Prevalence of Frailty and Reliability of Established Frailty Instruments in Adult Elective Colorectal Surgical Patients: a Prospective Cohort Study

Simon James Howell (✉ s.howell@leeds.ac.uk)  
University of Leeds  https://orcid.org/0000-0001-8467-1466

Oliver Baker  
Leeds Teaching Hospitals NHS Trust

Dermot Burke  
University of Leeds

Thomas Dale MacLaine  
University of Leeds

Research article

Keywords: Frailty, Surgery, Colorectal

Posted Date: October 4th, 2019

DOI: https://doi.org/10.21203/rs.2.15617/v1

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Abstract

Background: Frailty is associated with adverse outcome in older surgical patients but the strength of the association varies widely between studies. This may be due in part to the wide range of instruments used to assess frailty. Large population studies now demonstrate that frailty is prevalent in all adult age groups. However, there are limited data on the association between frailty and surgical outcome in younger patients. We studied the agreement between three established frailty instruments and their predictive value for postoperative complications in an adult colorectal surgery population.

Methods: We studied patients aged 18 years or over presenting for elective colorectal surgery at a major teaching hospital. Preoperative frailty assessments were performed using the clinical frailty scale (CFS), accumulation deficit (AD) and frailty phenotype (FP) instruments. Data were collected on postoperative complications, length of stay, and readmission. The correlation and agreement between the frailty measures was examined in pairwise comparisons. Measures of association and prediction for postoperative complications were calculated and compared for the instruments.

Results: Frailty scores were recorded in 200 patients (91 male), mean(range) age 57(18-92) years. The prevalence of pre-frailty was 52-67% and that of frailty 2-32% depending on the instrument used. Agreement between the instruments was poor, kappa 0.08 to 0.17 in pairwise comparisons. Outcome data were available on 160 patients. Only the frailty phenotype was significantly associated with adverse outcomes, odds ratio 6.1(1.5-24.5) for postoperative complications. The three frailty scoring instruments studies had good sensitivity (CFS-90%, AD-96%, FP-97%) but poor specificity (CFS-12%, AD-13%, FP-18%) for the prediction of postoperative complications. All three instruments were poorly predictive of adverse outcomes with likelihood ratios of CFS-1.03, AD-1.03 and FP-1.12.

Conclusions: This study showed a significant prevalence of pre-frailty and frailty in adult colorectal surgical patients of all ages. There was poor agreement between three established frailty scoring instruments. Our data do not support the use of current frailty scoring instruments in all adult colorectal surgical patients. However, the significant prevalence of pre-frailty and frailty across all age groups of adult surgical patient justifies further research to refine frailty scoring in surgical patients.

Background

The term frailty describes a lack of physiological resilience.\(^1\) Frail patients recover slowly from illness and insults such as surgery. Frailty is generally understood to relate to ageing and to place a significant health burden on many older adults. It has been reported to be associated with adverse outcome in older patients undergoing various types of surgery.\(^2\)-\(^4\)

Elective colorectal surgery is associated with a significant risk of complications with postoperative morbidity rates of up to 35% reported in some studies.\(^5\) Frailty is likely to contribute to the burden of
postoperative complications in older surgical patients. One study identified 43% of colorectal cancer patients as frail. Whilst frailty is most common in the elderly, a significant population burden of frailty is reported in younger adults and may impact on surgical outcomes across all age groups. A large Canadian study reported a prevalence of frailty of between 1.8% and 11.6% in patients aged less than 65 years, depending on frailty instrument used and the age group studied. A small study of emergency surgical admissions found a prevalence of frailty in patients aged under 65 of 16% and reported that this was associated with a five-fold increased risk of postoperative mortality. A study using the American College of Surgeons NSQIP database reported that a modified frailty index is a strong predictor of 30-day mortality and complications in patients less than 60 years old. These studies examine mixed surgical populations. Fewer data focusing on particular surgical populations. Colorectal surgery carries a significant risk of postoperative complications. We studied the impact of frailty in chronologically young patients undergoing colorectal surgery.

The identification of frailty in surgical patients brings its own challenges. A number of clinical scoring systems for the identification of frailty are available. The extent of agreement between these scores is variable. The optimal scoring system for identifying surgical patients at risk of complications is unclear.

Widely used assessments of frailty include the Accumulation Deficit (AD) model, the Frailty Phenotype (FP) model, and the Clinical Frailty Scale (CFS). The AD model uses the presence of co-morbidities, disabilities, clinical signs and symptoms, and abnormal investigations to generate a frailty index. The FP model (often known as the Fried model) rests on measurements in five domains: weight loss, mood, activities of daily living, functional gait speed and grip strength. Both the AD and FP instruments can be time consuming to use in clinical practice. The Clinical Frailty Scale (CFS) is based on an estimate of the patient’s fitness made by an experienced clinician or investigator. The patient is allocated to one of nine categories ranging from one (very fit) to eight (very severely frail) and nine (terminally ill). Its use for the rapid evaluation of frailty status is well described. The classification of patients into frail, prefrail and not-frail categories arises from the FP model and has been shown to be a valid approach to characterising the frailty syndrome. It has been mapped to other frailty instruments and is widely used in clinical practice.

The aims of this study were collect initial data on the prevalence and impact of frailty in all adult colorectal surgery patients (as opposed to only older patients); to assess the agreement between the CFS, AD and FP in this colorectal surgical population, and to determine the association between the three frailty instruments and post-operative complications.
Methods

Ethical approval was received from the West Midlands UK Research Ethics Committee (15/WM/0148). Adult elective colorectal (cancer and non-cancer) surgical patients were recruited in the surgical pre-assessment clinic at St James’ University Hospital. Patients were eligible for the study if they were aged over 18 years, fluent in English or had an NHS translator present, and were attending the pre-assessment clinic prior to elective colorectal surgery. Patients were excluded if they were taking anti-Parkinsonian medication or anti-depressants as Parkinson's disease, depression and the effects of related medications impact on the assessment of frailty.1 Clinical staff identified candidates for the study; the study was explained, and consent taken by the investigators.

Full details of the frailty assessment instruments used in this study are given in the relevant methodology papers.12-14 Patient characteristics were recorded from the clinical proforma routinely used for all patients attending the clinic. Frailty assessments were performed consecutively in the order of CFS, the AD model and finally the FP assessment. Assessments were timed and patients were classified as non-frail, pre-frail or frail according to each frailty assessment. For practical reasons, the CFS was timed using five-second increments. The CFS frailty score was estimated first to ensure that it was based on the usual pre-assessment process and overall impression of the patient and was not influenced by the results of the AD and FP instruments. Surgical, ward and anaesthetic staff were blinded to the frailty scores throughout the study, to avoid impacting on routine care.

Post-operative data were recorded from the patients’ records for up to 30-days following their procedure. Data were collected on post-operative complications classified by Clavien-Dindo score, postoperative mortality length of stay, and readmission within 30-days of surgery.21 The difference between observed and expected length of stay was calculated for each patient using local hospital data on median length of stay for each operation.

Analyses were performed using SPSS (IBM Statistical Package for the Social Sciences for Mac, Version 24.0, IBM Corp., Armonk, New York, USA). Correlations between frailty instruments were calculated and agreement was examined using the Kappa statistic. The differences between the frailty instruments were analysed using the chi-squared statistic. The differences in time taken to perform the AD and FP methods were analysed using a paired t-test. It is possible that the assessment of frailty takes longer in more frail patients. We therefore examined the correlation between the time taken to complete the FP and AD
scores and the frailty scores themselves using Pearson's correlation coefficient. The differences between frailty scores by sex was analysed using the Mann Whitney-U test.

The associations between postoperative outcome and frailty as assessed by the different instruments were analysed. We combined the categories of pre-frail and frail for the analyses of the association between frailty and surgical outcomes. Analyses of contingency tables for frailty and surgical outcomes were used to examine the ability of the frailty instruments to positively and negatively predict surgical outcomes. Risk ratios and likelihood ratios were used to test if the knowledge of a frailty score would materially change the expectations of a patient's post-operative recovery. A formal power calculation was not undertaken due to the lack of robust data on the association between frailty and outcome in non-elderly colorectal patients to inform such a calculation. We aimed to collect prevalence data on 200 patients over a six-month period. Follow-up data were collected on 160 patients over eight months at which point the study was closed for logistical and financial reasons.

**Results**

Two hundred patients (91 male) were recruited into the study. The mean(range) age of participants was 57(18-92) years, with 61% being less than 65 years of age. No patients withdrew from the study.

The results from the three frailty instruments are presented in Table 1. The prevalence of frailty ranged from 1.5% to 32% depending on the instrument used. There was a statistical difference in the prevalence of frailty and pre-frailty between the three frailty instruments (P<0.001). All three methods reported a relatively high prevalence of pre-frailty, ranging from 51.5% to 66.5%. There was no difference in the prevalence of pre-frailty and frailty between the sexes (CFS, AD and FP; P=0.530, P=0.196, P=0.183 respectively).

Table 1: The number(percentage) of non-frail pre-frail and frail patients in the study population (n=200)
The number (percentage) of pre-frail and frail patients in the study population (n=200), as defined by the clinical frailty scale (CFS), accumulation deficit (AD) and frailty phenotype (FP). Data are shown for the population as a whole and divided by sex. Some rows do not sum to 100% due to rounding.

There was statistically significant moderate correlation between the three frailty instruments with R-values from 0.30 to 0.46. There was little agreement with the kappa statistic for pairwise comparisons ranging from 0.08 to 0.17. (Table 2)

| Assessment method | Non-frail | Pre-frail | Frail |
|-------------------|-----------|-----------|-------|
| CFS               | 64 (32%)  | 133 (67%) | 3 (2%)|
| AD                | 31 (16%)  | 105 (53%) | 64 (32%)|
| P                 | 86 (43%)  | 103 (52%) | 11 (6%)|

| FS | Male     | 31 (16%) | 59 (25%) | 1 (1%) |
|    | Female   | 33 (17%) | 74 (37%) | 2 (1%) |
| AD | Male     | 16 (8%)  | 50 (25%) | 25 (13%)|
|    | Female   | 15 (8%)  | 55 (28%) | 39 (20%)|
| P  | Male     | 43 (22%) | 45 (23%) | 3 (2%) |
|    | Female   | 43 (22%) | 58 (29%) | 8 (4%) |

### Table 2: Correlation and agreement between the Clinical Frailty Scale, Accumulation Deficit and Frailty Phenotype instruments

| Instruments compared                          | Statistic test   | Result     | P value |
|-----------------------------------------------|------------------|------------|---------|
| Clinical Frailty Scale and Accumulation Deficit | Correlation      | R = 0.41   | <0.001  |
|                                                | Kappa            | K = 0.08   | 0.06    |
| Clinical Frailty Scale and Frailty Phenotype  | Correlation      | R = 0.28   | <0.001  |
|                                                | Kappa            | K = 0.17   | <0.005  |
| Accumulation Deficit and Frailty Phenotype    | Correlation      | R = 0.46   | <0.001  |
|                                                | Kappa            | K = 0.16   | <0.001  |

Correlation and Kappa analyses between the Clinical Frailty Scale, Accumulation Deficit and Frailty Phenotype instruments in 200 elective colorectal surgery patients
Mean(SD) times for undertaking the assessments were CFS 7(3) sec, AD 224(108) sec, and FP 340(83) sec. The CFS was so much quicker than both AD and FP methods to perform that it was unnecessary to undertake formal statistical testing to confirm the differences. The AD instrument was quicker than the FP (paired t-test, P<0.001). The CFS and FP displayed weak positive correlations between time taken to perform the assessment and severity of frailty as measured by the same tool (R=0.279, P<0.001 and R=0.154, P<0.001 respectively). For the AD tool there was a moderate correlation between the severity of frailty and the time taken for the assessment (R=0.549, P<0.001).

Of the 200 participants, 160 underwent surgery during the study period. Thirty-six patients had not undergone surgery by the point the study had concluded. Of these, two were deemed medically unfit for surgery, one had had surgery delayed to allow treatment of co-morbid disease, and one patient died prior to the surgery being performed. In the remaining cases the patient was awaiting surgery at the end of the study.

Eighteen(11%) of the 160 patients had one or more post-operative complications and 10(6%) patients were re-admitted within 30-days of surgery. Of the 18 patients with post-operative complications, six had Clavien-Dindo scores of 1, six scored 2 and six patients scored 3. (Table 3) The median(range) difference between actual and expected length of stay was 0(-2 to 21 days).

Table 3: Post-operative complications (Clavien-Dindo > 1 and causes of 30-day readmission in 160 patients
### Outcome measure

**Post-operative complications during index admission.**

| Condition | Count |
|-----------|-------|
| Wound infection | 4 |
| Hypotension/Early sepsis | 2 |
| Hospital acquired pneumonia | 2 |
| Persistent pyrexia/other infective sign warranting empiric treatment | 2 |
| Surgical site bleeding | 2 |
| Protracted ileus/delayed return of bowel function | 2 |
| Severe pain delaying mobilisation and recovery | 2 |
| Anastomotic Leak | 1 |
| Small bowel obstruction | 1 |

**Readmission within 30 days of surgery (n=10 patients)**

| Condition | Count |
|-----------|-------|
| Bowel obstruction | 2 |
| Anastomotic leak | 1 |
| Incisional hernia | 1 |
| GI bleeding | 1 |
| Wound infection | 1 |
| Pancreatitis | 1 |
| Admission under another clinical service | 3 |

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*Post-operative complications (Clavien-Dindo ≥ 1 and causes of readmission within 30 days of surgery in 160 elective colorectal surgery patients.*

The Frailty Phenotype was significantly associated with postoperative complications, risk ratio (95% CI) 6.1 (1.5 - 24.5), readmission within 30 days of surgery 3.4 (1.1 - 10.4), and extended length of stay 1.8 (1.1 - 10.4). The Clinical Frailty Scale was significantly associated with extended length of stay 1.8 (1.2 - 2.8). Other associations were not significant (Table 3).
Table 4: Risk ratios and predictive value of three frailty instruments for adverse outcome following surgery.

|                          | Instrument | Risk ratio (Confidence Interval) | PPV(%) | NPV(%) | Sensitivity(%) | Specificity(%) |
|--------------------------|------------|----------------------------------|--------|--------|----------------|----------------|
| Post-operative complications (Clavien-Dindo >1) | CFS        | 1.2 (0.5 - 2.8)                  | 32     | 72     | 90             | 12             |
|                          | AD         | 3.2 (0.3 - 32.2)                 | 17     | 94     | 96             | 13             |
|                          | FP         | 6.1 (1.5 - 24.5)                 | 47     | 89     | 97             | 18             |
| Re-admission within 30 days | CFS        | 1.4 (0.5 - 3.7)                  | 32     | 75     | 92             | 11             |
|                          | AD         | 1.3 (0.3 - 5.2)                  | 16     | 88     | 92             | 10             |
|                          | FP         | 3.4 (1.1 - 10.4)                 | 47     | 81     | 96             | 14             |
| Extended Length of Stay  | CFS        | 1.8 (1.2 - 2.8)                  | 36     | 80     | 82             | 33             |
|                          | AD         | 1.5 (0.3 - 5.2)                  | 17     | 89     | 80             | 30             |
|                          | FP         | 1.8 (1.1 - 10.4)                 | 50     | 69     | 80             | 35             |

The associations between and predictive value of the Accumulation Deficit model (AD) and Frailty Phenotype (FP) for post-operative complications, 30-day readmission and an extended length of stay in 160 elective colorectal surgery patients. PPV; positive predictive value, NPV; negative predictive value. In this table, the ‘frail’ and ‘pre-frail’ states are collapsed into frail.

The sensitivity, specificity, positive predictive value and negative predictive value of frailty for post-operative complications (Clavien-Dindo score of ≥1) and 30-day readmission and extended length of stay are reported in Table 3. The sensitivity of the three instruments was high for all outcomes. However, many patients classified as pre-frail or frail did not suffer adverse outcomes, resulting in a high false-positive rate and low specificity with all three instruments. For post-operative complications, the sensitivity of the instruments ranged from 90% to 97%, whereas the specificity ranged from 12% to 18% depending on the frailty instrument used. For all surgical outcomes, positive predictive values ranged from 16% to 50%, and negative predictive values ranged from 69% to 94%.
The likelihood ratios for the CFS, AD and FP instruments were 1.02, 1.09, and 1.17 respectively for postoperative complications; 1.03, 1.03 and 1.12 respectively for 30-day readmission and 1.22, 1.14 and 1.23 respectively for extended length of stay. As the likelihood ratios are close to unity, classifying an individual as frail or pre-frail using any of the three instruments studied does not materially change the expectations of an adverse outcome for an individual.

**Discussion**

This study suggests that pre-frailty is common in adult colorectal surgical patients of all ages. This finding was consistent across three different frailty assessment instruments but there was imperfect agreement between the instruments as to which patients were classified as frail and pre-frail. There was a significant association between being classified as pre-frail or frail by the Frailty Phenotype instrument and the adverse outcomes studied. The Clinical Frail Scale was associated with extended length of stay but not other outcomes. Being identified as pre-frail or frail had very good sensitivity for the identification of patients who suffered postoperative complications but poor specificity. The high false positive rate limited the value of frailty assessment for the identification of patients at risk of post-operative complications. The findings of this pilot study have implications for current clinical practice and for the design of future research.

The burden of frailty in older patients presenting for colorectal surgery and its impact on outcome are well described.\(^7,22-24\) Large epidemiological studies demonstrate that frailty is common in older patients but affects all age groups. Data from the Canadian Heath Measures study showed a prevalence of frailty as assessed by the frailty phenotype ranging from 1.8% in the 18-34 age group to 11.6% in the 50-64 age group and 20.2% in people aged 65 years or older.\(^8\) UK Biobank data on 493,737 people aged 37-73 years demonstrated a 3% prevalence of frailty and a 38% prevalence of pre-frailty.\(^25\) Our finding of a high prevalence of pre-frailty in the adult colorectal surgical population of all ages is consistent with the results from the UK Biobank.

Data on the association between frailty and perioperative outcome in younger adults are sparse. The association between frailty and perioperative outcome may not be constant across all ages. Although frailty denotes a loss of physiological resilience younger patients classified as frail by one of the commonly used instruments may be better able to recover from surgery than their older peers (but less well than non-frail patients). In the current study all three of the frailty instruments studied had a sensitivity for the prediction of postoperative complications of 90% or greater, that is to say that the majority of patients who experienced complications were pre-frail or frail. However, we also found a high false positive rate. Many patients identified as pre-or frail did not experience a postoperative
complication. The frailty instruments studied had poor specificity for the identification of postoperative complications (12-18%). Consequently, all three instruments had likelihood ratios close to unity for the prediction of postoperative complications.

The instruments that we studied all reported a significant prevalence of pre-frailty/frailty with mild to moderate correlations between the scores (R=0.28-0.46). However, agreement between the instruments was modest at best (K=0.08-0.17). This is consistent with findings in non-surgical patients. A study which used data from the English Longitudinal Study of Aging to compare 35 different scores and found substantial variation in the associations between the different scores and seven year all-cause mortality, cardiovascular disease, and cancer. A review of instruments to detect frailty in community dwelling adults identified seven instruments examined in three studies and reported important variation in the performance. Most, if not all, instruments used to study frailty in surgical patients were first developed and validated in the community setting. It cannot be assumed that they are suitable for use in surgical patients. Different instruments use different constructs of frailty. The FP includes assessments of function (grip strength and walk speed) and brief questionnaire on leisure activity, depression and exhaustion. The AD assumes the increased history of co-morbidities indicates increased frailty severity. The CFS is based on a global assessment of frailty. It is argued by some authors that the frailty phenotype best reflects the condition of frailty (as opposed to the accumulation deficit model reflecting a burden of aging and comorbid disease). Proponents of the cumulative deficit approach to characterising frailty suggest that this approach gives an inclusive view of the changes associated with biological (as compared with chronological) aging. The accumulation deficit approach can be implemented using routinely collected clinical information and may be automated for use in electronic records. A pragmatic approach should take into account both the ease of assessment and the strength of association with surgical outcome. Further comparative studies of the performance of different instruments in surgical patients are needed to inform this judgement.

The time taken for an assessment is an important consideration for its implementation into practice. The CFS was quick to perform but in this study was poor in its association with outcomes. This may reflect the fact the CFS was originally designed to summarise the output of a comprehensive geriatric assessment rather than to be used as a tool in its own right. It has evolved with an expansion of the scale from seven to nine points and its seemingly intuitive format has made it attractive as a tool for rapid assessment. However, some guidelines point out that it was not originally designed as an assessment instrument and should not be used for this purpose. The AD was quicker to perform than the FP but again in this study had limited power to predict outcome. The FP was a consistent in its time to complete and had the highest likelihood ratios for the prediction of adverse outcomes. Thus, our data suggest that the FP is best of the three instruments studied for the identification of frailty across all age
groups. However, it is more time consuming to use than other instruments and requires the use of a handgrip dynamometer which incurs addition equipment costs. The likelihood ratio of 1.12 for the FP tool, whilst better than that for the other two instruments, suggests that it is a relatively weak tool for predicting outcome and does not support its routine use across all age groups. Studies to refine this approach for use in surgical patients may be of value. The cut-off values used in frailty assessment have generally been set in studies in non-surgical settings and may not be applicable to the analysis of risk in the perioperative setting.\textsuperscript{20}

There are a number of limitations of the current study. This was a single centre study reflecting the surgical population and practice in a one surgical unit. Frailty instruments were studied in a fixed order. This was done to reflect the use of the CFS in other studies by ensuring that assessment based on a global impression of the patient was not influenced by the more detailed FP and AD instruments. It brought with it the risk that the CFS could itself bias the other assessments. This was mitigated by the structured nature of the FP and AD instruments but bias cannot be excluded. Resource constraints limited patient follow-up so that not all patients could be followed to surgery, death, or an explicitly documented decision not to operate. We collapsed ‘pre-frail’ and ‘frail’ into one group to investigate the associations between frailty and surgical outcomes. This approach allowed the examination of the frailty instruments for the binary classification of patients for the purpose of preoperative risk stratification but involved the loss of some information.

**Conclusions**

In summary, we studied three frailty assessment instruments, all of which demonstrated a significant prevalence of pre-frailty but a low prevalence of frailty in the adult colorectal surgical population at all ages. Our data suggest that pre-frailty is present in all age groups in this population and is consistent with population wide data from large studies. We found a lower prevalence of frailty than has been reported in the general population and this may reflect the selection of patients for surgery. We did not find pre-fraility/frailty to be strongly predictive of surgical complications. This may reflect the fact that we studied all adult age groups or it may be that pre-frailty is less predictive of adverse outcome in younger patients. The three common scoring instruments were inconsistent in identifying frailty. The purpose of identifying frailty in the pre-assessment clinic is to inform decision making and to allow appropriate modifications to perioperative care. Labelling a patient as pre-frail or frail has implications for the patient, the care pathway and resource use. Our data do not support screening for frailty across all adult patients undergoing colorectal surgery but do imply that larger studies would be of value to compare the performance of frailty scoring instruments in adult patients and to calibrate cut-off points for the prediction of postoperative outcome.

**Abbreviations**
Declarations

Ethics approval and consent to participate:

Ethical approval was received from the West Midlands Edgbaston UK Research Ethics Committee (15/WM/0148). Informed written consent was obtained from all participants, and were all deemed to have capacity my healthcare.

Consent for publication:

Not applicable.

Availability of data and material:

The datasets generated and analysed during the current study are available from the corresponding author on reasonable request.

Competing interests:

The authors declare no competing interests.

Funding:

This study was supported by a grant from the British Journal of Anaesthesia/Royal College of Anaesthetists. The funder had no role in the study design, data collection, analysis, or writing of the manuscript.

Authors’ contributions:

TDM, DB and SJH were responsible for the study design.

TDM and OB recruited patients.

TDM and OB performed data cleaning and preliminary analyses.
TDM, DB and SJH performed the final data analysis as presented in this paper

TDM, DB and SJH wrote the manuscript

All authors commented on the manuscript leading to the final submitted version

Acknowledgements:

The authors acknowledge the St James’ Hospital pre-assessment nurses, anaesthetists, surgeons, and other physicians for their support of this study.

We also thank Cath Moriarty and Holly Speight in the Abdominal Medicine and Surgery Research team at St James’ Hospital.

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