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What is the utility of preoperative frailty assessment for risk stratification in cardiac surgery?

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Abstract

A best evidence topic in cardiac surgery was written according to a structured protocol. The question addressed was whether frailty scoring can be used either separately or combined with conventional risk scores to predict survival and complications. Five hundred and thirty-five papers were found using the reported search, of which nine cohort studies represented the best evidence to answer the clinical question. The authors, journal, date and country of publication, patient group studied, study type, relevant outcomes and results of these papers are tabulated. There is a paucity of evidence, as advanced age is a criterion for exclusion in most randomized controlled trials. Conventional models of risk following cardiac surgery are not calibrated to accurately predict the outcomes in the elderly and do not currently include frailty parameters. There is no universally accepted definition for frailty, but it is described as a physiological decline in multiple organ systems, decreasing a patient's capacity to withstand the stresses of surgery and disease. Frailty is manifest clinically as deficits in functional capacity, such as slow ambulation and impairments in the activities of daily living (ADL). Analysis of predictive models using area under receiver operating curves (AUC) suggested only a modest benefit by adding gait speed to a Society of Thoracic Surgeons (STS score)-Predicted Risk of Mortality or Major Morbidity (PROM) risk score (AUC 0.04 mean difference). However, a specialist frailty assessment tool named FORECAST was found to be superior at predicting adverse outcomes at 1 year compared with either EuroSCORE or STS score (AUC 0.09 mean difference). However, risk models incorporating frailty parameters require further validation and have not been widely adopted. Routine collection of objective frailty measures such as 5-metre walk time and ADL assessment will help to provide data to develop new risk-assessment models to facilitate risk stratification and clinical decision-making in elderly patients. Based on the best evidence currently available, we conclude that frailty is an independent predictor of adverse outcome following cardiac surgery or transcatheter aortic valve implantation, increasing the risk of mortality 2- to 4-fold compared with non-frail patients.

Keywords: Review • Elderly • Cardiac surgery • Frailty • Outcome

INTRODUCTION

A best evidence topic was constructed according to a structured protocol. This is fully described in the *ICVTS* [1].

THREE-PART QUESTION

In patients [undergoing cardiac procedures] what is the [utility of preoperative frailty assessments] to [predict survival and complications]?

CLINICAL SCENARIO

You review an 80-year old man with critical aortic stenosis to determine whether to recommend aortic valve replacement (AVR) or transcatheter aortic valve implantation (TAVI). His left ventricular ejection fraction is 34%. He has had congestive cardiac failure (New York Heart Association Grade 2), moderate pulmonary hypertension, chronic kidney disease (glomerular filtration rate 46 ml/min/1.73 m^2), mild cognitive impairment and depression since his wife died 18 months ago. He lives alone in a ground-floor flat and performs his own personal grooming, but carers assist with household chores. His body mass index is 18.2. He reports a fair quality of life, walking inside his home with a stick and ventures outside with the assistance of his daughter. You calculate his predicted mortality: EuroSCORE = 8.61%, EuroSCORE II = 4.66% and Society of Thoracic Surgeons (STS) risk = 11.9%. However, you are unsure how frailty may alter his periprocedural risks, and therefore you research the best available evidence on this topic.

SEARCH STRATEGY

Medline from 1948 to January 2013 was interrogated using PubMed interface with the following terms: ('frail', 'frailty', 'dependence', 'vulnerable', 'decline') AND ('aged'*, 'aged', 'elderly', 'geriatric') AND ('risk assessment'*, 'risk') AND ('cardiac surgery', 'cardiac' AND 'surgery', 'cardiac surgical procedures'*, 'aortic valve'*, ('transcatheter' AND 'aortic valve')). MeSH terms are

Table 1: Best evidence papers

Author, date, journal and country Study type (level of evidence: USPSTFQR score)	Patient group	Outcomes	Key results	Comments
Afilalo *et al.* (2010), J Am Coll Cardiol, USA/Canada [4] Multicentre prospective cohort study (fair quality)	131 patients aged 70 or older undergoing elective CABG and/or valve replacement/repair Mean age 75.8 ± 4.4 years M:F–87:44 Frailty defined by slow walking speed <6 m in 5 s (*n* = 60) Fit by normal walking speed >6 m in 5 s (*n* = 71)	Composite 30-day mortality or major morbidity 30-day mortality Length of stay (still in hospital at 14 days) Institutional discharge	Slow gait increase risk 9 of 71 fit vs 21 of 60 frail ($P = 0.002$) OR 3.17 (95% CI 1.17–8.59) AUC 0.74 (0.64–0.84) STS score with gait speed added vs 0.7 (0.6–0.8) STS alone; IDI 5% (95% CI 1–8%) 1 of 71 fit vs 6 of 60 frail ($P = 0.047$) 13 of 71 fit vs 21 of 60 frail ($P = 0.03$) 14 of 71 fit vs 25 of 60 frail ($P < 0.0001$)	There was no correlation between gait speed and STS score, suggesting that these were representing distinct domains Slow gait speed conferred a 2- to 3-fold increase in risk for any level of STS-predicted mortality or major morbidity compared with normal gait speed
Afilalo *et al.* (2012), Circ Cardiovasc Qual Outcomes, USA/Canada [5] Multicentre prospective cohort study (poor quality)	152 patients aged 70 or older undergoing elective CABG and/or valve replacement/repair Mean age 75.9 ± 4.4 years M:F–100:52 Frailty scales (1) CHS scale: gait speed, handgrip, inactivity, exhaustion, weight loss; (2) CHS scale with cognitive impairment and depression; (3) gait speed, handgrip, inactivity, cognitive impairment; (4) gait speed alone Disability scales: (1) Katz ADL scale, (2) IADL, (3) Nagi scale: pushing heavy object, benching, arm raising, picking up small objects, lifting >5 kg, walking up stairs, walking 1 mile	Composite 30-day mortality or major morbidity	Gait speed (frailty) + Nagi score (disability) score + Parsonnet (cardiac) vs Parsonnet alone AUC = 0.76 vs 0.72 (IDI 2%; 95% CI 0–5%)	Frailty and disability parameters when combined with cardiac risk scores increase the predictive power of major morbidity or mortality
Lee *et al.* (2010), Circulation, Canada [6] Single-centre retrospective cohort study (clinical database linked to provincial administrative database) (good quality)	3826 patients undergoing elective cardiac surgery (*n* = 157 frail) Median age in non-frail 66 (IQR 57–74) vs 71 (IQR 61–78) years M:F—2828:998 Frailty defined as any impairment in ADL, ambulation or diagnosis of dementia	In-hospital mortality Mid-term mortality (1.8 years median follow-up) Institutional discharge	164 of 3826 fit vs 23 of 157 frail ($P < 0.0001$) OR 1.8 [95% CI 1.1–3] ($P = 0.03$) 330 of 3826 fit vs 41 of 157 frail ($P < 0.0001$) HR 1.5 [95% CI 1.1–2.2] ($P = 0.01$) 1316 of 3826 fit vs 65 of 157 frail ($P < 0.0001$) OR 6.3 [95% CI 4.2–9.4] ($P = 0.0001$)	Patients with either impairments of ADL, ambulation or dementia have higher mortality and need for institutional discharge This study did not compare frailty with conventional cardiac risk scores, and included patients younger than 65 years old

Continued

Table 1: (*Continued*)

Author, date, journal and country Study type (level of evidence: USPSTFQR score)	Patient group	Outcomes	Key results	Comments
Sundermann *et al.* (2011), Eur J Cardiothorac Surg, Germany [7] Single-centre prospective cohort study (poor quality)	400 patients undergoing elective cardiac surgery aged 74 years or older Mean age 80.1 ± 4.0 years M:F–194:206 CAF score: 1–10 not frail, 11–25 moderately frail, 26–35 severe frail. Gait speed, weakness, handgrip, exhaustion, low activity, IADL, tandem balance testing, chair rise ×3, pick up object, serum albumin, creatinine, BNP, FEV1, clinical frailty scale (scored by two doctors)	30-day mortality	7 of 199 fit vs 13 of 170 moderately frail vs 7 of 31 severely frail AUC EuroSCORE: 0.79, STS: 0.76 and CAF score: 0.71	The CAF frailty score correlated with cardiac risk scores EuroSCORE (P = 035) and to the STS score (P = 0.42), suggesting that frailty overlaps with traditional cardiac risk scores The CAF is very complex, may be impractical for clinical use and has not been shown to be superior to cardiac risk scores
Sundermann *et al.* (2011), Interact CardioVasc Thorac Surg Germany [8] Single-centre prospective cohort study (good quality)	213 patients undergoing elective cardiac surgery aged 74 years or older Mean age 80.1 ± 4.0 years M:F–110:103 Frailty score: derivative of CAF, FORECAST score: chair rise ×3, subjective reported weakness, stair climb, clinical frailty scale (scored by two doctors), serum creatinine	1-year mortality ITU length of stay	7 of 99 fit vs 12 of 95 moderately frail vs 42 of 19 severely frail (P < 0.01) AUC EuroSCORE: 0.67 [95% CI 0.56–0.78], STS score: 0.67 [95% CI 0.52–0.82], FORECAST: 0.76 [95% CI 0.67–0.85] 12 h 'fit' vs 19 h 'moderately frail' vs 27 h 'severely frail'. Not significant	This was a follow-up report of 1-year outcomes of the first 213 patients enrolled in the Sundermann *et al.* (2011) study to reach 1-year maturity FORECAST has not yet been validated in other populations
de Arenaza *et al.* (2010), Heart, Global [9] Multicentre study–secondary analysis of a RCT (good quality)	208 patients with severe AS who underwent 6MWT prior to AVR Mean age 70.0 ± 9.2 years M:F–127:81 Frail = walk <300 m in 6 min, Fit = walk >300 m in 6 min	Death MI or stroke at 1 year	4.7% (n = 3) of people who walked >300 m in 6 min had adverse event vs 23.8% (n = 15) of people who walked <300 m in 6 min (P = 0.03)	In patients identified by EuroSCORE to be high risk, i.e. Score >6 (n = 63), 6MWT was able to further stratify patients into low- and high-risk groups with increased discriminatory power
Stortecky *et al.* (2011), J Am Coll Cardiol Interv, Switzerland [10] Single-centre prospective cohort study (fair quality)	100 patients undergoing TAVI aged 70 years or older Mean age 83.7 ± 4.6 years M:F–40:60 Frailty index based on: MMSE, MNA, TUG, BADL, IADL preclinical mobility disability. 0–7 points. Dichotomized at ≥3 points = frail	30-day mortality 1-year mortality 30-day MAACE 1-year MACCE	OR 8.33 [95% CI 0.99–70.98] P = 0.03 OR 3.68 [95% CI 1.21–11.19] P = 0.02 OR 4.78 [95% CI 0.96–23.77] P = 0.05 OR 4.89 [95% CI 1.64–14.60] P = 0.003	This study demonstrates that a frailty score as part of a multidimensional geriatric assessment correlates with adverse outcomes, but is relatively time-consuming. To complete the assessments
Green *et al.* (2012), JACC, USA [11] Single-centre prospective cohort study (good quality)	159 patients aged 60 or over with severe aortic stenosis who underwent TAVI Mean age 86.2 ± 7.7 years M:F–79:80 Dichotomized into fit and frail groups by median frailty score (low albumin, slow gait speed,	30-day mortality 30-day complications Length of stay 1-year all-cause mortality	4 of 83 fit vs 4 of 83 frail (P = 0.9) No significant difference between fit and frail groups 6 ± 5 days fit vs 9 ± 6 days frail (P = 0.04) 7 of 83 fit vs 17 of 76 frail (P = 0.01)	A risk model incorporating frailty did not significantly improve the predictive power of 1-year mortality over a clinical model using receiver operating characteristic curves

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Table 1: (*Continued*)

Author, date, journal and country Study type (level of evidence: USPSTFQR score)	Patient group	Outcomes	Key results	Comments
	weak handgrip strength, IADLs and ADL)		Frailty, adjusted for confounders, was associated with 1-year mortality: Hazard ratio 3.51 [95% CI 1.4–8.5] $P = 0.007$ AUC 0.727 (95% CI 0.62–0.83) clinical model vs AUC 0.772 (95% CI 0.68–0.86) frailty and clinical model	
Scheoenenberger *et al.* (2012), Eur Heart J, Switzerland [12] Single-centre prospective cohort study (fair quality)	119 patients undergoing TAVI aged 70 years or older (including patients in the study by Stortecky *et al.* [10]) Mean age 83.4 ± 4.6 years M:F–53:66 Frailty index as described in [10] Functional decline was observed in 22 of 106 patients (21%) who survived 6 months following TAVR	Functional decline at 6 months Functional decline or death at 6 months	Dichotomized frailty index (frail vs non-frail) OR 3.31 [95% CI 1.12–9.03] $P = 0.02$ Bivariate analysis controlled for EuroSCORE frailty index linear OR 1.56 [95% CI 1.20–2.04] $P = 0.001$ Dichotomized frailty index (frail vs non-frail) OR 4.46 [95% CI 1.85–10.75] $P = 0.0001$ Bivariate analysis controlled for EuroSCORE frailty index linear OR 1.73 [95% CI 1.36–2.20] $P<0.001$	EuroSCORE and STS did not predict functional decline. However, frailty index strongly predicted functional decline Overall predictive performance was best for frailty index (Nagelkerke's $R^2 = 0.135$) and low for EuroSCORE (Nagelkerke's $R^2 = 0.015$) and STS score (Nagelkerke's $R^2 = 0.034$)

6MWT: 6-min walk test; ADL: activities of daily living; AVR: aortic valve replacement; AUC: area under the curve; BADL: basic activities of daily living; BNP: brain natriuretic peptide; CABG: coronary artery bypass graft; CAF: comprehensive assessment of frailty score; CHS: cardiovascular health study; EuroSCORE: European System for Cardiac Operative Risk Evaluation; FEV1: forced expiratory volume in 1 s; FORECAST: Frailty predicts death One yeaR after Elective Cardiac Surgery Test; HR: hazard ratio; IDI: integrated discrimination improvement; IADL: instrumental activities of daily living; IQR: interquartile range; ITU: intensive therapy unit; MMSE: mini-mental state examination; MNA: mini-nutritional assessment; OR: odds ratio; STS-PROM: Society of Thoracic Surgeons Predicted Risk of Mortality or Major Morbidity score; TAVI: transcatheter aortic valve implantation; TUG: timed up and go; USPSTFQR: US Preventive Services Task Force Quality Rating.

denoted with an asterisk. Related articles and references were screened for suitable articles.

SEARCH OUTCOME

Five hundred and thirty-five papers were found using the reported search. From these, nine papers were identified that provided the best evidence to answer the question. These are presented in Table 1.

RESULTS

Cardiac scores, including EuroSCORE and STS, have been developed to predict the risk of adverse outcomes following surgery. Frailty, an independent predictor of mortality and complications [2], is not included in these risk algorithms. We sought to ascertain the utility of preoperative frailty in predicting survival and complications, either separately or combination with conventional cardiac scores. The level of evidence of included studies was determined in accordance with the US Preventive Services Task Force Quality Rating Criteria [3].

Afilalo *et al.* [4] determined that patients with slow preoperative gait speed (≥6 s to walk 5 m) had a 2- to 3-fold increased risk of mortality and major morbidity for any given level of STS-Predicted Risk of Mortality or Major Morbidity (PROM) compared with normal speed. Gait speed added to STS-PROM marginally increased model performance from 0.70 (0.60–0.80) to 0.74 (0.64–0.84). Forty-three percent of patients died or sustained a major complication assessed as high STS-PROM risk (≥15%) together with slow gait speed, compared with 21.7% low STS risk with slow gait and 18.9% high STS risk with normal gait. Afilalo *et al.* [5] subsequently evaluated the prognostic power of various frailty, disability and cardiac risk scores to identify the optimal combination to predict adverse outcome. Patients with slow gait speed and ≥3 impairments on the Nagi disability scale predicted in-hospital morbidity and mortality above that of the Parsonnet cardiac risk score (AUC 0.76 vs 0.72 with Parsonnet score alone).

Lee *et al.* [6] performed a retrospective review of a large cardiac registry, comparing outcomes between non-frail and frail individuals (coded as having deficiencies in the activities of daily living,

need for walking aids or diagnosis of dementia). Frailty was an independent risk factor for in-hospital mortality (risk-adjusted odds ratio [OR] 1.8; 95% confidence interval [CI] 1.1–3.0; $P = 0.03$) and mortality at 2 years (risk-adjusted hazards ratio [HR] 1.5, 95% CI 1.1–2.2; $P = 0.01$).

Sündermann *et al.* [7] evaluated the predictive power of STS and EuroSCORE in a specialized comprehensive assessment of frailty (CAF) in 400 patients undergoing cardiac surgery. CAF scores predicted 30-day mortality, but were not superior to that of conventional risk scores: AUC 0.71 (CAF), 0.79 (EuroSCORE) and 0.76 (STS). Sündermann *et al.* [8] subsequently analysed the results of the first 213 patients to reach 1-year maturity and found CAF scores correlated with 1-year mortality, as did EuroSCORE and STS. The authors generated a simplified CAF score using the five components that contributed most to its predictive ability, called FORECAST. Based on the area under receiver operating characteristic curves, 1-year mortality prediction was superior using the FORECAST model (0.76, 95% CI 0.67–0.85), compared with EuroSCORE (0.67, 95% CI 0.56–0.78) and STS (0.67, 0.52–0.82). However, FORECAST needs to be validated in a new and larger patient population.

In a study by de Arenaza *et al.* [9] of 208 patients undergoing AVR, the composite mortality, myocardial infarction (MI) or stroke rate was 13% ($n = 14$) in patients walking <300 m compared with 4% ($n = 4$) in those who walked >300 m in 6 min ($P = 0.017$). For patients with an EuroSCORE of >6 ($n = 63$), the 6-min walk test (6MWT) was able to further stratify patients into low- and high-risk groups with significant additional discriminatory ability ($P = 0.030$). In a regression analysis, 6MWT distance was the only independent predictor of the composite outcome of death, MI or stroke at 12 months (HR 0.28; 95% CI 0.09–0.85, $P = 0.025$). The 6MWT may therefore complement existing scoring systems, but further validation studies are required.

Preoperative frailty has also been shown to be associated with mortality, complications and functional decline in patients undergoing TAVI [10–12]. Two studies, one by Stortecky *et al.* [10] and one by Green *et al.* [11], demonstrated that frail patients had a 3- to 4-fold increase risk of 1-year all-cause mortality following TAVI. In the latter study, a predictive model incorporating frailty was superior to a clinical model, but this did not achieve statistical significance: AUC 0.727 (95% CI 0.62–0.83) in the clinical model vs AUC 0.772 (95% CI 0.68–0.86) in the frailty and clinical model.

CLINICAL BOTTOM LINE

Nine studies demonstrated that preoperative frailty correlates with adverse outcomes in elderly patients undergoing cardiac surgery [4–12]. Four studies found that the addition of frailty increased the predictive power of conventional risk scores, but this requires further validation [4, 5, 8, 11]. Frail individuals, such as those with cognitive impairment, slow gait and poor ambulation or requiring assistance to complete basic daily tasks, should be counselled that they face a 2- to 4-fold increase risks of perioperative mortality compared with non-frail patients.

Conflict of interest: none declared.

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