**Table 1:** Summary of frailty assessment tools used in included studies

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Tool** | **Assessment domains** | | | | | | | | | **Score/**  **Index** | **Frailty definition** | **Validation** | **Studies** |
| Mobility | Function | Cognition | ADLs | Nutrition | Mood | Social | Comorbidity  (health) | Medications |
| **AVFS** |  |  |  |  |  |  |  |  |  | 0 – 6 | N/A | x | 1 |
| **Barthel index** |  |  |  |  |  |  |  |  |  | 0 - 20 | N/A | x | 1 |
| **CFS** |  |  |  |  |  |  |  |  |  | 1 – 9 | ≥5 | ● | 4 |
| **CLI frail** |  |  |  |  |  |  |  |  |  | 0 – 3 | ≥2 | x | 1 |
| **EFS** |  |  |  |  |  |  |  |  |  | 0 – 17 | ≥8 | ● | 2 |
| **FiND** |  |  |  |  |  |  |  |  |  | Frailty: 0 – 3  Disability: 0 – 2 | Frailty: ≥1 | ● | 1 |
| **Fried criteria** |  |  |  |  |  |  |  |  |  | 0 – 5 | ≥3 | ● | 1 |
| **FD** |  |  |  |  |  |  |  |  |  | N/A | Fully/partially dependent | N/A | 6 |
| **GFI** |  |  |  |  |  |  |  |  |  | 0 – 15 | ≥4 | ● | 2 |
| **Katz index** |  |  |  |  |  |  |  |  |  | 0 – 6 | ≤5 | ● | 2 |
| **mEFT** |  |  |  |  |  |  |  |  |  | 0 – 5 | ≥3 | ○ | 1 |
| **mFI** |  |  |  |  |  |  |  |  |  | 0 – 1 | ≥0.25 | ○ | 10 |
| **MPI** |  |  |  |  |  |  |  |  |  | 0 – 1 | ≥0.34 | ● | 1 |
| **O’Neill et al.** |  |  |  |  |  |  |  |  |  | Fit/  Not fit | Not fit | N/A | 1 |
| **RAFS** |  |  |  |  |  |  |  |  |  | 0 – 9 | N/A | x | 1 |
| **RAI** |  |  |  |  |  |  |  |  |  | 0 – 75 | ≥11 | ○ | 2 |

*ADLs, Activities of Daily Living; AVFS, Addenbrooke’s Vascular Frailty Score; CFS, Clinical Frailty Scale; CLI frail, Critical limb ischaemia frail; EFS, Edmonton Frail Scale; FD, Functional Dependence; FiND, Frail Non-Disabled; FRAIL scale, GFI, Groningen Frailty Indicator; mEFT, Modified Essential Frailty Toolset; mFI, Modified Frailty Index; MPI, Multidimensional Prognostic Index; RAFS, Ruptured Aneurysm Frailty Score; RAI, [Frailty] Risk Analysis Index.*

*Assessment method for individual domains:*  *= Clinician assessment or record-linked assessment;*  *= patient self-report.*

*Validation of the definition of frailty for individual frailty tools: ● = validated in a population of healthy/community-dwelling older adults; ○ =validated in a disease-specific population; x = frailty not defined or not validated in previous research; N/A = not applicable (not a multi-domain tool).*

**Table 2:** Summary of studies included in the meta-analysis

|  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Study details** | | | | | | | | **Quality assessment** | | |
| **1st Author** | **Year** | **Country** | **Design** | **Patients** | **Undergoing procedure?** | **Tool(s)** | **Sample size** | | **Validated?** | **NOS** |
| **Studies using frailty assessment tool(s)** | | | | | | | | | | |
| **Crawford21** | 2010 | USA | Retrospective cohort | All infra-inguinal bypass (LEAD) | Yes | FD | 5639 | | x | 9 |
| **Scarborough**  **(CEA)33** | 2015 | USA | Retrospective cohort | Elective CEA (CAD) | Yes | FD | 33,468 | | x | 9 |
| **Scarborough**  **(OAR)33** | 2015 | USA | Retrospective cohort | Elective OAR (AAA) | Yes | FD | 5,475 | | x | 9 |
| **Partridge11** | 2015 | UK | Prospective cohort | All surgery for AAA or LEAD; Aged ≥60 | Yes | EFS | 125 | | ● | 9 |
| **O’Neill31** | 2016 | UK | Retrospective cohort | Proposed elective LEAD or AAA surgery | Both | Initial clinical impression | 392 | | x | 9 |
| **Morisaki30** | 2017 | Japan | Retrospective cohort | All infra-popliteal revascularisation (LEAD) | Yes | CLI frail | 266 | | x | 8 |
| **Harris26** | 2017 | USA | Retrospective cohort | Elective EVAR  (AAA) | Yes | FD | 13,432 | | x | 9 |
| **Dinga Madou22** | 2017 | USA | Retrospective cohort | EVT for CLI;  Aged ≥70 (LEAD) | Yes | FD | 1048 | | x | 9 |
| **Takeji17** | 2018 | Japan | Prospective cohort | All revascularisation for CLI (LEAD) | Yes | CFS | 643 | | ● | 9 |
| **Donald23** | 2018 | USA | Retrospective cohort | Elective AAA, TAA, LEAD & CAD procedures | Yes | CFS | 134 | | ● | 9 |
| **Ghaffarian24** | 2019 | USA | Retrospective cohort | All vascular patients undergoing CT | Both | CFS | 415 | | ● | 7 |
| **Studies using a clinical or radiological measure of sarcopenia** | | | | | | | | | | |
| **Matsubara29** | 2015 | Japan | Retrospective cohort | All revascularisation for CLI (LEAD) | Yes | SMA (L3) (CT) | 64 | | ● | 8 |
| **Hale25** | 2016 | USA | Retrospective cohort | Elective EVAR (AAA) | Yes | SMA (L3) (CT) | 200 | | ○ | 8 |
| **Reeve32** | 2018 | USA | Cross-sectional | AAA, LEAD or CAD (clinic visit) | No | Dominant hand grip strength (kg) | 311 | | ● | 7 |
| **Thurston34** | 2018 | Australia | Retrospective cohort | Elective EVAR (AAA); Aged ≥50 | Yes | TPA/height2 (L3) (CT) | 191 | | ○ | 9 |
| **Kays28** | 2018 | USA | Retrospective cohort | All OAR or EVAR (AAA) | Yes | SMA/height2  (L3) | 505 | | ○ | 7 |
| **Heard27** | 2018 | UK | Retrospective cohort | All vascular admissions | Both | SMA/height2  (L3) | 314 | | ○ | 7 |
| **Addison20** | 2018 | USA | Cross-sectional | LEAD patients (clinic visit);  Aged ≥50 | No | ALM/height2 (DEXA) | 108 | | ○ | 7 |
| **Waduud35** | 2019 | UK | Retrospective Cohort | Elective OAR or EVAR (AAA) | Yes | TPA/height2  (L3) | 380 | | ○ | 9 |

*AAA, Abdominal Aortic Aneurysm; AFS, AMT, Abbreviated Mental Test; ALM, Appendicular lean mass; CAD, Carotid Artery Disease; CEA, Carotid Endarterectomy, CFS, Clinical Frailty Scale; CLI, Critical limb ischaemia; CT, Computed tomography; DEXA, Dual-energy x-ray absorptiometry; EFS, Edmonton Frail Scale; EVAR, Endovascular Aneurysm Repair; FD, Functional Dependence; FiND, Frail Non-Disabled; LEAD, Lower Extremity Arterial Disease; MUST, Malnutrition Universal Screening Tool; NOS, Newcastle-Ottawa Scale; OAR, Open Aneurysm Repair; SMA, Skeletal muscle area; TPA, Total psoas area*

*Quality assessment: ● = tool and frailty definition validated in previous research in healthy/community-dwelling older adults. ○ = tool and frailty definition validated in previous research in a disease-specific cohort. x = tool and/or frailty definition not validated in previous research.*

**Table 3:** Summary of meta-analysis results: associations of patient factors with frailty

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Patient factor** | **Studies** | **Patients** | **Effect estimate†** | **I2** | **GRADE score** |
| **Continuous variables (MD; inverse variance method; random effects model)** | | | | | |
| Age (years) | 12 | 22166 | **MD 4.05 (3.35, 4.75)** | 44% | Moderate |
| BMI | 3 | 19486 | **MD -1.81 (-2.94, -0.68)** | 81% | Very low |
| **Categorical variables (Mantel-Haenszel method; random effects model)** | | | | | |
| Sex (female)\* | 13 | 23354 | **RR 1.32 (1.14, 1.54)** | 78% | Very low |
| Current smoking | 9 | 21818 | **RR 0.76 (0.64, 0.91)** | 65% | Very low |
| Hypertension | 9 | 16469 | RR 1.15 (0.86, 1.53) | 80% | Very low |
| Ischaemic heart disease | 8 | 2192 | RR 1.09 (0.88, 1.35) | 56% | Very low |
| Respiratory disease | 6 | 20859 | **RR 1.57 (1.25, 1.96)** | 73% | Very low |
| Diabetes | 11 | 22415 | RR 1.19 (0.94, 1.51) | 88% | Very low |
| Renal impairment | 4 | 1383 | RR 1.14 (1.00, 1.30) | 0% | Very low |
| Dialysis | 7 | 8275 | RR 1.49 (1.00, 2.20) | 94% | Very low |
| Cerebrovascular disease | 8 | 7735 | **RR 1.41 (1.07, 1.86)** | 88% | Very low |

*BMI, Body-mass index; GRADE, Grading of recommendations assessment, development and evaluations; RR, Risk ratio.*

*\*Effect estimate >1 = increased risk of frailty in females vs males*

*†Values are difference in means (MD) frail vs non-frail (continuous variables) or risk ratios (RR) (categorical variables) with 95% confidence intervals in parentheses. Values* ***underlined in bold*** *highlight factors with significant associations with frailty.*

**Table 4:** Summary of meta-analysis results: associations of frailty with outcomes

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| **Outcome measure** | **Studies** | **Patients** | | **Effect estimate†** | | **I2** | **GRADE score** |
| **Unadjusted variables (Mantel-Haenszel method; random effects model)** | | | | | | | |
| Pneumonia | 4 | 14669 | **OR 5.76 (3.70, 8.96)** | | 0% | | Low |
| MI/ACS | 3 | 14605 | OR 1.48 (0.55, 3.94) | | 51% | | Very low |
| Stroke/TIA | 3 | 14544 | OR 2.13 (0.79, 5.76) | | 10% | | Very low |
| Surgical site infection | 3 | 13621 | **OR 2.62 (1.30, 5.29)** | | 0% | | Very low |
| Composite post-op complications | 8 | 58528 | **OR 2.63 (1.93, 3.59)** | | 87% | | Very low |
| Non-home discharge | 3 | 13710 | **OR 3.57 (1.29, 9.87)** | | 88% | | Very low |
| 30-day mortality | 6 | 59105 | **OR 4.81 (4.02, 5.75)** | | 0% | | Very low |
| **Adjusted variables (generic inverse variance method; random effects model)** | | | | | | | |
| Composite post-op complications | 3 | 19196 | **OR 2.16 (1.55, 3.02)** | | 58% | | Very low |
| 30-day mortality | 3 | 20028 | **OR 2.77 (2.01, 3.81)** | | 13% | | Low |
| Long-term mortality | 9 | 2904 | **HR 1.85 (1.31, 2.62)** | | 74% | | Low |

*ACS, Acute coronary syndrome; GRADE, Grading of recommendations assessment, development and evaluation; HR, Hazards ratio; MI, Myocardial infarction; OR, Odds ratio; TIA, Transient ischaemic attack.*

*†Values are odds or hazard ratio for outcome event in frail vs non-frail patients with 95% confidence intervals in parentheses. Values* ***underlined in bold*** *highlight events with significant associations with frailty.*