Original research article

JVA The Journal of Vascular Access

Risk factors of infection of totally implantable venous access port: A retrospective study

The Journal of Vascular Access
1–9

DOI: 10.1177/11297298221085230
journals.sagepub.com/home/jva
SAGE

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Abstract

Background: Infection is the most frequent complication associated with the use of totally implantable venous access port (TIVAP). This retrospective study was conducted to determine the risk factors affecting TIVAP-related infection.

Methods: A total of 1406 patients implanted with TIVAP at our center were included in this retrospective study. Incidence of perioperative infection, patient characteristics and bacteriologic data were retrieved and analyzed. Univariable analyses and multiple logistic regression analyses were used to determine the risk factors.

Results: Overall, 72 (5.1%) patients had perioperative infection, and TIVAP was finally removed from 12 (0.85%) patients. There was significantly more hematologic malignancy in the infection group, compared to the non-infection group. Patients with chemotherapy and infection within 30 days before operation also had more infections. There were more inpatients in the infection group than in the non-infection group. The rate of hematoma was higher in the infected patients. Multivariate logistic analysis revealed that hematoma (OR 5.695, $p < 0.001$), preoperative hospital stay (⩾14d) (OR 2.945, $p < 0.001$), history of chemotherapy (OR 2.628, $p = 0.002$), history of infection (within 30 days) (OR 4.325, $p < 0.001$) were independent risk factor for infection.

Conclusions: This study demonstrated that hematoma, preoperative hospital stay (⩾14d), history of chemotherapy and history of infection (within 30 days) are independent risk factor for all patients.

Keywords

Totally implantable venous access port, perioperative infection, complication, cancer patient, antibiotics

Date received: 25 July 2021; accepted: 12 February 2022

Background

Totally implantable venous access port (TIVAP) has been widely used for the infusion of chemotherapeutic drugs and parenteral nutrition for more than twenty years.[1] Compared with traditional infusion device, TIVAP has the advantages of long-term retention, complete implantation, and no external exposure. With the increase in the number of patients implanted with the infusion port, the complications caused by implantation also increase.[2] The main group of patients who receive the implantation of infusion port is cancer patients. These patients are often elderly with immune dysfunction, and are more prone to postoperative infection.[3] Infection is the most frequent complication associated with TIVADs and could result in increased risk of morbidity and mortality, removal of device, delay in treatment, prolonged hospitalization, and elevated healthcare costs.[4] As recommended by clinical guidelines, dedicated room for the port implantation operation, proper hand hygiene, skin antisepsis, and ultrasound-guided venipuncture have become the standard practices of aseptic management to minimize infection.[5] In addition, once

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infected, systemic antibiotic treatment and antibiotic lock therapy (ALT) would be initiated, and removal of the device is recommended in case of *S. aureus*, Gram-negative bacteria, or Candida infections. As a consequence, TIVAP-associated infection rate was reported to be between 3% and 10%.[6–9] Once infection occurs, patients would be forced to remove the infusion port, due to the risk of systemic, and even life-threatening, infections.[10] Therefore, it is necessary to analyze the risk factors leading to postoperative infection in connection with the use of infusion port to further minimize the infection and to develop the corresponding measures for the prevention and treatment of infection.

Subject and methods

Subjects

A total of 1406 patients implanted with TIVAP at our hospital between January 2015 to December 2019 were all included in this retrospective study. Among them, 1036 were cancer patients and 370 were non-cancer patients. Patients were included if they needed the following indications for a venous port: (1) long-term repeated infusion of vesicant and/or irritating drugs; (2) long-term parenteral nutrition support; (3) long-term intermittent infusion and transfusion of blood products. Patients who had difficulty establishing peripheral venous access were also included. Patients with following contraindications were excluded: (1) did not tolerate TIVAP and/or cooperate in surgery; (2) had uncontrolled bacteremia or local infection at the operation site (confirmed or suspected local infection by puncture, bacteremia or symptoms of septicemia); (3) confirmed or suspected allergies to port materials; (4) had abnormal venous return, such as vena cava compression syndrome; and (5) had obvious coagulation dysfunction. According to whether postoperative infection occurred or not, they were divided into infection and non-infection groups. Definition of TIVAP-related infection was adapted from the Infectious Diseases Society of America (IDSA) guidelines and Kidney Disease Outcomes Quality Initiative (KDOQI)[11,12] as having the following conditions: bacteremia/fungemia in a patient with TIVAP with at least 1 positive blood culture and with clinical manifestations of infections (i.e., fever, chills, and/or hypotension) and no apparent source for the bloodstream infection except the catheter. One of the following should be present: a positive culture of the TIVAP associated with a positive peripheral blood culture with the same microorganism. For semiquantitative (>15 CFU/ catheter segment) or quantitative ($>10^2$ CFU/catheter segment), whereby a colony count of microbes grown from blood obtained through the catheter hub that is at least 3-folds greater than the colony count from the blood obtained from a peripheral vein or a differential time to positivity of a blood culture drawn from the catheter versus from a peripheral vein (positivity of the catheter blood sample at least 2 h before the peripheral blood sample). The primary outcome was postoperative infection, which was divided into non-bacteremic local infection and catheter-related bloodstream infection (CRBSI). Non-bacteremic local infection was defined as superficial skin infection, in which the infection was limited to the surface skin or incision site, but not to the tract of tunneled catheter and portal pocket. CRBSI was defined as the presence of bacteremia originating from both the peripheral veins and catheters as described in the guidelines.[12]

Port implantation operation

In all patients, we first attempted to insert the catheter via the axillary vein under ultrasound guidance, followed by other veins (internal/external jugular vein) only if the initial insertion was unsuccessful or in case of radiotherapy or previous surgery at the puncture site. The patient was laid in the supine position with the head turning to the opposite side, exposing the operation area on the neck. The skin was disinfected with 2% chlorhexidine. Infiltration with 1% lidocaine was applied for local anesthesia on the operating region. After that, the axillary vein was punctured using the Seldinger technique under ultrasound guidance and a guide wire was introduced to enter the superior vena cava by fluoroscopy. An introducer sheath was inserted along the guide wire into the vein, and the port catheter was introduced through the introducer sheath. A cutaneous incision of about 2–3 cm long was made 2–3 cm below the 1/3 clavicle on the same side. A portal pocket was prepared by blunt preparation on the pectoral fascia through the incision. The port was placed into the portal pocket and the course and radian of the catheter were adjusted in the subcutaneous tunnel to avoid corner folding. A 2-0 non-absorbable suture was used to fix the port and the surrounding tissues with one stitch, absorbable suture. The skin was closed cyanoacrylate glue, and finally the wound was bound with dressing.

Post-infection treatment

When a port-related perioperative infection was diagnosed, specific therapy was initiated as soon as possible. A conservative strategy was used to deal with mild infections, including use of systemic antibiotics, antibiotic lock therapy (ALT), and immediate wound debridement. Bacterial cultures of wound secretions were carried out prior to antibiotic administration. A non-conservative strategy was conducted when CRBSI occurred or the conservative strategy failed. In addition to systemic antibiotics, the port might be removed immediately (Figure 1).

Statistical analysis

The normality of distribution of continuous variables was tested by one-sample Kolmogorov-Smirnov test.

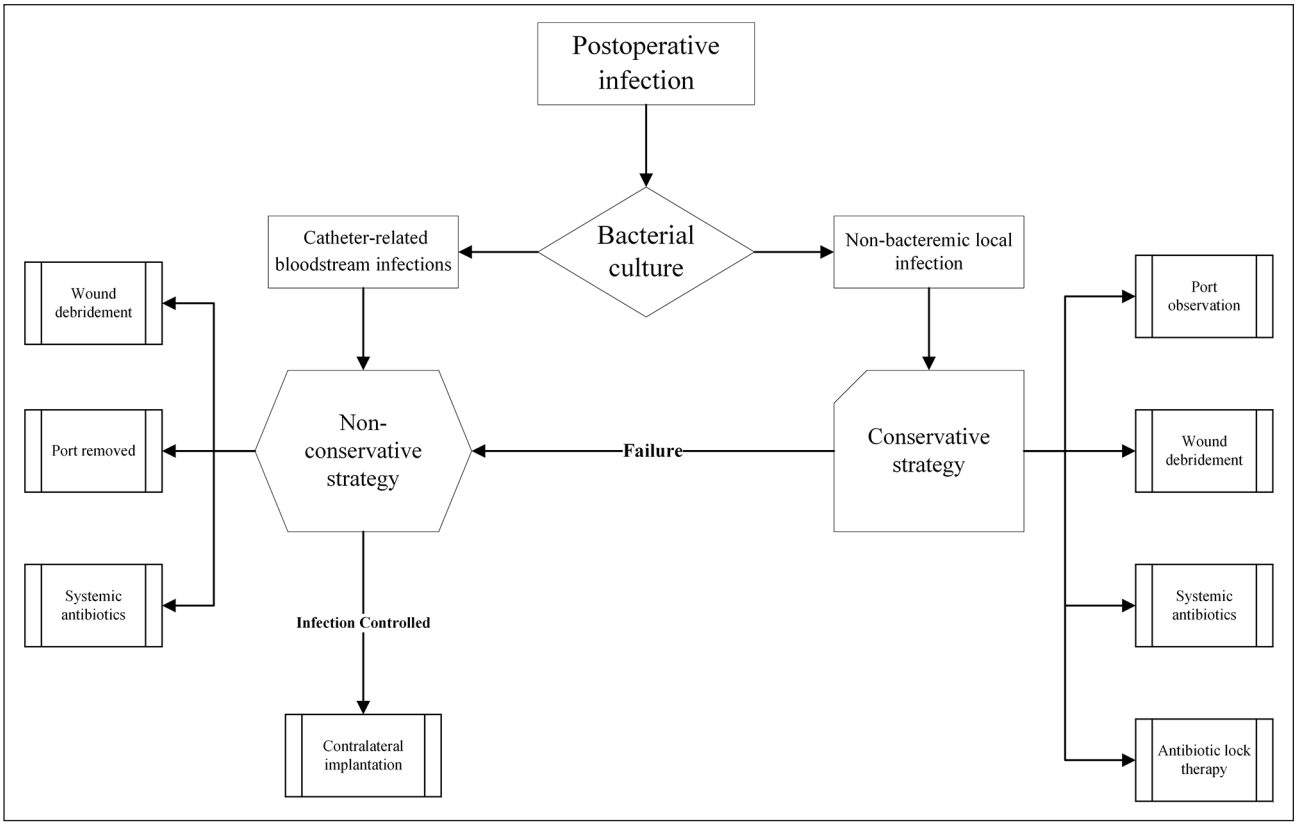

Figure 1. The flow chart of the process of infection therapy.

Continuous variables with normal distribution were presented as mean ± standard deviation and analyzed using Student's *t*-test. Categorical variables were presented as percentage, and analyzed using $\chi 2$ test Fisher's exact test, as appropriate. Multivariate logistic regression was performed to analyze the independent risk factors for primary outcome. Odds ratio was calculated using logistic regression. Variables in the adjusted model were age, gender, BMI, smoking, type of patient, puncture site, first use time, prophylactic antibiotic, hematoma, chemotherapy history, infection history, preoperative hospital stay, type of cancer, operation time, and comorbidities which include diabetes, hypertension, hyperlipidemia, coronary disease. A value of $p < 0.05$ was considered significant. SPSS version 25.0 for Windows (SPSS Inc., Chicago, IL, USA) was used to analyze the data.

Results

Patient demographic information is presented in Table 1. A total of 1406 patients were enrolled in the study, including 679 (48.3%) women and 727 (51.7%) men. The average age was 52.9 ± 13.5 years (ranged from 27 to 79 years). One thousand thirty-six cancer patients had indications for TIVAP placement. Among them, 22.7% patients had hematologic malignancy, 22.0% patients had lung cancer, 17.0% patients had gastrointestinal cancer, 14.2% patients had genitourinary cancer, 18.0% patients had breast cancer, and 7.2% had other cancers. BMI of the infection group was higher than that of the non-infection group (28.45 ± 4.51 vs 24.35 ± 3.79, $p < 0.001$). There were significantly more diabetic patients in the infection group than in the non-infection group (48.6% vs 30.4%, $p = 0.001$). There was significantly more hematologic malignancy in the infection group, compared to the non-infection group (26.4% vs 16.2%, $p = 0.024$). Compared with the non-infection group, the infection group also had more patients with chemotherapy history (25.0% vs 8.2%, $p < 0.001$), more patients with the history of infection within 30 days before operation (15.3% vs 2.5%, $p < 0.001$), more inpatients (69.4 vs 32.8%, $p < 0.001$) and higher rate of hematoma (19.4% vs 3.3%, $p < 0.001$). In this study, a liquid dark area with a diameter greater than or equal to 2 cm in the ultrasound examination was defined as hematoma when abnormal wave motion of the pocket was found during the dressing from the next day of operation to 1 week after operation. There was no significant difference in prophylactic antibiotic use, first use time, operation time, total parenteral nutrition (TPN), and other comorbidities between the two groups (Table 1).

In the cancer patients, there were 51 (87.9%) local infections and 7 (12.1%) CRBSI. Among them, TIVAP

Table 1. Patient characteristics.

	Infection group ($n=72$)	Non-infection group ($n=1334$)	T/χ^2	p
Age (year)	53.03 ± 10.23	52.91 ± 13.62	0.070	0.944
BMI (kg/m^2)	28.45 ± 4.51	24.35 ± 3.79	8.849	0.000*
Male, *n* (%)	34 (47.2)	693 (51.9)	0.611	0.434
Hypertension, *n* (%)	25 (34.7)	352 (26.4)	2.419	0.120
Diabetes, *n* (%)	35 (48.6)	405 (30.4)	10.584	0.001*
Hyperlipidemia, *n* (%)	17 (23.6)	234 (17.5)	1.716	0.190
Coronary disease, *n* (%)	15 (20.8)	173 (13.8)	3.648	0.056
Smoke, *n* (%)	18 (25.0)	255 (19.1)	1.512	0.219
Cancer, *n* (%)	58 (80.6)	978 (73.3)	1.848	0.174
Hematologic malignancy, *n* (%)	19 (26.4)	216 (16.2)	5.103	0.024*
Solid organ malignancy, *n* (%)	39 (54.2)	762 (57.1)	0.243	0.622
Lung, *n* (%)	10 (13.9)	210 (15.7)	0.178	0.673
Gastrointestinal, *n* (%)	6 (8.3)	167 (12.5)	1.109	0.292
Breast, *n* (%)	12 (16.7)	174 (13.0)	0.781	0.377
Genitourinary, *n* (%)	9 (12.5)	138 (10.3)	0.339	0.560
Others, *n* (%)	2 (2.8)	73 (5.5)	0.982	0.322
Chemotherapy history, *n* (%)	18 (25.0%)	110 (8.2%)	23.173	0.000*
Infection history, *n* (%)	11 (15.3)	34 (2.5)	35.727	0.000*
Patient category				
outpatient, *n* (%)	22 (30.6)	897 (67.2)	40.609	0.000*
inpatient, *n* (%)	50 (69.4)	437 (32.8)		
preoperative hospital stay, day	11.14 ± 6.42	11.36 ± 5.90	−0.292	0.770
Total parenteral nutrition, *n* (%)	5 (6.9)	76 (5.7)	0.196	0.658
Puncture sites				
Axillary vein, *n* (%)	60 (83.3)	1043 (78.2)	1.071	0.301
Others, *n* (%)	12 (16.7)	291 (21.8)		
First medication time, day	6.31 ± 2.23	6.54 ± 2.25	−0.878	0.380
Hematoma, *n* (%)	14 (19.4)	44 (3.3)	45.029	0.000*
Prophylactic antibiotic, *n* (%)	10 (13.9)	188 (14.1%)	0.002	0.961
Operation time (min)	34.81 ± 8.49	36.55 ± 8.05	−1.789	0.074

*$p < 0.05$.

was finally removed from 7 CRBSI and 2 local infection patients. In the non-cancer patients, there were 12 (85.7%) local infections and 2 (14.3%) CRBSI. TIVAP was finally removed from 2 CRBSI and 1 local infection patients. No statistically significant difference was found in incidence of CRBSI and final removal rate between the groups ($p=0.822$, $p=0.908$). There was no recurrence of infection after the curettage and excision of the infected tissues and TIVAP removal. Pathogens responsible for infections in the cancer group included *Staphylococcus aureus* ($n=23$), *Candida* ($n=9$), *Staphylococcus epidermidis* ($n=17$), *Acinetobacter baumannii* ($n=3$), and *Klebsiella pneumonia* ($n=6$). The pathogens in the non-cancer patients were *Staphylococcus aureus* ($n=3$), *Candida* ($n=2$), *Staphylococcus epidermidis* ($n=3$), *Acinetobacter baumannii* ($n=3$), and *Klebsiella pneumonia* ($n=3$). There was no significant difference in the types of pathogens, first use time, prophylactic antibiotics between the two groups. The preoperative hospital stay of the non-cancer patients was significantly longer than that of the cancer patients ($p=0.003$, Table 2).

Multivariate logistic analysis tests revealed that hematoma (OR 5.695, 95%CI 2.847–11.395, $p<0.001$), preoperative hospital stay (⩾14d) (OR 2.945, 95%CI 1.681–5.160, $p<0.001$), history of chemotherapy (OR 2.628, 95%CI 1.425–4.846, $p=0.002$) and history of infection (within 30 days) (OR 4.325, 95%CI 1.991–9.515, $p<0.001$) were independent risk factors for infection (Table 3). Further multivariate logistic regression analysis showed that hematoma (OR 4.872, 95%CI 2.271–10.260, $p<0.001$), preoperative hospital stay (⩾14d) (OR 2.096, 95%CI 1.120–3.925, $p=0.021$), history of chemotherapy (OR 3.219, 95%CI 1.753–5.910, $p<0.001$) were independent risk factors for both cancer and non-cancer patients (Table 4).

In addition, multivariate logistic regression analysis found that hematoma (OR 6.407, 95%CI 1.495–27.466, $p=0.012$), preoperative hospital stay (⩾14d) (OR 5.457, 95%CI 1.295–22.998, $p=0.021$), history of infection

Table 2. Characteristics of Infection patients.

	Cancer patients ($n=58$)	Non-Cancer patients ($n=14$)	T/χ^2	p
Local infection, *n* (%)	51 (87.9)	12 (85.7)	0.051	0.822
CRBSI, *n* (%)	7 (12.1)	2 (14.3)		
Bacteraemia, *n* (%)	2 (3.4)	1 (7.1)	–	0.483※
Port, *n* (%)	5 (8.6)	1 (7.1)	–	1.000※
Final removal, *n* (%)	9 (15.5)	2 (14.3)	0.013	0.908
Microorganisms				
Staphylococcus aureus, *n* (%)	23 (39.7)	3 (21.4)	1.624	0.203
Candida species, *n* (%)	9 (15.5)	2 (14.3)	0.013	0.908
Staphylococcus epidermidis, *n* (%)	17 (29.3)	3 (21.4)	0.349	0.555
Acinetobacter baumannii, *n* (%)	3 (5.2)	3 (21.4)	–	0.083※
Klebsiella pneumonia, *n* (%)	6 (10.3)	3 (21.4)	1.267	0.260
Inpatient, *n* (%)	39 (67.2)	11 (78.6)	0.682	0.409
Preoperative hospital stay, day	12.05 ± 5.94	18.27 ± 5.35	−3.131	0.003*
First medication time, day	6.33 ± 2.23	6.21 ± 2.33	0.169	0.866
Prophylactic antibiotic, *n* (%)	6 (10.3)	4 (28.6)	3.133	0.077

※Fisher's exact test; *$p < 0.05$; CRBSI: catheter-related bloodstream infections.

Table 3. Multivariate Logistic analysis for risk factors of infection in all patients.

Variable	β	SE	Wald χ^2	OR	p	95% CI	
Hematoma	1.740	0.354	24.170	5.695	0.000*	2.847	11.395
Preoperative hospital stay (⩾14d)	1.080	0.286	14.254	2.945	0.000*	1.681	5.160
History of chemotherapy	0.966	0.312	9.581	2.628	0.002*	1.425	4.846
History of infection within 30 days	1.471	0.399	13.579	4.352	0.000*	1.991	9.515
Constant	−3.540	0.171	430.717	0.029	0.000		

Adjusted for age, gender, BMI, smoking, cancer, hypertension, diabetes, hyperlipidemia, coronary disease, hematologic malignancy, chemotherapy history, infection history (within 30 days), patient category, preoperative hospital stay (⩾14d), total parenteral nutrition, hematoma, puncture sites, first medication time, prophylactic antibiotic, operation time.
*$p < 0.05$.

Table 4. Multivariate Logistic analysis for risk factors of infection in Cancer patients.

Variable	β	SE	Wald χ^2	OR	p	95% CI	
hematoma	1.574	0.385	16.746	4.872	0.000*	2.271	10.260
preoperative hospital stay (⩾14d)	0.740	0.320	5.353	2.096	0.021*	1.120	3.925
History of chemotherapy	1.169	0.310	14.219	3.219	0.000*	1.753	5.910
constant	−3.358	0.188	317.407	0.035	0.000		

Adjusted for age, gender, BMI, smoking, hypertension, diabetes, hyperlipidemia, coronary disease, hematologic malignancy, hematoma, chemotherapy history, infection history (within 30 days), preoperative hospital stay (⩾14d), total parenteral nutrition, puncture sites, first medication time, prophylactic antibiotic, operation time.
*$p < 0.05$.

(within 30 day) (OR 8.966, 95%CI 2.213–44.951, $p=0.003$) were independent risk factors for infection in the non-cancer patients (Table 5).

Discussion

In this study we measured 72 infections over 1406 patients (5.12%). In particular, in non-cancer patients we found 14 (3.8%) infections, in cancer patients we found 58 (6.0%) infections. The infection rates are similar to the findings of previous studies (2 to 9.6%).[6–9,13,14] The final device removal rate in our study was 0.78% which is similar to the results reported in previous RCT studies, and there was no difference in the removal rate between cancer (15.5%) and non-cancer patients (14.3%) with infection. According to the previous research experience and guidelines, the

Table 5. Multivariate logistic analysis for risk factors of infection in non-cancer patients.

Variable	β	SE	Wald χ^2	OR	p	95% CI	
hematoma	1.857	0.743	6.256	6.407	0.012*	1.495	27.466
preoperative hospital stay (⩾14d)	1.697	0.734	5.345	5.457	0.021*	1.295	22.998
History of infection within 30 days	2.300	0.768	8.966	9.974	0.003*	2.213	44.951
constant	−3.869	0.382	102.696	0.021	0.000		

Adjusted for age, gender, BMI, smoking, hypertension, diabetes, hyperlipidemia, coronary disease, hematoma, Infection history (within 30 days), preoperative hospital stay (⩾14d), puncture sites, first medication time, prophylactic antibiotic, operation time
*$p < 0.05$.

device should be removed only when infections that involve the reservoir pocket or bacteremia occur.[15,16] There was significantly more hematologic malignancy in the infection group than in the non-infection patients. Similar results were also reported previously.[17–19] However, multivariate analyses showed that the hematologic malignancy is not an independent risk factor for infection in all patients or in the cancer patients. Recently, a propensity score matching study of 5967 patients also suggests that there is no relation between hematological malignancy and increased risk of TIVAP infection.[20] So far, most studies have found that prophylactic antibiotics will not decrease rate of postoperative infectious complications. In our study, only a small number of people received prophylactic antibiotics. Multivariate analysis confirmed that it is not an independent risk factor of infection. Therefore, prophylactic antibiotics is not recommended in TIVAD insertion. Previously, it was shown that inpatients had a significantly higher infection rate and a greater hazard (44%) of needing port removal than that of outpatients.[18] Our study also showed that the incidence of infection is significantly higher in the inpatients than in the outpatients. But multivariate logistic regression analysis showed patient category is not an independent risk factor. Further analysis showed that preoperative hospital stay (⩾14) is significantly associated with infection in all patients. This finding might be explained by the fact that longer hospitalization increases the risk of exposure to pathogens.

The time interval between the port implantation and first use may be a risk factor for the occurrence of port-related infections.[21] A four-year prospective study with 4045 patients demonstrated that a time interval between port implantation and first use of >6 d could significantly reduce the risk of complications and catheter removal rates.[22] Time interval between port implantation and first use was 6.31 ± 2.23 days in the infection patients and 6.54 ± 2.25 days in the non-infection patients in our study. Based on the above data, no correlation is founded between the timing of the first use and infection in our study. We also found that there is no difference in CRBSI rate and the type of microorganism in the infected patients between the cancer and no cancer patients. Multivariate analysis further confirmed that preoperative hospital stay is an independent risk factor of infection in all patients, cancer, and non-cancer patients. Hematoma also was found to be an independent risk factor of infection. Hematoma provides a good growth environment for pathogens. Therefore, once hematoma complicated with infection occurs, thorough debridement would be the best way to control infection. In our experience, hematoma might occur because of puncture difficulty, abnormal coagulation function, incomplete hemostasis, and fat liquefaction. Therefore, the experience of the surgeon is particularly important to prevent hematoma. In hospitals where ultrasound or X-ray guidance is not routinely used, these should be used as soon as possible when puncture is found difficult to avoid blind puncture. Real-time ultrasound-guided puncture and cannulation of the vein appear to have a role not only for the prevention of infection but also for the prevention of mechanical complication.[23] Using fluoroscopy guidance means that the operation will be performed in the catheter room instead of the central operating room. To minimize potential cross-infection, the operation interval should be more than 30 min, the operation room should be disinfected with ultraviolet rays during this time. In addition, all equipment used in this operation should be disinfected with 70% alcohol prior to use in the operating room. For patients with oral anticoagulant drugs, the damage of muscular membrane should be avoided as much as possible. After the pocket is made, the bleeding situation of the wound should be carefully observed, and the bleeding should be stopped completely using high-frequency electric knife. The injured arterioles should be sutured and ligated with nylon suture. The excess adipose tissue should be cleaned before suturing the wound. If there is more bleeding and hemostasis is unsatisfactory, intermittent suture and indwelling drainage strip could be used to reduce the occurrence of hematoma. Coagulation dysfunction is often associated with tumor patients receiving infusion port implantation. The main causes include oral anticoagulants and thrombocytopenia. Operators should be vigilant to these patients. Wave motion on the pocket surface is the most direct manifestation of hematoma and should be the focus of postoperative observation. In addition, we should also pay attention to the indirect manifestations such as incision exudation, congestion around the pouch and under the armpit. Early detection, identification and notification of

hematoma in post-operative care would reduce the occurrence of infection.

Previous study has shown that more postoperative complications have been observed with nonabsorbable sutures than absorbable.[24] It is always better to use absorbable suture unless there is contraindication. Cyanoacrylates have been shown to provide a barrier to bacterial penetration.[25] Therefore, we used absorbable suture to suture most of the subcutaneous tissue and closed the wound with cyanoacrylate glue.

Another important finding is that chemotherapy is an independent risk factor for infection in all patients and in the cancer patients. Myelosuppression and immunosuppression are the common side effects for most chemotherapy drugs.[26,27] Patients with malignant tumors have defective immunity, and when treated with chemotherapy, their immune systems would weaken further and even fail to prevent infection.[28] Evidences suggest that most cancer patients usually have low immunity after radiotherapy or chemotherapy[29] and palliative chemotherapy had a higher risk than adjuvant chemotherapy.[13,30] These results indicate that immune status is very important to prevent infection. This risk can be avoided by implanting TIVAP before the first chemotherapy. The last significant finding is that history of infection within 30 days is an independent risk factor for non-cancer unlike cancer patients. This result may partially be attributed to the fact that most non-cancer patients receiving TIVAP have multiple chronic diseases and need long-term parenteral nutrition. Recent infectious diseases and further cumulatively low level of nutrition could lead to low immunity. For these patients, it is necessary to correct malnutrition and comprehensively control infection before operation. Total parenteral nutrition (TPN) as a risk factor was reported by previous studies.[31–33] Some part of the normal flora that can cause infection in immunocompromised patients such as *Candida* which has the ability to grow in a solution with high glucose concentration as in TPN fluids.[34] At our center, TIVAP is used for chemotherapy and antibiotics in most patients and TPN is rarely performed, especially in patients who have just been implanted the TIVAP. Therefore, TPN is not found to be a risk factor in this study.

There are limitations in our study. It was a retrospective single-center study with relatively small sample size. The type and dose of antibiotics were not fully regulated and mainly depended on the doctor's experience. Finally, the specimens were taken from various sources, including blood culture, wound secretion, catheter tip, and catheter interior. Previous study suggested that the accuracy of culture inside the catheter is higher than others,[35] which may affect the use and results of antibiotics.

Conclusion

This study analyzed the risk factors of perioperative infection in different groups of patients received TIVAP. The findings clearly indicate that hematoma, preoperative hospital stay (⩾14d), history of chemotherapy, and history of infection (within 30 days) are independent risk factor in all patients; hematoma, preoperative hospital stay (⩾14d), and history of chemotherapy are independent risk factor for cancer patients. In non-cancer patients, hematoma, preoperative hospital stay (⩾14d), and history of infection (within 30 days) are independent risk factor for infection. Multiple regression analysis revealed that the patient category and hematologic malignancy are not independent risk factor. These findings would help develop clinical measure to prevent and treat perioperative infection during TIVAP.

Acknowledgements

Not applicable.

Authors' contributions

XG, HY, JZ, and YZ: Project conceptualization, investigation, and data analysis. XG, HY, JZ, and YL: Data collection, analysis, and methodology development. XG, HY, JZ, and YL: Investigation and methodology development. All authors wrote and approved the final version of the manuscript.

Availability of data and material

The datasets used and/or analysed during the current study are available from the corresponding author on reasonable request.

Declaration of conflicting interests

The author(s) declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

Ethics approval and consent to participate

The study was approved by Ethics Committee of Capital Medical University, Beijing China and written informed consent was obtained from every participant.

Funding

The author(s) received no financial support for the research, authorship, and/or publication of this article.

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References

1. Marcy PY, Schiappa R, Ferrero JM, et al. Patient satisfaction and acceptance of their totally implanted central venous catheter: a French prospective multicenter study. *J Vasc Access* 2017; 18: 390–395. DOI: 10.5301/jva.5000744.
2. Bademler S, Ucuncu M, Yildirim I, et al. Risk factors for complications in cancer patients with totally implantable access ports: A retrospective study and review of the literature. *J Int Med Res* 2019; 47: 702–709. DOI: 10.1177/0300060518808167.

3. Lin Y, Gustafson MP, Bulur PA, et al. Immunosuppressive CD14+HLA-DR(low)/- monocytes in B-cell non-Hodgkin lymphoma. *Blood* 2011; 117: 872–881. DOI: 10.1182/blood-2010-05-283820.
4. Pinelli F, Cecero E, Degl'Innocenti D, et al. Infection of totally implantable venous access devices: a review of the literature. *J Vasc Access* 2018; 19: 230–242. DOI: 10.1177/1129729818758999.
5. Chan D, Downing D, Keough CE, et al. Joint practice guideline for sterile technique during vascular and interventional radiology procedures: from the society of interventional radiology, association of perioperative registered nurses, and association for radiologic and imaging nursing, for the society of interventional radiology [corrected] standards of practice committee, and endorsed by the cardiovascular interventional radiological society of Europe and the Canadian interventional radiology association. *J Vasc Interv Radiol* 2012; 23: 1603–1612. DOI: 10.1016/j.jvir.2012.07.017.
6. Barbetakis N, Asteriou C, Kleontas A, et al. Totally implantable central venous access ports. Analysis of 700 cases. *J Surg Oncol* 2011; 104: 654–656. DOI: 10.1002/jso.21990.
7. Chang L, Tsai JS, Huang SJ, et al. Evaluation of infectious complications of the implantable venous access system in a general oncologic population. *Am J Infect Control* 2003; 31: 34–39. DOI: 10.1067/mic.2003.29.
8. Fischer L, Knebel P, Schroder S, et al. Reasons for explantation of totally implantable access ports: a multivariate analysis of 385 consecutive patients. *Ann Surg Oncol* 2008; 15: 1124–1129. DOI: 10.1245/s10434-007-9783-z.
9. Hsieh CC, Weng HH, Huang WS, et al. Analysis of risk factors for central venous port failure in cancer patients. *World J Gastroenterol* 2009; 15: 4709–4714. DOI: 10.3748/wjg.15.4709.
10. Zhang KC, Chen L, Chinese Research Hospital Association Digestive Tumor C, et al. Chinese expert consensus and practice guideline of totally implantable access port for digestive tract carcinomas. *World J Gastroenterol* 2020; 26: 3517–3527. DOI: 10.3748/wjg.v26.i25.3517.
11. Lok CE, Huber TS, Lee T, et al. KDOQI clinical practice guideline for vascular access: 2019 update. *Am J Kidney Dis* 2020; 75: S1–S164. DOI: 10.1053/j.ajkd.2019.12.001.
12. Mermel LA, Allon M, Bouza E, et al. Clinical practice guidelines for the diagnosis and management of intravascular catheter-related infection: 2009 update by the infectious diseases society of America. *Clin Infect Dis* 2009; 49: 1–45. DOI: 10.1086/599376.
13. Ji L, Yang J, Miao J, et al. Infections related to totally implantable venous-access ports: long-term experience in one center. *Cell Biochem Biophys* 2015; 72: 235–240. DOI: 10.1007/s12013-014-0443-1.
14. Karanlik H, Kurul S, Saip P, et al. The role of antibiotic prophylaxis in totally implantable venous access device placement: results of a single-center prospective randomized trial. *Am J Surg* 2011; 202: 10–15. DOI: 10.1016/j.amjsurg.2010.05.005.
15. Di Carlo I, Toro A, Pulvirenti E, et al. Could antibiotic prophylaxis be not necessary to implant totally implantable venous access devices? Randomized prospective study. *Surg Oncol* 2011; 20: 20–25. DOI: 10.1016/j.suronc.2009.09.003.
16. Covey AM, Toro-Pape FW, Thornton RH, et al. Totally implantable venous access device placement by interventional radiologists: are prophylactic antibiotics necessary? *J Vasc Interv Radiol* 2012; 23: 358–362. DOI: 10.1016/j.jvir.2011.11.004.
17. Shim J, Seo TS, Song MG, et al. Incidence and risk factors of infectious complications related to implantable venous-access ports. *Korean J Radiol* 2014; 15: 494–500. DOI: 10.3348/kjr.2014.15.4.494.
18. Pandey N, Chittams JL and Trerotola SO. Outpatient placement of subcutaneous venous access ports reduces the rate of infection and dehiscence compared with inpatient placement. *J Vasc Interv Radiol* 2013; 24: 849–854. DOI: 10.1016/j.jvir.2013.02.012.
19. Samaras P, Dold S, Braun J, et al. Infectious port complications are more frequent in younger patients with hematologic malignancies than in solid tumor patients. *Oncology* 2008; 74: 237–244. DOI: 10.1159/000151393.
20. Nezami N, Xing M, Groenwald M, et al. Risk factors of infection and role of antibiotic prophylaxis in totally implantable venous access port placement: propensity score matching. *Cardiovasc Intervent Radiol* 2019; 42: 1302–1310. DOI: 10.1007/s00270-019-02255-0.
21. Narducci F, Jean-Laurent M, Boulanger L, 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: 913–918. DOI: 10.1016/j.ejso.2011.06.016.
22. Kakkos A, Bresson L, Hudry D, et al. Complication-related removal of totally implantable venous access port systems: Does the interval between placement and first use and the neutropenia-inducing potential of chemotherapy regimens influence their incidence? A four-year prospective study of 4045 patients. *Eur J Surg Oncol* 2017; 43: 689–695. DOI: 10.1016/j.ejso.2016.10.020.
23. Penel N, Neu JC, Clisant S, et al. Risk factors for early catheter-related infections in cancer patients. *Cancer* 2007; 110: 1586–1592. DOI: 10.1002/cncr.22942.
24. Sajid MS, McFall MR, Whitehouse PA, et al. Systematic review of absorbable vs non-absorbable sutures used for the closure of surgical incisions. *World J Gastrointest Surg* 2014; 6: 241–247. DOI: 10.4240/wjgs.v6.i12.241.
25. Stoffel J and Bernatchez SF. Effect on microbial growth of a new skin protectant formulation. *Adv Wound Care (New Rochelle)* 2017; 6: 73–79. DOI: 10.1089/wound.2016.0706.
26. Guckenberger M, Allgauer M, Appold S, et al. Safety and efficacy of stereotactic body radiotherapy for stage 1 non-small-cell lung cancer in routine clinical practice: a patterns-of-care and outcome analysis. *J Thorac Oncol* 2013; 8: 1050–1058. DOI: 10.1097/JTO.0b013e318293dc45.
27. Deng X, Li X, Luo S, et al. Antitumor activity of Lycium barbarum polysaccharides with different molecular weights: an in vitro and in vivo study. *Food Nutr Res* 2017; 61: 1399770. DOI: 10.1080/16546628.2017.1399770.
28. Yu Y, Guo D, Qu T, et al. Increased risk of toxoplasma gondii infection in patients with colorectal cancer in Eastern China: seroprevalence, risk factors, and a case-control study. *Biomed Res Int* 2020; 2020: 2539482. DOI: 10.1155/2020/2539482.
29. Tian X, Huang C, Ye X, et al. Carbapenem-resistant enterobacter cloacae causing nosocomial infections in

Southwestern China: molecular epidemiology, risk factors, and predictors of mortality. *Infect Drug Resist* 2020; 13: 129–137. DOI: 10.2147/IDR.S234678.
30. Wang TY, Lee KD, Chen PT, et al. Incidence and risk factors for central venous access port-related infection in Chinese cancer patients. *J Formos Med Assoc* 2015; 114: 1055–1060. DOI: 10.1016/j.jfma.2015.06.013.
31. Li D, Xia R, Zhang Q, et al. Evaluation of candidemia in epidemiology and risk factors among cancer patients in a cancer center of China: an 8-year case-control study. *BMC Infect Dis* 2017; 17: 536. DOI: 10.1186/s12879-017-2636-x.
32. Okada S, Shiraishi A, Yamashiro Y, et al. A retrospective statistical analysis of the late complications associated with central venous port placements. *Jpn J Radiol* 2015; 33: 21–25. DOI: 10.1007/s11604-014-0375-0.
33. Brandt CF, Tribler S, Hvistendahl M, et al. Home parenteral nutrition in adult patients with chronic intestinal failure: catheter-related complications over 4 decades at the main Danish tertiary referral center. *JPEN J Parenter Enteral Nutr* 2018; 42: 95–103. DOI: 10.1177/0148607116678766.
34. Yamin DH, Husin A and Harun A. Risk factors of candida parapsilosis catheter-related bloodstream infection. *Front Public Health* 2021; 9: 631865. DOI: 10.3389/fpubh.2021.631865.
35. Douard MC, Arlet G, Longuet P, et al. Diagnosis of venous access port-related infections. *Clin Infect Dis* 1999; 29: 1197–1202. DOI: 10.1086/313444.