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Risk Factors of Infection and Role of Antibiotic Prophylaxis in Totally Implantable Venous Access Port Placement: Propensity Score Matching

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Abstract

Background To evaluate risk factors of infection and effectiveness of preprocedural single-dose intravenous prophylactic antibiotic (PABX) during totally implantable venous access port (TIVAP) placement in preventing procedure-related infections.

Methods This was a retrospective single-institution multicenter study evaluating short-term (30-day) infection outcomes after TIVAP placement. Correlation between infection rates and clinical factors, including hematologic versus non-hematologic malignancy, inpatient versus outpatient status, single versus double lumen and PABX, was investigated using univariate and multivariable analysis in the overall study population as well as the propensity-score-matched cohort.

Results Overall, 5967 patients underwent TIVAP placement from 2005 to 2016, of which 3978 (67%) patients received PABX. On propensity score matching, 1952 patients with PABX were matched to the same number of patients without PABX. TIVAP was removed due to infection concern in 48 patients in unmatched and 30 patients in matched population. There was no difference in the rate of infection between those who received PABX and those who did not in both unmatched and matched population ($p = 0.5387$ and 0.9999). Although infection rate was significantly higher in patients who had TIVAP placement in inpatient setting ($p < 0.0001$), who received a double-lumen TIVAP ($p < 0.0001$), or who had hematologic malignancy ($p = 0.0004$) on univariate analysis, inpatient status was the sole factor associated with higher rate of TIVAP infection on multivariable analysis of both overall (odds ratio 2.31, $p < 0.0001$) and matched populations (odds ratio 4.36, $p = 0.0004$).

Conclusion Placement of TIVAP in inpatient setting increases the risk of TIVAP infection. PABX before TIVAP placement does not prevent short-term procedure-related infections.

Keywords Port · Antibiotic · Prophylaxis · Infection · Removal · Central venous · Catheter

This retrospective study qualified for institutional review board waiver.

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Introduction

Totally implantable venous access port (TIVAP) devices are used for long-term infusion of chemotherapy, antibiotic therapy, repeated blood sampling, apheresis, fluid infusions, blood transfusions or administration of total parenteral nutrition [1]. Although placement of TIVAP is a minimally invasive procedure with very few adverse effects, no intervention is completely risk free.

Complications are generally divided into immediate (e.g., pneumothorax, accidental arterial puncture), early (e.g., pocket hematoma) and delayed (e.g., catheter-related bacteremia, thrombosis, catheter migration). The overall incidence of complications ranges between 1.6 and 28%, of which the most common is TIVAP-associated infection, reported in 3–10% of the cases [2].

Central-line-associated bloodstream infections (CLABSI) are described by the Center for Disease Control and Prevention (CDC) as presence of bacteremia or fungemia in a patient with an intravascular catheter with at least one positive culture obtained from the peripheral vein or artery or from the catheter segment, with clinical manifestations of infection (i.e., fever, chills and/or hypotension), and no other apparent source of the infectious microorganism other than the catheter [3, 4]. Catheter-related bacteremia is the most serious infectious complication, which in many instances leads to TIVAP removal.

TIVAP placement is generally considered a sterile procedure with a very low rate of infection (< 1%) [5]. In spite of growing evidence that preprocedural antibiotic administration for TIVAP procedures may be unnecessary [5–8], a survey among American College of Surgery fellows found that an overwhelming majority (> 88%) continued to use prophylactic antibiotics (PABX) for TIVAP placement under the hypothesis that the associated risk is outweighed by the benefit of reducing significant infection-related costs and morbidity [9].

The primary objective of this study was to assess whether PABX reduces the rate of infection and TIVAP removal within 30 days of placement. Secondary objective of the study was to assess whether specific clinical factors (e.g., patient diagnosis, outpatient versus inpatient status at the time of placement) and technical factors (device type) are correlated with an increased rate of TIVAP infection within 30 days of placement.

Patients and Methods

Study Design and Population

This retrospective study was qualified for institutional review board waiver. Subsequently, the institutional patient archiving communication system (PACS) was screened for consecutive patients who presented to Interventional Radiology Department for TIVAP placement between January 2005 and May 2016. This was a single-institution but multicenter study encompassing one tertiary care academic hospital, one community hospital with a radiology training program and one community hospital without an associated radiology training program.

The PACS database was further queried using montage search engine to identify those patients that presented for TIVAP removal within 30 days of placement with through June 2016. Data extracted from the patient's medical records included demographic characteristics, medical diagnosis, indication for TIVAP placement, and if administered, information about type and dose of antibiotic prophylaxis. Additional technical factors including access site of placement, device type and operator experience were also recorded. Chart review was performed for TIVAPs removed due to infection concern to gather data regarding infection type (local vs. systemic) and causative agent (skin flora vs. another site). Infections in patients with clearly identified source (e.g., E. coli bacteremia in a patient with urosepsis) were not counted as TIVAP-related infection.

Prophylactic Antibiotics

Choice of prophylactic antibiotic type was left to the interventional radiologists' preference. The guidelines did not change during the study. A single weight-adjusted dose of intravenous cefazolin was administered through the indwelling IV line prior to starting the procedure. Patients who had a history of allergic reaction to penicillin or cephalosporin antibiotics were administered vancomycin or clindamycin or doxycycline instead.

Totally Implantable Venous Access Port Placement Technique

The interventionists performed full-barrier technique and full surgical scrub. The surgical field was prepped and draped using standard technique. Skin preparation protocol was persistently modified over the period of the study, but was the same between centers. Local anesthesia was then reached with 1% lidocaine at the venotomy site and subcutaneous tract, and a combination of 1% lidocaine and epinephrine for the chamber site. A 21-gauge micropuncture needle was subsequently used to access the vein under continuous ultrasound guidance and a 0.018-inch wire advanced centrally under fluoroscopic guidance. The needle was exchanged for a 5 Fr micropuncture catheter and the micropuncture wire exchanged for a 0.035-inch or 0.038-inch guidewire. Next, a 2-cm horizontal incision was made on the anterior upper chest wall approximately 4–5 cm inferior to the clavicular margin, wide enough to accommodate the device chamber, followed by subcutaneous blunt dissection to complete the pocket. A tunneling device was subsequently used to create a connection between the pocket and the venipuncture site. Next, an appropriate-size, peel-away sheath was inserted, through which the catheter was advanced into the vein under

fluoroscopy until the tip was at the cavoatrial junction or just central to it. TIVAP patency was then assessed with small-volume blood aspiration followed by infusion of the 1.6–2 mL (based on the device guideline) of 100 units/mL of heparin solution. The subcutaneous layer of the pocket was then closed with absorbable sutures (usually 2–0), while the skin at both sites (venous access and pocket) was closed with absorbable suture material (usually 4–0). One final image was captured to confirm the correct tip positioning and absence of any kinks along the catheter. Standard wound dressing was applied to both incision sites.

Propensity Score Matching

Given that patients were not randomly assigned to receive prophylactic antibiotics, propensity scoring was used to limit the influence of selection bias on infectious outcomes. Propensity scores for prophylactic antibiotic administration were calculated on the basis of six predefined covariates: patient age, gender, single- or double-lumen TIVAP, inpatient or outpatient status, access site of TIVAP placement and type of malignancy. For each pair, a greedy 1:1 algorithm was used to match randomly treated patients to one of the two groups with prophylactic antibiotic administration by using the closest propensity score.

Statistical Analysis

Data were analyzed using JMP Pro 11 (SAS Inc, Cary, NC, USA). The primary endpoint was TIVAP removal within 30 days due to concern for implant site infection or bacteremia with skin pathogen. Patients were then grouped into two arms: antibiotic prophylaxis and non-prophylaxis. Univariate analysis of incidence rates for positive events was performed via χ^2 analysis or Fisher exact test, multivariable analysis was then used to compare risk factors. A p value of less than 0.05 was reported as statistically significant.

Results

A total of 5967 TIVAPs, placed by 16 interventionists, were included in the initial analysis. Demographic characteristics of the all patients are listed in Table 1. Mean age of the patients was 59.32 ± 4.24 years, with male-to-female ratio of 0.63. The most common indications for TIVAP placement are shown in Fig. 1. The five most common indications for TIVAP placement were breast cancer (19%), followed by lymphoma (12%), lung cancer (11%), pancreatic cancer (10%) and colorectoanal cancer (10%). When grouped, 15% of TIVAPs were placed for treatment of hematologic malignancy (e.g., lymphomas, acute myeloblastic leukemia, multiple myeloma, chronic lymphocytic leukemia, etc.), 75% for treatment of non-hematologic cancers (e.g., breast cancer, etc.) and 10% for non-malignant indications (e.g., inflammatory bowel disease, sickle cell anemia, etc.) (Table 1). Ratio of single- to double-lumen TIVAPs was 2.25 (Table 1). The most frequent access site was via internal jugular vein. Other access sites that were used when internal jugular access was not feasible are listed in Table 1. Majority of patients, 3978 (66.67%), received PABX, while 1989 (33.33%) did not. The most commonly used antibiotic was cefazolin (3757; 94.44%). The patients who had a history of allergic reaction to penicillin or cephalosporin antibiotics were administered clindamycin (186 patients, 4.68), vancomycin (34 patients, 0.85%) or doxycycline (one patient, 0.03%) instead. Demographic characteristics of the patients based on antibiotic prophylaxis are also listed in Table 1. There was a significant difference in the gender and single- versus double-lumen TIVAP distribution between patients who received PABX and who did not ($p = 0.004$ and < 0.001, respectively). Following propensity score matching, there was no difference in age, gender, type of TIVAP placed, inpatient versus outpatient, hematologic versus non-hematologic and access site.

In unmatched population, the total number of TIVAPs removed within 30 days of placement was 65 (1.09%), of which 48 (0.80%, 0.27 events/1000 catheter days) were removed due to either implant site infection concern or skin flora bacteremia that was presumed related to the TIVAP, and the remaining were removed due to TIVAP hematoma or non-functioning (nine TIVAPs), bacteremia with another source or non-skin agent (eight TIVAPs). All removed TIVAPs were placed through internal jugular access. Characteristics of the overall study population and matched population whose TIVAPs were removed for infection concern are demonstrated in Table 2. In the overall study population, the infection incidence rate was 0.29 events/1000 catheter days ($n = 34$) in patients who received PABX and 0.24 events/1000 catheter days ($n = 14$) in patients who did not receive PABX. In the propensity-score-matched cohort, 30 TIVAPs were removed due to infection concern, with an infection incidence rate of 0.26 events/1000 catheter days ($n = 15$ each) in both PABX and non-PABX groups.

No TIVAP was removed during the first week, while 27.08% were removed in the second week, 41.67% in the third week and 31.25% in the fourth week. PABX did not lead to statistically significant proportions of TIVAP removal due to concern for infection ($p = 0.157$). Additionally, there was no difference in the rate of TIVAP infection between different years ($p = 0.271$) or different centers ($p = 0.387$).

Table 1 Characteristics of the overall study population and matched cohort, based on whether antibiotic prophylaxis was administered

	Overall study population (n = 5967) n (%)	Prophylactic antibiotics (n = 3978) n (%)	No prophylactic antibiotics (n = 1989) n (%)	p value	Matched cohort (n = 3904) n (%)	Prophylactic antibiotics (n = 1952) n (%)	No prophylactic antibiotics (n = 1952) n (%)	p value
Age (mean ± SD years)	59.32 ± 14.24	58.94 ± 14.16	60.07 ± 14.37	0.004[a]	60.23 ± 13.94	60.16 ± 14.19	60.32 ± 13.69	0.726
Gender								
Male	2297 (38.49%)	1599 (26.80%)	698 (11.70%)	< 0.001[b]	1385 (35.48%)	691 (17.78%)	694 (17.70%)	0.920
Female	3670 (61.51%)	2385 (40.00%)	1285 (21.50%)		2519 (64.52%)	1261 (32.30%)	1258 (32.22%)	
Device type								
Single lumen	4130 (69.21%)	2681 (44.90%)	1449 (24.30%)	< 0.001[c]	2837 (72.67%)	1411 (36.14%)	1426 (36.53%)	0.590
Double lumen	1837 (30.79%)	1303 (21.80%)	534 (8.90%)		1067 (27.33%)	541 (13.86%)	526 (13.47%)	
Patient status								
Inpatient	1348 (22.59%)	917 (15.4%)	433 (7.20%)	0.160	815 (20.88%)	394 (10.09%)	421 (10.78%)	0.287
Outpatient	4619 (77.41%)	3067 (51.4%)	1550 (26.0%)		3089 (79.12%)	1558 (39.91%)	1531 (39.22%)	
Placement indication								
Hematologic	908 (15.22%)	607 (10.17%)	301 (5.04%)	0.362	589 (15.09%)	280 (7.17%)	309 (7.91%)	0.195
Non-hematologic	4454 (74.64%)	2971 (49.79%)	1483 (24.85%)		3315 (84.91%)	1672 (42.83%)	1643 (42.09%)	
Other	605 (10.14%)	424 (7.11%)	181 (3.04%)		0 (0%)	0 (0%)	0 (0%)	–
Access site								
Internal Jugular	5840 (97.87%)	3911 (65.54%)	1929 (32.33%)	0.099	3856 (98.77%)	1930 (49.44%)	1926 (49.33%)	0.866
Subclavian	54 (0.90%)	29 (0.48%)	25 (0.42%)		33 (0.85%)	16 (0.41%)	17 (0.44%)	
External Jugular	40 (0.67%)	31 (0.52%)	9 (0.15%)		13 (0.33%)	8 (0.20%)	5 (0.13%)	
Translumbar	10 (0.17%)	9 (0.15%)	1 (0.02%)		0 (0%)	0 (0%)	0 (0%)	
Other	23 (0.39%)	4 (0.07%)	19 (0.32%)		2 (0.05%)	1 (0.03%)	1 (0.03%)	

[a]The mean age of patients with no prophylactic antibiotics was significantly higher than the patients with prophylactic antibiotics

[b]The percentage of male gender was significantly higher in patients who had no prophylactic antibiotics

[c]The percentage of single lumen TIVAP was significantly higher in patients who had no prophylactic antibiotics

SD standard deviation

Univariate analysis of the overall study population (Table 3 and Fig. 2) demonstrated that there was a statistically significant higher rate of infection in patients who received a double-lumen TIVAP ($p < 0.0001$), had their TIVAP placed as an inpatient ($p < 0.0001$) and had hematologic malignancy ($p = 0.0004$) (Table 3). Similarly, univariate analysis of matched population (Table 3) showed that there was a statistically significant higher rate of infection in patients who received a double-lumen TIVAP ($p < 0.043$) or had their TIVAP placed as an inpatient ($p < 0.0001$).

Follow-up multivariable analysis (Table 4) revealed that the rate of TIVAP infection was higher in patients with TIVAP placement in the inpatient setting both in overall (odds ratio of 2.31, $p < 0.0001$) and matched population (odds ratio of 4.36, $p = 0.0004$), although inpatients and outpatients were equally likely to be administered PABX during TIVAP placement (68% vs. 66%, $p = 0.311$).

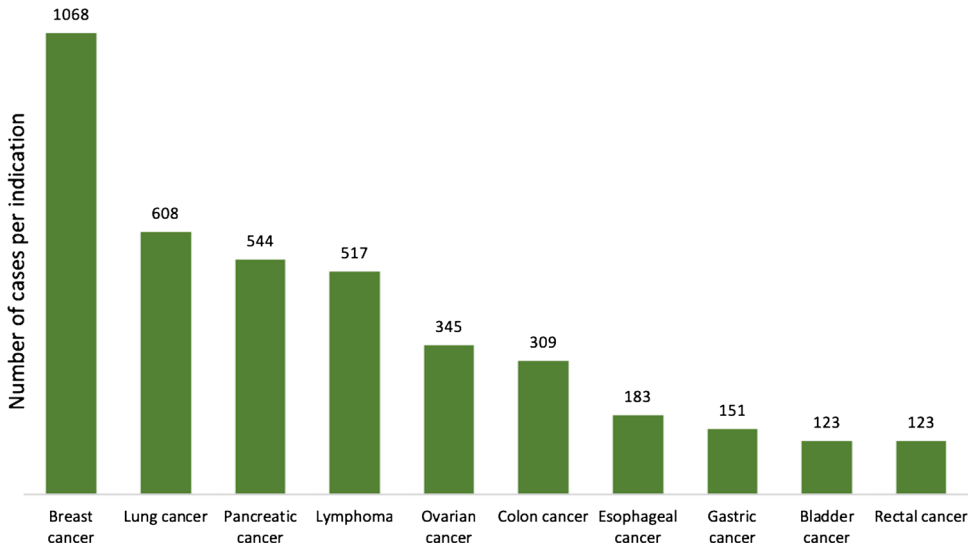

Fig. 1 Ten most common indications for placement of 5967 totally implantable venous access ports

Table 2 Patient characteristics of ports removed for infection concern

	Overall study population (n = 48) n (%)	Matched cohort (n = 30) n (%)
Age (mean ± SD; years)	52.00 ± 15.36 (range: 17–81)	51.97 ± 16.25 (range 22–81)
Gender		
Male	22 (45.83%)	14 (46.67%)
Female	26 (54.17%)	16 (53.33%)
Reason for port removal		
Site Infection	18 (37.50%)	11 (36.67%)
Bacteremia	27 (56.25%)	17 (56.67%)
Fungemia	3 (6.25%)	2 (6.67%)
Prophylactic antibiotic		
Yes	34 (70.83%)	15 (50.00%)
No	14 (29.17%)	15 (50.00%)
Device type		
Single lumen	14 (29.17%)	17 (56.67%)
Double lumen	34 (70.83%)	13 (43.33%)
Patient status		
Inpatient	25 (52.08%)	16 (53.33%)
Outpatient	23 (47.92%)	14 (46.67%)
Placement indication		
Hematologic	16 (33.33%)	8 (26.67%)
Non-hematologic	27 (56.25%)	22 (73.33%)
Other	5 (10.42%)	0 (0%)

SD standard deviation

Discussion

Our findings suggest that a single dose of PABX before TIVAP placement does not prevent short-term procedure-related infections. Furthermore, our results recommend that the TIVAP infection rate is 4.31 times higher in the inpatient setting.

TIVAPs have revolutionized cancer care and have become long-term venous access of choice for a variety of indications, with significant improvements in patients' quality of life [2]. Even though TIVAP placement is common and safe, it is not entirely risk free. Major complications include access site or systemic infection, catheter thrombosis, catheter obstruction, fracture and catheter migration [10]. TIVAP-associated infection has a reported

Table 3 Univariate analysis of factors affecting port removal for infection concern

Total *n*		Overall study population			Total *n*	Matched cohort		
		Infection, *n* (%)	Incidence (events per 1000 catheter days)	*p* value		Infection, *n* (%)	Incidence (events per 1000 catheter days)	*p* value
Prophylactic antibiotic								
Yes	3978	34 (0.85%)	0.29	0.5387	1952	15 (0.77%)	0.26	0.9999
No	1989	14 (0.70%)	0.24		1952	15 (0.77%)	0.26	
Device type								
Single lumen	4130	14 (0.34%)	0.12	< 0.0001[a]	2837	17 (0.60%)	0.20	0.0430[b]
Double lumen	1837	34 (1.85%)	0.57		1067	13 (1.22%)	0.41	
Patient status								
Inpatient	1348	25 (1.85%)	0.62	< 0.0001[c]	815	16 (1.96%)	0.66	< 0.0001[d]
Outpatient	4619	23 (0.80%)	0.17		3089	14 (0.45%)	0.15	
Placement indication								
Hematologic	908	16 (1.76%)	0.59	0.0004[e]	589	8 (1.36%)	0.46	0.1012
Non-hematologic	4454	27 (0.61%)	0.18		3315	22 (0.66%)	0.22	

[a]There was a statistically significant higher rate of infection in patients who received double-lumen TIVAP in overall study population

[b]There was a statistically significant higher rate of infection in patients who received a double-lumen TIVAP in the matched cohort

[c]There was a statistically significant higher rate of infection in patients who received TIVAP in inpatient setting in overall study population

[d]The rate of port infection was significantly higher in patients whose TIVAP was placed in inpatient setting in the matched cohort

[e]The rate of port infection was significantly higher in patient with hematologic malignancy in overall study population

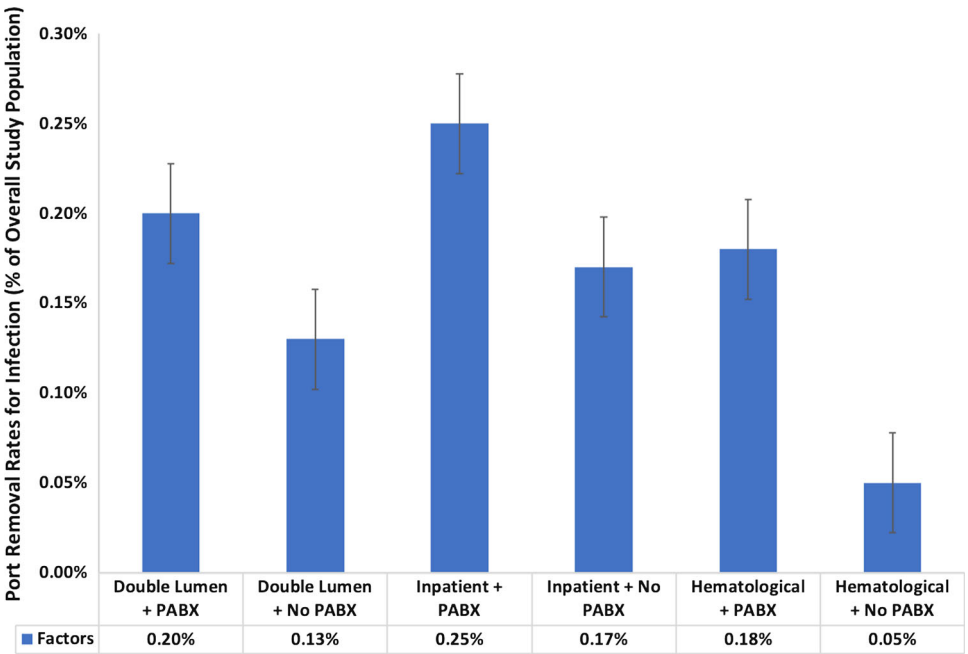

Fig. 2 Comparison of totally implantable venous access port removal rates due to infection based on prophylactic antibiotics

incidence between 3 and 10% and is the most commonly occurring complication [11].

Six years after CLABSI guidelines came into public spotlight in 1999 [5], the Society of Interventional Radiology updated its adult practice guidelines giving an ambiguous recommendation for PABX in the absence of clear consensus regarding its benefits for sterile procedures such as TIVAP placement [12]. In a 3-year single-center

Table 4 Multivariable analysis of factors affecting port removal for infection concern

	Overall study population			Matched cohort		
	Total *n*	Odds ratio of infection	*p* value	Total *n*	Odds ratio of infection	*p* value
Prophylactic antibiotic						
Yes	3978	1.21	0.8692	1952	1.00	0.9347
No	1989			1952		
Device type						
Single lumen	4130	5.44	0.2703	2837	2.03	0.1364
Double lumen	1837			1067		
Patient status						
Inpatient	1348	2.31	< 0.0001[a]	815	4.36	0.0004[b]
Outpatient	4619			3089		
Placement indication						
Hematologic	908	2.88	0.0782	589	2.06	0.2161
Non-hematologic	4454			3315		

[a]There was a significant higher rate of infection in patients who received TIVAP in inpatient setting in overall study population

[b]The rate of port infection was significantly higher in patients who received TIVAP in inpatient setting in the matched cohort

study by two surgeons on 459 TIVAPs, the authors concluded that single-dose perioperative PABX may decrease TIVAP-associated infection [13]. Two subsequent randomized controlled studies on 108 patients from Italy [7] and 404 patients from Turkey [6] did not show a difference over a 30-day-period post-TIVAP. Retrospective evaluation of 1183 TIVAPs placed by interventional radiologists reported no need for preprocedural PABX [5], and a follow-up meta-analysis [8] again concluded that there was no significant difference in infection rates when PABX is used. Our single-institution retrospective study with 5967 TIVAPs is the largest of its kind to date, a sample size almost three times of all the previous studies combined. The results of this study are consistent with the majority of current literature indicating no measurable short-term benefit from a single dose of PABX against both surgical site infections and skin flora bacteremia in the setting of TIVAP device placement. The infection rate in our study was 0.804% which is at the lower range of the reported rates from 0 to 9.6% [2, 5–7, 10, 13, 14].

Higher rate of infection has been shown for different types of double-lumen catheters in the prior studies [15, 16], and current institutional guidelines recommend the use of fewest number of lumens to minimize the risk of infection by reducing colonization portals [12, 17]. Although our initial analysis showed double-lumen TIVAPs may be associated with higher risk of infection, multivariable analysis on both the overall population and matched populations proved otherwise.

In our study, while patients had the same likelihood of receiving PABX irrespective of their inpatient or outpatient status, inpatients had a higher rate of infection compared to outpatient status. This relationship was previously reported in several studies [10, 18] and is thought to be the result of increased frequency of TIVAP access (e.g., laboratories, therapy, etc.) and more pathogenic hospital ecosystem. Although access data across our study population were difficult to assess, most inpatients who underwent TIVAP placement left the procedure suite with the TIVAP accessed and ready for immediate treatment. In addition, most of those were patients with acute leukemias/lymphomas, who required urgent treatment. In addition, subgroup analysis revealed no effect of PABX on infection incidence in inpatient setting.

While several studies reported higher rate of infection in patients with hematological malignancy [10, 19, 20], our result from multivariable analysis in both overall and matched populations did not show any relation between hematological malignancy and increased risk of TIVAP infection. The exact cause for this observed difference is uncertain, but it may be attributed to disease-specific factors (neutropenia, dysfunctional immune cells, impaired healing, etc.), higher likelihood of hematoma development due to thrombocytopenia, therapy characteristics and intensity (chemotherapy, radiation, stem cell transplant, etc.), as well as frequency of device access [10, 19–21]. Patients who have severe neutropenia do not receive TIVAP in our institute.

Furthermore, PABX had no effect on the timing of TIVAP removal due to infection—TIVAP was equally likely to be removed for infection within the first or last

two weeks of the 30-day interval after placement regardless of PABX.

In general, many institutions still seem unaware of the accumulating body of evidence that PABX for TIVAP placement is unnecessary. A 2013 survey of the fellows of the American College of Surgeons showed that 88% of responders use preoperative PABX for CVAP placement because of medicolegal reasons, general liability and hospital requirements [9].

The cost of a single dose of PABX, specifically cefazolin, which is the most commonly used one, is relatively insignificant compared to the cost of potential infectious complications. However, administration of PABX is not risk free and could result in side effects such as diarrhea, nausea, vomiting, stomach cramps and pseudomembranous colitis [22] which could potentially increase the level of care required, with associated financial implications. Furthermore, practicing physicians should use more recent guidelines updated based on the growing epidemiological challenge of emerging antibiotic resistance. Although cefazolin is currently an effective antibiotic, the evolutionary pressures of antibiotic use are real and rapid, highlighting the necessity of appropriate and judicious use.

Consequently, taking into account the aforementioned considerations of expected costs, side effects and rising antibiotic resistance, the adjusted risk–benefit ratio does not support the use of PABX for TIVAP placement. Incidence of infection has been further reduced with use of maximum sterile barriers (sterile gown, sterile gloves, drape, etc.), development of new biocompatible cleaning solutions, as well as novel dressing and device materials [3]. These effects are evident in the literature, with TIVAP-associated infection rates following a downward sloping trend, irrespective of PABX administration [10, 23].

A strength of this study is that it is the largest of its kind to date with almost near to 6000 patients in the sample, spanning over 11 years. It includes operators and assistants of varying degrees of experience (attendings, fellows, residents, medical students, PAs and APRNs), with varied practice environments including academic and community settings. However, this study is limited by its retrospective and single institutional nature and lack of randomization, and leaving choice of prophylactic antibiotic type on the interventional radiologists. Important clinical data including diabetes mellitus, stage of malignant disease, type and extent of preceding therapies (for example, chemotherapy already started/ongoing or not yet initiated), length of procedure or laboratory values, such as patients' absolute neutrophil counts, platelet counts and other coagulation parameters at the time of placement could not be consistently extracted due to changes in the medical record platforms over the years. In addition, frequency of access was not always recorded, though most TIVAPs placed on an inpatient basis were usually left accessed. This would be an important factor to consider in a prospective study.

In conclusion, our study demonstrates that PABX prior to TIVAP placement is not effective at reducing the likelihood of skin infection or bacteremia. In the setting of rising healthcare costs and antimicrobial resistance, the medical community needs to focus on evidence-based practice to collectively tackle these growing challenges. Further studies are needed to elucidate the potential benefits of PABX for specific patient populations and to investigate its true efficacy in a myriad of other similar minimally invasive procedures for which prophylaxis, even when not entirely evidence based, is still perceived to be the standard of care.

Conflict of interest The authors declare that they have no conflict of interest.

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