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Risk factors for 30-day soft tissue complications after pelvic sarcoma surgery: A National Surgical Quality Improvement Program study

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Abstract

Introduction: Soft tissue (ST) complications after resection of bone and ST sarcomas of the pelvis occur more frequently than in appendicular tumors. We sought to identify risk factors for complications within 30 days of surgery.

Methods: The National Surgical Quality Improvement Program database was used for this study. Patients with sarcomas of bone and ST of the pelvis were retrieved using Current Procedural Terminology and International Classification of Diseases codes. Outcomes assessed were ST complications, overall complication rates, 30-day reoperation, and mortality.

Results: A total of 770 patients with pelvic bone and ST sarcoma were included. The ST complication rate was 12.6%, including 4.9% superficial and 4.7% deep surgical site infections. Higher ST complication rates were seen in patients >30 years, with partially dependent health status, hematocrit <30%, bone tumors, tumor >5 cm, amputation procedures, and longer operative times. ST complication rates were 1.5 and 3 times higher in pelvic sarcoma surgeries than in the lower and upper extremities, respectively. Age >30 years (odds ratio [OR] = 5.07), hematocrit <30% (OR = 1.84), operative time 1–3 h (OR = 2.97), and >3 h (OR = 4.89) were risk factors for ST complications.

Conclusion: One in nine patients with pelvic sarcoma surgery will develop ST complications within 30 days. Risk factors for ST complications were age >30, hematocrit <30%, and longer operative time.

KEYWORDS

bone sarcoma, soft tissue complications, soft tissue sarcoma, wound complication

1 | INTRODUCTION

Bone and soft tissue (ST) sarcomas are a heterogenous group of tumors collectively accounting for close to 1% of all cancer cases annually diagnosed in the United States.[1–3] Although these tumors are mainly located in the extremities, they have been reported to involve the pelvis in 5% of all cases.[4] Pelvic location has been described as a risk factor for worse postoperative outcomes and higher recurrence rates, and therefore its management remains challenging.[5,6] Unlike appendicular tumors, which are often detected early due to their mass effect, pelvic bone, and ST sarcomas can remain hidden until symptomatic and present as a more aggressive tumor.[4,5,7]

Advances in neoadjuvant radiation therapy (RT) and/or systemic treatment have allowed limb-salvage surgery (LSS) to become the

current *standard of care* instead of amputation.[3,8] Although limb-salvage procedures have led to drastically improved functional outcomes, postoperative complication rates remain particularly high. In pelvic tumors, the risk is even higher due to their larger size, proximity to vital organs and neurovascular structures, difficulty attaining adequate resection margins, and inadequate radiation delivery to the area.[3,5,6,8] In these patients, postoperative ST complication rates between 29% and 34.1% have been reported,[5,9] in comparison with the 14%–22% rate reported for extremity sarcomas.[10,11] Studies on pelvic sarcomas have identified histologic grade, surgical margins, and tumor size as risk factors for postoperative wound complications.[5,8]

Studies seeking to identify risk factors for postoperative ST complications in pelvic tumors are limited and often fail to find significant findings due to their low sample size.[6,8] Using the strengths of the National Surgical Quality Improvement Program (NSQIP) database, we seek to identify risk factors for developing 30-day ST complications, unplanned reoperations, readmission, and mortality.

2 | MATERIALS AND METHODS

After Institutional Review Board approval was obtained, data from the NSQIP database was obtained. This database, administered by the American College of Surgeons, contains retrospectively collected information on demographic, clinical, and treatment outcomes from more than 700 hospitals spread across the United States. Data collection in each affiliated center is overseen by a full-time clinical data reviewer, achieving interobserver disagreement rates as low as 2% and making the NSQIP database the gold standard for surgical quality of care evaluation.[12]

We included patients with primary malignant neoplasms of bone, connective tissue, or peripheral nerve located in the pelvis who received tumor removal surgery, either as a limb-salvage procedure or amputation. Initial patient selection based on diagnosis was performed using the International Classification of Diseases (ICD) 9th and 10th revision codes. We restricted the sample using Current Procedural Terminology (CPT) codes to only include patients receiving surgical treatment (Supporting Information: Appendix 1). Determining the tumor location was based on both CPT and ICD codes; in cases of disagreement, CPT codes were used as the final parameter under the assumption that billing data (CPT codes) is more accurate than ICD diagnostic data. We included patients with pelvic bone or ST sarcoma diagnosed from 2005 to 2021. For comparison of ST complication rates between locations, bone and soft tissue sarcomas in the upper or lower extremity were identified using ICD and CPT codes (Supporting Information: Appendix 2).

Patient demographics and preoperative information were retrieved from the database. Demographic variables included age, sex, and race. Preoperative information included patient comorbidities as well as functional health status and preoperative labs. We only included lab values taken up to 14 days before surgery. Body mass index (BMI) was calculated using height and weight data provided by the database. Data on tumor characteristics were derived from CPT code descriptions and included the type of tumor (bone or ST), size (smaller or larger than 5 cm), and tumor depth (subcutaneous or subfascial). All these variables were only available for soft tissue sarcomas. Available treatment data included the type of surgery (tumor resection vs. amputation), the use of RT and/or chemotherapy preoperatively, and the operative time.

Perioperative and postoperative 30-day outcomes were additionally extracted. Complications were classified as either ST complications or overall complications. The former includes superficial surgical site infection (SSI), deep SSI, organ SSI, and wound dehiscence. All other complications were included in the overall complication group. Although non-ST complications were not individually assessed since they fall outside of the scope of our study, these include cardiac (cardiac arrest, myocardial infarction), respiratory (on ventilator ≥48 h, unplanned intubation, pneumonia), thromboembolic (deep vein thrombosis, pulmonary embolism), or renal (urinary tract infection, acute kidney injury/renal failure), and septic (sepsis, septic shock) complications. Rates of 30-day unplanned reoperation, unplanned readmission, and mortality were also analyzed.

2.1 | Statistical analysis

Continuous variables were reported as medians with interquartile ranges (IQRs) and categorical variables were displayed as proportions. Comparison of continuous variables between groups was done through the Mann–Whitney test on bivariate analysis; for categorical variables, we used the χ^2 test.

Univariate logistic regression was carried out to identify potential risk factors for ST complications. Multivariate (adjusted) analysis was additionally performed to correct the model for collinearity and confounding factors. Statistical analysis was performed using Stata software (StataCorp LLC).

3 | RESULTS

3.1 | Demographic and clinical characteristics

For the entire cohort, the median age was 60 years (IQR: 47–70), 57% were male, and 84.5% were White (Table 1). No significant differences were found in these variables between patients with and without ST complications. Preoperative blood transfusions and diagnosis of systemic sepsis were more common in patients that developed ST complications than in those that did not ($p < 0.05$). ASA class III and IV were more common in patients with ST complications (69%) than in those without (56.5%) ($p < 0.001$). Twenty-one percent (21.7%) of patients with ST complications had a preoperative hematocrit <30%, compared with 10.2% in those without complications ($p = 0.001$).

TABLE 1 Demographic, clinical, and tumor characteristics of patients with bone and soft tissue sarcomas of the pelvis.

	All patients (*n* = 770)	ST complications (*n* = 97)	No ST complications (*n* = 673)	*p*
Age[a]	60 (47–70)	62 (48–70)	60 (46–70)	0.35
Male sex	439 (57.0%)	55 (56.7%)	384 (57.1%)	0.95
Race				
White	556 (84.5%)	63 (87.5%)	493 (84.1%)	0.35
Black	59 (9.0%)	7 (9.7%)	52 (8.9%)	
Asian	38 (5.8%)	1 (1.4%)	37 (6.3%)	
Other	5 (0.8%)	1 (1.4%)	4 (0.7%)	
BMI > 30	250 (33.1%)	36 (37.9%)	214 (32.4%)	0.29
Smoking during last year	95 (12.3%)	12 (12.4%)	83 (12.3%)	0.99
DM status				
No DM	661 (85.8%)	83 (85.6%)	578 (85.9%)	0.45
Noninsulin-dependent DM	78 (10.1%)	12 (12.4%)	66 (9.8%)	
Insulin-dependent DM	31 (4.0%)	2 (2.1%)	29 (4.3%)	
COPD	19 (2.5%)	3 (3.1%)	16 (2.4%)	0.67
CHF	5 (0.6%)	1 (1.0%)	4 (0.6%)	0.62
Hypertension requiring pharmacologic Tx	332 (43.1%)	43 (44.3%)	289 (42.9%)	0.8
Recipient of dialysis	4 (0.5%)	0 (0.0%)	4 (0.6%)	0.45
Disseminated cancer	85 (11.0%)	9 (9.3%)	76 (11.3%)	0.55
Chronic steroid use	17 (2.2%)	1 (1.0%)	16 (2.4%)	0.4
Bleeding disorder	27 (3.5%)	2 (2.1%)	25 (3.7%)	0.41
Blood transfusion in 72 h before surgery	19 (2.5%)	8 (8.2%)	11 (1.6%)	**<0.001**
Systemic sepsis in 48 h before surgery	24 (3.1%)	7 (7.2%)	17 (2.5%)	**0.013**
Functional health status before surgery				
Independent	743 (96.9%)	89 (91.8%)	654 (97.6%)	**0.006**
Partially dependent	22 (2.9%)	7 (7.2%)	15 (2.2%)	
Totally dependent	2 (0.3%)	1 (1.0%)	1 (0.1%)	
ASA class				
I	40 (5.2%)	3 (3.1%)	37 (5.5%)	**<0.001**
II	282 (36.7%)	27 (27.8%)	255 (38.0%)	
III	401 (52.2%)	53 (54.6%)	348 (51.9%)	
IV	45 (5.9%)	14 (14.4%)	31 (4.6%)	
Preoperative labs				
Hematocrit < 30%	82 (11.7%)	20 (21.7%)	62 (10.2%)	**0.001**
Platelet count				
<150 000	41 (6.0%)	4 (4.5%)	37 (6.2%)	0.12
150 000–450 000	603 (87.6%)	75 (84.3%)	528 (88.1%)	
>450 000	44 (6.4%)	10 (11.2%)	34 (5.7%)	

(Continues)

TABLE 1 (Continued)

	All patients ($n = 770$)	ST complications ($n = 97$)	No ST complications ($n = 673$)	p
Na+ < 135 mmol/L	52 (7.8%)	10 (11.2%)	42 (7.3%)	0.2
Creatinine > 1.5 mg/dL	26 (3.8%)	4 (4.4%)	22 (3.7%)	0.73
Albumin < 3.5 g/dL	97 (21.0%)	18 (29.0%)	79 (19.7%)	0.093
Tumor characteristics				
Type of tumor				
Bone tumor	116 (17.1%)	18 (26.1%)	98 (16.1%)	**0.037**
Soft tissue tumor	562 (82.9%)	51 (73.9%)	511 (83.9%)	
Size > 5 cm	193 (48.7%)	25 (78.1%)	168 (46.2%)	**<0.001**
Soft tissue tumor depth				
Subcutaneous	75 (22.8%)	2 (10.0%)	73 (23.6%)	0.16
Subfascial	254 (77.2%)	18 (90.0%)	236 (76.4%)	
Treatment				
Type of surgery				
Limb salvage	678 (88.1%)	69 (71.1%)	609 (90.5%)	**<0.001**
Amputation	92 (11.9%)	28 (28.9%)	64 (9.5%)	
QT in 30 days before surgery	10 (7.0%)	1 (7.1%)	9 (7.0%)	0.98
RT in 90 days before surgery	18 (12.6%)	4 (28.6%)	14 (10.9%)	0.058
Operative time, h				
<1	153 (19.9%)	5 (5.2%)	148 (22.0%)	**<0.001**
1–3	262 (34.0%)	29 (29.9%)	233 (34.6%)	
>3	355 (46.1%)	63 (64.9%)	292 (43.4%)	

Note: Bold values are statistically significant $p < 0.05$.

Abbreviations: ASA, American Standards Association; BMI, body mass index; CHF, chronic heart failure; COPD, chronic obstructive pulmonary disease; DM, diabetes mellitus; IQR, interquartile range; QT, chemotherapy; RT, radiation therapy.

[a]Median (IQR).

Among patients with ST complications, tumors were significantly larger (>5 cm) and a higher proportion were primary bone tumors ($p < 0.05$). No significant differences in tumor depth (only for ST sarcomas) were found between the groups. Amputation was the primary procedure in 28.9% and 9.5% of patients with ST and without ST complications ($p < 0.001$). RT was administered in 28.6% of cases with ST complications and 10.9% of those without them ($p = 0.058$). Operative time was longer than 3 h in 64.9% of patients with ST complications and 43.4% of patients without complications ($p < 0.001$).

3.2 | Postoperative complications and outcomes

Out of a total of 770 patients with pelvic bone and ST sarcoma, 97 (12.6%) developed any ST complications postoperatively. Superficial, deep, and organ SSI occurred in 4.9%, 4.7%, and 3.2% of patients with pelvic bone and ST sarcomas, respectively (Table 2). Wound dehiscence occurred in 1.6% of patients. Unplanned reoperation within 30 days was required in 10.6% of patients, unplanned readmission in 8.2% and 30-day mortality was 0.8%.

We additionally compared complication rates with bone and ST sarcomas located in the upper or lower extremity (Table 3). Distribution of LSS and amputation procedures as a percent of all tumor resection surgeries according to location is displayed on Figure 1. Patients who underwent pelvic sarcoma resection had a higher rate of deep SSI ($p < 0.001$), organ SSI ($p < 0.001$), any ST complication ($p < 0.001$), any complication ($p < 0.001$), unplanned reoperations ($p < 0.001$), and unplanned readmissions ($p = 0.023$). Overall ST complication rates were almost 1.5 times higher in the pelvis group (12.6%) than in the lower extremity group (8.5%), and 3 times higher than in the upper extremity group (4.4%). A trend toward higher 30-day mortality in the pelvic group (0.8%) was seen; this was not statistically significant ($p = 0.05$).

3.3 | Risk factors for ST complications

On univariate analysis, age over 30, partially dependent functional status, hematocrit <30%, tumor size >5 cm, the operative time between 1 and 3 h, and operative time >3 h were risk factors for any ST complication (Table 4).

On multivariate analysis, patients older than 30 years had a five times greater risk of developing ST complications (odds ratio [OR] = 5.07, $p = 0.027$). A hematocrit <30% led to a 1.8-fold increase in the risk of ST complications (OR = 1.84, $p = 0.042$) (Table 4). Operative time led to an increased risk of ST complications, with an almost threefold increase for 1–3-h long surgeries (OR = 2.97, $p = 0.031$) and fivefold for >3-h long surgeries (OR = 4.89, $p = 0.001$).

4 | DISCUSSION

Bone and ST sarcomas of the pelvis have long been associated with a worse prognosis and a high rate of postoperative complications.[13–15] However, reported risk factors are often based on bivariate analysis without adjusting for potential confounders; this is often the result of a constrained sample due to an infrequent location in an already rare neoplasm. Using the NSQIP database, we found that the 30-day ST complication rate was 12.6% in patients undergoing a tumor resection procedure for bone or ST sarcoma of the pelvis. The most common ST complications were superficial (4.9%) and deep (5.7%) SSIs. Risk factors for ST complications after pelvic sarcoma surgery

TABLE 2 ST complication rates and postoperative outcomes after resection of the pelvic bone and ST sarcomas.

	Patients ($n = 770$)
Superficial SSI	38 (4.9%)
Deep SSI	36 (4.7%)
Organ SSI	25 (3.2%)
Wound dehiscence	12 (1.6%)
Any ST complication	97 (12.6%)
Any complication	136 (17.7%)
Unplanned reoperation	82 (10.6%)
Unplanned readmission	52 (8.2%)
30-day mortality	6 (0.8%)

Abbreviations: SSI, surgical site infection; ST, soft tissue.

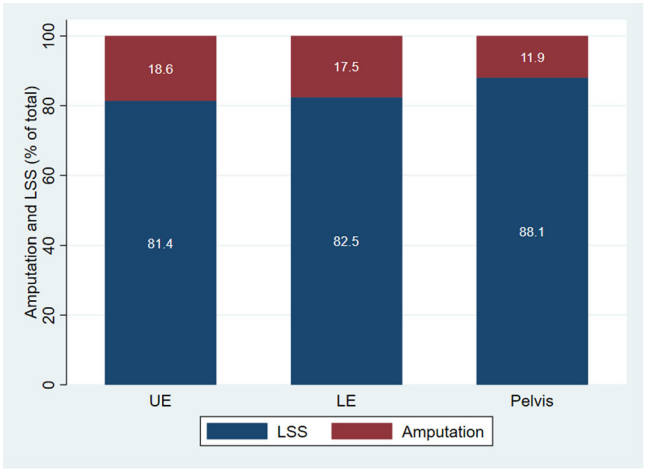

FIGURE 1 Rate of patients undergoing LSS or amputation as primary surgery for tumor resection of bone and soft tissue sarcomas according to location. LE, lower extremity; LSS, limb-salvage surgery; UE, upper extremity.

TABLE 3 Comparison of ST complications and postoperative outcomes by location of the bone tumor or STS.

	Pelvis ($n = 770$)	Lower extremity ($n = 1140$)	Upper extremity ($n = 688$)	p
Superficial SSI	38 (4.9%)	52 (4.6%)	19 (2.8%)	0.084
Deep SSI	36 (4.7%)	22 (1.9%)	5 (0.7%)	**<0.001**
Organ SSI	25 (3.2%)	9 (0.8%)	4 (0.6%)	**<0.001**
Wound dehiscence	12 (1.6%)	21 (1.8%)	2 (0.3%)	**0.017**
Any ST complication	97 (12.6%)	97 (8.5%)	30 (4.4%)	**<0.001**
Any complication	136 (17.7%)	121 (10.6%)	37 (5.4%)	**<0.001**
Unplanned reoperation	82 (10.6%)	67 (5.9%)	38 (5.5%)	**<0.001**
Unplanned readmission	52 (8.2%)	70 (7.2%)	26 (4.4%)	**0.023**
30-day mortality	6 (0.8%)	4 (0.4%)	0 (0.0%)	0.055

Note: Bold values are statistically significant $p < 0.05$.
Abbreviations: SSI, surgical site infection; ST, soft tissue.

TABLE 4 Risk factors for the development of ST complications after tumor resection of the pelvic bone and ST sarcoma.

	Univariate		Multivariate	
	OR (95% CI)	*p*	OR (95% CI)	*p*
Age > 30	3.46 (1.07–11.24)	**0.039**	5.07 (1.21–21.29)	**0.027**
BMI > 30	1.27 (0.81–1.99)	0.29		
DM	1.03 (0.56–1.88)	0.933		
Functional status				
Partially dependent	3.43 (1.36–8.64)	**0.009**	2.54 (0.96–6.71)	0.06
Totally independent	7.35 (0.46–118.52)	0.16	4.69 (0.29–76.53)	0.278
HCT < 30%	2.44 (1.39–4.28)	**0.002**	1.84 (1.02–3.31)	**0.042**
Subfascial tumor (depth)	2.78 (0.63–12.28)	0.176		
Size > 5 cm	4.17 (1.76–9.88)	**0.001**		
Chemotherapy in the last 30 days	1.03 (0.12–8.75)	0.982		
Radiotherapy in the last 90 days	3.29 (0.91–11.88)	0.07		
Operative time, h				
1–3	3.68 (1.39–9.73)	**0.008**	2.97 (1.11–7.99)	**0.031**
>3	6.39 (2.52–16.22)	**<0.001**	4.89 (1.9–12.58)	**0.001**

Note: Bold values are statistically significant $p < 0.05$.

Abbreviations: BMI, body mass index; CI, confidence interval; DM, diabetes mellitus; HCT, hematocrit; OR, odds ratio; ST, soft tissue.

included age >30 years, partially dependent functional status, hematocrit <30%, and increased operative time.

We found an overall ST complication rate of 12.6%, significantly lower than the 20.4% to 75% rate reported in the literature.[15–19] Additional studies on bone and ST sarcomas of the upper and lower extremity using the NSQIP have also described lower complication rates than those reported by the literature.[3,20] Our lower rates might be explained by the shorter timeframe analyzed and the higher proportion of tumors requiring reconstruction procedures in other treatment centers. A study by Angelini et al. in 270 patients undergoing pelvic bone tumor resection reported a 15% SSI rate in patients without reconstruction and 26% for those that underwent pelvic reconstruction.[19] Although we were not able to determine what patients got a reconstruction after sarcoma resection, we conducted a subanalysis by location (bone or ST) under the assumption that reconstruction procedures were most commonly performed after the resection of primary bone tumors. This analysis revealed that ST complications were higher after resection of bone sarcoma (15.5%) than ST sarcoma (9.1%) of the pelvis ($p = 0.037$). Additionally, our reported lower rate could also reflect the more recent nature of this database (going from 2005 onward) compared to previous studies dating back to the 1990s when postoperative complications in orthopedic oncology occurred at significantly higher rates.

Regarding demographic, patients >30 years had a higher rate of ST complications (13.4%) than those younger than 30 (4%) ($p = 0.028$). Age >30 was also proved to be a risk factor for ST complications on multivariate analysis (OR = 5.07, $p = 0.027$). Although age can be an independent risk factor for postoperative complications, we consider that our findings might be affected by different ST sarcoma histologies affecting specific age groups Tumor subtypes such as undifferentiated pleomorphic sarcoma, which usually affects patients over 60 years of age, often require more extensive ST resections than certain pediatric tumors such as rhabdomyosarcoma; this might partially explain the difference in ST complication rates by age.[21,22] Unfortunately, our analysis could not be adjusted for tumor histology due to the limitations of the NSQIP database.

Surprisingly, patients with obesity (BMI > 30) and did not show a higher rate of ST complications (Table 1) and were not a risk factor for ST complications, either. We consider that is the result of a non-normal distribution of preoperative variables that might serve as confounders, as there is significant literature describing worse postoperative outcomes in obese patients after ST sarcoma resection.[23,24] For this, we conducted a bivariate analysis and found that amputations occurred in 13.9% of patients with a BMI < 30 and 7.6% of those with a BMI ≥ 30 ($p = 0.012$). As amputation is a stronger risk factor for ST complications than obesity, we consider that this variable is skewing the results of our findings. Additional studies on sarcoma resection using the NSQIP database have found obesity to be an important risk factor for ST complications.[3,20,25]

A Preoperative hematocrit <30% was an important risk factor for ST complications after pelvic sarcoma (OR = 1.84, $p = 0.042$). Pre-treatment anemia has already been identified as a poor prognostic marker in ST sarcoma, associated with poorer overall- and disease-free survival.[26,27] However, most studies focus on its role

in long-term outcomes, and to date, there are no studies assessing the impact of this variable after sarcoma resection in the pelvis. Our findings suggest that preoperative hematocrit carries a prognostic value on short-term complications.

Regarding tumor characteristics, patients with tumors >5 cm had a higher rate of ST complications on bivariate analysis. Tumor size was also a risk factor on univariate analysis (OR = 4.17, $p = 0.001$) but was excluded from our multivariate model due to (1) a high amount of missing data (57%), and (2) only being available for ST sarcomas and not for bone sarcomas. Although not included in our multivariate model, tumor size (and/or volume) is probably the strongest of postoperative wound complications as larger tumors require more extensive ST resection.[28,29] This is extremely important in the setting of Preoperative RT which impairs wound healing. Preoperative RT was performed in 28.6% of patients with ST complications, compared with 10.9% of patients without ST complications ($p = 0.058$). Although our findings were not significant, this is due to the high amount of missing data on this variable (81.4%).

Longer operative time, a reflection of case complexity, was also associated with an increased risk of postoperative ST complications on multivariate analysis. A longer median operative time in the pelvis (163.5 min) than lower (155 min) or upper extremity (101.5 min) ($p < 0.001$) does also explain the higher complication rates in this location. A recent meta-analysis by Cheng et al. found a 14% increase in the likelihood of complications for every 30 min of additional operating time.[30]

4.1 | Limitations

This study presents its limitations, mainly due to the nature of the NSQIP database. First, this database only covers the first 30 days after surgery. Since some complications occur after 30 days, this can lead to an underestimation of the real postoperative complication rate.[31] Second, certain variables that are key to properly assessing the risk of ST complications have a high degree of missing data (RT) or can only be extracted indirectly through CPT codes (tumor size). Third, no data on pathology findings (tumor depth, grade, lympho-vascular invasion, tumor histology) are available and the definition of bone or ST sarcoma is based only on CPT and ICD codes.

5 | CONCLUSION

About one in nine patients treated for pelvic bone and ST, sarcomas will develop ST complications within 30 days, and nearly one in five will have any type of complication. The risk of ST complications after pelvic sarcoma surgery is almost 1.5- and 3-fold higher than in lower and upper extremity sarcoma surgery, respectively. Important risk factors for ST complications were age >30, hematocrit <30%, and longer operative time. The effort to optimize hematocrit preoperatively and surgery by specialized centers with specialized surgical teams are potential interventions that can minimize the risk of surgical site complications in pelvic sarcoma surgery.

CONFLICT OF INTEREST STATEMENT

The authors declare no conflict of interest.

DATA AVAILABILITY STATEMENT

NA.

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SUPPORTING INFORMATION

Additional supporting information can be found online in the Supporting Information section at the end of this article.

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