ORIGINAL ARTICLE

OUTCOMES OF TOTALLY IMPLANTABLE VENOUS ACCESS PORT IMPLANTATION IN OLDER ADULTS: AGE IS NOT THE KEY DETERMINANT

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Abstract

Introduction: Totally implantable venous access ports are used in oncologic care, yet the impact of age on outcomes remains controversial. This study aimed to evaluate whether geriatric status is associated with complications, catheter malposition, or port revision, and to identify independent predictors of adverse outcomes.

Materials and Method: This cohort study included 1,215 patients who underwent totally implantable venous access port implantation at a single tertiary center between June 2022 and December 2025. All procedures were performed by a single thoracic surgeon. Patients were categorized as non-geriatric (<65 years) and geriatric (≥65 years), with analysis for those aged ≥75 years. Primary outcomes were any complication and port revision, and the secondary outcome was catheter malposition. Univariable and multivariable logistic regression analyses were performed.

Results: Of the 1,215 patients, 487 (40.1%) were geriatric. Geriatric patients had lower rates of complications (4.9% vs 7.7%), malposition (0.4% vs 1.1%), and revision (2.9% vs 4.5%), with no significant differences. Geriatric status was not an independent predictor of any outcome. Prior chemotherapy and port structural parameters independently increased the risk of complications, while port size parameters remained the strongest predictors of revision, with port thickness associated with a 2.5-fold higher risk. Subclavian access and multiple insertion attempts were associated with malposition in univariable analyses.

Conclusion: Advanced age was not associated with adverse outcomes following implantation. Procedural and device-related factors, rather than chronological age, were the primary determinants of complications and revision. These findings support the safe use of ports in older patients and emphasize the importance of technical optimization and device selection.

Keywords: Vascular Access Devices; Aged; Catheterization, Central Venous; Postoperative Complications; Risk Factors.

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INTRODUCTION

Totally implantable venous access ports (TIVAPs) have become an essential component of modern oncologic care, enabling the safe and repeated administration of chemotherapy, targeted therapies, and supportive treatments over prolonged periods. Compared to external central venous catheters and peripherally inserted central catheters, TIVAP systems offer several advantages, including lower infection rates, improved patient comfort, and better quality of life, particularly in patients requiring long-term vascular access. In addition, their fully implantable design allows greater freedom in daily activities and reduces the psychosocial burden associated with visible external devices (1).

Despite these advantages, TIVAP implantation remains a minor surgical procedure associated with both early and late complications. Early complications include pneumothorax, hematoma, and catheter malposition, whereas late complications are typically related to infection, thrombosis, catheter dysfunction, or device-related issues (1). Reported complication rates vary across studies but are generally low, with overall complication rates around 3-10% and device removal is most commonly driven by infection, thrombosis, or mechanical dysfunction. Importantly, although these complications are relatively infrequent, they may interrupt oncologic treatment, increase healthcare costs, and negatively affect patient outcomes (2).

The identification of risk factors associated with TIVAP-related complications has therefore become a major focus of recent research. Several patient-related and procedural variables have been implicated, including body mass index, comorbidities, vascular access site, and characteristics of the implanted device. In particular, the choice of venous access route has been associated with technical success and complication risk, with subclavian access linked to specific complications such as malposition or mechanical issues in some series (3). Similarly, device-related factors such as catheter design and port structure have been suggested to influence long-term outcomes, although these relationships are not consistently reported across studies (4).

Among these factors, the role of the patient's age remains controversial. With the aging global population and the increasing incidence of malignancies in older individuals, a growing proportion of patients undergoing TIVAP implantation are geriatric. These patients often present with a higher burden of comorbidities, altered vascular anatomy, and increased frailty, which may theoretically increase the risk of procedural complications. However, existing evidence on the impact of age is conflicting. While some studies suggest that advanced age may be associated with higher complication rates due to comorbidity burden and reduced physiological reserve, others report no increase, or even a paradoxical decrease, in complication risk among older patients (5).

This inconsistency may be partially explained by differences in study design, patient selection, and the relative contribution of procedural versus patient-related factors. In particular, it remains unclear whether chronological age itself is an independent determinant of TIVAP-related complications, or whether observed differences are primarily driven by modifiable factors such as device selection, vascular access strategy, or procedural complexity.

Given these uncertainties, further real-world data are needed to clarify the relationship between age and TIVAP outcomes, especially in large, homogeneous cohorts with standardized procedural techniques. The present study aims to compare geriatric and non-geriatric patients undergoing TIVAP implantation in a single-center, single-surgeon cohort, with a particular focus on complication rates, malposition, and port revision. In addition, the study seeks to identify independent predictors of adverse outcomes, with special emphasis on procedural and device-related factors.

By addressing these questions, this study aims to provide clinically relevant evidence regarding the safety of TIVAP implantation in elderly patients



and to better define the relative importance of age versus modifiable technical factors in determining outcomes.

MATERIALS AND METHOD

Study Design and Setting

This retrospective cohort study was conducted at a single tertiary referral center and included consecutive patients who underwent TIVAP implantation by a single thoracic surgeon between 13 June 2022 and 31 December 2025. The study was designed to evaluate the association between age and port-related outcomes, as well as to identify independent predictors of complications and revision. Institutional approval was obtained prior to data collection from the Clinical Research Ethics Committee (approval no: KAEK/25.03.2026.146), and the study was conducted in accordance with the principles of the Declaration of Helsinki.

Patient Selection

Patients aged ≥18 years who underwent TIVAP implantation for hematologic or oncologic indications and who had complete data were included. Patients not meeting these criteria were excluded from the analysis. Patients were stratified into two groups based on age at the time of port implantation: non-geriatric (<65 years) and geriatric (≥65 years). In addition, a subgroup analysis was performed for patients aged ≥75 years.

Procedure

All TIVAP implantations were performed in an operating room setting under local anesthesia with or without sedation, according to patient condition and clinician preference. A standardized landmark-based technique was used in all cases, without routine ultrasound guidance. Venous access was obtained via either the internal jugular or subclavian vein, depending on anatomical considerations and intraoperative feasibility. The port chamber was placed in a subcutaneous pocket in the anterior chest wall. Device selection, including port size and type, was determined according to availability. The catheter position was verified postoperatively using chest x-ray imaging as per institutional practice.

Variables and Definitions

Baseline demographic and clinical variables included age, sex, body mass index (BMI), underlying diagnosis, and comorbidities (diabetes mellitus, hypertension, smoking status, steroid use, thyroid dysfunction, and organ failure). Organ failure was defined as documented renal failure, hepatic failure, or heart failure requiring ongoing medical follow-up; patients with combined organ failure were included in this category as well. Procedural variables included venous access site (jugular vs subclavian), laterality (left vs right), and procedural difficulty. Procedural difficulty was defined as the need for two or more attempts to achieve successful venous access and was recorded as a binary variable ("multiple attempts").

Port-related variables included device characteristics such as port thickness, weight, and external volume. Given the high degree of collinearity among these parameters, each was analyzed separately in multivariable models.

Treatment-related variables included reception of chemotherapy prior to port implantation (binary) and, when available, the number of chemotherapy cycles administered before the procedure. In addition, systemic treatment modalities were categorized according to major therapeutic classes, including fluoropyrimidines, platinum-based agents, anti-vascular endothelial growth factor (anti-VEGF) therapies, anti-epidermal growth factor receptor (anti-EGFR) therapies, and immunotherapy.

Outcomes

The primary outcomes were (1) any complication and (2) port revision. Any complication was defined as the occurrence of at least one adverse event related to port implantation, including catheter malposition, hematoma, pneumothorax, infection, skin erosion, thromboembolism, arrhythmia, or port rotation.

Port revision was defined as any subsequent surgical or interventional corrective procedure performed in the operating room due to port-related dysfunction or complications, including but not limited to port removal, replacement, repositioning, pocket revision, wound debridement, or re-suturing.

Because port revision reflects a management consequence rather than a mutually exclusive clinical event, overlap between complication and revision outcomes was possible when a complication required corrective operative or interventional management.

The secondary outcome was catheter malposition, defined as incorrect positioning of the catheter tip outside the intended central venous location as confirmed by imaging or clinical assessment.

Statistical Analysis

Continuous variables were summarized using median and interquartile range (IQR), and categorical variables were presented as counts and percentages. Normality was assessed using the Shapiro–Wilk test. As most continuous variables were not normally distributed, non-parametric tests were used for group comparisons. Continuous variables were compared using the Mann–Whitney U test, and categorical variables were compared using the chi-square test or Fisher's exact test, as appropriate.

Univariable logistic regression analyses were performed to evaluate the association between potential predictors and each outcome (complications, revision, and malposition). Variables included demographic, clinical, procedural, treatment-related, and port-specific factors.

Multivariable logistic regression models were constructed to identify independent predictors of each outcome. Given the limited number of events, the number of predictors in each model was restricted to avoid overfitting. Clinically relevant variables were selected a priori, including age group (geriatric vs non-geriatric), BMI, venous access site, procedural difficulty (multiple attempts), and one port-related variable (thickness, weight, or volume). Due to high collinearity among port variables, separate models were built for each parameter.

Adjusted odds ratios (aORs) with 95% confidence intervals (CIs) were reported. Multicollinearity was assessed using variance inflation factors (VIFs), with values <5 considered acceptable. Model discrimination was evaluated using the area under the receiver operating characteristic curve (AUC), and calibration was assessed using the Hosmer–Lemeshow goodness-of-fit test.

Sensitivity analyses were performed by including and excluding the chemotherapy-before-port variable to assess the robustness of the models. Additional analyses included modeling age as a continuous variable and performing subgroup analysis for patients aged ≥75 years.

All statistical analyses were performed using IBM SPSS Statistics for Windows, Version 25.0 (IBM Corp., Armonk, NY, USA). A two-sided p-value <0.05 was considered statistically significant.

RESULTS

Cohort Characteristics

A total of 1,215 patients who underwent a TIVAP implantation between 13 June 2022 and 31 December 2025 were included in the analysis. Of these, 728 (59.9%) were classified as non-geriatric (<65 years) and 487 (40.1%) as geriatric (≥65 years). Complete data were available for all patients, and no cases were excluded due to missing variables.

Baseline Characteristics

Baseline demographic and clinical characteristics are summarized in Table 1. As expected, median age differed significantly between the groups (56.0 vs. 70.0 years, p<0.001). Geriatric patients had a higher prevalence of comorbidities, including hypertension (53.4% vs. 24.9%, p<0.001), diabetes mellitus (31.2% vs. 22.8%, p=0.001), and organ failure (7.0% vs. 3.4%, p=0.006). The proportion of patients without comorbid conditions was significantly lower in the geriatric group (20.9%



vs. 39.6%, p<0.001). Female sex was less frequent among geriatric patients (35.7% vs. 42.3%, p=0.023), while BMI did not differ significantly between groups (p=0.702).

Procedural and Port Characteristics

Procedural characteristics are presented in Table 2. The rate of subclavian vein access was higher in geriatric patients, although this difference did not reach statistical significance (25.3% vs. 20.9%, p=0.080). Multiple-attempt insertions were significantly more frequent in the geriatric group (21.1% vs. 15.0%, p=0.007).

Port-related characteristics, including thickness, weight, and volume, were similarly distributed

Table 1. Baseline Patient Characteristics

Variable	Overall (N=1215)	Non-Geriatric (N=728)	Geriatric (N=487)	p-value
Age, years - median (IQR)	62.0 (53.0–69.0)	56.0 (48.0–60.0)	70.0 (67.0–74.0)	**<0.001**
Female sex - n (%)	482 (39.7%)	308 (42.3%)	174 (35.7%)	**0.023**
BMI, kg/m² - median (IQR)	25.6 (22.8–29.1)	25.7 (22.7–29.1)	25.4 (22.8–28.7)	0.702
Diabetes mellitus - n (%)	318 (26.2%)	166 (22.8%)	152 (31.2%)	**0.001**
Hypertension - n (%)	441 (36.3%)	181 (24.9%)	260 (53.4%)	**<0.001**
Smoking - n (%)	326 (26.8%)	204 (28.0%)	122 (25.1%)	0.262
Steroid use - n (%)	21 (1.7%)	14 (1.9%)	7 (1.4%)	0.655
Thyroid dysfunction - n (%)	82 (6.7%)	54 (7.4%)	28 (5.7%)	0.294
Organ failure - n (%)	59 (4.9%)	25 (3.4%)	34 (7.0%)	**0.006**
No comorbidities - n (%)	390 (32.1%)	288 (39.6%)	102 (20.9%)	**<0.001**

Values: median (IQR) or n (%). Bold = p<0.05. BMI = body mass index; IQR = interquartile range.

Table 2. Procedural and Port Variables

Variable	Overall (N=1215)	Non-Geriatric (N=728)	Geriatric (N=487)	p-value
Left-sided approach - n (%)	30 (2.5%)	20 (2.7%)	10 (2.1%)	0.572
Subclavian vein - n (%)	275 (22.6%)	152 (20.9%)	123 (25.3%)	0.080
Multiple attempts (2+) - n (%)	212 (17.4%)	109 (15.0%)	103 (21.1%)	**0.007**
Port thickness, mm - median (IQR)	10.6 (10.6–12.2)	10.6 (10.6–12.2)	10.6 (10.6–12.2)	0.883
Port weight, g - median (IQR)	5.9 (5.9–7.6)	5.9 (5.9–7.6)	5.9 (5.9–7.6)	0.617
Port volume, mL - median (IQR)	6.1 (6.1–8.5)	6.1 (6.1–8.5)	6.1 (6.1–8.5)	0.883
Chemotherapy before port - n (%)	292 (24.0%)	183 (25.1%)	109 (22.4%)	0.274
Chemo cycles before - median (IQR)	0 (0–0)	0 (0–1)	0 (0–0)	0.274
Fluoropyrimidines - n (%)	222 (18.3%)	-	-	-
Platinum-based - n (%)	189 (15.6%)	-	-	-
Anti-VEGF - n (%)	79 (6.5%)	-	-	-
Anti-EGFR - n (%)	44 (3.6%)	-	-	-
Immunotherapy - n (%)	13 (1.1%)	-	-	-

Bold = p<0.05. Values: median (IQR) or n (%). IQR = interquartile range; VEGF = vascular endothelial growth factor; EGFR = epidermal growth factor receptor. Treatment variable frequencies reported for the overall cohort. Note: Device structural parameters were derived from four discrete port models with fixed specifications; therefore, identical median (IQR) values may still correspond to small differences in group distributions.

between geriatric and non-geriatric patients (all p>0.60), indicating that device selection was not influenced by age group. The proportion of patients receiving chemotherapy prior to port implantation was also comparable between groups (22.4% vs. 25.1%, p=0.274).

Primary Outcomes

Clinical outcomes are summarized in Table 3. The overall complication rate was 6.6% (80/1,215), malposition occurred in 0.8% (10/1,215), and port revision was required in 3.9% (47/1,215) of patients. Among the 47 patients with skin erosion, 42 required revision, whereas 5 were managed conservatively. Overall, among the 47 revision procedures, 42 were performed for skin erosion, 3 for infection, and 2 for thromboembolic complications. Notably, catheter malposition did not require revision in any patient and was managed conservatively.

There were no statistically significant differences between geriatric and non-geriatric patients in any of the primary outcomes. Complication, malposition, and revision rates were numerically lower in the geriatric group (Figure 1a). Complication rates were 4.9% in the geriatric group and 7.7% in the non-geriatric group (p=0.060). Malposition occurred in 0.4% and 1.1% of patients, respectively (p=0.332). Similarly, port revision rates were 2.9% in geriatric patients and 4.5% in non-geriatric patients (p=0.172).

Notably, all outcomes were numerically lower in the geriatric group, although these differences were not statistically significant.

Subgroup Analysis (Age ≥75 Years)

Among the 120 patients aged ≥75 years, complication, malposition, and revision rates were 1.7%, 0.8%, and 3.3%, respectively. These rates did not differ significantly from those observed in patients younger than 75 years (all p>0.57).

Univariable Analysis

Univariable logistic regression identified port size parameters as the strongest predictors across the studied outcomes, while subclavian access and multiple attempts remained important predictors of catheter malposition. For complications, port structural parameters were the strongest predictors in univariable analyses. Increasing port thickness (OR 1.811, 95% CI 1.453–2.257, p<0.001), weight (OR 1.625, 95% CI 1.359–1.942, p<0.001), and external volume (OR 1.507, 95% CI 1.292–1.759, p<0.001) were all significantly associated with increased complication risk. Geriatric status

Table 3. Clinical Outcomes by Age Group.

Outcome	Overall (N=1215)	Non-Geriatric (N=728)	Geriatric (N=487)	p-value
Any complication - n (%)	80 (6.6%)	56 (7.7%)	24 (4.9%)	0.060
Erosion	47 (3.9%)	32 (4.4%)	15 (3.1%)	0.289
Malposition	10 (0.8%)	8 (1.1%)	2 (0.4%)	0.332
Infection	6 (0.5%)	3 (0.4%)	3 (0.6%)	0.689
Haematoma	5 (0.4%)	3 (0.4%)	2 (0.4%)	1.000
Pneumothorax	5 (0.4%)	5 (0.7%)	0 (0.0%)	0.087
Thromboembolism	3 (0.2%)	3 (0.4%)	0 (0.0%)	0.279
Rotation	2 (0.2%)	1 (0.1%)	1 (0.2%)	1.000
Arrhythmia	2 (0.2%)	1 (0.1%)	1 (0.2%)	1.000
Port revision - n (%)	47 (3.9%)	33 (4.5%)	14 (2.9%)	0.172

Values: n (%). Tests: Fisher's exact for primary outcomes.

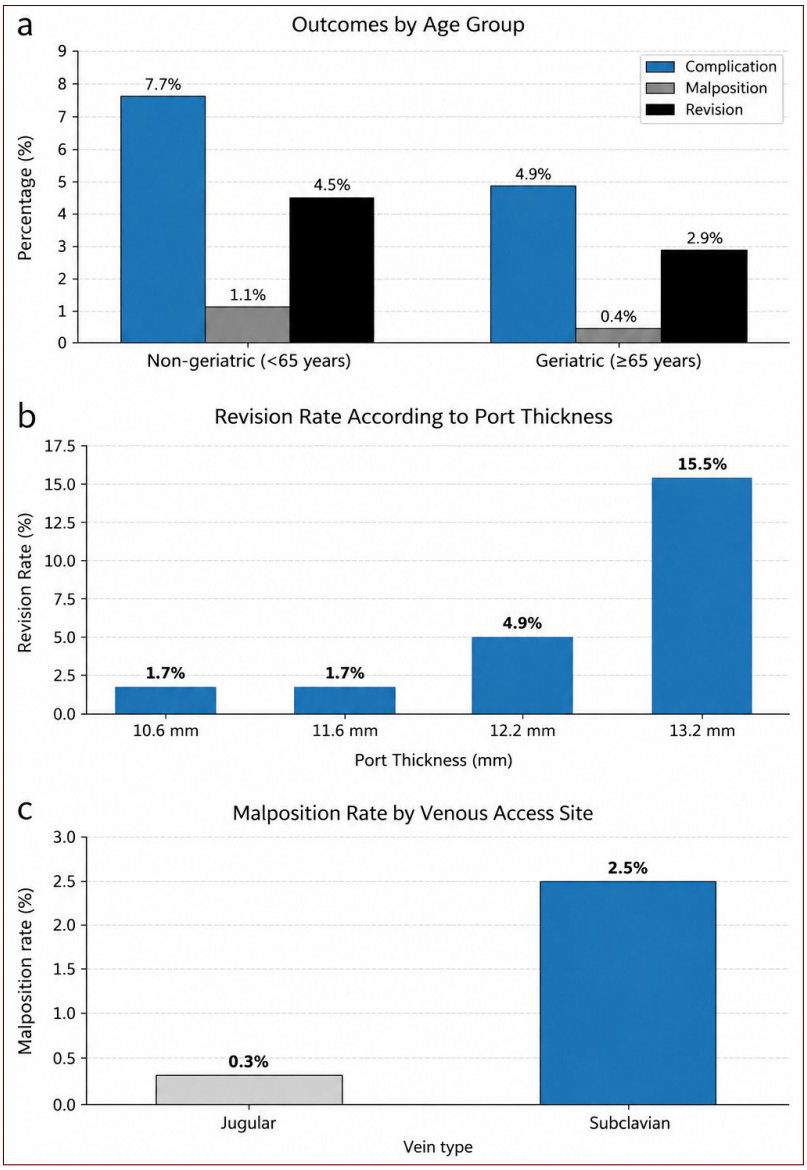


Figure 1. Clinical outcomes and procedural risk patterns in TIVAP implantation. (a) Outcomes by age group. Comparison of complication, malposition, and revision rates between non-geriatric (<65 years) and geriatric (≥65 years) patients. No statistically significant differences were observed between the groups for any outcome. (b) Revision rate according to port thickness. Revision rates stratified by port thickness. A progressive increase in revision rates was observed with increasing port thickness. (c) Malposition rate by venous access site. Comparison of malposition rates between jugular and subclavian venous access. Malposition was more frequently observed in procedures performed via the subclavian vein.

showed a borderline protective association (OR 0.622, p=0.059), while subclavian venous access demonstrated borderline significance (OR 1.609, p=0.059).

For port revision, port size variables were the strongest predictors, with increasing port thickness (OR 2.487, 95% CI 1.850–3.344, p<0.001), weight (OR 2.110, 95% CI 1.671–2.665, p<0.001), and volume (OR 1.883, 95% CI 1.526–2.323, p<0.001) all significantly associated with higher revision risk. Geriatric status was not significant (OR 0.623, p=0.145).

For malposition, subclavian access (OR 8.158, 95% CI 2.095–31.763, p=0.003) and multiple attempts (OR 7.274, 95% CI 2.035–26.007, p=0.002) were strongly associated with increased risk. Geriatric status was not associated with malposition (OR 0.371, p=0.211).

The complete univariable regression analysis is provided in Supplementary Table 1.

Multivariable Analysis

Multivariable logistic regression demonstrated that both chemotherapy before port implantation and port size parameters independently predicted complications, whereas port size parameters remained the dominant predictors of port revision. For complications, both chemotherapy prior to port implantation and port structural parameters remained independently associated with increased risk across all models. Increasing port thickness was associated with an 85.7% increase in complication risk (aOR 1.857, 95% CI 1.482–2.326, $p<0.001$), with similar results observed for port weight (aOR 1.656, 95% CI 1.380–1.988, $p<0.001$) and port volume (aOR 1.534, 95% CI 1.310–1.795, $p<0.001$). Chemotherapy prior to port implantation remained an independent predictor across all models (adjusted OR range 1.755–1.762, all $p\leq0.032$). Geriatric status consistently showed a protective trend (aOR approximately 0.62), although statistical significance was not reached.

For port revision, port size was the sole independent predictor in all models. Increasing port thickness was associated with a 2.5-fold increase in revision risk (aOR 2.499, 95% CI 1.851–3.373, $p<0.001$), with similar results observed for port weight and volume. Geriatric status, BMI, procedural difficulty, and chemotherapy were not independently associated with revision.

For malposition, no variable retained statistical significance after multivariable adjustment. Although subclavian access demonstrated a large effect size (aOR approximately 4.5–4.7), the association did not reach statistical significance, likely due to the limited number of events and its correlation with multiple attempts.

Across all models, geriatric status was not an independent predictor of any outcome, although it consistently demonstrated a protective trend in complication models.

The complete multivariable regression models, including model diagnostics (AIC, AUC, Hosmer–Lemeshow test, and variance inflation factors), are provided in Supplementary Table 2.

Sensitivity Analysis

Sensitivity analyses excluding chemotherapy prior to port implantation did not materially alter the main findings. Chemotherapy remained relevant only in the complication model, whereas its exclusion did not change the associations observed for port revision or catheter malposition. The effects of geriatric status and device-related parameters remained stable across models.

Additional Findings

Revision rates demonstrated a clear increase with larger port size categories, with the highest-profile devices showing substantially higher revision rates compared with lower-profile devices (Figure 1b). Malposition rates were higher in procedures performed via the subclavian vein compared with the jugular approach (2.5% vs. 0.3%) (Figure 1c). Skin erosion accounted for 47 of 80 complications (58.8%), making it the most common adverse event.

Overall, these findings suggest that treatment-related and device-related factors, rather than patient age, are the primary determinants of TIVAP-related outcomes.

DISCUSSION

Main Findings

In this single-center cohort of 1,215 consecutive TIVAP implantations performed by a single thoracic surgeon, advanced age was not associated with higher rates of complications, catheter malposition, or port revision. Geriatric patients (≥65 years) accounted for 40.1% of the cohort and presented with a significantly higher burden of comorbidities, including hypertension, diabetes mellitus, and organ failure. Despite this profile, all



three primary outcomes were numerically lower in the geriatric group (complications 4.9% vs 7.7%; malposition 0.4% vs 1.1%; revision 2.9% vs 4.5%), and the same pattern persisted in the oldest-old subgroup of patients aged ≥75 years (n=120). After multivariable adjustment, geriatric status remained non-significant across all models for every outcome examined, although complication models consistently showed a protective effect estimate (adjusted OR approximately 0.62).

The dominant independent risk drivers were treatment-related and device-related rather than demographic. Prior chemotherapy independently predicted complications (adjusted OR range 1.76, all $p \leq 0.032$), while overall device bulk independently predicted both complications and revision. In complication models, increasing port thickness was associated with an 85.7% increase in complication risk (adjusted OR 1.86, 95% CI 1.48–2.33, $p<0.001$), with similar results observed for port weight and external volume. For revision, port thickness was associated with a 2.5-fold increase in revision odds (adjusted OR 2.50, 95% CI 1.85–3.37, $p<0.001$) with parallel results for port weight and external volume. The device-bulk gradient was particularly striking at the descriptive level, with revision rates rising from 1.7% for the lowest-profile devices to 15.5% for the highest-profile devices, an approximately ninefold differential. Skin erosion accounted for 47 of 80 complications (58.8%), further supporting chronic mechanical stress as the dominant pathway linking device bulk to adverse outcomes.

Comparison with the Literature

Reports on age and TIVAP outcomes have produced inconsistent findings. Some series have suggested elevated rates of infection, thrombosis, or mechanical complications in elderly recipients (3,6–8), whereas other large cohorts and systematic reviews have concluded that chronological age alone does not independently predict adverse outcomes once comorbidities and procedural factors are accounted for (9–12). Three factors largely explain this heterogeneity. First, comorbidity burden and frailty are related but not interchangeable constructs. Although geriatric patients in our cohort had higher rates of hypertension, diabetes, and organ failure, these variables do not fully capture functional reserve, frailty phenotype, or performance status. Therefore, selection bias may still operate in retrospective port studies, as older patients selected for TIVAP implantation may remain functionally more suitable for prolonged systemic therapy than the broader elderly oncology population, despite carrying greater chronic comorbidity burden (13–15). Second, definitions of complications and revision differ substantially across series, and small studies are insufficient for disentangling age effects from confounding by comorbidity. Third, procedural standardization varies widely. Centers reporting higher event rates in older patients often combine multiple operators, heterogeneous techniques, and diverse device portfolios, all of which inflate the apparent contribution of age. Studies based on standardized procedural protocols, including the present cohort, consistently show that age becomes statistically inert once procedural, device-related, and geriatric functional factors are considered (10–15).

Mechanistic Interpretation: Device Bulk as a Single Construct

The mechanistic picture emerging from these data is internally coherent. Port thickness, weight, and external volume were highly collinear and collectively reflected a single underlying construct: overall device bulk. Larger and bulkier port reservoirs exert greater mechanical stress on the overlying skin and subcutaneous tissue, promoting dermal thinning, erosion, rotation, and pocket-related complications. The dose-response between port thickness category and revision rate observed in this cohort (1.7% for the lowest-profile devices and 15.5% for the highest-profile devices) reinforces this mechanism, as does the parallel behaviour from port weight and external volume.

This interpretation is further supported by recent data demonstrating that port reservoir thickness is an independent predictor of skin erosion requiring revision, with a clear size-dependent increase in risk across millimeter thresholds (16).

Prior chemotherapy may increase complication risk through impaired wound healing, immunosuppression, and reduced tissue resilience (17,18). The independent association of prior chemotherapy with complications, even after adjustment for age and comorbidity, supports a direct biological effect rather than mere confounding by disease stage or treatment intensity.

Subclavian access and multiple-attempt insertions, both linked to malposition in univariable analysis, reflect technical difficulty in challenging anatomy. Subclavian puncture is performed without direct visualization of the catheter trajectory, and aberrant tip positioning into the contralateral brachiocephalic vein, internal mammary vein, or azygos system is well described (19,20). The loss of statistical significance for these variables in the multivariable malposition model should not be interpreted as a true null effect. Both predictors retained large adjusted point estimates (subclavian access aOR ≈4.7; multiple attempts aOR ≈2.2), but the model was substantially underpowered because it was fitted to only 10 malposition events, resulting in wide confidence intervals and limited inferential precision. The direction and magnitude of effect remain clinically substantial and biologically plausible, and these variables should be regarded as actionable risk factors despite the wide intervals. Contemporary best-practice consensus statements likewise endorse imaging-guided access and minimization of attempts as central to procedural safety (20,21).

Age as a Surrogate, Not a Causal Factor

The most important interpretive point is that chronological age is best understood as a surrogate marker rather than a causal driver of TIVAP-related risk. Geriatric patients in this cohort carried more comorbidities and required multiple insertion attempts more frequently, yet showed numerically lower event rates than younger patients, a counterintuitive paradox that is incompatible with age operating as a true mechanistic risk factor. The consistency of the protective effect estimate across complication models (adjusted OR approximately 0.62, p≈0.06) further suggests that any true age-related signal, if present, is more likely protective than harmful. Three converging mechanisms likely produce this pattern. This paradox is most likely explained by selection effects and residual unmeasured geriatric factors. Older patients selected for TIVAP implantation may represent a functionally more suitable subgroup despite higher chronic comorbidity burden, consistent with contemporary geriatric oncology frameworks emphasizing frailty and functional assessment over chronological age (13–15). In addition, standardized technique and device selection likely further reduce the independent contribution of age to port-related complications.

Clinical Implications

Elderly patients should not be denied TIVAP placement based on chronological age alone, even at advanced ages, a position aligned with the broader concern that age-based undertreatment remains a persistent problem in older adults with cancer (22). Decision-making should instead be redirected toward modifiable factors that genuinely influence outcome: minimizing the number of insertion attempts, preferring jugular over subclavian access when anatomically feasible, and selecting the lowest-profile device compatible with the planned therapy and infusion requirements. In patients with prior or planned chemotherapy, the elevated complication risk identified here supports reinforced postoperative surveillance, attention to wound integrity, and timely identification of pocket infection or erosion. Given the magnitude of the device-bulk effect, institutional device portfolios



may improve outcomes in centers routinely using larger-profile ports.

Limitations

Several limitations should be acknowledged, and findings should be interpreted in the context of a retrospective design. The study is observational, which limits causal inference and leaves residual confounding by unmeasured factors despite multivariable adjustment. In particular, important geriatric variables such as frailty indices, performance status, and nutritional status were not available in this retrospective dataset, although these factors may independently influence procedural tolerance, complication risk, and recovery in older adults. The overall event rates were low, particularly for malposition (n=10), producing wide confidence intervals and limiting statistical power, as reflected in the non-significant adjusted estimates for subclavian access and multiple attempts despite clear directional effects of substantial magnitude. The absence of a routine ultrasound-guided insertion group precludes direct comparison with ultrasound-assisted technique, which has been shown to reduce mechanical complications and is increasingly endorsed as the default approach in current consensus recommendations (20,21,23). This may be particularly relevant in elderly patients with challenging vascular anatomy or reduced tissue reserve, in whom real-time imaging may further improve access safety. Selection bias regarding elderly patients cannot be excluded, since frailer or more functionally impaired older adults may have been preferentially managed with peripheral access rather than referred for TIVAP. Finally, the single-center, single-surgeon design strengthens internal validity but may limit generalizability to environments with less procedural standardization or with different device portfolios. These caveats do not undermine the central observation that age behaves as a surrogate rather than as a causal risk factor in this large, technically homogeneous series.

Conclusion

In a large, homogeneous, single-surgeon cohort of TIVAP implantations, advanced age was not an independent risk factor for procedural complications, catheter malposition, or port revision, even in patients aged ≥75 years. The dominant determinants of adverse outcomes were modifiable, particularly port structural bulk and prior chemotherapy, whereas chronological age was not an independent predictor of complications, malposition, or revision. Both effect sizes are clinically substantial, with overall device bulk increasing revision risk approximately 2.5-fold and prior chemotherapy nearly doubling complication risk. These findings challenge the long-standing practice of age-based decision-making in vascular access referral and reframe risk stratification around procedural quality and device selection. In the contemporary care of older oncology patients, chronological age should yield primacy to modifiable treatment-related, procedural, and device-related factors as the dominant determinants of TIVAP outcomes.

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