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 Congress of Neurological Surgeons

## The Risk Assessment and Prediction Tool (RAPT) for Discharge Planning in a Posterior Lumbar Fusion Population

**BACKGROUND:** As the use of bundled care payment models has become widespread in neurosurgery, there is a distinct need for improved preoperative predictive tools to identify patients who will not benefit from prolonged hospitalization, thus facilitating earlier discharge to rehabilitation or nursing facilities.

**OBJECTIVE:** To validate the use of Risk Assessment and Prediction Tool (RAPT) in patients undergoing posterior lumbar fusion for predicting discharge disposition.

**METHODS:** Patients undergoing elective posterior lumbar fusion from June 2016 to February 2017 were prospectively enrolled. RAPT scores and discharge outcomes were recorded for patients aged 50 yr or more ( $n = 432$ ). Logistic regression analysis was used to assess the ability of RAPT score to predict discharge disposition. Multivariate regression was performed in a backwards stepwise logistic fashion to create a binomial model.

**RESULTS:** Escalating RAPT score predicts disposition to home ( $P < .0001$ ). Every unit increase in RAPT score increases the chance of home disposition by 55.8% and 38.6% than rehab and skilled nursing facility, respectively. Further, RAPT score was significant in predicting length of stay ( $P = .0239$ ), total surgical cost ( $P = .0007$ ), and 30-d readmission ( $P < .0001$ ). Amongst RAPT score subcomponents, walk, gait, and postoperative care availability were all predictive of disposition location ( $P < .0001$ ) for both models. In a generalized multiple logistic regression model, the 3 top predictive factors for disposition were the RAPT score, length of stay, and age ( $P < .0001$ ,  $P < .0001$  and  $P = .0001$ , respectively).

**CONCLUSION:** Preoperative RAPT score is a highly predictive tool in lumbar fusion patients for discharge disposition.

**KEY WORDS:** Discharge disposition, Lumbar spine, Predictive scale, Spine

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**W**ith the advent of bundled healthcare payments, optimizing neurosurgical care and disposition is increasingly relevant for surgeons and patients.<sup>1</sup> In an attempt to reduce cost, surgeons have made efforts to reduce hospital length of stay (LOS). As a result, this approach may have generated increased discharge rates to expensive postacute

care facilities, such as acute rehabilitation (AR) and skilled nursing facilities (SNFs).<sup>2</sup> In the setting of bundled care payments, surgeons and hospitals are incentivized to help patients avoid extended postacute inpatient care at rehabilitation centers and SNF when not needed.<sup>3</sup> Although minimizing overutilization of postacute care inpatient resources may be accomplished through extended hospital LOS, it is inevitable that some patients will need the support provided at these postacute care facilities. Thus, there is an urgent need for a tool that effectively predicts postoperative disposition prior to surgical admission.

Accurately predicting care components such as LOS and disposition based on preoperative patient evaluation is invaluable for surgeons to provide quality care and help patients and

**ABBREVIATIONS:** AR, acute rehabilitation; ARF, acute rehabilitation facility; BMI, body mass index; CI, confidence interval; LOS, length of stay; OR, odds ratio; RAPT, Risk Assessment And Prediction Tool; SNF, skilled nursing facility

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families plan for their intervention and align expectations. The Risk Assessment and Predictor Tool (RAPT) was developed to assess the need for postsurgical inpatient care within orthopedic surgery populations.<sup>4-8</sup> The RAPT Score consists of 6 components, each assigned an individual score and summed for a combined score: age, sex, walk score, gait assist score, community support score, and home support score (Figure 1). Though RAPT has proven to accurately predict disposition to home in a heterogeneous neurosurgical patient population<sup>9</sup> and a cervical spine surgical population,<sup>10</sup> it has not been exclusively applied to patients undergoing elective lumbar surgery. The study herein seeks to evaluate RAPT, as well as other preoperative patient characteristics, in a population of posterior lumbar fusion patients and its ability to predict disposition to home, acute rehabilitation facility (ARF), or SNF.

## METHODS

### Patient Selection

All consecutive adult patients undergoing elective posterior lumbar fusion ( $n = 508$ ) at a multihospital 1659 bed university health system from June 2016 to February 2017 were prospectively enrolled in this IRB approved study (Figure 2). A waiver of informed consent was granted by the IRB, as this study was considered to be minimal risk to patients. This study was approved by the IRB at the Hospital of the University of Pennsylvania. IRB number for this study is: 826 300. All ethical guidelines and rules were followed to protect patient privacy. Patient RAPT score data, as well as relevant baseline and clinical variables, were captured in a prospective fashion during the presurgical office visit. Key data were acquired using the Neurosurgery Quality Initiative (NQII) EpiLog tool (University of Pennsylvania). EpiLog is a nonproprietary data acquisition system built and layered on top of the existing electronic health record architecture (by the senior author and department on the present paper) to enhance quality improvement efforts with low cost and minimal employee workflow impact.<sup>11</sup>

Patients were excluded if they were under the age of 50 because the RAPT score has not been validated in this population ( $n = 76$ ). Discharge disposition was extracted for patients aged 50 yr or more ( $n = 432$ ) using the EpiLog system, verified by a blinded reviewer, and broadly divided into home, AR, or SNF. In addition to RAPT score, the following variables were also obtained and assessed for capacity to predict discharge disposition: age, medical comorbidities, body mass index (BMI), American Society for Anesthesiologists Physical Status Classification System (ASA grade), and anatomic level of spine surgery. Comorbidities that were considered in the data included hypertension, diabetes mellitus, cancer, chronic obstructive pulmonary disease, congestive heart failure, coronary artery disease, and chronic renal failure. The EpiLog system was used to extract all remaining data.

### Statistical Analysis

Logistic regression analysis was used to assess the ability of RAPT score and other preoperative characteristics, in 2 models: predicting either home vs ARF vs SNF (Model A) or home vs ARF and/or SNF (Model B) (Table 1). For those variables that were significant in predicting discharge disposition in univariate analysis, multivariate regression was performed in a backwards, stepwise logistic fashion. Receiver Operating Characteristic analysis was used to compare the predictive power of

RAPT score to the novel grading scales generated from multivariate analysis.

Age and BMI were included as continuous variables, whereas RAPT score, RAPT subcomponent, and ASA grade were included as ordinal variables. All other variables were categorical. A binomial model to predict discharge disposition defined by Model B was created using backward selection and variables significant on univariable analysis. This model excluded LOS, as this would not be known preoperatively.  $P$  values of .05 were used to define statistical significance. All analyses were performed using SPSS (IBM Analytics, Armonk, New York), R Statistics (R Core Team, Vienna, Austria, 2017), and SAS Version 9.4 (SAS Institute Inc, Cary, North Carolina).

## RESULTS

### RAPT Score Prediction of Discharge Disposition

A total of 432 patients remained in the study after exclusions. Mean RAPT scores by model and disposition are shown in Table 1. RAPT scores effectively predicted discharge disposition in both Models A and B ( $P < .0001$ ). For Model A, every unit increase in RAPT score increased the chance of home disposition by 55.8% and 38.6% than rehab and SNF, respectively (odds ratio [OR] 1.6; 95% CI [95% CI] 1.3-1.9) or SNF (OR 1.4; 95% CI 1.2-1.6) (Figure 3). However, there was no significant difference in RAPT scores between patients discharged to SNF or AR. For Model B, every unit increase in RAPT score increased the chance of disposition to home by 43.1% (OR 1.4; 95% CI 1.3-1.6).

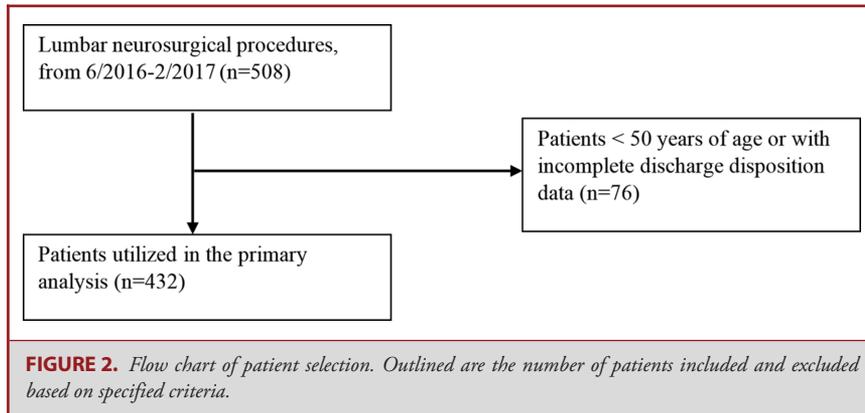
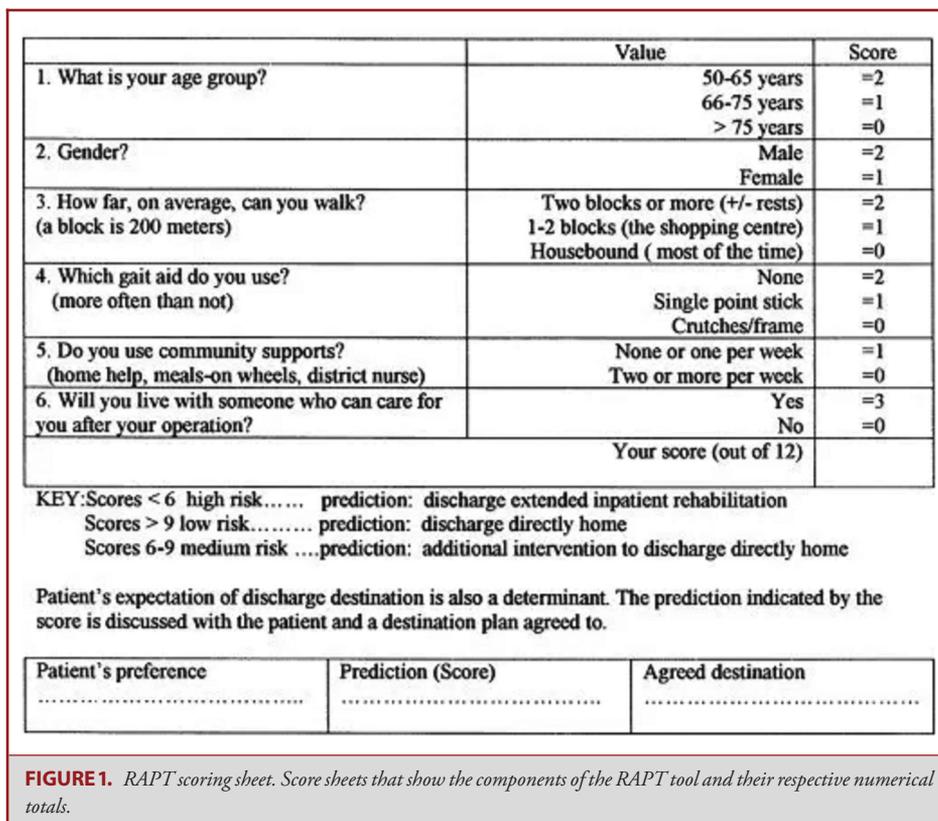
### Individual RAPT Components Predict Discharge Disposition

RAPT subcomponents included the following: walk, gait, and postoperative care. In brief, these consist of average number of blocks the patient can walk, use of gait assistance, and if someone at home can provide postoperative care. Model A demonstrated the RAPT walk, RAPT gait, and RAPT postoperative care scores to be predictive of home discharge ( $P < .0001$ ). Every unit increase in RAPT walk score increased the chance of home dispositions by 1.4 times than SNF ( $P = .0004$ , OR 1.4; 95% CI 1.1-2.7). Each unit increase in RAPT gait scores increased the chance of home disposition by 2.31 times than rehab ( $P = .0001$ , OR 2.3; 95% CI 1.7-3.5) and 1.5 times higher to rehab than SNF ( $P = .0001$ , OR 2.5; 95% CI 1.1-4.2), whereas each incremental increase in RAPT postoperative care score (ie, from 0 to 3) increased the chance of home disposition by 1.4 times than SNF ( $P = .0039$ , OR 1.5; 95% CI 1.1-1.9) (Figure 4).

Model B demonstrated the RAPT walk and RAPT postoperative care scores to be predictive of home discharge ( $P < .0001$ ). Every unit increase in RAPT walk and RAPT postoperative care scores increased the chance of home dispositions by 1.8 and 1.4 times, respectively, as opposed to SNF and AR combined.

### Preoperative Patient Characteristics Influence on Postoperative Postacute Care Needs

Demographics for the cohort are shown in Table 2. Both models demonstrated that age, when assessed as a distinct



independent variable, separate from RAPT score, was a significant predictor of discharge disposition ( $P < .0001$ ). Older patients had an increased chance of being discharged to AR or SNF compared to home. Model B demonstrated that every year of age reduced the chance of being discharged home by 9.2% (OR 0.91; 95% CI 0.88-0.93).

The total number of a patient's medical comorbidities was not predictive of discharge disposition. When individually analyzing comorbidities, Model A showed that hypertension, coronary atherosclerotic disease and diabetes are significant predictors of

discharge disposition ( $P = .0160$ , OR 2.3; 95% CI 1.3-4.2). However, in Model B, only hypertension predicted discharged disposition ( $P = .0043$ , OR 1.9; 95% CI 1.1-3.2). Nonsignificant factors included prior lumbar fusion, surgeon, BMI, and smoking among others.

**Peri- and Postoperative Factors Influence Discharge Disposition**

Hospital LOS was predictive of disposition in both Model A and Model B ( $P < .0001$  and  $P < .0003$ , respectively). Patients

**TABLE 1. Mean RAPT Scores by Model and Discharge Disposition (n = 432)**

	Model A			Model B		p
	Home	AR	SNF	Home	AR/SNF	
N	349 (81%)	23 (5%)	60 (14%)	349 (81%)	83 (19%)	–
Mean	9.48	7.70	8.20	9.48	8.06	<.001

that had an increased LOS had a decreased chance of being discharged to home. Additionally, Model B showed that each additional hour spent in the hospital decreased the chance of being discharged home by 1.0% (OR 0.99; 95% CI 0.99-0.99). Month and season of surgery, specific surgeon, and location of the surgery did not predict increased postacute needs.

Increasing the number of levels that are surgically treated decreased the likelihood of home disposition in both models (Model A,  $P = .0140$ , OR 0.69; 95% CI 0.5-0.9; Model B,  $P = .0078$ , OR 0.77; 95% CI 0.6-0.9). Using Model A, each additional treatment level led to a 31.52% decrease in chance of home disposition. Using Model B, each additional treatment level led to a 22.60% decrease in chance of home disposition.

#### Pilot RAPT Score Prediction of Cost and Readmission

Regression analysis found that RAPT was predictive of surgical supply cost ( $P = .0007$ ), and each unit increase in RAPT score corresponded with a \$599 reduction in the supply and implant cost of surgery. RAPT score was able to significantly predict

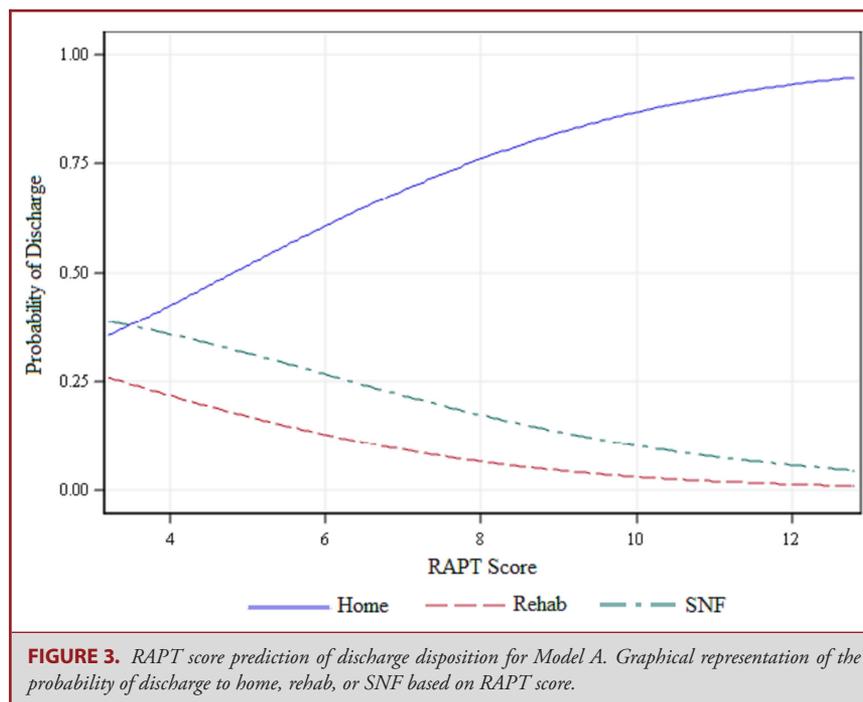
30-d readmission ( $P < .0001$ , OR 1.4; 95% CI 1.2-1.7), but not a visit to the ER within 30 d. Each unit increase in RAPT decreased the chance of 30-d readmission by 42.6%. In addition, outpatient visits were analyzed to see if they influenced readmission and ER visit rates. An office visit within the postoperative follow-up period was not significantly associated with a decrease in either of these rates.

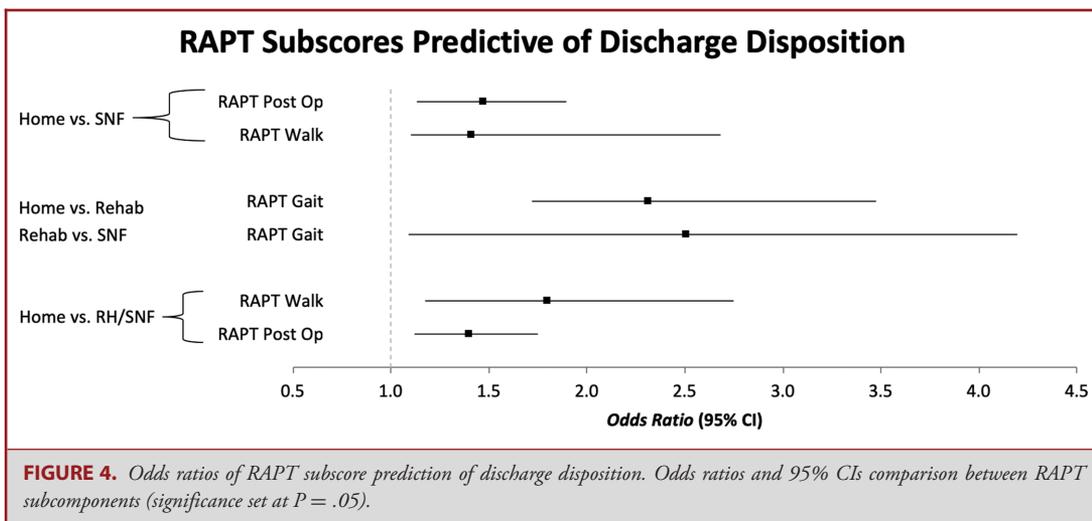
#### Enhancing Preoperative Disposition Prediction for Model B

The generalized multiple logistic regression model used for analysis was created with backward selection showed that RAPT score, LOS, and age together significantly enhance predictive capability ( $P < .0001$ ; OR 1.5; 95% CI 1.2-1.7,  $P < .0001$ , OR 1.0; 95% CI 0.99-1.0, and  $P = .0001$ , respectively). With each unit increase in RAPT score, the chance of home disposition increased by 45.6% after accounting for LOS and age ( $P = .0063$ ). Additionally, the chance of home disposition on average significantly reduces by 0.9% for every hour increase in LOS.

#### DISCUSSION

The results of the present study substantiate the potential utility of the RAPT score as an accurate tool for predicting discharge disposition in a lumbar neurosurgical cohort. RAPT Score, and in particular, the RAPT walk, RAPT gait, and RAPT postoperative care score subcomponents were highly predictive of discharge disposition. Higher RAPT and subcomponent walk,





**TABLE 2. Patient Demographics of the Analytic Cohort**

Variable Name	Overall (n = 432)
<b>Age, mean</b>	
Home	60.64
AR	76.43
SNF	69.69
Female sex	268 (53%)
BMI, mean	37.8
Smoking status, yes	116 (23%)
<b>Disposition</b>	
Home	349 (69%)
AR	23 (4.5%)
SNF	60 (12%)
<b>LOS (hours), mean</b>	
Home	94
AR	174
SNF	210
ER visit within 30 d	6 (1%)
Admission within 30 d	43 (8.5%)
Office visit within 30 d	142 (28%)

gait, and postoperative care scores equate to greater odds of discharge to home and lower odds of requiring postacute care inpatient needs. Important factors in predicting discharge disposition were additionally identified, including multiple representations of age and hospital LOS. Multivariate analysis identified these 2 variables, in addition to RAPT walk score, as independent predictors of discharge disposition. The evaluation of age as a distinct independent variable, separate from RAPT score, is valuable as many practicing surgeons may not have the quality infrastructure necessary to capture all components of the RAPT; however, age is easily captured.

Prior studies making use of the RAPT score have largely been focused within the orthopedic population. RAPT has twice been

assessed in neurosurgery, with one study validating the tool in a cervical spine population<sup>10</sup> and another investigation applying RAPT in a general heterogeneous neurosurgical population.<sup>9</sup> This is the first report in the literature to assess the utility of RAPT in a lumbar spine surgery population.

The predictive capability of RAPT and its subcomponent scores suggest that the capacity to ambulate unaided is critical to potentiating home disposition subsequent to surgical intervention. Of note, patients with poor baseline status are less likely to be able to fully participate in postoperative physical therapy and thus might require more services on discharge. Shamji et al<sup>12</sup> previously showed that patients with preoperative myelopathy utilize postacute care at higher rates. Risk scores similar to RAPT have been previously shown to predict discharge disposition, although it is unclear through which mechanism this occurs.<sup>13</sup> RAPT, and perhaps RAPT walk specifically, can potentially be used to stratify patients and preoperatively reserve beds at postacute care facilities to expedite postoperative transfer. Alternatively, for patients with relatively high RAPT scores, it may be used to determine if they can avoid discharge to a facility by slightly increasing their time in the hospital.

Analysis demonstrates that an increase in the number of levels involved in the operation increased the likelihood of postdischarge resource utilization. Larger surgeries involve larger incisions, more postoperative pain, and more muscle dissection. Thus, these patients in the early phase of recovery are less likely to participate in recovery protocols that enable home discharge. The results of this study coincide with prior work that found, in a matched cohort, that patients undergoing posterior fusion were 3 times more likely to be discharged to facilities than anterior fusions.<sup>14</sup> These patients may benefit from discharge planning prior to surgery, because the approach is known preoperatively.

The data herein additionally show that an increased LOS predicted discharge to a facility. This finding has been reported across a variety of surgical subspecialties, including posterior

spinal fusion.<sup>15-18</sup> Of note, it is important to consider potential effects of confounding in the impact of LOS, because of the requirement of a 3-d hospital stay in the Medicare population prior to eligibility for SNF discharge. Hence, there remains the possibility that patients with extended LOS are more likely to be Medicare patients, with LOS being prolonged simply to meet the requirement for SNF discharge eligibility. However, even when studied prior to implementation of Medicare guidelines, increased LOS has historically predicted the need for postacute care admission in the author's own datasets and the literature.<sup>8,19</sup> Nevertheless, it is possible, and merits additional study, that posterior lumbar fusion patients may be a target population for extended LOS to maximize opportunity for home discharge.

The present study importantly suggests that patients with decreased mobility preoperatively have increased 30-d readmission rates. Lee et al<sup>20</sup> previously found that 6-min walking distance was a risk factor for complications. Much of the prior literature has focused on postoperative ambulation as a method to predict discharge disposition. An example of this is inpatient step counts being associated with readmission rates in multiple contexts.<sup>21,22</sup> Thus, ambulation status should be valued as an important predictor of postoperative need. Future research should explore employing knowledge of preoperative capacity to walk as an actionable predictive tool and perhaps, where possible, to pursue mechanisms to improve patient ambulation status preoperatively. However, patients who are able to change their preoperative ambulation status may be different from those who are not, and this result is unlikely to be captured by the RAPT scoring system.

This study interestingly did not find a significant relationship between BMI/ASA grade and discharge disposition. This result contrasts previous findings that also specifically analyzed lumbar neurosurgical populations. McGirt et al<sup>23</sup> identified ASA grade as a significant predictor of discharge disposition in patients undergoing lumbar spine surgery. Niedermeier et al<sup>19</sup> studied patients undergoing lumbar posterior spinal fusion and found that BMI was predictive of inpatient rehabilitation postoperatively. Murphy et al<sup>24</sup> identified both BMI and ASA grade as significant predictors of nonhome discharge disposition in their study of 8627 patients undergoing lumbar decompressive surgery. Though it is unclear why this difference arose, the results of this study suggest that ambulation preoperatively is associated with postoperative disposition. It is possible that this result encompasses patients with increased BMI/poor ASA grade as they are likely to ambulate less preoperatively. Regardless, the very powerful predictive results demonstrated by this work must be confirmed in future work.

Comorbidities, in aggregate or individually, were of minimal importance in the present analysis, with only hypertension as a significant individual predictor of discharge disposition in both models and no observed relationship between number of comorbidities and disposition. This contrasts prior studies which report comorbidity burden predicts unfavorable discharge

disposition.<sup>23-25</sup> This difference may reflect varied definitions of comorbidity burden in these studies compared to the present analysis.

The present study found that increasing RAPT score predicted a reduction in surgical supply costs. For the purpose of this analysis, costs included all off-shelf equipment used in surgery (such as thrombin, arterial line equipment, antibiotic irrigation, and instrumentation implants). Prior data suggest that less healthy patients have higher supply utilization or cost of care.<sup>26,27</sup> The authors believe RAPT is a useful surrogate for degree of health and thus hypothesized that patients with lower RAPT scores would, alike the literature, result in higher supply utilization. An example of this might be that a patient with severe renal disease commonly might also have a lower RAPT score as an indicator of overall health (mobility, etc.). That same patient would be expected to have platelet dysfunction. Patients with platelet dysfunction might require higher use of hemostatic agents during surgery, such as Floseal (Baxter International Inc, Deerfield, Illinois). Higher Floseal use would be associated with higher hospital costs. The authors recognize this is only an initial assessment in this line of inquiry; however, this finding suggests that RAPT may offer useful information for cost management, which warrants further investigation.

### Strengths

A strength of the study herein is that identifying patients likely to require AR or SNF early on in their care might be employed to increase coordination between care teams to selectively decrease, and increase, length of hospitalization as appropriate. Patients strongly predicted to be discharged home might benefit from extended LOS as needed in order to facilitate a home discharge. The cost of a longer hospital stay would likely offset the cost of utilization of AR of SNF in these patients. Alternatively, patients strongly predicted to benefit from postacute care might be discharged earlier in the postoperative course of care in order to maximize recovery supports and eliminate unnecessary acute care hospitalization. Future studies will focus on assessing the predictive power of RAPT on specific subpopulations of neurosurgical patients by presenting diagnosis.

### Limitations

When assessing the data herein the reader must note inherent selection bias present in a study in which patients were enrolled through a single neurosurgery department. Though the results of this study may not be equally applicable throughout all departments, patients were drawn from multiple hospitals in a tertiary care system that serves a heterogeneous, diverse metropolitan community. There may additionally be unmeasured socioeconomic variables, not included in the regression model, which may impact the decision to discharge a patient home or to a facility. Although numerous institutions have incorporated RAPT, no published study has documented its economic impact, which must be verified before its widespread adoption for that

purpose. However, RAPT potentially provides valuable information to patients and surgeons in order to calibrate postoperative expectations. RAPT has not been validated for patients younger than 50 yr old, thus this group was excluded from analysis. Moving forward, RAPT and the model utilized in this study must undergo validation in younger patients before being applied.

## CONCLUSION

As the healthcare payment system becomes increasingly scrutinized, minimizing costs while optimizing patient care in and out of the hospital is a delicate balance. Utilizing tools such as the RAPT score preoperatively to anticipate patient needs during admission and postoperatively may help improve recovery by selectively increasing LOS, for patients identified as likely to be discharged to home, in order to favor a home discharge instead of another facility. Similarly, RAPT may aid in safely expediting patients to ARF or SNF if there is a low chance of disposition to home. These strategies may improve cost of care, average LOS, postdischarge recovery, and unexpected returns to care. Surgeons and staff can provide more individualized expectations for recovery for patients during preoperative consultation while optimizing healthcare resource usage.

## Disclosures

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