

Comparison of ultrasound-guided oblique-axis versus short-axis approaches for right internal jugular vein cannulation in the left decubitus position: a prospective, randomized, single-center trial

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Abstract

Background

Central venous cannulation in the left decubitus position is more difficult than in the supine position and may be required when patients cannot safely return to supine. Whether the oblique-axis (OA) approach improves the success and safety of right internal jugular vein (RIJV) cannulation compared with the short-axis (SA) approach remains unknown.

Methods

Seventy-four patients (ASA I–III) scheduled for elective surgery in the left decubitus position under general anesthesia requiring RIJV cannulation were randomly assigned 1:1 to the OA or SA group (n = 37 each). Under real-time ultrasound guidance and a 20° Trendelenburg tilt, cannulation was performed by one of three experienced attending anesthesiologists, each with more than 15 years of experience in ultrasound-guided central venous cannulation. Venipuncture attempts and total procedure time were recorded by a separate investigator; patients were blinded by general anesthesia. The primary outcome was first-time puncture success; secondary outcomes were overall cannulation success, procedure time, venipuncture attempts, and mechanical complications.

Results

All 74 randomized patients completed the trial and were analyzed. The first-time puncture success rate was higher in the OA group (27/37 [73.0%] vs. 18/37 [48.6%]; risk difference 24.3%, 95% CI 2.8% to 45.9%; $P = 0.032$, Pearson chi-square test; Fisher exact test $P = 0.056$). Venipuncture attempts were fewer in the OA group (median 1 vs. 2; IQR 1–2; $P = 0.037$). Total procedure time was similar between groups (median 2.79 [IQR 2.46–3.19] vs. 3.01 [2.72–3.45] min; $P = 0.060$). Mechanical complications occurred in 6 of 37 patients (16.2%) in the SA group (one arterial puncture and five posterior wall penetrations) and in none in the OA group ($P = 0.025$); overall cannulation success was 100% in both groups.

Conclusions

For RIJV cannulation in the left decubitus position, the oblique-axis approach was associated with a higher first-time puncture success rate than the short-axis approach and with fewer mechanical complications; however, the primary-endpoint evidence was borderline and the complication estimates were imprecise.

Trial registration:

Introduction

Central venous cannulation (CVC) is a commonly performed procedure in emergency, intensive care, and perioperative settings. It provides safe vascular access for the precise administration of potent vasoactive drugs, rapid fluid resuscitation, central venous pressure monitoring, transvenous cardiac pacing, and temporary hemodialysis^[1]. The right internal jugular vein (RIJV) is the most commonly used site for perioperative cannulation, with fewer catheter-related infections than the femoral vein^[1, 2] and a lower risk of pneumothorax than the subclavian vein^[1, 3].

Most studies of CVC have been performed in the supine position. In clinical practice, however, an unplanned need for central venous access occasionally arises in patients who are already positioned for surgery in a non-supine position — for example, semi-recumbent, prone, or lateral decubitus — and repositioning to the supine position is often neither feasible nor safe once the patient is draped and surgically positioned. In the decubitus position, the internal jugular vein (IJV) is frequently the only feasible access site, and the relatively fixed head-and-neck position, the loss of palpable anatomical landmarks, and the increased overlap between the carotid artery and the IJV all increase the technical difficulty of cannulation.

Ultrasound guidance (USG) has fundamentally changed the practice of CVC access. Compared with the landmark technique, USG reduces overall complications, increases first-attempt success rates, and shortens cannulation time^[4]. Current guidelines from intensive care^[5], anesthesiology^[6, 7], and health technology assessment bodies^[8], together with international evidence-based recommendations^[9] and expert reviews^[10–12], recommend real-time USG as the preferred method for central venous access.

The ultrasound-guided oblique-axis (OA) approach is an intermediate orientation between the short-axis (SA) and long-axis views. It allows simultaneous visualization of the puncture needle tip and shaft throughout the procedure while maintaining a side-by-side view of the IJV and carotid artery^[13]. Previous studies comparing probe orientations have been performed predominantly in the supine position; the OA approach has rarely been evaluated in special positions such as the left decubitus position. We therefore conducted this prospective, randomized, single-center trial to evaluate the feasibility and safety of the USG OA approach compared with the USG SA approach for RIJV cannulation in the left decubitus position. Because randomized evaluation is not feasible in emergency or critically ill patients who require unplanned central venous access and cannot be repositioned to supine, we studied elective surgical patients scheduled for surgery in the left decubitus position, in whom RIJV cannulation was clinically indicated and the two approaches could be compared under standardized, controlled conditions.

Methods

Trial design and ethics

This was a prospective, single-center, parallel-group randomized controlled trial conducted at Shanghai Tongren Hospital, China. The study protocol (version 2.0) was approved by the Ethics Committee of Shanghai Tongren Hospital (No. 2024-067-02) on 17 October 2024, and the trial was registered with the Chinese Clinical Trial Registry (ChiCTR2400091385) on 28 October 2024. Written informed consent was obtained from all participants before enrollment. The trial is reported in accordance with the CONSORT 2010 statement. The full trial protocol is available from the corresponding author on reasonable request.

Participants

Consecutive patients scheduled for elective surgery in the left decubitus position under general anesthesia who required RIJV cannulation were screened during the preoperative interview between 1 November 2024 and 31 December 2025. Inclusion criteria were: (1) age 18–65 years; (2) ASA physical status I–III; (3) body mass index (BMI) 18.5–30 kg/m². Exclusion criteria were: abnormal blood coagulation function; infection at the puncture site; IJV anatomical variations or venous thrombosis detected by ultrasound; superior vena cava syndrome; presence of a central venous catheter in the target vein within the preceding 72 hours; and refusal to participate.

Randomization, allocation concealment, and blinding

Eligible patients were enrolled by the attending anesthesiologist during the preoperative interview and were randomly assigned in a 1:1 ratio to the SA group (control) or the OA group (experimental) using a computer-generated permuted-block randomization sequence with a fixed block size of 6, prepared by an investigator (JW Z) not involved in the procedures. No stratification factors were used. Allocation was concealed in opaque, sealed, sequentially numbered envelopes prepared by an investigator (LH) who was not involved in subsequent procedures; the envelope was opened immediately before surgery by the operating anesthesiologist after confirmation of eligibility. Both the operating anesthesiologists and the recording investigator (MJ Y) were aware of group allocation; the operators could not be blinded because the two techniques require distinct probe orientations and needle trajectories. To reduce—but not eliminate—the risk of bias from unblinded outcome assessment, the number of venipuncture attempts and total procedure time were recorded intraoperatively by MJ Y, who was present throughout the procedure and did not perform the cannulation. Total procedure time was measured with a digital stopwatch that was started and stopped by MJ Y on the operator's verbal command at the defined start and end points (see Outcomes). Patients were under general anesthesia and therefore unaware of their group assignment. All remaining outcomes, including the diagnosis of mechanical complications, were assessed and recorded in real time by the operating anesthesiologist using the pre-defined criteria.

Preoperative preparation and positioning

Standard monitoring (electrocardiography, invasive arterial pressure, pulse oximetry) was established, and an 18-G peripheral venous catheter was inserted for infusion of lactated Ringer's solution.

Anesthesia was induced with propofol 1–2 mg/kg, sufentanil 0.3–0.4 µg/kg, and rocuronium 0.6 mg/kg, followed by tracheal intubation and mechanical ventilation adjusted to maintain an end-tidal carbon dioxide level of 35–45 mmHg.

After tracheal intubation, patients were placed in a true left lateral decubitus position, with the trunk aligned parallel to the longitudinal axis of the operating table. The head and neck were immobilized in a neutral position with a pillow, avoiding any rotation of the cervical spine. The hips and knees were flexed to nearly 90° to stabilize the position and relax the abdominal wall; the upper leg was kept straight with a soft pad between the legs. Both arms were extended forward, parallel to the torso, and secured with a double brace. To promote venous filling of the RIJV, the surgical bed was tilted to a 20° Trendelenburg position. Before puncture, a linear array probe (6–13 MHz; EDGE II, FUJIFILM Sonosite, USA) was used to scan the RIJV, the carotid artery, and adjacent structures to exclude anatomical variations and venous thrombosis.

Interventions

All cannulations were performed by one of three attending anesthesiologists (Z S, WJ L, and JF Z) at our center, each with more than 15 years of experience in ultrasound-guided central venous cannulation, using the standard Seldinger technique with an 18-Ga, 6.5-cm introducer needle (Centra-Line™, Biometrix, Israel) attached to a 5-mL syringe. All three operators performed both the oblique-axis (OA) and the short-axis (SA) technique, and the technique used for each patient was determined solely by the randomization sequence. Before the trial, all three operators completed a standardized training program on both approaches and were required to demonstrate proficiency in the oblique-axis technique (each performing a minimum of 20 supervised oblique-axis cannulations) to ensure uniform application of the two techniques across the groups. Each operator managed both the probe and the needle; the probe was enclosed in a sterile cover under standard aseptic conditions. Once the needle tip was identified within the vein, the syringe was removed, a J-wire was advanced, and its position within the IJV was confirmed ultrasonographically. Cannulation was defined as successful if the guidewire advanced smoothly without resistance and was confirmed inside the IJV. After the catheter had been inserted over the guidewire and secured in place, the surgical bed was returned to the horizontal position.

SA group (control)

The ultrasound probe was positioned transversely on the neck, parallel to the clavicle. After clear visualization of the IJV at the center of the ultrasound image, the needle was inserted using an out-of-plane technique, with a trajectory perpendicular to the long axis of the transducer^[14].

OA group (experimental)

The target vessel was first identified in the standard short-axis orientation. The probe was then rotated to an intermediate position approximately midway between the short-axis and long-axis views^[15],

maintaining visualization of both the IJV and the carotid artery in a slightly elongated view. The needle was advanced along the long axis of the probe (in-plane), providing real-time visualization of the entire needle trajectory from skin entry to vessel penetration.

Outcomes

The primary outcome was the first-time puncture success rate, defined as successful cannulation achieved with a single venipuncture attempt—that is, venous blood flashback obtained on the first needle pass, followed by smooth guidewire advancement and catheter placement, without any further needle puncture. Under the pre-specified counting rule, in which every successive needle withdrawal and re-advancement (with or without a new skin puncture site) constituted an additional attempt^[16], first-time puncture success corresponded to a recorded venipuncture-attempt count of one. Patients with exactly one recorded attempt, as recorded intraoperatively by a designated investigator (MJ Y), were classified as having first-time puncture success.

Secondary outcomes were: (1) **overall cannulation success rate** — cannulation was classified as failed if the IJV was not cannulated after three venipuncture attempts^[17]; (2) **total procedure time** (min) — the interval from the first needle puncture of the skin to completion of catheter fixation, recorded by MJ Y using a digital stopwatch^[17]; the stopwatch was started and stopped by MJ Y on the operator's verbal command at the defined start and end points, respectively; (3) **number of venipuncture attempts** — the number of venipuncture attempts required for successful cannulation^[17], counted and recorded at the time of the procedure by MJ Y, who was present throughout the procedure and did not perform the cannulation; and (4) **mechanical complications** — arterial puncture, posterior venous wall penetration, pneumothorax, air embolism, and catheter malposition, detected during or after the procedure. Arterial puncture was defined as needle penetration of the carotid artery^[16], which was managed by immediate needle withdrawal and local compression. **Posterior venous wall penetration** was defined as penetration of the deep (posterior) wall of the IJV by the puncture needle^[17], diagnosed when any of the following was observed: (i) real-time ultrasound visualization of the needle tip traversing the posterior wall and entering the tissue plane behind the vein; (ii) resistance to, or an abnormal trajectory of, guidewire advancement despite an apparently venous blood flashback through the needle, indicating that the needle tip had exited the lumen through the posterior wall; or (iii) immediate post-procedural ultrasound evidence of a needle tract or a small hematoma adjacent to the posterior wall of the vein. Confirmed events were managed by immediate needle withdrawal and re-puncture under real-time ultrasound guidance. All adverse events were managed according to clinical best practice and reported to the ethics committee as required. For posterior venous wall penetration, criteria (i) and (iii) depended on the operator's real-time sonographic interpretation, whereas criterion (ii) was based on the observed behavior of the guidewire.

Sample size

Sample size was calculated on the basis of a pilot study conducted before the main trial, in which 20 patients were randomly assigned in a 1:1 ratio (10 per group) and the first-time puncture success rates were 5/10 (50%) in the experimental group and 2/10 (20%) in the control group. To detect this anticipated 30-percentage-point between-group difference with a two-tailed test for the difference between two proportions at $\alpha = 0.05$ and $\beta = 0.20$ (power 80%), a sample of approximately 37 participants per group was required, giving a total planned sample of 74; all 74 randomized participants completed the trial.

Statistical analysis

Statistical analyses were performed with SPSS version 21.0 (SPSS Inc., Chicago, IL, USA). Continuous data are presented as mean $\pm$ SD or median (interquartile range [IQR]) according to distribution, and categorical data as numbers (percentages). Between-group comparisons of normally distributed continuous variables used the Student's *t* test; skewed continuous and ordinal variables (procedure time, number of venipuncture attempts) were compared with the Mann–Whitney U test, and for these variables the between-group difference is expressed as the median difference with 95% confidence interval obtained by the Hodges–Lehmann method (normal approximation with correction for ties). Categorical variables (first-time puncture success, overall success, and complications) were compared with the chi-square test or Fisher's exact test, as appropriate. ASA class was reported descriptively and was not subjected to between-group statistical comparison because no patient in the SA group had ASA class I; a dichotomized (I–II vs. III) classification was not used for comparison. The primary outcome analysis used the Pearson chi-square test (pre-specified), with the Fisher exact test as a sensitivity analysis. Between-group differences in binary outcomes are expressed as risk differences with 95% confidence intervals, computed by the Wald method or, when one group had zero events, by the Newcombe hybrid score method. A two-sided $P < 0.05$ was considered statistically significant. No adjustment for multiple testing was made; secondary outcomes were pre-specified but exploratory, and their effect estimates, confidence intervals, and *P* values are reported without multiplicity correction. All analyses followed the intention-to-treat principle; no interim analysis was planned.

Results

Participant flow and baseline characteristics

Between 1 November 2024 and 31 December 2025, 80 patients were assessed for eligibility. Six patients were excluded before randomization: three because their surgery was canceled, two because the surgical approach was changed to one requiring a supine position, and one because the body mass index (BMI) exceeded the inclusion criterion ($> 30 \text{ kg/m}^2$). The remaining 74 patients were randomized, 37 to the OA group and 37 to the SA group. All 74 patients completed the protocol without withdrawal or protocol deviation and were included in the analysis (Fig. 1). Baseline characteristics were similar between the two groups (Table 1).

Table 1
Baseline characteristics of the study participants

Variable	OA group (n = 37)	SA group (n = 37)
Age (years), mean $\pm$ SD	49.2 $\pm$ 15.6	50.5 $\pm$ 14.4
Male, n (%)	19 (51.4)	21 (56.8)
Height (cm), mean $\pm$ SD	167.0 $\pm$ 9.3	164.5 $\pm$ 7.6
Weight (kg), mean $\pm$ SD	68.1 $\pm$ 13.1	65.6 $\pm$ 14.1
BMI (kg/m ²), mean $\pm$ SD	24.3 $\pm$ 3.5	24.1 $\pm$ 4.3
ASA class I, n (%)	2 (5.4)	0 (0)
ASA class II, n (%)	8 (21.6)	9 (24.3)
ASA class III, n (%)	27 (73.0)	28 (75.7)
Continuous variables are presented as mean $\pm$ SD; categorical variables as n (%).		
OA, oblique-axis; SA, short-axis; SD, standard deviation; BMI, body mass index; ASA, American Society of Anesthesiologists.		

Primary outcome

The first-time puncture success rate was significantly higher in the OA group than in the SA group (27/37 [73.0%] vs. 18/37 [48.6%]; risk difference 24.3%, 95% CI 2.8% to 45.9%; RR 1.50, 95% CI 1.02 to 2.20; P = 0.032, Pearson chi-square test). In a pre-specified sensitivity analysis using the Fisher exact test, the difference showed a consistent trend toward significance (P = 0.056).

Secondary outcomes

The number of venipuncture attempts was significantly lower in the OA group than in the SA group (median 1 vs. 2; IQR 1–2 for both groups; median difference [SA – OA] 1 venipuncture attempt, 95% CI 0 to 1; P = 0.037, Mann–Whitney U test; Fig. 2). Total procedure time tended to be shorter in the OA group (2.90 $\pm$ 0.76 min; median 2.79, IQR 2.46–3.19) than in the SA group (3.24 $\pm$ 0.88 min; median 3.01, IQR 2.72–3.45), but the difference did not reach statistical significance (median difference [SA – OA] 0.28 min, 95% CI – 0.01 to 0.59; P = 0.060, Mann–Whitney U test). The overall cannulation success rate was 100% in both groups (37/37 vs. 37/37).

Mechanical complications occurred in 6 of 37 patients (16.2%) in the SA group – one arterial puncture and five posterior venous wall penetrations, each in a different patient – and in none of the 37 patients in the OA group (risk difference – 16.2%, 95% CI – 31.1% to – 3.5%; P = 0.025, Fisher exact test; Table 2). No pneumothorax, air embolism, or catheter malposition occurred in either group. All complications were managed conservatively without sequelae.

Table 2
Study outcomes

Outcome	OA group (n = 37)	SA group (n = 37)	Effect (95% CI)	P value
Primary outcome				
First-time puncture success, n (%)	27 (73.0)	18 (48.6)	RD 24.3% (2.8% to 45.9%); RR 1.50 (1.02 to 2.20)	0.032*
Secondary outcomes				
Overall cannulation success, n (%)	37 (100)	37 (100)	—	—
Total procedure time (min), mean $\pm$ SD	2.90 $\pm$ 0.76	3.24 $\pm$ 0.88	—	—
Total procedure time (min), median (IQR)	2.79 (2.46–3.19)	3.01 (2.72–3.45)	Median difference (SA – OA) 0.28 min (95% CI – 0.01 to 0.59)¶	0.060‡
Venipuncture attempts, median (IQR)	1 (1–2)	2 (1–2)	Median difference (SA – OA) 1 attempt (95% CI 0 to 1)¶	0.037‡
Mechanical complications, n (%)				
Arterial puncture	0 (0)	1 (2.7)	—	1.000
Posterior venous wall penetration	0 (0)	5 (13.5)	—	0.054
Pneumothorax	0 (0)	0 (0)	—	—
Air embolism	0 (0)	0 (0)	—	—
Catheter malposition	0 (0)	0 (0)	—	—
Any mechanical complication	0 (0)	6 (16.2)	RD – 16.2% (– 31.1% to – 3.5%)§	0.025

Outcome	OA group (n = 37)	SA group (n = 37)	Effect (95% CI)	P value
Primary outcome				
OA, oblique-axis; SA, short-axis; RD, risk difference; RR, relative risk; IQR, interquartile range; CI, confidence interval.				
* Pearson chi-square test (pre-specified primary analysis); Fisher exact test sensitivity analysis P = 0.056.				
‡ Mann–Whitney U test.				
§ Risk difference with 95% CI computed by the Newcombe hybrid score method (the OA group had zero events).				
¶ 95% CI obtained by the Hodges–Lehmann method. Because the data are coarse and heavily tied, the Hodges–Lehmann shift cannot be localized more precisely than 0–1 attempts; the median difference of 1 attempt is reported.				
Secondary outcomes were pre-specified but exploratory; no adjustment for multiple testing was made. —, not estimable (100% success or no events in both groups) or not reported (sparse individual complications).				

Discussion

In this randomized controlled trial of ultrasound-guided RIJV cannulation in the left decubitus position, the oblique-axis approach achieved a higher first-time puncture success rate (73.0% vs. 48.6%) and was associated with fewer mechanical complications (0% vs. 16.2%) than the short-axis approach. These findings suggest that the OA approach is both more feasible and safer than the conventional SA approach for IJV cannulation in this challenging position. Central venous cannulation remains one of the most commonly performed procedures in perioperative and critical care practice, with millions of central venous catheters inserted each year^[18], and is associated with substantial catheter-related morbidity^[3]. Real-time ultrasound guidance has become the standard of care for central venous access, and its benefit is greatest when the needle is tracked in-plane during vessel puncture^[19].

The SA approach is traditionally preferred by clinicians for performing and teaching ultrasound-guided IJV cannulation, but it is associated with a higher rate of posterior venous wall penetration because the needle is visualized only as a cross-sectional dot and its depth within the vein cannot be reliably tracked^[14, 16, 17]. In the decubitus position, gravitational effects collapse the IJV and reduce its cross-sectional area, further increasing the technical challenge^[20, 21]. Consistent with this, in the present study all five posterior wall penetrations and the single arterial puncture occurred in the SA group. These events were diagnosed in real time by the unblinded operating anesthesiologist. The oblique-axis orientation offers the advantages of both the short- and long-axis views: the needle is followed in real time from skin to vein while the IJV and carotid artery remain visible side by side, which should reduce both posterior wall penetration and inadvertent arterial injury^[13, 22]. The number of venipuncture

attempts and the rate of posterior wall penetration in the SA group in our study are consistent with those reported in previous comparisons of probe orientations^[14, 17, 23, 24].

The observed reduction in posterior wall penetration (13.5% vs. 0%) is clinically meaningful: posterior wall penetration can produce hematoma and, in the setting of increased arteriovenous overlap, increases the probability of arterial injury^[20]. The higher number of venipuncture attempts in the SA group (median 2 vs. 1) may itself be a contributing mechanism, because repeated puncture increases the cumulative risk of posterior wall penetration; conversely, in-plane visualization of the full needle shaft may have reduced the need for redirection in the OA group.

The interpretation of the primary endpoint deserves particular emphasis. The primary analysis met the pre-specified significance criterion (Pearson chi-square test, $P = 0.032$); however, the sensitivity analyses were borderline (Fisher exact test, $P = 0.056$; chi-square test with Yates' continuity correction, $P = 0.057$), and the fragility index of the primary endpoint was 1, meaning that reclassifying a single patient's outcome would render the primary analysis non-significant. This fragile statistical basis is explained by the modest sample size and, more importantly, by the effect size used for the sample size calculation, which was derived from a pilot study of only 20 patients (5/10 vs. 2/10); the pilot estimate carried very low precision (95% CI of the difference approximately - 10 to 70 percentage points) and, like most estimates from small pilot studies, likely overestimated the true effect, consistent with the smaller between-group difference (24.3 percentage points) observed in the main trial. Nevertheless, the direction of effect was coherent across the primary endpoint and the independent secondary endpoint of mechanical complications: the risk difference (24.3%, 95% CI 2.8% to 45.9%) and the relative risk (1.50, 95% CI 1.02 to 2.20) both excluded no effect, and the between-group difference in mechanical complications ($P = 0.025$) pointed in the same direction, although the wide confidence intervals indicate appreciable uncertainty. Because the primary outcome was derived from the intraoperatively recorded venipuncture-attempt count, the lower number of attempts in the OA group ($P = 0.037$, Mann-Whitney U test) reflects the same underlying count and does not constitute independent corroborating evidence. These caveats, compounded by the unblinded nature of most operator-assessed outcomes (see Limitations), warrant larger confirmatory trials before firm recommendations are made.

Several additional points merit discussion. First, the approximately 20–30 s shorter total procedure time in the OA group did not reach statistical significance. Because total procedure time was measured from the first skin puncture, the time spent on pre-puncture ultrasound scanning and probe repositioning – including the additional probe rotation required to obtain the oblique-axis view – was not captured by this metric; whether inclusion of this preparatory phase would widen, narrow, or leave unchanged the between-group difference in overall procedural time cannot be determined from the present data. Second, all cannulations were performed by three attending anesthesiologists, each with more than 15 years of experience in ultrasound-guided central venous cannulation, all of whom performed both techniques after a standardized pre-trial training program covering the oblique-axis approach. This design reduced operator-related variability without the limitation of a single-operator study; nevertheless,

all operators were highly experienced, and the results may not generalize to practitioners with less experience or to centers without established expertise in the oblique-axis view.

Limitations

This study has several limitations. First, it was a single-center trial with a modest sample size ($n = 74$). The sample size was calculated from the pilot-based anticipated effect (a 30-percentage-point difference in first-time puncture success, based on 5/10 vs. 2/10), which indicated that approximately 37 participants per group were required; the observed between-group difference was smaller (24.3 percentage points), for which the achieved power was only approximately 60%, so the primary-endpoint test had limited power and its result was borderline. The modest sample size also limits the precision of secondary-outcome and complication estimates and precluded multivariable adjustment. Second, the inclusion criteria restricted enrollment to adults aged 18–65 years with ASA I–III and BMI 18.5–30 kg/m²; whether the findings extend to older, higher-ASA, or obese patients requires further study. Third, only elective surgical patients undergoing RIJV cannulation in the left decubitus position were evaluated, and only right-sided cannulation was performed; whether the findings extend to unplanned cannulation in emergency or critically ill patients who cannot be repositioned to supine requires further study. Fourth, blinding of the operators was not feasible because the two techniques require distinct probe orientations and needle trajectories. The number of venipuncture attempts and total procedure time were recorded intraoperatively by a separate investigator (MJ Y), who was present throughout the procedure but did not perform the cannulation; however, the diagnosis of mechanical complications including posterior venous wall penetration and the remaining outcomes were assessed and recorded in real time by the unblinded operating anesthesiologist without independent adjudication by a third party; the primary endpoint of first-time puncture success, by contrast, was derived from the venipuncture-attempt count recorded intraoperatively by MJ Y; because MJ Y was also aware of the group allocation, separate recording of this count may reduce, but cannot fully eliminate, bias arising from operator-influenced outcome assessment. Because the diagnosis of posterior venous wall penetration relied in part on the operator's real-time subjective interpretation of the ultrasound images (criteria (i) and (iii)), and because such images were not systematically archived for every procedure, an independent imaging-based re-review was not feasible, and under-ascertainment of these events in either group cannot be completely excluded. Expectation bias and differential misclassification of these operator-assessed outcomes therefore cannot be excluded, and any such bias, if present, would be expected to favor the experimental (OA) group. Total procedure time was measured with a digital stopwatch that was started and stopped by MJ Y on the operator's verbal command at the defined start and end points; although this removed the need for the operating anesthesiologist to read and record the time, the timing still depended on the operator's real-time judgment of when the first skin puncture occurred and when catheter fixation was completed. Patients were under general anesthesia and therefore unaware of their group assignment. Fifth, the observed complication rate was based on events detected during or immediately after the procedure; late catheter-related complications (e.g., infection, thrombosis) were not assessed. Sixth, total procedure time was defined as the interval from the first skin puncture to completion of catheter

fixation and therefore did not include the time spent on the pre-puncture ultrasound survey and probe repositioning (e.g., the probe rotation required to obtain the oblique-axis view in the OA group). Because these preparatory steps may differ systematically between the two approaches, the reported between-group difference in total procedure time may not fully reflect the overall time required for the cannulation procedure, and the direction of any resultant bias (over- or underestimation of the time advantage of the OA approach) cannot be determined from the present data. A composite time metric spanning the entire ultrasound-guided procedure — from the start of the ultrasound examination to completion of catheter fixation — would provide a more comprehensive measure of overall procedural efficiency and should be considered as a reference indicator in future studies.

Conclusions

In patients undergoing RIJV cannulation in the left decubitus position under general anesthesia, the ultrasound-guided oblique-axis approach was associated with a higher first-time puncture success rate and fewer mechanical complications than the short-axis approach; however, the primary-endpoint finding was borderline and sensitive to the choice of statistical test. The OA approach may be a preferable option for ultrasound-guided IJV cannulation in the decubitus position, but larger multicenter trials are needed to confirm these findings before firm recommendations can be made.

Abbreviations

ASA
American Society of Anesthesiologists
BMI
body mass index
CI
confidence interval
CVC
central venous cannulation
IJV
internal jugular vein
IQR
interquartile range
OA
oblique-axis
RD
risk difference
RIJV
right internal jugular vein
RR
relative risk

SA
short-axis
USG
ultrasound guidance.

Declarations

Ethics approval and consent to participate:

The study was approved by the Institutional Ethics Committee of Shanghai Tongren Hospital (No. 2024-067-02, 17 October 2024). Written informed consent was obtained from all participants.

Consent for publication:

Not applicable.

Competing interests:

The authors declare no competing interests.

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Author Contribution

WJ L is the principal investigator and drafted the manuscript. JF Z designed the study. Z S, WJ L, and JF Z performed all ultrasound-guided cannulations. MJ Y recorded the number of venipuncture attempts and total procedure time intraoperatively and collected and interpreted the data. L H prepared the allocation concealment envelopes and collected and interpreted the data. JW Z performed the sample size calculation and statistical design and generated the randomization sequence. All authors read and approved the final manuscript.

Acknowledgements:

Not applicable.

Availability of data and materials:

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

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Figures

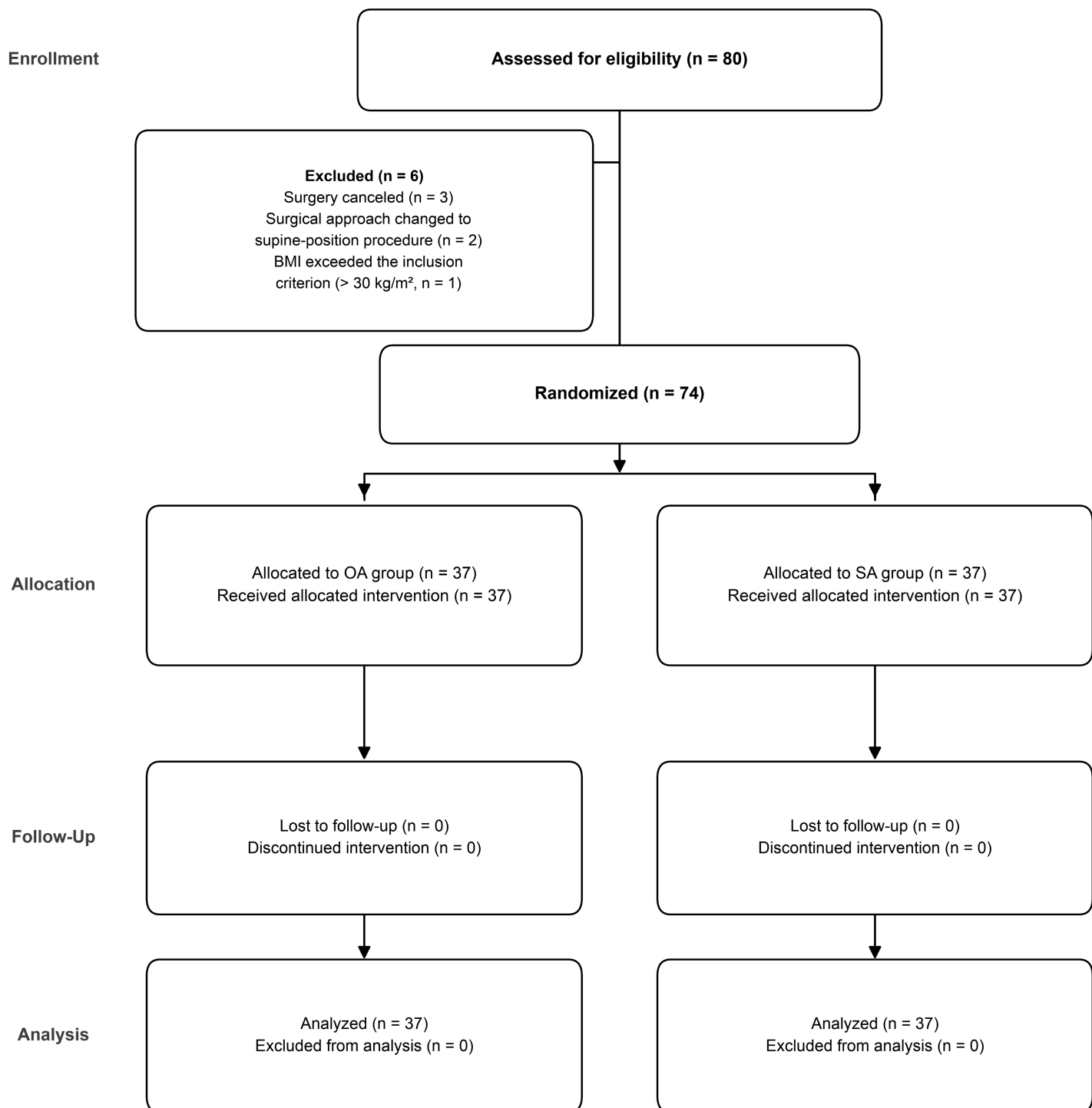


Figure 1

CONSORT flow diagram of participant enrollment, randomization, and analysis. Of 80 patients assessed for eligibility between 1 November 2024 and 31 December 2025, six were excluded before randomization (three because their surgery was canceled, two because the surgical approach was changed to one requiring a supine position, and one because the body mass index exceeded the inclusion criterion), and 74 were randomized (37 per group); all completed the trial.

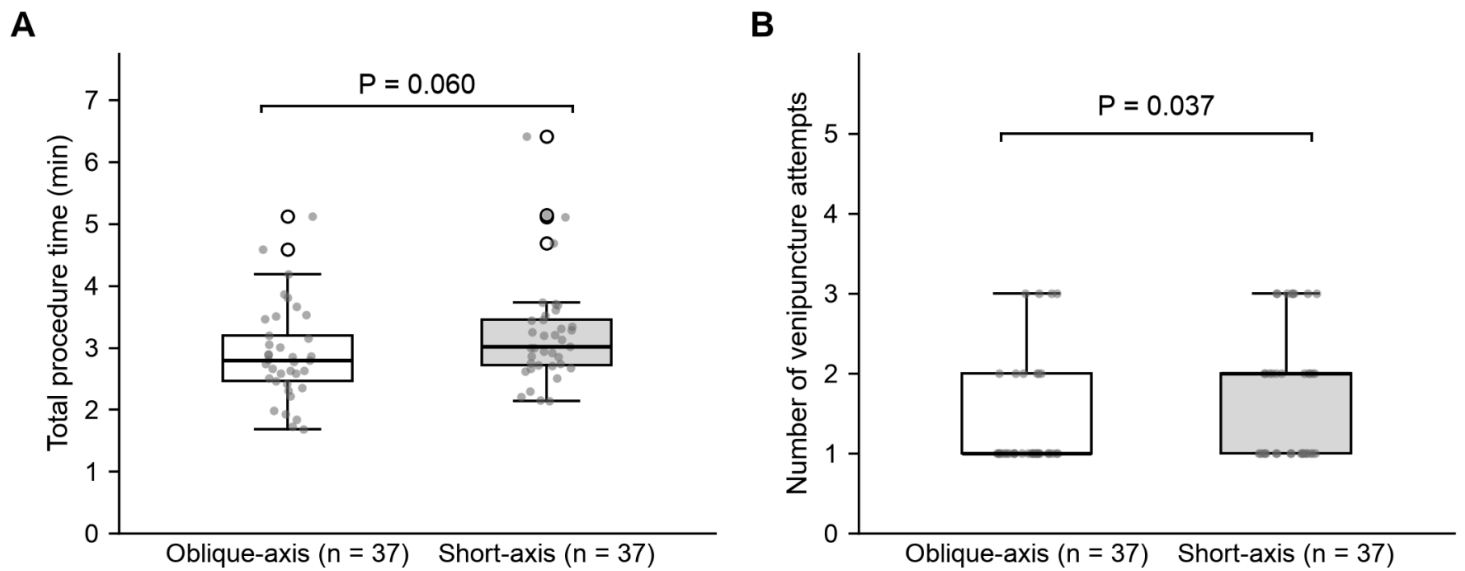


Figure 2

Box-and-whisker plots of (A) total procedure time and (B) number of venipuncture attempts by group.

Supplementary Files

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