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Original Article

The causes and managements of catheter misplacement in implantable vascular access devices: a retrospective analysis of 8534 patients in a single center

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Abstract: Objective: To investigate the incidence and risk factors of catheter misplacement in implantable vascular access devices (TIVAD), in order to reduce the occurrence of catheter misplacement. Methods: Retrospective analysis was performed to examine the incidence and risk factors of catheter misplacement in 8534 patients with TIVAD implantation. Results: The incidence of catheter misplacement in all TIVAD cases was 1.49%, and the cases with left subclavian vein puncture had the highest incidence of catheter misplacement (11.69%) (χ^2=63.480, P=0.000). There was no significant difference in the incidence of catheter misplacement among the patients with different ages, genders or body mass index (P>0.05). Conclusion: TIVAD implantation should strictly follow the standard operation procedure, and the vascular variability in patients needs to be examined before operation. In addition, to reduce the incidence of catheter misplacement, the right internal jugular vein should be the preferred location for TIVAD.

Keywords: TIVAD, catheter misplacement, complication management, prevention

Introduction

Totally implanted vascular access device (TIVAD), also called intravenous port, is a central intravenous infusion device buried in subcutaneous tissue. It is implantable and can indwell in patient body for a long time. Currently, TIVAD is widely used in cancer patients or the patients who need long-term intravenous nutrition support [1].

The complications during the implantation of intravenous port mainly include catheter misplacement, pneumothorax, arterial injury, thoracic duct injury, inability of catheter implantation, hemorrhage/hematoma, nerve injury, arrhythmia, and large vessel injury [2-4]. In this study, we retrospectively analyzed and discussed the causes and managements of catheter misplacement during the implantation, in order to better guide the clinical use of TIVAD.

Materials and methods

General information

We did a retrospective analysis on 8534 patients who received TIVAD from December 2008 to Mar 2019 at the Breast Center of the Fourth Hospital of Hebei Medical University. The ages of patients ranged from 17 to 85 years old, with an average of 50 years old. Among the 8534 cases, 8382 of them were breast cancer patients, and 152 had other cancers.

TIVAD type

The TIVAD with three-way valve catheter from the Bard Company (USA) was selected for implantation. According to specific patient condition, 7Fr or 8Fr intravenous infusion ports were chosen.

Table 1. The incidence of catheter misplacement in internal jugular vein puncture and subclavian vein puncture

Puncture location	total cases (n)	catheter misplacement (n)	Incidence rate of catheter misplacement (%)	χ^2	P
Internal jugular vein	8355	116	1.39	23.90	0.000
Subclavian vein	179	11	6.15		

Table 2. The incidence of catheter misplacement in different puncture locations

Puncture location	total cases (n)	catheter misplacement (n)	Incidence rate of catheter misplacement (%)	χ^2	*P*
Left internal jugular vein	3756	116	3.09	63.480	0.000
Right internal jugular vein	4599	0	0		
Left subclavian vein	77	9	11.69		
Right subclavian vein	102	2	1.96		

Intravenous port implantation method

All the intravenous port implantation procedures were performed in a sterile operating room. Local infiltration anesthesia was used, and the position of catheter end was examined with X-ray after implantation.

Diagnostic criteria for catheter misplacement

For all patients, the location of catheter end was examined with X-ray after implantation. If the catheter end did not enter the right superior vena cava but entered other veins, the case would be considered as catheter misplacement (excluding the situation where the catheter was too long and entered the atria and ventricle).

Statistical analysis

SPSS 13.0 was used to perform data analysis, and χ^2 test was used to examine the statistical differences.

Results

Implantation methods and the incidence of catheter misplacement

Among the 8534 patients with TIVAD implantation, 127 cases had catheter misplacement, with an incidence rate of 1.49%. More specifically, 8355 cases received internal jugular vein puncture, and 116 of them had catheter misplacement (incidence rate 1.39%). In more details, among the 8355 patients with internal jugular vein puncture, 3756 of them underwent left internal jugular vein puncture, and 116 cases had catheter misplacement (incidence rate 3.09%); 4599 cases underwent right internal jugular vein puncture, and none of them had catheter misplacement. Moreover, 179 cases received subclavian vein puncture, and 11 of them had catheter misplacement, with an incidence rate of 6.15%. Among the 179 patients with subclavian vein puncture, 77 cases underwent left subclavian vein puncture, and catheter misplacement occurred in 9 cases (incidence rate 11.69%); 102 cases underwent right subclavian vein puncture, and 2 of them had catheter misplacement (incidence rate 1.96%). The statistical analysis showed that the incidence of catheter misplacement was significantly lower in the patients with internal jugular vein puncture than the patients with subclavian vein puncture (χ^2=23.90, P=0.000). Further analysis showed that the patients with left internal jugular vein puncture had the highest incidence of catheter misplacement (χ^2= 63.480, P=0.000) (**Tables 1**, **2**). We also compared the incidence of catheter misplacement among the patients with different ages, genders or body mass index and there was no significant difference (P>0.05) (**Table 3**).

The adjustment of catheter misplacement

Among the 127 patients with catheter misplacement, 124 (97.64%) received catheter adjustment via X-ray intervention, and their catheters reached the expected position. For 2 patients with left internal jugular vein puncture, the catheters had to be removed because they cannot be adjusted to the right normal superior vena cava; then, the catheter was redelivered

Table 3. The incidence of catheter misplacement in different baseline characteristics

Category	Number	catheter misplacement (n)	χ^2	*P*
Age				
<50 y	4421	73	1.663	0.197
≥50 y	4113	54		
Genders				
Male	28	1	0.599	0.343
Female	8506	126		
BMI				
<25	4062	51	2.861	0.107
≥25	4472	76		

successfully through the right internal jugular vein. In one patient, the catheter end was located on the left residual superior vena cava and was confirmed by CT and ultrasound; thereby, the catheter was used normally without adjustment.

Discussion

TIVAD has been widely used in clinical practice due to its convenience and long-term indwelling, but its related complications have also been a big concern for clinicians. So far, there are very few large-scale studies about the occurrence of catheter misplacement in TIVAD implantation. It has been reported that the incidence of catheter misplacement in intravenous infusion port is 4% to 38%, and the common locations are ipsilateral or contralateral subclavian vein, azygous vein, internal thoracic vein, and lateral thoracic vein [5-7]. In this study, we retrospectively analyzed the incidence of catheter misplacement in 8534 patients with TIVAD implantation (1.49%), and discussed the related clinical experience and catheter adjustment after misplacement. We hope this study can help and guide more applications of TIVAD in clinical practice.

Puncture location is the main cause for catheter misplacement

The intravenous infusion port is usually implanted via internal jugular vein, subclavian vein, upper limb venous vein, femoral vein, intercostal vein, and hepatic vein by percutaneous puncture [8, 9]. The commonly used puncture locations are internal jugular vein and subclavian vein [10-12]. During the initial phase of introducing TIVAD technology, we mostly performed puncture via subclavian vein due to the lack of experience. However, as our skills became better, and subclavian vein puncture caused more pinch-off syndrome than internal jugular vein puncture [13-15], we gradually shifted to performing internal jugular vein puncture for most cases. Therefore, the number of patients with subclavian puncture was small in our study.

Due to the anatomical variation of the selected puncture vessel valve or bifurcation, the catheter can be placed against the vessel valve or bifurcation, and thereby cannot reach the correct position [16]. The right internal jugular vein and the subclavian vein merge into brachiocephalic vein and then directly flow into the right superior vena cava, making the catheterization relatively easier. In our study, none of the patients with right internal jugular vein puncture had catheter misplacement. On the other hand, for the patient with left internal jugular vein puncture or left subclavian vein puncture, because the left internal jugular vein and left subclavian vein are far from the junction between superior vena cava and right atrium, and these two veins merge and flow into the superior vena cava in a right angle, the implantation process is more likely to have variability, and the catheter can enter azygous vein, right subclavian vein or right internal jugular vein. Especially for the patients with vascular variations, the incidence of catheter misplacement is higher. Our study showed that although the number of cases was small, the incidence of catheter misplacement in left subclavian vein puncture was 11.69%, significantly higher than left internal jugular vein puncture and right subclavian vein puncture (χ^2=63.480, P=0.000). Therefore, when selecting puncture blood vessels, the doctors should try to avoid left subclavian vein, and primarily choose internal jugular vein. If the patient has breast cancer on the right side, then the left internal jugular vein is preferred.

The management and precautions for catheter misplacement

Once catheter misplacement is found after the TIVAD implantation, adjustment should be performed as soon as possible, together with the intervention using radiology techniques. Aseptic operation should be strictly followed during

the procedure, and the doctor should ask patient to relax. To conduct the catheter adjustment, the catheter end is first pulled back to the edge of the big vessel to be injected; then, the catheter is re-delivered under interventions using radiology techniques. During the re-delivery, the catheter can be flushed or infused with saline to maintain a certain degree of hardness for catheter, and the patient position can be adjusted at the same time. In most cases, the adjustment can send the catheter to correct position along the direction of blood flow and gravity. Our study showed that the success rate of catheter adjustment was 97.64% (124/127). However, for the patients with vascular malformations, the catheter might not be able to reach the correct position via adjustment. In addition, some studies show that catheter delivery can be affected by multiple factors, such as the history of clavicular trauma, the pressure from enlarged lymph node on the puncture side, and the presence of a large mass in the mediastinum. Residual left-sided superior vena cava is also a rare anatomical variation with 0.3-0.5% of the standard population [17-19]. In our study, one patient with left internal jugular vein puncture was found to have the catheter end delivered on the left side. Before catheter adjustment, CT and ultrasound were performed and found that the patient had residual left vena cava with normal blood return. Therefore, we did not conduct adjustment and the catheter was used normally. However, during the early stage of TIVAD application, due to the lack of experience, we did not consider the situation of residual left superior vena cava for 2 patients. Thus, the catheter adjustment was performed on these two patients and failed multiple times. Finally, the intravenous port was pulled out and implanted successfully through the right internal jugular vein.

In summary, before the catheterization of TIVAD, the patient should be fully evaluated for vascular malformations, scars, stenosis, or other factors affecting the entry of the catheter, in order to avoid the physical and economic loss to the patient due to the inability to adjust catheter misplacement. Especially during the left internal jugular puncture, the patient should be evaluated for residual left superior vena cava before surgery. X-ray after implantation to identify the tip of the catheter is also essential.

Our data showed that to reduce the incidence of catheter misplacement, the optimal puncture site is the right internal jugular vein for the TIVAD. Most importantly, the vascular variability in patients needs to be examined before operation.

Disclosure of conflict of interest

None.

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