



Impact of frailty on outcomes of elderly patients undergoing percutaneous coronary intervention: A systematic review and meta-analysis

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Abstract

BACKGROUND

Frailty is a common condition in elderly patients who receive percutaneous coronary intervention (PCI). However, how frailty affects clinical outcomes in this group is unclear.

AIM

To assess the link between frailty and the outcomes, such as in-hospital complications, post-procedural complications, and mortality, in elderly patients post-PCI.

METHODS

The PubMed/MEDLINE, EMBASE, Cochrane Library, and Web of Science databases were screened for publications up to August 2023. The primary outcomes assessed were in-hospital and all-cause mortality, major adverse cardiovascular events (MACEs), and major bleeding. The Newcastle-Ottawa Scale was used for quality assessment.

RESULTS

Twenty-one studies with 739693 elderly patients undergoing PCI were included. Frailty was consistently associated with adverse outcomes. Frail patients had significantly higher risks of in-hospital mortality [risk ratio: 3.45, 95% confidence interval (95%CI): 1.90-6.25], all-cause mortality [hazard ratio (HR): 2.08, 95%CI: 1.78-2.43], MACEs (HR: 2.92, 95%CI: 1.85-4.60), and major bleeding (HR: 4.60, 95%CI: 2.89-7.32) compared to non-frail patients.

CONCLUSION

Frailty is a pivotal determinant in the prediction of risk of mortality, development of MACEs, and major bleeding in elderly individuals undergoing percutaneous coronary intervention.

Key Words: Frailty; Elderly; Percutaneous coronary intervention; Systematic review; Meta-analysis

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Core Tip: This comprehensive meta-analysis elucidates the significant impact of frailty on outcomes in elderly patients undergoing percutaneous coronary intervention (PCI). The study underscores the consistent association between frailty and heightened risks of in-hospital mortality, all-cause mortality, major adverse cardiovascular events, and major bleeding. The convergence of results across diverse study designs, patient populations, and methodological approaches underscores the robustness of these findings. Recognizing frailty as a potent predictor allows for tailored care plans, emphasizing the need for standardized frailty assessment in the pre-PCI evaluation of elderly patients.

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INTRODUCTION

Gradual aging of the world population presents a significant challenge to healthcare systems globally[1]. Prolonged life expectancy correlates with an increased prevalence of cardiovascular diseases, which, in turn, requires complex interventions to effectively manage these conditions[2]. Percutaneous coronary intervention (PCI) is an essential modality in contemporary cardiovascular care, especially in elderly patients, who often present with complex comorbidities[3,4].

Frailty is an important factor that impacts the outcomes of elderly patients undergoing PCI. It is characterized by diminished physiological reserves, reduced functional capacity, and elevated susceptibility to stressors[5-7]. Numerous studies show that frailty is a crucial determinant of healthcare outcomes in the elderly and has a profound influence on morbidity, mortality, and healthcare resource utilization[8,9].

The precise impact of frailty on post-PCI outcomes in the elderly remains a subject of ongoing scientific inquiry and discourse. Understanding the exact association between frailty and procedural outcomes, post-procedural complications, and long-term prognoses in this population is imperative for optimizing patient care and resource allocation[10,11].

This study aimed to assess the link between frailty and outcomes, such as in-hospital complications, post-procedural complications, and mortality, in elderly patients post-PCI.

MATERIALS AND METHODS

The study was done per PRISMA guidelines[12].

The PubMed/MEDLINE, EMBASE, Cochrane Library (CENTRAL), and Web of Science databases were searched for publications up to August 31, 2023. The search strategy was designed to identify studies exploring the link between frailty and outcomes in elderly PCI patients.

The study was registered with PROSPERO (registration number: CRD42023446018).

We combined appropriate Medical Subject Headings terms and keywords, including "frailty", "elderly", "percutaneous coronary intervention", and associated synonyms. Only studies in English were considered (Table 1).

Additionally, a manual search was done, and the bibliography of the eligible studies was also thoroughly screened for any missed citations. No restrictions or filters were applied during the search.

Two authors screened titles and abstracts of identified articles independently for eligibility. Disputes were resolved by discussion. Full-texts of studies selected at the first stage were then assessed for eligibility.

Inclusion criteria

Study design: Randomized controlled trials and cohort, case-control, and observational studies.

Population: Studies involving elderly coronary artery disease patients 65 years and older who underwent PCI.

Exposure variable: Frailty status was assessed using validated tools or criteria, such as the Fried Frailty Phenotype, Clinical Frailty Scale (CFS), or other recognized measures.

Outcome measures: Studies reporting on relevant clinical outcomes, including but not limited to procedural success rates, post-procedural complications (e.g., bleeding and vascular complications), in hospital and all-cause mortality, and

Table 1 Search strategy of electronic databases

Database	Search string	No. of records
PubMed/MEDLINE	("Frailty"[MeSH] OR "Frail Elderly"[MeSH] OR "Frailty, Psychological"[MeSH] OR "Physical Frailty"[MeSH] OR "Frailty Phenotype"[MeSH] OR "Frailty Scale"[MeSH] OR "Clinical Frailty Scale"[MeSH] OR "Frailty Index"[MeSH] OR "Fried Frailty Criteria" OR "Frailty assessment" OR "Frailty evaluation") AND ("Aged"[MeSH] OR "Elderly"[MeSH] OR "Geriatric"[MeSH] OR "Older Adults" OR "Seniors" OR "Aging" OR "Elderly population") AND ("Percutaneous Coronary Intervention"[MeSH] OR "Coronary Angioplasty"[MeSH] OR "PCI" OR "PTCA" OR "Coronary stenting")	66
EMBASE	('frailty'/exp OR 'frail elderly'/exp OR 'psychological frailty'/exp OR 'physical frailty'/exp OR 'frailty phenotype'/exp OR 'frailty scale'/exp OR 'clinical frailty scale'/exp OR 'frailty index'/exp OR 'fried frailty criteria' OR 'frailty assessment' OR 'frailty evaluation') AND ('aged'/exp OR 'elderly'/exp OR 'geriatric'/exp OR 'older adults' OR 'seniors' OR 'aging' OR 'elderly population') AND ('percutaneous coronary intervention'/exp OR 'coronary angioplasty'/exp OR 'PCI' OR 'PTCA' OR 'coronary stenting') AND ('human'/exp AND 'english'/exp)	158
Cochrane Library (CENTRAL)	("Frailty"[MeSH] OR "Frail Elderly"[MeSH] OR "Frailty, Psychological"[MeSH] OR "Physical Frailty"[MeSH] OR "Frailty Phenotype"[MeSH] OR "Frailty Scale"[MeSH] OR "Clinical Frailty Scale"[MeSH] OR "Frailty Index"[MeSH] OR "Fried Frailty Criteria" OR "Frailty assessment" OR "Frailty evaluation") AND ("Aged"[MeSH] OR "Elderly"[MeSH] OR "Geriatric"[MeSH] OR "Older Adults" OR "Seniors" OR "Aging" OR "Elderly population") AND ("Percutaneous Coronary Intervention"[MeSH] OR "Coronary Angioplasty"[MeSH] OR "PCI" OR "PTCA" OR "Coronary stenting")	104
Web of Science	TS=("frailty" OR "frail elderly" OR "physical frailty" OR "frailty phenotype" OR "clinical frailty scale" OR "fried frailty criteria" OR "frailty assessment" OR "frailty evaluation") AND TS=("aged" OR "elderly" OR "geriatric" OR "older adults" OR "seniors" OR "aging" OR "elderly population") AND TS=("percutaneous coronary intervention" OR "coronary angioplasty" OR "PCI" OR "PTCA" OR "coronary stenting")	111

major adverse cardiovascular events (MACEs).

Exclusion criteria

Studies with insufficient data or outcomes that are not pertinent to the research question were excluded. Studies with a sample size of fewer than 30 participants and those with participants not undergoing PCI were also excluded. Conference abstracts, case reports, series, and blog spots, if found, were not included in this review and regarded as excluded.

Data extraction

A standardized data extraction form included the following information: (1) Study characteristics: Author(s), publication year, study design, and setting; (2) Participant characteristics: Demographics, including age, sex, and comorbidities; (3) Frailty assessment: Details of the frailty assessment tool used and the criteria for categorizing participants as frail or non-frail; (4) PCI details: Information on the type of PCI, procedural details, and any relevant interventions; and (5) Outcome measures: Data on primary and secondary outcomes, including post-procedural complications (*e.g.*, bleeding and vascular complications), in hospital and all-cause mortality, and MACEs.

Study quality assessment was done using the Newcastle-Ottawa Scale (NOS) for observational studies.

Data analysis

The qualitative analysis included the summary of the findings of the eligible studies. Quantitative synthesis or meta-analysis was performed if data were deemed suitable and sufficiently homogeneous, using a random-effects model to calculate pooled effect estimates. Risk ratios (RRs) and hazard ratios (HRs) were used for categorical outcomes like mortality, risk of developing MACEs, and major bleeding. The adjusted HRs provided were plotted using a generic inverse variance model to calculate the cumulative estimate. Heterogeneity was measured by the I^2 statistic. Subgroup analyses were done based on factors such as the study design, frailty assessment tools, and other relevant variables like age and type of patients undergoing PCI. Publication bias was evaluated using visualization of funnel plots and statistical tests, including Egger's and Begg's tests, if required.

RESULTS

The literature search identified 439 records. Of them, 404 records remained after deduplication and underwent screening of title and abstract. Full-texts of 26 potentially eligible records were thoroughly assessed, and 21 studies [13–33] were deemed eligible for inclusion in the analysis (Figure 1). The details of the included studies are shown in Table 2. All studies were of moderate to high quality (NOS scores of 7–9) (Table 3).

Eleven studies were retrospective cohorts [13,14,16–18,20,21,23,24,27,32], six were prospective cohorts [15,19,22,28,29,33], and four were cross-sectional studies [25,26,30,31]. Studies were conducted between 2015 and 2023, in various countries, and investigated the correlation between frailty and cardiovascular outcomes in different cardiac patient populations. The included studies employed a range of frailty assessment tools, including Gilbert's hospital frailty score, CFS, Fried criteria, Hospital Frailty Risk Score, and other validated measures. The sample sizes varied significantly, ranging from as low as 42 participants to massive cohorts with over 7 million patients. Patient ages also exhibited a considerable diversity, with mean ages ranging from approximately 62 to over 84 years.

Table 2 Characteristics of included studies

Ref.	Country	Study design	Frailty criteria	Population	Sample size	Age (yr)	Male (%)	Frail (%)	Follow-up period	Outcomes
Shimono <i>et al</i> [13], 2023	Japan	RC	CFS	Stable coronary artery disease	239	79.5 + 7.5	68.40%	15.90%	962 d	MACes, major bleeding, all-cause death, ischaemic events
Özbek and Balun [14], 2023	Turkey	RC	CFS	PCI	244	84.6 + 3.4	53.70%	46.30%	1 yr	Major bleeding, all-cause death, revascularization, stroke
Mangale <i>et al</i> [15], 2023	India	PC	Clinical frailty scale by Rockwood <i>et al</i> [43], AFN, DFI	STEMI	402	75 + 6	64.70%	32%	28 d	MACes
Noike <i>et al</i> [16], 2023	Japan	RC	CFS	Stable angina pectoris	608	77 + 9.2	66%	23.19%	529 d	MACes, all-cause death, stroke, cardiac death
Heaton <i>et al</i> [17], 2023	United States	RC	Gilbert's hospital frailty score	STEMI	584918	63.58 + 13.08	69.37%	all	1 mo	30-d readmission, mortality
Borovac <i>et al</i> [18], 2022	United States	RC	Hospital Frailty Risk Score (HFRS)	STEMI		64.6 + 13.7	66.80%	28.40%	NA	Death, cerebrovascular event, and major bleeding
Kanwar <i>et al</i> [19], 2021	United States	PC	Fried criteria	CAD	629	69	69%	18.60%	35 mo	All-cause mortality, MACes
Kurobe <i>et al</i> [20], 2021	Japan	RC	CFS	STEMI	331	77.3 + 10.5	57.60%	22.20%	35.6 mo	MACes, all-cause death, stroke
Kanenawa <i>et al</i> [21], 2021	Japan	RC	CFS	PCI	2439	71.9 + 10.1	72.70%	28.30%	1 yr	All-cause death, MI, stroke, major bleeding
Nishihara <i>et al</i> [22], 2021	Japan	PC	Walking, cognition, and ADL	AMI	546	84.5 (82–88)	47.80%	27.80%	589 d	All-cause mortality, bleeding
Kwok <i>et al</i> [23], 2020	United Kingdom	RC	Validated Hospital Frailty Risk Score	CAD	73,06,007	66.1 + 12.3	65.30%	1836 patients	In hospital	All-cause mortality, MACes
Yoshioka <i>et al</i> [24], 2019	Japan	RC	CSHA-CFS	STEMI	273	84.6 + 3.8	46.20%	12.50%	565 d	All-cause mortality
Nguyen <i>et al</i> [25], 2019	Vietnam	CS	REFS	PCI	163	73.5 + 8.3	60.80%	41.70%	30 d	30-d mortality
Damluji <i>et al</i> [26], 2019	United States	CS	Frail index	AMI	140089	> 75	46.80%	9.90%	NA	In-hospital mortality
Herman <i>et al</i> [27], 2019	Netherlands	RC	VMS	STEMI	206	79 + 6.4	57.80%	27.70%	30 d	All-cause mortality
Calvo <i>et al</i> [28], 2019	Spain	PC	CFS	STEMI	259	82.6 + 6	57.90%	19.70%	In hospital	In-hospital mortality
Batty <i>et al</i> [29], 2019	United Kingdom	PC	Fried criteria	NSTEMI	280	81.0 + 3.5	60.00%	27.50%	1 yr	MACes
Dodson <i>et al</i> [30], 2018	United States	CS	FPSS	NSTEMI	100	75.3 + 7.7	60.20%	19.80%	In-hospital	In-hospital bleeding
Patel <i>et al</i> [31], 2018	Australia	CS	Frail index	STEMI	1275	> 65	NA	52.60%	NA	All-cause death, major bleeding
Sujino <i>et al</i> [32], 2015	Japan	RC	CSHA-CFS	STEMI	42	88.1 + 2.5	58.10%	26.20%	In hospital	In-hospital mortality
Murali Krishnan <i>et al</i>	United Kingdom	PC	CSHA-CFS	CAD	746	62.2 + 7.4	70.10%	10.85%	1 yr	All-cause mortality

RC: Retrospective cohort; PC: Prospective cohort; CS: Cross-section; CFS: Clinical frailty scale; STEMI: ST elevated myocardial infarction; CAD: Coronary artery disease; PCI: Percutaneous coronary intervention; AMI: Acute myocardial infarction; MACEs: Major adverse cardiovascular events; NA: Not applicable; AFN: Acute frailty network; DFI: Derby frailty index; ADL: Activities of daily living; CSHA: Canadian study of health and aging; REFS: Reported Edmonton Frail Scale; VMS: Dutch Safety Management system; FPSS: Frailty point scoring system.

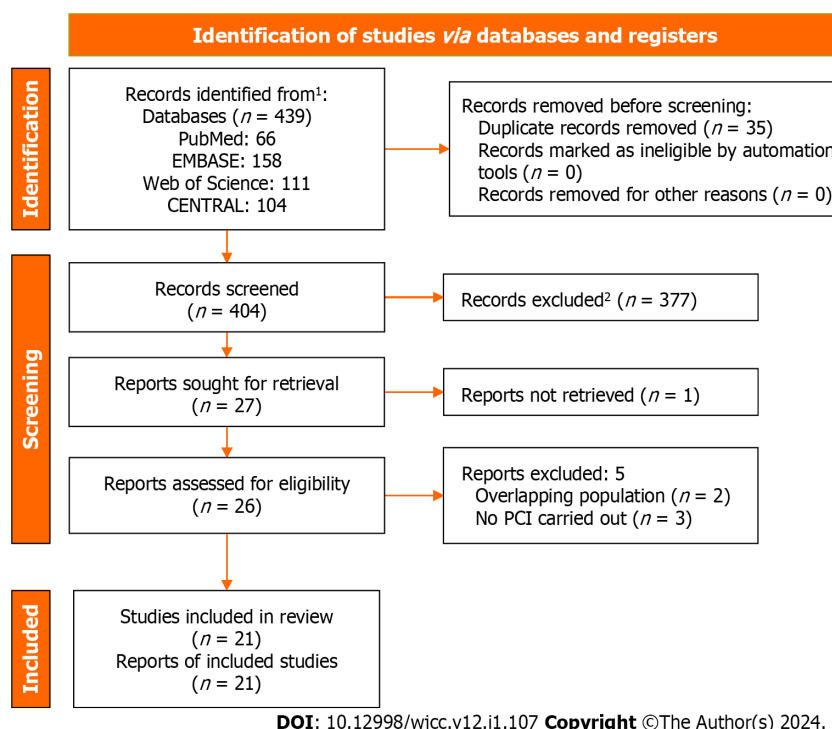


Figure 1 Study selection process. ¹Records identified from digital databases; ²Excluded based on title and abstract screening.

In terms of gender distribution among participants, the included studies reported a range from 46.2% to 72.7% of male patients. Frailty prevalence among these populations varied from 9.9% to 66.8%.

The relevant outcomes included a wide array of cardiovascular events, such as MACEs, which encompassed outcomes such as myocardial infarction, stroke, major bleeding, and all-cause mortality. Additionally, revascularization procedures, 30-d readmission rates, and in-hospital mortality were assessed. The follow-up periods ranged from 28 to 962 d.

Meta-analysis

The presented meta-analysis results demonstrate a significant impact of frailty on various outcomes in the aged population of patients undergoing PCI. The analysis categorized patients into "frail" and "non-frail" groups, and the effect estimates (RR for in-hospital mortality and HR for all-cause mortality, MACEs, and major bleeding) were calculated.

In-hospital mortality

There was a substantial difference in in-hospital mortality between frail and non-frail patients. The overall RR was 3.45 [95% confidence interval (95%CI): 1.90-6.25], showing that frail patients have a significantly higher risk of in-hospital mortality after PCI.

As shown by the subgroup analyses, retrospective studies reported an RR of 2.92 (95%CI: 1.09-7.81), while prospective studies showed an even higher RR of 4.02 (95%CI: 1.62-9.97). These findings underscore the consistency and strength of the relationship between frailty and in-hospital mortality (Figure 2).

All-cause mortality

The meta-analysis demonstrated a substantial impact of frailty on all-cause mortality. The HR was 2.08 (95%CI: 1.78-2.43), indicating an over two-fold higher risk of all-cause mortality in frail than in non-frail patients after PCI (Figure 3). The subgroup analysis demonstrated that frailty consistently predicted all-cause mortality across various subgroups, including different study designs, age groups, and indications for PCI (Table 4). The funnel plot showed an evident skewness suggesting publication bias across the studies depicting the estimate of risk for all-cause mortality.

Table 3 Quality of included studies

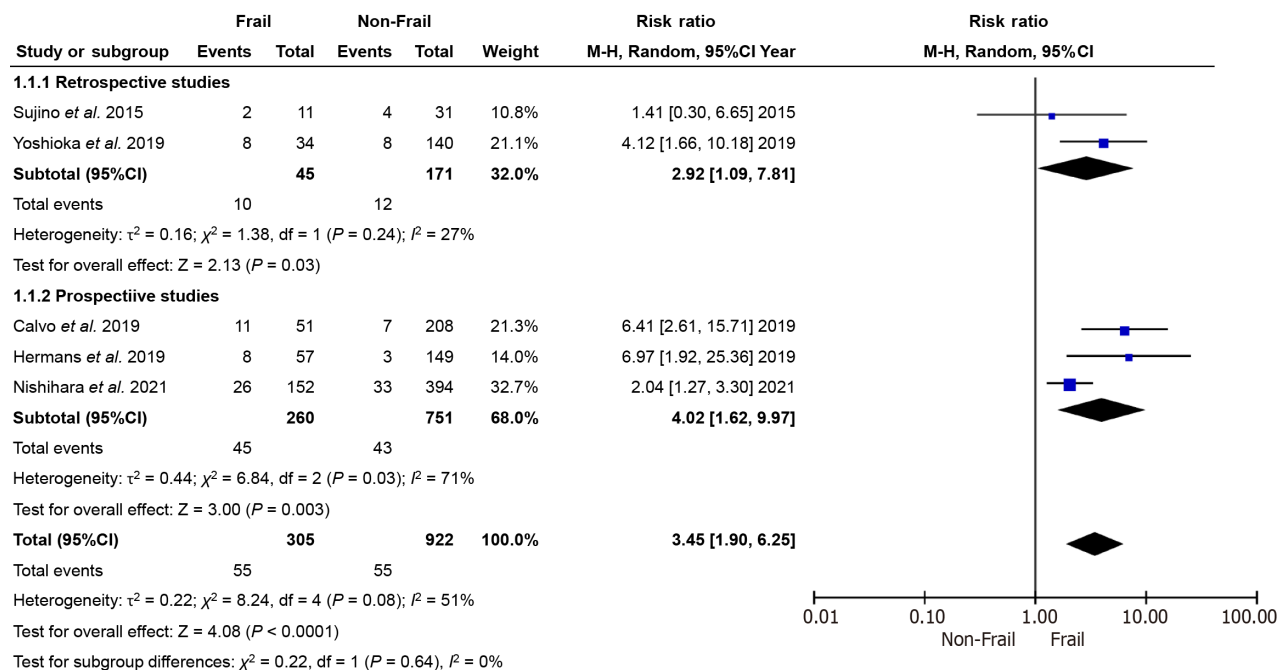
Ref.	Selection		Comparability			Outcome			Total
	Representativeness of the exposed cohort	Selection of the nonexposed cohort	Ascertainment of exposure	Demonstration that outcome of interest	Basis of the design or analysis	Assessment of outcome	Follow-up long enough for outcomes	Adequate follow-up	
Shimono <i>et al</i> [13], 2023	0	1	1	1	1	1	1	1	7
Özbek and Balun [14], 2023	0	1	1	1	1	1	1	1	7
Mangale <i>et al</i> [15], 2023	0	1	1	1	1	1	1	1	7
Noike <i>et al</i> [16], 2023	1	1	0	1	1	1	1	1	7
Heaton <i>et al</i> [17], 2023	1	1	1	1	2	1	1	1	9
Borovac <i>et al</i> [18], 2022	1	1	0	1	1	1	1	1	7
Kanwar <i>et al</i> [19], 2021	1	1	1	1	1	1	1	1	8
Kurobe <i>et al</i> [20], 2021	1	1	1	1	1	1	1	1	8
Kanenawa <i>et al</i> [21], 2021	1	1	1	1	1	1	1	1	8
Nishihara <i>et al</i> [22], 2021	0	1	1	1	1	1	1	1	7
Kwok <i>et al</i> [23], 2020	1	1	0	1	1	1	1	1	7
Yoshioka <i>et al</i> [24], 2019	1	1	0	1	1	1	1	1	7
Nguyen <i>et al</i> [25], 2019	1	1	0	1	1	1	1	1	7
Damluji <i>et al</i> [26], 2019	0	1	1	1	1	1	1	1	7
Herman <i>et al</i> [27], 2019	1	1	1	1	1	1	1	1	8
Calvo <i>et al</i> [28], 2019	1	1	0	1	1	1	1	1	7
Batty <i>et al</i> [29], 2019	1	1	1	1	1	1	1	1	8
Dodson <i>et al</i> [30], 2018	1	1	1	1	1	1	1	1	8
Patel <i>et al</i> [31], 2018	1	1	1	1	1	1	1	1	8

Sujino <i>et al</i> [32], 2015	1	1	1	1	1	1	1	1	8
Murali Krishnan <i>et al</i> [33], 2015	1	1	0	1	1	1	1	1	7

Table 4 Subgroup analysis for all-cause mortality

Criteria	Subgroup	HR (95%CI)	P value	I ² (%)
Overall		2.08 (1.78-2.43)	< 0.0001	98
Study design	Prospective	2.70 (1.78-2.43)	< 0.0001	98
	Retrospective	2.45 (1.51-3.98)	0.0003	90
Age	< 75 yr	2.24 (1.15-3.25)	< 0.0001	98
	> 75 yr	3.58 (1.29-9.94)	0.01	94
Frailty scale	CFS	3.89 (1.88-8.05)	0.0003	86
	Others	1.82 (1.53-2.17)	< 0.0001	99
Patients for PCI	CAD	1.74 (1.50-2.30)	< 0.0001	98
	STEMI	3.48 (2.00-6.03)	< 0.0001	64

CFS: Clinical Frailty Scale; CAD: Coronary artery disease; PCI: Percutaneous coronary intervention; HR: Hazard ratio; 95%CI: 95% confidence interval.



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Figure 2 Forest plot showing association of in-hospital mortality and frailty among elderly patients undergoing percutaneous coronary intervention.

MACEs

Frailty correlated with a significantly increased risk of MACEs following PCI, with an HR of 2.92 (95%CI: 1.85-4.60) (Figure 4).

Major bleeding

Frail patients undergoing PCI were at a considerably higher risk of experiencing major bleeding events. The HR was 4.60

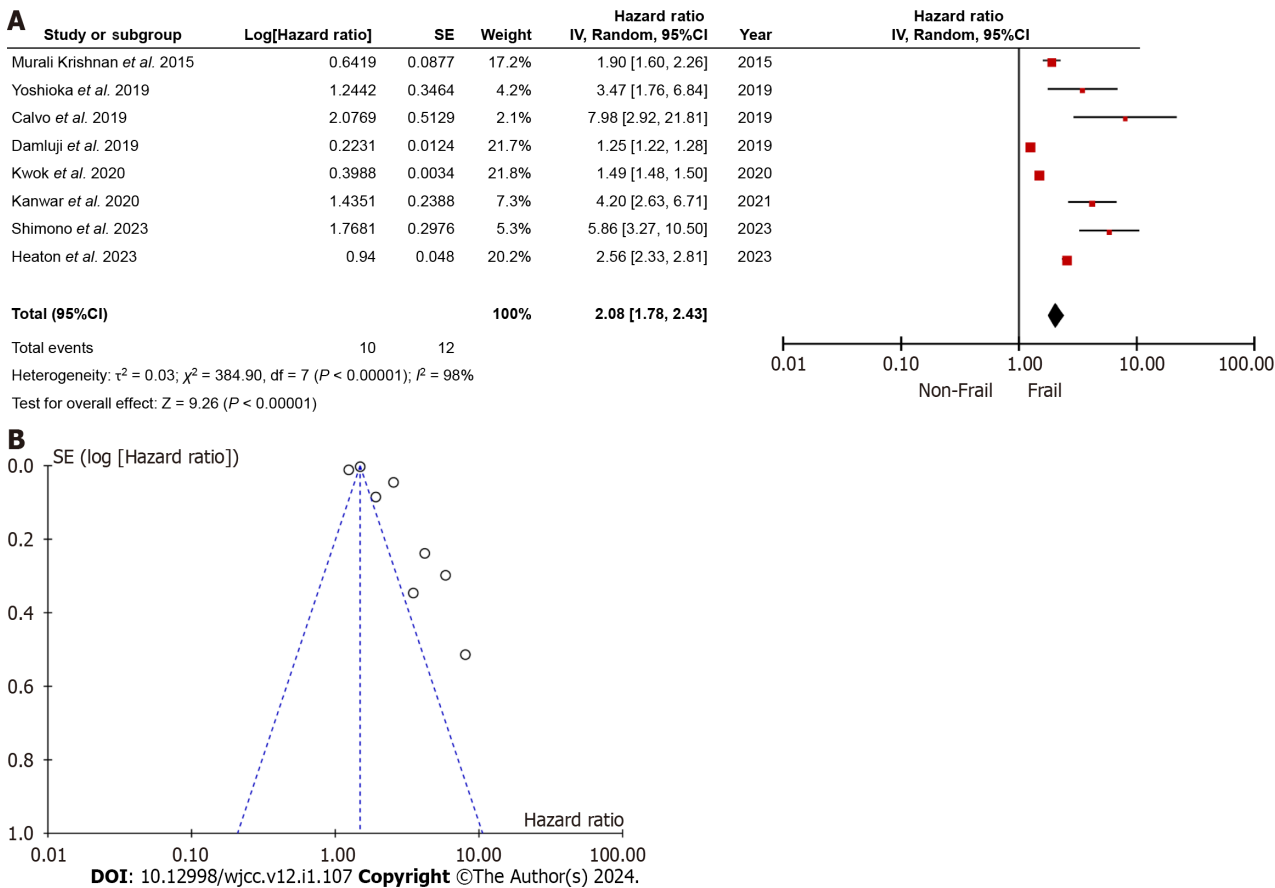


Figure 3 Meta-analysis plot showing association of all-cause mortality and frailty. A: Forest plot showing risk of all-cause mortality and frailty among elderly percutaneous coronary intervention patients; B: Funnel plot depicting publication bias.

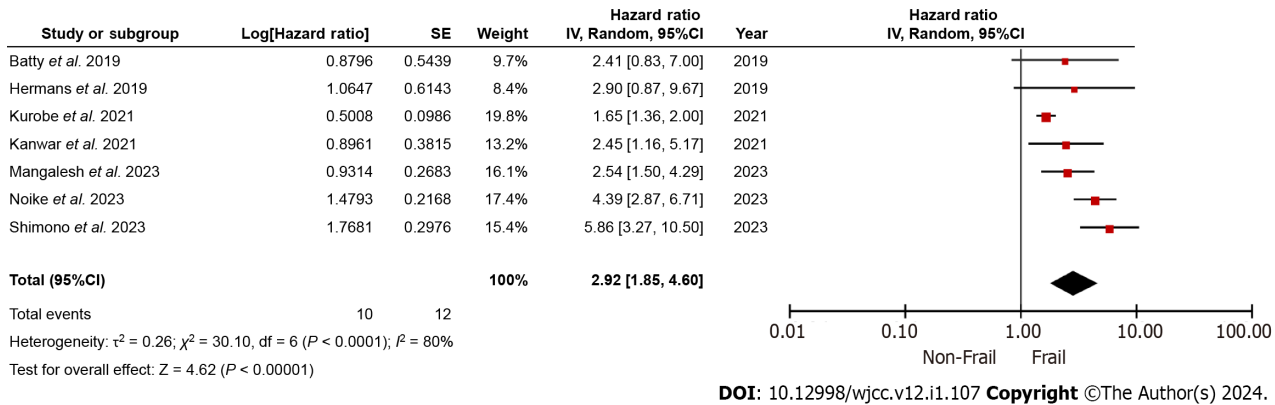


Figure 4 Forest plot showing risk of major adverse cardiovascular events and frailty among elderly percutaneous coronary intervention patients.

(95%CI: 2.89-7.32), indicating that frailty is a strong predictor of major bleeding complications (Figure 5).

DISCUSSION

Our results reported that frailty significantly correlates with higher mortality rates in elderly patients undergoing PCI. Frail individuals had a three-fold bigger risk of in-hospital mortality and a two-fold higher risk of all-cause mortality. Frailty was also consistently linked to a nearly three-fold increased risk of MACEs and a two-fold higher risk of major bleeding in elderly PCI patients.

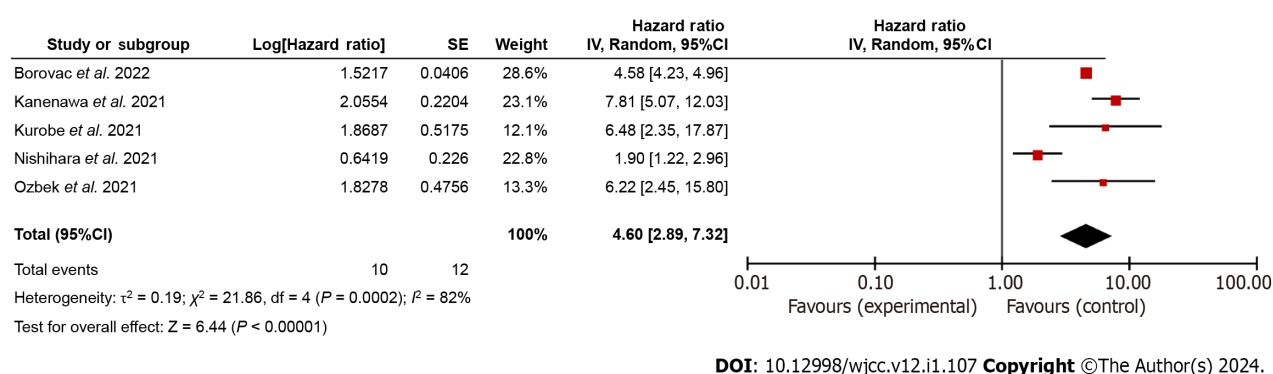


Figure 5 Forest plot showing risk of major bleeding and frailty among elderly percutaneous coronary intervention patients.

The clinical implications of our findings are significant. Frailty has emerged as a significant factor affecting healthcare outcomes, particularly in cases of invasive procedures in the elderly population. Therefore, identifying frailty in elderly patients who require PCI should prompt a comprehensive evaluation of potential risks and benefits[34,35]. Frailty assessments can aid clinicians in tailoring treatment plans, optimizing post-procedural care, and providing realistic expectations to patients and their families[36,37]. Interventions aimed at mitigating frailty and optimizing overall health may be crucial in improving PCI outcomes in this population. Moreover, frailty assessment can inform shared decision-making processes and guide discussions regarding the suitability of PCI *vs* alternative treatment strategies.

The subgroup analysis of all-cause mortality in our study demonstrated that frailty consistently predicts all-cause mortality across various subgroups, including different study designs, age groups, and indications for PCI. Our results confirm that frailty assessment is a valuable tool for risk stratification in elderly PCI patients, regardless of study design or age. Moreover, frailty appears to be particularly influential in predicting mortality in older patients and those with acute conditions like ST elevated myocardial infarction[38,39]. However, the substantial heterogeneity within some subgroups suggests the need for further investigation into potential sources of variation in the effect of frailty on mortality in these specific contexts.

Our results are in agreement with previous observations highlighting the adverse impact of frailty on various healthcare outcomes. A meta-analysis by He *et al*[40] in 2022, with nine studies and a cohort of 2658 patients, showed that the occurrence of frailty was between 12.5% and 27.8% and correlated with higher in-hospital [odds ratio (OR) = 3.59, 95%CI: 2.01-6.42, $I^2 = 35\%$], short-term (OR = 6.61, 95%CI: 2.89-15.16, $I^2 = 0\%$), as well as long-term mortality (HR = 3.24, 95%CI: 2.04- 5.14, $I^2 = 70\%$) of PCI patients. A meta-analysis by Wang *et al*[41] in 2021 demonstrated an independent positive association of frailty and all-cause mortality (adjusted RR = 2.94, 95%CI: 1.90-4.56, $I^2 = 56\%$, $P < 0.001$) and MACEs (adjusted RR = 2.11, 95%CI: 1.32-3.66, $I^2 = 0\%$, $P = 0.002$). Similarly, a meta-analysis of six studies by Yu *et al*[42] in 2023 reported higher rates of all-cause mortality (HR= 2.29, 95%CI: 1.65-3.16, $P = 0.285$), rehospitalization (HR = 2.53, 95%CI: 1.38-4.63), and in-hospital major bleeding (HR = 1.93, 95%CI: 1.29-2.90, $P = 0.825$) in PCI cohort. Our findings corroborate and extend the understanding of frailty's role in predicting complications and mortality in this specific clinical scenario.

Heterogeneity among the included studies is an essential consideration. We observed variations in frailty assessment tools, study designs, and patient populations. Different frailty assessment methods may yield varying effect estimates, emphasizing the importance of standardized assessment tools in future research. Additionally, subgroup analyses by study design highlighted the robustness of the correlation of frailty with adverse PCI outcomes across different research methodologies.

While we detected certain variability in the quality of evidence across outcomes, it generally ranged from moderate to high. This suggests that further studies are needed to strengthen the certainty of the observed associations.

Our study has several limitations. First, the included studies exhibited substantial heterogeneity in frailty assessment methods, potentially influencing effect estimates. Second, our analysis relied on aggregate data rather than individual patient data, limiting our ability to control for confounders at the individual level. Third, we report a potential publication bias across the studies, as shown in the forest plot for all-cause mortality. Therefore, our results need to be interpreted with caution.

The observed slight differences in ORs between retrospective and prospective studies could be attributed to several factors despite the consistent association between frailty and in-hospital mortality. Retrospective studies rely on historical data and may be subject to inherent biases related to data collection and documentation practices. On the other hand, prospective studies, by their nature, involve real-time data collection and standardized protocols, potentially providing a more accurate reflection of the studied outcomes. Also, retrospective studies may include a broader range of patients over an extended period, leading to potential heterogeneity in patient characteristics, and prospective studies, with their predefined inclusion criteria, might exhibit a more homogeneous patient population.

Future research should focus on standardizing frailty assessment methods and exploring the impact of various interventions to improve frailty in the PCI setting. Longitudinal studies with larger sample sizes and more comprehensive patient data can enhance our understanding of the relationship between frailty and PCI outcomes. Additionally, more studies are needed to establish optimal timing and methods of frailty assessment during the pre-procedural evaluation.

CONCLUSION

In conclusion, our study provides compelling evidence that frailty is a pivotal determinant of outcomes in elderly individuals undergoing PCI. This underscores the importance of frailty assessment as an integral component of patient management in this population of patients. While our study contributes valuable insights, further research is needed to refine risk stratification, optimize interventions, and improve outcomes for frail elderly patients undergoing PCI.

ARTICLE HIGHLIGHTS

Research background

In exploring the intricate relationship between frailty and outcomes in elderly patients undergoing percutaneous coronary intervention (PCI), this study addressed existing gaps in understanding. The relevance of this issue is emphasized given the increasing prevalence of frailty in the aging population.

Research motivation

The motivation behind this research lies in recognizing the clinical significance of frailty in elderly PCI patients and its potential influence on short-term and long-term outcomes. The study aimed to inform clinical practices and enhance patient care by comprehensively exploring the impact of frailty.

Research objectives

The research objectives encompassed a thorough assessment of the association between frailty and key outcomes, including in-hospital mortality, all-cause mortality, major adverse cardiovascular events, and major bleeding. The investigation also sought to identify potential outcome variations based on different study designs, patient characteristics, and indications for PCI. Furthermore, it explored the implications of frailty assessment on personalized care plans and its integration into routine clinical practice.

Research methods

Comprehensive search strategies were applied across the PubMed/MEDLINE, EMBASE, Cochrane Library, and Web of Science databases. Statistical methods, including risk ratios and hazard ratios, ensured a robust and standardized approach. Subgroup analyses were conducted to explore variations in outcomes across different study characteristics.

Research results

The results of the study established a compelling association between frailty and adverse outcomes in elderly PCI patients. Specific risk increments, such as a three-fold higher risk of in-hospital mortality and a two-fold increase in all-cause mortality, underscored the comprehensive impact of frailty on cardiovascular health. The findings were consistent across retrospective and prospective study designs, affirming the robustness of the association.

Research conclusions

In conclusion, the study emphasizes the clinical significance of frailty assessment in the pre-PCI evaluation of elderly patients. It underscores the need for tailored care plans, acknowledging frailty as a potent predictor of adverse events. The research contributes to the existing knowledge by synthesizing key findings and provides a foundation for future research endeavors.

Research perspectives

Future research is encouraged to explore interventions targeting frailty and their potential to improve outcomes in elderly PCI patients, advocating for standardized frailty assessment tools and multidisciplinary approaches to enhance the holistic care of this vulnerable patient population.

FOOTNOTES

Author contributions: Wang SS and Liu WH designed the research; Wang SS and Liu WH performed the research; Wang SS analyzed the data; Wang SS and Liu WH wrote the paper.

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