PAPER 49

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.

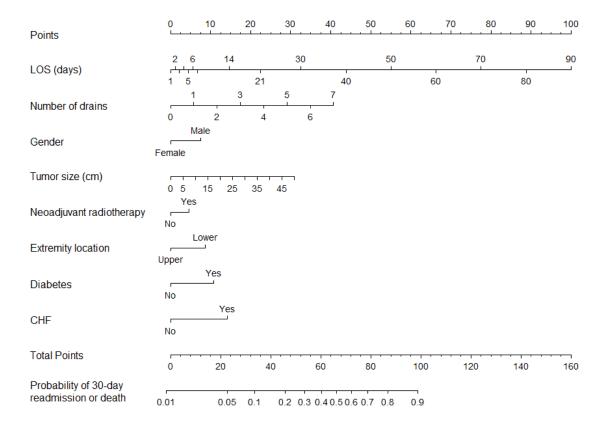
Results: 2015 patients underwent resection for their localized primary or recurrent STS. After missing values were eliminated, 1933 patients with STS were evaluated. Median age was 59 and median tumor size was 8.5 cm. The 30-day readmission or death rate was 7.4% (144/1993). Results of the UVA are in 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
<u>Gender</u> Female Male	826 (95%) 963 (91%	48 (5.5%) 96 (9.1%)	0.003
<u>Health Insurance</u> 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
<u>Congestive Heart Failure</u> No Yes Unknown	1748 (93%) 25 (80%0 17	138 (7%) 6(20%) 0	0.021
<u>COPD</u> No Yes Unknown	1,755 (93%) 16 (73%) 18	137 (7%) 6(27%) 1	0.004
<u>Diabetes</u> No Yes Unknown	1,553 (93%) 218 (87%) 18	112 (7%) 32 (13%) 0	0.002
<u>Smoking History</u> 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
<u>Neoadjuvant chemotherapy</u> No Yes Unknown	1472 (93%) 306 (92%) 11	112 (7%) 28 (8%) 4	0.418
<u>Neoadjuvant Radiotherapy</u> 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

Independent Independent Unknown 1,715 (93%) 133 (7%) 0.033 Part-totally dependent Unknown 47 (84%) 9 (16%) 0.033 2 2 2 2 Tumor Category Primary 1,218 (92%) 110 (8%) 0.040 Recurrent 571 (94%) 34 (6%) 0.040 Extremity Closure by Plastic Surgeon 322 (93%) 98 (7%) 0.001 Yes 282 12 0.001 Unknown 282 12 0.001 Mean 3.8 (4.8) 8.0 (11.3) <0.001 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 Yes 82 (75%) 27 (25%) Unknown 53 1 Yes 82 (75%) 114 (6%) Acute Rehab 37 (77%) 114 (6%) Subacute rehab 7 (78%) 2 (22%)	Functional Status			
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Image Image <th< td=""><td></td><td></td><td></td><td>0.035</td></th<>				0.035
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Primary Recurrent 1,218 (92%) 110 (8%) 0.040 Recurrent 571 (94%) 34 (6%) 0 Extremity Closure by Plastic	Tumor Category			
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$\begin{tabular}{ c c c c } \hline Surgeon & 1,322 (93\%) & 98 (7\%) & <0.001 \\ \hline No & 185 (84\%) & 34 (16\%) & <0.001 \\ \hline Yes & 282 & 12 & & \\ \hline Unknown & & & & \\ \hline Unknown & & & & & \\ \hline Uength of Stay (days) & & & & & \\ \hline Mean & 3.8 (4.8) & 8.0 (11.3) & <0.001 \\ \hline Median & 3.0 (1.0, 5.0) & 5.0 (3.0, 8.8) & & \\ \hline Median & & & & & & \\ \hline Median & & & & & & \\ \hline Median & & & & & & \\ \hline Median & & & & & & \\ \hline Median & & & & & & \\ \hline Median & & & & & & \\ \hline Median & & & & & & \\ \hline Median & & & & & & & \\ \hline Median & & & & & & & \\ \hline Median & & & & & & & \\ \hline Median & & & & & & & \\ \hline Median & & & & & & & \\ \hline Median & & & & & & & \\ \hline Median & & & & & & & \\ \hline Median & & & & & & & \\ \hline Median & & & & & & & \\ \hline Max & & & & & & & \\ \hline Max & & & & & & & & \\ \hline Max & & & & & & & & \\ \hline Max & & & & & & & & \\ \hline Max & & & & & & & & \\ \hline Max & & & & & & & & \\ \hline Max & & & & & & & & \\ \hline Max & & & & & & & & \\ \hline Max & & & & & & & & \\ \hline Max & & & & & & & & & \\ \hline Max & & & & & & & & & \\ \hline Max & & & & & & & & \\ \hline Max & & & & & & & & \\ \hline Max & $	Recurrent	571 (94%)	34 (6%)	
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Yes Unknown 282 12 Length of Stay (days) Mean 3.8 (4.8) 8.0 (11.3) <0.001	_			< 0.001
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 7 250 <0.001 Intraoperative Blood	Yes			
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EBL (mL) (Median) 100 250 <0.001 Intraoperative Blood Transfusion 1,654 (93%) 116 (6.6%) <0.001	Mean	3.8 (4.8)	8.0 (11.3)	< 0.001
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$\begin{array}{ c c c c } \hline \begin{tabular}{ c c c } \hline Iteration & I&I&I&I&I&I&I&I&I&I&I&I&I&I&I&I&I&I&$	EBL (mL) (Median)	100	250	< 0.001
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Unknown 53 1 Discharge Destination Home 1,647 (94%) 114 (6%) , 114 (6%) Acute Rehab 37 (77%) 111 (23%) <0.001	No	1,654 (93%)	116 (6.6%)	< 0.001
$\begin{array}{c c c c c c c c } \hline \textbf{Discharge Destination} \\ Home & 1,647 (94\%) & 114 (6\%) \\ Acute Rehab & 37 (77\%) & 11 (23\%) & <0.001 \\ Subacute rehab & 7 (78\%) & 2 (22\%) \\ Skilled Nursing Facility & 44 (75\%) & 15 (25\%) & \\ Unknown & 54 & 2 & \\ \hline \textbf{Intraoperative Drain} & & & \\ \hline \textbf{Placement} & & & & \\ \hline \textbf{No} & 793 (96\%) & 37 (4\%) & <0.001 \\ \hline Yes & 969 (90\%) & 105 (10\%) & \\ \hline Unknown & 27 & 2 & \\ \hline \textbf{Number of Drains} & & & \\ \hline 0 & 793 (96\%) & 37 (4\%) & 51 (7\%) & \\ 1 & 701 (93\%) & 51 (7\%) & \\ 2 & 233 (84\%) & 43 (16\%) & <0.001 \\ \hline 3 & 26 (84\%) & 5 (16\%) & \\ \hline 4 & 6 (55\%) & 5 (45\%) & \\ \hline \end{array}$	Yes	82 (75%)	27 (25%)	
Home $1,647 (94\%)$ $114 (6\%)$ $<$ Acute Rehab $37 (77\%)$ $111 (23\%)$ <0.001 Subacute rehab $7 (78\%)$ $2 (22\%)$ $Skilled Nursing Facility44 (75\%)15 (25\%)Unknown542Placement2No793 (96\%)37 (4\%)<0.001Yes969 (90\%)105 (10\%)Unknown272Number of Drains0793 (96\%)37 (4\%)1701 (93\%)51 (7\%)2233 (84\%)43 (16\%)<0.001326 (84\%)5 (16\%)<0.001$	Unknown	53	1	
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Subacute rehab 7 (78%) 2 (22%) Skilled Nursing Facility 44 (75%) 15 (25%) Unknown 54 2 Intraoperative Drain 2 2 Placement 793 (96%) 37 (4%) <0.001	Home	1,647 (94%)	114 (6%)	
Skilled Nursing Facility 44 (75%) 15 (25%) Unknown 54 2 Intraoperative Drain 2 Placement	Acute Rehab	37 (77%)	11 (23%)	< 0.001
Unknown 54 2 Intraoperative Drain	Subacute rehab	7 (78%)	2 (22%)	
Intraoperative Drain Placement	Skilled Nursing Facility	44 (75%)	15 (25%)	
Placement No </td <td>Unknown</td> <td>54</td> <td>2</td> <td></td>	Unknown	54	2	
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Unknown 27 2 Number of Drains	No	793 (96%)	37 (4%)	<0.001
Number of Drains 793 (96%) 37 (4%) 0 793 (96%) 37 (4%) 1 701 (93%) 51 (7%) 2 233 (84%) 43 (16%) <0.001	Yes	969 (90%)	105 (10%)	
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3 26 (84%) 5 (16%) 4 6 (55%) 5 (45%)	1	701 (93%)	51 (7%)	
3 26 (84%) 5 (16%) 4 6 (55%) 5 (45%)	2	233 (84%)	43 (16%)	<0.001
	3		5 (16%)	
7 0 (0%) 1 (100%)	4	6 (55%)	5 (45%)	
	7	0 (0%)	1 (100%)	
unknown 30 2	unknown	30	2	

Table 1: Demographics, Treatment and Tumor Characteristics



Nomogram for 30-day Readmission in Soft Tissue Sarcomas after Resection