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Development of a Prognostic Nomogram to Predict 30-day Readmission in Localized Soft Tissue Sarcomas of the Extremity

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Background: As healthcare costs rise, the need to prevent hospital readmissions is essential and has been tied to reimbursement. Post-operative readmissions after musculoskeletal oncologic procedures range from 10-20% and pose inherent challenges to patients with localized extremity soft tissue sarcomas (STS). Estimation of an individual's risk for 30-day readmission post-resection may allow for proactive management in the perioperative setting. A nomogram is a useful tool for predicting survival outcomes and wound complications in sarcoma patients, however, there is no such individualized predictive model for 30-day readmissions in localized STS patients

Questions/Purposes: The goal of this study is to 1) assess risk factors associated with 30-day readmission after primary resection in localized STS of the extremity using multi-centric data and 2) create a predictive nomogram that will assess an individual's risk of 30-day readmission after STS resection.

Patients and Methods: Patients undergoing limb-salvage resection for localized primary or recurrent extremity STS between January 2000 and April 2016 at participating US Sarcoma Collaborative institutions were identified. The analysis focused on 30-day hospital readmissions following surgical resection of the primary tumor. Patients who died during the index hospitalization or were lost to follow-up within 30 days post-discharge were excluded from analysis. Eleven patients died within 30-days of readmission and to handle deaths as a competing event, the composite outcome of 30-day readmission or death was analyzed as the primary outcome. Variables were selected a priori as potential factors for 30-day readmission: age, gender, BMI, insurance status, functional status, ASA class,

heart failure, COPD, diabetes, smoking, albumin, tumor location, tumor category, size, tumor, closure by plastic surgery, length of stay, discharge destination, EBL, intraoperative transfusions and drain placement and number of drains.

Univariate analysis was performed using Fisher's exact tests for categorical and Wilcoxon rank-sum tests for continuous predictors. Multiple logistic regression was used to train the prediction model used to create the nomogram. The first 2/3 of each dataset was used to train the logistic regression model, which was tested on the remaining 1/3 of the dataset. Recursive Feature Elimination was used during cross validation to select variables for the final model. Prediction performance of the datasets was evaluated using the receiver operating curve, area under the curve, and calibration plot. All statistical analyses were performed using R, version 3.6.0.

Results: 2015 patients underwent resection for their localized primary or recurrent STS. After missing values were eliminated, 1933 patients with STS were evaluated. Median age was 59 and median tumor size was 8.5 cm. The 30-day readmission or death rate was 7.4% (144/1993). Results of the UVA are in Table 1. On MVA, males (aOR 1.66, 95% CI 1.03-2,70, p=0.04), increasing length of stay (aOR 1.08, 95% CI 1.04-1.12, p=<0.001); number of drains (aOR 1.48, 95% CI 1.15-1.90, p=0.003); tumor size (aOR 1.04, 95% CI 1.01-1.07, p=0.006) and diabetes (aOR 2.08, 95% CI 1.15-3.64) were associated with 30-day post-resection readmission. Results were incorporated into a predictive nomogram for 30-day readmission (Figure 1). The resultant nomogram was internally validated by the methods described.

Conclusions: 30-day readmission rates after STS resection are not only a relevant issue for patients, but also impacts the healthcare economic components of our hospitals. Gender, hospital length of stay, number of drains, tumor size and diabetes are all associated factors of 30-day readmission risk. A validated nomogram has been established that can provide individual prediction of readmission for patients with resected STS of the extremity. This prognostic model may help clinicians identify and counsel patients at high risk for readmission and inform payers in the healthcare industry about factors that ultimately could affect reimbursement.

	No 30-Day Readmission or Death	30-Day Readmission or Death	p-value
Age (Median)	58	61	0.018
BMI (Median)	28	29	0.018
Gender Female Male	826 (95%) 963 (91%	48 (5.5%) 96 (9.1%)	0.003
Health Insurance Uninsured Government Private Uknown	53(98%) 461(90%) 640(93%) 635	1 (2%) 51(10%) 50(7%) 42	0.055
ASA Class 1 2 3 4 Unknown	199 (94%) 518 (94%) 527(89%) 35(88%) 510	12 (6%) 34 (6%) 65 (11%) 5(12% 28	0.007
Congestive Heart Failure No Yes Unknown	1748 (93%) 25 (80%0 17	138 (7%) 6(20%) 0	0.021
COPD No Yes Unknown	1,755 (93%) 16 (73%) 18	137 (7%) 6(27%) 1	0.004
Diabetes No Yes Unknown	1,553 (93%) 218 (87%) 18	112 (7%) 32 (13%) 0	0.002
Smoking History No Yes Unknown	1,568 (93%) 203 (88%) 18	114 (7%) 29 (12%) 1	0.003
Albumin (g/dL)	3.90	3.60	<0.001
Tumor Size (cm)	6	10	<0.001
Neoadjuvant chemotherapy No Yes Unknown	1472 (93%) 306 (92%) 11	112 (7%) 28 (8%) 4	0.418
Neoadjuvant Radiotherapy No Yes Unknown	1,387 (94%) 390 (88%) 12	90 (6%) 51 (12%) 3	<0.001
Extremity Location Upper Lower Unknown	370 (96%) 1,141 (91%) 278	17 (4%) 115 (9%) 12	0.002

Functional Status			
Independent	1,715 (93%)	133 (7%)	
Part-totally dependent	47 (84%)	9 (16%)	0.033
Unknown	27	2	
Tumor Category			
Primary	1,218 (92%)	110 (8%)	0.040
Recurrent	571 (94%)	34 (6%)	
Extremity Closure by Plastic			
Surgeon	1,322 (93%)	98 (7%)	
No	185 (84%)	34 (16%)	<0.001
Yes	282	12	
Unknown			
Length of Stay (days)			
Mean	3.8 (4.8)	8.0 (11.3)	<0.001
Median	3.0 (1.0, 5.0)	5.0 (3.0, 8.8)	
EBL (mL) (Median)	100	250	<0.001
Intraoperative Blood Transfusion			
No	1,654 (93%)	116 (6.6%)	<0.001
Yes	82 (75%)	27 (25%)	
Unknown	53	1	
Discharge Destination			
Home	1,647 (94%)	114 (6%)	
Acute Rehab	37 (77%)	11 (23%)	<0.001
Subacute rehab	7 (78%)	2 (22%)	
Skilled Nursing Facility	44 (75%)	15 (25%)	
Unknown	54	2	
Intraoperative Drain Placement			
No	793 (96%)	37 (4%)	<0.001
Yes	969 (90%)	105 (10%)	
Unknown	27	2	
Number of Drains			
0	793 (96%)	37 (4%)	
1	701 (93%)	51 (7%)	
2	233 (84%)	43 (16%)	<0.001
3	26 (84%)	5 (16%)	
4	6 (55%)	5 (45%)	
7	0 (0%)	1 (100%)	
unknown	30	2	

Table 1: Demographics, Treatment and Tumor Characteristics

Points

0   10   20   30   40   50   60   70   80   90   100

LOS (days)

2 6   14   30   50   70   90
1 5   21   40   60   80

Number of drains

1   3   5   7
0   2   4   6

Gender

Male
Female

Tumor size (cm)

0 5   15   25   35   45

Neoadjuvant radiotherapy

Yes
No

Extremity location

Lower
Upper

Diabetes

Yes
No

CHF

Yes
No

Total Points

0   20   40   60   80   100   120   140   160

Probability of 30-day readmission or death

0.01   0.05   0.1   0.2 0.3 0.4 0.5 0.6 0.7 0.8   0.9
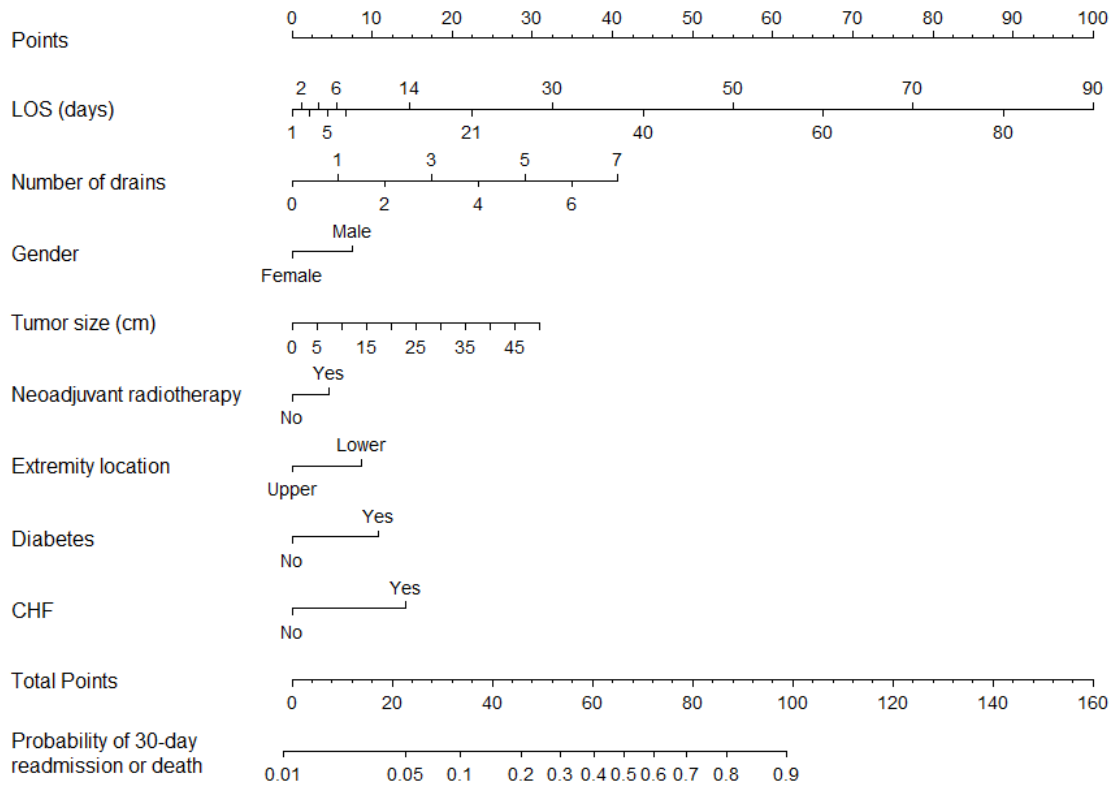
Nomogram for 30-day Readmission in Soft Tissue Sarcomas after Resection