OREGON HEALTH AND SCIENCE UNIVERSITY
OFFICE OF CLINICAL INTEGRATION AND EVIDENCE-BASED PRACTICE

Evidence-Based Practice Summary
Predicting Discharge Disposition after Spinal Surgery

Prepared for: Jason Cheng, MD; Darren Malinoski, MD; Eugene Cardi, MS
Authors: Tovah Kohl, MA; Andrew Hamilton, MLS

BACKGROUND AND RATIONALE

Healthcare spending in the United States has continued to rise, and surgical services can represent a significant cost to the overall healthcare budget. Given the need to control overall healthcare expenditures, the federal government has proposed alternate payment models designed to reward value rather than volume. These models cover the entire episode of care associated with a surgical procedure including post-acute care. Bundled payment models, where providers work towards providing care using a single spending target for the surgery and initial hospital stay, as well as the costs of post-acute care for up to ninety days after surgery, require increased care coordination.[12] OHSU is a participant in the Center for Medicare Services (CMS) Bundled Payment for Care Improvement Initiative (BPCI) for spine surgery procedures and is accountable for the cost of care of the index admission and all care up to 90 days after discharge.

The post-acute discharge disposition, home versus inpatient rehabilitation facility, is an important aspect of coordinating care in this period. The Risk Assessment and Prediction Tool (RAPT) is a validated tool used to predict discharge disposition in total joint replacement patients, but has not been validated in spine surgery patients.[12] However, there are various indices and assessments which are used to risk-stratify spine surgery patients to predict 30-day readmission and post-operative morbidity.

This evidence brief seeks to determine the optimal assessment tool for predicting discharge disposition in patients undergoing spine and joint surgery.

ASK THE QUESTION

1.In patients undergoing spine or joint surgery, what assessment tool (i.e. Risk Assessment and Prediction Tool [RAPT], NSQIP Surgical Risk Calculator), is most accurate at predicting discharge disposition (i.e. extended inpatient rehabilitation services or additional interventions)?

2. What is the predictive accuracy of the Risk Assessment and Prediction Tool (RAPT) for discharge disposition in patients undergoing joint surgery in comparison to patients undergoing spine surgery?

SEARCH FOR EVIDENCE

Databases included: Ovid MEDLINE, Cochrane Database of Systematic Reviews, Cochrane Central Register of Controlled Trials

Search strategy included: MeSH terms: Spinal Diseases, Joint Diseases, Risk Management, Needs Assessment, RAPT

Filters/limits included: Articles published in English

For full search Strategy please see Appendix A.

CRITICALLY ANALYZE THE EVIDENCE

Summary of the Primary Literature:

Our search discovered no external clinical practice guideline recommendations mentioning RAPT or other clinical risk assessment tools for THA/TKA or spinal surgeries.

Question 1: In patients undergoing spine or joint surgery, what assessment tool (i.e. Risk Assessment and Prediction Tool [RAPT], NSQIP Surgical Risk Calculator), is most accurate at predicting discharge disposition (i.e. extended inpatient rehabilitation services or additional interventions)?

Eleven non-randomized studies are included in the appraisal of the question regarding the predictive accuracy of discharge disposition for different assessment tools post joint or spine surgery. The assessments are divided by: modality (either spine or joint), assessment tool, and the outcome of predictive accuracy (either discharge disposition, 30-day readmission, or postoperative morbidity). Overall, there was *low quality of evidence* to support using the RAPT tool to predict discharge disposition after joint replacement[1-4], *very low quality evidence* suggesting that higher modified Frailty Index, EPASS and POSSUM scores are associated with complications after spine surgery[5-8]. There was *very low quality evidence* indicating that the RAT score and high ASA Class was useful to predict 30-day readmission rates for spine surgery patients[9-10]. Spine surgery patients with cardiac comorbidities, prior strokes and with the lowest tertile psoas all were statistically significantly more likely to have postoperative complications[11] (*Very low quality evidence*).

Question 2: What is the predictive accuracy of the Risk Assessment and Prediction Tool (RAPT) for discharge disposition in patients undergoing joint surgery in comparison to patients undergoing spine surgery?

One non-randomized study was included in the appraisal of the RAPT to predict discharge disposition in patients undergoing spine surgery. Overall, there was *very low quality evidence* to suggest that the RAPT is able to successfully predict discharge disposition in spine surgery patients[12].

Primary Literature:

Question 1: In patients undergoing spine or joint surgery, what assessment tool (i.e. Risk Assessment and Prediction Tool [RAPT], NSQIP Surgical Risk Calculator), is most accurate at predicting discharge disposition (i.e. extended inpatient rehabilitation services or additional interventions)?

Modality: Joint Surgery

Tool: RAPT

Outcome: Accuracy of discharge disposition prediction

Studies Included: 4 non-randomized studies

The first non-randomized study (Coudeyre 2014) assessed the relevance of the RAPT (Risk Assessment and Prediction Tool), among patients undergoing total hip arthroplasty (THA). This prospective cohort study included 134 patients evaluated before and after THA. The RAPT score was significantly correlated to being discharged to a rehabilitation center, whether studied as a continuous quantitative variable from 1 to 12 or divided into three categories (< 6, 6 to 9 and > 9) with P < 0.0001 for both analytic modes. The "age" variable (P=0.0144), the “female” variable (P=0.0009), and the “living alone” variable (P< 0.0001) was significantly correlated to being discharged to a rehabilitation center.

The second study (Hansen 2015) is a prospective cohort study including 3213 patients that assessed the predictive accuracy of the RAPT on US patients undergoing total hip and knee arthroplasty (THA/TKA) and attempted to determine the predictive accuracy of each individual score (1-12). The RAPT scores of patients were prospectively captured during the preoperative clinical visit. The overall predictive accuracy of the RAPT was 78%. RAPT scores<6 and >10 (of 12) predicted with >90% accuracy discharge to inpatient rehabilitation and home, respectively. Predictive accuracy was lowest for scores between 7 and 10 at 65.2% and almost 50% of patients received scores in this range.

The third study (Oosting 2016) is a prospective cohort study evaluating the value of conventional factors, the Risk Assessment and Predictor Tool (RAPT) and performance-based functional tests as predictors of delayed recovery after total hip arthroplasty (THA) in 315 patients. The dependent variable, recovery of function, was assessed with the Modified Iowa Levels of Assistance scale. Delayed recovery was defined as taking more than 3 days to walk independently. Independent variables were: age, sex, BMI, Charnley score, RAPT score and scores for four performance-based tests [2-minute walk test, timed up and go test (TUG), 10-meter walking test (10 mW) and hand grip strength]. Analysis identified older age (>70 years), Charnley score C, slow walking speed (10 mW >10.0 s) and poor functional mobility (TUG >10.5 s) as the best predictors of delayed recovery of function. This model (AUC 0.85, 95% CI 0.79-0.91) performed better than a model with conventional factors and RAPT scores, and significantly better (P= 0.04) than a model with only conventional factors (AUC 0.81, 95% CI 0.74-0.87).

The final study (Tan 2014) is a prospective cohort study of 569 patients that explored the use of the Risk Assessment and Predictor Tool (RAPT) as a pre-operative tool to predict postoperative discharge destination and length of stay for patients undergoing total knee replacement (TKR) in Singapore. Total RAPT score and preferred discharge destination (PDD) were recorded pre-operatively, while actual discharge destination (ADDest) and length of stay (LOS) were obtained immediately after discharge. The total RAPT score was a significant predictor of LOS for patients following TKR (R=0.24, P<0.001); the higher the RAPT score, the longer the LOS. Total RAPT score was also a significant predictor of actual discharge to home [odds ratio (OR) 2.32, 95% confidence interval (CI) 1.11 to 4.85]. PDD was a significant predictor for LOS (R=0.22, P<0.001) and ADDest (R=0.33, P<0.001). Patients who chose to be discharged home were more likely to be directly discharged home (OR 9.79, 95% CI 5.07 to 18.89, P<0.001).

Overall, there was *low quality of evidence* to support using the RAPT tool to predict discharge disposition after joint replacement.

Modality: Spine Surgery

Tool: Frailty Indices

Outcome: Accuracy of post-operative morbidity prediction

Included Studies: 3 non-randomized studies

The first non-randomized study (Ali 2016) is a retrospective chart review of over 18,000 patients which sought to determine whether the modified frailty index (mFI) was predictive of postoperative morbidity and mortality in a national sample of patients undergoing spine surgery. Sixteen preoperative clinical NSQIP variables were matched to 11 CSHA-FI variables (Non-independent functional status, history of diabetes mellitus, history of chronic obstructive pulmonary disease, history of congestive heart failure, history of myocardial infarction, history of percutaneous coronary intervention, cardiac surgery, or angina, hypertension requiring the use of medication, peripheral vascular disease or rest pain, impaired sensorium, transient ischemic attack or cerebrovascular accident w/o residual deficit, and Cerebrovascular accident w/ deficit) to make the mFI. The outcomes assessed were 30-day occurrences of adverse events. In 8.1% of patients with an mFI of 0 there was at least one morbid complication, compared with 24.3% of patients with an mFI of >= 0.27 (p < 0.001). An mFI of 0 was associated with a mortality rate of 0.1%, compared with 2.3% for an mFI of >= 0.27 (p < 0.001). Patients with an mFI of 0 had a 1.7% rate of surgical site infections and a 0.8% rate of Clavien IV complications, whereas patients with an mFI of >= 0.27 had rates of 4.1% and 7.1% for surgical site infections and Clavien IV complications, respectively (p < 0.001 for both). Multivariate analysis showed that the preoperative mFI and American Society of Anesthesiologists classification of >= III had a significantly increased risk of leading to Clavien IV complications and death.

The second study (Leven 2016) is a retrospective cohort study of 1001 patients which sought to analyze the utility of the modified Frailty Index (mFI) in predicting postoperative complications and mortality after surgery for adult spinal deformity (ASD) using the American College of Surgeons (ACS) National Surgical Quality Improvement Program (NSQIP) registry. The authors found that an increasing mFI score was associated

with higher complication, reoperation, and mortality rates (P < 0.05). MFI of 0.09 and 0.18 was an independent predictor of any complication, mortality, requiring a blood transfusion, pulmonary embolism/deep vein thrombosis, and reoperation (all P < 0.05). In comparison with age >60 years obesity class III, mFI was a superior predictor of several postoperative complications and reoperation.

The final included study (Miller 2017) is a retrospective cohort study of 417 patients analyzing the value of an adult spinal deformity frailty index (ASD-FI) in preoperative risk stratification. Using 40 variables, the authors calculated frailty scores for patients with a minimum 2-year follow-up in an ASD database. On the basis of these scores, the authors categorized patients as not frail (NF) (< 0.3 points), frail (0.3-0.5 points), or severely frail (SF) (> 0.5 points). The correlation between frailty category and incidence of complications was analyzed. Compared with NF patients (n = 183), frail patients (n = 158) and SF patients (n = 109) had longer mean hospital stays (1.2 and 1.6 times longer, respectively; P < 0.001). The adjusted odds of experiencing a major intraoperative or postoperative complication were higher for frail patients (OR 2.8) and SF patients (4.1) compared with NF patients (P < 0.01). The SF patients had higher odds of developing pseudarthrosis (OR 13.0), deep wound infection (OR 8.0), and wound dehiscence (OR 13.4) than NF patients (P < 0.05), and they had 2.1 times greater odds of reoperation (P < 0.05).

Overall, there was *very low quality of evidence* to support using frailty indexes to predict post-operative morbidity after spine surgery.

Modality: Spine Surgery

Tool: Estimation of Physiological Ability and Surgical Stress (E-PASS) and Physiological and Operative Severity Score for the enUmeration of Mortality and Morbidity (POSSUM)

Outcome: Accuracy of post-operative morbidity prediction

Included Studies: 1 non-randomized

The included study (Hirose 2014) is a retrospective study of 601 patients that sought to assess the usefulness of the Estimation of Physiological Ability and Surgical Stress (E-PASS) and Physiological and Operative Severity Score for the enUmeration of Mortality and Morbidity (POSSUM) algorithms and compared the predictive ability of both systems in patients with spinal disorders considered for surgery. The E-PASS system includes a preoperative risk score, a surgical stress score, and a comprehensive risk score that is determined by both the preoperative risk score and surgical stress score. The POSSUM system is composed of a physiological score and an operative severity score; its total score is based on both the physiological score and operative severity score All EPASS scores (P≤ 0.001) and the operative severity score and total score of the POSSUM (P< 0.03) were significantly higher in patients with postoperative complications than in those without postoperative complications. The area under the receiver operating characteristic curve for the predicted morbidity rate was 0.668 for the E-PASS and 0.588 for the POSSUM system.

Overall, there was *very low quality of evidence* to suggest that the E-PASS score may be able to predict post-operative morbidity after spine surgery, but not the POSSUM system.

Modality: Spine Surgery

Tool: The American Society of Anesthesiologists (ASA) Class

Outcome: Accuracy of 30 day readmission prediction

Included Studies: 1 non-randomized

The included study (Pham 2017) is a retrospective cohort study of 1701 patients that assessed the American Society of Anesthesiologists (ASA) score as an independent predictor of 30-readmissions after anterior cervical discectomy and fusion (ACDF). Data collected for the American College of Surgeons National Surgical Quality Improvement Program (ACS-NSQIP) database were used in the analysis. The primary study outcome was 30-day readmission rates after elective ACDF in adults. Univariate and multivariate analysis was used to determine whether any of age, sex, race, body mass index, comorbidities, operative variables, or ASA class were predictors of 30-day readmission rates after ACDF. Using ASA class 1 as a reference, significant independent predictors of 30 day readmission included being in ASA class 4 [odds ratio (OR) 5.7; 95% confidence interval (CI) 0.58-56.7; P = 0.039], having cardiac comorbidities (OR 2.2; 95% CI 1.2-4.2; P = 0.017), and prior strokes (OR 3.8; 95% CI 1.4-10.1; P = 0.0086).

Overall, there was *very low quality of evidence* to suggest that ASA Class 4, cardiac comorbidities, and prior strokes are predictors of 30 day readmission.

Modality: Spine Surgery

Tool: Risk Assessment Tool (RAT) for spinal surgery

Outcome: Accuracy of post-operative complication prediction

Included Studies: 1 non-randomized

One study (Veeravagu 2017) is a prospective cohort study of 246 patients which prospectively validated the Risk Assessment Tool (RAT) for spinal surgery. The spinal Risk Assessment Tool (RAT), an instrument for the assessment of risk for patients undergoing spine surgery, was prospectively applied to 246 patients undergoing 257 spinal procedures over a 3-month period. Prospectively collected data were used to compare the RAT to the Charlson Comorbidity Index (CCI) and the American College of Surgeons National Surgery Quality Improvement Program (ACS NSQIP) Surgical Risk Calculator. Study end points were occurrence and type of complications after spine surgery. Area under the curve (AUC) analysis showed comparable predictive accuracy between the RAT and the ACS NSQIP calculator (0.670 [95% CI 0.60-0.74] in RAT, 0.669 [95% CI 0.60-0.74] in NSQIP). The RAT produced mean probabilities of 34.6% for patients who had a complication and 24% for patients who did not (P= 0.0003). The generated predicted values were stratified into low, medium, and high rates. For the RAT, the predicted complication rate was 10.1%

in the low-risk group (observed rate 12.8%), 21.9% in the medium-risk group (observed 31.8%), and 49.7% in the high-risk group (observed 41.2%). The ACS NSQIP calculator consistently produced complication predictions that underestimated complication occurrence: 3.4% in the low-risk group (observed 12.6%), 5.9% in the medium-risk group (observed 34.5%), and 12.5% in the high-risk group (observed 38.8%).

Overall, there was *very low quality of evidence* to suggest that the RAT may be able to predict post-operative complications.

Modality: Spine Surgery

Tool: Morphometircs

Outcome: Accuracy of post-operative morbidity prediction

Included Studies: 1 non-randomized

Zakaria (2015) is a retrospective cohort study of 395 patients that evaluated whether morphometrics can be applied to the cases of patients undergoing lumbar spine surgery. The authors performed a review of the perioperative course of patients who underwent lumbar surgery. Preoperative risk factors such as age, diabetes, smoking, coronary artery disease, and body mass index (BMI) were recorded. Preoperative MRI was used to measure the psoas muscle area at the L-4 vertebra and paraspinal muscle area at the T-12 vertebra. Primary outcomes included: unplanned return to the operating room, 30- and 90-day readmissions, surgical site infection, wound dehiscence, new neurological deficit, deep vein thrombosis, pulmonary embolism, myocardial infarction, urinary tract infection, urinary retention, hospital-acquired pneumonia, stroke, and prolonged stay in the intensive care unit. Greater age (P = 0.015) and tobacco usage (P = 0.026) were both significantly associated with complications for all patients, while diabetes, coronary artery disease, and high BMI were not. No surgery-related characteristics were associated with postoperative morbidity. Using multivariate regression analysis, male and female patients with the lowest psoas tertile had an OR of 1.70 (95% CI 1.04-2.79, P = 0.035) for having postoperative complications. Male patients in the lowest psoas tertile had an OR of 2.42 (95% CI 1.17-5.01, P= 0.016) for having a postoperative complication. The paraspinal muscle groups did not provide any significant data for postoperative morbidity, even after multivariate analysis.

Overall, there was *very low quality of evidence* to suggest that psoas size may be able to predict post-operative morbidity.

<u>Question 2:</u> What is the predictive accuracy of the Risk Assessment and Prediction Tool (RAPT) for discharge disposition in patients undergoing joint surgery in comparison to patients undergoing spine surgery?

Modality: Spine Surgery

<u>Tool:</u> RAPT

<u>Outcome:</u> Accuracy of discharge disposition prediction

<u>Studies Included</u>: 1 non-randomized study

Slover (2017) conducted a prospective cohort study of 767 patients (535 primary unilateral total joint arthroplasty; 150 cardiac valve replacement; 82 spinal fusions) to evaluate the relationship between the Risk Assessment and Predictor Tool (RAPT) and patient discharge disposition in an institution participating in bundled payment program for total joint replacement, spine fusion and cardiac valve surgery patients. RAPT scores of patients)were prospectively captured. Total RAPT scores were grouped into three levels for risk of complications: <6 = 'high risk', between 6 and 9 = 'medium risk', and >9 = 'low risk' for discharge to a post-acute facility. Associations between RAPT categories and patient discharge to home versus any facility were conducted. Multivariate analysis was performed to determine if there was any correlation between RAPT score and discharge to any facility. 70.5% of total joint patients, 80.7% of cardiac valve surgery patients and 70.7% of spine surgery patients were discharged home rather than to a post-acute facility. RAPT risk categories were related to discharge disposition as 72% of those in the high risk group were discharged to a facility and 91% in the low risk group were discharged to home in the total joint replacement cohort. In the cardiac cohort, only 33% of the high risk group was discharged to a facility, and 94% of the low risk group was discharged to home. In the spinal fusion cohort, 60% of those in the high risk group were discharged to a facility and 86% in the low risk group were discharged to home. Multivariate analysis showed that being in the high risk category versus low risk category was significantly associated with substantially increased odds of discharge to a facility in the total joint cohort (OR=22.40, 95%CI 10.22-49.12), cardiac cohort (OR=11.61, 95%CI, 1.28-105.39) and spine cohort (OR=17.78, 95% CI, 1.74-181.32) after the initial post-operative acute care stay, although in the cardiac valve surgery cohort, 2/3 of patients in the high risk category were still able to be discharged home.

Overall, there was *very low quality of evidence* to support using the RAPT tool to predict discharge disposition after spine replacement.

Tools Included in Primary Literature

Spinal Risk Assessment Tool (RAT)[9]

RAT
Age
Sex
Comorbidities
Pulmonary dysfunction
Neurological dysfunction
Hypercholesterolemia
Smoker
Hypertension
Cardiac dysfunction
DM
Systemic malignancy
Gastroesophageal dysfunction
Substance abuse
Psychiatric disorder
Preop diagnosis
Degenerative disease
Tumor
Trauma
Infection/misc.
Location of surgery
Anterior cervical
Posterior cervical
Anterior thoracolumbar
Posterior thoracolumbar
>1 level surgery
Use of BMP
Fusion status
Instrumentation status

American Society of Anesthesiologists (ASA) Class[10]

ASA-Physical Status Class	Definition	Examples, Including, but Not Limited to
I	A normal healthy patient	Healthy, nonsmoking, no or minimal alcohol use
II	A patient with mild systemic disease	Mild diseases only without substantive functional limitations. Examples include (but not limited to) current smoker, social alcohol drinker, pregnancy, obesity (30 < BMI < 40), well-controlled DM/HTN, mild lung disease
III	A patient with severe systemic disease	Substantive functional limitations; one or more moderate to severe diseases. Examples include (but not limited to) poorly controlled DM or HTN, COPD, morbid obesity (BMI ≥ 40), active hepatitis, alcohol dependence or abuse, implanted pacemaker, moderate reduction of ejection fraction, ESRD undergoing regularly scheduled dialysis, premature infant PCA < 60 weeks, history (> 3 months) of MI, CVA, TIA, or CAD/stents
IV	A patient with severe systemic disease that is a constant threat to life	Examples include (but not limited to) recent (< 3 months) MI, CVA, TIA, or CAD/stents, ongoing cardiac ischemia or severe valve dysfunction, severe reduction of ejection fraction, sepsis, DIC, ARDS, or ESRD not undergoing regularly scheduled dialysis
V	A moribund patient who is not expected to survive without the operation	Examples include (but not limited to) ruptured abdominal/thoracic aneurysm, massive trauma, intracranial bleed with mass effect, ischemic bowel in the face of significant cardiac pathology or multiple organ/system dysfunction
VI	A declared brain-dead patient whose organs are being removed for donor purposes	

The addition of "E" denoted emergency surgery: an emergency is defined as existing when delay in treatment of the patient would lead to a significant increase in the threat to life or body part.

ARDS = acute respiratory distress syndrome; BMI = body mass index; CAD = coronary artery disease; COPD = chronic obstructive pulmonary disease; CVA = cerebrovascular accident; DIC = disseminated intravascular coagulation; DM = diabetes mellitus; ESRD = end-stage renal disease; HTN = hypertension; MI = myocardial infarction; PCA = post conceptual age; TIA = transient ischemic attack.

Adapted from https://www.asahq.org/resources/clinical-information/asa-physical-status-classification-system.

Adult Spinal Deformity modified Frailty Index (ASD-mFI)[7]

TABLE 1. Factors included in the ASD-FI

Health deficits
Documented by physician
>3 medical problems
Body mass index <18.5 or >30 kg/m²
Cancer
Cardiac disease
Currently on disability
Depression
Diabetes
Hypertension
Liver disease
Lung disease
Osteoporosis
Peripheral vascular disease
Previous blood clot (deep vein thrombosis/pulmonary embolism/ stroke)
Smoking status
Patient-reported (questionnaire, question no.)
Bladder incontinence
Bowel incontinence
Deteriorating health this yr (SF-36v2, 2)
Difficulty climbing 1 flight of stairs (SF-36v2, 3e)
Difficulty driving a car (LSDI, 3)
Difficulty getting dressed (SF-36v2, 3j; LSDI, 1 & 2)
Difficulty getting in/out of bed (LSDI, 6)
Difficulty sleeping >6 hrs (ODI, 7)
Difficulty walking 100 yards (SF-36v2, 3i)
Difficulty w/ light activity (SF-36v2, 3b)
Feeling downhearted/depressed most of the time (SF-36v2, 9f; SRS-22r, 16)
Feeling tired most of the time (SF-36v2, 9i)
Feeling worn out most of the time (SF-36v2, 9g)
General health: fair/poor (SF-36v2, 1)
Inability to bathe w/o assistance (SF-36v2, 3j; LSDI, 8)
Inability to cheer up often (SF-36v2, 9c; SRS-22r, 7)
Inability to do normal work/schoolwork/housework (ODI, 10; SRS-22r, 9 & 12)
Inability to lift heavy objects (SF-36v2, 3c; ODI, 3)
Inability to travel >1 hr (ODI, 9)
Inability to walk w/o assistive device (ODI, 4)
Leg weakness
Loss of balance
Not in excellent health (SF-36v2, 11d)
Personal care dependency (ODI, 2)
Restricted activity level (SRS-22r, 5)
Restricted social life (ODI, 8; SRS-22r, 14 & 18)

LSDI = Lumbar Stiffness Disability Index; ODI = Oswestry Disability Index; SF-36v2 = 36-Item Short-Form Health Survey, version 2; SRS-22r = Scoliosis Research Society-22r questionnaire.

Risk Assessment and Prediction Tool (RAPT)[2]

	Value	Score
1. What is your age group?	50–65 years 66–75 years >75 years	=2 =1 =0
2. Gender?	Male Female	=2 =1
3. How far on average can you walk? (a block is 200 metres)	Two blocks or more (+/-rest) 1-2 blocks (+/-rest) Housebound (most of time)	=2 =1 =0
4. Which gait aid do you use? (more often than not)	None Single-point stick Crutches/frame	=2 =1 =0
5. Do you use community supports? (home help, meals on wheels, district nursing)	None or one per week Two or more per week	=1 =0
6. Will you live with someone who can care for you after your operation?	Yes No	=3 =0
	Your score (out of 12)	

Key: Destination at discharge from acute care predicted by score.

Scores <6 — extended inpatient rehabilitation

Score 6-9 — additional intervention to discharge directly home (e.g. *Rehabilitation in the Home)*

Score >9 — directly home.

Estimation of Physiological Ability and Surgical Stress (E-PASS) and Physiological and Operative Severity Score for the enUmeration of Mortality and Morbidity (POSSUM) [6]

TABLE 1: Variables considered in each model*

Parameters	E-PASS	POSSUM
physiological	age, severe heart disease, severe pulmonary disease, diabetes mellitus, performance status index, ASA classification	age, cardiac signs, respiratory history, systolic blood pressure, pulse rate, GCS score, hemoglobin, white blood cell count, serum urea, serum sodium, serum potassium, electrocardiogram
operative	blood loss, body weight, operative time, extent of skin incision	op severity, reop, blood loss, peritoneal soiling, malignancy, urgency of op

* ASA = American Society of Anesthesiologists; GCS = Glasgow Coma Scale.

Modified Frailty Index[5]

TABLE 1. List of 11 variables used by the CSHA to construct the mFI

Variables
Non-independent functional status
History of diabetes mellitus
History of chronic obstructive pulmonary disease
History of congestive heart failure
History of myocardial infarction
History of percutaneous coronary intervention, cardiac surgery, or angina
Hypertension requiring the use of medication
Peripheral vascular disease or rest pain
Impaired sensorium
Transient ischemic attack or cerebrovascular accident w/o residual deficit
Cerebrovascular accident w/ deficit

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Appendix A. Search Strategy

Search Strategy:

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1 (Risk Assess* adj2 (Predict* adj Tool*)).mp. [mp=title, abstract, original title, name of substance word, subject heading word, floating sub-heading word, keyword heading word, protocol supplementary concept word, rare disease supplementary concept word, unique identifier, synonyms] (16)
2 (rapt and (Risk* adj3 Assess* adj3 Predict* adj3 Tool*)).mp. [mp=title, abstract, original title, name of substance word, subject heading word, floating sub-heading word, keyword heading word, protocol supplementary concept word, rare disease supplementary concept word, unique identifier, synonyms] (9)
3 1 or 2 (16)

AND

1 (risk* adj3 (assess* or predic* or stratif* or calculat* or evaluat* or assign* or judg*) adj5 (tool* or assay* or survey* or checklist* or instrument* or algorith*)).mp. [mp=title, abstract, original title, name of substance word, subject heading word, floating sub-heading word, keyword heading word, protocol supplementary concept word, rare disease supplementary concept word, unique identifier, synonyms] (11776)
2 exp Spinal Diseases/su [Surgery] (35596)
3 exp SPINE/su [Surgery] (35585)
4 exp Joint Diseases/su [Surgery] (59465)
5 exp JOINTS/su [Surgery] (63403)
6 2 or 3 or 4 or 5 (148244)
7 exp Spinal Diseases/ (114827)
8 exp spine/ (134691)
9 exp Joint Diseases/ (355325)
10 exp joints/ (228224)
11 7 or 8 or 9 or 10 (630583)
12 exp Orthopedic Procedures/ (278573)
13 11 and 12 (120934)
14 6 or 13 (176590)
15 exp Risk Management/ (270243)
16 exp risk/ (1095700)

17 15 or 16 (1126570)
18 exp "Sensitivity and Specificity"/ (539279)
19 exp "UTILIZATION REVIEW"/ (12230)
20 exp "Health Services Needs and Demand"/ (56776)
21 exp Needs Assessment/ (27792)
22 exp Decision Making/ (181948)
23 exp Decision Support Systems, Clinical/ (6972)
24 exp Decision Support Techniques/ (72212)
25 18 or 19 or 20 or 21 or 22 or 23 or 24 (873721)
26 14 and 17 and 25 (623)
27 exp Postoperative Complications/ (506025)
28 exp PROGNOSIS/ (1466622)
29 exp health surveys/ (515340)
30 exp health status/ (297583)
31 exp REHABILITATION/ (280221)
32 exp REHABILITATION CENTERS/ (13825)
33 exp "Recovery of Function"/ (45755)
34 rh.fs. (187138)
35 exp Hospitalization/ (213764)
36 27 or 28 or 29 or 30 or 31 or 32 or 33 or 34 or 35 (2925071)
37 14 and 17 and 36 (6904)
38 14 and 25 and 36 (2311)
39 1 and 37 (34)
40 ((risk* or complicat* or (advers* adj3 (event* or outcome*))) adj5 (assess* or predic* or stratif* or probab* or calculat* or evaluat* or assign* or judg*) adj7 (tool* or assay* or survey* or checklist* or instrument* or algorith*)).mp. (17593)
41 14 and 40 (144)
42 ((assess* or predic* or stratif* or probab* or valid* or calculat* or evaluat* or assign* or judg*) adj7 (tool* or assay* or survey* or checklist* or instrument* or algorith*)).mp. (315239)
43 37 or 38 (8719)
44 42 and 43 (309)
45 41 or 44 (402)
46 limit 45 to english language (387)

47 limit 45 to abstracts (400)
48 46 or 47 (402)

Appendix B. Evidence Evaluation and GRADE criteria for rating a body of evidence on an intervention

1. **In patients undergoing spine or joint surgery, what assessment tool (i.e. Risk Assessment and Prediction Tool [RAPT], NSQIP Surgical Risk Calculator), is most accurate at predicting discharge disposition (i.e. extended inpatient rehabilitation services or additional interventions)?**

BODY OF EVIDENCE APPRAISAL TABLE FOR:
Modality: Joint Surgery
Outcome: Accuracy of discharge disposition prediction
Studies Included: 4 non-randomized studies

Quality (certainty) of evidence for: discharge disposition prediction
☐ High
☐ Moderate
☒ Low
☐ Very Low

Risk of Bias across studies:	**Lower Quality Rating if:**	**Other Considerations:**
☐ High ☐ Medium ☒ Low	☐ Studies inconsistent (*wide variation of treatment effect across studies, population, interventions, or outcomes varied*) ☐ Studies are indirect (*PICO question is quite different from the available evidence in regard to population, intervention, comparison, or outcome)* ☐ Studies are imprecise (*when studies include few patients and few events, and thus have wide confidence intervals, and the results are uncertain)*	Lower Quality Rating if: ☐ Publication Bias (*e.g. pharmaceutical company sponsors study on effectiveness of drug only small, positive studies found)* Increase Quality Rating if: ☐ Large effect ☐ Dose-response gradient ☐ Plausible confounders or other biases increase certainty of effect

Study Acronym; Author; Year Published; Location	Aim of Study	Patient Population	Study Methods	Endpoint Results / Outcome (Absolute Event Rates, P values; OR or RR; & 95% CI)	Design Limitations
Author: Coudeyre, E., et al. Year Published: 2014 Location: France Journal: *Annals of Physical & Rehabilitation Medicine*	To assess the relevance of the RAPT (Risk Assessment and Prediction Tool), among a cohort of patients undergoing total hip arthroplasty (THA).	**Size:** 134 patients **Inclusion Criteria**: all patients referred to preoperative rehab consultation before total hip arthroscopy (THA) **Exclusion Criteria**: missing data,	**Type:** Prospective study of a cohort of patients evaluated before and after THA **Methods:** The difference between the postoperative orientation predicted by the RAPT and the real one was assessed.	**Results:** The average length of stay in the surgery ward was 10 (+/-3) days. It was significantly higher for patients referred to a rehabilitation ward (P<0.0001). Sixty-six percent of patients were referred to a rehabilitation ward and 34% returned directly home. The average length of stay in rehabilitation ward was 27 (+/-13) days. **The RAPT score was significantly correlated to being discharged to a PM&R center, whether studied as a continuous quantitative**	**Study Limitations:** ☒ None **Non-Randomized Studies** ☐ Failure to develop and apply appropriate eligibility criteria ☐ Flawed measurement of both exposure and outcome ☐ Failure to adequately control confounding

		rehospitalizations not related to THA		**variable from l to 12 or divided into three categories (< 6, 6 to 9 and > 9) with P < 0.0001 for both analytic modes.** **The "age" variable was significantly correlated to being discharged to a PM&R center (P = 0.0144)**. In all, 41% of patients (n = 56) were 75 years or older and 75% of them were hospitalized in a PM&R center after THR. Among the 24% (n = 33) of patients < 65 years, only 45% were discharged to a PM&R center. **The "female" variable was statistically associated with a discharge to a PM&R center (P = 0.0009).** Overall, 74% of women pursued their rehabilitation in a PM&R center vs. 45% of men; on average in this cohort women were older than men. **"Living alone" variable was significantly correlated to being discharged to a PM&R center. It was the most significant criterion within the RAPT with P < 0.0001,** 80% of patients who reported "living alone" were discharged to a PM&R center vs. 60% of patients who reported not living alone.	☐ Incomplete or inadequately short follow-up
Author: Hansen, V. J., et al. Year Published: 2015 Location: USA Journal: *Clinical Orthopaedics & Related Research*	This study attempts (1) to assess predictive accuracy of the RAPT on US patients undergoing total hip and knee arthroplasty (THA/TKA); and (2) to determine predictive accuracy of each individual score (1-12).	**Size:** 3213 patients (1449 Total Hip Arthroscopies (THA); 1764 TKAs) **Inclusion Criteria**: all patients undergoing TJA's June 2006-December 2011	**Type:** Prospective cohort study **Methods:** RAPT scores of patients were prospectively captured during the preoperative clinical visit. Scores were stored along with other clinical data, including discharge disposition, in a dedicated database on a secure server. The database was queried by the nursing case manager to retrieve the RAPT scores of all patients captured during this time period. Binary logistic regression was used to analyze the scores and determine predictive accuracy.	**Results:** Overall predictive accuracy was 78%. RAPT scores<6 and >10 (of 12) predicted with >90% accuracy discharge to inpatient rehabilitation and home, respectively. Predictive accuracy was lowest for scores between 7 and 10 at 65.2% and almost 50% of patients received scores in this range.	**Study Limitations:** ☒ None **Non-Randomized Studies** ☐ Failure to develop and apply appropriate eligibility criteria ☐ Flawed measurement of both exposure and outcome ☐ Failure to adequately control confounding ☐ Incomplete or inadequately short follow-up

				Table 3. Predictive accuracy of the RAPT for all patients and for specific risk groups Cohort | Overall | Home | Rehabilitation | p value All patients | 78.3% | 82.4% | 73.4% | < 0.0001 THA | 79.6% | 91.1% | 63.0% | < 0.0001 TKA | 77.4% | 83.3% | 71.3% | < 0.0001 Original high risk (0–5) | 92.8% | 0.0% | 100.0% | < 0.0001 High risk (0–6) | 89.4% | 0.0% | 100.0% | < 0.0001 Original intermediate risk (6–9) | 66.0% | 44.0% | 79.8% | < 0.0001 Intermediate risk (7–10) | 65.2% | 100.0% | 0.0% | < 0.0001 Original low risk (10–12) | 84.4% | 100.0% | 0.0% | < 0.0001 Low risk (11–12) | 89.5% | 100.0% | 0.0% | < 0.0001	
Author: Oosting, E., et al. Year Published: 2016 Location: Netherlands Journal: *Disability & Rehabilitation*	The aim of this study was to evaluate the value of conventional factors, the Risk Assessment and Predictor Tool (RAPT) and performance-based functional tests as predictors of delayed recovery after total hip arthroplasty (THA).	**Size:** 315 patients **Inclusion Criteria**: patients scheduled for THA	**Type:** Prospective cohort study **Methods**: patients scheduled for THA were referred by the orthopedic surgeon for screening by a physical therapist approximately 6 weeks before surgery. All patients received postoperative rehabilitation once or twice a day, initiated the day after surgery. Physical therapy consisted of progressively improving walking ability, other functional activities and walking stairs, based on the individual patient's needs and progress. Discharge criteria were the ability to walk independently with a walking aid, being in a stable medical condition, and adequate wound healing. The dependent variable recovery of function was assessed with the Modified Iowa Levels of Assistance scale. Delayed recovery was defined as taking more than 3 days to walk independently. Independent variables were age, sex, BMI, Charnley score, RAPT score	**Results:** Regression analysis with all variables identified older age (>70 years), Charnley score C, slow walking speed (10 mW >10.0 s) and poor functional mobility (TUG >10.5 s) as the best predictors of delayed recovery of function. This model (AUC 0.85, 95% CI 0.79-0.91) performed better than a model with conventional factors and RAPT scores, and significantly better (p = 0.04) than a model with only conventional factors (AUC 0.81, 95% CI 0.74-0.87).	**Study Limitations:** ☒ None **Non-Randomized Studies** ☐ Failure to develop and apply appropriate eligibility criteria ☐ Flawed measurement of both exposure and outcome ☐ Failure to adequately control confounding ☐ Incomplete or inadequately short follow-up

			and scores for four performance-based tests [2-minute walk test, timed up and go test (TUG), 10-meter walking test (10 mW) and hand grip strength].		
Author: Tan, C., et al. Year Published: 2014 Location: Singapore Journal: *Physiotherapy*	To explore the use of the Risk Assessment and Predictor Tool (RAPT) as a pre-operative tool to predict postoperative discharge destination and length of stay for patients undergoing total knee replacement (TKR) in Singapore.	**Size:** 569 **Inclusion Criteria**: Patients undergoing an elective primary TKR were included, regardless of whether the arthroplasty was a unilateral, bilateral or compartmental joint replacement **Exclusion Criteria**: Patients were excluded from the study if they were admitted for TKR due to trauma, congenital deformity or cancer.	**Type:** Prospective cohort study **Methods:** Total RAPT score and preferred discharge destination (PDD) were recorded pre-operatively, while actual discharge destination (ADDest) and length of stay (LOS) were obtained immediately after discharge. Multivariable logistic regression and multivariable regression analysis were used to determine whether the RAPT items and score could predict the discharge outcomes.	**Results**: Total RAPT score was a significant predictor of LOS for patients following TKR (R=0.24, P<0.001); the higher the RAPT score, the longer the LOS. Total RAPT score was also a significant predictor of actual discharge to home [odds ratio (OR) 2.32, 95% confidence interval (CI) 1.11 to 4.85]. PDD was a significant predictor for LOS (R=0.22, P<0.001) and ADDest (R=0.33, P<0.001). Patients who chose to be discharged home were more likely to be directly discharged home (OR 9.79, 95% CI 5.07 to 18.89, P<0.001).	**Study Limitations:** ☒ None **Non-Randomized Studies** ☐ Failure to develop and apply appropriate eligibility criteria ☐ Flawed measurement of both exposure and outcome ☐ Failure to adequately control confounding ☐ Incomplete or inadequately short follow-up

BODY OF EVIDENCE APPRAISAL TABLE FOR:
Modality: Spine Surgery
Tool: Frailty Indexes
Outcome: Accuracy of post-operative morbidity prediction
Included Studies: 3 non-randomized studies

Quality (certainty) of evidence for: (outcome)
☐ High
☐ Moderate
☐ Low
☒ Very Low

Risk of Bias across studies:	**Lower Quality Rating if:**	**Other Considerations:**
☒ High ☐ Medium ☐ Low	☒ Studies inconsistent (*wide variation of treatment effect across studies, population, interventions, or outcomes varied*)	Lower Quality Rating if: ☐ Publication Bias (*e.g. pharmaceutical company sponsors study on effectiveness of drug only small, positive studies found)*

		☐ Studies are indirect (*PICO question is quite different from the available evidence in regard to population, intervention, comparison, or outcome)* ☐ Studies are imprecise (*when studies include few patients and few events, and thus have wide confidence intervals, and the results are uncertain)*		Increase Quality Rating if: ☐ Large effect ☐ Dose-response gradient ☐ Plausible confounders or other biases increase certainty of effect	
Study Acronym; Author; Year Published; Location	**Aim of Study**	**Patient Population**	**Study Methods**	**Endpoint Results / Outcome (Absolute Event Rates, P values; OR or RR; & 95% CI)**	**Design Limitations**
Author: Ali, R., et al. Year Published: 2016 Location: USA Journal: *Journal of Neurosurgery Spine*	To determine whether the modified frailty index (mFI) was predictive of postoperative morbidity and mortality in a national sample of patients undergoing spine surgery.	**Size:** 18,294 patients **Inclusion Criteria**: The 2006–2010 ACS NSQIP data sets were used to identify the neurosurgical population undergoing spinal surgeries based on Current Procedural Terminology (CPT) codes and surgeon specialty.	**Type:** Retrospective chart review **Methods:** Sixteen preoperative clinical NSQIP variables were matched to 11 CSHA-FI variables (Non-independent functional status, history of diabetes mellitus, history of chronic obstructive pulmonary disease, history of congestive heart failure, history of myocardial infarction, history of percutaneous coronary intervention, cardiac surgery, or angina, hypertension requiring the use of medication, peripheral vascular disease or rest pain, impaired sensorium, transient ischemic attack or cerebrovascular accident w/o residual deficit, and Cerebrovascular accident w/ deficit) to make the mFI. The outcomes assessed were 30-day occurrences of adverse events. These were then summarized in groups: any infection, wound-related complication, Clavien IV complications (life-threatening, requiring ICU admission), and mortality.	**Results:** In 8.1% of patients with an mFI of 0 there was at least one morbid complication, compared with 24.3% of patients with an mFI of >= 0.27 ($p < 0.001$). An mFI of 0 was associated with a mortality rate of 0.1%, compared with 2.3% for an mFI of >= 0.27 ($p < 0.001$). Patients with an mFI of 0 had a 1.7% rate of surgical site infections and a 0.8% rate of Clavien IV complications, whereas patients with an mFI of >= 0.27 had rates of 4.1% and 7.1% for surgical site infections and Clavien IV complications, respectively ($p < 0.001$ for both). Multivariate analysis showed that the preoperative mFI and American Society of Anesthesiologists classification of >= III had a significantly increased risk of leading to Clavien IV complications and death. **TABLE 5. Dose-response relationship between ASA class and rate of complications in 18,279 patients** Relationship Btwn ASA Class & Rate of Complications Complications | ASA I & II | ASA III–V | p Value Clavien Grade IV | 0.48 | 1.29 | <0.001 Death | 0.06 | 0.43 | <0.001 **TABLE 3. Dose-response relationship between mFI and rate of complications in 18,294 patients** Relationship Btwn mFI & Rate of Complications Complications | Non-Frail | 0.09 | 0.18 | ≥0.27 | p Value Wound infection | 1.7 | 2 | 2.9 | 4.1 | <0.001 Clavien Grade IV | 0.8 | 1.9 | 3.7 | 7.1 | <0.001 Any type of infection | 8.1 | 12.3 | 16.1 | 24.3 | <0.001 Death | 0.1 | 0.3 | 1.1 | 2.3 | <0.001	**Study Limitations:** ☐ None **Non-Randomized Studies** ☐ Failure to develop and apply appropriate eligibility criteria ☒ Flawed measurement of both exposure and outcome ☒ Failure to adequately control confounding ☐ Incomplete or inadequately short follow-up

Author: Leven, D. M., et al. Year Published: 2016 Location: USA Journal: *Spine*	To analyze the utility of the modified Frailty Index (mFI) in predicting postoperative complications and mortality after surgery for adult spinal deformity (ASD) using the American College of Surgeons (ACS) National Surgical Quality Improvement Program (NSQIP)	**Size:** 1001 patients **Inclusion Criteria**: Adult patients (>= 18 years) undergoing spinal fusion for deformity were identified based on Current Procedural Terminology (CPT) codes **Exclusion Criteria**: missing preoperative data, emergencies, open wounds, current sepsis, pneumonia, cardiopulmonary resuscitation before surgery, prior surgery within 30 days, non-elective trauma, or neoplasm of the spine.	**Type:** Retrospective cohort study **Methods:** The American College of Surgeons NSQIP is a large multicenter clinical registry that prospectively collects preoperative variables, patient demographics, operative factors, and 30-day postoperative morbidity and mortality outcomes from about 400 hospitals nationwide. CPT codes were used to query the database for adults who underwent fusion for spinal deformity. The mFI was calculated based on the number of positive factors and univariate and multivariate logistic regression analysis were used to analyze the risk factors associated with mortality.	**Results:** The mean mFI score was 0.09 (range: 0–0.545). Increasing mFI score was associated with higher complication, reoperation, and mortality rates ($P < 0.05$). MFI of 0.09 and 0.18 was an independent predictor of any complication, mortality, requiring a blood transfusion, pulmonary embolism/deep vein thrombosis, and reoperation (all $P < 0.05$). In comparison with age >60 years obesity class III, mFI was a superior predictor of several postoperative complications and reoperation.	**Study Limitations:** ☐ None **Non-Randomized Studies** ☐ Failure to develop and apply appropriate eligibility criteria ☒ Flawed measurement of both exposure and outcome ☒ Failure to adequately control confounding ☐ Incomplete or inadequately short follow-up
Author: Miller, E. K., et al. Year Published: 2017 Location: USA Journal: *Neurosurgical Focus*	To analyze the value of an adult spinal deformity frailty index (ASD-FI) in preoperative risk stratification.	**Size:** 417 patients **Inclusion Criteria**: surgery for ASD between 2010 and 2014 for scoliosis (major curve ≥ 20°), thoracic kyphosis ≥60°, pelvic tilt ≥ 20°, or sagittal vertical axis (SVA) > 5 cm; and age≥ 18 years.	**Type:** Retrospective cohort **Methods:** Using 40 variables, the authors calculated frailty scores with a validated method for patients (enrolled between 2010 and 2014) with a minimum 2-year follow-up in an ASD database. On the basis of these scores, the authors categorized patients as not frail (NF) (< 0.3 points), frail (0.3-0.5 points), or severely frail (SF) (> 0.5 points). The correlation between frailty category and incidence of complications was analyzed.	**Results:** The overall mean ASD-FI score was 0.33 (range 0.0-0.8). Compared with NF patients (n = 183), frail patients (n = 158) and SF patients (n = 109) had longer mean hospital stays (1.2 and 1.6 times longer, respectively; $p < 0.001$). The adjusted odds of experiencing a major intraoperative or postoperative complication were higher for frail patients (OR 2.8) and SF patients (4.1) compared with NF patients ($p < 0.01$). The SF patients had higher odds of developing pseudarthrosis (OR 13.0), deep wound infection (OR 8.0), and wound dehiscence (OR 13.4) than NF patients ($p < 0.05$), and they had 2.1 times greater odds of reoperation ($p < 0.05$).	**Study Limitations:** ☐ None **Non-Randomized Studies** ☐ Failure to develop and apply appropriate eligibility criteria ☒ Flawed measurement of both exposure and outcome ☒ Failure to adequately control confounding ☐ Incomplete or inadequately short follow-up

BODY OF EVIDENCE APPRAISAL TABLE FOR:
Modality: Spine Surgery
Tool: Estimation of Physiological Ability and Surgical Stress (E-PASS) and Physiological and Operative Severity Score for the enUmeration of Mortality and Morbidity (POSSUM)
Outcome: Accuracy of post-operative morbidity prediction
Included Studies: 1 non-randomized

Quality (certainty) of evidence for: (outcome)
☐ High
☐ Moderate
☐ Low
☒ Very Low

Risk of Bias across studies:	**Lower Quality Rating if:**	**Other Considerations:**
☒ High ☐ Medium ☐ Low	☐ Studies inconsistent (*wide variation of treatment effect across studies, population, interventions, or outcomes varied*) **Not Applicable** ☐ Studies are indirect (*PICO question is quite different from the available evidence in regard to population, intervention, comparison, or outcome)* ☐ Studies are imprecise (*when studies include few patients and few events, and thus have wide confidence intervals, and the results are uncertain)*	Lower Quality Rating if: ☐ Publication Bias (*e.g. pharmaceutical company sponsors study on effectiveness of drug only small, positive studies found)* Increase Quality Rating if: ☐ Large effect ☐ Dose-response gradient ☐ Plausible confounders or other biases increase certainty of effect

Study Acronym; Author; Year Published; Location	Aim of Study	Patient Population	Study Methods	Endpoint Results / Outcome (Absolute Event Rates, P values; OR or RR; & 95% CI)	Design Limitations
Author: Hirose, J., et al. Year Published: 2014 Location: Japan Journal: *Journal of Neurosurgery Spine*	To assess the usefulness of the The Estimation of Physiological Ability and Surgical Stress (E-PASS) and Physiological and Operative Severity Score for the enUmeration of Mortality and Morbidity (POSSUM) algorithms and compared the predictive ability of both systems in patients with spinal disorders considered for surgery	**Size:** 601 consecutive patients **Inclusion Criteria**: The surgical procedures included laminoplasty and anterior fusion to treat cervical disorders (169 patients); posterior fusion for thoracic disorders (16 patients); laminectomy, posterior fusion, and discectomy for lumbar disorders (259 patients); resection of spinal tumors (117 patients); spinal fusion for scoliosis (27	**Type:** Retrospective cohort study **Methods:** The E-PASS system includes a preoperative risk score, a surgical stress score, and a comprehensive risk score that is determined by both the preoperative risk score and surgical stress score. The POSSUM system is composed of a physiological score and an operative severity score; its total score is based on both the physiological score and operative severity score. The authors calculated the E-PASS	**Results:** Postoperative complications developed in 64 patients (10.6%); there were no in-hospital deaths. All EPASS scores ($p <= 0.001$) and the operative severity score and total score of the POSSUM ($p < 0.03$) were significantly higher in patients with postoperative complications than in those without postoperative complications. The morbidity rates correlated linearly and significantly with all E-PASS scores ($p <= 0.001$); their coefficients (preoperative risk score, $p = 0.179$; surgical stress score, $p = 0.131$; and comprehensive risk score, $p = 0.198$) were higher than those for the POSSUM scores (physiological score, p =	**Study Limitations:** ☐ None **Non-Randomized Studies** ☐ Failure to develop and apply appropriate eligibility criteria ☒ Flawed measurement of both exposure and outcome ☐ Failure to adequately control confounding ☒ Incomplete or inadequately short follow-up

		patients); and curettage or spinal fusion for pyogenic spondylitis (13 patients).	and POSSUM scores for 601 consecutive patients who had undergone spinal surgery and investigated the relationship between the individual scores of both systems and the incidence of postoperative complications. They also assessed the correctness of the predicted morbidity rate of both systems.	0.059; operative severity score, p = 0.111; and total score, p = 0.091). The area under the receiver operating characteristic curve for the predicted morbidity rate was 0.668 for the E-PASS and 0.588 for the POSSUM system.	

BODY OF EVIDENCE APPRAISAL TABLE FOR:
Modality: Spine Surgery
Tool: the American Society of Anesthesiologists (ASA) score
Outcome: Accuracy of post-operative morbidity prediction
Included Studies: 1 non-randomized

Quality (certainty) of evidence for: (outcome)
☐ High
☐ Moderate
☐ Low
☒ Very Low

Risk of Bias across studies:	**Lower Quality Rating if:**	**Other Considerations:**
☒ High ☐ Medium ☐ Low	☐ Studies inconsistent (*wide variation of treatment effect across studies, population, interventions, or outcomes varied*) **Not applicable** ☐ Studies are indirect (*PICO question is quite different from the available evidence in regard to population, intervention, comparison, or outcome)* ☐ Studies are imprecise (*when studies include few patients and few events, and thus have wide confidence intervals, and the results are uncertain)*	Lower Quality Rating if: ☐ Publication Bias (*e.g. pharmaceutical company sponsors study on effectiveness of drug only small, positive studies found)* Increase Quality Rating if: ☐ Large effect ☐ Dose-response gradient ☐ Plausible confounders or other biases increase certainty of effect

Study Acronym; Author; Year Published; Location	**Aim of Study**	**Patient Population**	**Study Methods**	**Endpoint Results / Outcome (Absolute Event Rates, P values; OR or RR; & 95% CI)**	**Design Limitations**

Author: Phan, K., et al. Year Published: 2017 Location: Australia Journal: *Spine*	To assess the American Society of Anesthesiologists (ASA) score as an independent predictor of 30-readmissions after anterior cervical discectomy and fusion (ACDF).	**Size:** 1701 **Inclusion Criteria**: Patients undergoing elective ACDF older than 18 years **Exclusion Criteria**: patients who underwent spinal deformity surgery, dependent on ventilator, disseminated cancer, radiotherapy for malignancy, pregnancy, tumors of the central nervous system, chemotherapy, emergency operations, preoperative sepsis, acute renal failure, non-elective procedures, combined approaches, posterior approach, patients with missing preoperative data, and underweight patients(body mass index, BMI < 18.5 kg/m2).	**Type:** Retrospective cohort study **Methods:** Data collected for the American College of Surgeons National Surgical Quality Improvement Program (ACS-NSQIP) database in the period 2005 to 2012 were used in the present analysis. Current Procedural Terminology codes were used to identify elective ACDF cases (CPT codes: 22551, 22554, and 63075). The primary study outcome was 30-day readmission rates after elective ACDF in adults. Univariate and multivariate analysis was used to determine whether any of age, sex, race, body mass index, comorbidities, operative variables, or ASA class were predictors of 30-day readmission rates after ACDF.	**Results:** Using ASA class 1 as a reference, significant independent predictors of 30 day readmission included being in ASA class 4 [odds ratio (OR) 5.7; 95% confidence interval (CI) 0.58-56.7; P = 0.039], having cardiac comorbidities (OR 2.2; 95% CI 1.2-4.2; P = 0.017), and prior strokes (OR 3.8; 95% CI 1.4-10.1; P = 0.0086).	**Study Limitations:** ☐ None **Non-Randomized Studies** ☐ Failure to develop and apply appropriate eligibility criteria ☒ Flawed measurement of both exposure and outcome ☒ Failure to adequately control confounding ☐ Incomplete or inadequately short follow-up

BODY OF EVIDENCE APPRAISAL TABLE FOR:
Modality: Spine Surgery
Tool: Risk Assessment Tool (RAT) for spinal surgery
Outcome: Accuracy of post-operative morbidity prediction
Included Studies: 1 non-randomized

Quality (certainty) of evidence for: (outcome)
☐High
☐ Moderate
☐ Low
☒ Very Low

Risk of Bias across studies: ☐ High ☒ Medium ☐ Low		**Lower Quality Rating if:** ☐ Studies inconsistent (*wide variation of treatment effect across studies, population, interventions, or outcomes varied*) **Not applicable** ☐ Studies are indirect (*PICO question is quite different from the available evidence in regard to population, intervention, comparison, or outcome)* ☒ Studies are imprecise (*when studies include few patients and few events, and thus have wide confidence intervals, and the results are uncertain)*		**Other Considerations:** Lower Quality Rating if: ☐ Publication Bias (*e.g. pharmaceutical company sponsors study on effectiveness of drug only small, positive studies found)* Increase Quality Rating if: ☐ Large effect ☐ Dose-response gradient ☐ Plausible confounders or other biases increase certainty of effect	
Study Acronym; Author; Year Published; Location	**Aim of Study**	**Patient Population**	**Study Methods**	**Endpoint Results / Outcome (Absolute Event Rates, P values; OR or RR; & 95% CI)**	**Design Limitations**
Author: Veeravagu, A., et al. Year Published: 2017 Location: USA Journal: *Journal of Neurosurgery Spine*	To prospectively validate the Risk Assessment Tool (RAT) for spinal surgery.	**Size:** 246 **Inclusion Criteria**: patients undergoing spine surgery procedures in neurosurgery and orthopedics	**Type:** Prospective cohort study **Methods:** The spinal Risk Assessment Tool (RAT), a novel instrument for the assessment of risk for patients undergoing spine surgery that was developed based on an administrative claims database, was prospectively applied to 246 patients undergoing 257 spinal procedures over a 3-month period. Prospectively collected data were used to compare the RAT to the Charlson Comorbidity Index (CCI) and the American College of Surgeons National Surgery Quality Improvement Program (ACS NSQIP) Surgical Risk Calculator. Study end point was occurrence and type of complication after spine surgery.	**Results:** The authors identified 69 patients (73 procedures) who experienced a complication over the prospective study period. Cardiac complications were most common (10.2%). Area under the curve (AUC) analysis showed comparable predictive accuracy between the RAT and the ACS NSQIP calculator (0.670 [95% CI 0.60-0.74] in RAT, 0.669 [95% CI 0.60-0.74] in NSQIP). The CCI was not accurate in predicting complication occurrence (0.55 [95% CI 0.48-0.62]). The RAT produced mean probabilities of 34.6% for patients who had a complication and 24% for patients who did not (p = 0.0003). The generated predicted values were stratified into low, medium, and high rates. For the RAT, the predicted complication rate was 10.1% in the low-risk group (observed rate 12.8%), 21.9% in the medium-risk group (observed 31.8%), and 49.7% in the high-risk group (observed 41.2%). The ACS NSQIP calculator consistently produced complication predictions that underestimated complication occurrence: 3.4% in the low-risk group (observed 12.6%), 5.9% in the medium-risk group (observed 34.5%), and 12.5% in the high-risk group (observed 38.8%). The RAT was more accurate than the ACS NSQIP calculator (p = 0.0018).	**Study Limitations:** ☐ None **Non-Randomized Studies** ☐ Failure to develop and apply appropriate eligibility criteria ☐ Flawed measurement of both exposure and outcome ☒ Failure to adequately control confounding ☐ Incomplete or inadequately short follow-up

BODY OF EVIDENCE APPRAISAL TABLE FOR:
Modality: Spine Surgery
Tool: Morphometircs
Outcome: Accuracy of post-operative morbidity prediction
Included Studies: 1 non-randomized

Quality (certainty) of evidence for: (outcome)
☐ High
☐ Moderate
☐ Low
☒ Very Low

Risk of Bias across studies:	**Lower Quality Rating if:**	**Other Considerations:**
☒ High ☐ Medium ☐ Low	☐ Studies inconsistent (*wide variation of treatment effect across studies, population, interventions, or outcomes varied*) **Not Applicable** ☐ Studies are indirect (*PICO question is quite different from the available evidence in regard to population, intervention, comparison, or outcome)* ☐ Studies are imprecise (*when studies include few patients and few events, and thus have wide confidence intervals, and the results are uncertain)*	Lower Quality Rating if: ☐ Publication Bias (*e.g. pharmaceutical company sponsors study on effectiveness of drug only small, positive studies found)* Increase Quality Rating if: ☐ Large effect ☐ Dose-response gradient ☐ Plausible confounders or other biases increase certainty of effect

Study Acronym; Author; Year Published; Location	Aim of Study	Patient Population	Study Methods	Endpoint Results / Outcome (Absolute Event Rates, P values; OR or RR; & 95% CI)	Design Limitations
Author: Zakaria, H. M., et al. Year Published: 2015 Location: USA Journal: *Neurosurgical Focus*	To evaluate whether morphometrics can be applied to the cases of patients undergoing lumbar spine surgery.	**Size:** 395 **Inclusion Criteria**: all patients who had undergone lumbar surgery (T-11 through S-1, inclusive)	**Type:** Retrospective cohort study **Methods:** The authors performed a retrospective review of the perioperative course of patients who underwent lumbar surgery. Preoperative risk factors such as age, diabetes, smoking, coronary artery disease, and body mass index (BMI) were recorded. Preoperative MRI was used to measure the psoas muscle area at the L-4 vertebra and paraspinal muscle area at the T-12 vertebra. Primary outcomes included unplanned return to the	**Results:** The overall rate of adverse events was 30%, the most common event being urinary retention (12%). Greater age (p = 0.015) and tobacco usage (p = 0.026) were both significantly associated with complications for all patients, while diabetes, coronary artery disease, and high BMI were not. No surgery-related characteristics were associated with postoperative morbidity, including whether surgery required instrumentation, whether it was a revision, or the number of vertebral levels treated. **Using multivariate regression analysis, male and female patients with the lowest psoas tertile had an OR of 1.70 (95% CI 1.04-2.79, p = 0.035) for having postoperative complications. Male patients in the lowest psoas tertile had**	**Study Limitations:** ☐ None **Non-Randomized Studies** ☐ Failure to develop and apply appropriate eligibility criteria ☒ Flawed measurement of both exposure and outcome ☒ Failure to adequately control confounding ☐ Incomplete or inadequately short follow-up

			operating room, 30- and 90-day readmissions, surgical site infection, wound dehiscence, new neurological deficit, deep vein thrombosis, pulmonary embolism, myocardial infarction, urinary tract infection, urinary retention, hospital-acquired pneumonia, stroke, and prolonged stay in the intensive care unit.	**an OR of 2.42 (95% CI 1.17-5.01, p = 0.016) for having a postoperative complication. The paraspinal muscle groups did not provide any significant data for postoperative morbidity, even after multivariate analysis.**	

2. What is the predictive accuracy of the Risk Assessment and Prediction Tool [RAPT] for discharge disposition in patients undergoing joint surgery in comparison to patients undergoing spine surgery?

BODY OF EVIDENCE APPRAISAL TABLE FOR:
Modality: RAPT tool
Outcome: Predictive accuracy of discharge disposition
Studies Included: 1 non-randomized study

Quality (certainty) of evidence for: (outcome)
☐ High
☐ Moderate
☐ Low
☒ Very Low

Risk of Bias across studies:	**Lower Quality Rating if:**	**Other Considerations:**
☐ High ☒ Medium ☐ Low	☐ Studies inconsistent (*wide variation of treatment effect across studies, population, interventions, or outcomes varied*) **-N/A** ☐ Studies are indirect (*PICO question is quite different from the available evidence in regard to population, intervention, comparison, or outcome)* ☒ Studies are imprecise (*when studies include few patients and few events, and thus have wide confidence intervals, and the results are uncertain)*	Lower Quality Rating if: ☐ Publication Bias (*e.g. pharmaceutical company sponsors study on effectiveness of drug only small, positive studies found)* Increase Quality Rating if: ☐ Large effect ☐ Dose-response gradient ☐ Plausible confounders or other biases increase certainty of effect

Study Acronym; Author; Year Published; Location	**Aim of Study**	**Patient Population**	**Study Methods**	**Endpoint Results / Outcome (Absolute Event Rates, P values; OR or RR; & 95% CI)**	**Design Limitations**
Author: Slover, J., et al. Year Published: 2017 Location: NYU	The purpose of this study was to evaluate the relationship between the Risk Assessment and Predictor Tool (RAPT) and	**Size:** 767 patients (535 primary unilateral total joint arthroplasty; 150 cardiac valve replacement; 82 spinal fusions)	**Type:** Prospective cohort study	**Results:** 70.5% of total joint patients, 80.7% of cardiac valve surgery patients and 70.7% of spine surgery patients were	**Study Limitations:** ☐ None **Non-Randomized Studies**

Journal: *International Journal Of Surgery*	patient discharge disposition in an institution participating in bundled payment program for total joint replacement, spine fusion and cardiac valve surgery patients.	**Inclusion Criteria**: all patients in the institution's bundled payment program	**Methods:** RAPT scores of patients (535 primary unilateral total joint arthroplasty; 150 cardiac valve replacement; 82 spinal fusions) were prospectively captured. Total RAPT scores were grouped into three levels for risk of complications: <6 = 'high risk', between 6 and 9 = 'medium risk', and >9 = 'low risk' for discharge to a post-acute facility. Associations between RAPT categories and patient discharge to home versus any facility were conducted. Multivariate analysis was performed to determine if there was any correlation between RAPT score and discharge to any facility.	discharged home rather than to a post-acute facility. RAPT risk categories were related to discharge disposition as 72% of those in the high risk group were discharged to a facility and 91% in the low risk group were discharged to home in the total joint replacement cohort. In the cardiac cohort, only 33% of the high risk group was discharged to a facility, and 94% of the low risk group was discharged to home. In the spinal fusion cohort, 60% of those in the high risk group were discharged to a facility and 86% in the low risk group were discharged to home. Multivariate analysis showed that being in the high risk category versus low risk category was significantly associated with substantially increased odds of discharge to a facility.	☐ Failure to develop and apply appropriate eligibility criteria ☐ Flawed measurement of both exposure and outcome ☒ Failure to adequately control confounding ☐ Incomplete or inadequately short follow-up

Developed by the GRADE Working Group

Grades and interpretations:

High: Further research is very unlikely to change our confidence in the estimate of effect.
Moderate: Further research is likely to have an important impact on our confidence in the estimate of effect and may change the estimate.
Low: Further research is very likely to have an important impact on our confidence in the estimate of effect and is likely to change the estimate.
Very low: Any estimate of effect is very uncertain.

Type of evidence and starting level

Randomized trial–high
Observational study–low

Any other evidence–very low

Criteria for increasing or decreasing level

Reductions Study quality has serious (–1) or very serious (–2) problems Important inconsistency in evidence (–1) Directness is somewhat (–1) or seriously (–2) uncertain Sparse or imprecise data (–1) Reporting bias highly probable (–1) **Increases** Evidence of association† strong (+1) or very strong (+2) †Strong association defined as significant relative risk (factor of 2) based on consistent evidence from two or more studies with no plausible confounders Very strong association defined as significant relative risk (factor of 5) based on direct evidence with no threats to validity.