



Efficacy and safety of ultrasound-guided totally implantable venous access ports via the right innominate vein in adult patients with cancer: Single-centre experience and protocol

Xingwei Sun ^{a,1}, Jin Xu ^{b,1}, Rui Xia ^b, Caishan Wang ^c, Ziyang Yu ^c, Jian Zhang ^a, Xuming Bai ^{a,**}, Yong Jin ^{a,*}

^a Department of Intervention, The Second Affiliated Hospital of Soochow University, Suzhou, 215004, Jiangsu, China

^b Department of Oncology, The Second Affiliated Hospital of Soochow University, Suzhou, 215004, Jiangsu, China

^c Department of Ultrasound, The Second Affiliated Hospital of Soochow University, Suzhou, 215004, Jiangsu, China

ARTICLE INFO

Article history:

Accepted 18 July 2018

Available online 26 July 2018

Keywords:

Cancer

Innominate vein

Totally implantable venous access ports

Ultrasonography

ABSTRACT

Background: Totally implantable venous access ports (TIVAPs) are widely used and are an essential tool in the efficient delivery of chemotherapy. This study aimed to evaluate the feasibility and safety of implantation of ultrasound (US)-guided TIVAPs via the right innominate vein (INV) for adult patients with cancer.

Methods: This study retrospectively reviewed the medical records of 283 adult patients with cancer who underwent US-guided INV puncture for TIVAPs between September 2015 and September 2017. It also analysed the technical success rate, operation time, and short-term and long-term surgical complications.

Results: Technical success was achieved in all patients (100%). The mean operation time was 28.31 ± 7.31 min (range: 23–39 min), and the puncture success rate for the first attempt was 99.30% (281/283). Minor complications included artery puncture during the operation in one patient, but no pneumothorax was encountered. The mean TIVAP time was 304.16 ± 42.54 days (range: 38–502 days). The rate of postoperative complications was 2.83% (8/283), including poor healing of the incision in one patient, catheter-related infections in three patients, port thrombosis in one patient, and fibrin sheath formation in three patients; no catheter malposition, pinch-off syndrome, catheter fracture, or other serious complications were observed.

Conclusions: TIVAPs are widely employed for chemotherapy. The present study found that the novel approach of using US-guided INV puncture to implant TIVAPs in adult patients with cancer is both short-termly feasible and safe for long-term central venous access.

© 2018 Elsevier Ltd, BASO ~ The Association for Cancer Surgery, and the European Society of Surgical Oncology. All rights reserved.

Introduction

A totally implantable venous access port (TIVAP) consists mainly of a port for puncture and a venous catheter system, which could be used for the infusion of various chemotherapeutic drugs, supplemental liquids, nutritional support treatments, blood transfusions,

and blood specimen collection [1]. Compared with peripherally inserted central catheters, TIVAPs are widely accepted by patients with cancer due to the advantages of a higher success rate of catheterization, longer service life, fewer complications, and simpler care [2]. In recent years, a new approach has been suggested, consisting of cannulation of the innominate vein (INV) from the supraclavicular area, which could offer advantages in neonates and infants [3–6]. However, it is rarely reported in adult patients. In this study, the clinical records of adult patients who underwent TIVAP implantation via US-guided percutaneous punctures of the right INV were collected and analysed retrospectively to evaluate the efficacy of this technique.

* Corresponding author.

** Corresponding author.

E-mail addresses: sdfeyxw@163.com (X. Bai), 578898234@qq.com (Y. Jin).

¹ These authors contributed equally to this work.

Materials and methods

Between September 2015 and September 2017, 283 patients with cancer who underwent US-guided TIVAP implantations via the right INV were selected. Clinical information was collected from the electronic medical record, including 113 men and 170 women between 33 and 78 years of age (mean age: 52.21 ± 15.32 years). There were 127 patients with breast cancer, 59 with liver cancer, 52 with lung cancer, 29 with gastric cancer, and 16 with other malignant tumours. This study was approved by the Ethics Committee of the Second Affiliated Hospital of Suzhou University, and written informed consent was obtained. TIVAPs were obtained from BARD Medical (BardPort, 0603870, 7F; 8806061, 6F; UT, USA). The operation was performed by two trained interventional physicians and an ultrasound physician with our team.

Preoperatively, all patients underwent a routine examination, including routine blood and coagulation studies. Meanwhile, the superior vena cava was assessed, and the integrity of the skin at the puncture site was examined to rule out operational contraindications. During the surgery, guidance on washing hands, disinfection, and other sterile procedures was strictly followed. The patient was placed in the supine position, and the surgical field was disinfected and draped routinely. A high-frequency ultrasound probe was used to explore the INV: the probe was moved downward along the internal jugular vein (IJV) to the superior sternoclavicular joint to display the confluence of the right IJV and right subclavian vein (SCV), which is the origin of the right INV. Meanwhile, the status of veins was assessed, and the location of the subclavian artery (SCA) (beside the SCV) was identified. Under local anaesthesia, with 3 mL 1% lidocaine, the right INV was punctured in-plane with real-time ultrasound guidance (Fig. 1), and a guide wire was introduced. An introducer sheath was passed over the guide wire into the vein. The guide wire was then removed, and the port catheter was introduced through the introducer sheath. The correct position was checked by fluoroscopy. A pocket was constructed on the right upper chest wall, sized to exactly contain the port. Above the pocket, the thickness of the retained subcutaneous tissue was approximately 0.5–1.0 cm. The catheter was guided with a tunnel needle to cross the incision via the supraclavicular port, and its tip was adjusted to the junction of the superior vena cava and the right atrium under digital subtraction angiography fluoroscopy.

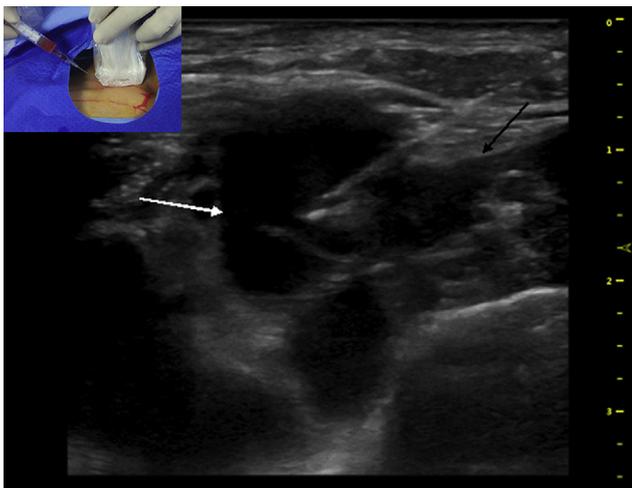


Fig. 1. Ultrasound-guided real-time puncture of the right INV. The figure shows the needle inserted into the origin of the right INV (white arrow) where the SCV (black arrow) affluxes; the posterior part shows the right subclavian artery and pleura. INV, Innominate vein; SCV, subclavian vein.

Subsequently, the port catheter was cut off and connected with the port, and the port was implanted into the pocket, followed by suturing of the incision. Flow for blood withdrawal and infusion was tested via a cutaneous puncture. The incision was covered with sterile dressings and a compression bandage (Fig. 2).

Results

TIVAPs were successfully implanted in the 283 patients, with a success rate of 100%. The operation time ranged from 23 to 39 min, with a mean time of 28.31 ± 7.31 min. The success rate of the first puncture was 99.30% (281/283). One patient (0.35%, 1/283) was mistakenly arterially punctured (known as SVA by ultrasound) during the operation, while the secondary puncture of the INV was successfully performed and did not show complications such as haemothorax or pneumothorax. The port-carrying time ranged from 38 to 502 days, with an average time of 304.16 ± 42.54 days. The overall central venous access port-related infection (CPI) incidence rate was 0.12 per 1000 catheter-days. The incidence of postoperative complications was 2.83% (8/283) (Table 1). No other serious complications, such as catheter allotopia, rupture, or pinch-off syndrome (POS), were observed. The port was removed from five patients due to catheter-related infection, thrombosis, and fibrin shell formation. It is still working normally in 181 patients.

Discussion

TIVAPs are increasingly being used in cancers because of their convenient application, good concealment, easy maintenance, and improvement of the patient's quality of life [2,7]. Although many port implantations are done via traditional surgical vein incision under direct visualization, percutaneous punctures have been routinely applied for implantations because of their high technological success rate and low rate of complications [8]. At present, percutaneous punctures consist mainly of IJV and SCV approaches, with complications that include haemothorax, pneumothorax,

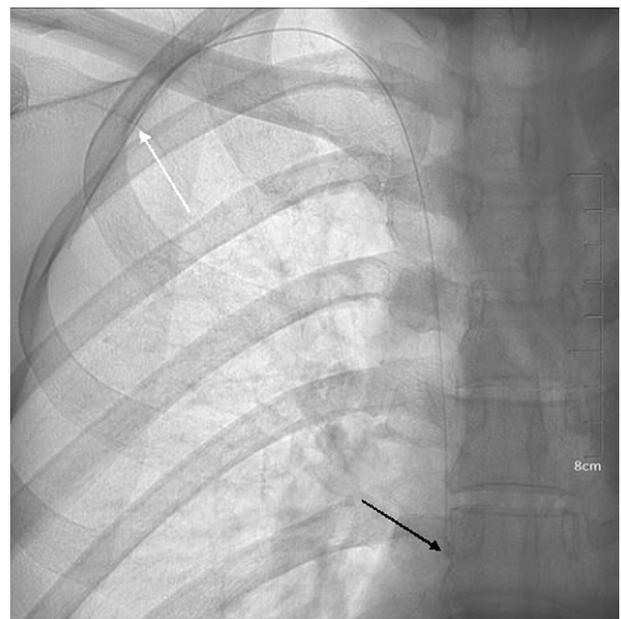


Fig. 2. Implantation of TIVAP via the right INV approach. The catheter (white arrow) crosses over the clavicle to enter the right INV at the posterior sternoclavicular joint while avoiding the sternocleidomastoid muscle; the catheter tip (black arrow) is located at the junction of the superior vena cava and the right atrium. INV, Innominate vein; TIVAP, totally implantable venous access port.

Table 1
Incidence of postoperative complications and processing measures.

Complications	No. (%)	Actions taken
Delayed incision healing	1 (0.35)	Secondary suture
Catheter-related infection	3 (1.06)	Antibiotics and port removal
Deep vein thrombosis	1 (0.35)	Anticoagulation and port removal
Fibrin formation	3 (1.06)	Thrombolysis and port removal
Total	8 (2.83)	

infection, catheter malposition, POS, and catheter fracture. A study involving 2996 patients performed by Li et al. found a total complication rate of 6.24% [9]. Complications delay treatment of the disease, reduce the rate of effective utilization of the port, and gradually attract attention.

IJV and SCV are two well-known approaches to implant TIVAPs with shortcomings related to specific complications. Considering the high puncture point of IJV, the catheter is turned 180° to connect with the port on the upper chest wall. The wide angle of the fold and the longer catheterization pathways are important factors leading to ectopic catheter, dislodgement, clogging, fracture, and reduction in patient comfort [7,10–12]. Moreover, POS related to the SCV approach is the main reason for the rupture or even fracture of the catheter, as reported in the study done by Tamura et al., in which the POS rates reached as high as 4% [13]. How to overcome the specific shortcomings related to these complications remains a challenge.

The INV is formed by the confluence of the ipsilateral IJV and SCV at the rear of the sternoclavicular joint. Compared with the IJV and SCV, the position is fixed and the diameter is larger, making it possible for the right supraclavicular approach to puncture the INV during the implantation of TIVAPs [13]. Statistically, the cannulation success of the left INV proved to be superior to the right for infants and neonates [14]. However, in adults, the left INV is in a deeper location, has more variation compared with the right one, and it is poorly visualized on ultrasound. In addition, an ultrasound is unable to identify the thoracic catheter if it is merged via the left BCV junction. The right INV approach was performed to avoid lymphorrhagia caused by thoracic catheter damage. Patients with surgical contraindications, such as right breast cancer, were given priority for the left lower jugular vein approach for the implantation of TIVAPs.

An ultrasound-guided in-plane puncture has the advantage of being able to detect the location of the needle in real time, thereby reducing the risk of arterial puncture and pneumothorax [13]. In this study, the success rate of the first puncture was 99.30% (281/283), and two patients successfully underwent a secondary puncture. The incidence of puncture-related complications was 0.35% (1/283), which included one patient who was mistakenly arterially punctured (SCA). After confirmation with fluoroscopy, this patient underwent a secondary puncture of the right INV, local haematoma or other severe puncture-related complications did not occur. Two other studies [6,15] reported a success rate of 97%–100% in INV catheterization with ultrasound guidance in paediatric patients. In the study by Avanzini et al., one patient suffered from a mistaken puncture of the artery (0.92%, 1/109), while neither study found other serious puncture-related complications.

In addition, it has been reported [16,17] that port implantation with a puncture of the INV under direct visualization via surgical incision can effectively reduce the incidence of puncture-related complications and catheter rupture. However, a surgical incision not only requires a longer operation time but can also lead to trauma. A prospective, randomized, controlled trial by Nocito et al. [16] found a success rate of 71% in port implantation with surgical incision of the INV. Conessa et al. [17] found a success rate of 89% in

port implantation with surgical incision of the INV, with an average operation time of 64.8 min, which was much longer than the 28.31 min found in the present study.

In this study, the port-carrying time ranged from 38 to 502 days, with a mean time of 304.16 ± 42.54 days. The overall incidence of postoperative complications was 2.83% (8/283), which was lower than that reported in most other studies [9,18,19]. In terms of short-term complications (within 1 month), one patient suffered from a malunited wound 2 weeks after the surgery, without swelling or effusion; it healed well after treatment consisting of debridement and suturing. In terms of long-term complications (greater than 1 month), three patients suffered from catheter-related infections in the 5th, 12th, and 28th weeks after surgery, respectively. Of these, the port was removed from two patients after they were given local antibiotics and general anti-infection treatment, which was ineffective. Another two patients presented with poor infusion due to fibrin shell formation and thrombosis, respectively, and their ports were removed after they were given thrombolytic therapy, which was found to be ineffective.

Lin et al. [20] investigated 2626 patients who were implanted with venous ports via SCV punctures, reported a 2.56% incidence of catheter rupture, and identified that catheter rupture was associated with POS. In this study, a supraclavicular puncture was adopted, in which the catheter crossed over the top of the clavicle, preventing POS-related catheter rupture. None of the patients had catheter displacement, which might be associated with smooth catheterization, smaller range of motion of the clavicle, and precise positioning of the catheter end [9,21,22].

This work had some limitations. First, this retrospective study was lack of predefined protocol for assessing long-term failures. In addition, since only a small number of patients (who were followed up for a limited duration) were enrolled, the number of patients in this study is limited. A comparison with studies conducted on other central venous sites (IJV, SCV) is needed, and the results require verification with large-sample, randomized controlled trials.

TIVAPs are accepted by an increasing number of cancer patients because these ports can avoid repeated venipuncture and increase the movement of patients. The implantation of TIVAPs via the right INV under ultrasound guidance has a high puncture success rate, is safe and reliable, and has low intraoperative and postoperative complications; thus, it is worthy of widespread usage.

Funding

This study was supported by the National Natural Science Foundation of China (81702806), Suzhou people's livelihood science and technology project (SYS201730).

Conflict of interest statement

All authors declare that they have no conflict of interests.

Acknowledgements

None.

References

- [1] Zhou J, Qian S, He W, Han G, Li H, Luo R. Implanting totally implantable venous access port via the internal jugular vein guided by ultrasonography is feasible and safe in patients with breast cancer. *World J Surg Oncol* 2014;12:378.
- [2] Viart H, Combe C, Martinelli T, Thomas J, Hida H. Comparison between implantation costs of peripherally inserted central catheter and implanted subcutaneous ports. *Ann Pharm Fr* 2015;73:239–44.

- [3] Lau TN, Kinney TB. Direct US-guided puncture of the innominate veins for central venous access. *J Vasc Interv Radiol* 2001;12:641–5.
- [4] Breschan C, Graf G, Jost R, Stettner H, Feigl G, Goessler A, et al. Ultrasound-guided supraclavicular cannulation of the right brachiocephalic vein in small infants: a consecutive, prospective case series. *Paediatr Anaesth* 2015;25: 943–9.
- [5] Thompson ME. Ultrasound-guided cannulation of the brachiocephalic vein in infants and children is useful and stable. *Turk J Anaesthesiol Reanim* 2017;45: 153–7.
- [6] Avanzini S, Mameli L, Disma N, Zanaboni C, Dato A, Montobbio G, et al. Brachiocephalic vein for percutaneous ultrasound-guided central line positioning in children: a 20-month preliminary experience with 109 procedures. *Pediatr Blood Cancer* 2017;64:330–5.
- [7] Kreis H, Loehberg CR, Lux MP, Ackermann S, Lang W, Beckmann MW, et al. Patients' attitudes to totally implantable venous access port systems for gynecological or breast malignancies. *Eur J Surg Oncol* 2007;33:39–43.
- [8] Bruijninx CM. Letter 2: randomized clinical trial comparing venous cutdown with the Seldinger technique for placement of implantable venous access ports (*Br J Surg* 2009; 96: 1129–1134). *Br J Surg* 2010;97:295–6. author reply 296–297.
- [9] Ma Li, Liu Y, Wang J, Chang Y, Yu L, Geng C. Totally implantable venous access port systems and associated complications: a single-institution retrospective analysis of 2,996 breast cancer patients. *Mol Clin Oncol* 2016;4:456–60.
- [10] Ruesch S, Walder B, Tramer MR. Complications of central venous catheters: internal jugular versus subclavian access—a systematic review. *Crit Care Med* 2002;30:454–60.
- [11] Granic M, Zdravkovic D, Krstajic S, Kostic S, Simic A, Sarac M, et al. Totally implantable central venous catheters of the port-a-cath type: complications due to its use in the treatment of cancer patients. *J Buon* 2014;19:842–6.
- [12] Xiao SP, Xiong B, Chu J, Li XF, Yao Q, Zheng CS. Fracture and migration of implantable venous access port catheters: cause analysis and management of 4 cases. *J Huazhong Univ Sci Technolog Med Sci* 2015;35:763–5.
- [13] Tamura A, Sone M, Ehara S, Kato K, Tanaka R, Nakasato T, et al. Is ultrasound-guided central venous port placement effective to avoid pinch-off syndrome? *J Vasc Access* 2014;15:311–6.
- [14] Breschan C, Platzer M, Jost R, Stettner H, Feigl G, Likar R. Ultrasound-guided supraclavicular cannulation of the brachiocephalic vein in infants: a retrospective analysis of a case series. *Paediatr Anaesth* 2012;22:1062–7.
- [15] Aytekin C, Ozyer U, Harman A, Boyvat F. Ultrasound-guided brachiocephalic vein catheterization in infants weighing less than five kilograms. *J Vasc Access* 2015;16:512–4.
- [16] Nocito A, Wildi S, Rufibach K, Clavien PA, Weber M. Randomized clinical trial comparing venous cutdown with the Seldinger technique for placement of implantable venous access ports. *Br J Surg* 2009;96:1129–34.
- [17] Conessa C, Talfer S, Herve S, Chollet O, Poncet JL. Cephalic vein access for implantable venous access devices. Technique and long-term follow-up. *Rev Laryngol Otol Rhinol (Bord)*. 2002;123:143–8.
- [18] Voog E, Campion L, du Rusquec P, Bourgeois H, Domont J, Denis F, et al. Totally implantable venous access ports: a prospective long-term study of early and late complications in adult patients with cancer. *Support Care Cancer* 2018;26:81–9.
- [19] Narducci F, Jean-Laurent M, Boulanger L, El Bedoui S, Mallet Y, Houpeau JL, et al. Totally implantable venous access port systems and risk factors for complications: a one-year prospective study in a cancer centre. *Eur J Surg Oncol* 2011;37:913–8.
- [20] Lin CH, Wu HS, Chan DC, Hsieh CB, Huang MH, Yu JC. The mechanisms of failure of totally implantable central venous access system: analysis of 73 cases with fracture of catheter. *Eur J Surg Oncol* 2010;36:100–3.
- [21] Wallace JA, Afonso E, Yu H, Birchard K, Isaacson A. Factors that predict increased catheter tip movement in left internal jugular vein implantable venous access ports upon standing. *J Vasc Access* 2015;16:223–6.
- [22] Wu CY, Lin FS, Wang YC, Chou WH, Lin WY, Sun WZ, et al. Fast Track ultrasound protocol to detect acute complications after totally implantable venous access device placement. *Ann Surg Oncol* 2015;22:1943–9.