



The Safety Level of Total Central Venous Access Port Implantation Performed by Residents

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OBJECTIVE: The implantation of totally implantable venous access ports (TIVAPs) is one of the first procedures surgical residents learn. Complications after implantation procedures have a major impact on patient outcomes, as it may lead to a delay of chemotherapy regimens or of parenteral nutrition. The aim of this study was to compare the outcomes after totally implantable venous access ports implantations done by resident and attending surgeons.

DESIGN: The study was performed as a retrospective analysis.

SETTING: The study took place in primary care at the Department of General and Visceral Surgery at Frankfurt University Hospital.

PARTICIPANTS: A total of 760 primary totally implantable venous access ports implantations performed between March 2008 and December 2016 were included in a database.

Three groups of surgeons doing the implantations were defined: Group A (residents alone), Group B (resident with help), and Group C (attending surgeons).

RESULTS: There was a significant difference between the surgeon groups in operation time ($p < 0.001$). The groups differed between Group A (mean, 49; SD, 22) and Group C (mean, 39; SD, 20); $p < 0.001$ and Group B (mean, 53; SD, 23) and Group C (mean, 39; SD, 20); $p < 0.001$). The incidence of surgical site infections between Groups A and C (3.6% vs. 0.3%; $p = 0.003$) and Groups B and C (2.5% vs. 0.3%; $p = 0.027$) differed also significantly.

Based on multivariable logistic regression analysis operation time in minutes (OR, 1.04; 95%CI, 1.03-1.06; $p < 0.001$) was an independent risk factor for any intraoperative complications. For any postoperative complications younger age of the patient (OR, 0.98; 95%CI, 0.97-0.99; $p = 0.004$) and benign primary disease (OR, 3.25; 95%CI, 1.55-6.64; $p = 0.002$) were independent risk factors based on multivariable regression analysis. Based on multivariable regression analysis a lower body mass index of the patient (OR, 0.93; 95%CI, 0.86-0.99; $p = 0.044$), benign primary disease (OR, 2.89; 95%CI, 1.07-7.79; $p = 0.036$), and no chemotherapy (OR, 3.55; 95%CI, 1.50-8.39; $p = 0.004$) were independent risk factors for postoperative catheter infections. Surgeon group was no risk factor, neither for intraoperative and postoperative complications, nor for catheter explanation due to complications.

CONCLUSION: Residents performing alone or residents performing with help can safely handle a central venous access port implantation. In patients with several risk factors, however, an attending should assist. (J Surg Ed 76:182–192. © 2018 Association of Program Directors in Surgery. Published by Elsevier Inc. All rights reserved.)

KEY WORDS: resident involvement, resident participation, patient care, education

COMPETENCIES: Patient Care, Professionalism, Practice-Based Learning and Improvement

INTRODUCTION

Because of the provision of substantial resources, operation time in university hospitals is much more expensive per minute compared with a regional or community hospital. Therefore, basic surgical procedures often create a controversial situation, given their importance for

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additional surgical education, as university hospitals educate a significant number of residents. Totally implantable venous access ports (TIVAPs) represent one of these procedures, although it is necessary to be taught.¹⁻³ Despite that, TIVAP implantation is typically one of the first procedures residents learn to perform.⁴ It includes skills like vessel preparation, protection of soft tissue, and identification of structures; it is also one of the first procedures that demand assistance from attending to surgical residents.^{5,6} Problems during TIVAP implantations or postoperative complications could lead to a delay of vital parenteral nutrition or chemotherapy, and could impair patients' health.^{7,8}

However, this surgery has also been reported to result in severe complications, such as hemothorax, pneumothorax, catheter infections, and catheter dislocation.⁹⁻¹¹

This exemplifies how surgical education is confronted with conflict on a daily basis: costs, need to educate residents, and patient outcomes.

As many studies can be found discussing the participation of residents in procedures for basic surgeries, which are widely done by residents only; very few publications discuss the outcome.⁴

The aim of this study was to compare TIVAP implantations by three different groups of surgeons: residents alone, residents with senior residents or attending surgeons, and attending surgeons alone.

METHODS

All TIVAP implantations were performed between March 2008 and December 2016 in the Department of General and Visceral Surgery of the University Hospital Frankfurt, and were included in a retrospective database.

Patients

Clinical patients' data such as age, sex, comorbidities, primary illness leading to TIVAP implantation, type of chemotherapy, first date of TIVAP use, body mass index (BMI) (kg/m²), and comorbidities (diabetes mellitus, arterial hypertension, and chronic obstructive pulmonary disease) have been recorded.

Primary illness leading to TIVAP implantations was furthermore divided into benign and malignant diseases. Patients with benign diseases, including short-bowel-syndrome and HIV, received TIVAP implantation due to necessity of parenteral nutrition or difficult vessel conditions. Malignant diseases included all kind of carcinomas or lymphomas.

Surgeons

We defined three groups of surgeons: Group A (residents alone; years 1-3), Group B (residents with the help

of a senior resident (years 4-6) or an attending surgeon), and Group C (attending surgeons/consultants). All residents, attending surgeons, and consultants in the department were included. Attending surgeons performed TIVAP alone or with residents as their first assistants.

Surgical residents (years 1-3) are trained for the TIVAP implantation procedure; the first step is assisting an attending during the implantation. The next step is residents performing implantation with the help of an attending surgeon or an older resident (years 4-6). When they can perform the complete procedure correctly, they can perform it alone. In this case, an attending is directly available if difficulties occur.

Surgical Procedure

The standard procedure for TIVAP implantation is using the primary vena section of the cephalic vein, preferably on the right side with local anesthesia. General anesthesia was administered at a patient's request if there was a pre-known obstruction of the cephalic vein, with primary puncture of the subclavian vein performed. Catheter placement was controlled during surgery with an intraoperative X-ray. Afterwards, all patients received a chest X-ray in the radiology department and could leave the hospital within 2 to 4 hours.

Complications

Complications were divided into intraoperative complications or postoperative complications. Intraoperative complications were pneumothorax and hemothorax, diagnosed through chest X-ray or computer tomography. If catheter implantation was not possible, it was also defined as an intraoperative complication. Postoperative complications were surgical site infections (SSI), catheter infections, postoperative bleedings, catheter thrombosis, perforation of the port reservoir through the skin, and dislocation of the catheter.

Catheter infections were defined as infections with a local reaction or positive blood culture, which normally requires removal of the TIVAP. SSI were defined adjacent to the CDC guidelines of SSI.¹²

Outcome Parameters

For comparison of the outcome of TIVAP implantations between the three surgeon groups, the following parameters were used: any intraoperative complications, any postoperative complications, catheter infections, and catheter explantations due to complications. The parameter "any intraoperative complication" included pneumothorax, hemothorax, and impossible catheter implantation. "Any postoperative complication" consisted of SSI, catheter infections, bleeding, catheter thrombosis, perforation through skin, and dislocation of

catheter. As some patients have developed more than one postoperative complication, the number of any postoperative complications differs from the sum of all detailed enumerated complications.

Statistics

All statistical analyses were performed using International Business Machines Corporation Statistical Package for the Social Sciences for Windows (version 22.0; International Business Machines Corporation, Chicago, IL). Categorical variables were described in frequencies and percentages. Continuous variables were represented as a mean and its standard deviation (SD). Categorical variables were compared by the chi-squared (χ^2)-test or Fisher's exact test, as needed. First χ^2 -test was performed over all three groups of surgeons. Pearson χ^2 and the degrees of freedom (df) are shown in all tables. Cramer's V as a measure of the strength of association between the categorical variables is also given in the tables. For a better interpretation of the test results, the χ^2 -test with Bonferroni correction was performed pairwise between the groups. Results are shown in the tables. Continuous variables were compared using one-way analysis of variance (ANOVA). To ensure the homogeneity of variances Levene's test was performed. For interpretation of the results the *F*-distribution (*F*-ratio) as test of overall fit is given in the tables. The results are given in the text in the following form: *F*-test [*F*] ([df], residual) = *F*-ratio; *p*-value, partial eta-square [η^2], number [*n*].

A *p*-value <0.05 was considered statistically significant in all tests.

Logistic regression analysis was used to assess factors associated with any intraoperative or any postoperative complications, postoperative catheter infections or catheter explantation due to complications. The following parameters were considered for intraoperative complications in the univariable logistic regression analysis: age and sex of the patient, BMI, primary disease leading to TIVAP implantation, operation time, secondary vena section, and surgeon group. For univariable logistic regression for any postoperative complications, catheter infections, and catheter explantations due to complications the following variables were used: age and sex of the patient, BMI, diabetes, primary disease leading to TIVAP implantation, chemotherapy, time to chemotherapy, operation time, secondary vena section, and surgeon group. Variables with a *p*-value <0.05 in univariable logistic regression analyses were used for multivariable analyses. All variables were entered in a single step. These following parameters were considered in the multivariable analysis for any intraoperative complications: operation time and secondary vena section. For any postoperative complications and catheter

explantations due to complications, following parameters were used: age of the patient, malign primary disease, and chemotherapy. For catheter infections age of the patients, BMI, malign primary disease, and chemotherapy were included in the multivariable analysis. Results were expressed as Odds ratio (OR) with a 95% confidence interval (CI). Nagelkerke *R* square was used to calculate Cohen's *f* as measurement for effect size.

RESULTS

Between March 2008 and December 2016, there were 799 TIVAP implantations in our clinic. After exclusion of reimplantations, 760 cases were analyzed (Figure).

Patients' Characteristics

The mean age was 60 years (SD \pm 13). Moreover, 428 patients (56.3%) were male. 709 patients (93.3%) needed TIVAP due to a malignant disease. Following implantation: 573 patients (75.4%) underwent recorded chemotherapy regimens, whereas in 136 patients, data on their chemotherapy treatment were not available. No significant difference could be shown between the groups based on chemotherapy (*p* = 0.08). There was also no significant difference for patient's age between the groups (*F*(2, 757) = 0.59; *p* = 0.55, partial η^2 = 0.002, *n* = 760). There was no significant difference for patients BMI between the groups (*F*(2, 554) = 0.13; *p* = 0.88, partial η^2 = 0.00, *n* = 557). No significant difference was shown between the time from TIVAP implantation to chemotherapy (*F*(2, 367) = 2.12; *p* = 0.12, partial η^2 = 0.01, *n* = 370).

Patients' comorbidities were unequally distributed between surgeon groups. The incidence of diabetes mellitus in patients differed significantly between surgeon groups (*p* = 0.004). Patients in the Groups A and B had significant more often diabetes mellitus than in Group C (A vs. C, *p* = 0.003; B vs. C, *p* = 0.005). Details are shown in Table 1.

Surgical Details

There were 634 patients (83.4%) who received the TIVAP implantation on the right side. In 577 cases (75.9%), implantation was planned and successfully performed due to a primary vena section. In 147 cases (19.3%), implantation was planned as a vena section, but was performed as a venous puncture.

There was a significant difference between the groups in operation time (*F* (2, 735) = 34.9; *p* < 0.001, partial η^2 = 0.09, *n* = 760). Exactly, the groups differed between Group A (mean, 49; SD, 22) and Group C (mean, 39; SD, 20); *p* < 0.001) and Group B (mean, 53; SD, 23) and Group C (mean, 39; SD, 20; *p* < 0.001). No

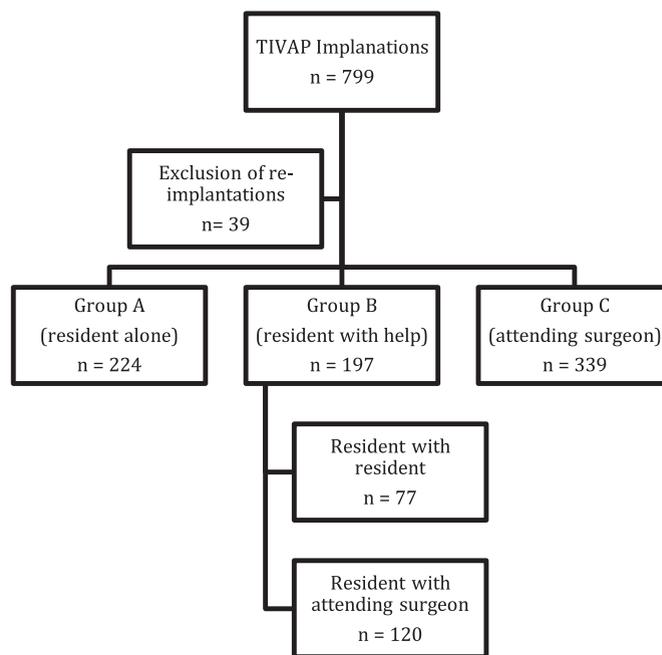


FIGURE. Study flow chart.

difference was shown between Groups A and B ($p = 0.18$).

Intraoperative complications occurred in 16 patients (2.1%). There were no significant differences in intraoperative complications between groups (Table 2).

Postoperative complications occurred in 119 patients (15.7%). Compared for all postoperative complications, no differences between the groups could be revealed ($p = 0.07$). Detailed comparison of surgeon groups showed a significant difference in the incidence of SSI between Groups A and C (3.6% vs. 0.3%; $p = 0.003$) and Groups B and C (2.5% vs. 0.3%; $p = 0.027$). Between the groups, no differences for the time to explantation have been found ($F(2, 98) = 1.64$; $p = 0.20$, partial $\eta^2 = 0.03$; $n = 101$). There was also no significant difference between the group for the follow up ($F(2, 757) = 1.56$; $p = 0.21$, partial $\eta^2 = 0.004$; $n = 760$). More details are shown in Table 2.

Logistic Regression Analysis

A logistic regression analysis was performed for the following outcome parameters: any intraoperative complication, any postoperative complication, catheter infections, and catheter explantation due to complications.

Based on univariable logistic regression analysis, risk factors for any intraoperative complications were operation time in minutes (OR, 1.05; 95%CI, 1.04-1.07; $p < 0.001$) and secondary venous puncture (OR, 9.84; 95%CI,

3.37-28.77; $p < 0.001$). Based on multivariable logistic regression analysis, only operation time (OR, 1.04; 95%CI, 1.03-1.06; $p < 0.001$) remained an independent risk factor for any intraoperative complication (Table 3). Cohen's f was $f = 0.46$.

For any postoperative complication, univariable logistic regression analysis revealed younger age (OR, 0.97; 95%CI, 0.96-0.99; $p < 0.001$), benign primary disease (OR, 4.50; 95%CI, 2.26-8.98; $p < 0.001$), and no chemotherapy (OR, 1.83; 95%CI, 1.12-2.99; $p < 0.016$) as risk factors. In the multivariable regression analysis, younger age (OR, 0.98; 95%CI, 0.97-0.99; $p = 0.004$) and benign primary disease (OR, 3.25; 95%CI, 1.55-6.64; $p = 0.002$) remained an independent risk factors for any postoperative complications (Table 4). Cohen's f was $f = 0.07$.

Univariable logistic regression analysis for postoperative catheter infections showed younger age of patients (OR, 0.98; 95%CI, 0.96-0.99; $p = 0.012$), lower BMI of the patient (OR, 0.88; 95%CI, 0.82-0.95; $p = 0.001$), benign primary disease (OR, 8.80; 95%CI, 4.45-17.41; $p < 0.001$), and no chemotherapy (OR, 3.86; 95%CI, 2.17-6.88; $p < 0.001$) as risk factors. Based on multivariable regression analysis a lower BMI of the patient (OR, 0.93; 95%CI, 0.86-0.99; $p = 0.044$), benign primary disease (OR, 2.89; 95%CI, 1.07-7.79; $p = 0.036$), and no chemotherapy (OR, 3.55; 95%CI, 1.50-8.39; $p = 0.004$) remained independent risk factors for postoperative catheter infections (Table 5). Cohen's f was $f = 0.23$.

For catheter explantation certain cases (due to patient's wishes) were excluded.

TABLE 1. Patients Characteristics. For Analysis of Categorical Variables Chi-Square Test was Used. Pairwise Comparisons Between Groups were Done with Bonferroni Correction (marked with #). For Continuous Variables one-way ANOVA Analysis with Bonferroni Correction was Performed

	Total (%) n = 760	Group A (%) n = 224	Group B (%) n = 197	Group C (%) n = 339	Pearson chi- square (df)	Cramer's V	p-value	p-value between Groups (pairwise) [#]		
								A vs. B	B vs. C	A vs. C
Sex					0.02 (2)	0.006	0.98	1.00	1.00	1.00
Male	428 (56.3)	127 (56.7)	111 (56.3)	190 (56.0)						
Primary disease					2.02 (2)	0.05	0.37	1.00	1.00	0.48
Benign	51 (6.7)	11 (4.9)	13 (6.6)	27 (8.0)						
Malignant	709 (93.3)	113 (95.1)	184 (93.4)	312 (92.0)						
Comorbidities										
Diabetes mellitus	118 (15.5)	44 (19.6)	38 (19.3)	36 (10.6)	11.24 (2)	0.12	0.004	1.00	0.015	0.009
Arterial hypertension	245 (32.2)	83 (37.1)	67 (34.0)	95 (28.0)	5.42 (2)	0.08	0.07	1.00	0.45	0.072
Chronic obstructive pulmonary disease	36 (4.7)	12 (5.4)	10 (5.1)	14 (4.1)	0.52 (2)	0.03	0.77	0.90	0.61	0.50
Chemotherapy					5.19 (2)	0.08	0.08	1.00	0.21	0.12
Yes	573 (75.4)	161 (71.9)	143 (72.6)	269 (79.4)						
	Total n = 760	Group A n = 224	Group B n = 197	Group C n = 339	F-ratio	p-Value	p-value between Groups (post-hoc)			
							A vs. B	B vs. C	A vs. C	
Age in years (mean, SD)	60 (13)	59 (12)	60 (14)	60 (14)	0.59	0.55	1.00	1.00	0.93	
BMI (kg/m ²) (mean, SD)	25 (5)	25 (6)	25 (5)	25 (5)	0.13	0.88	1.00	1.00	1.00	
Time to chemotherapy in days (mean, SD)	11 (10)	9 (8)	11 (10)	12 (12)	2.12	0.12	1.00	1.00	0.12	

TABLE 2. Surgical Details. For Analysis of Categorical Variables Chi-Square Test was Used. If Appropriate Fisher's Exact Test was Used (marked with *). Pairwise Comparisons Between Groups Were Done with Bonferroni Correction (marked with #). For Continuous Variables one-way ANOVA Analysis with Bonferroni Correction was Performed

	Total (%) n = 760	Group A (%) n = 224	Group B (%) n = 197	Group C (%) n = 339	Pearson Chi-Square (df)	Cramer's V	p-value	p-value between Groups (pairwise) [#]		
								A vs. B	B vs. C	A vs. C
								Operation side		
Right	634 (83.4)	196 (87.9)	159 (80.7)	279 (82.8)						
Surgical procedure										
Prim. vena section	577 (75.9)	168 (75.0)	152 (77.2)	257 (75.8)	0.27 (2)	0.02	0.87	1.00	1.00	1.00
Prim. venous puncture	14 (1.8)	3 (1.3)	2 (1.0)	9 (2.7)	2.30 (2)	0.06	0.32	1.00	0.60	1.00
Sec. venous puncture	147 (19.3)	51 (22.8)	37 (18.8)	59 (17.4)	2.54 (2)	0.06	0.28	0.96	1.00	0.36
Local anesthesia					4.38 (2)	0.08	0.11	0.15	0.36	1.00
Yes	664 (87.4)	201 (89.7)	164 (83.2)	299 (88.2)						
Any intraoperative complications	16 (2.1)	5 (2.2)	5 (2.5)	6 (1.8)	0.38 (2)	0.02	0.83	1.00	1.00	1.00
Detailed intraop. complications										
Impossible implantation	11 (1.4)	4 (1.8)	3 (1.5)	4 (1.2)	0.36 (2)	0.02	0.84	1.00*	1.00*	1.00*
Pneumothorax	4 (0.5)	1 (0.4)	2 (1.0)	1 (0.3)	1.27 (2)	0.04	0.53	1.00*	1.00*	1.00*
Hemothorax	1 (0.1)	0	0	1 (0.3)	1.24 (2)	0.04	0.54	—	1.00*	1.00*
Any postoperative complications	119 (15.7)	43 (19.2)	30 (15.2)	46 (13.6)	3.27 (2)	0.07	0.20	0.84	1.00	0.21
Detailed postop. complications										
Surgical site infections	14 (1.8)	8 (3.6)	5 (2.5)	1 (0.3)	8.72 (2)	0.12	0.01	1.00*	0.027*	0.012*
Catheter infections	50 (6.6)	18 (9.1)	14 (8.2)	18 (6.1)	1.80 (2)	0.05	0.41	1.00	1.00	0.57
Bleeding	4 (0.5)	1 (0.4)	0	3 (0.9)	1.90 (2)	0.05	0.39	1.00*	0.90*	1.00*
Catheter thrombosis	41 (5.4)	17 (7.6)	9 (4.6)	15 (4.4)	3.00 (2)	0.06	0.22	0.60	1.00	0.33
Perforation through skin	7 (0.9)	2 (0.9)	3 (1.5)	2 (0.6)	1.19 (2)	0.04	0.55	1.00*	1.00*	1.00*
Dislocation of catheter	12 (1.6)	1 (0.4)	3 (1.5)	8 (1.5)	3.18 (2)	0.07	0.20	1.00*	1.00*	0.27*
Explantation (n = 106)										
Due to complications	84 (79.2)	28 (80.0)	23 (88.5)	33 (73.3)	1.86 (2)	0.04	0.58	1.00	1.00	0.93
Due to patient wish	22 (20.8)	7 (20.0)	3 (11.5)	12 (26.7)	1.08 (2)	0.05	0.39	1.00	0.51	1.00

	Total n = 760	Group A n = 224	Group B n = 197	Group C n = 339	F-ratio	p-value	p-value between Groups (post-hoc)		
							A vs. B	B vs. C	A vs. C
							Operation time in min (mean, SD)	46 (22)	49 (22)
Time to explantation in months (mean, SD)	12 (12)	15 (15)	9 (12)	12 (9)	1.64	0.20	0.23	1.00	0.77
Follow up in months (mean, SD)	17 (19)	17 (20)	16 (18)	19 (21)	1.56	0.210	1.00	0.31	0.63

TABLE 3. Uni- and Multivariable Logistic Regression Analysis of Risk Factors for any Intraoperative Complication ($n = 760$)

Factors	Univariable				Multivariable			
	OR	95%CI	<i>b</i> coefficient	p-value	OR	95% CI	<i>b</i> coefficient	p-value
Age (years)	1.00	0.97-1.04	0.005	0.79				
Sex				0.61				
Male	0.77	0.29-2.08	-0.260					
BMI (kg/m ²)	1.03	0.93-1.15	0.032	0.55				
Primary disease				0.94				
Benign	0.93	0.12-7.15	0.078					
Operation time (min)				< 0.001				< 0.001
	1.05	1.04-1.07	0.051		1.04	1.03-1.06	0.043	
Surgical procedure				< 0.001				0.08
Sec. venous								
Puncture	9.84	3.37-28.77	2.286		3.25	0.87-12.17	1.178	
Surgeon Group								
Resident alone	1.27	0.38-4.20	0.237	0.70				
Resident with help	1.45	0.44-4.80	0.368	0.55				

TABLE 4. Uni- and Multivariable Logistic Regression Analysis of Risk Factors for any Postoperative Complication ($n = 760$)

Factors	Univariable				Multivariable			
	OR	95% CI	<i>b</i> coefficient	p-value	OR	95% CI	<i>b</i> coefficient	p-value
Age (years)	0.97	0.96-0.99	-0.028	< 0.001	0.98	0.97-0.99	-0.022	0.004
Sex				0.69				
Male	0.92	0.62-1.37	-0.081					
BMI (kg/m ²)	0.98	0.94-1.02	-0.034	0.31				
Diabetes				0.33				
Yes	1.29	0.77-2.15	0.425					
Primary disease				< 0.001				0.002
Benign	4.79	2.64-8.67	-1.566		3.25	1.55-6.64	-1.165	
Chemotherapy				0.016				0.37
No	1.83	1.12-2.99	-0.669		1.26	0.76-2.11	-0.233	
Time to chemotherapy (days)				0.65				
	1.01	0.98-1.03	0.006					
Operation time (min)				0.06				
	1.01	1.00-1.02	0.008					
Surgical procedure				0.62				
Sec. venous								
Puncture	1.13	0.70-1.83	0.123					
Surgeon group								
Resident alone	1.51	0.96-2.39	0.414	0.07				
Resident with help	1.14	0.70-1.88	0.135	0.60				

Based on logistic regression analysis, risk factors of catheter explantations included younger age (OR, 1.031; 95%CI, 1.015-1.047; $p < 0.001$), benign primary disease (OR, 6.300; 95%CI, 3.347-11.857; $p < 0.001$), and no involvement of chemotherapy (OR, 3.069; 95%CI, 1.924-4.896; $p < 0.001$). Based on multivariable logistic regression analysis, all three risk factors remained independent risk factors for TIVAP explantation due to complications (Table 6). Cohen's f was $f = 0.11$.

Surgeon groups were no independent risk factors in the uni- and multivariable logistic regression analyses for

any intra- and post-operative complications, catheter infections and catheter explantations due to complications.

DISCUSSION

This retrospective analysis shows postoperative results after TIVAP implantations performed by residents in comparison to attending surgeons. It revealed that TIVAP implantations can be safely done by residents.

TABLE 5. Uni- and Multivariable Logistic Regression Analysis of Risk Factors for Postoperative Catheter Infections (*n* = 760)

Factors	Univariable				Multivariable			
	OR	95% CI	<i>b</i> coefficient	p-value	OR	95% CI	<i>b</i> coefficient	p-value
Age (years)	0.98	0.96-0.99	-0.025	0.012	0.99	0.98-1.01	-0.012	0.37
Sex				0.94				
Male	1.02	0.58-1.82	0.024					
BMI (kg/m ²)	0.88	0.82-0.95	-0.124	0.001	0.93	0.86-0.99	-0.078	0.044
Diabetes				0.22				
Yes	1.55	0.77-3.11	0.436					
Primary disease				<0.001				0.036
Benign	8.80	4.45-17.41	-2.175		2.89	1.07-7.79	-1.060	
Chemotherapy				<0.001				0.004
No	3.86	2.17-6.88	1.351		3.55	1.50-8.39	1.267	
Time to chemotherapy (days)				0.90				
Operation time (min)	1.00	0.96-1.04	0.002					
	1.01	1.00-1.02	0.011	0.06				
Surgical procedure				0.75				
Sec. venous								
Puncture	1.13	0.54-2.37	0.120					
Surgeon group								
Resident alone	1.65	0.85-3.22	0.502	0.14				
Resident with help	1.36	0.66-2.81	0.311	0.40				

TABLE 6. Uni- and Multivariable Logistic Regression Analysis of Risk Factors for Complications Leading to Catheter Explantation (*n* = 738)

Factors	Univariable				Multivariable			
	OR	95% CI	<i>b</i> coefficient	p-value	OR	95% CI	<i>b</i> coefficient	p-value
Age (years)	0.97	0.96-0.99	-0.030	<0.001	0.98	0.96-0.99	-0.021	0.015
Sex				0.77				
Male	0.94	0.59-1.48	-0.067					
BMI (kg/m ²)	0.95	0.90-1.00	-0.050	0.06				
Diabetes				0.92				
Yes	0.97	0.52-1.81	-0.032					
Primary disease				<0.001				0.006
Benign	6.30	3.35-11.86	-1.841		2.95	1.37-6.34	-1.082	
Chemotherapy				<0.001				0.011
Yes	3.07	1.92-4.90	1.121		2.06	1.18-3.58	0.722	
Time to chemotherapy (days)				0.32				
Operation time (min)	0.98	0.94-1.02	-0.022					
	1.01	0.99-1.02	0.007	0.17				
Surgical procedure				0.31				
Sec. venous								
Puncture	1.32	0.77-2.27	0.280					
Surgeon group								
Resident alone	1.32	0.77-2.26	0.278	0.31				
Resident with help	1.20	0.68-2.11	0.181	0.53				

Nevertheless, there are differences between attending surgeons and residents performing TIVAP implantations. Attending surgeons and consultants demonstrated a significantly shorter operative time and a lower rate of SSI.

But no significant differences were found for major complications, like catheter infections or complications leading to catheter explantation, after surgery was performed by residents.

In an era of enhanced emphasis on patient safety, resident training in basic surgical procedures is still a neglected field. They are unable to learn the required knowledge on models; residents must practice actual surgery as well. Having learned a procedure under supervision, the next step is to perform the procedure alone or with someone less experienced.

Although it represents a basic surgical procedure, TIVAP implantations are not completely risk-free. Overall complication rate for this procedure may be low, but major, life-threatening complications can occur. Regarding the literature, the rate of pneumothorax or hemothorax after TIVAP implantation is reported to be between 3% and 6%.^{13,14} There are no studies, which showed that these complications occur more often due to resident involvement. Our study showed a much lower rate of pneumothorax (0.5%) and hemothorax (0.1%) complications compared with other groups. One reason could be that only 21.1% of implantations were done by venous puncture (21.1%). Pneumothorax and hemothorax are typical complications after incorrect puncture of the vein, whereas using the vena section technique, the risk is again much lower.^{15,16} The PORTAS-3-Trial by Huttner and colleagues may bring new results to this question, but data have not been published yet.⁹

Postoperative complications only indicate a difference on the surgical side of infection rate between groups. One difference in patient characteristics between groups was having significantly more patients with diabetes mellitus in the resident group. Along with longer operating time, this may lead to a higher rate of SSIs. Elevated blood glucose levels are a well-known risk factor in patients undergoing surgery, who can develop postoperative infections.^{17,18}

Other reports also revealed differences in postoperative complications. Matsushima showed a significantly higher rate of postoperative hematomas in the resident group, such that residents should confirm hemostasis more carefully. In this study, only 4 postoperative bleedings occurred and attending surgeons performed 3 out of 4 cases.⁴ This may again be explained by varying patient characteristics.

Other severe complications are rare. Burbridge and coworkers described port catheter fractures and embolizations as a major problem in TIVAP implantations.¹⁰ They found 1.6% catheter fractures in their patient collective, whereas no cause of these catheter fractures could be found. In the data presented here, only 12 patients (1.6%) experienced catheter dislocations. Implantation technique had no impact on complication rate, which was reported by Matsushima et al.⁴

One question after TIVAP implantation concerned the ideal time to use the system. Many patients who need

TIVAPs are critically ill and need a functioning system as soon as possible. Kakkos et al. analyzed the complication rate of TIVAPs the day after implantation.⁷ They found an interval of 6 days between implantation and first use as ideal for reducing complications. Other studies showed no increased acute or chronic complications even if chemotherapy application over TIVAP was started the day of surgery.¹⁹ Our data do not confirm an influence of time between surgery and chemotherapy on the rate of complications and postoperative catheter infections.

This study has some limitations. First of all, these findings are limited due to their retrospective character and the low complication rate of this surgical procedure itself. Second, although it is a large sample of patients, it has been split into 3 groups for analysis, resulting in smaller samples of patients per subgroup. Third, limitations could also result from the used statistical methods. For logistic regression analysis, only parameters, which were statistically significant in univariable analysis, were used for multivariable regression analysis. It is possible, that insignificant variables in the univariable analysis become significant in a multivariable analysis by using other methods of variable entry, such as forward or backward selection. However, this study embodies several strengths. To our knowledge, we performed the highest number of TIVAP implantation procedures that were specifically analyzed for differences in complication rate, comparing residents, and attending surgeons. Furthermore, this study not only investigated the question about differences between attendings and residents performing the TIVAP implantation, but took a closer look at the resident group, thus dividing it into residents performing the procedure alone or under supervision. In the future, randomized studies comparing residents in different stages of their training program would be desirable.

CONCLUSION

TIVAP implantation is a surgical procedure requiring basic skills: It has a low overall complication rate; although major, life-threatening complications can occur. This study reveals that TIVAP implantations by surgical residents are safe and can be used as a training procedure without putting patients at risk of severe complications.

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AUTHOR CONTRIBUTIONS

All authors made substantial contributions to the design and analysis of this work, which included drafting and assessing the manuscript. All authors approved the final manuscript for submission and agreed to be accountable for the work.

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