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Risk factors for and countermeasures against postoperative infection associated with the placement of implantable central venous ports

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Objective: Clinical data on postoperative infections after the placement of implantable central venous ports remain inadequate. This study was undertaken to clarify risk factors for port infection in patients in whom subcutaneous implantable central venous ports were placed.
Methods: The study group was comprised of 891 patients in whom subcutaneous implantable central venous ports were placed from January 2005 through December 2017. The underlying diseases were malignant disease in 809 patients and benign disease in 82 patients. The approach was via the subclavian vein in 420 patients, the internal jugular vein in 420 patients, and the femoral vein in 51 patients.
Results: Postoperative complications occurred in 98 patients. Infection developed in 67 patients, pinch-off occurred in 15 patients, and thrombosis occurred in 12 patients. Independent risk factors for infection were port placement for the provision of nutrition ($P < 0.0001$) and usage of a femoral vein approach ($P < 0.0001$).
Conclusions: Independent risk factors are useful for the provision of nutrition and to determine to use a femoral vein approach. To prevent infection, measures to decrease the number of punctures and disinfection methods should be reinvestigated to improve methods for appropriate port placement.

Key words: central venous ports, infection, port site marking

Introduction

Subcutaneously implantable central venous ports are one type of vascular access device that are placed to provide anticancer drug therapy and central venous nutrition. In recent years, the number of patients in whom ports have been implanted to administer chemotherapy regimens has gradually increased owing to recent progress in chemotherapy.[1] The use of ports to provide intravenous nutrition has also become possible in patients with terminal cancer, patients with collagen disease, and patients in whom it is difficult to provide oral or enteral nutrition because of short bowel syndrome. On the other hand, complications associated with port placement, such as infection and pinch-off, have been reported.[2-5] The reason for the increase in port site infection (PSI) compared to the previous reports is that the use of ports has expanded even for patients with poor general conditions such as undernourished patients.

At present, various surveillance and investigative studies have been reported concerning the occurrence of CLABSIs (central line-associated bloodstream infections).[6-7] Although adequate clinical data on port usage are still not available, PSIs associated with the use of ports during routine diagnoses and treatments are not rare, and it is not unusual for such complications to become severe. We designed the present study to establish the risk factors for PSIs in a single hospital.

Materials and Methods

The study group was comprised of 891 patients who underwent emplacement of subcutaneous implantable central venous ports in our hospital sometime from

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Table 1. Patients' demographic characteristics

Characteristic	Variable	Mean (range)	N = 891	%
Sex	Male		395	44
	Female		496	56
Age (yr)		64 (6－91)		
BMI (kg/m^2)		20 (11－46)		
Purpose	Chemotherapy		688	77
	Nutrition		203	23
Disease	Benign		82	9
	Inflammatry bowel disease		40	40
	Collagen disease		42	5
	Malignant		809	91
	Gastroenterogy		517	58
	Breast		119	13
	Gynecology		98	11
	Blood		51	6
	Urology		24	3
Approach	Subclavian vein & Internal jugular vein		420	47
	Femoral vein		51	6

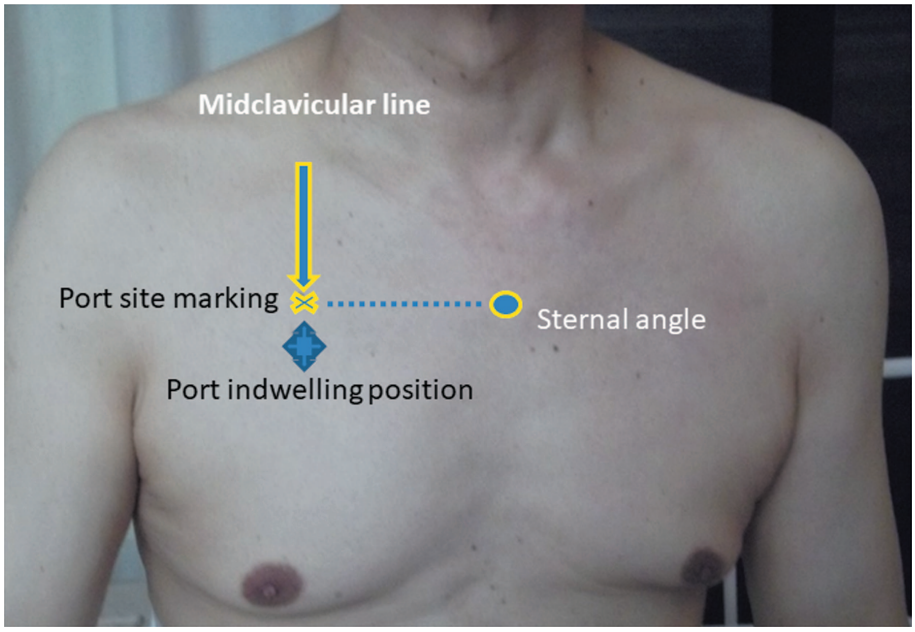

Figure 1. Port site marking: The marking was made with the patient in the sitting position if possible, obtaining a frontal view using a mirror. The sites corresponding to the midclavicular line and the sternal angle were marked, and a port was first placed below these markings.

January 2005 through December 2017 (Table 1). There were 395 males (44%) and 496 females (56%). The mean age was 64 (range, 6－91) years. The body mass index (BMI) was 20.7 (range, 11－46) kg/m^2. A total of 809 patients had malignant tumors. Eighty-two patients had benign diseases. The reason for port placement was to provide anticancer drug therapy in 688 patients (77%) and to provide nutrition in 203 patients (23%). The mean operation time was 65.4 (±23.7) minutes.

From 2005 through 2010, the procedure was mainly performed in a blind manner via the subclavian vein. From 2011 onward, the procedure was mainly performed via an internal jugular vein approach under ultrasonic guidance. If the subclavian and internal jugular vein approaches were precluded by the patient's condition, a femoral artery approach was used. The approach was the subclavian vein in 420 patients, the internal jugular vein, in 420 patients, and the femoral vein in 51 patients. Regarding the ports used, the Bard X-Port isp implantable port (Medicon, Osaka) was used from January 2005 through February 2014, and a power port (Bard X-Port isp implantable port, Medicon) was used from March 2014 through December 2017.

Port site marking

Port site marking was defined as marking the body surface at an appropriate site for port placement before placement of the port. The marking was made with the patient in the sitting position if possible, while obtaining a frontal view with the use of a mirror. As shown in Figure 1, the site corresponding to the midclavicular line and the sternal angle was marked, and a port was first placed below the mark. This procedure was initially used in October 2017 and has been used for 8 patients to date. There have been no port complications or infections. The objective is to safely place and use postoperative ports in appropriate positions (port puncture and needle removal), thereby facilitating the safe use and management of postoperative ports without placing a burden on the patients' activities of daily life (ADLs) or anticancer drug therapies. The objective is to place ports in appropriate, easy-to-use sites after surgery, thereby allowing the safe use and administration of the ports (port placement and needle removal), thereby facilitating postoperative port management, without negatively affecting the ADLs or anticancer therapy. In principle, the optimal sites in terms of port placement and removal by the patient should be decided on the basis of the movable ranges of the shoulders, elbows, and hands at the times of port placement and removal. If possible, the port site should be marked with the patient in a sitting position (with a mirror placed in front of the patient) and in the supine position. If the inguinal region is used, the sites should be marked with the patient in a standing position (with a mirror placed in front of the patient) and in a bent position. The patient's ADLs, social background, and appearance should be considered.

The following seven variables were studied as risk factors for postoperative infection: sex, age, BMI, underlying disease, objective of placement, approach site, and operation time. Port infection was evaluated to be present on the detection of positive blood cultures and port and catheter cultures after the exclusion of other diagnoses on the basis of the results of heat scrutiny tests. In univariate analysis, P values of <0.05 were considered to indicate statistical significance on chi-square analysis using log-rank tests. A Cox proportional-hazards model was used to select variables. (The stepwise variable increase method was used with P values of <0.1, calculated by Wald's classification statistical test, considered to indicate statistical significance.) The hazard ratios of the explanatory variables in the final model and the 95% confidence intervals (CIs) were calculated. Statistical analysis was performed with the SPSS, version 8, OJ software (SPSS, Chicago, IL, USA).

Results

Postoperative complications developed in 98 patients (11%). Infections developed in 67 patients (7.5%), pinch-off in 15 patients (catheter closure in 2 patients, abnormal catheter position in 1 patient, catheter damage in 8 patients, catheter breakage in 4 patients) (3.4%), thrombosis in 12 patients (1.3%), port trouble in 3 patients (damage, 2 patients; exposure, 1 patient), and postoperative bleeding in 1 patient. Infection developed 8 months (range, 1－68 months) after port placement, within 1 month after placement in 50 patients (74.6%), and 2 or more months after placement in 17 patients (25.4%). As for the objective of port placement, infection developed within 1 year in 25 patients who received chemotherapy and in 25 patients who received nutrition. There was no significant difference in the observation period between the two groups of chemotherapy and nutritional therapy.

The causative organisms were *Staphylococcus epidermidis* in 20 patients, methicillin-sensitive *Staphylococcus Aureus* in 4 patients, methicillin-resistant *Staphylococcus Aureus* in 2 patients, Acinetobacter species in 4 patients, Pseudomonas aeruginosa in 2 patients, *Enterobacter aerogenes* in 2 patients, gram-positive rods in 2 patients, and culture negatives in 29

patients. On univariate analysis, the two factors of nutritional purpose (P < 0.0001) and the femoral vein approach P < 0.0001) were significant risk factors for infection (Table 2). On multivariate analysis, the two factors of objective (nutrition) and approach site (femoral vein) were independent risk factors for infection (Table 3).

Discussion

We reported on 891 patients who underwent port implantation surgery at our hospital. Cases in which port implantation surgery was done more than once were excluded. In the present study, 98 patients (11%) had complications after port placement. Port site infection was the most common complication. The two main risk factors for infection were port placement to provide nutrition and the use of a femoral vein approach. This study is meaningful because all the surgical procedures were performed in one hospital under the guidance of the same chief surgeon. Ports are widely used as a route for the systemic administration of anticancer drugs and to provide central venous nutrition to patients with inadequate oral intake. In particular, the increased use of anticancer drugs to treat colorectal cancer, gastric cancer, and pancreatic cancer in recent years has led to a remarkable increase in the use of ports. As the administration routes of anticancer drugs become more diverse, the treatment periods become longer, and the number of administered doses increases, the need for securing a reliable peripheral vein and the number of ports placed because of drug-induced vascular pain or other reasons steadily increase.[1] In addition, ports are often placed to serve as routes to provide nutrition in patients who have inadequate oral intake caused by terminal cancer, patients with intestinal obstruction or inflammatory bowel disease associated with inadequate oral intake or peritoneal dissemination, and patients in whom the gastrointestinal tract cannot be used because of factors such as collagen disease.

Catheter infection is often associated with infusion infections caused by bacterial invasion via sites of thrombosis or bacterial penetration or bacterial invasion via three-way valves. Sotir et al.[8] reported that 1.23 infections occurred per 1,000 days of using an implantable vascular access device. Moreover, concurrent infection can lead to serious complications such as septicemia. Fungal infections often develop in patients with long-term catheter placement and patients who are in poor general condition. Scolapio et al.[9] reported that 11 (5%) of 225 patients with ports died of catheter-related septicemia. Appropriate action and early catheter removal in a timely fashion are therefore required when catheter infection is suspected.[9] In our hospital, port infections

Table 2. Risk factors for port infecion: univariate analysis

Characteristic	Variable	Infection (+)	Infection (-)	P value
Sex	Male:female	31:36	364:460	0.8383
Age (yr)	<65:≥65	38:29	418:406	0.4145
BMI (kg/m^2)	<25:≥25	59:8	681:143	0.3336
Purpose	Chemotherapy vs. nutrition	32:3	656:168	<0.0001
Approach (vein)	Subclavian vein vs. internal jugular vein	22:3	398:387	0.2022
	Subclavian & internal jugular vein vs. femoral vein	55:12	786:38	<0.0001
Operation time (min)	<60:≥60	31:36	331:493	0.3963

Table 3. Risk factors for port infection: multivariate analysis

Risk facto	Odds ratio	95% CI	P value
Purpose			
Nutrition	4.1219	2.4635－6.8966	0.0001
Approach			
Femoral vein	3.9058	1.8816－8.1074	0.0003

were diagnosed in 7.5% of patients, which is considered slightly higher than that reported previously. The most common pathogen was Staphylococcus epidermidis, and there were no fugal infections. These findings suggested that infections were transmitted via the skin of patients or medical staff. The infection systems were thought to involve bacterial invasion from the skin at the time of port placement or bacterial invasion via the solution infusion route. However, port infection was uncertain, and the catheter and blood cultures were negative in 29 patients in whom the ports were removed to determine the cause of infection (43%). With respect to the objective for port placement, the use of ports to provide nutrition differed from the use of ports to provide anticancer treatment in that puncture and needle removal were frequently performed, and the high-calorie infusion bag had to be changed daily. Furthermore, sediment associated with the lipid emulsion or electrolytes might have contributed to the high incidence of infection.

As countermeasures against port infection, there were two main risk factors for port infection: the nutritional objective and a femoral vein approach. A common factor was that the ports used to provide nutrition required multiple punctures whereas those used to provide chemotherapy only required a single puncture. It is therefore important that puncture and needle removal can be performed safely and easily by the patients and/or healthcare workers. We, therefore, proposed this technique for port site marking as a countermeasure against infection. As a countermeasure with respect to disinfection, along with sterile preparation of the drug solutions, it is important to sterilize the skin at the time of the Huber needle insertion. Guidelines issued by the Center for Disease Control and Prevention in the United States recommend the use of an alcohol preparation containing chlorhexidine in a concentration higher than 5% at the time of catheter insertion and dressing change. This preparation is recommended because chlorhexidine tends to remain in the skin, and good disinfectant activity in combination with alcohol has been reported.[10] These factors will most likely lead to the replacement of the currently used 10% povidone-iodine by 1% chlorhexidine ethanol or ethanol for disinfection. By performing port site marking, ports can be placed in an appropriate position in patients and used safely. Port infection will most likely be decreased by the ability to effectively place and remove needles.

Conflicts of interest: None

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