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RESEARCH PAPER

Frailty and stroke thrombectomy outcomes—an observational cohort study

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Abstract

Introduction: Mechanical thrombectomy (MT) can improve outcomes following ischaemic stroke. Patient selection for MT is predominantly based on physiological and imaging parameters. We assessed whether people living with pre-stroke frailty had differing outcomes following MT.

Methods: We included consecutive patients undergoing MT at a UK comprehensive stroke centre. We calculated a cumulative deficits frailty index to identify pre-stroke frailty in those patients presenting directly to the centre. Frailty was defined as an index score ≥ 0.24. We assessed univariable and multivariable association between pre-stroke frailty and stroke outcomes. Our primary outcomes were modified Rankin Scale (mRS) and mortality at 90 days.

Results: Of 175 patients who underwent MT (2014–2018), we identified frailty in 49 (28%). Frail and non-frail patients had similar rates of thrombolysis administration, successful recanalization and onset to recanalization times. Those with pre-stroke frailty had higher 24 hour National Institutes of Health Stroke Scale (12(IQR: 8–17) versus 3(IQR: 2–13); $P = 0.001$); were less likely to be independent (mRS 0–2: 18% versus 61%; $P < 0.001$) and more likely to die (47% versus 14%; $P < 0.001$) within 90 days. Adjusting for age, baseline NIHSS and thrombolysis, frailty remained a strong, independent predictor of poor clinical outcome at 90 days (Death OR: 3.12 (95% CI: 1.32–7.4); dependency OR: 3.04 (95%CI: 1.10–8.44). Age was no longer a predictor of outcome when adjusted for frailty.

Conclusion: Pre-stroke frailty is prevalent in real-world patients eligible for MT and is an important predictor of poor outcomes. Routine assessment of pre-stroke frailty could help decision-making around patient selection for MT.

Keywords: frailty, stroke, thrombectomy, older people

Key Points

- Pre-stroke frailty is common in patients otherwise eligible for mechanical thrombectomy.
- Patients with pre-stroke frailty are more likely to be dead or dependent at 3 months following mechanical thrombectomy, despite similar rates of thrombolysis, successful recanalization and treatment times.
- Pre-stroke frailty remained a strong independent predictor of poor functional outcome even when adjusted for other important prognostic markers including age and stroke severity.
- The association between pre-stroke frailty and poor functional outcome following thrombectomy is sufficiently strong to support routine assessment of frailty in the acute stroke setting.

Introduction

Frailty is a syndrome encompassing a reduction in multi-system physiological reserve leading to impaired homeostasis and greater susceptibility to external stressors [1]. Although there is debate around both the conceptualisation of frailty and optimal methods of frailty assessment [2], it is widely accepted that assessment of frailty has utility in the acute care setting, as increasing frailty is strongly associated with hospitalisation, morbidity and mortality across a variety of health conditions [3].

Frailty is prevalent in patients presenting with acute stroke. A single centre study found that four in every five unselected acute stroke admissions exhibited either frank frailty or pre-frailty (a state of heightened risk of becoming frail but not currently considered frail) at the time of their index stroke event [4]. Despite its prevalence, the impact of pre-stroke frailty on stroke outcomes has received relatively little research attention to date.

The use of revascularisation therapies such as intravenous thrombolysis and mechanical thrombectomy (MT) have revolutionised the pathways and outcomes for patients with acute ischaemic stroke. Randomised controlled trials (RCTs) of revascularisation therapies generally exclude patients with complex co-morbidity or pre-stroke disability [5]. The operationalisation of this assessment of the pre-stroke state varies across RCTs. The most common approach is to use the modified Rankin Scale (mRS) [6], a scale with an emphasis on pre-stroke mobility. Additionally, trials may require an upper age limit [7] and commonly report the interaction between advanced age and treatment outcome in pre-specified subgroup analyses [8, 9]. If the intention is to identify those acute stroke presentations with the greatest vulnerability to the adverse effects of both the stroke and its treatment, then a measure of frailty may provide useful information.

There are data to suggest that pre-stroke frailty is not only associated with poor stroke outcomes but may be associated with a differential response to acute treatments. In a UK hospital registry, patients with pre-stroke frailty were less likely to achieve significant improvement in their National Institutes of Health Stroke Scale (NIHSS) than non-frail patients following administration of intravenous thrombolysis, even when adjusted for differences in age, baseline stroke severity and treatment times [10]. However, little is known about the association between frailty and outcome after MT, and whether assessment of frailty could help improve prognostication for the individual patient referred for thrombectomy.

We aimed to describe the prevalence of pre-stroke frailty in real world patients, treated with MT for acute ischaemic stroke and determine the association between pre-stroke frailty and functional outcomes following MT.

Methods

We created a single centre, inception cohort including all patients who underwent MT in the Royal Victoria Hospital, Belfast. Patient characteristics, process times and early outcomes were recorded contemporaneously for all patients as part of their routine care. For quality control and to minimise missing data, each case also had retrospective retrieval of data from medical records.

We followed the STROBE guideline for reporting observational research [11]. This work was supported internally and received no external funding. The local MT register is approved as a tool for service evaluation and did not require additional ethical approvals. As a clinical resource, the individual patient level data contained in the registry is not available for sharing.

Setting and context

During the analysis period, we offered a Monday–Friday 08:00–17:00 MT service to patients presenting directly to the comprehensive stroke centre (mothership) and to those who presented to a regional primary stroke centre within Northern Ireland and were transferred (drip-and-ship). For this analysis, we included only mothership patients to allow derivation of the frailty index, as we had access to full primary and secondary care data for this group. Outcomes for drip-and-ship patients at our centre are similar to mothership patients as reported previously [12]. We routinely perform thrombectomy procedures under local anaesthesia or conscious sedation, with only a small proportion of patients (<10%) receiving general anaesthetic (GA).

Population

Our centre operates eligibility based on national guidance [13] and informed by the seminal RCTs [9]. Patients were deemed eligible for MT with proven large vessel occlusion on angiography, NIHSS ≥ 5, onset; last seen well within 12 hours (anterior circulation) or 24 hours if basilar artery thrombosis, small infarct core (Alberta stroke program early CT score (ASPECTS) ≥ 5), and pre-stroke mRS 0–2. Patients with no known onset time were considered if they met the other criteria. Patients with NIHSS < 5 were considered if they had a disabling deficit. Patients with ASPECTS < 5 were considered if they had a significant area of ischaemic penumbra on perfusion imaging.

Exposure

There is no consensus on the optimal approach to frailty assessment in stroke, and the agreement between different approaches is imperfect [14]. In the absence of routine, prospective frailty assessment, we derived a 33-item cumulative deficit frailty index. We used component items included in a frailty index previously validated in a stroke population [4, 14] and recommended in a recent review of frailty and stroke [15] (Supplementary Material). Historical data from primary and secondary care, laboratory results and radiological reports were reviewed to record conditions present prior to the index stroke presentation. The Frailty Index was created by dividing the number of conditions present by the total number of conditions defined in the list (i.e. 33). Thus, possible results ranged from 0.0 to 1.0, with scores closer to 1.0 suggesting greater pre-stroke frailty. Patients were categorised as frail with a score of ≥0.24 [4].

Outcomes

The primary outcome measure was mRS at 90 days obtained via in-person clinic or telephone review, blinded to pre-stroke frailty status. Secondary outcome measures were 24 hour NIHSS, symptomatic intracerebral haemorrhage (sICH) and dependency (mRS 3–5) or death at 90 days. The Safe Implementation of Thrombolysis in Stroke Monitoring Study criteria for sICH were used (i.e. parenchymal haemorrhage type 2 at post-treatment scan combined with neurological deterioration leading to an increase of 4 points or more on the NIHSS) [16]. Patients with subarachnoid haemorrhage causing equivalent neurological deterioration were also considered to have had sICH. Successful recanalization was defined as thrombolysis in cerebral infarction (TICI) score 2b or greater and determined by an expert interventional neuroradiologist.

Analyses

We described outcomes for frail versus non-frail stroke admissions using the Frailty Index as a dichotomised variable (frail ≥ 0.24; non-frail < 0.24) and comparing groups with parametric, non-parametric or proportional analyses as suggested by the data distribution. Data were checked for normality using Kolmogorov–Smirnov testing. We created a multivariable regression model to include pre-stroke frailty and other important stroke prognostic indicators, including age (years), sex, baseline NIHSS and administration of IV thrombolysis [17]. Given the potential for correlation between our included variables, multicollinearity was evaluated by generating variance inflation factor (VIF) scores. We used an intention to treat approach and included follow-up data for all patients who began the procedure, even if the procedure was not completed. Based on dichotomous functional outcome, our sample size was sufficient to support a model with five input variables. As a sensitivity analysis, we ran the model with pre-stroke frailty as both a dichotomous and continuous construct to ensure dichotomisation did not confound results.

Results

Population

We included data from 1 January 2014 to 31 December 2018 inclusive, representing 329 patients undergoing MT, of whom 175 mothership patients were included in this analysis (Figure 1). Mean age at presentation was 72 years (SD:13), 75 (43%) were male and median baseline NIHSS was 16 (IQR:10–20)). The majority of patients had culprit thrombus in the anterior circulation with a similar distribution of right and left hemisphere strokes (Table 1). Our patients were broadly similar to those included in seminal MT trials. (Supplementary Materials).

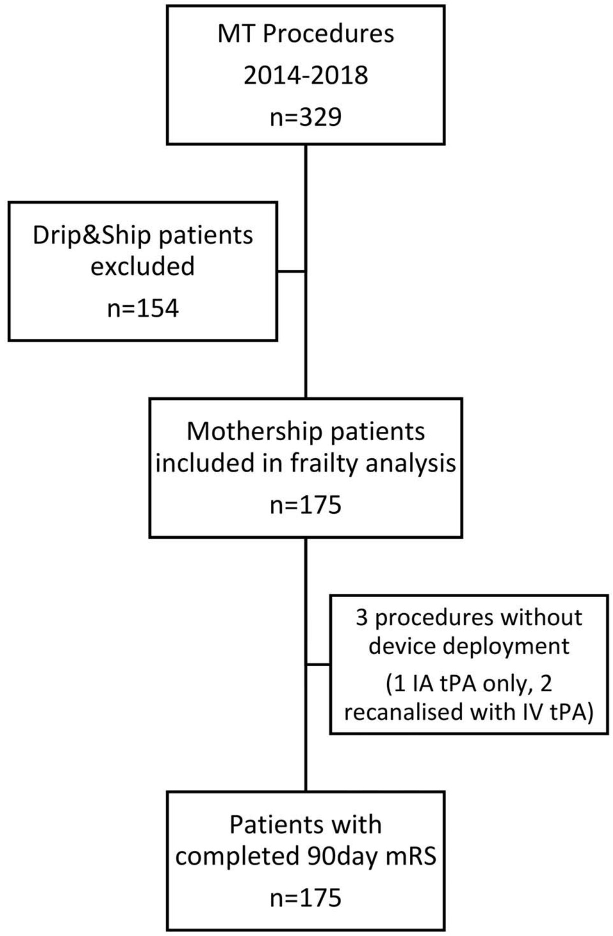

Figure 1. Flowchart of included patients. MT, mechanical thrombectomy; IA, intra-arterial; tPA, thrombolysis; IV, intravenous; mRS, modified Rankin Scale.

Frailty status

Using the dichotomised Frailty Index (≥0.24 defined as frail), there were 49 patients classified as having pre-stroke frailty (28%) and 126 classified as non-frail (72%). Median Frailty Index score was 0.15 (IQR: 0.08, 0.24). The group with frailty were older (mean age: 80 years (SD: 8) versus 69 years (SD: 14)), with greater baseline stroke severity (median baseline NIHSS: 19 (IQR: 15–24) versus 16 (IQR: 10–22)) than the non-frail group (Table 1).

Outcomes

There were no missing data for death and disability (mRS) outcomes at 90 days**.** At 3 months, outcomes for patients with pre-stroke frailty were significantly worse than non-frail patients (median 90-day mRS 5 versus 2; $P < 0.001$) (Figure 2). Mortality at 3 months following thrombectomy was 47% for patients with pre-stroke frailty (23/49) and 9% for patients without frailty (11/126) ($P < 0.001$). Patients

Table 1. Patient characteristics and process outcomes for frail and non-frail patients

	Frail ($n=49$)	Non-Frail ($n=126$)	P value
Age (years, mean, SD)	80 (7.7)	69	<0.0001
Male	51%	40%	0.173
Baseline NIHSS (median, IQR)	19 (15,24)*	16 (10,19)	0.0004
Left hemisphere	21/43 (49%)	54/115 (47%)	0.91
Clot location			
Intracranial ICA	11	12	
M1	25	77	
M2	4	15	
Tandem (ICA and M1/M2)	3	9	
Basilar Artery	6	9	
Other	0	4	
IV tPA	19/49 (39%)	55/126 (44%)	0.58
Successful recanalisation (≥TICI 2b)	37/49 (76%)	107/123 (87%)	0.65
Onset to recanalisation (mins, median, IQR)	200 (163,305) ≠	191 (155,275) ≠	0.22
Door to CT	17 (13,29)	21 (13,30)	
CT to Groin	37 (30,83)	39 (27,61)	
Groin to recanalisation	38 (26,60)	36 (25,59)	

*Baseline NIHSS were missing for three frail patients. ≠ Stroke onset time was unknown for nine frail patients and 29 non-frail patients. NIHSS, National Institute for Health Stroke Scale Score; ICA, internal carotid artery; M1, M1 segment of middle cerebral artery; M2, M2 segment of middle cerebral artery; IV tPA, intravenous thrombolysis; TICI, thrombolysis in cerebral infarction score; CT, computerised topography scan.

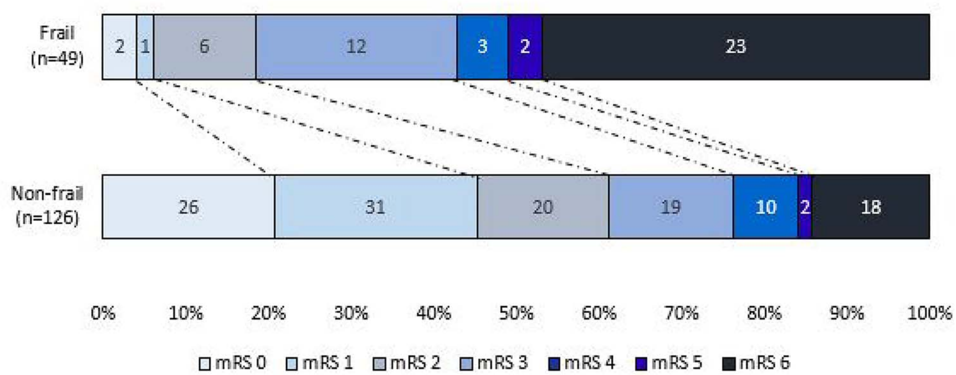

Figure 2. Distribution of mRS scores at 90 days following thrombectomy for frail and non-frail patients.

with pre-stroke frailty who survived were much more likely to be dependent at 3 months (90 day mRS 3-5: 17/26 (65%) versus 38/115 (33%); $P < 0.001$). Although 24-hour NIHSS was higher for frail patients in univariate analysis (12 (IQR:8,17) versus 3 (IQR:2,13); $P = 0.001$), when adjusted for age, sex, baseline NIHSS and tPA administration there was no difference in stroke severity at 24 hours between the groups (Table 2). Multicollinearity was not a problem in the model according to VIF scores (all <2). Symptomatic intracerebral haemorrhage occurred in 1 frail patient (1/49) and 1 non-frail patient (1/123).

On multivariate analysis, adjusting for age, sex, baseline NIHSS and administration of IV thrombolysis, frailty remained a strong, independent predictor of both death and dependency at 90 days (death at 90 days: OR 3.12 (95% CI: 1.32–7.4); dependency at 90 days: OR 3.04 (95%CI: 1.10–8.44). On sensitivity analyses, when frailty was treated as a continuous variable, the association remained significant for dependency at 90 days, but not for mortality (Table 3).

Administration of intravenous thrombolysis was similar between the frail and non-frail groups (39% versus 44%; $P = 0.58$). Likewise, rates of successful recanalization (TICI ≥ 2b) were similar, achieved in 37/49 frail patients (76%) and 107/123 non-frail patients (87%) ($P = 0.07$). Three patients in the non-frail cohort did not have a thrombectomy procedure performed following groin puncture (two patients had recanalised with IV tPA and 1 patient had IA tPA administered only). Treatment times were also similar for both groups with median onset to recanalization times of 200 minutes and 190 minutes for frail and non-frail patients respectively, ($P = 0.93$).

Discussion

In our centre, pre-stroke frailty was evident in over a quarter of patients deemed eligible for MT. The group with pre-stroke frailty had poor outcomes following MT with just over half alive at 3 months, and of the survivors, a further two-thirds were physically dependent. This association between pre-stroke frailty and poor outcome remained apparent even after adjusting for other important prognostic markers.

Table 2. Association between frailty and 24-hour NIHSS

Variable	Unstandardised CoefficientsBeta	Unstandardised CoefficientsStandard error	Standardised CoefficientsBeta	Significance
Constant	−3.97	3.03		0.19
Age	0.09	0.04	0.16	0.03
Sex (Male/female)	0.07	1.01	0.01	0.95
Baseline NIHSS	0.47	0.07	0.47	0.00
IV tPA (yes/no)	−1.25	0.99	−0.08	0.21
Frailty (frail/non-frail)	0.85	1.23	0.05	0.49

NIHSS, National Institute for Health Stroke Scale Score, IV tPA, intravenous thrombolysis.

Table 3. Association between frailty and death or dependency at 90 days

Variable	Death at 90 days			Dependency at 90 days		
	Odds ratio	95% confidence intervals	Significance	Odds ratio	95% confidence intervals	Significance
Frailty as a dichotomised variable						
Age	1.035	0.996–1.075	0.081	1.020	0.987–1.054	0.236
Sex (male/female)	0.736	0.322–1.682	0.467	1.113	0.491–2.525	0.797
Baseline NIHSS	1.059	1.001–1.120	0.048	1.096	1.034–1.161	0.002
IV tPA (yes/no)	0.428	0.184–0.993	0.048	0.907	0.407–2.023	0.812
Frailty (frail/non-frail)	3.119	1.315–7.397	0.010	3.038	1.093–8.442	0.033
Frailty as a linear variable						
Age	1.038	0.998–1.079	0.063	1.011	0.976–1.046	0.542
Sex (male/female)	0.797	0.355–1.791	0.583	1.170	0.515–2.658	0.707
Baseline NIHSS	1.069	1.011–1.130	0.018	1.099	1.037–1.166	0.002
IV tPA (yes/no)	0.410	0.179–0.939	0.035	0.883	0.394–1.980	0.763
Frailty (linear)	1.028	0.986–1.072	0.198	1.062	1.012–1.115	0.014

NIHSS, National Institute for Health Stroke Scale Score; IV tPA, intravenous thrombolysis.

The association is not explained by process factors, indeed recanalization rates and stroke onset to recanalization times were similar between the groups with and without frailty. Rather, our data suggest that pre-stroke frailty is an independent and important marker of prognosis following MT.

Pre-stroke frailty as a continuous construct was not associated with mortality following thrombectomy. The potential for dichotomisation of continuous variables to conflate results is known [18]. However, this does not negate our message of poor MT outcomes in those with pre-stroke frailty. MT is not a life-saving intervention. Meta-analysis of seminal RCTs observed no difference in mortality at 90 days between intervention and control groups [9]. The benefits of MT are in the significant reduction in stroke related disability. Importantly, the strong association between pre-stroke frailty and greater disability following thrombectomy was not altered by dichotomisation on sensitivity analyses.

We are aware of two other papers describing frailty and MT outcomes [19, 20]. In these German registry studies, frailty was assessed using the Hospital Frailty Risk Score (HFRS) based on hospital administrative ICD-10 coding data, and strongly associated with poor outcomes following thrombectomy. However, frailty prevalence was 30% when HFRS was calculated at hospital discharge following thrombectomy [19] and only 2% when HFRS was calculated on admission (excluding acute stroke symptoms) [20]. The results are aligned with ours, but our measure of frailty is arguably more clinically relevant as it considers only pre-stroke factors, without the potential inaccuracies of hospital coding data at the point of admission.

An association between frailty and poor outcomes following emergency procedures is not unique to stroke. For revascularisation, frailty was associated with major bleeding, in-hospital death and 6-month mortality in a study of patients undergoing percutaneous coronary intervention for acute myocardial infarction [21]. Similarly, older adults with frailty undergoing emergency laparotomy had significantly higher length of ICU stay, overall hospital stay, complication risk and mortality [22].

Previous studies in acute care settings have shown that assessment of frailty adds value to prognostic information from routine demographic data especially age [23]. Our data support this. The influence of age and outcome after MT has been reported [24]. Excellent outcomes for patients even in advanced age can be achieved, albeit the magnitude of the effect size is much lower than observed for younger patients [25]. Frailty and chronological age are inextricably linked but are not interchangeable. The association between frailty and poor outcome following MT was independent of age. In fact, on multivariate analysis with frailty included in the model, age no longer predicted mortality or dependency.

For all patients admitted with stroke, and especially those being assessed for hyperacute interventions, national guidance recommends assessment of pre-stroke functioning [26]. Patients with severe disability are not routinely offered MT at our centre. Like most centres, we use pre-stroke mRS to inform treatment decisions, based largely on the eligibility criteria of pivotal RCTs [9] However, despite its wide application in clinical and research settings the mRS was never designed to assess pre-stroke physical ability. The mRS is known to both over and under-estimate function [27] and correlations with other markers of frailty and function are poor [28]. A large real-world registry study of patients treated with intravenous thrombolysis has shown that even with severe pre-existing disability some patients may still benefit from the intervention [29]. Our data suggest that assessment based on mRS alone may not be valid and subsequent exclusions may not be justified.

Whether frail patients have been included in RCTs of MT to date is unknown because it has never been systematically recorded. Our data suggest that in practice, stroke patients presenting as candidates for thrombectomy are often frail. Moreover, comprehensive stroke centres capable of delivering endovascular services are sparsely located and often require long journey times for patients. It is important to ensure patients who might benefit are not missed, but equally important to avoid unnecessary and arduous journeys for those patients unlikely to benefit. Our study provides a step towards more accurate prediction of outcomes that can inform discussions around the risk and benefit of referral for interventional procedures.

Our study has some notable strengths. It provides 'real world' clinical data on unselected patients with complete follow-up for death and disability at 90 days. However, there are also limitations. Our sample size is relatively small, and all patients were treated at a single centre. We have used a single method of assessment for frailty and recognise that prevalence of frailty within a cohort of patients can vary depending on the method of assessment applied [4]. The retrospective nature of our study allowed us to extract the necessary information for our frailty measure from primary and secondary care records. Prospective manual calculation of a Frailty Index may not be feasible in acute stroke settings and other direct assessments such as Clinical Frailty Scale [30] may be more suitable. The relationship between frailty and pre-morbid mRS is complex [04,28]. Exclusion of patients with a pre-stroke mRS > 2 may have introduced selection bias, however the inclusion of patients with mRS of 3 or 4 is unlikely to make the association between frailty and poor outcome any weaker. The limits of our approvals constrained that data that could be collected and ideally, we would have had greater detail on prognostically important factors like acute blood pressure variability. Finally, with no best medical care control group, it is not possible to say whether thrombectomy is a useful or harmful intervention in people living with frailty. However, we believe the association with poor outcomes is sufficiently strong to suggest that clinicians and researchers alike consider incorporating pre-stroke frailty status to standard baseline assessments.

Our study suggests that a more comprehensive assessment of pre-stroke function that includes a measure of frailty could potentially improve prognostication. Future thrombectomy RCTs should consider including assessment of pre-stroke frailty status to provide more clarity on interactions between acute stroke intervention and outcomes. There remain unanswered questions for future research, in particular which of the differing frailty assessment tools is best suited to acute stroke, accounting for both prognostic accuracy but also feasibility of assessment in an emergency situation. Having identified the importance of frailty in stroke, a natural next question is what to do about it. Ensuring that in the drive towards an increasingly interventional approach, stroke services are still able to deliver compressive, multidisciplinary, person centred care seems an important first consideration.

Conclusion

Frailty is common in patents otherwise eligible for MT, and the presence of pre-stroke frailty is associated with high mortality and disability following the procedure. Our data do not support excluding frail patients from consideration of endovascular treatment for ischaemic stroke. However, there is enough of a concern to support the routine assessment of frailty in acute stroke. A knowledge of frailty would inform discussions on treatment decisions and tailor decision-making to the individual. There is also a pressing need to include assessment of pre-stroke frailty status in future thrombectomy research studies.

Declaration of Conflicts of Interest: None.

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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. Rockwood K, Mitnitski A. Frailty in relation to the accumulation of deficits. J Gerontol: Series A 2007; 62: 722–7.
3. Morley JE, Vellas B, Van GA *et al.* Frailty consensus: a call to action. J Am Med Dir Assoc 2013; 14: 392–7.
4. Taylor-Rowan M, Cuthbertson G, Keir R *et al.* The prevalence of frailty among acute stroke patients, and evaluation of method assessment. Clin Rehabil 2019; 33: 1688–96.
5. Demaerschalk BM, Kleindorfer DO, Adeoye OM *et al.* American Heart Association Stroke Council and Council on Epidemiology and Prevention. Scientific rationale for the inclusion and exclusion criteria for intravenous alteplase in acute ischemic stroke: a statement for healthcare professionals from the American Heart Association/American Stroke Association. Stroke 2016; 47: 581–641.
6. Quinn TJ, Dawson J, Walters MR, Lees KR. Functional outcome measures in contemporary stroke trials. Int J Stroke 2009; 4: 200–5.
7. Saver JL, Goyal M, Bonafe A *et al.* Stent-retriever thrombectomy after intravenous t-PA vs. t-PA alone in stroke. N Engl J Med 2015; 372: 2285–95.
8. Emberson J, Lees KR, Lyden P, on behalf of the Stroke Thrombolysis Trialists' Collaborative Group. Effect of treatment delay, age, and stroke severity on the effects of intravenous thrombolysis with alteplase for acute ischaemic stroke:

a meta-analysis of individual patient data from randomised trials. Lancet 2014; 384: 1929–35.
9. Goyal M, Menon BK, van Zwam WH *et al.* Endovascular thrombectomy after large-vessel ischaemic stroke: a meta-analysis of individual patient data from five randomised trials. Lancet 2016; 387: 1723–31.
10. Evans NR, Wall J, To B, Wallis SJ, Romero-Ortuno R, Warburton EA. Clinical frailty independently predicts early mortality after ischemic stroke. Age Ageing 2020; 49: 588–91.
11. von Elm E, Altman DG, Egger M *et al.* The strengthening the reporting of observational studies in epidemiology (STROBE) statement: guidelines for reporting observational studies. J Clin Epidemiol 2008; 61: 344–9.
12. Adams KM, Burns PA, Hunter AM *et al.* Outcomes after thrombectomy in Belfast: mothership and drip-and-ship in the real world. Cerebrovasc Dis 2019; 47: 231–7.
13. England NHS. Clinical commissioning policy: mechanical thrombectomy for acute ischaemic stroke (all ages). NHS England 2018; 1–20. Reference 170033P (update 2019).
14. Taylor-Rowan M, Keir R, Cuthbertson G *et al.* Pre-stroke frailty is independently associated with post-stroke cognition: a cross-sectional study. J Int Neuropsychol Soc 2019; 25: 501–6.
15. Evans NR, Todd OM, Minhas JS *et al.* Frailty and cerebrovascular disease: concepts and clinical implications for stroke medicine. Int J Stroke 2021. https://doi.org/10.1177/17474930211034331.
16. Lees KR, Ford GA, Muir KW *et al.* Thrombolytic therapy for acute stroke in the United Kingdom: experience from the safe implementation of thrombolysis in stroke (SITS) register. QJM 2008; 101: 863–9.
17. Quinn TJ, Singh S, Lees KR, Bath PM, Myint PK, Collaborators VISTA. Validating and comparing stroke prognosis scales. Neurology 2017; 89: 997–1002.
18. Altman DG, Royston P. The cost of dichotomising continuous variables. BMJ 2006; 332: 1080.
19. Pinho J, Küppers C, Nikoubashman O *et al.* Frailty is an outcome predictor in patients with acute ischemic stroke receiving endovascular treatment. Age Ageing 2021; 50: 1785–91.
20. Schnieder M, Bähr M, Kirsch M *et al.* Analysis of frailty in geriatric patients as a prognostic factor in endovascular treated patients with large vessel occlusion strokes. J Clin Med 2021; 10: 2171. https://doi.org/10.3390/jcm10102171.
21. Nishihira K, Yoshioka G, Kuriyama N *et al.* Impact of frailty on outcomes in elderly patients with acute myocardial infarction who undergo percutaneous coronary intervention. Eur Heart J Qual Care Clin Outcomes 2021; 7: 189–97.
22. Hewitt J, Carter B, McCarthy K *et al.* Frailty predicts mortality in all emergency surgical admissions regardless of age. An observational study Age Ageing 2019; 48: 388–94.
23. Hewitt J, Carter B, Vilches-Moraga A *et al.* The effect of frailty on survival in patients with COVID-19 (COPE): a multicentre, European, observational cohort study. Lancet Public Health 2020; 5: 444–51.
24. Hilditch CA, Nicholson P, Murad MH *et al.* Endovascular management of acute stroke in the elderly: a systematic review and meta-analysis. AJNR Am J Neuroradiol 2018; 39: 887–91.
25. Meyer L, Alexandrou M, Flottmann F *et al.* Endovascular treatment of very elderly patients aged ≥90 with acute ischemic stroke. J Am Heart Assoc 2020; 9: e014447.
26. Turc G, Bhogal P, Fischer U, *et al.* European Stroke Organisation (ESO) — European Society for Minimally Invasive Neurological Therapy (ESMINT) guidelines on mechanical thrombectomy in acute ischemic stroke. J NeuroIntervent Surg 2019. doi: https://doi.org/10.1136/neurintsurg-2018-014569
27. Quinn TJ, Taylor-Rowan M, Coyte A *et al.* Pre-stroke modified Rankin scale: evaluation of validity, prognostic accuracy, and association with treatment. Front Neurol 2017; 8: 275.
28. Fearon P, McArthur KS, Garrity K *et al.* Prestroke modified Rankin stroke scale has moderate interobserver reliability and validity in an acute stroke setting. Stroke 2012; 43: 3184–8.
29. Gensicke H, Strbian D, Zinkstok SM *et al.* Intravenous thrombolysis in patients dependent on the daily help of others before stroke. Stroke 2016; 47: 450–6.
30. Wallis SJ, Wall J, Biram RW, Romero-Ortuno R. Association of the clinical frailty scale with hospital outcomes. QJM 2015; 108: 943–9.

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