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Clinical Study

Frailty status as a predictor of 3-month cognitive and functional recovery following spinal surgery: a prospective pilot study

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Abstract

BACKGROUND CONTEXT: As increasing numbers of elderly Americans undergo spinal surgery, it is important to identify which patients are at highest risk for poor cognitive and functional recovery. Frailty is a geriatric syndrome that has been closely linked to poor outcomes, and short-form screening may be a helpful tool for preoperative identification of at-risk patients.

PURPOSE: This study aimed to conduct a pilot study on the usefulness of a short-form screening tool to identify elderly patients at increased risk for prolonged cognitive and functional recovery following elective spine surgery.

STUDY DESIGN/SETTING: This is a prospective, comparative cohort study.

PATIENT SAMPLE: The sample comprised 100 patients over age 65 who underwent elective spinal surgery (cervical or lumbar) at a single, large academic medical center from 2013 to 2014.

OUTCOME MEASURES: Fatigue, Resistance, Ambulation, Illnesses, Loss of Weight (FRAIL) scale, Postoperative Quality of Recovery Scale (PQRS), and instrumental activities of daily living (IADL) scores were the outcome measures.

METHODS: Included patients were assessed with the FRAIL scale and stratified as robust, pre-frail, or frail. The PQRS and IADL scores were also obtained. Patients were re-examined at 1 day, 3 days, 1 month, and 3 months after surgery for cognitive recovery at 3 months, and secondarily, functional recovery at 3 months.

RESULTS: At 3 months, only 50% of frail patients had recovered to their cognitive baseline compared with 60.7% of pre-frail and 69.2% of robust patients (trend). At 3 months, 66.7% of frail patients had recovered to their functional baseline compared with 57% of pre-frail and 76.9% of robust patients (trend). Using multivariate regression modeling, at 3 months, frail patients were less likely to have recovered to their cognitive baseline compared with pre-frail and robust patients (odds ratio 0.39, confidence interval 0.131–1.161).

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CONCLUSIONS: This pilot study demonstrates a trend toward poorer cognitive recovery 3 months following elective spinal surgery for frail patients. Frailty screening can help preoperatively identify patients who may experience protracted cognitive and functional recovery.

Keywords: Cognitive recovery; Elderly spinal surgery; Frailty; Functional recovery; Geriatric spinal surgery; Spinal rehabilitation

Introduction

Elective spinal surgery on patients over 65 years of age has become increasingly common. There will be a continued increase in spine surgery in this age group due to the demographics of the US population. From 1990 to 2004 there has been a 28-fold increase in cervical spine fusion procedures, and in the United States in 2007, 1.6 billion dollars were spent on lumbar spine surgery in the elderly [1,2]. Older spine surgery patients are at increased risk for protracted or partial cognitive and functional recovery [3]. Postoperative cognitive decline is an insidious and common problem in the elderly, which affects approximately 13% of patients at 3 months after surgery [4]. In turn, a decline in cognition can be associated with falls and decreased ability to comply with medications and rehabilitation, which impedes even further a patient's recovery [5–8].

Given the number of older adults who undergo spine surgery, identification of patients at high risk for protracted recovery is very important. Prior studies have shown that the American Society of Anesthesiologists (ASA) Physical Status Classification System can be a useful measure of comorbidity to predict complications in a younger adult cohort [8–10]. The presence of medical comorbidities, however, may not be the best way to identify which prospective elderly spine surgery patients are at risk for prolonged recovery [11,12]. After all, medical comorbidities are present in greater than 75% of patients over the age of 65 [13]. There is an emerging literature that suggests that frailty is a more holistic view of health status and might better describe the elderly patient's physiological reserve and ability to withstand the stress of surgery [13,14].

Frailty is a geriatric syndrome characterized by weakness and fatigue [15]. It transcends age and comorbidity to describe the overall health status of the individual. The traditional screen for frailty is performed by a geriatrician and includes tests for physical strength, such as walking and grip strength. Given the constraints of the preoperative period, however, the ideal frailty screening tool must be brief and able to be administered by physician extenders or perioperative physicians. Recently, short-form frailty screening tools amenable to use by non-geriatricians have been employed in the perioperative setting. The Fatigue, Resistance, Ambulation, Illnesses, Loss of Weight (FRAIL) scale is a simplified five-point questionnaire that can be administered over the phone [16]. As a screening tool, this questionnaire has been shown to correlate strongly with cognitive and physical decline as well as mortality in a broad array of surgical groups [17]. To date, there has been no prospective study that has used the FRAIL scale in spine surgery patients.

Better risk stratification for elderly spine surgery patients has the potential to influence treatment planning and allocation of surgical resources, and thereby improve postoperative outcomes. To address whether short-form frailty screening can predict recovery of postoperative cognition, activities of daily living (ADL), and instrumental activities of daily living (IADL), we conducted a prospective cohort study of 100 patients over 65 years of age who underwent elective cervical and lumbar surgery. Our hypothesis was that a patient's frailty status before surgery is associated with worse cognitive recovery. Secondarily, we assessed whether baseline frailty is associated with worse functional recovery. If so, this information could be used for clinical decision-making, patient counseling, and allocation of preoperative and postoperative resources to improve patient outcomes and to help minimize unnecessary morbidity associated with surgery.

Methods

This prospective cohort study was approved by the Mount Sinai Institutional Review Board (HS#: 14–00429, GCO#:1:14–1224) from 2013 to 2014. Subjects were recruited from the Mount Sinai Electronic Scheduling system with the agreement of the patient's surgeon. See Fig. 1 for inclusion and exclusion criteria.

Measurements

Data were collected at baseline and then at four time points after surgery: day 1, day 3, 1 month, and 3 months (Fig. 2). In addition to demographic, medical, and surgical data, three instruments were used to assess recovery.

The FRAIL scale is a five-point frailty screening tool validated by Morley et al. which operationalizes frailty as (1) fatigue over the past 4 months, (2) ability to climb a flight of stairs unassisted, (3) ability to walk two blocks unassisted, (4) medical comorbidities, and (5) loss of weight. Each component makes up one point and the total score is considered as follows: 0, robust health status; 1–2, pre-frail; and 3–5, frail.

The Postoperative Quality of Recovery Scale (PQRS) measures recovery after surgery from baseline, and examines cognitive recovery and ADL. Activities of daily living recovery is defined as return to baseline score or better. Cognitive

Inclusion criteria

- Age 65 years and older
- ASA status I-III
- English literacy

Exclusion criteria

- Metastatic disease
- Past intracranial surgery or recent cardiac surgery (within 1 year)
- End stage renal failure (eGFR<15mL/min/1.73m^2)
- End stage liver failure (serum bilirubin > 300μmol/L)
- Severe baseline cognitive impairment based on cognitive component of the postoperative quality of recovery score (PQRS)
  - Orientation (C1): <3
  - Numbers forward (C2): <3
  - Numbers backward (C3): <2
  - Word recall (C4): <4
  - Word generation (C5): <4
- Significant psychiatric history
- Severe hearing or vision impairment (which have not been corrected)
- Parkinson's disease
- Stroke with residual deficit

Fig. 1. Inclusion and exclusion criteria. eGFR, estimated glomerular filtration rate.

recovery is defined as a return to the patient's baseline score, allowing for a two-point tolerance factor. The Alzheimer's Disease Research Center IADLs are a more granular tool used to assess complex function.

Before surgery, included patients were contacted by telephone. Informed consent was obtained and demographic data were gathered in addition to baseline data with all three scales. The PQRS cognition and ADL questions were repeated at day

	Pre-op (between 30 days and 24 hours)	Post-op day 1	Post-op day 3	Post-op 1 month	Post-op 3 months
Consent	X				
PQRS	X	X	X	X	X
RUI	X				X
ADCS/MCI/ADL24	X			X	X
FRAIL Scale	X				X

Fig. 2. Testing schedule for data collection. ADCS, Alzheimer's Disease Cooperative Study; ADL, activities of daily living; FRAIL, Fatigue, Resistance, Ambulation, Illnesses, Loss of Weight; MCI, mild cognitive impairment; PQRS, Postoperative Quality of Recovery Scale; RUI, Resource Utilization Interview.

3, and 1 and 3 months after surgery. The Alzheimer's Disease Research Center IADL scale was repeated at 1 and 3 months after surgery. The data were stored and managed using Research Electronic Data Capture (REDCAP) tools hosted at Mount Sinai.

Analysis

We performed a univariate comparison at each of the three time points of the proportion of patients who were judged as cognitively "recovered," and covariates (demographics such as age, gender, education, and surgical procedure) in the frail, pre-frail, and robust groups. We then created a logistic regression model via backward selection with the outcome of cognitive recovery at 3 days and 3 months after surgery, using predictors that were identified a priori and at least moderately associated with the outcome (p<.15). These were age, diabetes mellitus, baseline ADL score, PQRS C1, PQRS C2, PQRS C3, PQRS C4, and PQRS C5.

We also performed a secondary analysis with a univariate comparison of the proportion of patients who recovered their ADLs and select IADLs. We then created a logistic regression model via backward selection with the outcome of ADL recovery at 3 days and 3 months after surgery, using predictors that were identified a priori and at least moderately associated with the outcome (p<.15). These were age; gender; ASA level; body mass index; diabetes status; hypertension status; cancer history; PQRS C2, C3, C4, and C5; surgical procedure; frailty status; and education level.

Results

Among the 100 patients enrolled, there were 51 cervical and 49 lumbar surgeries. Of these, 87 patients completed 3-month testing, with 7 patients dropping out because of postponement, change, or cancellation of surgery; death; voluntary withdrawal; or loss to follow-up (see Fig. 3). For the 87 patients who remained in the study, all required data points were completed.

Baseline demographic data are presented in Table 1. The median age was 71 years old (interquartile range [IQR] 67–76), and 63% were male. Only 26% of patients were robust before surgery, 56% were pre-frail, and 18% were frail. Our cohort was predominantly white and well educated (65% went to college). The vast majority of patients had at least one medical comorbidity, and the comorbidities were classified as ASA II (defined as presence of systemic conditions that do not affect function, 58%), or ASA III (systemic conditions that do affect function, 39%).

Surgical data are presented in Table 2. Most operations performed were instrumented (76%) versus laminectomy without instrumentation (24%). Median surgical and anesthetic duration were 168 minutes (116.75–253.25) and 263.5 minutes (207.75–367.25), respectively. The median number of levels for fusions was 2 (IQR 1–3.75) and for laminectomy

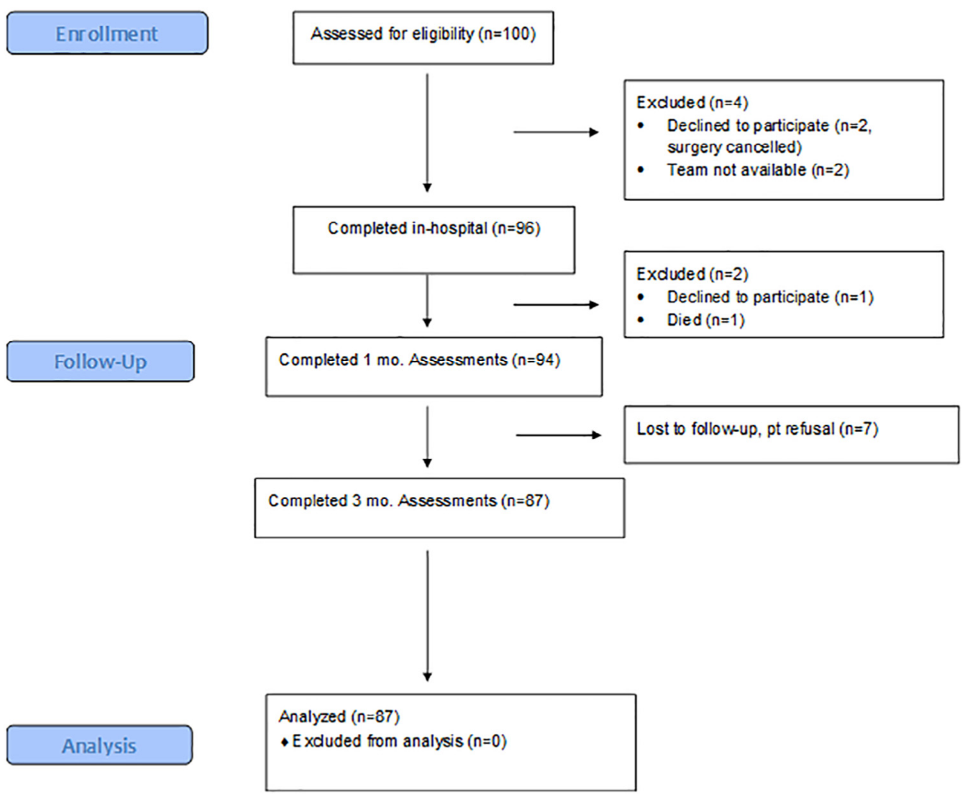

Fig. 3. CONSORT flow diagram. CONSORT, Consolidated Standards of Reporting Trials.

Table 1
Baseline demographic data

	Number	%/IQR
Gender		
Male	63	63.00%
Female	37	37.00%
Age		
Median	71	67,76
Marital status		
Married	61	61.00%
Divorced	16	16.00%
Widowed	11	11.00%
Never married	10	10.00%
Separated	1	1.00%
Unknown	1	1.00%
Race		
Black or African American	16	16.00%
White	80	80.00%
Asian	4	4.00%
American Indian/Alaska Native	0	0.00%
Native Hawaiian or other Pacific Islander	0	0.00%
Years of education		
Did not finish high school (<12 y)	6	6.00%
Finished high school	25	25.00%
Some college	8	8.00%
Finished college	16	16.00%
Graduate work	41	41.00%
Unknown	4	4.00%
Primary language		
English	94	94.00%
Spanish	2	2.00%
Other	4	4.00%
BMI (kg/m^2)		
Underweight (<18.5)	1	1.00%
Normal weight (18.5–24.9)	19	19.00%
Overweight (25–29.9)	53	53.00%
Obese (30–34.9)	19	19.00%
Severely obese (35–39.9)	6	6.00%
Unknown	2	2.00%
ASA status		
1	1	1.00%
2	58	58.00%
3	39	39.00%
Unknown	2	2.00%
Frailty status at baseline		
Robust health	26	26.00%
Pre-frail	56	56.00%
Frail	18	18.00%

ASA, American Society of Anesthesiologists physical status classification scale; BMI, body mass index; IQR, interquartile range.

was 3 (IQR 2–4). The majority of cervical procedures (76.5%) were via a posterior approach (posterior cervical laminectomy and fusion or cervical laminoplasty), which requires more extensive muscle dissection than anterior discectomy and fusion, and has resultant increased associated pain and in-hospital recovery time. Elderly patients typically have multilevel cervical pathology, which traditionally favors a posterior approach. All lumbar procedures were via a posterior approach (no anterior lumbar interbody fusions).

Table 2
Surgical data

	Number	%/IQR
Duration of surgery (median, min)	168	116.8–253.3
Duration of anesthesia (median, min)	263.5	207.8–367.3
Cervical surgery	51	51%
Anterior cervical fusion	12	23.5%
Posterior cervical fusion	26	51.0%
Posterior cervical laminoplasty	11	21.6%
Posterior cervical, not instrumented	2	3.9%
Lumbar surgery	49	49%
Posterior lumbar, not instrumented	22	44.9%
Posterior lumbar fusion	27	55.1%
Extent of surgery		
Average no. of spinal levels, instrumented	2	1–4
Average no. of spinal levels, not instrumented	3	2–4

IQR, interquartile range.

Frailty and cognitive recovery

Fig. 4 shows the percent that patients recovered in cognition, ADLs, and IADLs at three time points for robust, pre-frail, and frail patients. Upon univariate comparison, the robust and pre-frail group had a larger proportion of patients who demonstrated cognitive recovery at 3 days after surgery (50.0% and 48.2%, respectively) versus frail patients (33.3%). At 3 months, fewer frail patients were at their baseline (50.0%) versus pre-frail and robust patients (60.7% and 69.2%, respectively). These differences, however, were trends and not statistically significant.

Using a multivariate logistic regression model, several associations were identified as predictive of cognitive recovery at 3 days and 3 months. At 3 days, patients who had cervical surgery were less likely to be recovered compared with patients who had lumbar surgery (odds ratio [OR] 0.23, confidence interval [CI] 0.079–0.66); patients with higher BMI were less likely to have recovered (OR 0.88, CI 0.78–0.99); and patients with lower baseline performance on the C3 (numbers backward) test from the PQRS (OR 0.53, CI 0.37–0.77) were associated with decreased odds of cognitive recovery. At 3 months, patients who were frail were less likely to have recovered to their cognitive baseline (compared with pre-frail and robust patients). However, this was not statistically significant (OR 0.39, CI 0.131–1.161).

Frailty and functional recovery

Functional recovery was measured using the ADL component of the PQRS, with recovery defined as a return to the baseline score. Upon univariate comparison, the robust and frail group had a larger proportion of patients recovered at 3 days (34.6% and 33.3%, respectively) versus pre-frail patients (21.4%). The frail and robust group continued to improve at 3 months (66.7% and 76.9%, respectively). The pre-frail (57.0%) group, however, had plateaued. These differences were not statistically significant.

Using a multivariate logistic regression model, at postoperative day 3, patients with higher baseline ADLs were less

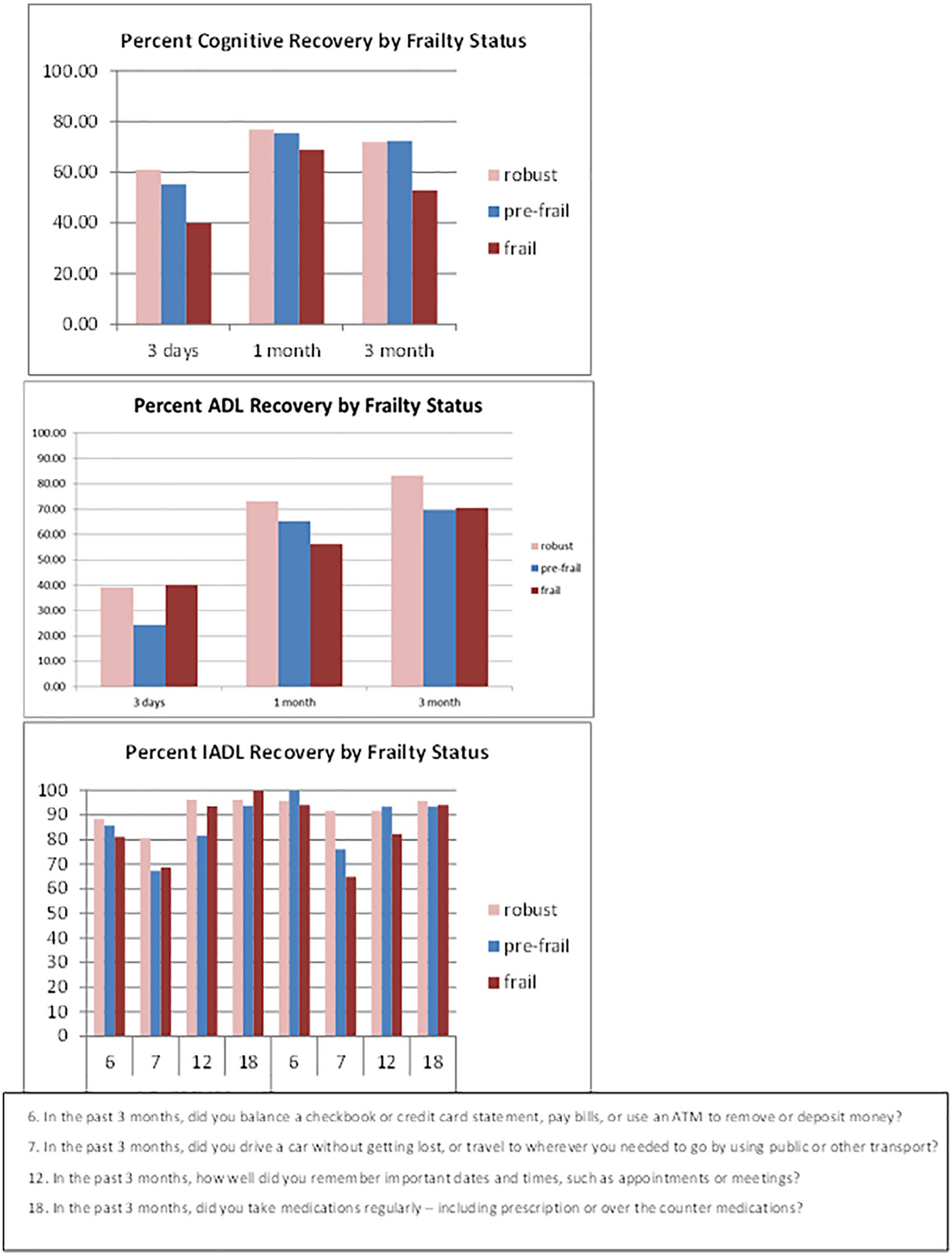

Fig. 4. Recovery of cognition, ADLs, IADLs by frailty status at 3 days, 1 month, and 3 months after surgery. ADLs, activities of daily living; IADLs, instrumental activities of daily living.

likely to have recovered (OR 0.65, CI 0.47–0.89). Several associations were identified as trends. Patients who were pre-frail were less likely to have recovered their ADLs compared with patients who were frail or robust (OR 0.43, CI 0.16–1.17), which was not statistically significant. Patients with higher educational levels were more likely to have recovered their ADLS (OR 1.33, CI 0.95–1.88). At 3 months, odds of recovery of ADLs were lower with higher baseline ADLs (OR 0.55, CI 0.34–0.90), which was statistically significant. Patients who were frail and pre-frail were less likely to have recovered compared with patients who were robust (OR 0.2, CI 0.37–1.10 and OR 0.32, CI 0.087–1.17, respectively).

In terms of IADLs, only some questions seemed to stratify by frailty status. Some examples are presented in Fig. 4. For example, driving is a skill more quickly recovered by robust patients versus frail. In contrast, the ability to self-administer medications and manage money was similar in all three groups at 1 and 3 months.

Discussion

Our study found that frailty is related to cognitive and functional recovery (ADLs) after surgery. Frail patients recover more slowly, and a higher proportion of them do not recover compared with robust patients. Regarding ADLs, a similar proportion of frail versus robust patients were able to return to their baseline ADL status, but the frail patients had statistically lower ADL scores at baseline (ie, easier to recover a low level of function). Notably, IADLs were different among frailty groups, with more cerebral functions self-reported as recovered (medications, money management), in contrast to more physical activities such as driving and transport.

An important consideration when examining return to functional baseline following elective spinal surgery stems from the goals of treatment and indication for surgery. Generally, the indications for elective spinal surgery are significant pain and weakness that impede functional ability and quality of life. Thus, the decision for spinal surgery often implies a baseline functional impairment. The goal of surgery should be to get the patient to return to or surpass his or her preoperative baseline. A failure to return to baseline is therefore particularly significant for spinal surgery, and indeed, perhaps a return to baseline alone may not represent true recovery. This study, however, did not specifically examine surgical indications, which would be worth examining in the future.

As with frailty's relationship to many other disease states, there is overlap between the signs and symptoms of frailty and those of disability associated with spine disorder. This likely helps explain the high prevalence of pre-frail and frail patients in our study. Such overlap introduces a potential confounding effect, given that symptoms associated with spine disorder would hopefully improve after surgery, and may represent a modifiable rather than fixed characteristic. Still, we think that the holistic approach of frailty, which has been demonstrated across many different disease states, is an effective and validated metric and useful in the setting of spine patients.

Our study is one of the most nuanced studies of the relationship of frailty to outcomes in spine surgery. To date, this is the first study to look at frailty, function, and cognition. In the spine literature, several studies have associated frailty with postoperative complications such as wound infection and need for reoperation. In a large cohort of 3,920 patients from the NSQIP database, Phan et al. found that frailty is associated with increased surgical morbidity for patients who underwent anterior lumbar interbody fusion [18,19]. Miller et al. found that frailty status is associated with increased risk for major intra- and postoperative complications in 417 patients who underwent adult spinal deformity surgery [20]. Ours is the first study, however, to prospectively investigate the role of frailty status in relationship to cognitive and postsurgical recovery in spine surgery.

With respect to the greater literature of frailty and outcomes, our findings are in agreement with Mitnitski et al. who found that frail patients were more likely to demonstrate cognitive decline over time [21]. Similarly, Armstrong et al. found that frailty predicts a decline in cognition in a community dwelling cohort of older men [22]. These studies each used a different method to measure cognition, and had much longer follow-up period (years) than our study. Compared with these studies, our patients had more comorbidities and all underwent surgery, which may have made them more likely to experience cognitive decline over a shorter period of time. It is also important to note that in our study (and the previous literature), cognitive decline was a relatively subtle finding only discovered on neuropsychiatric testing. In all of these studies, the patient's subjective experience of his or her cognition was not measured, and it may be interesting to investigate whether patients perceived a sense of impairment. Whether our frail patients' cognition would improve or decline over a longer follow-up period is unclear and merits study in the future.

Frailty has also been shown to be a risk factor for further functional decline. Medina-Mirapeix et al. found that frail patients who were hospitalized for acute chronic obstructive pulmonary disease exacerbation were more likely than other groups to demonstrate functional decline 3 months after hospitalization [23]. In contrast, our frail patients appeared to be less vulnerable to functional decline from their baseline. This baseline function, however, was relatively low, and may have been subject to floor effects (ie, difficult to decline when baseline scores are already low). This was still clinically relevant, however, as only two-thirds of frail patients were recovered to baseline function at 3 months after surgery.

Interestingly, our study demonstrated that the pre-frail patients took longer to recover, and fewer recovered overall in terms of ADLs relative to the robust and frail groups. Whether additional intervention such as prehabilitation or targeted physical therapy could help these individuals recover more quickly is unclear but is an area for further investigation.

Our study demonstrates that a short-form screening tool for frailty can identify spine surgery patients who are at risk for a decline in cognition and functional status after surgery. Short forms are important in the perioperative period, as most settings will not have a geriatrician to perform an in-depth examination of the large number of older patients who present for spine surgery. The FRAIL scale has been shown to perform well in community settings and other medically complicated populations such as diabetics [16,24]. Although there is a fair amount of heterogeneity between frailty screening tools (components, sensitivity, and specificity), the FRAIL scale has generally compared favorably with other indices [25,26].

It may be worthwhile to undertake future studies to compare predictive ability of different frailty indices to predict specific outcomes in the spine population.

Limitations

In longitudinal studies of the elderly, patients lost to follow-up are often the sickest, which would tend to bias our findings toward the null. However, we did have a relatively high follow-up rate. Tools like the PQRS may not capture subtle deficits found on in-depth neuropsychiatric batteries. These batteries can be very difficult to perform in a normal clinical setting, however. Our findings are confounded by the effects and timing of pain medications, sleep quality, depression, and anxiety. We did not collect data on postoperative analgesia regimens, which may include benzodiazepines and other medications with known psychotropic effects that may impair recovery. In addition, we did not analyze our data according to the specific anesthesia agents that patients received during the perioperative and operative period. Both of these variables may have had a confounding effect.

There is the potential that self-reported functional measures may not be accurate in patients with cognitive impairment. Given that the data were collected via telephone interviews and were self-reported, it is difficult to verify the reliability of the information received from patients. Farias et al. demonstrated, however, that even patients with cognitive impairment can generally report basic outcomes accurately [27]. Patients with severe cognitive impairment or psychiatric impairment were excluded from this study (see Fig. 1). Future studies could use caregiver or physician assessments to maximize data accuracy.

One major limitation to our study was size. Post hoc calculations demonstrated that our study was underpowered with only 100 patients; 80% power would require 364 patients. Our sample size, however, was limited by resources for follow-up for greater than 100 patients. We aim to continue our investigation with both a larger sample as well as an extended follow-up period (up to 1 year).

Our small study may not have adjusted for all potential differences in spine surgery between patients. Future studies could look at more homogenous populations (ie, cervical, thoracic, lumbar, fusion vs. laminectomy alone). Finally, our follow-up period was relatively short, and it is certainly possible that pre-frail and frail patients did continue to improve, albeit more slowly than robust patients.

Conclusions

The exponential growth in spine surgery in the elderly has produced a large and heterogeneous group of patients, some of whom are at higher risk for protracted or incomplete cognitive or functional recovery. Our study found that preoperative frailty status can identify patients who more often develop cognitive decline at 3 months, and that pre-frail and frail patients recover their functional status more slowly. Short-form frailty screening is a promising avenue toward prospectively identifying which older patients may be at risk for prolonged or incomplete recovery after surgery. More studies are needed to evaluate which frailty screens are most useful, which outcomes are most meaningful to patients and providers, and whether interventions before or immediately after surgery are possible. This information may also assist surgeons to preemptively identify the highest risk patients, and thus advise procedure choice, and counsel patients and families appropriately. Given the magnitude of the problem, better preoperative screening for elderly spine patients has the potential to ameliorate significant suffering, patient and caregiver burden, and health-care cost.

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