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ORIGINAL ARTICLE

Clinical application of ultrasound-guided totally implantable venous access ports implantation via the posterior approach of the internal jugular vein

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Abstract

Background: To determine the feasibility and safety of ultrasound-guided totally implantable venous access port (TIVAP) implantation via the posterior approach of the internal jugular vein (IJV).

Methods: From September 2021 to August 2022, 88 oncology patients underwent ultrasound-guided implantation of TIVAPs via the posterior approach of the IJV for the administration of chemotherapy. The catheter tip was adjusted to be positioned at the cavoatrial junction under fluoroscopic guidance. Clinical data including surgical success, success rate for the first attempt, intraoperative, and postoperative complications were all collected and analyzed.

Results: All patients underwent successful surgery (100%), whereby 58 were via the right IJV and 30 via the left IJV, and the success rate for the first attempt was 96.59% (85/88). The operation time was 20 to 43 minutes, with an average of 26.59±6.18 minutes with no intraoperative complications. The follow-up duration ranged from 1 to 12 months (mean = 5.28±3.07) and the follow-up rate was 100%. The rate of postoperative complications was 4.55% (4/88), including port-site infection in two cases, fibrin sheath formation in one case, and port flip in one case. No other complications were observed during follow-up.

Conclusion: Ultrasound-guided TIVAP implantation via the posterior approach of the IJV is feasible, safe, and effective, with a low rate of intraoperative and postoperative complications. Not only was the curvature of the catheter device smooth, but patients were satisfied with the comfort and cosmetic appearance. Additionally, we could reduce the possible complications of pinching and kinking of the catheter by using this approach. Therefore, further large-sample, prospective, and randomized controlled trials are warranted.

Keywords: Complications; Internal jugular vein; Posterior approach; Totally implantable venous access ports; Ultrasound-guided

1. INTRODUCTION

Because Niederhuber et al[1] first introduced totally implantable venous access ports (TIVAPs) at the MD Anderson Cancer Center in 1982, they have gained worldwide popularity in oncology for long-term chemotherapy infusions, hydration, parenteral nutrition, and serial blood withdrawals.[2,3] Compared with peripherally inserted central catheters (PICCs), TIVAPs allow for the long-term administration of venotoxic compounds, reduce the risk of infection and thrombosis, and alleviate the burden of intravenous therapy, thereby significantly improving quality of life.[4–6] The implantation of TIVAPs can be performed using different methods, such as percutaneous insertion and surgical venous cut-down.[7] Although the literature has shown no differences in the peri- or post-operative complication rates between the percutaneous technique and the cut-down technique, percutaneous TIVAP implantation has become the preferred method of implantation worldwide.[6,7]

The internal jugular vein (IJV) is generally the first choice site for percutaneous TIVAP implantation[7] as the use of the IJV can reduce potential complications of subclavian vein (SCV) access, such as catheter malpositioning, thrombosis, pneumothorax/hemothorax, and pinch-off syndrome (POS).[7,8] With the conventional approach, the IJV is penetrated at the apex of Sedillot triangle (the middle approach), formed by the clavicle and the sternal and clavicular heads of the sternocleidomastoid (SCM) muscle (Fig. 1). This approach is considered the safest and most effective percutaneous technique for reaching the IJV.[9] However, some patients undergoing TIVAP implantation by the middle approach complained of an aesthetically unappealing appearance, with an obvious subcutaneous catheter over the neck region. Moreover, they felt like they had something against their neck and they were afraid to turn their head for several days after the implantation of the TIVAP. To increase comfort and cosmetic outcome, we changed the venipuncture site from the Sedillot triangle to the posterior triangle (the posterior approach), which consisted of the posterior margin of the SCM muscle, anterior margin of the trapezius muscle, and clavicle (Fig. 1). With assistance from ultrasound guidance, we were able to perform the posterior approach venipuncture safely.

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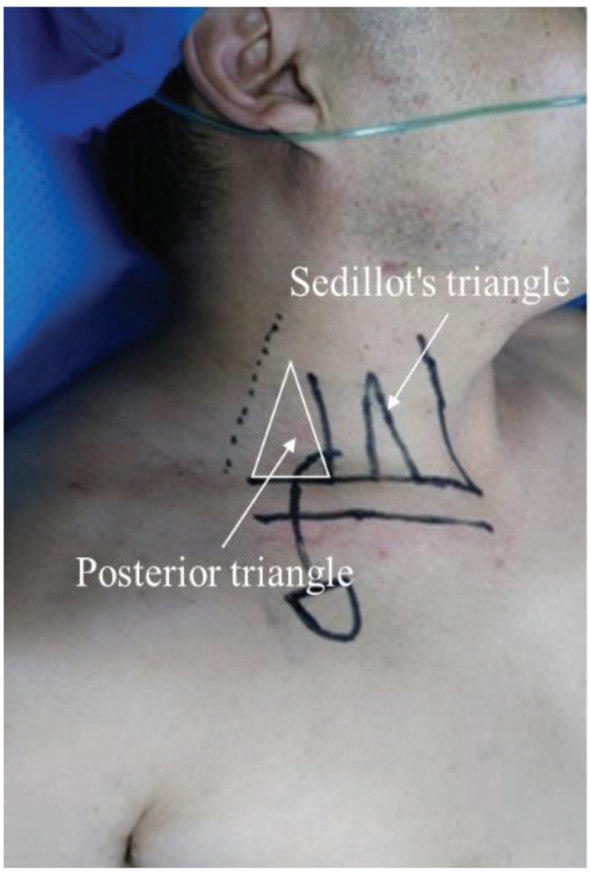

Fig. 1 Sedillot triangle and posterior triangle. Sedillot triangle is formed by the clavicle and the sternal and clavicular heads of the SCM muscle. Posterior triangle is formed by posterior margin of the SCM muscle, anterior margin of the trapezius muscle, and clavicle. SCM = sternocleidomastoid.

Only a relatively few studies using ultrasound-guided central vena catheterization (CVC) for hemodialysis via the posterior approach of the IJV have been reported previously.[10,11] The results suggest that the posterior approach for central lines is equivalent to, or better than, the conventional middle approach. There are some advantages to the posterior approach: first, the IJV usually lies central to the common carotid artery (CA), and thus, the artery lies medially to the IJV when the vein is punctured, which decreases the chance of puncturing the artery when compared to the middle approach; second, the catheter can gradually be inserted into the vein from a lateral direction, which results in a straighter course for tunneling; thirdly, the posterior approach does not cross the SCM muscle and consequently there is less pain and discomfort during and after the procedure.[11] However, the posterior approach of the IJV has been rarely reported for TIVAPs, and it is still overlooked.

The aim of this article, therefore, was to describe the feasibility and safety of ultrasound-guided TIVAP implantation via the posterior approach of the IJV with detailed consideration to the technical points. Clinical data including technical success, success rate for the first attempt, intraoperative, and postoperative complications were collected and analyzed.

2. METHODS

2.1. Patients

Clinical and nursing data for 88 adult patients with cancer who underwent TIVAP implantation via the posterior approach of the IJV from September 2021 to August 2022 were collected. All patients underwent complete preoperative examination, including routine blood tests, coagulation function, liver and kidney functions, and ultrasound evaluation of blood vessels.

We excluded from this study patients with abnormal clotting that could not be corrected, thrombotic and stenotic IJV (<5 mm), local infection or pathology over the intended venipuncture or incision site, a potential risk of compromised airways, and abnormalities in imaging studies, such as a huge mediastinal tumor seen on chest radiography or compression of the superior vena cava by a tumor mass seen on chest computed tomography.

The study was approved by the ethics committee of the First Affiliated Hospital to Shandong First Medical University & Shandong Provincial Qianfoshan Hospital, and all methods were performed in accordance with the relevant guidelines and regulations.

2.2. Technique

The IJV and CA were identified using ultrasound. The diameter and depth of the IJV and the presence of blood vessels, nerves, and other tissues in the puncture route were evaluated.

The IJV was cannulated by advancing an introducer needle (18-gauge; Terumo Corporation, Hanoi city, Vietnam) in the posterior triangle under ultrasound guidance using the short-axis lateral in-plane technique (Fig. 2A). No more than three puncture attempts were allowed during one approach.

2.3. Surgical procedure

Two trained senior vascular surgeons performed the surgery in the operating theater and the trained vascular surgeons were skilled in ultrasound-guided puncture. TIVAPs from B. Braun Medical (6.5F; B. Braun Medical, Chassneuil-du-Poitou, France) were used.

In the supine position under local anesthesia, the head was turned slightly to the contralateral side and the SCM muscle popped out of the neck. For ultrasound-guided puncture, the ultrasound probe was wrapped in a sterile cover and the IJV and CA were identified using ultrasound. The entry site of the needle was lateral to the lateral margin of the SCM muscle in the posterior triangle and it was directed toward the IJV through the nonmuscular area under the SCM muscle. The course of the needle was angled to approximately 30° to a horizontal line and the puncture site was locally anesthetized with 1% lidocaine. With the guidance of the ultrasound probe (the short axis lateral in-plane technique), the needle was advanced once the IJV was visualized on the ultrasound screen (Fig. 2A, B). Retraction of the syringe plunger produced a flush of dark red blood when the IJV was entered. After a successful puncture, the guide wire, sheath, and catheter were entered sequentially under fluoroscopy (Fig. 2C). A subcutaneous pocket was created by blunt dissection on the anterior chest wall, and the pocket was sized to just fit the port. A tunnel needle catheter traction crossed above the clavicle through the incision, and the catheter was cut in a suitable position under fluoroscopy and joined to the port. Care was taken to ensure that the tunnel provides a gentle curve to the catheter from the skin puncture site to the port pocket and suture fixation of the port was not routinely necessary. Good blood aspiration was performed via the TIVAP to confirm correct placement, and the device was then flushed with heparinized saline (100 U/mL). The incision was sutured and covered with a sterile adhesion strip. The final catheter position and the subcutaneous tunnel curve were checked again (Fig. 2D, E).

2.4. Maintenance and follow-up

Specialized nurses at the venous access care center of our hospital maintained the TIVAPs after implantation. The catheter was flushed with 10 mL of 100 IU/mL heparin saline in a pulsatile

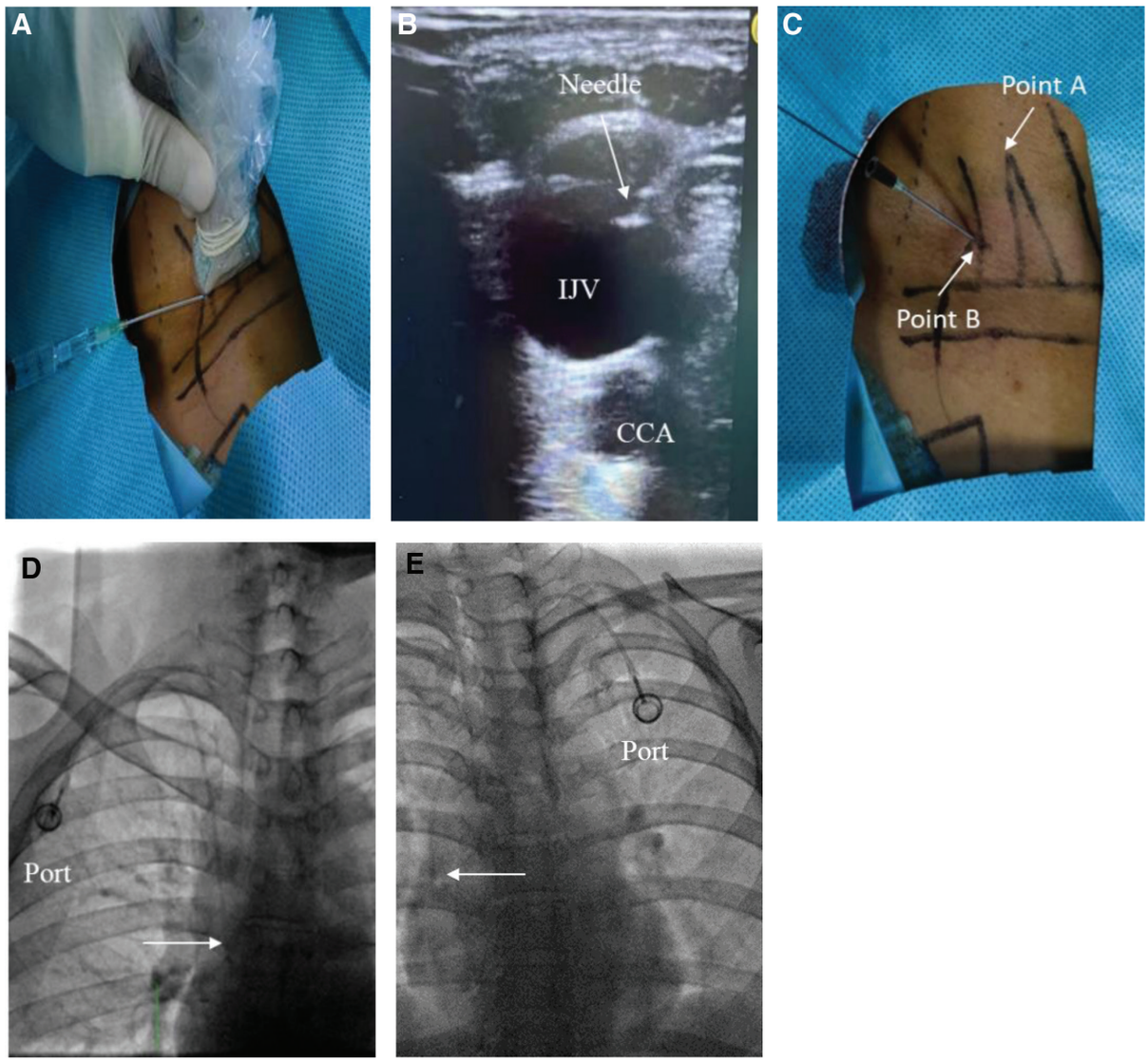

Fig. 2 Images of ultrasound-guided TIVAP implantation via the posterior approach of the internal jugular vein. A, Short axis, lateral in-plane technique; it allows simultaneous view of the full length of the needle, the IJV, CA, and adjacent tissue. B, The ultrasound-guided successful puncture of the IJV needle insertion (white arrow) using short axis, lateral in-plane technique. C, Puncture needle was inserted at the posterior triangle. Point A is the puncture site of middle approach and point B is the puncture site of posterior approach. D, A TIVAP is implanted via the posterior approach of right IJV, crossing over the right clavicle. The port is located on the right chest wall, and the tip of the catheter (white arrow) is located at the junction of the superior vena cava and the right atrium. E, A TIVAP is implanted via the posterior approach of left IJV, crossing over the left clavicle. The port is located on the left chest wall, and the tip of the catheter (white arrow) is located at the junction of the superior vena cava and the right atrium. CA = carotid artery; CCA = common carotid artery; IJV = internal jugular vein; TIVAP = totally implantable venous access port.

manner not more than once every 28 days. Patients were regularly followed up and interventions were considered in cases of suspected local wound or systemic infection, hematoma formation, or device dysfunction.

2.5. Outcome measures

Clinical outcomes were recorded: the success rate for the first puncture; operation time; intraoperative complications, such as arterial puncture, pneumothorax/hemothorax, local hematoma formation, kinking of the catheter over the subcutaneous tunnel, and curvature of the catheter; postoperative complications, such as catheter-related thrombosis, infection, fibrin sheath formation, catheter malposition or fracture.

All patients received an assessment of comfort on day 7 using a comfort scale. The comfort scale is a visual analog scale which is divided into six grades (grade 0: without any discomfort; grade 1: extremely mild discomfort; grade 2: a little discomfort; grade 3: some discomfort; grade 4: a lot of discomfort; grade 5: extremely discomfortable), and has been applied in many medical research studies and has been shown to be a simple and effective method for assessing patient comfort and satisfaction.[12,13]

Cosmetic outcome was assessed postoperatively on day 7 through evaluation of the changes in dressing habit after TIVAP implantation: (1) no need to change dressing habit; (2) need to wear collared clothes; (3) need to button the top button of the collared clothes; and (4) difficulty in dressing.[14]

3. RESULTS

Between September 2021 and August 2022, 88 patients were involved, and the general information of the patients is shown in Table 1. The IJV was cannulated by advancing a needle in the posterior triangle under ultrasound guidance. All patients underwent successful surgery (100%), including 58 via the right IJV and 30 via the left IJV. The success rate for the first attempt was 96.59% (85/88). Two attempts were needed in three patients (3.41%). However, there was no kinking of the subcutaneous tunnel and a good curvature was attained in all patients, as observed by postoperative fluoroscopy. Patients felt comfortable after the procedure, and were satisfied with the improved appearance and the ease of covering the subcutaneous catheter at the lower neck region with collared clothes (Table 2).

The mean operation time was 26.59±6.18 minutes (range: 20-43 minutes). No intraoperative complications occurred. The follow-up duration ranged from 1-12 months (mean 5.28±3.07) and the follow-up rate was 100%. The rate of postoperative complications was 4.55% (4/88). Two patients suffered from port-pocket infections during the 6th and 40th weeks after surgery. In one case, the patient was managed successfully with appropriate systemic antibiotics and wound dressing. However, in the second case, the port was removed due to the failure of active anti-infective therapy. One patient presented with poor infusion due to fibrin sheath formation 9 weeks after surgery. The Fibrin sheath formation was confirmed by angiography and managed with thrombolysis (250 000 units urokinase in 50 mL normal saline, intravenous drip for 3 hours, once a day). Eventually, the catheter function was successfully restored on the third day. One patient suffered from port inversion 7 weeks after surgery. The port was found turned upside down under radiograph and its function was restored following readjustment. No other complications were observed during follow-up (Table 2).

Table 1

Patient characteristics

Age (mean ± SD)	52.93±11.32 (30-74)
Sex (male/female)	7/81
Breast cancer (n)	65
Gastrointestinal cancer (n)	11
Lung cancer (n)	5
Gynaecological cancer (n)	3
Pancreatic cancer (n)	2
Hepatic cancer (n)	1
Lymphoma (n)	1

Table 2

Surgical results and complications

Success rate of surgery, %	100
TIVAPs via the right IJV, %	65.91
TIVAPs via the left IJV, %	34.09
Success rate of first attempt, %	96.59
Two attempts were needed (n)	3
Three attempts were needed (n)	0
Operation time, min (mean ± SD)	26.59±6.18 (20-43)
Comfort scale grade[a] (range)	0-2
0	33 (37.5%)
1	38 (43.2%)
2	17 (19.3%)
3	0
4	0
5	0
Cosmetic outcome score[b] (range)	1-2
1	21 (23.9%)
2	67 (76.1%)
3	0
4	0
Port-pocket infection (n)	2
Fibrin sheath formation (n)	1
Port inversion (n)	1

IJV = internal jugular vein; TIVAPs = totally implantable venous access ports.
[a]0 = without any discomfort; 5= extremely discomfort.
[b]1 = no need to change; 4= difficulty in dressing.

4. DISCUSSION

TIVAPs have been in use for four decades and provide comfort and convenience for patients and healthcare providers. Before ultrasound guidance was widely used in CVC puncture, SCV was less commonly used than IJV because of the higher risk of complications such as pneumothorax/hemothorax. After the first attempt of ultrasound-guided CVC placement, it was found that complications of CVC puncture decreased sharply.[15,16] Therefore, recently, SCV has been increasingly applied to CVC placement in the clinic. However, currently, the optimal choice of venous access site remains undetermined and comparisons between complication incidences between SCV and IJV remains unclear. A meta-analysis of three randomized controlled trials and nine nonrandomized cohort studies, all of which included a total of 3905 patients, compared the efficacy of the IJV and the SCV as the percutaneous access site for a TIVAP.[17] The results suggested that compared with the SCV, the IJV seems to be a safer venous access site with significantly reduced major mechanical complications. Specifically, the IJV is associated with a lower risk of catheter dislocation and malfunction.[17] There were also studies that have demonstrated no significant differences in total complication rates between the SCV and the IJV puncture with ultrasound guidance. However, there appears to be more catheter misplacement during SCV catheterization.[18,19] Therefore, the IJV remains the most commonly chosen site for venous access in current clinical practice.[7]

As previously described, the middle approach of the IJV is considered as the safest and most effective percutaneous access site. The middle approach is used to avoid major complications.[14] However, the high puncture point seems to be one of the shortcomings of the middle approach, here the large angle of the fold of the catheter due to the high puncture point may lead to catheter discount, clogging, and fracture.[20] Larger angles and longer catheterization pathways are important factors in the reduction of patient comfort and may cause an unesthetic sensation for patients after TIVAPs implantation.[21] The puncture point of the SCV approach is lower, which is more convenient and comfortable than the IJV, but the occurrence of POS may lead to dysfunction of the catheter.[22] POS is the main cause of catheter malfunction, damage, or fracture for the SCV approach.[20] Although ultrasound-guided puncture of the more distal site of SCV can avoid the occurrence of POS. There are also disadvantages of the SCV approach when compared to the IJV approach, such as the subclavian artery is not compressible and the risk of the pneumothorax/hemothorax is higher.[23,24] To ensure the safety and efficacy of TIVAP implantation, while taking into account comfort and aesthetics, we changed the venipuncture site from the middle approach to the posterior approach of the IJV. In the "short-axis lateral in-plane" view, the operators can visualize the surrounding structures simultaneously with visualization of the whole length of the needle. This allows the operator to avoid iatrogenic puncture complications, such as arterial puncture and pneumothorax. Additionally, no adjustment of the probe is required during the procedure. The probe was positioned in the transverse orientation just above the clavicle and the needle was

inserted at the lateral edge of the ultrasound probe. Hence, the needle can be inserted near to the clavicle. The distance from the puncture site to the clavicle was 1-1.5 cm. The puncture site we selected was lateral to the posterior margin of the SCM muscle. Therefore, when the catheter was tunneled into the IJV, the catheter passed under the SCM muscles instead of between them as with the middle approach. This means that the inserted catheter has a smoother curvature over the clavicle, which decreases the incidence of catheter kinking and increases the degree of comfort for the patients. The lower neck wounds and subcutaneous catheter could be easily covered with collared clothes, and the patients were all satisfied with the cosmetic outcome.

In this study, no intraoperative complications occurred, and the overall postoperative complication rate was 4.55% (4/88), which was lower than that in reported results (13%, 9.8%, and 33.95%) from other studies.[3,25,26] Supraclavicular puncture of the IJV avoided the occurrence of POS by crossing above the clavicle, and no catheter fracture was found. In addition, none of the patients had catheter malpositioning after the procedure, which might be related to the fact that the range of catheter activity using the IJV approach was small, and the location of the catheter was accurately positioned by fluoroscopy during the operation. Port-pocket infection was recorded in two patients. Among them, one patient was managed successfully with appropriate systemic antibiotics and wound dressing. However, the other patient underwent port removal due to the failure of anti-infective therapy. Fibrin sheath formation was confirmed by angiography in one patient and managed successfully with thrombolysis. Port inversion was found in one patient due to the inability to puncture the port chamber, and its function was restored following readjustment. It remained important to avoid unplanned port removal by standardizing the operation and paying attention to the maintenance and management of the TIVAPs.

Given the preliminary results reported here (the study was retrospective, and the cases were limited), there is a clear need for large-sample, prospective, and randomized controlled trials to confirm the feasibility and safety of the ultrasound-guided TIVAP implantation via the posterior approach of the IJV, which may stimulate future research in this area.

In conclusion, ultrasound-guided TIVAP implantation via the posterior approach of the IJV is feasible, safe, and effective, with a low rate of perioperative and postoperative complications. Not only was the curvature of the device catheter smooth, but patients were satisfied with the comfort and cosmetic appearance. Additionally, we could reduce the possible complications of pinching and kinking of the catheter by using this approach. Therefore, we advocate for increased use of the posterior approach of the IJV for TIVAP implantation in the future.

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