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Frailty assessment in the acute care surgery population - the agreement and predictive value on length of stay and re-admission of 3 different instruments in a prospective cohort

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ABSTRACT

Background: We compared the Emergency General Surgery Specific Frailty Index (EGSFI), Risk Analysis Index (RAI-C) and the Katz Index (KI) at assessing frailty in acute care surgery (ACS).
Methods: A prospective cohort of ACS patients was stratified into frail or non-frail by the EGSFI, RAI-C and KI. The agreement between scales were compared.
Results: Of 272 eligible patients, 72, 75, and 56 were categorized as frail by the EGSFI, RAI-C, and KI respectively. There was weak to no agreement between instruments and consensus among all three scales was 59.4%.
Conclusion: Between 21 and 28% of patients seen in this ACS cohort were categorized as frail using the EGSFI, RAI-C and KI. These frailty tools have different measures of what constitutes frailty and there was poor agreement between them. Only the KI definition of frailty was associated with a longer LOS. The KI may be more useful for assessing ACS patients in a tertiary care facility.

Introduction

Background

There are many assessment tools available for evaluating the suitability of a patient to undergo a medical or surgical intervention. In the surgical population, patient frailty is frequently assessed to evaluate the patient's ability to tolerate an operative procedure or to predict the likelihood of complications after surgery, often measured as the 30-day readmission rate. Frailty has been variously defined, and there have been several instruments used in practice that incorporate physical, mental, and social components. Frailty is often a measure of reserve in each of these areas. Due to differences in population, disease, and management, frailty instruments must be adapted or tailored for use by different surgical specialties. There have been recent attempts to develop a specific frailty score that can be widely adapted for use in acute care surgery (ACS) settings.[1]

Several scales have been previously used to stratify between frail and non-frail. They are calculated from different variables, some focusing on comorbidities while others weigh more heavily functional status. The Emergency General Surgery Specific Frailty Index (EGSFI) is an instrument developed specifically for assessing operative risk in the elderly population for emergency general surgery procedures.[2] A recent prospective study using this scale in geriatric patients to implement a frailty intervention pathway showed decreases in length of stay (LOS), loss of independence, and 30-day readmission rates.[3] The Risk Analysis Index is a tool designed specifically to assess for frailty in all (acute care and non-acute care) surgical populations. It has been adapted to be used retrospectively (RAI-A) or prospectively (RAI-C) using variables commonly found in surgical quality improvement databases.[4] The Katz Index (KI) has been widely used for assessing the functional status of elderly patients, but not as a traditional frailty instrument.[5]

The American Association for the Surgery of Trauma defines ACS as encompassing trauma, critical care, and emergency surgery. The

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volume of ACS is increasing, as is the number of elderly patients receiving emergency surgical care.[6] While physiologic reserve is diminished with older age, chronologic age itself may be a poor proxy for frailty. Frailty is multifactorial, of which age is only one component. A recent study specifically in emergency general surgery patients 65 years and older found no correlation between clinical frailty and age. But frailty was predictive of postoperative complications and hospital LOS.[6] A concurrent study by our own research group demonstrated that the EGSFI, RAI-C and KI were predictive of discharge disposition to a setting other than home, as well as the need for home healthcare services. If we can also use a frailty score to identify patients who are likely to require a longer LOS or who are more likely to be readmitted within 30 days after discharge, we could more efficiently allocate additional resources to those patients to improve outcomes, reduce costs from unnecessary days in the hospital and reduce readmissions.[7]

Objectives

This study set out to assess the ability of the EGSFI, RAI-C, and KI to agree in stratifying patients as frail or non-frail. Additional outcomes we examined included whether any of these tools were predictive of increased hospital LOS within our sample. We also assessed whether these instruments were predictive of increased odds of 30-day readmission after hospital discharge.

Methods

Ethical statement

The study protocol was approved by the Institutional Review Board at Emory University. A complete waiver of HIPAA authorization and informed consent was granted. The data utilized in the study was gathered for the principle purpose of ongoing clinical care.

Setting

This study was conducted by the Acute and Critical Care Surgery (ACCS) service at Emory University Hospital in Atlanta, Georgia, USA. The hospital is a non-trauma tertiary referral hospital which also serves a substantial number of patients from neighboring states. Services provided include complex gastrointestinal surgery, extracorporeal membranous oxygenation, neurological surgery, and organ transplantation.

Participants

The participants of this study were patients treated by the Emory University Hospital ACCS service between May and September 2018. Participants were eligible if they were under the care of the ACCS service for at least 48 h, were not intubated or sedated, and were able and willing to provide information for the frailty assessments. Patients with altered mental status were included if authorized family members or caretakers were available to provide information.

Instruments

The EGSFI was developed to assess operative risk in the elderly population for emergency general surgery. It was previously validated in patients who were 65 and older and underwent a surgical procedure. It consists of 4 sections with scores for individual items ranging from 0 to 1 depending on severity. There are 4 questions on co-morbidities, 5 questions pertaining to daily activities, 5 questions on health attitude, and 1 laboratory value for nutrition. The total points are aggregated and divided by 15 to obtain a final score. A higher number indicates greater severity. A patient with a score equal to or above 0.325 is considered frail.

The RAI-C consists of 14 items. The instrument includes 5 items on medical co-morbidities, 1 on residence, 5 on activities of daily living, 2 demographic items, and an item regarding history of cancer. Eleven of these items are variables from the Revised Minimum Data Set Mortality Risk Index, and the remaining 4 serve to assess activities of daily living (ADLs). Increasing points are given for advanced age and the score is modified by the presence of most cancers. The ADLs score is also modified for recent cognitive decline. Accumulated points range between 2 and 76. A final score equal to or above 21 stratifies a patient as being frail.

The KI of Independence of Daily Living was designed purely as an instrument to assess functional status in the elderly population. The scale was originally developed to be completed after observing patients over periods of days. However, it is the practice at many hospitals, including our own, for the nursing staff to administer the questionnaire at admission and then daily. The KI consists of the assessment of six ADLs. One point is given for each activity that the patient can complete independently. A score of 2 or below, which corresponds to severe deficit in ADLs, designates frailty by this instrument.

Data collection

The data was collected in a prospective database from May to September 2018. In addition to basic demographic information, including age and gender, information specific to the frailty instruments was also recorded. Information for the KI was already being collected on a daily basis at our institution by nursing staff and recorded in the electronic medical record. The earliest KI obtained from a patient's current admission was used.

Information for the RAI-C and EGSFI was collected first from a review of documented patient history, and then from any available mental health, physical therapy, and occupational therapy consult notes. Remaining questionnaire items were administered to participants by study authors. Unlike the KI, the RAI-C and EGSFI were always obtained after the ACCS service had been consulted.

Analysis

Statistical analyses were conducted in Stata 12. Missing data were not imputed and dropped from analysis. Differences in demographic characteristics between frail and non-frail were calculated using Pearson's chi-squared tests (X^2) for categorical variables and two sample *t*-tests for continuous variables. Differences in LOS between frail and non-frail were calculated using a two-sample *t*-test comparison of means. The significance level for differences was set at $p = 0.05$ and two-tailed. Differences in 30-day readmission rate were calculated as unadjusted odds ratios. Subgroup analyses were similarly conducted among operative only and non-operative patients. Agreement between different scales on frailty status was calculated using Cohen's kappa statistic (κ). We used the following interpretation for level of agreement: 0 to 0.2 as none, 0.21 to 0.39 as minimal, 0.40 to 0.59 as weak, 0.60 to 0.79 as moderate, 0.80 to 0.90 as strong, and above 0.90 as almost perfect.[8]

Results

During the May to September 2018 study period 272 patients treated by the ACCS service met the eligibility criteria to be included in the study. At least one operative procedure was performed on 123 (45%) participants and 149 (55%) were managed

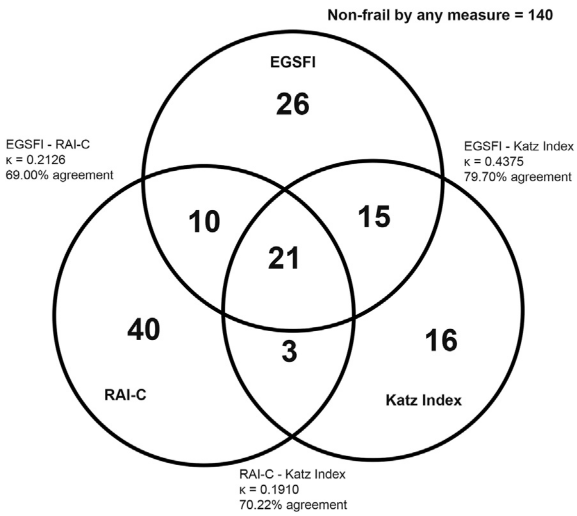

Fig. 1. Venn diagram showing agreement on positive frailty status between the three different frailty instruments.

non-operatively. The EGSFI was unavailable for 1 patient due to the patient's unwillingness to complete the question regarding feeling sexually active. There were 72 (27%), 75 (28%), and 56 (21%) patients who were identified as frail by the EGSFI, RAI-C, and KI scale, respectively.

Frailty scale agreement

In comparing the ability of the three different scales to reliably assess the same patients as frail, the percentage agreement and Cohen's kappa statistic was calculated between the indices. There was minimal agreement ($\kappa = 0.2077$) between the EGSFI and RAI-C instruments. There was weak agreement ($\kappa = 0.4441$) between the EGSFI and KI instruments. Lastly, there was little to no agreement ($\kappa = 0.1855$) between the RAI-C and KI instruments (Fig. 1). Out of the 272 patients with all three frailty scales completed, there was consensus among the three scales on frailty status in only 161 (59.4%) of patients.

Operative and nonoperative patients

The frail subsets tended overall to have fewer operative versus nonoperative patients. This proportion was only statistically significant in the EGSFI grouping, in which 39.3% underwent surgery (Table 1).

Demographic characteristics

There was a significant difference in the gender distribution among frail and non-frail in all scales. The RAI-C frail group had a significantly higher proportion of males (65.3%) than the RAI-C non-frail group. In contrast, the EGSFI and KI frail groups had significantly higher proportion of females (68.1% and 69.6%) than their respective non-frail groups.

Patients identified as frail by the EGSFI, RAI-C and KI were all significantly more likely to be older than those identified as non-frail by those indices. The mean difference between the frail and non-frail in those groups was between 7 and 11 years.

Patients identified as frail by the EGSFI and RAI-C also had higher rates of hypertension and dementia than those identified as non-frail by the same scales. Additionally, patients in the RAI-C frailty group had significantly higher rates of cancer than those in the RAI-C non-frail group, while those identified as frail by the EGSFI had higher rates of coronary artery disease than the EGSFI non-frail group. There were no significant differences in comorbidities between those identified as frail and not frail by the KI.

Length of stay

There was no statistically significant difference in the LOS between the EGSFI frail and EGSFI non-frail groups or the RAI-C frail and RAI-C non-frail groups. The mean LOS among those identified as frail by the KI was approximately 11 days longer than those identified as non-frail by the KI ($p < 0.001$). (Table 2).

Subgroup analyses showed similar results to the overall analysis among operative patients, with longer stays on average across categories. Among operative patients only the KI frail group had a statistically significant mean LOS of approximately 19 days longer than the KI non-frail group. In non-operative patients, all scales became significant for frailty predicting increased LOS. Among non-operative patients only, mean length of stay was increased by approximately 5, 4, and 6 days between EGSFI frail, RAI-C frail, and KI frail compared to their non-frail groups respectively.

Readmission within 30 days

Out of the 272 patients, 47 (17.3%) patients were readmitted to the hospital within 30 days of being discharged from the hospital. Frailty as defined by the EGSFI, RAI-C, or KI was not significantly predictive of increased odds of readmission within 30 days of discharge. This lack of significance persisted in operative and non-operative subgroup analyses (Table 3). There were no significant differences in operative status, gender distribution, mean age, or frailty status by any of the 3 frailty scales between those who were readmitted within 30 days and those who were not. Readmitted patients were more likely to have coronary artery disease (Table 4).

Discussion

This is the first study to our knowledge comparing three different frailty instruments in an acute care general surgery population that is not limited to geriatric patients. The EGSFI, RAI-C and KI defined 21–28% of our patient population as frail. Yet, the three scales, when compared to each other, agreed on frailty status for only approximately 59.2% of cases. Accounting for chance agreement, the κ statistics between the EGSFI and RAI-C, RAI-C and KI, and EGSFI and KI all showed little to weak agreement. While the EGSFI and RAI-C identified 27–28% of patients as frail, the KI identified 21%.

The EGSFI and RAI-C both purport to identify frailty and the KI has been used in practice to identify those who are frail. The poor concordance between these instruments is noteworthy. This is not entirely unexpected since the instruments assess different variables and the variables they share are still given different weights. For example, age and cancer diagnosis, which intuitively have a connection to frailty, are incorporated very differently. Functional status is measured by all instruments, but constitutes 100% of the weight of the KI.

The clinical settings in which the instruments are implemented likely influence their efficacy in separating the frail from the non-frail. In a tertiary referral care hospital, patients are likely to be older, sicker and with more comorbidities. For example, 1 in 5 patients in our dataset had cancer. So, while the EGSFI and RAI-C were designed to fit the field of ACS, they may be less discriminating in facilities with overall higher acuity. Interestingly, as we will discuss, the KI separation of frail from not frail was the only instrument to provide some predictive value for both operative and non-

Table 1
Comparison of demographic characteristics and comorbidities between frail and non-frail patients separately analyzed by each of the three frailty instruments.

	EGSFI			RAI-C			Katz Index		
	Frail	Non-Frail		Frail	Non-Frail		Frail	Non-Frail	
N	72	199		75	197		56	216	
Operative	25 (34.7%)	97 (48.7%)	0.040	29 (38.7%)	94 (47.7%)	0.180	22 (39.3%)	101 (46.8%)	0.317
Non-operative	47 (65.3%)	102 (51.3%)		46 (61.3%)	103 (52.3%)		34 (60.7%)	115 (53.2%)	
Gender									
Male	23 (32.0%)	96 (48.2%)	0.017	49 (65.3%)	71 (36.0%)	<0.001	17 (30.4%)	103 (47.3%)	0.02
Female	49 (68.1%)	103 (51.8%)		26 (34.7%)	126 (64.0%)		39 (69.6%)	113 (52.3%)	
Age									
Mean (years)	64.8 (15.2)	55.6 (16.3)	<0.001	62.9 (15.3)	56.2 (16.6)	0.0024	66.3 (16.5)	55.9 (15.8)	<0.001
Comorbidities									
Cancer	18 (25.0%)	38 (19.1%)	0.289	49 (65.3%)	7 (3.5%)	<0.001	12 (21.4%)	44 (20.4%)	0.861
Hypertension	54 (75.0%)	88 (44.2%)	<0.001	47 (62.7%)	96 (48.7%)	0.04	34 (60.7%)	109 (50.5%)	0.171
Coronary Artery Disease	15 (20.8%)	20 (10.0%)	0.019	13 (17.3%)	22 (11.1%)	0.175	11 (19.6%)	24 (11.1%)	0.089
Dementia	7 (9.7%)	6 (3.0%)	0.022	7 (9.3%)	6 (3.0%)	0.03	4 (7.1%)	9 (4.2%)	0.352

EGSFI frailty is defined as EGSFI score greater than or equal to 0.325.
RAI-C frailty is defined as RAI-C score greater than or equal to 21.
Katz Index frailty is defined as Katz Index score less than or equal to 2.

operative patients on outcomes studied. This was true even though it was not designed with an ACS population in mind. This may be because when the study population has a significant number of patients who are elderly and with multiple comorbidities, a major differentiating factor may simply be whether or not age and comorbidities affect daily function.

While frailty instruments have commonly been used in the elderly population, frailty may affect patients of any age. Of the instruments tested, only the RAI-C directly takes account of age in determining the frailty score. Nevertheless, by all three frailty tools, patients were more likely to be classified as frail if they were older. Besides age, patients classified as frail were also likely to differ by gender using the RAI-C or KI instruments. While RAI-C frail patients were more likely to be male, KI and EGSFI frail patients were more likely to be female. The RAI-C scores males higher by an additional 5 points, but the EGSFI and KI do not have any gender component. Points for functional status make up a significant component of the EGSFI with ADLs constituting 33% of the total possible points, but ADLs and health attitude points combined constituting 67% of the total possible points. In contrast, ADLs only constitute 21–28% of total possible points in the RAI-C, including adjustments for cognitive status. It is unclear if male patients are truly more independent in the ADLs or if they are less likely to report the need for assistance with ADLs. A prior study using the Katz Index did identify higher rates of disability in women, with osteoarthritis and sedentary lifestyles being potential factors.[9] Unlike the EGSFI and RAI-C instruments, the KI solely assesses function and does not incorporate co-morbidities or psychosocial issues. Also, with a smaller score range, the KI tends to be less discriminatory towards degrees of frailty. Perhaps the risk of co-morbidities and other factors affecting frailty are impactful only if they are severe enough to affect function.

The KI provided greater utility in this ACS patient population compared to the EGSFI and RAI-C in predicting increased LOS for both operative and non-operative patients. Frailty, when defined by the KI, was significantly associated with increased hospital LOS by an average of around 11 additional days in the ACS patients. Frailty as defined by the EGSFI or RAI-C was not useful in predicting which patients were likely to have an increased LOS in our patients, even though the trend was approximately 3 additional days compared to non-frail patients. This is more likely to be significant in a larger sample size than this present study. But when looking only at non-operative patients, positive frailty by all scales was still significantly predictive of increased LOS. The majority of non-operative patients

Table 2
Comparison of in-hospital length of stay between frail and non-frail patients assessed separately by different frailty instruments using two sample *t*-tests.

	EGSFI			RAI-C			Katz		
	Frail	Non-Frail	P-value	Frail	Non-Frail	P-value	Frail	Non-Frail	P-value
All									
N	72	199		75	197		56	216	
Mean (SD)	14.6 (12.1)	11.2 (17.9)	0.1332	14.5 (13.3)	11.3 (17.7)	0.1497	21.0 (28.3)	9.9 (10.8)	<0.001
Median [IQR]	10 [6.5–19]	6 [4–12]		9 [6–18]	6 [3–12]		12.5 [7–24]	6 [4–11]	
Operative only									
N	25	97		29	94		22	101	
Mean (SD)	19.2 (13.1)	15.1 (24.3)	0.4162	19.3 (18.0)	15.0 (23.7)	0.3748	32.0 (40.9)	12.6 (14.0)	0.0002
Median [IQR]	16 [8–26]	7 [4–16]		11 [7–27]	8 [4–17]		20.5 [10–34]	8 [4–16]	
Non-operative only									
N	47	102		46	103		34	115	
Mean (SD)	12.2 (10.8)	7.5 (6.1)	0.0010	11.5 (8.0)	7.8 (8.1)	0.0109	13.9 (11.9)	7.5 (6.0)	<0.001
Median [IQR]	9 [6–17]	5 [3–10]		8.5 [6–17]	5 [3–10]		10 [6–18]	5 [3–10]	

EGSFI frailty is defined as EGSFI score greater than or equal to 0.325.
RAI-C frailty is defined as RAI-C score greater than or equal to 21.
Katz Index frailty is defined as Katz Index score less than or equal to 2.

Table 3
Comparison of re-admission rates between frail and non-frail patients assessed separately by different frailty instruments using univariate logistic regression.

EGSFI	Readmission within 30 days?		Odds Ratio	95% CI	P-value
	Yes	No			
All					
Frail (0.325 and greater)	14 (19.4%)	58 (80.6%)	1.21	0.61–2.43	0.583
Not frail (less than 0.325)	33 (16.6%)	166 (83.4%)	Ref.		
Operative only					
Frail	5 (20.0%)	13 (13.4%)	1.61	0.52–5.05	0.41
Not frail	20 (80.0%)	84 (86.6%)	Ref.		
Non-operative only					
Frail	9 (19.1%)	38 (80.9%)	0.97	0.40–2.33	0.948
Not frail	20 (19.6%)	82 (80.4%)	Ref.		
RAI-C					
All					
Frail (21 and greater)	14 (18.7%)	61 (81.3%)	1.14	0.57–2.27	0.709
Not frail (less than 21)	33 (16.7%)	164 (83.3%)	Ref.		
Operative only					
Frail	5 (17.2%)	24 (82.8%)	1.30	0.42–4.01	0.65
Not frail	13 (13.8%)	81 (86.2%)	Ref.		
Non-operative only					
Frail	9 (19.6%)	37 (80.4%)	1.01	0.42–2.43	0.983
Not frail	20 (19.4%)	83 (80.6%)	Ref.		
Katz Index					
All					
Frail (2 and less)	6 (10.7%)	50 (89.3%)	0.51	0.21–1.28	0.151
Not frail (greater than 2)	41 (19.0%)	175 (81.0%)	Ref.		
Operative only					
Frail	2 (9.1%)	20 (90.9%)	0.53	0.11–2.50	0.423
Not frail	16 (15.8%)	85 (84.2%)	Ref.		
Non-operative only					
Frail	4 (11.8%)	30 (88.2%)	0.48	0.15–1.49	0.204
Not frail	25 (21.7%)	90 (78.3%)	Ref.		

Table 4
Comparison of demographic characteristics, comorbidities, and frailty status between patients re-admitted within 30 days of discharge and those not re-admitted in the same time frame.

	Readmitted within 30 days		
	Yes	No	P-value
N	47	225	
Operative	18 (38.3%)	105 (46.7%)	0.294
Gender			
Male	18 (38.3%)	102 (45.3%)	0.377
Female	29 (61.7%)	123 (54.7%)	
Age			
Mean (years)	53.9 (17.3)	58.9 (16.2)	0.059
Comorbidities			
Cancer	8 (17.0%)	48 (21.3%)	0.506
Hypertension	27 (57.5%)	116 (51.6%)	0.462
Coronary Artery Disease	12 (25.5%)	23 (10.2%)	0.004
Dementia	2 (4.3%)	11 (4.9%)	0.853
Frailty			
EGSFI	14 (29.8%)	58 (25.9%)	0.583
RAI-C	14 (29.8%)	61 (27.1%)	0.709
Katz Index	6 (12.8%)	50 (22.2%)	0.145

EGSFI frailty is defined as EGSFI score greater than or equal to 0.325
RAI-C frailty is defined as RAI-C score greater than or equal to 21
Katz Index frailty is defined as Katz Index score less than or equal to 2

were categorized as frail. Patients presenting with complex or chronic surgical issues or numerous medical comorbidities were more likely to receive nonoperative interventions. Their hospital stays were often markedly longer than those of non-frail patients who underwent urgent surgeries with short in-house recovery periods, such as appendectomy, None of the three frailty scales tested in our study sample were useful in predicting which patients would be readmitted within 30 days after discharge. Ironically, the KI came close to statistical significance for predicting a *lower rate* of 30-day readmission for frail patients. These same patients were likely to have longer hospital stays. Additional hospital days may have secondarily ensured the observation and treatment of post-operative complications, such as wound infections. Similarly, comorbidities such as congestive heart failure or diabetes may have been better stabilized prior to discharge. This effect would be more prominent in tertiary care facilities with readily available subspecialty consulting services. Longer LOS may also positively impact post-hospital planning for home health services or transfers to rehabilitation facilities. The frail patients may simply have had more problems handled during their index stay or they may have been better prepared against complications by the time of discharge.

From a feasibility assessment, the KI is easier to complete than both the RAI-C and the EGSFI, as it has only 6 questions pertaining to functional status. At our institution, the information is recorded in the medical record during the nursing intake assessment.

The EGSFI has several questions not routinely asked of acute care surgery patients. Therefore, implementing the EGSFI requires additional questions to be part of routine intake. The RAI-C can largely be completed from review of existing intake records on admission.

The timing of data collection in our tertiary care setting likely impacted the accuracy of the frailty indices. The KI data points used for this study were recorded on or near the time of admission. The EGSFI and RAI-C scores, on the other hand, were usually obtained later, after the ACCS service was consulted. In many cases, the surgical team did not become involved in care until many days into a hospital stay. During the time intervals between admission and consultation, some of the factors incorporated by the EGSFI and RAI-C likely changed. Comorbidities and health attitudes are fluid and fluctuate in hospital. Some may deteriorate while others are likely ameliorated or resolved by therapeutic interventions and relief of symptoms. Neither instrument reliably provided a snapshot of frailty status at the starting point of hospitalization. This might account for the KI score's utility in predicting LOS, serving potentially as better a proxy of how acutely sick the patients were on presentation. The frailty of the patient on admission might be more predictive of total LOS than the state of the patient at the time of ACCS consultation.

The different predictions from the three frailty instruments chosen for this study underscores their unique intentions. Ours is a high complexity non-trauma setting where patients are often referred or transferred for specialized surgical care. This study suggests that for ACS patients in such a tertiary care facility, evaluation for frailty using a short functional assessment tool such as the KI may be sufficient over more detailed instruments that also include comorbidities, psychosocial factors, and/or laboratory results. The data collection may already be a part of routine care, and therefore the KI can easily be utilized for this purpose. Identification of frail patients at risk for longer hospital stays can inform the clinical team about allocating early on additional resources for these patients such as physical therapy, nutrition consultation and discharge planning services.

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Declaration of competing interest

We declare that as authors of this work, none of us has a conflict of interest, financial or otherwise.

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