

**The association of peri-operative scores, including frailty, with length of stay after unscheduled surgery<sup>+</sup>**

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## Summary

Postoperative hospital stay is longer for frail, older patients, who are more likely to experience prolonged postoperative morbidity and reduced long-term survival. We recorded in-hospital mortality, morbidity and length of stay for 164 patients aged at least 65 years after unscheduled surgery. We evaluated pre-operative frailty with the seven-point Clinical Frailty Scale: 81 patients were 'not vulnerable' (frailty score 1-3) and 83 were 'vulnerable or frail' (frailty score  $\geq 4$ ), with mean (sd) ages of 74.7 (7.5) years vs. 79.4 (8.3) years, respectively,  $p < 0.001$ . Within 30 postoperative days 8/164 (5%) patients died, all with frailty scores  $\geq 4$ ,  $p = 0.007$ . Postoperative morbidity was less frequent in patients categorised as 'not vulnerable' on 4/6 days it was measured (days 3, 5, 8, 14, 23, 28). Median (IQR [range]) postoperative stay was 9 (6-18 [2-221]) days for patients with frailty scores 1-3, and 22 (12-33 [2-270]) days for patients with score  $\geq 4$ ,  $p < 0.001$ . Four variables independently associated with hospital discharge, hazard ratio (95% CI): E-POSSUM, 0.74 (0.60-0.92),  $p = 0.007$ ; ASA 2, 0.35 (0.13-0.98),  $p = 0.046$ , ASA 3, 0.17 (0.06-0.47),  $p = 0.001$ , and ASA 4/5, 0.08 (0.02-0.28),  $p < 0.001$ ; operative severity 'major +', 0.69 (0.41-1.08),  $p = 0.10$ ; and the Surgical Outcome Risk Tool, 7.75 (0.81-74.40),  $p = 0.08$ .

## **Introduction**

Frailty can be broadly defined as ‘vulnerability to external stressors’, with increased rates of morbidity and death compared with similar people who are not frail [1]. The rate of frailty increases with age and might affect up to half of older surgical patients [2, 3]. Worldwide there were 461 million people older than 65 years in 2004, which might increase to two billion people by 2050 [4].

Frail patients are more likely to experience postoperative complications, such as pneumonia and delirium, prolonged hospital stay, discharge to care facilities and higher mortality rates [5-8]. Chronological age should be adjusted for frailty, although it is unclear which measures should be used, in both research and clinical practice [9]. An ideal peri-operative frailty score should be quick and easy to administer, and it should be associated with complications and mortality, so that their risks can be predicted, and the level of peri-operative care can be determined, including after hospital discharge [10].

Emergency surgery is associated with particularly poor outcomes. Only half of patients aged 80 years or more at the time of emergency surgery survive three years [11-13]. Previous evaluations of peri-operative frailty have been for scheduled surgery, often using physical tasks that may be impractical for use in acute care [14]. The first prospective study measuring frailty in the emergency surgical population used the seven-point Canadian Study of Health and Ageing Clinical Frailty Scale (CSHA CFS) [15]. The Clinical Frailty Scale is a subjective, deficit-accumulation scoring system based on visual observation combined with a review of the medical records. It is suitable for use before unscheduled surgery as in trained hands it takes a few minutes to complete and it has acceptable reliability and predictive validity [16]. However, the Clinical Frailty Scale was validated only after patients had undergone a comprehensive geriatric assessment by trained researchers, so it may be unsuitable for routine use [17].

This study evaluates the association of frailty, as measured by the Clinical Frailty Scale, as well as more traditional surgical prediction tools, in a population of elderly emergency surgical admissions.

## Methods

Our local Research and Development group determined that ethical approval was unnecessary for this non-interventional study of patients at least 65 years old who had unscheduled non-cardiac surgery at University College Hospital June 2012 to January 2013. Research nurses recorded peri-operative patient and surgical data, including the ASA physical status assigned by the surgical team. Specialist care-of-the-elderly trainees reviewed patients and spoke with their relatives postoperatively to categorise their function before hospital admission, using the Clinical Frailty Scale: 1, 'very fit'; 2, 'well'; 3, 'well, with treated comorbid disease'; 4, 'apparently vulnerable'; 5, 'mildly frail'; 6, 'moderately frail'; 7, 'severely frail'. We calculated five other scores: the Surgical Risk Scale [18]; the Charlson Age-Comorbidity Index [19]; two versions of the Physiological and Operative Severity Score for the enUmeration of Mortality and Morbidity, E-POSSUM and P-POSSUM [20, 21]; and the Surgical Outcome Risk Tool (SORT) [22].

We retrospectively determined an adjusted Post-Operative Morbidity Survey (POMS) for days 3, 5, 8, 14, 21 and 28 by reviewing patients' clinical notes, charts and electronic records [23, 24]. We excluded the presence of a urinary catheter from the diagnostic criteria, which in this population might be due to reasons other than renal dysfunction, such as poor mobility [25].

Our primary outcome was length of hospital stay. We did not perform a sample size calculation. Secondary outcomes were POMS-defined morbidity and mortality, in-hospital and at 30 days [23, 24]. We used Excel (Microsoft® Excel for Mac, 2008; Microsoft Corp, Redmond, WA, USA) and Stata (Intercooled version, release 13; StataCorp LP, College Station, TX, USA). We used ANOVA, the Kruskal Wallis test, the Fisher exact test and chi-squared test, as appropriate. We used the area under the receiver operating characteristics (ROC) curve to compare score discrimination [26]. Cox proportional hazards regression was used to evaluate the association between peri-operative risk scores and hospital length of stay [27]. We used the 'swaic' package in Stata to perform automatic multivariate model selection using Akaike information criterion (AIC). We tested the Cox proportional hazards assumption with Schoenfeld residuals.

## Results

Table 1 details the characteristics of the 164 patients who required urgent (162) or immediate (2) surgery, most commonly – in 60/164 (37%) – for hip fracture. Age accounted for 7% of the linear variation in frailty score, Pearson's correlation coefficient 0.27,  $p < 0.001$ . Approximately half the patients (81/164) were 'not vulnerable' (frailty score 1-3) and the other half (83/164) were 'vulnerable or frail' (frailty score  $\geq 4$ ); the proportions of these frailty subgroups who were ASA physical status  $< 3$  were 62/81 (77%) vs. 19/83 (23%),  $p < 0.001$ . The mean (sd) ages for these frailty subgroups were 74.7 (7.5) years vs. 79.4 (8.3) years,  $p < 0.001$ .

Within 30 postoperative days 8/164 (5%) patients died, all of whom had been assessed as 'vulnerable' or 'frail',  $p = 0.007$  (Table 2). The rates of postoperative morbidity on days 3, 5, 8, 14, 21, 28 for patients categorised as 'not vulnerable' vs. 'vulnerable or frail' were: 41/81 vs. 62/83,  $p = 0.002$ ; 33/81 vs. 46/83,  $p = 0.06$ ; 19/81 vs. 37/83,  $p = 0.005$ ; 11/81 vs. 23/83,  $p = 0.03$ ; 16/81 vs. 30/83,  $p = 0.02$ ; and 7/81 vs. 10/83,  $p = 0.69$  (Table 2). These differences were partly due to patients who were 'not vulnerable' being discharged sooner than patients scored 'vulnerable and frail', with median (IQR [range]) postoperative stays of 9 (6-18 [2-221]) days vs. 22 (12-33 [2-270]) days,  $p < 0.001$  (Fig. 1 and Table 2). However, frailty score was not independently associated with postoperative stay, which was accounted for by four other variables: E-POSSUM; ASA physical status; operative severity; and SORT (Table 3).

## Discussion

The duration of hospital stay after unscheduled surgery was independently associated with: pre-operative ASA physical status; the surgical severity; and the peri-operative E-POSSUM score and Surgical Outcome Risk Tool. The duration of stay was also associated with the Clinical Frailty Scale, but not independent of these variables.

Frailty scored by seven categories associated only weakly with postoperative morbidity, as well as mortality and re-admission to hospital, perhaps because frailty does not account for surgical type and severity. The POMS was not specifically designed for use in the elderly surgical population, for whom it may not be the most appropriate measure of postoperative adverse outcomes. Some complications are more common in elderly patients, and not all complications develop in the immediate postoperative period [28]. However, frailty was associated with postoperative morbidity if the seven categories of the CFS were amalgamated into two categories, 'not vulnerable' (1–3) and 'vulnerable or frail ( $\geq 4$ ), which suggests that a larger sample size might differentiate between the seven categories. Two studies have reported an association between frailty and mortality and hospital stay after elective surgery [9, 29]. Models that incorporate frailty may be associated with postoperative outcomes, including mortality, better than models that do not incorporate frailty, particularly those that are based on a single system [30, 31].

Surveys have identified ignorance of frailty as a key barrier to its incorporation into pre-operative assessments [32], but no frailty measure has been identified as the 'gold standard' [9]. Performance-based tests and complex assessments may be impractical for patients undergoing unscheduled surgery; different tools to detect frailty may be required for different situations.

Our study is subject to the biases of any single-centre observational study, as well as bias introduced by the postoperative categorisation of pre-operative frailty and too few patients to explore graded associations of frailty scored in seven categories.

In our population of patients undergoing unscheduled surgery, the CFS was not independently associated with hospital stay, postoperative morbidity, mortality and re-admission to hospital. Our study was not powered to explore whether there was a graded association of the seven categories of the CFS with any outcome. Future observational research should measure frailty before surgery and might use our study to adequately power the sample for a particular outcome.

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**Competing interests**

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## References

1. Clegg A, Young J, Iliffe S, Rikkert MO, Rockwood K. Frailty in elderly people. *Lancet* 2013; **381**: 752–62.
2. Partridge JS, Harari D, Dhesi JK. Frailty in the older surgical patient: a review. *Age and Ageing* 2012; **41**: 142-7.
3. Shamliyan T, Talley KM, Ramakrishnan R, Kane RL. Association of frailty with survival: a systematic literature review. *Ageing Research Reviews* 2013; **12**: 719-36.
4. Kinsella KG, Phillips DR. Global aging: the challenge of success. *Population Bulletin* 2005; **60**: 5-42.
5. Saxton A, Velanovich V. Preoperative frailty and quality of life as predictors of postoperative complications. *Annals of Surgery* 2011; **253**: 1223-9.
6. Revenig LM, Canter DJ, Taylor MD, et al. Too frail for surgery? Initial results of a large multidisciplinary prospective study examining preoperative variables predictive of poor surgical outcomes. *Journal of the American College of Surgeons* 2013; **217**: 665-70.
7. Hamel MB, Henderson WG, Khuri SF, Daley J. Surgical outcomes for patients aged 80 and older: morbidity and mortality from major noncardiac surgery. *Journal of the American Geriatrics Society* 2005; **53**: 424-9.
8. Patel SA, Zenilman ME. Outcomes in older people undergoing operative intervention for colorectal cancer. *Journal of the American Geriatrics Society* 2001; **49**: 1561–1564.
9. Aguagyo GA, Donneau AF, Vaillant MT, et al. Agreement between 35 published frailty scores in the general population. *American Journal of Epidemiology* 2017; **186**: 420–434.
10. Hubbard RE, Story DA. Patient frailty: the elephant in the operating room. *Anaesthesia* 2014; **69** (Suppl. 1): 26-34.
11. Gazala S, Tul Y, Wagg A, et al. Quality of life and long-term outcomes of octo- and nonagenarians following acute care surgery: a cross sectional study. *World Journal of Emergency Surgery* 2013; **8**: 23.
12. Svenningsen P, Manoharan T, Foss NB, Lauritsen ML, Bay-Nielsen M. Increased mortality in the elderly after emergency abdominal surgery. *Danish Medical Journal* 2014; **61**: A4876
13. Racz J, Dubois L, Katchky A, Wall W. Elective and emergency abdominal surgery in patients 90 years of age or older. *Canadian Journal of Surgery* 2012; **55**: 322-8.
14. Lin HS, Watts JN, Peel NM, Hubbard RE. Frailty and post-operative outcomes in older surgical patients: a systematic review. *BMC Geriatrics* 2016; **16**: 157.
15. Hewitt J, Moug SJ, Middleton M, et al. Prevalence of frailty and its association with mortality in general surgery. *American Journal of Surgery* 2015; **209**: 254-9.
16. Rockwood K, Stadnyk K, MacKnight C, McDowell I, Hebert R, Hogan DB. A brief clinical instrument to classify frailty in elderly people. *Lancet* 1999; **353**: 205-6.



17. Rolfson DB, Majumdar SR, Tsuyuki RT, Tahir A, Rockwood K. Validity and reliability of the Edmonton Frail Scale. *Age and Ageing* 2006; **35**: 526-9.
18. Sutton R, Bann S, Brooks M, Sarin S. The Surgical Risk Scale as an improved tool for risk-adjusted analysis in comparative surgical audit. *British Journal of Surgery* 2002; **89**: 763-8.
19. Charlson M, Szatrowski TP, Peterson J, Gold J. Validation of a combined comorbidity index. *Journal of Clinical Epidemiology* 1994; **47**: 1245-51.
20. Whiteley MS, Prytherch DR, Higgins B, Weaver PC, Prout WG. An evaluation of the POSSUM surgical scoring system. *British Journal of Surgery* 1996; **83**: 812-5.
21. Tran Ba Loc P, du Montcel ST, Duron JJ, et al. Elderly POSSUM, a dedicated score for prediction of mortality and morbidity after major colorectal surgery in older patients. *British Journal of Surgery* 2010; **97**: 396-403.
22. Protopapa KL, Simpson JC, Smith NC, Moonesinghe SR. Development and validation of the Surgical Outcome Risk Tool (SORT). *British Journal of Surgery* 2014; **101**: 1774–83.
23. Bennett-Guerrero E, Welsby I, Dunn TJ, et al. The use of a postoperative morbidity survey to evaluate patients with prolonged hospitalization after routine, moderate-risk, elective surgery. *Anesthesia and Analgesia* 1999; **89**: 514-9.
24. Grocott MP, Browne JP, Van der Meulen J, et al. The postoperative morbidity survey was validated and used to describe morbidity after major surgery. *Journal of Clinical Epidemiology* 2007; **60**: 919-28.
25. Howes TE, Cook TM, Corrigan LJ, Dalton SJ, Richards SK, Peden CJ. Postoperative morbidity survey, mortality and length of stay following emergency laparotomy. *Anaesthesia* 2015; **70**: 1020-7.
26. Swets JA. Measuring the accuracy of diagnostic systems. *Science* 1988; **240**: 1285–93.
27. Cox DR, Oakes D. Analysis of Survival Data. London: Chapman & Hall; 1984.
28. Peden CJ, Grocott MP. National Research Strategies: what outcomes are important in peri-operative elderly care? *Anaesthesia* 2014; **69**(Suppl. 1): 61–9. Wallis SJ, Wall J, Biram RWS, et al. Association of the clinical frailty scale with hospital outcomes. *QJM: An International Journal of Medicine* 2015; **108**: 943–9.
29. Moonesinghe SR, Mythen MG, Das P, Rowan KM, Grocott MP. Risk stratification tools for predicting morbidity and mortality in adult patients undergoing major surgery: qualitative systematic review. *Anesthesiology* 2013; **119**: 959–81.
30. Kim SW, Han HS, Jung HW, et al. Multidimensional frailty score for the prediction of postoperative mortality risk. *JAMA Surgery* 2014; **149**: 633–40.
31. Eamer G, Gibson J, Gillis C, et al. Surgical frailty assessment: a missed opportunity. *BMC*



**Table 1** The characteristics of 164 patients who underwent unscheduled surgery. Values are mean (SD), median (IQR [range]) or number (proportion).

<b>Age; y</b>	77.1 (8.3)
<b>Female</b>	104 (63%)
<b>Ethnicity</b>	
<b>White</b>	121 (74%)
<b>Asian</b>	6 (4%)
<b>Black</b>	2 (1%)
<b>Other</b>	6 (4%)
<b>Not stated</b>	29 (17%)
<b>Surgery</b>	
<b>Orthopaedic</b>	102 (62%)
<b>Colorectal</b>	28 (17%)
<b>Upper gastrointestinal</b>	10 (6%)
<b>Vascular</b>	11 (7%)
<b>Urology</b>	4 (2%)
<b>Other</b>	9 (6%)
<b>CSHA Clinical Frailty Score</b>	4 (3-5 [1-7])
<b>Mortality at one month; %</b>	
<b>SORT</b>	0.04 (0.01-0.09 [0.01-0.56])
<b>P-POSSUM</b>	2.14 (1.22-4.19 [0.19-39.25])
<b>Morbidity at one month; %</b>	
<b>E-POSSUM</b>	0.28 (0.21-0.33 [0.10-0.63])

CHSA, Canadian Study of Health and Ageing; E- and P-POSSUM, Elderly and Portsmouth Physiological and Operative Severity Score for the enUmeration of Mortality and Morbidity

**Table 2** Characteristics and outcome measures by frailty score of 164 patients who had unscheduled surgery. Values are number (proportion), mean (SD) or median (IQR [range]).

Characteristic	CSHA Clinical Frailty Scale							Total (n = 164)	p value
	1 (n = 7) 4%	2 (n = 19) 12%	3 (n = 55) 34%	4 (n = 23) 14%	5 (n = 24) 15%	6 (n = 21) 13%	7 (n = 15) 9%		
<b>Age; years</b>	68.7 (2.8)	75.2 (8.3)	75.2 (7.4)	77.4 (8.0)	82.8 (8.0)	78.6 (7.5)	78.3 (9.6)	77.1 (8.3)	< 0.001
<b>ASA</b>									
<b>1</b>	1	0	3	0	0	0	0	4 (2%)	
<b>2</b>	5	18	35	7	5	3	4	77 (47%)	
<b>3</b>	0	1	14	14	17	15	11	72 (44%)	< 0.001
<b>4</b>	0	0	3	2	2	3	0	10 (6%)	
<b>5</b>	1	0	0	0	0	0	0	1 (1%)	
<b>Operative severity</b>									
<b>Minor</b>	0	0	0	1	0	0	0	1 (1%)	
<b>Moderate</b>	0	0	9	2	4	0	2	17 (10%)	0.17
<b>Major</b>	2	5	9	1	2	1	1	21 (13%)	
<b>Major+</b>	5	14	37	19	18	20	12	125 (76%)	
<b>Hospital stay; days</b>	7 (3-8 [2-92])	8 (6-10 [2-28])	12 (5-23 [2-221])	23 (13-38 [4-97])	22 (11-33 [2-126])	17 (7-29 [2-270])	21 (14-42 [5-167])	14 (7-28 [2-270])	< 0.001
<b>POMS-defined morbidity</b>									
<b>Day 3</b>	5	6	30	22	15	15	10	103 (63%)	0.002
<b>Day 5</b>	3	4	26	16	12	10	8	79 (48%)	0.12
<b>Day 8</b>	1	1	17	14	8	8	7	56 (34%)	0.009
<b>Day 14</b>	1	0	10	7	5	5	6	34 (21%)	0.12
<b>Day 21</b>	1	2	13	12	9	3	6	46 (28%)	0.022
<b>Day 28</b>	1	0	6	4	3	2	1	17 (10%)	0.69
<b>Mortality</b>									
<b>Inpatient 30 days</b>	0	0	2	1	2	3	2	10 (6%)	0.35
<b>Planned postoperative critical care</b>	2	2	17	14	9	11	8	63 (38%)	0.014
<b>Discharge to institutional care</b>	0	0	2	2	0	3	2	9 (5%)	0.16

ASA, ASA physical status; CHSA, Canadian Study of Health and Ageing; POMS, Post-Operative Morbidity Survey

**Table 3** Multivariate time-to-event analysis (using Cox Proportional Hazards) of risk factors associated with length of hospital stay following unscheduled surgery

<b>Variable</b>	<b>Hazard ratio (95% CI)</b>	<b>p value</b>
<b>ASA</b>		
<b>2</b>	0.35 (0.13-0.98)	0.046
<b>3</b>	0.17 (0.06-0.47)	0.001
<b>4-5</b>	0.08 (0.02-0.28)	< 0.001
<b>E-POSSUM Morbidity*</b>	0.74 (0.60-0.92)	0.007
<b>Major+ operation</b>	0.69 (0.44-1.08)	0.10
<b>SORT</b>	7.75 (0.81-74.40)	0.08

ASA, ASA physical status; E-POSSUM, Emergency Portsmouth Physiological and Operative Severity Score for the enUmeration of Mortality and Morbidity; SORT, Surgical Outcome Risk Tool.

\* 0.1 unit change in morbidity risk.

**Figure 1** Kaplan-Meier plot for the proportion (95%) of patients in hospital after surgery, categorised by frailty score  $\geq 4$  (red) or  $< 4$  (blue).

