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Textbook Outcomes Among Patients Undergoing Retroperitoneal Sarcoma Resection

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Abstract. *Background/Aim: Recently, the concept of textbook outcome (TO) has emerged as a novel effort to develop a benchmark that reflects multiple domains of quality. The aims of the current study were to define TO for retroperitoneal sarcoma (RPS), evaluate the relationship of TO with hospital volume and assess the association of TO with overall survival. Patients and Methods: Patients who underwent resection for RPS diagnosed between 2004 and 2015 were identified in the National Cancer Database. The primary outcome was TO that was defined as: hospital length of stay<75th percentile, survival>90 days from surgery, no readmission within 30 days and grossly negative margins. Results: Of the 11,032 patients analyzed, 54.0% had a TO. Among patients who had a TO, 57.8% were treated in high-volume hospitals. Undergoing surgery at high-volume centers was associated with a higher probability of a TO (p=0.009). TO were associated with significantly longer overall survival (p<0.001). In a subgroup analysis with grossly negative margins and no 90-day mortality, the association of TO with improved survival persisted (p<0.001). Conclusion: The concept of TO is a promising tool for measuring patient-level hospital performance and may be useful for identifying important variations in care for patients with RPS.*

Surgical outcomes vary widely among hospitals and surgeons, generating the need for more accurate quality indicators, especially among patients undergoing complex operative procedures (1, 2). While outcomes have traditionally been reported as independent endpoints, composite benchmarks may be more useful in reflecting multiple domains of overall surgical and hospital quality (3-5). Recently, the concept of textbook outcome (TO) has emerged as a novel effort to construct a benchmark that reflects these multiple domains (6-9). In short, TOs are a composite of postoperative endpoints which collectively represent the ideal "textbook" hospitalization, and may include important markers of quality such as perioperative morbidity, short-term mortality, readmissions, as well as disease-specific variables, such as margin status and lymph node retrieval for specific cancer operations. Beyond a quality index across multiple domains of performance, TOs and other composite measures may allow for easier interpretation of quality by surgeons and patients. To date, TOs have been developed for several gastrointestinal malignancies-including esophagogastric and hepatobiliary malignancies (7, 10-13).

Retroperitoneal sarcoma (RPS) represents a heterogeneous, rare malignancy for which hospital-level outcomes data remain scarce (14, 15). Surgical resection remains the mainstay of management for RPS, since complete tumor resection (gross negative surgical margins) is the strongest predictor of outcome. However, factors such as hospital volume and multidisciplinary expertise in sarcoma are emerging as compelling factors in optimizing patient outcomes (16-18). Thus, there exists a need for composite metrics that can be utilized to inform both patients and providers regarding quality – and existing quality gaps – in the treatment of these complex malignancies.

The aims of the current study were to develop a novel, disease-specific TOs for patients with resectable RPS, to evaluate the relationship of TOs with hospital volume and to assess the association of TOs with overall survival.

Patients and Methods

Study population and definition of outcomes. Patients aged 18 years or older who underwent resection of a primary RPS diagnosed between 2004 and 2015 were identified in the National Cancer Database (NCDB). Patients were included if they had tumors in the retroperitoneum [International Classification of Diseases for Oncology, 3rd edition (ICD-O-3) topography codes C48.0, C49.4 and C49.5] with specific histological subtypes previously deemed relevant by a multidisciplinary oncology care team (19). The primary outcome was textbook outcome (TO), which was defined

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Key Words: Textbook outcome, retroperitoneal sarcoma, hospital volume, National Cancer Database, survival.

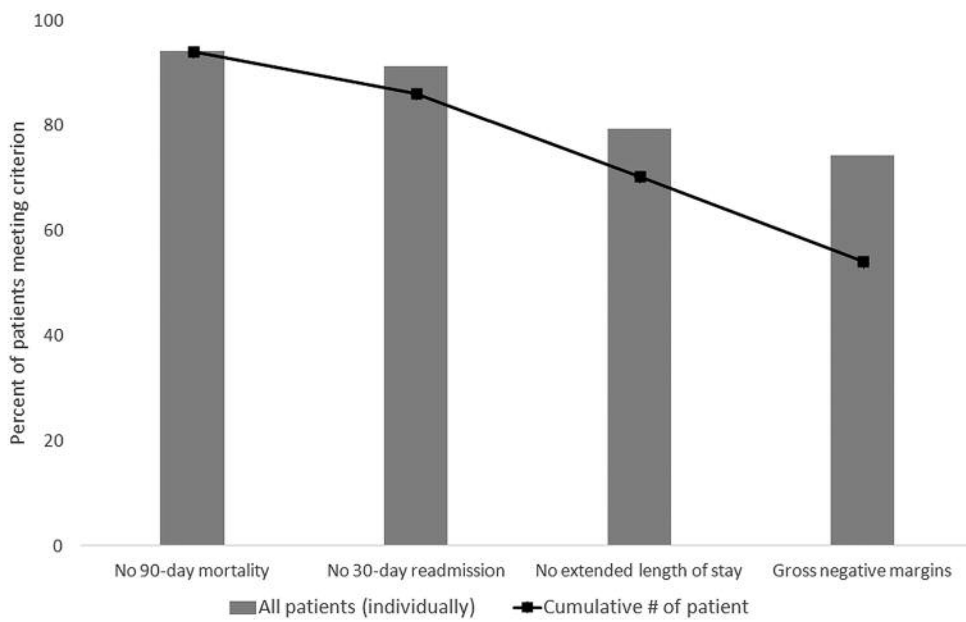

Figure 1. *Total patients and textbook outcome distribution by inclusion of individual criteria.*

as a composite of established perioperative and oncologic endpoints. These included hospital length of stay<75th Percentile, survival>90 days from the date of surgery, no readmission within 30 days of discharge, and gross negative margins of the tumor specimen.

Statistical analysis. Categorical data were summarized with proportions and continuous data reported as means with standard deviation or medians with interquartile ranges. Modified Poisson regression was used to evaluate the association between textbook outcome and patient and hospital-level factors. Given that hospital procedural volume for RPS resection is low (<1 case per year), stratification by procedural volume was determined over multi-year periods. Volume strata were therefore defined as <2 cases per period, 2-5 cases per period, 6-10 cases per period, or >10 cases per period (20). To characterize the relationship between hospital volume and textbook outcomes across different years of the study period, yearly risk-adjusted textbook outcome rates were estimated across hospital volume categories.

Finally, to determine the association between TO and overall survival, parametric survival models were constructed under the generalized gamma distribution. Furthermore, since overall survival in RPS has been shown to be dependent on margin status (21) and our definition of TO includes negative margins and survival beyond 90 days, we conducted a subset analysis of patients who had negative margins and >90 day survival. All analyses were conducted using Stata 15.0 IC (StataCorp LP, College Station, TX, USA). A *p*-value of <0.05 was defined as statistically significant. All patient data were de-identified and compliant with the Health Insurance Portability and Accountability Act of 1996 (HIPAA); patient consent was therefore waived and the study was approved by the Duke University Medical Center Institutional Review Board.

Results

Study population and descriptive analyses. Of the 11,032 patients included in the final analytic sample, 54.0% had a TO and 46.0% did not (Figure 1). For the patients who did not meet the criteria for TO, prolonged length of stay (LOS) and gross positive margins were the most common reasons for failure to achieve. More specifically, 45.0% of these patients had an extended LOS and 55.9% did not have gross negative margins. After evaluating patients in both groups for specific demographic, clinical and institutional factors, we found that TO were likely to be achieved among young (<45 years) and female patients, patients with fewer comorbidities and patients with Medicare and private insurance (Table I). Clinically, patients with smaller and well-differentiated tumors, who underwent minor resections and those who had surgery in academic institutions had significantly higher chance of achieving TO.

Textbook outcome and hospital volume. We evaluated the association between TO and hospital volume by stratifying patients according to hospital procedural volumes. Among patients who had TO, 57.8% were treated in a hospital with a higher procedural volume (Table I). Also, in a pooled analysis, diagnosis in the latter years of the study period as well as undergoing surgery at a higher volume center was also associated with higher probability of achieving TO (Table II). Also, larger tumor size and higher grade were associated with lower probability of TO across all strata. Higher income

Table I. *Descriptive statistics of patients included in the study period by receipt of textbook outcome*.

Characteristics	No textbook outcome (%)	Textbook outcome (%)	Total	*p*-Value
	5.072 (46)	5.960 (54)	11.032	
Age				<0.001
<45 years	301 (5.9)	392 (6.6)	693 (6.3)	
45-54 years	993 (19.6)	1,280 (21.5)	2,273 (20.6)	
55-69 years	1,938 (38.2)	2,544 (42.7)	4,482 (40.6)	
>70 years	1,840 (36.3)	1,744 (29.3)	3,584 (32.5)	
Gender				0.201
Male	2,512 (49.5)	2,879 (48.3)	5,391 (48.9)	
Female	2,560 (50.5)	3,081 (51.7)	5,641 (51.1)	
Race				0.464
White	4,239 (83.6)	5,028 (84.4)	9,267 (84.0)	
Black	571 (11.3)	628 (10.5)	1,199 (10.9)	
Other	262 (5.2)	304 (5.1)	566 (5.1)	
Charlson-Deyo score				<0.001
0	3,738 (73.7)	4,724 (79.3)	8,462 (76.7)	
1	1,035 (20.4)	997 (16.7)	2,032 (18.4)	
2	213 (4.2)	183 (3.1)	396 (3.6)	
3+	86 (1.7)	56 (.9)	142 (1.3)	
Insurance status				<0.001
Medicare	2,270 (44.8)	2,336 (39.2)	4,606 (41.8)	
Private insurance	2,208 (43.5)	3,061 (51.4)	5,269 (47.8)	
Medicaid/public	362 (7.1)	311 (5.2)	673 (6.1)	
Unknown or uninsured	232 (4.6)	252 (4.2)	484 (4.4)	
Income quartile (by ZIP code)				<0.001
1 (lowest)	802 (15.8)	780 (13.1)	1,582 (14.3)	
2	1,078 (21.3)	1,227 (20.6)	2,305 (20.9)	
3	1,364 (26.9)	1,563 (26.2)	2,927 (26.5)	
4 (highest)	1,828 (36.0)	2,390 (40.1)	4,218 (38.2)	
Year of diagnosis				<0.001
2004-2006	1,138 (22.4)	1,156 (19.4)	2,294 (20.8)	
2007-2009	1,400 (27.6)	1,576 (26.4)	2,976 (27.0)	
2010-2012	1,453 (28.6)	1,849 (31.0)	3,302 (29.9)	
2013-2014	1,081 (21.3)	1,379 (23.1)	2,460 (22.3)	
Tumor size				<0.001
<5 cm	632 (12.5)	1,331 (22.3)	1,963 (17.8)	
5-10 cm	1,174 (23.1)	1,793 (30.1)	2,967 (26.9)	
10-15 cm	1,027 (20.2)	1,128 (18.9)	2,155 (19.5)	
>15 cm	1,833 (36.1)	1,409 (23.6)	3,242 (29.4)	
Unknown	406 (8.0)	299 (5.0)	705 (6.4)	
Tumor grade				<0.001
Well-differentiated	910 (17.9)	1,253 (21.0)	2,163 (19.6)	
Moderate/intermediate differentiation	649 (12.8)	862 (14.5)	1,511 (13.7)	
Poorly differentiated	1,436 (28.3)	1,576 (26.4)	3,012 (27.3)	
Undifferentiated, anaplastic	972 (19.2)	977 (16.4)	1,949 (17.7)	
N/A, unknown, high-grade dysplasia	1,105 (21.8)	1,292 (21.7)	2,397 (21.7)	
Extent of surgery				<0.001
Local excision	1,982 (39.1)	2,373 (39.8)	4,355 (39.5)	
Simple resection	1,914 (37.7)	2,631 (44.1)	4,545 (41.2)	
Radical resection	1,176 (23.2)	956 (16.0)	2,132 (19.3)	
Preoperative radiation therapy				0.14
No	4,700 (92.7)	5,478 (91.9)	10,178 (92.3)	
Yes	372 (7.3)	482 (8.1)	854 (7.7)	
Median length of stay, IQR	7 (3-12)	4 (1-6)	5 (2-8)	NA
Hospital volume (per 3-year period)				<0.001
2 or fewer cases	1,135 (22.4)	1,193 (20.0)	2,328 (21.1)	
3-5 cases	1,217 (24.0)	1,319 (22.1)	2,536 (23.0)	
6-10 cases	1,139 (22.5)	1,457 (24.4)	2,596 (23.5)	
>10 cases	1,581 (31.2)	1,991 (33.4)	3,572 (32.4)	
Facility type				0.203
Community	279 (5.5)	285 (4.8)	564 (5.1)	
Comprehensive community	1,627 (32.1)	1,899 (31.9)	3,526 (32.0)	
Academic	3,166 (62.4)	3,776 (63.4)	6,942 (62.9)	

N/A: Not available, IQR: interquartile range.

Table II. *Correlation between TO and hospital volume. Results of modified Poisson regression across hospital volume strata.*

Hospital volume	2 cases or fewer		3-5 cases		6-10 cases		>10 cases	
Characteristics	RR (95%CI)	*p*-Value	RR (95%CI)	*p*-Value	RR (95%CI)	*p*-Value	RR (95%CI)	*p*-Value
Age								
<45 years			Reference		Reference			
45-54 years	1.15 (0.97-0.37)	0.114	1.02 (0.86-1.22)	0.794	1.01 (0.89-1.16)	0.85	0.98 (0.88-1.09)	0.743
55-69 years	1.18 (1.00-1.41)	0.057	1.11 (0.94-1.31)	0.229	1.02 (0.89-1.16)	0.801	1 (0.91-1.10)	0.967
>70	0.93 (0.77-1.14)	0.487	1.04 (0.86-1.25)	0.723	0.86 (0.74-1.00)	0.05	0.94 (0.83-1.07)	0.371
Gender								
Female (*vs.* male)	0.97 (0.90-1.06)	0.501	1.06 (0.98-1.14)	0.122	1.04 (0.97-1.12)	0.273	0.99 (0.94-1.04)	0.718
Income quartile								
1 (lowest)			Reference		Reference			
2	1.13 (0.99-1.30)	0.074	1.15 (1.00-1.33)	0.049	0.96 (0.85-1.08)	0.512	1.05 (0.94-1.17)	0.406
3	1.08 (0.94-1.24)	0.268	1.14 (0.99-1.31)	0.077	1.05 (0.94-1.17)	0.37	1.04 (0.93-1.16)	0.482
4 (highest)	1.16 (1.02-1.33)	0.025	1.18 (1.03-1.35)	0.021	1.07 (0.96-1.18)	0.219	1.08 (0.98-1.19)	0.119
Race								
White	Reference		Reference		Reference			
Black	0.95 (0.84-1.09)	0.476	0.98 (0.87-1.11)	0.773	1.07 (0.96-1.19)	0.251	0.98 (0.88-1.09)	0.659
Other	0.96 (0.78-1.18)	0.681	1.05 (0.89-1.23)	0.571	0.97 (0.85-1.10)	0.59	0.99 (0.87-1.12)	0.822
Charlson-Deyo score								
0	Reference		Reference		Reference		Reference	
1	0.87 (0.78-0.97)	0.016	0.86 (0.77-0.95)	0.004	0.91 (0.82-1.00)	0.042	0.96 (0.87-1.05)	0.368
2	0.9 (0.71-1.14)	0.384	0.92 (0.73-1.15)	0.469	0.87 (0.71-1.07)	0.186	0.85 (0.71-1.02)	0.075
3+	0.84 (0.58-1.22)	0.351	0.74 (0.49-1.10)	0.133	0.59 (0.34-1.01)	0.056	0.73 (0.53-1.00)	0.048
Insurance status								
Medicare	Reference		Reference		Reference		Reference	
Private insurance	0.95 (0.85-1.06)	0.363	1.14 (1.04-1.25)	0.006	0.98 (0.90-1.06)	0.568	1.09 (1.02-1.18)	0.017
Medicaid/public	0.90 (0.75-1.08)	0.245	0.98 (0.79-1.22)	0.834	0.9 (0.75-1.08)	0.251	0.8 (0.66-0.97)	0.022
Unknown or uninsured	0.94 (0.78-1.14)	0.551	1.03 (0.82-1.29)	0.793	0.98 (0.81-1.18)	0.812	0.99 (0.81-1.21)	0.951
Tumor size								
<5 cm	Reference		Reference		Reference		Reference	
5-10 cm	0.87 (0.79-0.95)	0.003	0.88 (0.80-0.96)	0.004	0.94 (0.86-1.03)	0.201	0.93 (0.86-1.00)	0.046
10-15 cm	0.75 (0.67-0.85)	<0.001	0.75 (0.67-0.84)	<0.001	0.88 (0.80-0.98)	0.016	0.75 (0.68-0.83)	<0.001
>15 cm	0.59 (0.52-0.66)	<0.001	0.65 (0.58-0.72)	<0.001	0.7 (0.63-0.77)	<0.001	0.67 (0.61-0.74)	<0.001
Unknown	0.64 (0.54-0.76)	<0.001	0.61 (0.51-0.73)	<0.001	0.7 (0.57-0.86)	0.001	0.66 (0.53-0.82)	<0.001
Tumor grade								
Well-differentiated	Reference		Reference		Reference		Reference	
Moderate/intermediate differentiation	0.97 (0.85-1.11)	0.702	0.9 (0.80-1.01)	0.074	0.88 (0.79-0.99)	0.032	0.99 (0.92-1.05)	0.667
Poorly differentiated	0.96 (0.85-1.09)	0.567	0.84 (0.76-0.93)	0.001	0.9 (0.83-0.99)	0.027	0.92 (0.84-1.00)	0.051
Undifferentiated, anaplastic	0.91 (0.80-1.04)	0.185	0.92 (0.81-1.03)	0.154	0.8 (0.71-0.90)	<0.001	0.88 (0.81-0.96)	0.002
N/A, unknown, high-grade dysplasia	0.94 (0.84-1.05)	0.241	0.91 (0.82-1.01)	0.083	0.85 (0.77-0.93)	0.001	0.91 (0.83-0.99)	0.031
Extent of surgery								
Local excision	Reference		Reference		Reference		Reference	
Simple resection	1.1 (1.01-1.20)	0.026	1.18 (1.09-1.27)	<0.001	1.05 (0.98-1.12)	0.167	1 (0.93-1.08)	0.972
Radical resection	0.99 (0.87-1.12)	0.853	0.96 (0.85-1.07)	0.454	0.9 (0.81-1.00)	0.04	0.81 (0.73-0.90)	<0.001
Received radiation preoperatively	1.13 (0.94-1.35)	0.193	1.18 (1.01-1.37)	0.032	0.95 (0.83-1.09)	0.484	1.05 (0.96- .14)	0.3
Year of diagnosis								
2004-2006	Reference		Reference		Reference		Reference	
2007-2009	1.07 (0.96-1.20)	0.236	1.18 (1.04-1.33)	0.009	1 (0.89-1.11)	0.965	1 (0.91-1.11)	0.931
2010-2012	1.1 (0.98-1.23)	0.112	1.24 (1.10-1.40)	<0.001	1.11 (1.00-1.23)	0.054	1.04 (0.95-1.14)	0.419
2013-2014	1.09 (0.97-0.22)	0.141	1.2 (1.06-1.36)	0.004	1.18 (1.07-1.31)	0.001	1.03 (0.93-1.14)	0.595
Facility type								
Community	Reference		Reference					
Comprehensive community	1.06 (0.95-1.17)	0.314	0.99 (0.78-1.25)	0.919	Reference		Reference	
Academic	0.98 (0.86-1.11)	0.731	0.92 (0.73-1.17)	0.514	1 (0.93-1.08)	0.97	1.05 (0.94-1.17)	0.362

NA: Not available; RR: relative risk; CI: confidence interval.

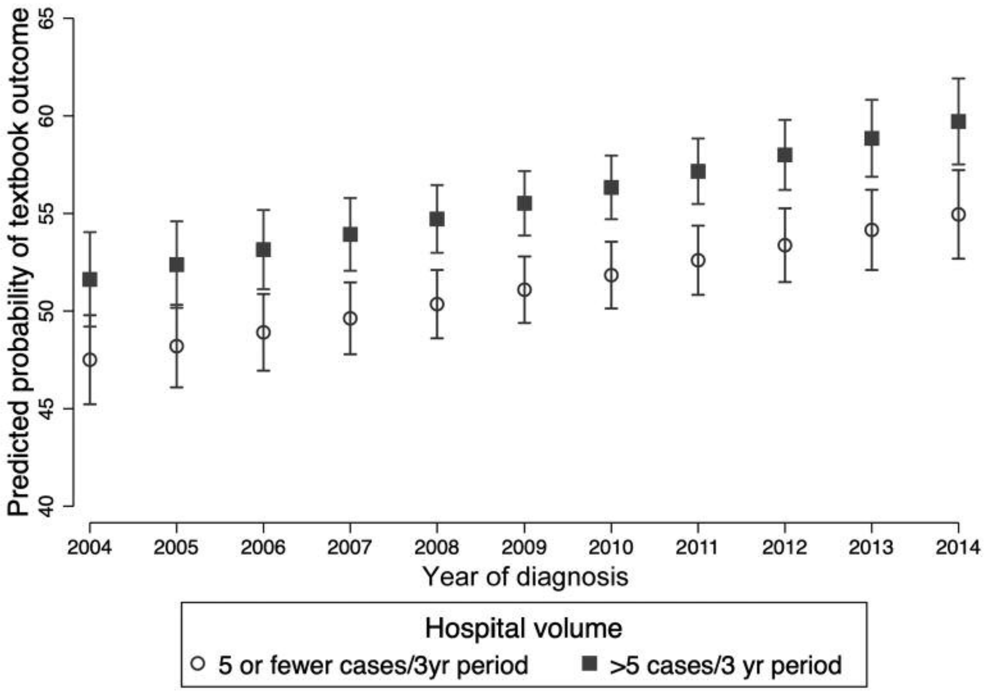

Figure 2. *Predicted probability of textbook outcome by hospital volume across years during the study period.*

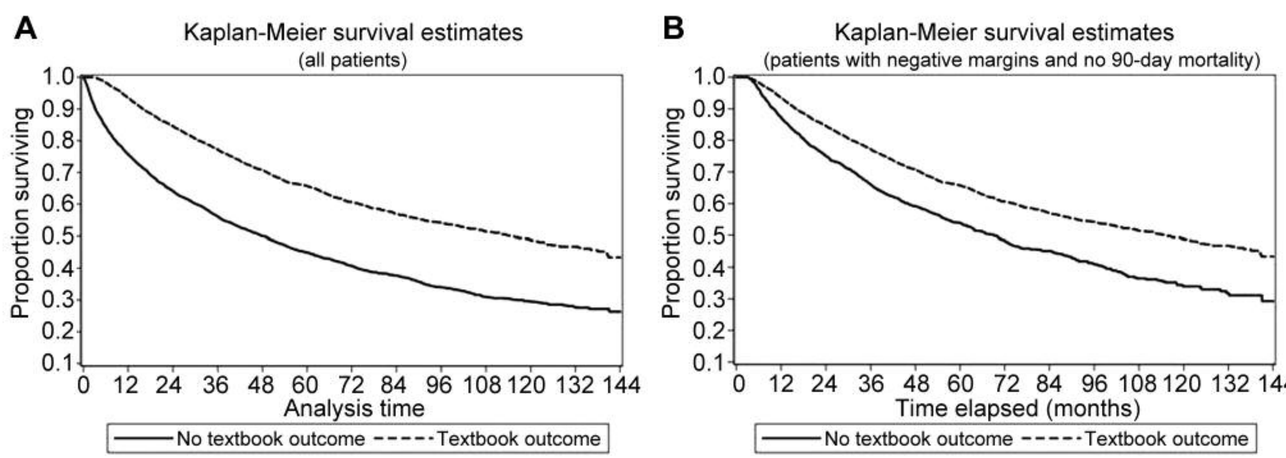

Figure 3. *Kaplan–Meier survival curve by receipt of textbook outcome of (a) all patients and (b) patients who had gross negative margins and survival >90 days.*

quartile was associated with greater probability of TO for patients treated at lower volume hospitals [(2 cases or fewer) ref: lowest income quartile, RR=1.16, 95%CI=1.02-1.33, *p*=0.025; (3-5 cases), ref: lowest income quartile, RR=1.18, 95%CI=1.03-1.35, *p*=0.021]. However, this was not noted in the higher strata of procedural volume (Table II).

Finally, to ascertain whether the distribution of outcomes across volume strata could be accounted for by secular trends, hospitals were dichotomized by total caseload within each 3-year period under study (on average, fewer than 2 cases per year or 2 or more cases per year). Then, risk-adjusted rates of TO were estimated within each year. Overall rates of TO increased in the entire period for all hospitals (Figure 2). In addition, the difference between risk-adjusted rates between low- and high-volume hospitals increased as well from 4.1% (95%CI=1.8-6.4%) in 2004 to 4.7% (95%CI=2.1-7.4%) in 2014.

Textbook outcome and overall survival. Finally, the association of TO with overall survival was evaluated. In a pooled analysis of all patients, TO were associated with 81.6% longer survival (95%CI=1.508-2.188, $p<0.001$, Figure 3a). Also, negative margins, independent of TO, were associated with an 18.7% longer survival (95%CI=1.068-1.320, $p=0.001$). Higher tumor grade was associated with progressively shorter overall survival, as was larger tumor size. Increasing age, and increasing comorbidity burden were also associated with shorter survival time. Receipt of neoadjuvant radiation therapy was associated with a 43.8% longer survival (95%CI=1.257-1.644, $p<0.001$). Relative to the lowest income quartile, highest income quartile was associated with a 25.6% longer survival (95%CI=1.122-1.406, $p<0.001$), and private insurance was associated with 30.6% longer survival (ref: Medicare, TR=1.182-1.442, $p<0.001$). Patients who underwent operations in later years (2013-2014) had 12.5% longer survival than patients who underwent operations in the first years of our study period (ref: 2004-2006, 95%CI=1.005-1.260, $p=0.041$).

Given the significant impact of operative margin status on patient outcomes, we performed a subgroup analysis on patients with grossly negative margins and no early postoperative deaths. Even within this subgroup analysis, patients with TO had superior OS outcomes compared to those who did not (time ratio: 1.315, 95%CI=1.217-1.422, $p<0.001$, Figure 3b). More specifically, improved survival was similarly associated with female sex, younger age, private insurance (*versus* Medicare) and higher income status. Also, worse survival was associated with larger tumor size and higher grade. Receipt of radiation preoperatively was associated with 23.4% longer survival in this subgroup (95%CI=1.095-1.392, $p=0.001$) (Table III).

Discussion

This study proposes a novel definition of TO in RPS surgery (a composite outcome that includes all of the following parameters: hospital length of stay<75th percentile, survival>90 days after discharge from surgical admission, no readmission within 30 days, and gross negative margins of the tumor specimen) using endpoints available in the largest national cancer database. This nationwide analysis demonstrates feasibility and utility. We report a TO rate for patients undergoing RPS resection of 54.0%. This rate is similar to TO reported for other complex surgical malignancies. A nationwide Dutch analysis showed that TO rates in esophagogastric malignancies varied from 8.5 to 52.4% (10, 22). The Dutch Pancreatic group reported a TO rate of 60.4% in patients undergoing pancreatic resections for malignancies (7). Finally, an analysis from Medicare patients showed that TO rates at the hospital level varied from 11.1% to 69.6% for pancreatic procedures and from 16.6% to 78.7% for liver procedures, variation that was attributed to a discrepancy in Medicare payments for patients who achieved TO *versus* patients who did not (12).

There was also considerable variation in TO rates between centers, which suggests potential utility as a quality metric at the hospital level. The present study demonstrates that higher volume centers had consistently higher TO rates, and we demonstrate further that despite the increase over time in TO across all hospitals, those performing at least two resections per year on average had greater than 4% higher TO than those below that threshold. Surgical volume has been well established as a metric associated with improved clinical outcomes in the management of complex malignancies (23). Recent literature demonstrates that surgical treatment of RPS is not different; surgery in high-volume centers is associated with significant reduction in short-term mortality and improved long-term survival, with several groups proposing a threshold of 10 cases/year to define high-volume centers (17, 20).

Finally, we demonstrate that patients with TO had improved survival. It has been well established that grossly negative margins are one of the strongest oncologic predictors of survival in patients undergoing RPS resection (24). Given the potential for a preponderant impact of this variable on patient survival, we performed a subset analysis of patients with grossly negative margins and lack of early postoperative mortality. Even when controlling for these factors, this composite metric was still predictive of improved outcomes in patients undergoing resection. Interestingly, TO in other complex malignancies has not been consistently linked to improved long-term survival, so this finding makes our tool for RPS even more compelling as a quality metric (7, 10-12).

Our study has strengths that should be mentioned. To our knowledge, it is the first study defining TO in RPS surgery using the largest national cancer database. The NCDB remains a valuable resource for evaluating patient-related and hospital-related factors that may impact patient care and oncologic outcomes, particularly in patients with rare malignancies such as primary RPS. The NCDB is a unique clinical database in that it collates both demographic and oncology-specific information, including the type of treatment facility, details of tumor pathology (*e.g.* histology, tumor size, and tumor grade), the extent of surgery, and margin positivity. Finally, traditional metrics of overall quality of care that are applicable to surgical patients broadly, including hospital length of stay, 30-day readmissions, and mortality within 90 days from discharge are also reported with fidelity. Our definition of hospital procedural volume accounted for the fact that due to the relative infrequency of resection of RPS, case numbers ought to be examined over a longer period, and thus cases were aggregated over 3-year periods beginning in 2004.

Table III. *Results of parametric survival analyses among all patients and patients with gross negative margins and survival >90 days.*

Variable	All patients			Patients with negative margins		
	TR	95%CI	*p*-Value	TR	95%CI	*p*-Value
Textbook outcome	2.157	[1.947, 2.389]	<0.001	1.315	[1.217, 1.422]	<0.001
Age						
<45 years	Reference			Reference		
45-54 years	0.774	[0.646, 0.927]	0.005	0.875	[0.738, 1.037]	0.123
55-69 years	0.665	[0.558, 0.792]	<0.001	0.793	[0.674, 0.933]	0.005
>70	0.394	[0.325, 0.477]	<0.001	0.533	[0.446, 0.637]	<0.001
Gender						
Female (*versus* male)	1.119	[1.042, 1.201]	0.002	1.114	[1.040, 1.193]	0.002
Income quartile						
1 (lowest)	Reference			Reference		
2	0.982	[0.870, 1.107]	0.762	0.993	[0.884, 1.117]	0.911
3	1.083	[0.964, 1.216]	0.179	1.052	[0.940, 1.178]	0.378
4 (highest)	1.256	[1.122, 1.406]	<0.001	1.164	[1.043, 1.299]	0.007
Race						
White	Reference			Reference		
Black	1.031	[0.916, 1.162]	0.609	1.109	[0.986, 1.247]	0.084
Other	1.223	[1.025, 1.458]	0.025	1.066	[0.899, 1.265]	0.462
Charlson-Deyo score						
0	Reference			Reference		
1	0.829	[0.758, 0.907]	<0.001	0.835	[0.767, 0.910]	<0.001
2	0.654	[0.548, 0.781]	<0.001	0.69	[0.575, 0.827]	<0.001
3+	0.504	[0.377, 0.674]	<0.001	0.756	[0.581, 0.985]	0.038
Insurance status						
Medicare	Reference			Reference		
Private insurance	1.306	[1.182, 1.442]	<0.001	1.26	[1.145, 1.386]	<0.001
Medicaid/public	0.853	[0.724, 1.006]	0.059	0,941	[0.801, 1.105]	0.455
Unknown or uninsured	0.947	[0.786, 1.141]	0.567	1,072	[0.895, 1.283]	0.449
Tumor size						
<5 cm	Reference			Reference		
5-10 cm	0.766	[0.679, 0.864]	<0.001	0,77	[0.689, 0.861]	<0.001
10-15 cm	0.587	[0.518, 0.665]	<0.001	0,599	[0.532, 0.673]	<0.001
>15 cm	0.463	[0.411, 0.523]	<0.001	0,499	[0.446, 0.559]	<0.001
Unknown	0.45	[0.377, 0.536]	<0.001	0,629	[0.518, 0.763]	<0.001
Tumor grade						
Well-differentiated	Reference			Reference		
Moderate/intermediate differentiation	0.53	[0.462, 0.609]	<0.001	0.619	[0.543, 0.705]	<0.001
Poorly differentiated	0.214	[0.190, 0.240]	<0.001	0.305	[0.274, 0.340]	<0.001
Undifferentiated, anaplastic	0.208	[0.184, 0.235]	<0.001	0.308	[0.274, 0.346]	<0.001
N/A, unknown, high-grade dysplasia	0.325	[0.286, 0.369]	<0.001	0.455	[0.404, 0.513]	<0.001
Extent of surgery						
Local excision	Reference			Reference		
Simple resection	1.118	[1.029, 1.214]	0.008	1.1	[1.015, 1.191]	0.02
Radical resection	1.071	[0.967, 1.186]	0.187	1.043	[0.943, 1.152]	0.414
Received radiation preoperatively	1.438	[1.257, 1.644]	<0.001	1.234	[1.095, 1.392]	0.001
Year of diagnosis						
2004-2006	Reference			Reference		
2007-2009	1.059	[0.962, 1.165]	0.246	1.036	[0.943, 1.139]	0.46
2010-2012	1.089	[0.988, 1.200]	0.087	1.015	[0.923, 1.116]	0.759
2013-2014	1.125	[1.005, 1.260]	0.041	0.984	[0.882, 1.098]	0.773
Facility type						
Community	Reference			Reference		
Comprehensive community	1.04	[0.887, 1.220]	0.627	1.04	[0.888, 1.219]	0.626
Academic	1.205	[1.032, 1.407]	0.018	1.119	[0.960, 1.305]	0.151
Gross negative margins	1.187	[1.068, 1.320]	0.001	-	-	-

N/A: Not available; CI: confidence interval; TR: time ratio.

In our definition we tried to include all relevant and available parameters captured in the NCDB, aiming to provide a powerful outcome measure that, in turn, can be easily operationalized for comparing quality of surgical practice between different institutions. But there are several limitations that should be considered when interpreting the results of this study. The outcomes included in the definition of TO were limited to the variables available in the database, thus we did not include some potentially relevant postoperative complications, such as prolonged operative time, intraoperative blood loss, or postoperative transfusions-variables that have been found to be associated with worse outcomes (25). Also, surgeon case volume could not be examined; however, hospital volume may be relevant for complex cancers such as RPS as it acts as surrogate for multidisciplinary care and ability to rescue patients who suffer postoperative complications (26-28). More granular data specific to oncology outcomes including progression-free survival, evidence of recurrence, or post-discharge complications are not available within the NCDB. However, the definition of TO is designed to measure quality of care in the short term. As with all retrospective studies of surgical procedures, the current cohort may have been subject to selection bias. In addition, other measures of quality in surgery, such as patient satisfaction, were not available and could not be evaluated.

In conclusion, we have created a novel composite TO metric to evaluate outcomes in patients undergoing resection for RPS. This TO tool utilizes readily available postoperative and oncologic variables amenable to study on a national level. In our period of study, TOs have improved for all patients over time but are consistently superior in high volume sarcoma centers. In addition, this tool was predictive of improved long-term survival. Given the rarity of RPS, this study presents further evidence of the importance of regionalization of care for complex surgical malignancies and provides a tool that may be a useful quality metric to define and assess hospital performance.

Conflicts of Interest

The Authors have no conflicts of interest to declare regarding this study.

Authors' Contributions

Design of the work: Dimitrios Moris, Marcelo Cerullo, Dan G. Blazer; Analysis and interpretation of data for the work: Marcelo Cerullo; Drafting the work: Dimitrios Moris, Dan G. Blazer; Revising it critically for important intellectual content: Dan G. Blazer, Daniel P. Nussbaum; Final approval of the version to be published: Dimitrios Moris, Marcelo Cerullo, Daniel P. Nussbaum, Dan G. Blazer; Agreement to be accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved: Dimitrios Moris.

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