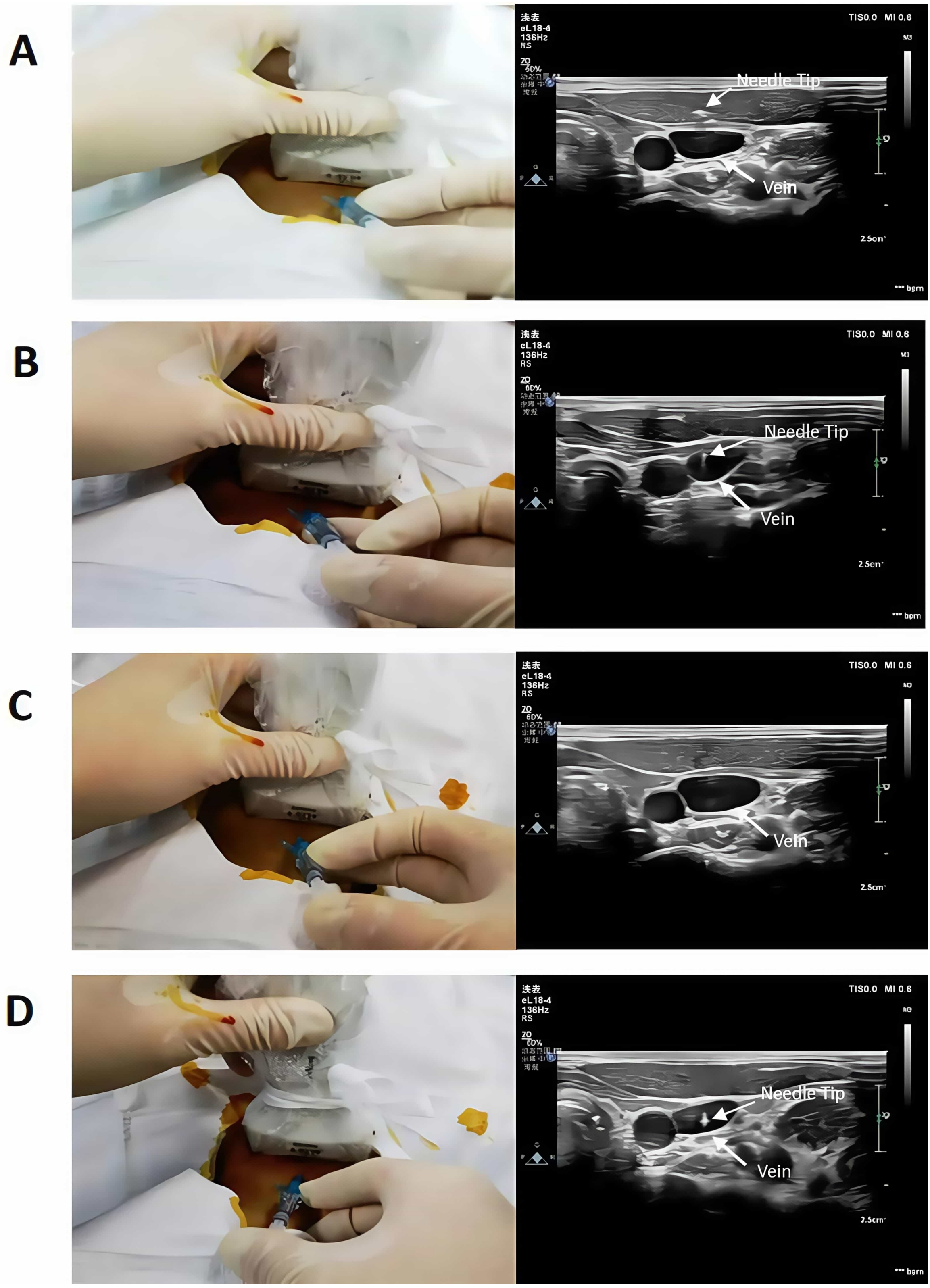

FIGURE 3. Procedure for ultrasound-guided internal jugular vein cannulation in infants using the modified dynamic needle tip positioning method. (A) The puncture needle is inserted at the contact point between the midpoint of the ultrasound probe and the skin, with the needle tip appearing as a highly reflective bright spot on the ultrasound image. (B) The needle is directed toward the center of the vein, where the needle tip appears as a hyperechoic bright spot on the ultrasound image. (C) Once the needle becomes visible, the ultrasound probe is advanced forward and gently positioned alongside the needle. When the needle reappears on the ultrasound image, the probe is moved proximally to allow real-time tracking of the needle as it passes through the subcutaneous tissue and cervical fascia, and ultimately penetrates the anterior wall of the internal jugular vein. (D) This process was repeated to ensure complete insertion of both the needle and catheter into the vessel.

continuous dynamic tracking of the probe (Fig. 3). Its key characteristic is the "needle-probe collaborative displacement under single-plane guidance", which is useful in pediatric patients with superficially located vessels, as it minimizes probe pressure and improves procedural safety.

2.2 Real-time biplane group

In the real-time biplane group, the procedure began by aligning the long axis of the ultrasound probe vertically with the long axis of the IJV for the simultaneous display of two ultrasound views: one in the long-axis plane and the other in the short-axis plane of the IJV. The probe was then gently slid to identify an appropriate puncture site, the puncture needle was inserted at a point directly beneath the center of the probe's long axis, and upon visualizing the needle on both ultrasound planes, its trajectory was carefully adjusted based on its spatial relationship with the target vessel. The detailed steps of the puncture procedure are illustrated in Fig. 4. After needle insertion, the inner stylet was removed, and the catheter was advanced into the vein. Successful venous access was confirmed by attaching a syringe to the catheter and observing smooth blood aspiration. Then, a guidewire was introduced, and ultrasound imaging was performed to verify the correct intravascular position of the wire. The biplane technique utilizes a real-time orthogonal plane fusion method for simultaneously visualizing the vessel's cross-sectional (short-axis) and longitudinal (sagittal) views through a matrix array probe. During needle advancement, the spatial orientation of the needle can be observed in both the anteroposterior (cross-sectional) and craniocaudal (sagittal) planes. Its primary advantage lies in providing "real-time, two-view navigation for precise three-dimensional control", making it particularly beneficial in pediatric patients with complex vascular anatomy or in cases where adjacent critical structures, such as the carotid artery, must be avoided.

2.3 Outcome measures

The primary outcome of this study was the first-time success rate, and the secondary outcomes were overall success rates, cannulation durations, and complication rates. First-time success was defined as successful IJV cannulation on a single puncture attempt, indicated by the aspiration of dark red blood and the successful advancement of a guidewire into the vein, which was further confirmed by ultrasound imaging to verify the guidewire's position within the vessel. Cannulation time for both groups was measured from the initial skin puncture to the moment dark red venous blood was aspirated and the inner stylet was withdrawn from the needle. If the procedure duration exceeded 10 minutes or if the operator decided to attempt cannulation at a different site, the attempt was deemed unsuccessful and recorded as 600 seconds for documentation. Each withdrawal of the needle towards its distal end was counted as an additional puncture attempt. Vascular complications were categorized as hematoma or thrombosis. Hematoma was defined by the presence of congestion and swelling at the puncture site, either palpable or visually apparent. Thrombosis was identified by either clinical signs, such as localized pallor, or by direct ultrasonographic detection of thrombus formation.

A comprehensive record was maintained for each case, including cannulation time, total number of puncture attempts, any complications encountered, and the anatomical site of IJV puncture. Additionally, patient demographic data such as sex, age, weight, BP and HR upon entry to the operating room were documented, and the diameter and depth of the IJV were also recorded to support subsequent analyses.

2.4 Statistical analysis

Statistical analyses were conducted using R 4.3.1. All collected data were thoroughly verified for completeness and assessed for normality using the Kolmogorov-Smirnov test. Descriptive statistics are presented as frequency (percentage), mean ± standard deviation (SD), median difference with 95% confidence interval (CI), and risk ratio with 95% CI. To evaluate the primary outcome, the first-time success rate of both techniques, Pearson's chi-squared test or Fisher's exact test, was applied, depending on the suitability of the data for each method. All statistical tests were two-tailed, and a p-value < 0.05 was considered statistically significant. Additionally, standardized differences were used to assess potential imbalances in baseline demographic and clinical characteristics between the two groups, such as sex, age, weight, baseline BP, HR, and IJV diameter and depth, for a comprehensive assessment of potential group differences.

2.5 Sample size calculation

The sample size for this randomized controlled trial (RCT) was calculated based on a previous study, which reported a 46% first-time success rate for ultrasound-guided IJV cannulation in premature infants using the MDNTP method [17]. We hypothesized that the real-time biplane technique would substantially improve the first-time success rate in pediatric patients, with an expected increase to approximately 77%, representing a marked improvement over existing techniques. Taking into account an anticipated dropout rate of 10%, and aiming for a statistical power of 85% with a two-sided type I error rate of 0.05, we determined that 44 patients per group would be required. This sample size was considered sufficient to ensure the robustness and reliability of our findings. No patient dropouts were recorded during the study.

3. Results

In this randomized controlled trial comparing ultrasound-guided IJV cannulation techniques in pediatric patients, significant differences were observed between the real-time biplane and MDNTP groups.

Data from all 88 enrolled cases were included in the analysis, with an equal distribution of 44 patients in each group. No statistically significant differences were found in baseline characteristics between the two groups (Table 1), confirming group comparability prior to intervention.

The MDNTP technique demonstrated significant advantages in both first-attempt success rates and procedural efficiency. Among the 44 patients in the MDNTP group, 35 (79.5%) achieved successful cannulation on the first attempt, compared to 24 (54.5%) in the real-time biplane group (p = 0.022; risk ratio (RR), 1.46; 95% confidence interval (CI),

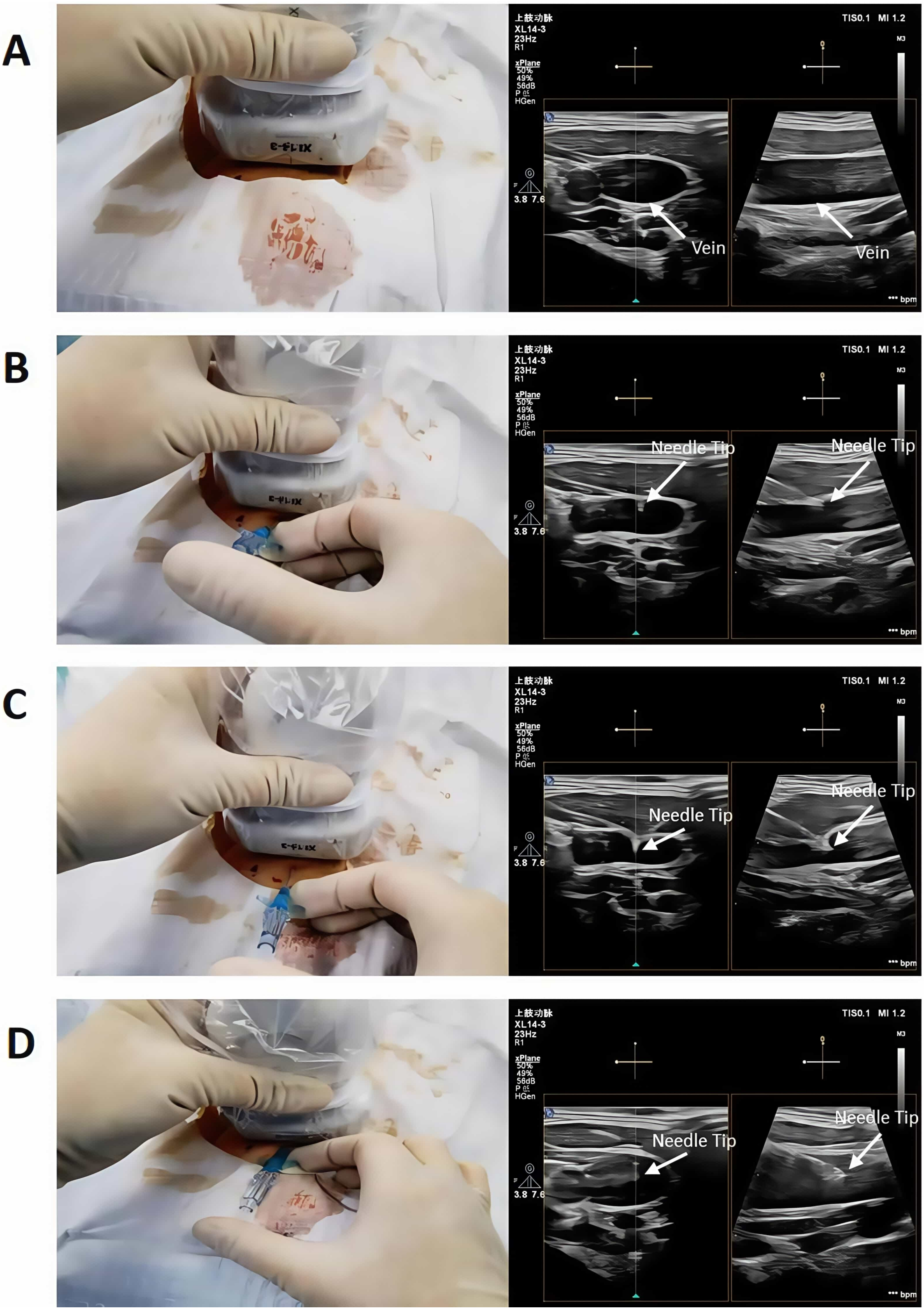

FIGURE 4. Procedure for ultrasound-guided internal jugular vein cannulation in infants using the real-time biplane method. (A) The biplane ultrasound probe is placed perpendicular to the long axis of the internal jugular vein, allowing the vein to be simultaneously visualized at the center of both ultrasound images in the long-axis in-plane and short-axis out-of-plane views. (B) The puncture needle is inserted below the midpoint of the probe's long axis. Once the needle appears in both ultrasound images, its direction is adjusted based on its position relative to the vessel, ensuring it is guided close to the anterior wall of the vein. (C) The direction of needle advancement is continuously adjusted using both the long-axis in-plane and short-axis out-of-plane images, with the needle kept oriented toward the center of the vessel. (D) This process was repeated to enable complete insertion of both the needle and the catheter into the vessel under dual-plane ultrasound guidance.

TABLE 1. Patient baseline characteristics.

Characteristics	Real-time biplane group (n = 44)	Modified Dynamic needle tip positioning group (n = 44)
Sex (male/female)	22/22	21/23
Age (mon)	30.09 ± 22.76	26.51 ± 23.89
Weight (kg)	12.13 ± 5.22	11.21 ± 5.25
Heart rate (bp)	107.93 ± 15.18	116.39 ± 20.60
Systolic blood pressure (mmHg)	82.18 ± 8.92	81.27 ± 12.03
Diastolic blood pressure (mmHg)	47.45 ± 8.24	47.00 ± 7.39
Internal jugular vein diameter (mm)	8.05 ± 1.83	7.44 ± 1.47
Internal jugular vein depth (mm)	7.16 ± 0.98	6.75 ± 1.00

Data are expressed as mean ± standard deviation or number of patients.

1.07–1.99). Additionally, the median cannulation time was significantly shorter in the MDNTP group (82.50 (55.50–115.50) seconds) compared to the biplane group (108.00 (71.80–174.00) seconds) ($p = 0.023$; median difference, 26.00 seconds; 95% CI, 3.00–47.00).

Despite differences in first-attempt success and procedure duration, both groups achieved comparable overall success rates, with 43 of 44 patients (97.7%) successfully cannulated in each group ($p = 1.000$; RR, 1.00; 95% CI, 0.938–1.066), indicating no statistically significant difference in the final procedural success. However, the MDNTP group required significantly fewer puncture attempts than the biplane group (median (interquartile range), 1.0 (1.0–1.0) *vs.* 1.0 (1.0–2.0); $p = 0.015$). No cases of thrombosis were observed in either group (Table 2).

4. Discussion

This study demonstrates that the MDNTP technique for IJV cannulation in pediatric patients results in a higher first-attempt success rate. Additionally, this method required fewer puncture attempts and a shorter cannulation time compared to the real-time biplane technique. It is important to highlight that although cannulation was performed exclusively on the right IJV in both groups, no statistically significant differences were observed in the overall success rate or complication rates between the two techniques.

The development of ultrasound visualization technologies has substantially improved the safety and efficacy of ultrasound-guided IJV cannulation while also reducing the incidence of complications such as hematoma, thrombosis, infection, carotid artery puncture, pneumothorax, hemothorax, and nerve injury [6, 19, 20]. In our previous research, we successfully employed a combined LAX-IP and SAX-OOP ultrasound-guided approach for IJV puncture in premature neonates [19], which integrates the advantages of both orientations. The LAX-IP method enables continuous visualization of the needle trajectory and its entry into the vessel lumen [21], while the SAX-OOP approach provides a single-plane image of the IJV, adjacent arteries, and surrounding anatomical structures, thereby enhancing procedural accuracy and safety [22]. However, the combined LAX-IP and SAX-OOP technique requires rotational adjustments of the ultrasound probe, rendering it technically challenging, particularly for inexperienced operators. To simplify the IJV cannulation procedure while maintaining simultaneous visualization of both the long- and short-axis views, we opted for a 3D ultrasound probe, which enhanced both visualization and procedural efficiency. The real-time biplane method is a derivative of the long and short-axis combination method, with the main benefit being its ability to display both axes simultaneously for improved needle visualization and accuracy during cannulation, thereby enhancing procedural precision and patient safety outcomes [16].

Currently, several researchers have conducted experiments on real-time biplane ultrasound-guided internal jugular venipuncture. One comparative study evaluated the short-axis and biplane techniques using the IE33 ultrasound system (Philips Ultrasound, Bothell, WA, USA), which features an advanced 3D phased-array transducer (X5-1) and optimized resolution settings to enhance imaging capabilities [23]. Another study compared the long-axis technique to the real-time biplane approach using a Philips CX50 system with an L12-3 probe and a Philips EPIQ system with an XL14-3 probe [15]. However, it is important to note that both studies were conducted exclusively in adult patients, and all procedures were performed by experienced anesthesiologists who were highly skilled in internal jugular venipuncture. Despite its potential, three-dimensional ultrasound has not achieved widespread adoption compared to conventional two-dimensional imaging, particularly in pediatric clinical settings, where its use remains limited. Our study aims to demonstrate the feasibility of real-time biplane ultrasound-guided IJV cannulation in pediatric patients and young children, with a specific focus on improving the technique among residents with limited experience in this challenging procedure.

TABLE 2. Results of primary and secondary study outcomes.

	Real-time biplane group (n = 44)	Modified Dynamic needle tip positioning group (n = 44)	p Value	Median difference (95% CI)	Risk ratio (95% CI)
First-time success rate, n (%)	24 (54.5%)	35 (79.5%)	0.022^{a}	-	1.46 (1.07–1.99)
Overall success rate, n (%)	43 (97.7%)	43 (97.7%)	1.000^{b}	-	1.00 (0.938–1.066)
Cannulation time (median (P25–P75), s)	108.00 (71.80–174.00)	82.50 (55.50–115.50)	0.023^{c}	26.00 (3.00–47.00)	-
Puncture attempts (median (P25–P75), n)	1.00 (1.00–2.00)	1.00 (1.00–1.00)	0.015^{c}	-	-
Hematoma, n (%)	1 (2.3%)	0 (0%)	1.000^{b}	-	-
Thrombosis, n (%)	0 (0%)	0 (0%)	-	-	-

Data are expressed as the median (P25–P75), count or number of patients (%).
[a]Pearson's chi-squared test. [b]Fisher's Exact Test. [c]Mann-Whitney U.
CI, confidence interval.

The study results showed that the first-attempt success rate for IJV puncture and cannulation, assisted by real-time biplane ultrasound and conducted by residents who lacked experience in performing IJV cannulation in pediatric patients, was 54.5%, significantly lower compared to previous studies that involved more experienced operators using the MDNTP method [14]. In contrast, the first-attempt success rate achieved by residents using the MDNTP method in this study was 79.5%. We believe this discrepancy could be primarily attributed to the larger size of the biplane probe (XL14-3) (Fig. 2) compared to the linear array probe (eL18-4) used in the SAX-OOP technique. The linear array probe is compact and can be more easily positioned and secured on the necks of pediatric patients, which allows smooth probe manipulation during the procedure. Conversely, the larger size of the biplane probe presents challenges in terms of placement and stabilization in pediatric necks, especially when maneuvering the probe. As a result, the real-time biplane method was associated with longer cannulation times and increased number of puncture attempts compared with the modified technique.

No statistically significant differences in the overall success rate were observed between the two groups, potentially due to the ability of both methods to effectively visualize the spatial relationship between the IJV, arteries, and surrounding anatomical structures [15, 22]. Similarly, the incidence of complications did not differ significantly between the two groups. We also observed that among the 88 patients included in our study, only one case of postoperative neck hematoma was reported in the group utilizing the real-time biplane method. However, after applying pressure to the site by the anesthesiologist, no hematoma was observed at the puncture site upon re-examination. This complication may have resulted from tissue structure damage due to an excessive number of puncture attempts during the procedure.

5. Limitations

This study had several limitations. First, the short observation period limited the evaluation of catheter durability and the detection of long-term complications. Second, the removal of IJV catheters occurred after patients were transferred to the Intensive Care Unit (ICU) rather than immediately following surgery, which might have led to prolonged catheter retention time and differences in postoperative management strategies, both of which could affect complication rates. Third, the study involved 11 anesthesiologists with limited experience, which may limit the comparability of our findings to studies involving more experienced operators. Further research is needed to determine whether the real-time biplane approach provides additional benefits for clinicians who already have experience in ultrasound-guided IJV cannulation. Fourth, our patient population included a slightly broader age range (0 to 6 years) compared to previous studies [14, 19], which may affect generalizability. Fifth, a potential source of bias in ultrasound-guided vascular access is the inadvertent compression of neck structures by the operator, which may reduce venous diameter and influence the success of puncture and cannulation. Future research could consider restricting the age range or focusing on neonatal patients, explore factors that may influence success and safety, and develop improved techniques or technologies to assist ultrasound-guided IJV cannulation in infants, including neonates.

6. Conclusions

Residents performing ultrasound-guided IJV cannulation in pediatric patients had a significantly higher first-attempt success rate with the MDNTP technique for IJV cannulation compared to the real-time biplane technique. The MDNTP approach required less cannulation time and fewer puncture attempts, indicating greater procedural efficiency and practicality. However, no statistically significant differences were observed between the two techniques in terms of overall success rates or complication rates.

AVAILABILITY OF DATA AND MATERIALS

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

AUTHOR CONTRIBUTIONS

SW—write, edit, revise, and submit the manuscript. YS and XC—write and edit the manuscript. WQC, PW and JWC—organize data. YZT and YHL—analyze the data. LFL—write, edit, revise, and supervise the manuscript.

ETHICS APPROVAL AND CONSENT TO PARTICIPATE

This study was approved by the Institutional Review Board of the Children's Hospital of Chongqing Medical University (Approval No. 440/2023). Written informed consent was obtained from the parents or legal guardians of all participating children.

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CONFLICT OF INTEREST

The authors declare no conflict of interest.

REFERENCES

[1] Miller AH, Roth BA, Mills TJ, Woody JR, Longmoor CE, Foster B. Ultrasound guidance versus the landmark technique for the placement of central venous catheters in the emergency department. Academic Emergency Medicine. 2002; 9: 800–805.

[2] D'Alessandro M, Ricci M, Bellini T, Chianucci B, Calevo MG, Piccotti E, *et al*. Difficult intravascular access in pediatric emergency department: the ultrasound-assisted strategy (DIAPEDUS Study). Journal of Intensive Care Medicine. 2024; 39: 217–221.

[3] Tripathi M, Pandey M. Modified anchoring maneuver using pilot puncture needle to facilitate internal jugular vein puncture for small children. Pediatric Anesthesia. 2008; 18: 1050–1054.

[4] Ramachandran S, Velayudhan S, Ramaraj KP, Kuppusamy S, Shanmugam B. Comparison of conventional needle holding technique and pen holding method of needle holding for real-time ultrasound-guided internal jugular venous cannulation—a randomised parallel-group study. Indian Journal of Anaesthesia. 2023; 67: 256–261.

[5] Vafek V, Skříšovská T, Kosinová M, Klabusayová E, Musilová T, Kramplová T, *et al*. Central venous catheter cannulation in pediatric anesthesia and intensive care: a prospective observational trial. Children. 2022; 9: 1611.

[6] Godínez-García F, López-Briones JS, Hernández-González MA, González-Carrillo PL. Ultrasound-guided insertion and the proportion of catheter-associated thrombosis. Revista Médica del Instituto Mexicano del Seguro Social. 2023; 61: S90–S95. (In Spanish)

[7] Cui Y, Wang Y, Gong T, Huang Q, Zhang QQ. Systematic review of ultrasound-guided central venous catheter placement-related complications in neonates and infants aged <12 months. Journal of International Medical Research. 2024; 52: 3000605241287168.

[8] de Souza TH, Brandão MB, Nadal JAH, Nogueira RJN. Ultrasound guidance for pediatric central venous cannulation: a meta-analysis. Pediatrics. 2018; 142: e20181719.

[9] Bhutia KO, Sharma A, Goyal S, Kothari N, Kumari K, Goel AD, *et al*. Comparison of novel anteroposterior short-axis in-plane technique with conventional short-axis out-of-plane technique for ultrasound-guided internal jugular vein cannulation: a randomized-controlled trial. Turkish Journal of Emergency Medicine. 2023; 23: 17–23.

[10] Maitra S, Bhattacharjee S, Baidya DK. Comparison of long-, short-, and oblique-axis approaches for ultrasound-guided internal jugular vein cannulation: a network meta-analysis. The Journal of Vascular Access. 2020; 21: 204–209.

[11] Mishra A, Kumar M, Kumar N, Goyal K, Soni KD, Yadav A. Short-axis versus long-axis approach for ultrasound-guided vascular access: an updated systematic review and meta-analysis of randomised controlled trials. Indian Journal of Anaesthesia. 2023; 67: S208–S217.

[12] AlGhamdi F, AlJoaib N, Aldawood A, AlGhamdi M, AlMulhim A. Comparing short-axis versus long-axis ultrasound-guided techniques for internal jugular vein cannulation: a meta-analysis of clinical outcomes and safety. Australasian Journal of Ultrasound in Medicine. 2024; 27: 149–158.

[13] Lee S, Chang JE, Oh Y, Yang HJ, Bae J, Cho YJ, *et al*. Comparison of dynamic needle tip positioning versus conventional long-axis in-plane techniques for ultrasound-guided internal jugular venous catheterization: a randomized controlled trial. Minerva Anestesiologica. 2021; 87: 294–301.

[14] Tan Y, Tu Z, Ye P, Xu Y, Ye M, Bai L, *et al*. Ultrasound guidance for internal jugular vein cannulation in neonates: modified dynamic needle tip positioning short-axis out-of-plane technique versus long-axis in-plane technique, a randomized controlled trial. The Journal of Vascular Access. 2022; 23: 922–999.

[15] Li YY, Liu YH, Yan L, Xiao J, Li XY, Ma J, *et al*. Single-plane versus real-time biplane approaches for ultrasound-guided central venous cannulation in critical care patients: a randomized controlled trial. Critical Care. 2023; 27: 366.

[16] Kaplowitz J, Bigeleisen P. A new biplane ultrasound probe for real-time visualization and cannulation of the internal jugular vein. Case Reports in Anesthesiology. 2014; 2014: 1–3.

[17] Pinelli F, Pittiruti M, Annetta MG, Barbani F, Bertoglio S, Biasucci DG, *et al*. A GAVeCeLT consensus on the indication, insertion, and management of central venous access devices in the critically ill. The Journal of Vascular Access. 2025; 26: 1096–1114.

[18] Brescia F, Pittiruti M, Ostroff M, Spencer TR, Dawson RB. The SIC protocol: a seven-step strategy to minimize complications potentially related to the insertion of centrally inserted central catheters. The Journal of Vascular Access. 2023; 24: 185–190.

[19] Liu W, Tu Z, Liu L, Tan Y. Combined short- and long-axis method for internal jugular vein cannulation in premature newborns: a randomized controlled trial. Acta Anaesthesiologica Scandinavica. 2021; 65: 420–427.

[20] Saugel B, Scheeren TWL, Teboul JL. Ultrasound-guided central venous catheter placement: a structured review and recommendations for clinical practice. Critical Care. 2017; 21: 225.

[21] Takeshita J, Tachibana K, Nakajima Y, Nagai G, Fujiwara A, Hamaba H, *et al*. Long-axis in-plane approach versus short-axis out-of-plane approach for ultrasound-guided central venous cannulation in pediatric patients: a randomized controlled trial. Pediatric Critical Care Medicine. 2020; 21: e996–e1001.

[22] Troianos CA, Hartman GS, Glas KE, Skubas NJ, Eberhardt RT, Walker JD, *et al*. Guidelines for performing ultrasound guided vascular cannulation: recommendations of the American society of echocardiography and the society of cardiovascular anesthesiologists. Journal of the American Society of Echocardiography. 2011; 24: 1291–1318.

[23] Panidapu N, Babu S, Koshy T, Sukesan S, Dash PK, Panicker VT. Internal jugular vein cannulation using a 3-Dimensional ultrasound probe in patients undergoing cardiac surgery: comparison between biplane view and short-axis view. Journal of Cardiothoracic and Vascular Anesthesia. 2021; 35: 91–97.

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