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A Novel Radiological Landmark–Guided Technique for Accurate and Reproducible Catheter Tip Positioning in Totally Implantable Venous Access Ports

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Abstract

Background

Accurate catheter tip placement in totally implantable venous access ports is crucial to minimize complications. This study aimed to evaluate the accuracy and safety of a newly developed radiological landmark-based method, the Demirgan Approach, for determining optimal catheter tip position.

Methods

This retrospective study included 261 patients who underwent right internal jugular vein totally implantable venous access ports implantation between March 2022 and March 2024. The optimal tip zone was defined as 2 cm above or below the cavoatrial junction. Postoperative computed tomography was used to verify tip position and assess early complications.

Results

The catheter tip was correctly positioned in 93.1% of patients. Malposition was significantly associated with failure of blood aspiration (44.4% vs 3.2%, $p < 0.0001$). The mean carina-to- cavoatrial junction distance was 1.5 vertebral body units, shorter than expected, likely due to positional variation.

Conclusions

The Demirgan Approach is a simple, reproducible, and radiation-sparing method ensuring accurate totally implantable venous access ports tip placement.

Level of Evidence:

Level 4, Case Series.

INTRODUCTION

Totally implantable venous access ports (TIVAPs) are widely utilized to provide long-term and comfortable vascular access for patients undergoing chemotherapy. Despite their routine use, the precise determination of the optimal catheter tip position remains controversial. Malposition of the tip is strongly linked to both early and late complications, including venous thrombosis, vascular injury, arrhythmia, valvular damage, and myocardial perforation [1, 2]. Such adverse events often necessitate device removal and reinsertion, thereby increasing healthcare costs, procedural workload, and patient

distress. In addition, malposition may lead to premature catheter dysfunction, resulting in treatment interruptions.

According to the National Association of Vascular Access Networks and the Infusion Nurses Society, the catheter tip should ideally be located within the lower third of the superior vena cava (SVC), near the cavoatrial junction (CAJ), where the SVC meets the right atrium (RA) [3, 4]. Several methods have been proposed to achieve correct tip placement, including fluoroscopy, intracavitary electrocardiography (IC-ECG) guidance, and surface landmark-based estimations [5, 6, 7].

Taking into account the limitations of existing techniques, we developed a new approach that employs the carina as a consistent radiological reference for determining catheter length. Preliminary observations indicated that this landmark-based strategy could provide accurate and safe tip localization.

Therefore, the present study aimed to evaluate the reliability of this newly developed radiological landmark-based technique by analyzing post-procedural thoracic computed tomography (CT) images. Furthermore, we assessed the association between catheter tip positioning and postoperative complications in a retrospective clinical cohort.

METHODS

Study Design

This retrospective, single-center clinical study was conducted at University of Health Science Bağcılar Training and Research Hospital. This study was approved by the institutional review board and complied with the principles of the Declaration of Helsinki. Written informed consent was obtained from all participants prior to enrollment.

Clinical and radiological data of patients who underwent TIVAP implantation via the right internal jugular vein (IJV) using the newly developed radiological landmark-based technique between March 2022 and March 2024 were retrospectively reviewed. Information on demographic and baseline characteristics, perioperative details, early and late postoperative complications, and radiological assessments were retrieved from the institutional electronic database. All study endpoints were predefined before submission of the protocol to the ethics committee.

Patient Demographics and Clinical Characteristics

Patient demographics and baseline clinical characteristics included age, gender, height, weight, body mass index (BMI), American Society of Anesthesiologists (ASA) physical status, IJV diameter (mm), comorbidities, cancer type, anticoagulant or antiplatelet drug use, smoking and alcohol status, and median follow-up time (months).

Perioperative data included the procedure duration (in minutes, defined as the interval between the initial IJV puncture and the final skin suture), number of venipuncture attempts, incidence of accidental arterial puncture, presence of atrial premature contractions and the highest numeric pain rating score recorded during the procedure. Intraoperative physiological parameters, mean arterial pressure (MAP), heart rate (HR), and oxygen saturation (SaO_2), were continuously monitored and documented.

Postoperative catheter-related complications were defined as hematoma, pneumothorax, venous thrombosis, local or systemic infection, catheter occlusion (dysfunction), inability to aspirate blood from the catheter, and local discomfort. Patient comfort was evaluated using a validated comfort and satisfaction scale on postoperative days 1 and 7, as previously described [8, 9]. The comfort scale was graded as follows: Grade 0, no discomfort; Grade 1, extremely mild discomfort; Grade 2, slight discomfort; Grade 3, moderate discomfort; Grade 4, marked discomfort; and Grade 5, extreme discomfort.

Selection Criteria

Patients aged 18 years or older with solid tumors who underwent TIVAP implantation through the right IJV using the new radiological landmark-based technique for chemotherapy administration were included. All consecutive eligible patients meeting these criteria during the study period were included to minimize sampling bias.

Exclusion criteria were: refusal to participate, absence of postoperative thoracic CT imaging, use of alternative venous access due to unsuitability of the right IJV, previous history of right IJV catheterization, pregnancy, destructive lung disease, history of cardiac surgery, or spinal deformity or surgery.

In total, 4 patients declined participation, 33 were unsuitable for right IJV access, 42 had a prior right IJV central line, 18 had a history of cardiac surgery, 16 had destructive lung disease, and 8 had spinal pathology or previous spinal surgery. The study flow diagram is shown in Fig. 1.

Procedures of TIVAP Implantation

Radiological Landmark-Based New Technique

Preoperative Phase

Before TIVAP implantation, all patients underwent routine preoperative evaluation including detailed medical history, complete blood count, coagulation profile, electrocardiography, posteroanterior chest radiography (CXR), and vascular ultrasonography.

The catheter insertion depth was calculated using a new formula derived from ultrasonography and CXR as radiological landmarks, with an additional 2-cm safety margin (Definition 2) [10]. This novel method, hereafter referred to as the **Demirgan Approach**, was developed to ensure precise and reproducible localization of the catheter tip at the CAJ.

The new technique can be summarized as follows:

The patient was placed in the supine position with the head turned 15^0–20^0 to the left. The ultrasound probe was positioned at the point where the IJV was most clearly visualized, closest to the clavicle, in an out-of-plane orientation (Fig. 2A). The IJV was centered on the ultrasound screen, and the skin was marked at this point (**Point A**) using a non-erasable marker (Fig. 2B). The accuracy of the mark was confirmed by applying gentle pressure with the marker while observing the vessel's position on the ultrasound screen (Fig. 2C).

An electrocardiography (ECG) electrode was then applied to the skin, with its metallic center precisely aligned over the mark (Fig. 2D). A posteroanterior CXR (DigitalDiagnost; Philips Digital Radiography Solutions, Germany) was obtained with the patient standing upright and holding full inspiration.

On the radiograph, the metallic center of the ECG electrode was clearly visible and defined as Point A (Fig. 3). The upper border of the clavicle–sternum junction was identified as Point B (Fig. 3). From Point B, a vertical line was drawn downward, and a point located two vertebral body units (VBUs) below the carina on this line was designated as Point C (Fig. 3). The CAJ was assumed to correspond to this level, and the catheter tip was targeted to reach it.

Using electronic calipers, two measurements were obtained: the distance from Point A to Point B (A–B) and from Point B to Point C (B–C) (Fig. 3). The sum of these two distances (A–B + B–C) represented the estimated post-puncture catheter length.

This radiological landmark-based approach was designed to provide a reproducible, anatomy-guided, and radiation-sparing method for predicting optimal catheter tip position prior to implantation.

Perioperative Phase

All procedures were performed under strict aseptic conditions in the outpatient operating room. Continuous ECG, noninvasive blood pressure, and pulse oximetry monitoring were applied.

All implanted port systems (Vygon Polysite 4000, France) were single-lumen devices inserted through the right IJV. At the beginning of the procedure, patients received midazolam (2 mg IV) and fentanyl (50–100 µg IV), with additional doses of midazolam administered as needed for sedation. Each patient was positioned at a 10° Trendelenburg tilt with the head slightly turned to the left. Local anesthesia was achieved using 2% lidocaine.

Under ultrasound guidance, IJV puncture was performed from the previously marked skin point (Point A). A guidewire was advanced through the puncture site, and an 8 F silicone catheter was inserted into the right IJV. The catheter was trimmed according to the pre-calculated length (A–B + B–C) to ensure accurate placement of the tip.

After the catheter was positioned, local anesthesia was administered at the site designated for the port chamber pocket. A 3-cm skin incision parallel to the clavicle was made using a No.15 scalpel blade. The subcutaneous tissue was bluntly dissected with a hemostat to create the port pocket, and the chamber was placed subcutaneously beneath the puncture site.

Neither prophylactic antibiotics nor routine anticoagulation therapy were administered. Postprocedural thoracic CT was performed to confirm catheter tip position and evaluate for early postoperative complications.

Imaging Examination and Assessment

Thoracic CT was used to evaluate the position of the TIVAP catheter tip. Computed tomography (CT) scans were conducted without the administration of contrast agents, utilizing a 128-slice sequential multislice CT scanner (Ingenuity, Philips, Amsterdam, Netherlands). The scanning parameters were as follows: tube voltage of 120 kV, tube current of 256 mAs, slice thickness of 4 mm, field of view 500 mm, matrix size of 512 × 512, pitch of 1.255, and a gantry rotation time of 0.5 seconds. All images were independently reviewed by a board-certified radiologist (initials blinded) with five years of experience in interventional radiology, who was unaware of the clinical data.

A VBU was defined as the distance between two adjacent vertebral bodies including the intervertebral disc space. Measurements included the distance from the carina to the CAJ (mm and VBUs), the distance from the catheter tip to the CAJ (mm), and the length of the SVC (mm). The angle between the catheter tip and the vessel wall was also recorded.

The CAJ on CT was defined as the base of the superior border of the crista terminalis. Optimal catheter tip positioning was defined as a tip located within 2 cm above or below the CAJ junction [10]. The distance from the tip to the CAJ was recorded as a positive value (above the junction) or a negative value (below).

Outcome Measures

Primary outcome:

The proportion of patients whose catheter tip was located within the target area on postoperative CT (success rate of the Demirgan Approach) and the association between tip position and postoperative complications such as venous thrombosis, catheter occlusion, and inability to aspirate blood.

Secondary outcomes:

Secondary endpoints included anatomical characteristics of the Turkish patient population (carina-to-CAJ distance in mm and VBU, SVC length, IJV diameter), sex-related anatomical differences, and correlations of these variables with age, height, and weight.

The effects of the IJV diameter-to-catheter diameter ratio and the catheter tip-to-vessel wall angle on postoperative complications were also evaluated. Patient comfort scores were compared between postoperative days 1 and 7.

Statistical Analysis

Statistical analyses were performed using GraphPad Prism version 10.6 (La Jolla, CA, USA). Continuous variables were expressed as mean ± standard deviation (SD) or median (interquartile range), and categorical variables as counts and percentages.

Normality was assessed using the Shapiro–Wilk test. Fisher's exact test was applied to categorical variables. The Mann–Whitney U test was used for two-group comparisons, and the Kruskal–Wallis test followed by Dunn's post-hoc analysis for multiple comparisons. Correlations between variables were analyzed using Spearman's rank correlation ($r = 0.20–0.39$: weak, 0.40–0.59: moderate, 0.60–0.79: strong, 0.80–1.0: very strong). A p-value < 0.05 was considered statistically significant. Of the 261 included patients, postoperative follow-up data were available for 243 patients, with 18 patients lost to follow-up. Analyses involving postoperative outcomes were therefore performed using complete-case analysis, and no imputation method was applied.

RESULTS

A total of 382 patients who underwent TIVAP implantation between March 2022 and March 2024 were retrospectively evaluated for eligibility. Of these, 121 patients were excluded, and 261 patients were included in the final analysis. The study flow diagram is presented in Fig. 1. Of these, 154 (59%) were male and 107 (41%) were female, with a median age of 61 years (range 18–88) and median follow-up 8.13 months (range 0.03–16.33). The most common comorbidity was hypertension (35.2%), and colorectal cancer was the predominant malignancy (40.6%). Nearly half (45.5%) had metastatic disease. Detailed demographics and clinical data are summarized in Table 1.

Table 1
Demographic and Baseline Characteristics of the Study Population (n = 261)

Age (year)	***Min-Max (Median)***	**18–88 (61)**	
	Mean ± SD	**60.13 ± 12.45**	
Gender	*Female / n (%)*	107 (41)	
	Male / n (%)	154 (59)	
Height (cm)	*Min-Max (Median)*	140–190 (168)	
	Mean ± SD	166.9 ± 8.30	
Weight (kg)	*Min-Max (Median)*	38–130 (70)	
	Mean ± SD	70.53 ± 13.99	
BMI	*Min-Max (Median)*	15.57–44.98 (24.77)	
	Mean ± SD	25.31 ± 4.65	
ASA	*1 / n (%)*	87 (33.3)	
	2 / n (%)	121 (46.3)	
	3 / n (%)	52 (19.9)	
	4 / n (%)	1 (0.3)	
Median follow-up (months)	*Min-Max (Median)*	0.03–16.33 (8.13)	
	Mean ± SD	8.15 ± 4.08	
Comorbidity*	*n (%)*	**Comorbidity***	*n (%)*
- Asthma	8 (3)	- **HT**	**92 (35.2)**
- CKD	1 (0.3)	- **Hypo/Hyperthyroidism**	12 (4.6)
- CVD	4 (1.5)	- **IHD**	23 (8.8)
- DM	67 (25.6)	- **COPD**	7 (2.6)
- HF	9 (3.4)	- **Obesity**	44 (16.8)
Cancer Type	*n (%)*	**Cancer Type**	*n (%)*
- Breast	29 (11.1)	- **Stomach**	80 (30.6)
- Colorectal	**106 (40.6)**	- **Pancreas**	21 (8)
- Esophagus	5 (1.9)	- **Other**	2 (0.7)

Numerical data are presented as mean ± standard deviation and median (minimum–maximum) values. Categorical variables are expressed as frequency and percentage [n (%)]. The prevalence of comorbidities was calculated with respect to the total study population (n = 261).

Age (year)	***Min-Max (Median)***		**18–88 (61)**	
	Mean ± SD		**60.13 ± 12.45**	
- Larynx	5 (1.9)	- **Ovary**		3 (1.1)
- Liver	2 (0.7)	- **Testis**		1 (0.3)
- Lung	5 (1.9)	- **Tongue**		1 (0.3)
- Skin	1 (0.3)			
Metastasis	*Yes / n (%)*		119 (45.5)	
	No / n (%)		142 (54.4)	
Blood-thinner drug usage	*Yes / n (%)*		68 (26)	
	No / n (%)		193 (73.9)	
Smoking status	*Never / n (%)*		146 (55.9)	
	Former / n (%)		68 (26)	
	Current / n (%)		47 (18)	
Alcohol use status	*Never / n (%)*		213 (81.6)	
	Former / n (%)		26 (9.9)	
	Current / n (%)		22 (8.4)	

Numerical data are presented as mean ± standard deviation and median (minimum–maximum) values. Categorical variables are expressed as frequency and percentage [n (%)]. The prevalence of comorbidities was calculated with respect to the total study population (n = 261).

Abbreviations: ASA, American Society of Anesthesiologists; BMI, body mass index; CKD, chronic kidney disease; COPD, chronic obstructive pulmonary disease; CVD, cerebrovascular disease; DM, diabetes mellitus; HF, heart failure; HT, hypertension; IHD, ischemic heart disease.

The catheter tip was accurately positioned within the target zone in 243 of 261 patients (**93.1%**), demonstrating a high procedural success rate of the newly developed radiological landmark-based technique. In addition, success rate was comparable between male and female patients, with no statistically significant difference observed (Fig. 4). This finding confirms that the method provided precise and reproducible localization of the catheter tip at the CAJ without the need for fluoroscopic or ECG guidance. Only 18 patients (6.9%) had tips located outside the optimal zone. In 3 patients (1.1%), the tip was located above the carina level. Migration of the TIVAP catheter tip into the RA occurred in 100 patients (38.3%) but did not cause any complications during follow-up. The median angle between the catheter tip and the vessel wall was 9° (range 1^0–36^0).

The most frequent postoperative complication was inability to aspirate blood (6.1%), followed by catheter occlusion (2.3%), local infection (1.9%), hematoma (1.5%), venous thrombosis (1.5%), and systemic infection (0.7%). Pneumothorax occurred in only one patient (0.3%) in the early postoperative period. Patient comfort improved significantly from postoperative day 1 to day 7 (min–max (median): 0–3 (0) vs. 0–4 (0), **p < 0.0001**).

The incidence of "inability to aspirate blood" was significantly higher in patients with the catheter tip outside the target zone compared to those with optimal placement (44.4% vs. 3.2%, **p < 0.0001**). However, no significant difference was found between groups in terms of venous thrombosis or catheter occlusion (p = 0.2499 and p = 0.3515, respectively; Table 2).

Table 2
Relationship Between Catheter Tip Position and Complications (n = 243)

		Is the catheter tip in the target area?		
		Yes	**No**	**P value**
Venous thrombosis	*Yes / n (%)*	3 (1.2)	1 (5.5)	0.2499
	No / n (%)	240 (98.7)	17 (94.4)	
Catheter occlusion	*Yes / n (%)*	5 (2)	1 (5.5)	0.3515
	No / n (%)	238 (97.9)	17 (94.4)	
Blood aspiration from catheter	*Yes / n (%)*	235 (96.7)	10 (55.5)	**< 0.0001*** **
	No / n (%)	8 (3.2)	8 (44.4)	

Complication rates are reported as percentages of the evaluated subgroup (n = 243). Data from 18 patients were excluded because postoperative follow-up information was unavailable. P values were calculated using Fisher's exact test. A **p-value < 0.05** was considered statistically significant.

Note: Of the total 261 patients included in the study, postoperative follow-up data were available for 243 patients; 18 patients were lost to follow-up.

The IJV-to-catheter diameter ratio was not associated with venous thrombosis, catheter occlusion, or blood aspiration difficulty. However, there was a positive correlation between the catheter tip-to-vessel wall angle and catheter occlusion (**r = 0.172**, **p = 0.0054**; **Supp.** Figure 1).

Anatomical characteristics of the study population are summarized in **Supp** Table 1. The SVC length and IJV diameter were significantly greater in males than in females (**p = 0.0019** and **p = 0.0317**, respectively).

Correlation analyses revealed a negative correlation between body weight and carina-to-CAJ distance (carina-to-CAJ [mm]: **r = − 0.203**, **p = 0.001**; carina-to-CAJ [VBU]: **r = − 0.233**, **p = 0.0001**), whereas no significant correlation was found with age or height. The SVC length showed a positive correlation with age (**r = 0.292, p < 0.0001**) and a weak, nonsignificant negative correlation with body weight (r = − 0.104,

p = 0.0925). The IJV diameter correlated significantly with age and weight (**r = 0.123, p = 0.047** and **r = 0.193, p = 0.0018** respectively) (**Supp.** Figure 2).

Perioperative and postoperative detailed data are provided in **Supplementary Tables 1 and 2**.

DISCUSSION

Accurate catheter tip placement in TIVAPs remains critical to device function and patient safety. Malposition has been consistently associated with early mechanical dysfunction, thrombotic complications, fibrin sheath formation, arrhythmia, and even cardiac perforation [11, 12, 13]. Contemporary guidelines recommend tip placement in the lower third of the SVC, near the CAJ [14]. On the other hand, it is also acceptable to locate it at the upper portion of the RA within 2 cm below the CAJ in the European guidelines [11]. In this context, our study introduces and evaluates the Demirgan Approach, a radiological-landmark-based method designed to estimate catheter insertion depth using ultrasonographic skin marking and CXR landmarks (carina + VBUs). Our findings demonstrate that the catheter tip was positioned within the predefined target zone (2 cm above or below the CAJ) in 93.1% of patients, underscoring the technique's reproducibility and effectiveness even without fluoroscopy or IC-ECG.

The use of the carina as a radiographic landmark has been well documented in the literature. For instance, studies have shown that the CAJ lies approximately 3.0–5.0 cm below the carina or around two VBUs inferior on chest radiograph [15, 16, 17]. Previously, Zhou et al. found that for catheter insertions via the right subclavian vein, using modified surface measurement method resulted in acceptable positioning in 92.4% of cases.[10] While the absolute accuracy of such landmarks may vary depending on patient anatomy and access side, their widespread availability and simplicity make them attractive for routine use especially when advanced guidance is unavailable. Our method builds on this premise by combining ultrasonographic identification of the skin entry point (Point A) with CXR landmarks (Points A, B and C) to compute catheter length (A–B + B–C). By achieving a 93.1% in-target rate, the Demirgan Approach compares favourably with other landmark-based modalities and approaches the performance of more resource-intensive techniques.

Several studies in the literature have reported that, in adults, the CAJ is located approximately 2.4–2.5 VBUs below the carina [16, 18]. Only one study conducted in adolescents and young adults identified the CAJ at a shallower depth of 2.0 VBUs [15]. In the early phase of our clinical experience with this newly developed technique, we initially adopted 2.4 VBUs below the carina as the reference level for the CAJ and calculated the insertion depth accordingly. However, after several procedures performed using this assumption, postoperative imaging revealed that nearly 65% of catheter tips were located within the RA, and approximately 17% extended beyond the 2-cm safety margin generally considered acceptable. Consequently, we revised our standard practice and began defining the CAJ as 2 VBUs below the carina, consistent with previous report [15]. which subsequently yielded optimal tip placement within the target zone.

Interestingly, in our cohort, although the target level was defined as 2 VBUs below the carina, postoperative thoracic CT measurements showed that the actual carina-to-CAJ distance averaged 1.5 VBUs. We believe this discrepancy stems from differences in patient positioning during imaging preoperative CXR were obtained in the upright position, whereas postoperative CT scans were acquired in the supine position. The upward displacement of the diaphragm and heart caused by abdominal viscera in the supine posture likely explains the apparent reduction in vertical distance between the carina and the CAJ. This physiologic shift should be taken into consideration when correlating radiographic measurements obtained in different body positions.

Although IC-ECG guidance and fluoroscopic confirmation remain the gold standards for tip positioning, with multiple meta-analyses reporting first-attempt success rates exceeding 95% and reduced complication rates [19, 20], these modalities require specialized equipment and operator expertise, and may not be available in all clinical settings. Moreover, a recent multicentre observational study published in the Journal of Vascular Access reported that, despite the use of IC-ECG, malposition occurred in 5.9% of cases [21]. Fluoroscopy-guided procedures achieve an excellent success rate of approximately 99%; however, they are associated with non-negligible radiation exposure, raising important safety considerations [19, 22]. Although our technique involves a single posteroanterior CXR to determine the insertion site, the overall radiation exposure is minimal and markedly lower than that associated with fluoroscopic guidance. Therefore, the Demirgan Approach can be considered a radiation-sparing and cost-effective alternative for accurate catheter tip placement. The high accuracy achieved suggests that this novel technique may serve as a practical option in outpatient settings or in institutions lacking IC-ECG or full fluoroscopic capability. Another advantage of this technique is the reduction in operating room time. Because the catheter length is precisely determined before the procedure using radiological landmarks, no intraoperative measurement or adjustment is required. This preoperative planning streamlines the implantation process and minimizes time spent in the operating room without compromising accuracy.

The significant finding of a markedly increased rate of blood-aspiration failure (44.4% vs 3.2%, $p < 0.0001$) among patients whose tips were outside the target zone reinforces the clinical relevance of precise tip placement. This result is consistent with known mechanisms of catheter malposition: suboptimal tip position leads to turbulent flow, endothelial irritation and sheath formation, predisposing to occlusion and thrombosis [23, 24]. Additionally, the detected positive correlation between the catheter tip-to-vessel-wall angle and catheter occlusion ($r = 0.172$, $p = 0.0054$) aligns with histopathological evidence of intimal hyperplasia and thrombosis associated with steep angles or abutment against the vessel wall [25, 26, 27]. Thus, our results not only confirm anatomical reproducibility but also correlate improved placement with tangible functional outcomes.

From an anatomical perspective, our study provides valuable insights. The SVC length and IJV diameter were significantly greater in males ($p = 0.0019$ and $p = 0.0317$). Furthermore, the negative correlation between body weight and the carina-to-CAJ distance ($r = -0.203$, $p = 0.001$) suggests that patient body

habitus influences thoracic vascular geometry. Incorporating these anatomical considerations into the pre-sizing formula may further enhance reproducibility across populations.

Several limitations of this study should be acknowledged. First, this was a retrospective, single-center analysis, which may limit the generalizability of the results. Second, although post-procedural CT was used to confirm the position of the catheter tip, it was not performed for validation of the technique itself. In our institution, early postoperative CT is routinely obtained to promptly identify potential complications such as pneumothorax, hematoma, or catheter malposition before patient discharge. Therefore, its use in this study reflects part of our standard postoperative safety protocol, rather than a requirement of the Demirgan Approach. Finally, the absence of a direct comparison with fluoroscopic or IC-ECG-guided methods precludes definitive conclusions regarding relative accuracy or cost-effectiveness. Prospective multicenter studies with parallel validation arms are warranted to further assess the reproducibility and clinical utility of this method across different practice settings.

In conclusion, this novel technique offers a simple, reproducible, and clinically effective method for achieving optimal catheter tip positioning in TIVAP implantation. Given its high in-target accuracy and low complication rate, the Demirgan Approach may represent a practical and resource-efficient alternative for routine TIVAP placement.

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Figures

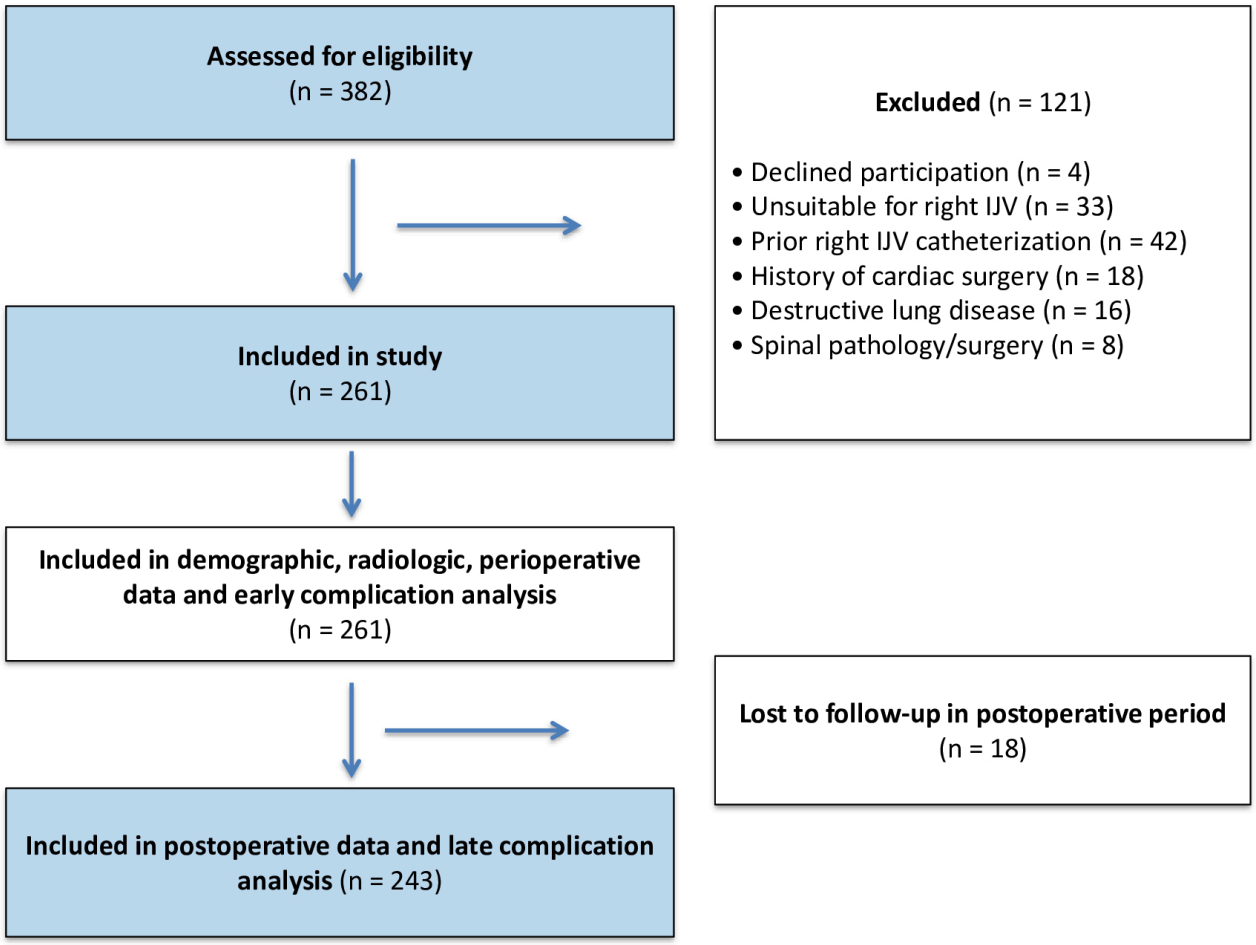


Figure 1

The study flow diagram

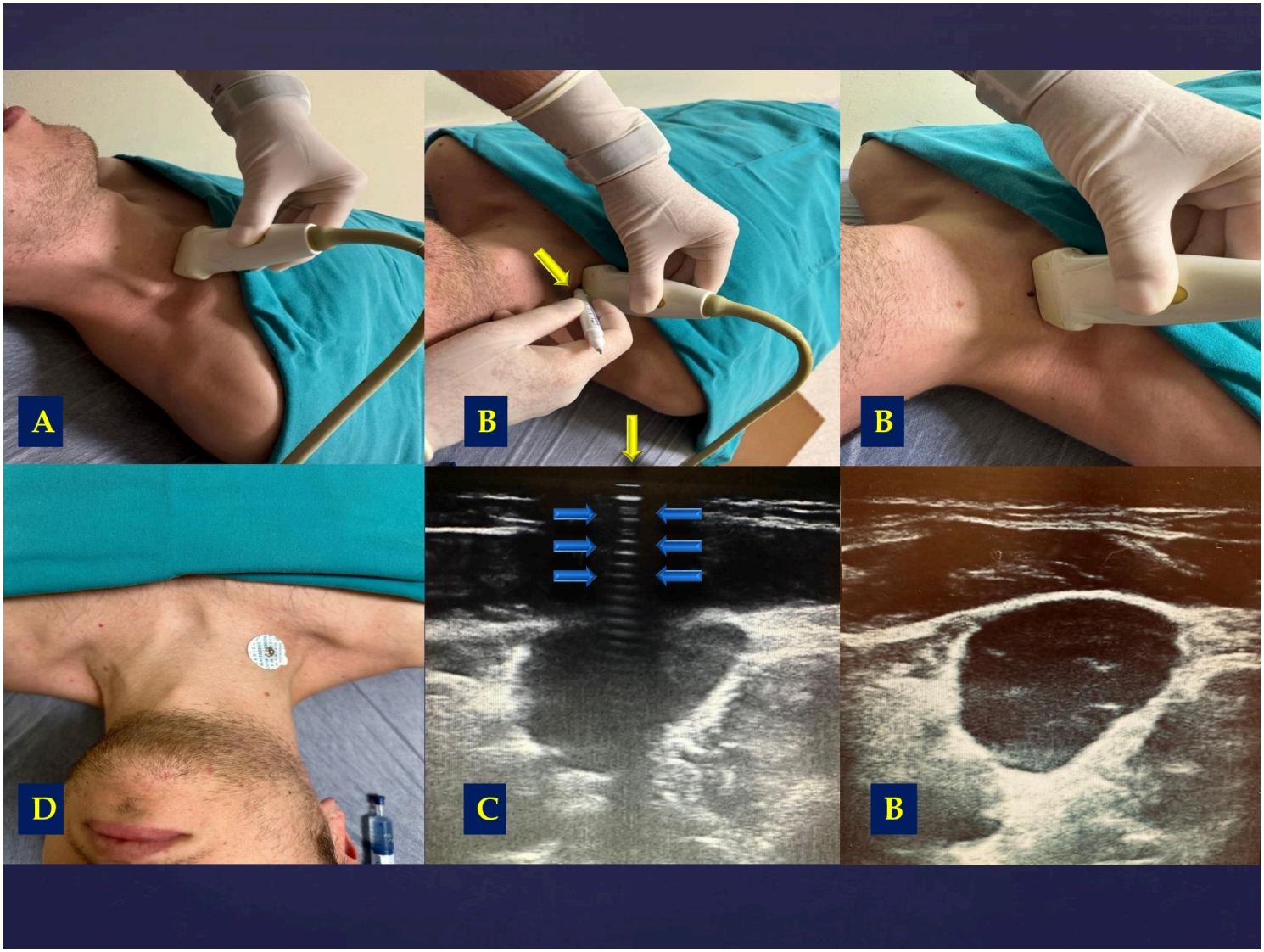


Figure 2

Stepwise ultrasound-guided surface landmarking in the Demirgan Approach

(A) The ultrasound probe is positioned at the most inferior and clearly visualized segment of the internal jugular vein (IJV) near the clavicle in an out-of-plane orientation.

(B) The corresponding skin point is marked after centering the IJV under ultrasound visualization, ensuring accurate localization (yellow arrow indicates marking confirmation).

(C) Ultrasonographic view demonstrating the IJV location beneath the probe after pressure verification (blue arrows indicate probe pressure response during real-time confirmation).

(D) An electrocardiography (ECG) electrode is placed with its metallic center aligned precisely over the marking point, serving as a radiopaque reference for subsequent posteroanterior chest radiography.

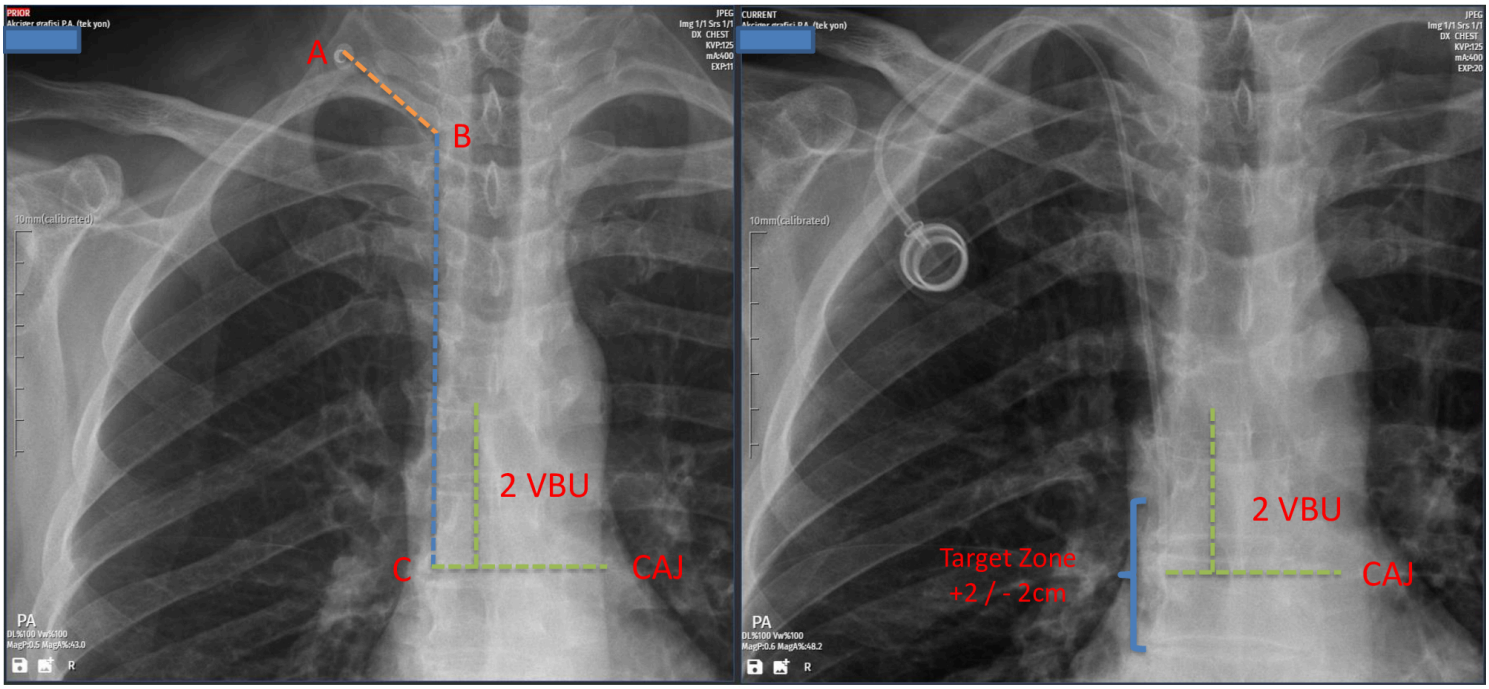


Figure 3

Radiological landmark–based catheter length estimation and final catheter positioning

Left: Posteroanterior chest radiograph demonstrating predefined reference points used for catheter length calculation. Point A corresponds to the metallic center of the ECG electrode placed over the ultrasound-identified puncture site. Point B represents the clavicle–sternum junction, and Point C is located two vertebral body units (VBU) below the carina, approximating the cavoatrial junction (CAJ). The sum of distances A–B and B–C was used to predict the optimal catheter length.

Right: Post-procedural radiograph confirming catheter tip placement within the predefined target zone (±2 cm from the CAJ level).

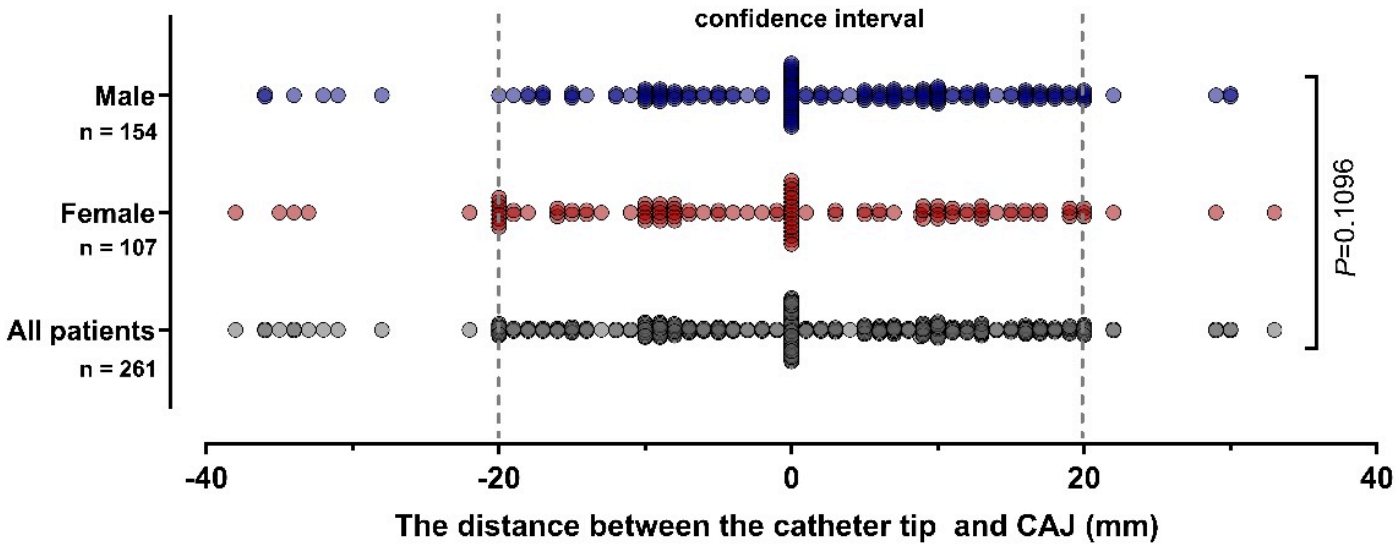


Figure 4

Distribution of Catheter Tip Distance From the Cavoatrial Junction

Scatter plot illustrating the distance (mm) between the catheter tip and the cavoatrial junction (CAJ) among all patients (n = 261), and stratified by sex (male, n = 154; female, n = 107). Dotted vertical lines represent the predefined optimal target zone (–20 to +20 mm from the CAJ).

The catheter tip was accurately positioned within this target zone in 243 of 261 patients (93.1%), indicating a high technical success rate for the applied method. No significant difference was observed between sexes regarding the mean catheter tip–CAJ distance (P=0.1096).

Supplementary Files

This is a list of supplementary files associated with this preprint. Click to download.

- SuppFig.11.jpg
- SuppTable1.docx