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RESEARCH ARTICLE

TOTAL IMPLANTABLE CENTRAL VENOUS ACCESS PORT IMPLANTATION IN A HYBRID OPERATING ROOM: SINGLE CENTER RESULTS

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ABSTRACT

Purpose: This study retrospectively evaluated the impact of ultrasound (USG) and fluoroscopy (XrF) guidance on perioperative and postoperative complications during total implantable venous access port (TIVAP) implantation in a hybrid operating room setting.

Material and Methods: Patients undergoing TIVAP implantation between November 1, 2022, and August 31, 2024, were screened. Data collected included demographics, diagnosis, complications, and TIVAP duration. Exclusion criteria were procedures not performed by cardiovascular surgeons, absence of USG-guided puncture, and non-use of XrF. Postoperative chest radiographs were used to assess malposition, pneumothorax, and hemothorax. TIVAP duration and reasons for removal were recorded.

Results: 112 patients were included. No malposition, pneumothorax, venous thrombosis, arterial puncture, or acute bleeding were observed. Infection was the most common complication leading to TIVAP removal. 70 patients remain under follow-up.

Conclusion: This series demonstrates the effectiveness of USG and XrF guidance during TIVAP implantation by cardiovascular surgeons. The absence of periprocedural complications and malpositions and the low infection rate according to published data are probably attributable to the procedure being performed in a sterile hybrid operating room environment and USG and XrF guidance.

Keywords: Infection, Malposition, Port, Vascular access

INTRODUCTION

A total subcutaneous implantable venous access port (TIVAP) is a drug delivery system that is placed under the skin and provides long treatment duration, completely isolated from the external environment (1). The increase in the elderly patient population and oncological diseases has increased the need for long-term treatment with intravenous (IV) access. TIVAP has been used in increasing numbers since 1982 as an effective, safe, long-term solution for this situation (2). It can be used safely for many treatments including chemotherapeutics, IV nutritional preparations and blood products. The advantages of TIVAP are the low risk of infection and embolism and the treatment comfort for the patient and healthcare personnel. TIVAP consists of a subcutaneous reservoir and a catheter connecting the reservoir to the central venous circulation via a tunnel. The front side of the reservoir anterior of the body surface and the reservoir can be accessed

percutaneously with a small noncoring (Huber) injector tip. The tip of the injector penetrates this leak-proof septum and reaches the reservoir chamber, and from there, IV treatment can be provided via a catheter extending into the superior vena cava (VCS). Although TIVAP is considered the safest method of central venous access for long-term, intermittent treatments, the implantation procedure has complications such as infection, catheter migration, deep venous thrombosis, catheter malposition, arterial puncture, pneumothorax, hemothorax and cardiac tamponade (4). Complications can be divided into early and late. Early complications occur due to injury to adjacent structures during catheter insertion and reservoir implantation. Late complications occur due to trauma or misuse (5). The development of interventional methods enables TIVAP implantation with similar success and lower complication rates as surgery (6). There is evidence in the literature that the use of intraoperative ultrasonography (USG) and X-ray fluoroscopy (XrF) reduces the possibility of malposition compared to other implantation methods (7). In addition, current clinical TIVAP application guidelines do not include pneumothorax, hemothorax, air embolism, arterial puncture, etc. The emphasis is on USG-guided puncture for complications and correct catheter positioning, especially to prevent catheter thrombus complications. Guidelines recommend the use of XrF to position the catheter tip or to determine catheter localization by postoperative chest radiography with a high level of evidence (8) The European Society for Medical Oncology guidelines have stated that the ideal tip position is at the junction of the VCS and the right atrium (9).

The catheter tip can be positioned blindly based on patient height or by electrocardiographic monitoring from the catheter tip. Randomized controlled trials have shown that intraoperative X-rays in the hybrid operating room significantly reduce the need for re-positioning of the catheter tip compared to blind positioning (10). Perioperative and early infection rates have been reported to be lower in operating rooms where effective surgical sterilization can be achieved (11). In our study, we aim to evaluate the relationship between the use of USG and XrF, which are considered innovative in TIVAP implantation in the hybrid operating room that includes both of these advantages, and the complications and to contribute the retrospective results of our technique to the literature The results that will emerge can shed light on clinical practice guidelines, can be compared with data from centers using different techniques, can guide practitioners in updating their methods, and can increase the number and use of hybrid operating rooms.

MATERIALS AND METHODS

This study was approved by Dokuz Eylul University Non-Interventional Research Ethics Committee (Date: 18.09.2024, Decision No: 2024/31-14). The data of patients who underwent TIVAP implantation using USG and XrF in the hybrid operating room in our clinic between 01.11.2022 and 31.08.2024 were retrospectively reviewed. Electronic patient records were accessed to collect study variables such as patient age, gender, body mass index (BMI), oncological diagnosis requiring IV treatment, TIVAP implantation and removal dates, punctured side and preferred vein, complications (infection, malposition, pneumothorax, hemothorax, etc.), and TIVAP duration in the preoperative period. Patients who were not implanted by cardiovascular surgeons, who were not punctured according to USG guidance, and who were not used for XrF when placing the catheter into the VCS were excluded from the study. Patients who were checked by the nurse and who used low-profile titanium reservoir ports connected to a 7.8 French silicone catheter were included in the study. In patients who meet the conditions, malposition, pneumothorax, hemothorax will be evaluated in postoperative direct chest radiographs, TIVAP usage periods of the patients until 31.08.2024 assessed, and the reasons for revision or TIVAP removal until this date will be listed. Electronic patient records were confirmed a second time by the nurse. Complications were divided into three groups as perioperative (first 24 hours), early (first 30 days) and late (after 30 days). TIVAP-related infection was grouped as local or systemic infection. The complication rate that caused TIVAP revision or removal was determined.

Data were analyzed using the Statistical Package for the Social Sciences (SPSS), Version 20 (IBM, Corp., Armonk, New York, USA). Complication rates were reported as absolute numbers and percentages. Catheter survival was defined as the presence of a catheter initially implanted. The event was defined as “TIVAP removal due to complications.” In the patients included in the study, the reasons for the termination of TIVAP use, other than complications, were death and termination of treatment. For this reason, the

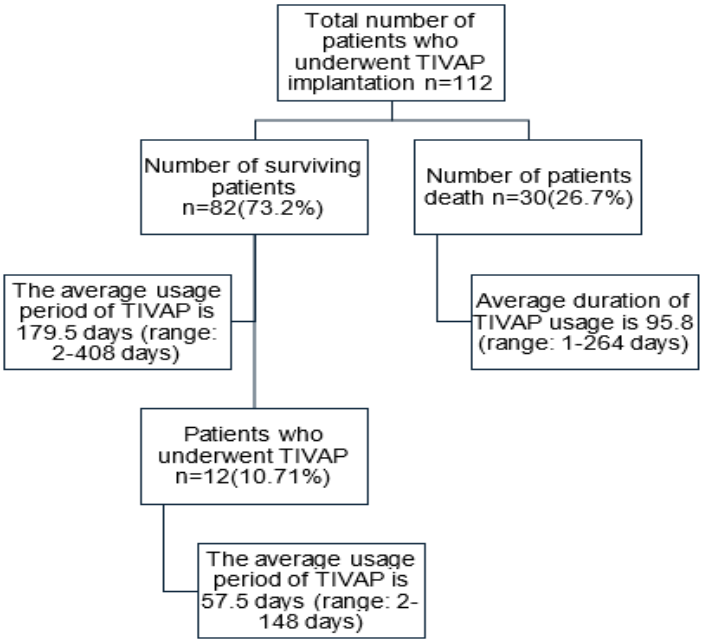

Figure 1. Overview of the usage times of patients who had TIVAP implanted at Dokuz Eylül University Hospital between 01.11.2022 and 31.08.2024.

duration of TIVAP use of the patients who died was analyzed separately. (Figure 1).

RESULTS

Demographic data of patients implanted with TIVAP at Dokuz Eylül University Hospital from November 2022 to August 2024 are shown in Table 1. (N=112)

During the study period, 134 patients were implanted with TIVAP. Twenty-two patients were excluded because electronic patient data were not available. All procedures were performed by cardiovascular surgeons.

For puncture, the right internal jugular vein (IJV) was preferred due to ease of access. The left IJV was preferred in 7 (6.2%) patients and the right subclavian vein was preferred in 1 (0.8%) patient. The left IJV puncture was performed in 4 patients with skin invasion in the pectoral region due to right breast cancer. The left side was preferred in the other 3 patients due to previous right IJV puncture. The only patient for whom the right subclavian vein was preferred had radiotherapy to the neck region due to laryngeal cancer. Data are summarized in Table 2.

By the end of the study, 82 (73.2%) survived. 30 patients died during the study period. The mean duration of TIVAP use among these patients was 95.8 (range: 1-264 days). The mean duration of TIVAP use among surviving patients was 179.5 days (range: 2-408 days). TIVAP was removed from a total of 12

Table 1. Characteristics and diagnoses of patients with cancer who had a TIVAP implanted at Dokuz Eylül University Hospital from November 2022 to August 2024 are summarized. (N=112)

Clinical Characteristics	**n (%)**
Sex	
Male	57(50,89)
Female	55 (49,10)
Body Mass Index (kg/m^2)	
Low(<18.5)	2(1,78)
Normal (18.5–24.9)	46(41,07)
High (25–30)	44(39,28)
Obese (>30)	20(18,60)
median	24,8
Oncological Diagnosis	
Breast cancer	14 (12,50)
Colorectal cancer	38 (33,92)
Esophageal-stomach cancer	11 (9,82)
Ovarian cancer	2 (1,78)
Pancreatic cancer	22 (19,64)
Lung cancer	2 (1,78)
Liver cancer	5 (4,46)
Prostate cancer	2 (1,78)
Other	16(14,28)

(10.71%) patients during the study period. A total of 10 (8.9%) complications were observed. In patients who developed complications, the duration of TIVAP use was significantly reduced by 57.5 days (range: 2-148 days). The TIVAP use duration scheme is shown in Figure 1.

No malposition was observed in any patient. Infection was determined as the factor that reduced the duration of TIVAP use the most and was observed in 6 (5.35%) patients. Other complications were reservoir-catheter separation in 3 (2.67%) patients, and kink at the reservoir-catheter junction in 1 (0.89%) patient. Systemic infection was observed in 2 (1.78%), and local infection was observed in 4 (3.57%) patients. Staphylococcus aureus was observed in 2 (1.78%) patients, Pseudomonas aeruginosa was observed in 1 (0.89%) patient, Candida was observed in 1 (0.89%) patient, Staphylococcus epidermidis was observed in 1 (0.89%) patient, and Staphylococcus hominis was observed in 1 (0.89%) patient. The overall median time to develop an infection was 84 days from the date of TIVAP placement.

No patient developed pneumothorax, venous thrombosis, arterial puncture or acute bleeding after the procedure. TIVAP was removed in 1 (0.89%) patient due to completion of chemotherapy treatment and in 1 (0.89%) patient due to pain in the pectoral region where the reservoir is located. 70 patients are still using TIVAP and are under follow-up. Complications are summarized in Table 3.

DISCUSSION

This study is a single-center retrospective analysis evaluating the efficacy and safety of TIVAP implantation using USG and XrF in a hybrid operating room. Our study results show that the use of USG and XrF in TIVAP implantations performed by cardiovascular surgeons is associated with low complication rates. In particular, the absence of perioperative complications and the low infection rate emphasize the advantages of this method.

Comparison with Literature

It has been shown in the literature that major complications (1.5%) in blind implantations result in more major complications than in TIVAP implantations performed with USG guidance. Similarly, the use of XrF eliminates the risk of malposition by ensuring correct positioning of the catheter. In line with this information, no major complications or malpositions were observed in our study. Structural deterioration in the catheter (kink, migration, etc.) is observed between 0.1% and 3.4% in the literature and is similar to our results (kink and reservoir catheter separation 2.67%) (13). The fact that no malposition was observed in our study once again demonstrates the importance of XrF use in this regard. The low complication rates obtained in our study are consistent with other studies in the literature and support that the use of USG and XrF is a safe and effective method in TIVAP implantation.

Table 2. Vein puncture localizations and localization preference reasons for TIVAP implantation at Dokuz Eylül University Hospital from November 2022 to August 2024 are summarized.

Puncture localization	n(%)	Description
Right IJV	103(%91,9)	Target puncture is preferred due to ease of access.
Left IJV	7(%6,2)	Due to skin-invasive right breast carcinoma and old right-sided puncture
Right Subclavian vein	1(%0,8)	Due to radiotherapy to the laryngeal region

Table 3. Time to complication and type of complication in patients undergoing TIVAP implantation.

Complication	Early(<30days)	Late(>30days)	Total Complications	Days to complication (Mean)
	n (%)	n (%)	n (%)	
Infection	2(1,78)	4(3,57)	6(5,35)	83,5
Reservoir-Catheter Separation	2(1,78)	1(0,89)	3(2,67)	24
Reservoir-Catheter Migration	1(0,89)	0(0)	1(0,89)	2

Infection Rates

In our study, the infection rate was found to be 5.35%. In a retrospective study including 516 patients performed in the radiology department, the infection rate was reported as 11.4% (14). In another retrospective analysis including 1406 patients and performed in a hybrid room, the infection rate (5.1%) was observed to be similar to this study (15). Infection, which is the most common complication of TIVAP implantation and reduces the duration of use the most, is related to the implantation conditions. The low infection rate in our study may be a result of the importance given to the sterilization of the operating room environment, the surgeon's application of the procedure and the catheter placement technique.

Complication Management

Other complications seen in our study (reservoir-catheter separation, kink) are complications observed in the long term and are generally due to surgical technical problems. Such complications can be minimized when performed carefully by experienced surgeons and appropriate catheter care techniques are applied. Early diagnosis and treatment of complications are important to improve the prognosis of patients. In addition, in the event of life-threatening complications such as cardiac tamponade and pneumothorax, the fact that the most effective diagnosis and most advanced treatments can be performed by the relevant surgeons in the hybrid operating room without the need for patient transport provides a significant advantage in terms of safety.

Strengths of the Study

The strengths of our study include including a relatively large patient population in a single center, evaluating the efficacy and safety of USG and XrF in TIVAP implantation, and analyzing complications in detail. In addition, the TIVAP implantation technique and operating room environment used in our study are more specific and standardized compared to other studies in the literature.

Limitations of the Study

There are also some limitations of our study. First of all, our study is a retrospective study. Prospective clinical studies should be planned for more definitive results. Second, since our study was conducted in a single center, the results may differ in different centers. Third, only the complication rates were evaluated in our study, and other important outcomes such as quality of life or satisfaction of the patients were not evaluated.

CONCLUSION

This series, which included a total of 112 patients, shows that TIVAP implantations performed using USG and XrF in a hybrid operating room are a safe and effective method. The absence of perioperative complications and the low infection rate were associated with TIVAP implantation being performed in hybrid operating rooms where imaging systems such as XrF were used and surgical sterile fields could be created. These results support that the optimal TIVAP implantation should be performed by cardiovascular surgeons in hybrid operating rooms.

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