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Original Article

Application of an ultrasound-guided low-approach insertion technique in three types of totally implantable access port

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Abstract

Background: Totally implantable access ports (TIAPs) are alternatives to central venous catheters for patients requiring chemotherapy. Since January 2003, we have used a central approach two-point incision technique to insert TIAPs. Following advances in ultrasound technique and clinical experience for tunneled dialysis catheter placement, we modified the central approach to a low-approach technique.

Methods: From January 2009 to June 2010, patients consulted for TIAP insertion in our department were enrolled in our study. Different brands and materials of central venous catheters of TIAPs were inserted by the low-approach two-point incision technique (Phase I) or the low-approach one-point incision technique (Phase II). The insertion time, failure rate, procedural and late complications, degree of satisfaction, and cosmetic scores were recorded.

Results: Ninety-seven patients and 107 patients were implanted via the two-point and one-point low-approach techniques, respectively, with different kinds of TIAP. No matter which type of TIAP was used, the success rate in both phases was 100% without procedural complications using the low-approach technique. The average time for device insertion was 30 minutes for the two-point incision technique used during Phase I and 26–28 minutes for the one-point incision technique used during Phase II. Satisfaction and cosmetic scores were high.

Conclusion: Our study highlights a revised technique for placement of TIAP systems of differing types of material or size. Not only was the curvature of the device catheter smooth, but patients were satisfied with the cosmetic appearance.

Keywords: catheterization; central venous catheter; jugular vein; totally implantable access port; ultrasound

1. Introduction

Central venous catheters are frequently used for chemotherapy delivery in oncological patients. For patients requiring frequent intravenous access, insertion of implanted central venous catheters such as totally implantable access ports (TIAPs) is usually performed.

Beginning January 2003, we used a modified two-point incision percutaneous placement technique to insert TIAPs.[1] We found that the technique was as effective as the traditional venous cutdown technique. The anatomical landmark technique was used for venipuncture of the right internal jugular vein (RIJV) because of lack of assistance from an ultrasound device at that time.[1] The central approach (paracricoid approach) was used to avoid major complications.[2–5] To ensure a smooth curvature and prevent kinking of the catheter over the neck, we invented the two-point incision percutaneous placement technique.[1]

Remarkable advancement of our technique came after the introduction of ultrasound in our department. The real-time

Conflicts of interest: The authors declare that there are no conflicts of interest related to the subject matter or materials discussed in this article.

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ultrasound-guided technique was used to perform venipuncture for vascular access.[6–12] With the assistance of real-time ultrasound guidance, we were able to perform low-approach venipuncture safely.

At first, we applied this ultrasound guidance technique for tunneled dialysis catheter (TDC) insertion.[6] We also found that by using low-approach venipuncture of the RIJV and a 1 cm transverse incision wound lateral to the venipuncture site, we could create a more smooth curvature of the subcutaneous tunnel than that which resulted from the central approach.[1,6] In recent years, we changed the venipuncture site from the central approach to an ultrasound-guided low approach for TIAP insertion. Initially, a two-point incision technique was used to create a subcutaneous tunnel from the port pocket to the venipuncture site. Subsequently, we modified the technique to a single small incision and tunneling technique. Furthermore, there are TIAPs of different brands, catheter materials, and diameters, and the material and size of the catheter of the TIAP system may affect the curvature of the device catheter and the success rate of insertion. Therefore, we designed this study to evaluate whether the ultrasound-guided one-incision low-approach technique could be applied for TIAP insertion.

2. Methods

2.1. Patients

From January 2009 to June 2010, our department was consulted regarding 214 patients requiring TIAP insertion. In the preprocedure visit, we performed a bedside ultrasound over the neck region to exclude those with thrombotic and stenotic RIJVs. We excluded from this study patients with thrombotic and stenotic RIJVs, local infection or pathology over the intended venipuncture or incision site, a potential risk of compromised airway, and abnormalities in image 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.

Informed consent was obtained from every patient and/or the patient's family who agreed to TIAP placement via the RIJV. Potential adverse events were explained in detail during the preprocedure visit. For each patient, routine preprocedure laboratory examinations included prothrombin time/activated partial thromboplastin time and complete blood count. Blood products were transfused to ensure that the prothrombin time international normalized ratio was smaller than 1.2 and the platelet count was greater than 70,000/mL.

2.2. General technique and catheter selection: Preprocedure preparation

The same two anesthesiologists (P.T.C. and H.W.C.) were responsible for all TIAP insertions. The study participants, most of whom were inpatients at the time of their procedures, underwent TIAP insertion in the anesthesia induction room. Standard preparation, monitoring and anesthesia were performed.[1] Induction of intravenous general anesthesia was usually done with alfentanyl 200–400 μg and midazolam 1–2 mg after skin sterilization.

2.2.1. Phase I low-approach two-point incision technique

The Arrow Implantable Vascular Access System (Arrow International Inc., Mount Holly, NJ, USA) was used for placement from January 2009 to August 2009.

Briefly, the procedure was as follows: First, the finding needle was slowly advanced from the intended skin puncture site (point 1, usually 1–1.5 cm above the clavicle) to above the RIJV under real-time ultrasound guidance, and 1–2 mL of 1% lidocaine was injected over the skin puncture site and this tract (Fig. 1). Ultrasound-guided venipuncture was then performed using an 18-gauge hollow needle. Once the vein was revealed, the hollow needle was removed after a guidewire was inserted through it.

Second, 1% lidocaine was injected over the intended tunnel tract and implantation site. A transverse incision 0.5 cm in length (point 1) was made and dissected next to the skin puncture site. Then, a skin incision 0.5 cm in length (point 2) was made 3–4 cm lateral to the skin puncture site (Fig. 1). Third, a subcutaneous pocket was created using the right deltopectoral groove approach with a 3–4 cm transverse skin incision, which was then dissected above the fascia of the pectoralis muscle to fix the TIAP *in situ*. Fourth, a subcutaneous tunnel was created from the port pocket using a tunneler over the clavicle, with the catheter mounted to its rear end, directed toward point 2 and later pulled out from point 2 along with the tunneler. Fifth, another tunnel between point 1 and point 2 was created using a mosquito from point 1 toward

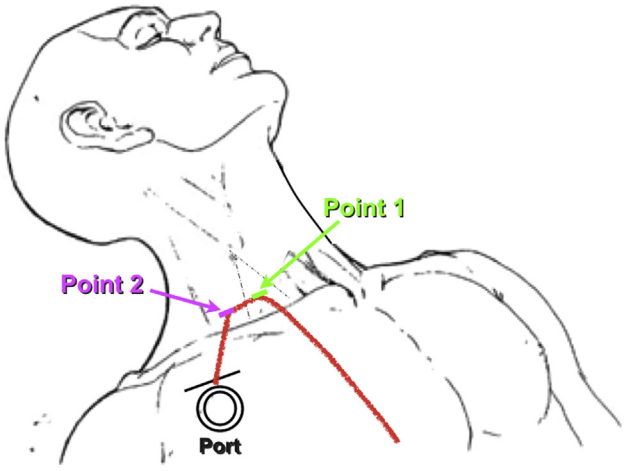

Fig. 1. Low-approach two-point incision technique. Ultrasound-guided venipuncture was performed on point 1 (0.5 cm in length, usually 1–1.5 cm above the clavicle). Then, a skin incision 0.5 cm in length (point 2) was made 3–4 cm lateral to point 1. A subcutaneous pocket was then created using the right deltopectoral groove approach with a 3–4 cm transverse skin incision. A subcutaneous tunnel was created from the port pocket using a tunneler over the clavicle, directed toward point 2 and later pulled out from point 2 along with the tunneler. Another tunnel between point 1 and point 2 was created using a mosquito from point 1 towards point 2, and the catheter was then pulled from point 2 to point 1.

point 2, then the catheter was pulled from point 2 to point 1 (Fig. 1).

Next, the catheter was trimmed to an appropriate length using the fourth right intercostal space as the estimated projection of the cavoatrial junction and inserted through the RIJV using a peel-away sheath and dilator that were fed over the guidewire. Good blood aspiration was performed via the TIAP to confirm correct placement, and the device was then flushed with heparinized saline (1000 U/mL). The incision wounds were sutured and covered with a sterile adhesion strip. Patients were then sent to the radiology suite for postoperative chest x-ray (CXR) to confirm the final catheter position and the subcutaneous tunnel curve.

2.2.2. Phase II low-approach one-point incision technique

We modified our two-point incision technique to a one-point incision technique with ultrasound guidance from September 2009, using the Arrow Implantable Vascular Access System (Arrow International Inc.) at first. Then we used Port-A-Cath II Low Profile (5.8 French; Smiths Medical Inc., St. Paul, MN, USA) and the X-Port isp Implantable Port (8 French; Bard Access Systems, Salt Lake City, UT, USA) for placement of TIAPs from January 2010. Patients were randomly implanted with one of the two polyurethane TIAPs. After completion of the ultrasound-guided venipuncture, insertion of the guidewire, and injection of local anesthetic, a transverse incision 0.5 cm in length was made and dissected next to the skin puncture site (point A; Fig. 2). Then, we bent the front 4 cm of the steel tunneler about 60° (Fig. 3), and created a subcutaneous tunnel from the port pocket using the tunneler over the clavicle. The tunneler was pointed toward a point 3–4 cm lateral to the skin puncture site (imaginary point B) with the catheter mounted to its rear end, along the lateral side of the sternocleidomastoid muscle. The tunneler was then redirected from imaginary point B to point A, and the catheter was pulled out from point A with the tunneler (Figs. 2 and 3).

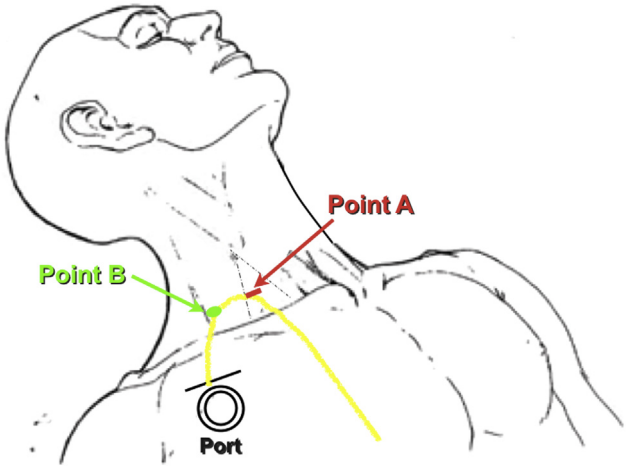

Fig. 2. Low-approach one-point incision technique. The subcutaneous tunnel was created antegrade from the subcutaneous pocket to imaginary point B and then incision point A.

The remaining procedures were as described for Phase I (Fig. 4).

2.3. Follow-up

For the remainder of their hospitalization, patients were followed up by the anesthesiology staff. After discharge, patients received twice weekly telephone calls from the anesthesiology staff regarding their access device. In addition, the oncology staff who evaluated and used the access devices as part of outpatient treatment served, as needed, as liaisons between patients and anesthesiology staff.

2.4. Outcome measures

Clinical outcome measures included the duration of the procedure, periprocedural complications such as arterial puncture, pneumothorax, or continued oozing or frank continued bleeding, kinking of the catheter over the subcutaneous tunnel, curvature of the device catheter, and late device-associated complications including infection, venous thrombosis, and device malfunction.

Periprocedural perceptions and long-term satisfaction with the access device itself were followed for patient outcomes. Periprocedure satisfaction and comfort scores were defined as follows: (1) comfortable and in no pain; (2) comfortable but with a slight sensation of pain; (3) tolerable pain; and (4) intolerable pain.

Cosmetic outcome was assessed postoperatively on Day 10 via evaluation of change in dressing habits after TIAP implantation: (1) comfortable and no need to change dressing habit; (2) comfortable but needed to wear a polo shirt; (3) comfortable but needed to button the top button of the polo shirt; and (4) difficulty in dressing.

All patients received long-term empirical antibiotic treatment and device care according to standard practice. Patients were regularly followed up and interventions were considered in cases of suspected local wound or systemic infection, hematoma formation, or device malfunction.

3. Results

Between January 2009 and June 2010, our department was consulted regarding 214 patients who required TIAP placement, and a total of 204 patients were enrolled in our study. During Phase I (from January 2009 to August 2009), 99 patients were assessed, with two patients excluded because of local infection over the skin puncture site and suspected malignancy over the supraclavicular region, respectively. Ninety-seven patients were therefore implanted with the Arrow Implantable Vascular Access System (Arrow International Inc.) by the low-approach two-point incision technique (Table 1).

During Phase II, 115 patients were assessed, and 8 patients were excluded (5 stenotic RIJVs, 2 RIJVs with large thrombus, and 1 local infection over the skin puncture site). Thirty-nine patients were implanted with the Arrow Implantable Vascular

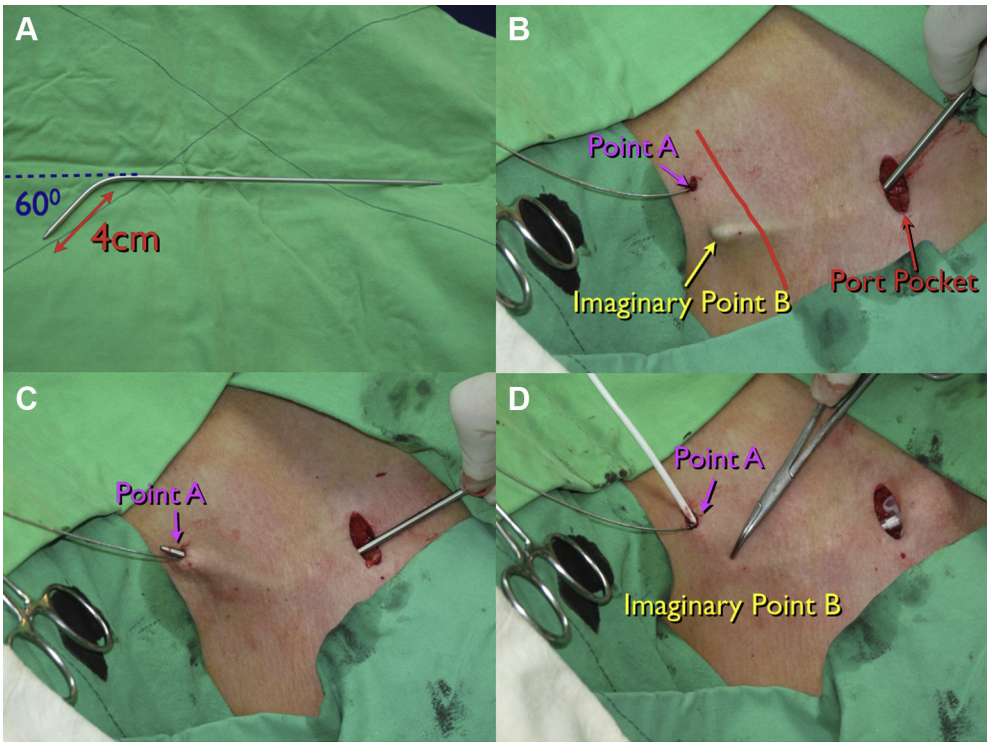

Fig. 3. Low-approach one-point incision technique. The Bard X-Port isp Implantable Port was implanted in a 40-year-old male patient. (A) The steel tunneler was bent at the front 4 cm to about 60°. (B) The ultrasound-guided venipuncture and insertion of the guidewire were performed at point A (skin puncture site, 1 cm above the clavicle). The pre-shaped tunneler was pointed from the port pocket toward a point (imaginary point B) 3 cm lateral to point A over the clavicle (red line, the upper edge of the clavicle). (C) The tunneler was then redirected from imaginary point B to point A. (D) The catheter was pulled out from point A with the tunneler mounted to its rear end. (For interpretation of the references to color in this figure legend, the reader is referred to the web version of this article.)

Access System (Arrow International Inc.), and 36 patients and 32 patients were implanted with the Port-A-Cath II Low Profile (Smiths Medical Inc.) and the X-Port isp Implantable Port (Bard Access Systems), respectively, using the low-approach one-point incision technique (Table 1).

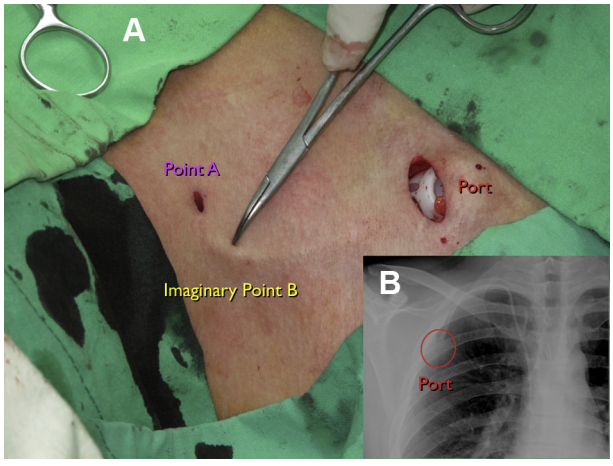

Fig. 4. TIAP implantation and postoperative chest X-ray (CXR). (A) The smooth subcutaneous tunnel was created antegrade from the subcutaneous pocket to imaginary point B and then incision point A. (B) Postoperative CXR revealed no kinking of the subcutaneous tunnel, with a good curvature (red circle, implanted port). (For interpretation of the references to color in this figure legend, the reader is referred to the web version of this article.)

No matter what type of TIAP system was used, the success rate for each subgroup was 100% for device placement without immediate occlusion. Meanwhile, there was no kinking of the subcutaneous tunnel and a good curvature in all four groups, as observed by postoperative CXR (Fig. 4). Patients felt comfortable after the procedure while under intravenous general anesthesia, and also were satisfied with the improved appearance and the ease of covering the subcutaneous catheter over the lower neck region with a polo shirt (Table 2).

In addition, there were no episodes of desaturation, nor were there any immediate procedural complications such as pneumothorax, arterial puncture, active bleeding or oozing, or great vessel perforation in any group. The average time for device insertion was 30 minutes for the two-point incision technique used during Phase I and 26–28 minutes for the one-point incision technique used during Phase II.

Premature removal of the device was required for six patients (6/204): three TIAPs were removed because the patients died, two TIAPs were shifted to a Hickman catheter for bone marrow harvest, and one TIAP was removed because of suspected infection. The surviving patients were then treated successfully with oxacillin.

4. Discussion

Dudrick et al[13] suggested the use of central venous catheters in clinical practice; thus, externalized tunneled central

Table 1
Demographics of the enrolled patients and their underlying diseases.

	Phase I (n = 97)	Phase II (n = 107)		
	Two-point	One-point		
Device	Arrow	Arrow	Bard	Smiths
Total number	97	39	36	32
Male/female (n)	50/47	17/22	20/16	15/17
Age (mean ± SD)	57.5 ± 18.1	55.2 ± 20.1	54.9 ± 21.6	58.1 ± 19.1
Origin of malignancy				
Esophagus	11	3	1	3
Lung	35	14	12	13
Nasopharynx	10	2	3	4
Lymphoma	9	5	3	4
Musculoskeletal	4	6	2	2
Colon	28	9	15	6
Insertion time [min (range)]	30 (26–35)	28 (26–32)	26 (22–28)	27 (20–30)

venous catheters equipped with Dacron cuffs and subcutaneously implanted ports became an important part of the management of chronic diseases.[13,14] Although most venous access devices are inserted by the traditional surgical venous cutdown technique, percutaneous techniques have been proposed for routine use.[15]

In our institute, we have performed percutaneous placement of TIAPs for more than 20 years, but because of the lack of ultrasound assistance, we were only able to perform percutaneous placement of TIAPs via the RIJV by the central approach to avoid major complications.[2–5] For a better curvature of the device catheter, we have used a modified technique since January 2003, and have demonstrated that the two-point incision percutaneous placement technique is as effective as the traditional venous cutdown technique.[1]

The importance of a preprocedure ultrasound cannot be overemphasized, according to our clinical experience of tunneled dialysis catheter placement. In this study, from January 2009 to June 2010, seven patients had abnormal findings during the preprocedure bedside ultrasound: stenotic RIJVs in five patients and RIJVs with large thrombi in two patients. Six TIAPs were placed via the left internal jugular vein and one TIAP was placed via the right subclavian vein. We advocate that preprocedure ultrasound examination is crucial for complete preoperative evaluation to exclude inappropriate patients. All of these seven patients had received central venous catheterization via the RIJV prior to consultation. Careful preprocedural ultrasound examination of the selected IJV is useful for detecting severe venous stenosis or thrombus, especially related to temporary or long-term central venous catheterization (catheter-induced venous thrombosis).[16–18] This examination can help us to improve periprocedure safety and avoid unnecessary trials, time wasting, thrombus dislodgement, or change of the access vein prior to actual venipuncture.

Table 2
Outcomes and complications.

	Phase I (n = 97)	Phase II (n = 107)		
	Two-point	One-point		
Port device	Arrow	Arrow	Bard	Smiths
Procedure failure rate	0	0	0	0
Comfort and satisfaction score[a]	1–2	1–2	1–2	1–2
Cosmetic outcome[b]	1–2	1–2	1–2	1–2
Procedural complication				
Arterial puncture	0	0	0	0
Kinking of catheter	0	0	0	0
Pneumothorax	0	0	0	0
Active bleeding or oozing	0	0	0	0
Late complication (follow-up)				
Infection	1 (1/97)	0	0	0
Venous thrombosis	0	0	0	0
Malfunction or occlusion	0	0	0	0

Data are presented as %, unless otherwise indicated.
[a] 1 = best score (least pain); 4 = worst pain (intolerable pain).
[b] 1 = no need to change; 4 = difficulty in dressing.

With real-time ultrasound assistance, venipuncture can be performed safely, decreasing procedure-related complications such as accidental arterial puncture, pneumothorax, or great vessel injury.[6,7,19,20] Initially, ultrasound-guided central approach venipuncture and the two-point incision technique were used for TIAP insertion.[1] But some patients who underwent TIAP placement by the central approach complained of an unesthetic appearance, with an obvious subcutaneous catheter over the neck region. We subsequently changed the venipuncture site to a low approach to increase the cosmetic outcome.

With our wide experience in the placement of tunneled dialysis catheters (TDCs), we presumed that, using the low approach, one small incision (1 cm) technique could result in a larger plane for subcutaneous tunneling during placement, a smoother curvature of the device catheter, a good appearance, and no kinking when turning the head to extremes.[6] We therefore decided to apply this technique for TIAP placement starting November 2009.

However, because of low stocks of the Arrow Implantable Vascular Access System (Arrow International Inc.) in January 2010, we had to change to two other polyurethane catheter TIAP systems: the Smith Port-A-Cath II Low Profile (Smiths Medical Inc.) and the Bard X-Port isp Implantable Port (Bard Access Systems), with catheters of different sizes: a Smith PolyFlow polyurethane catheter 5.8 Fr (1.0 mm inner diameter) and a Bard ChronoFlex polyurethane catheter 8 Fr (1.6 mm inner diameter), respectively. These two TIAP systems were both made of polyurethane, which was less likely to kink compared with silicone. From January 2010 to June 2010, we randomly assigned patients for insertion of one of the two TIAP systems. Most importantly, the TDC that we use is a 14.5 French polyurethane catheter, much larger than any TIAP catheter. Therefore, we designed this study to survey whether the one-incision ultrasound-guided low approach technique could be applied to insert TIAP catheters of different sizes and materials. In this study, we did not perform the two-incision technique using different brands of TIAP system, because our goal was to invent an effective new technique.

In the current study, a smooth curvature of the device catheter and a decreased incidence of catheter kinking resulted from using the low-approach two-point or one-point incision technique. The success rate, complication rate, patient

comfort, and cosmetic rating did not differ significantly between the four groups during Phases I and II. In the low-approach technique, the distance from the skin puncture site to the clavicle was 1−1.5 cm. In other words, the lowest skin puncture for RIJV insertion made was 1 cm above the clavicle, because of the width of the sterile prepared ultrasound probe.

If we focus on the results of Phase II, our new low-approach one-point incision technique could be applied with different kinds of TIAP, no matter what size or material of device catheter was used. In addition to the low-approach venipuncture with ultrasound assistance technique, the way we created the subcutaneous tunnel was also an important factor for better curvature of the device catheter. To decrease the incision wound, we used an imaginary turning point (point B) and a bent steel tunneler. The theory was similar to that of the two-point incision technique, but we replaced the incised point 2 by an imaginary point B. In other words, a subcutaneous tunnel was made from the port pocket to 3−4 cm lateral to the incision site as point B (near the lateral margin of the sternocleidomastoid muscle), and the tunneler was turned to point A. However, the attached straight steel tunneler in the manufactured set was not suitable for passing through point B to point A. Therefore, we bent the steel tunneler to about 60° to achieve our goal.

If the tunnel were to be made directly from the port pocket to the skin puncture site without using this technique, we hypothesized that the curvature of the device catheter would be easily transformed into a sharp angle, which would increase the incidence of catheter malfunction or kinking. We also considered that tunneling with a lateral imaginary turning point would not be suitable in the central approach technique, because the smaller subcutaneous plane over the higher neck region could be difficult for turning with the bent tunneler.

In our experience, patients who underwent TIAP placement via the RIJV by the central approach complained of an unesthetic appearance, with an obvious subcutaneous catheter over the neck region. By using the low-approach technique, we were able to achieve a smoother curvature of the device catheter over the lower neck region to avoid catheter kinking and also to provide a more satisfactory cosmetic appearance. The lower neck wounds and subcutaneous catheter could be easily covered with a polo shirt, and the patients were all satisfied with the cosmetic outcome. Compared with the two-point incision technique, only one wound would be seen over the neck region when using the one-incision technique. In this study, we did not compare the cosmetic outcome between the central approach and the low approach, because we routinely used the ultrasound-guided low-approach technique for TIAP insertion after the introduction of ultrasound, and it was difficult to collect the data from patients in whom a TIAP had been previously inserted.

In conclusion, our study demonstrated a revised novel clinical technique for percutaneous placement of TIAPs of differing materials or sizes, which resulted in a high success rate, a shorter procedural time, smooth curvature of the device catheter, and an acceptable cosmetic appearance.

Acknowledgments

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