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Assessment and Management of Older Adults Undergoing PCI, Part 1:

A *JACC: Advances* Expert Panel

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Abstract

As the population ages, older adults represent an increasing proportion of patients referred to the cardiac catheterization laboratory. Older adults are the highest-risk group for morbidity and mortality, particularly after complex, high-risk percutaneous coronary interventions. Structured risk assessment plays a key role in differentiating patients who are likely to derive net benefit vs those who have disproportionate risks for harm. Conventional risk assessment tools from national cardiovascular societies typically rely on 3 pillars: 1) cardiovascular risk; 2) physiologic and hemodynamic risk; and 3) anatomic and procedural risks. We propose adding a fourth pillar: geriatric syndromes, as geriatric domains can supersede all other aspects of risk.

Keywords

acute coronary syndrome; cardiac catheterization; cardiovascular disease; geriatric assessment; multimorbidity; older adults; percutaneous coronary intervention; polypharmacy

With the evolution in technical expertise and device technology of percutaneous coronary intervention (PCI), complex interventions in high-risk older populations are now increasingly feasible and often lifesaving and/or life restoring by improving quality of life. Nonetheless, older adults remain at elevated risk for morbidity and mortality both during and after PCI, particularly in the case of complex, high-risk procedures.[1] Structured risk assessment provides a vital function in clinical medicine, assisting clinicians in identifying patients most likely to derive relatively greater benefit than harm from a test or treatment.[2] Risk stratification tools are recommended as part of routine management for patients with acute coronary syndromes to help guide revascularization decisions and plan for potential complications.[3,4] Subjective risk assessment approaches are prone to bias, with potential for suboptimal care.[5] This is even more relevant to older patients, who may face implicit biases from clinicians related to ageism,[6] and in whom the contributors to overall risk become more numerous and complex. Early recognition of high-risk older adults can facilitate delivery of appropriate and/or necessary therapies more likely to provide benefit and plays an important role in complex decision-making, ultimately enhancing the care of this vulnerable population.[7] This supports the primacy of objective risk assessment approaches dedicated to older adult populations.

Although a plethora of risk stratification tools for PCI have been developed with excellent performance characteristics in the general population,[8–10] these models have either not been validated in older adults (>75 years old) or have failed to incorporate the contributions of geriatric-specific risk factors. While advanced age is an independent contributor to overall risk, several other contributors are also present in older adults. Geriatric syndromes, including frailty, multimorbidity, and polypharmacy, profoundly influence short- and long-

term outcomes following PCI.[11–13] Conventional risk approaches identify periprocedural and short-term risk from assessments in 3 pillars of risk: 1) cardiovascular risk assessment based on demographic, clinical, and presentation characteristics; 2) high-risk physiologic and hemodynamic subgroups; and 3) anatomic and procedural considerations.[14] However, the conventional approach does not incorporate geriatric syndromes.

In this 2-part Expert Panel from the Geriatric Cardiology and Interventional Cardiology Leadership Councils, we discuss key considerations for older adults undergoing PCI. In Part 1, we review the conventional 3 pillars of risk as they relate to older adults undergoing PCI and highlight the importance of a fourth pillar, the geriatric risk assessment (Central Illustration). In Part 2, we discuss a practical approach to using routine geriatric assessment as part of the comprehensive preprocedural evaluation of older adults being considered for PCI, pharmacotherapy considerations, and the role of the Geriatric Heart Team.

ASSESSMENT OF RISK

CARDIOVASCULAR RISK ASSESSMENT.

The first pillar of risk is the cardiovascular risk assessment, which includes data from the patient's demographics and clinical comorbidities, clinical presentation, physical examination, diagnostic tools, and validated risk scores to estimate prognosis, thrombotic risk, and bleeding risk (Table 1). This begins with baseline demographic and clinical predictors of risk, many of which are more common with age, followed by a diagnostic assessment that includes physical examination, laboratory, and noninvasive testing.[1,9,15] Clinical presentation characteristics also influence risk. For example, patients presenting with ST-segment elevation myocardial infarction or after surgical turndown for coronary artery bypass graft surgery both suffer from an increased risk of adverse outcomes.[9,15] Standard cardiovascular risk scores such as the GRACE (Global Registry of Acute Coronary Events) score, the TIMI score, and the CRUSADE (Can Rapid Risk Stratification of Unstable Angina Patients Suppress Adverse Outcomes with Early Implementation of the American College of Cardiology/American Heart Association Guidelines score can quantify risk of all-cause mortality, bleeding, and readmission following an index acute coronary syndromes event[16,23,25,26] (Table 1).

HEMODYNAMICS AS A RISK FACTOR.

The second traditional pillar of risk for patients undergoing PCI is the patient's hemodynamic status as many powerful predictors of procedural risk in prior models have been related to the high-risk hemodynamic features. These risks are especially common in older adults due to age-associated declines in cardiovascular reserve and the higher prevalence of vascular stiffening and impaired autonomic and neurohumoral autoregulation. Older adults also have higher prevalence of more advanced cardiovascular disease at the time of presentation, including valvular heart disease and acute heart failure. In the most recent risk models derived from the National Cardiovascular Data Registry (NCDR), the strongest predictors of in-hospital mortality were markers of clinical instability including salvage PCI and cardiogenic shock.[9,15] Particularly high risk clinical and hemodynamic groups are reviewed here are summarized in Table 2.

ANATOMIC AND PROCEDURAL RISK.

The consideration of anatomic and procedural risk represents the third pillar of risk for patients undergoing PCI and begins with a dedicated heart team that considers a patient-centered approach to anatomic and technical risks and optimal revascularization strategies.[40,41] An initial assessment involves recognition of certain high-risk anatomic lesions including left main disease and proximal left anterior descending artery disease, increased number of diseased vessels, chronic total occlusion(s), severe calcification requiring advanced techniques, long lesion length (>60 mm), and in-stent thrombosis, all of which confer increased risk of adverse outcomes.[9,15,42,43] Older patients with coronary artery disease often have high-risk coronary anatomic features that should prompt a systematic approach to minimize procedural risks and optimize outcomes.[44,45] Of particular importance in the older adult population are need for calcium modification techniques, mechanical support consideration, and bleeding avoidance strategies. We review these considerations in Table 3.

GERIATRIC SYNDROMES.

The fourth pillar of a comprehensive risk assessment in older patients is the measurement and consideration of geriatric syndromes. Geriatric syndromes refer to clinical conditions that do not fit into one disease category and have multiple shared risk factors including cognitive and functional impairment and reduced mobility. The presence of advanced geriatric syndromes in this population complicates decision-making, may result in significant delays in care, and increases procedural risks. A 4-domain framework has been proposed in other cardiovascular populations that include physical function, mind and emotion, medical, and social environment domains to address the multidimensional needs of older adults.[78] We review in detail the geriatric syndromes falling under the physical function, mind and emotion, and medical domains below as they relate to risk in older adults undergoing PCI.

PHYSICAL FUNCTION DOMAIN

The physical function domain includes geriatric syndromes impacting the individual patient's capacity to complete basic and more complex activities of daily life, including frailty, sarcopenia, disability, and falls.[79] These are reviewed within the context of risk for cardiac catheterization and PCI below.

FRAILTY.

Frailty has been defined as a state of vulnerability to outside clinical and nonclinical stressors due to reduced physiological reserve across multiple organ systems.[80–82] Multiple instruments are available to assess frailty, resulting in variable prevalence depending on the population undergoing cardiac catheterization and the particular scale utilized.[83] Frailty is associated with increased susceptibility to stressful events and has an extremely high prevalence among older adults with coronary heart disease, with >50% of older adults meeting frailty criteria according to some estimates.[11,81,84] One study showed that one-fifth of patients over the age of 65 are frail at the time of PCI based on Fried criteria,[80] and frailty was associated with a higher burden of comorbidities, greater burden of coronary disease,

and worsened functional status.[85] A separate study, also using the Fried criteria showed that up to two-thirds of patients undergoing PCI met frailty criteria.[62]

In addition to the high prevalence of frailty among older adults undergoing cardiac catheterization, the clinical impact of frailty is compounded by its association with a variety of adverse clinical outcomes, including higher rates of medication intolerance, procedural complications, and in-hospital mortality, as well as progression of cognitive decline, disability, falls, and loss of independence.[86,87] Several studies in patients undergoing coronary artery bypass grafting reveal an association between baseline frailty and increased risk of prolonged length of stay, readmission, disability, and mortality.[88,89] Fewer studies have examined the relationship between frailty in patients specifically undergoing PCI. In 1 single-center study of patients (mean age of 62 years) undergoing PCI, just 11% of patients were frail, defined as Clinical Frailty Score (CFS) ≥5, but the presence of frailty was associated with increased 30-day and 1-year mortality.[63] While frailty appears to be associated with higher risk among those undergoing PCI, in a claims-based study of nearly 500,000 patients (mean age 82 years) admitted with acute myocardial infarction (AMI), frail patients who underwent PCI had improved mortality compared with frail patients who did not undergo PCI (frailty prevalence = 19%).[11] Importantly, claims-based studies likely underestimate the prevalence of frailty due to marked under-coding of frailty among inpatients. Indeed, despite frailty conferring a higher risk for adverse outcomes, frail older patients with AMI still derive a survival benefit from revascularization.[11] Nonetheless, the presence of frailty, measured or assumed, likely influences clinical decision-making, resulting in a reduced probability of referral for an invasive procedure, and adversely impacts patients' quality of life.[11,72,90–92]

The addition of frailty to risk models can improve their performance in older adults. For example, the addition of frailty, comorbidity, and quality of life to the Mayo Clinic risk assessment mortality model significantly improved the prediction of long-term mortality in older adults following PCI with a net reclassification improvement of 43%.[62] More recently, the NCDR began collecting frailty, divided into 9 categories ranging from very fit to terminally ill and defined based on the Canadian Study of Health and Aging Clinical Frailty Scale.[93] With this, a risk model developed using the NCDR Cath PCI Registry was updated to include 5 new variables, including frailty, to the previous risk model, and the addition of frailty improved discrimination of risk.[9] Severe frailty conferred more than 3 times the odds of in-hospital mortality in the final risk model.[9] Studies examining the impact of frailty and other key geriatric syndromes in this patient population are summarized in Table 4.

SARCOPENIA.

Sarcopenia is defined by the progressive loss of skeletal muscle mass, quality, and function with associated weakness.[79,94] When clinical suspicion is high, sarcopenia can be diagnosed by a combination of instruments measuring muscle strength, muscle mass, and physical performance according to a recent statement from the American College of Cardiology Geriatric Leadership Council.[79] Cardiovascular disease is a risk factor for the development and acceleration of sarcopenia, with prevalence rates approaching 30% in older adults with

cardiovascular disease[79,95,96]; in juxtaposition, sarcopenia predicts the future development of atherosclerotic cardiovascular disease and is an independent predictor of major adverse cardiovascular events.[96,97] Lab markers of sarcopenia (sarcopenia index: serum creatinine to cystatin C ratio)[79,98] and reduced skeletal muscle mass[99] have also been correlated with lower quality of life after percutaneous procedures. While data on the association be- tween sarcopenia and mortality in patients undergoing PCI are limited, sarcopenia strongly predicts mortality risk among older adults undergoing transcatheter aortic valve replacement.[100]

DISABILITY.

Disability is the decreasing ability to care for oneself and to complete the usual activities of daily living, leading to loss of independence and reduced quality of life.[101] Disability before and after cardiac procedures is an important quality of life and mortality indicator, and trajectories are influenced by preprocedural frailty and postprocedural delirium and procedural complications. Atherosclerotic cardiovascular disease is associated with functional impairment, and disability is conversely associated with increased risk of periprocedural complications, cardiovascular events, and mortality.[102–104]

Disability can also influence treatment goals and priorities for individual patients. Temporary or non-permanent disability is a significant concern for hospitalized patients undergoing PCI who may require bedrest and interruption in normal sleep patterns.[105,106] While disability confers a higher risk for revascularization procedures, revascularization by PCI has been associated with significantly less functional decline in older (age 75 years or older) adults hospitalized with acute MI compared with those treated with medical management alone.[73] Thus, physical function and disability are important considerations not only when assessing the older patient's overall risk but also in light of the procedure's potential impact on future physical function (both positive and negative).

FALLS.

Falls are a major concern for older adults undergoing cardiac catheterization and are associated with high rates of morbidity and mortality.[107,108] Sedating medications and prolonged bedrest around catheterization can predispose older patients to falls and the use of anticoagulation and antiplatelet agents can put these patients at higher risk of severe bleeding complications in the context of falls. Heightened awareness of these risks is necessary to avoid complications while still maintaining access to necessary treatments. Fall prevention efforts are of paramount importance, including multifactorial assessments of risk, use of mobility aids, appropriate footwear, vision and hearing aids, and minimizing clutter that may cause a patient to trip and fall.[108]

MIND AND EMOTION DOMAIN

The mind and emotion domain includes geriatric syndromes that effect cognition and emotions that in turn have relevant effects for procedural risk. These include cognitive impairment, delirium, and depression as outlined below.

COGNITIVE IMPAIRMENT.

Cognitive function spans a spectrum from age-related cognitive decline, mild cognitive impairment, and major neurocognitive impairment (dementia), as well as delirium. Cognitive impairment increases in prevalence as patients age with rates exceeding 40% in nonagenarians.[109,110] Cognitive issues are particularly prevalent among older patients with overlapping comorbidities that lead to cardiac procedures, with one study (median age 80 years) reporting a prevalence of 39% in patients undergoing percutaneous procedures.[111]

Mild cognitive impairment is associated with decreases in cognitive function without loss of functional independence, while dementia is characterized by severe memory loss and loss of executive function, leading to loss of functional independence and ability to complete activities of daily living.[112,113] This can influence adherence to therapies, impair decision-making, increase the risk of delirium and periprocedural morbidity and mortality, and contribute to excess morbidity, mortality, and health care cost.[112–114] Individuals with moderate to severe dementia are less likely to undergo invasive cardiac procedures, such as in the setting of acute MI,[75,77] and moderate to severe dementia confers a high risk for delirium and poor prognosis overall.[12] Moderate to severe dementia is the most common reason for percutaneous revascularization to be deemed “rarely appropriate” based on appropriate use criteria.[115] However, it is important that the cardiovascular team does not deny “life-saving care” to patients with less severe degrees of dementia.

DELIRIUM.

Delirium is characterized by an acutely confused state with altered attention, orientation, awareness, cognition, and behavior.[116,117] Delirium is common among hospitalized older adults, with an incidence ranging from 20% in the cardiac intensive care unit to more than 80% of mechanically ventilated patients.[118–120] Delirium can be exacerbated by many of the medications older PCI patients are exposed to, especially commonly used agents for conscious sedation, including opiates and benzodiazepines.[121] Delirium has significant adverse consequences among older adults, with high rates of complications such as falls, prolonged length of stay, discharge to facilities, rehospitalization, mortality, and increased cost.[118,119,122,123]

DEPRESSION.

Depression and other mental health conditions are important contributors to overall risk among older adults. Despite being common with approximately 15% of community dwelling older adults having clinically significant depressive symptoms,[124–126] depression remains both underdiagnosed and undertreated in this population.[127] Depression is also linked to adverse clinical outcomes and mortality following PCI.[128]

MEDICAL DOMAIN.

The medical domain includes geriatric syndromes related to chronic conditions and the adverse consequences from those conditions including multimorbidity, polypharmacy, and incontinence.

MULTIMORBIDITY.

Multimorbidity, also described as multiple chronic conditions, is defined by the Centers for Medicare & Medicaid Services as having 2 or more chronic conditions. The majority of older adults undergoing PCI meet criteria for multimorbidity.[129,130] The presence of multiple chronic conditions also has a profound impact on clinical outcomes and quality of life, including increased risk of in-hospital complications and mortality with decreased likelihood of revascularization, and increased disability, polypharmacy, loss of independence and falls.[87,131,132] Certain comorbid conditions may be more relevant than others because they have greater effect on outcomes, for example, stroke, prior MI, heart failure, malignancy, or chronic kidney disease. In a recently published risk model by Singh and colleagues, the presence of metastatic malignancy stood out as one of the strongest predictors of complications following PCI.[43]

POLYPHARMACY.

Multimorbidity is often accompanied by polypharmacy, which increases the risk of medication interactions, delirium, hospitalizations, and other adverse events. Polypharmacy is commonly defined as the chronic use of 5 or more medications; the use of 10 or more medications has been termed hyper-polypharmacy.[133–135] The presence of polypharmacy in older adults poses significant risk for drug-drug and drug-disease interactions, adverse drug reactions, and procedural complications, in individuals undergoing PCI who frequently require sedating medications, anticoagulation, and platelet inhibition periprocedurally.[13,136,137] Notably, the majority of older individuals with polypharmacy have at least one potential severe drug-drug interaction, and the risk exceeds 90% in those with hyper-polypharmacy.[135]

INCONTINENCE.

Under-recognized and underappreciated, incontinence is a major contributor to morbidity in older patients, impacting quality of life and functional independence.[138,139] Incontinence can also have important implications periprocedurally and contribute to patient reluctance and apprehension about the procedure.

CONCLUSIONS

Quantification of risk is the foundation of any preprocedural assessment of older adults presenting to the cardiac catheterization laboratory. Given the prevalence of geriatric syndromes in older adults and their strong association with clinical outcomes, a comprehensive risk assessment in older adults should include a geriatric risk assessment with the incorporation of geriatric syndromes into the risk-benefit calculus. Accordingly, inclusion of a geriatric risk assessment into the routine care path of older adults presenting for invasive cardiovascular procedures must be prioritized if we are to achieve the successful integration of geriatric principles into interventional cardiology practice.

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ABBREVIATIONS AND ACRONYMS

MI	myocardial infarction
NCDR	National Cardiovascular Disease Registry
PCI	percutaneous coronary intervention

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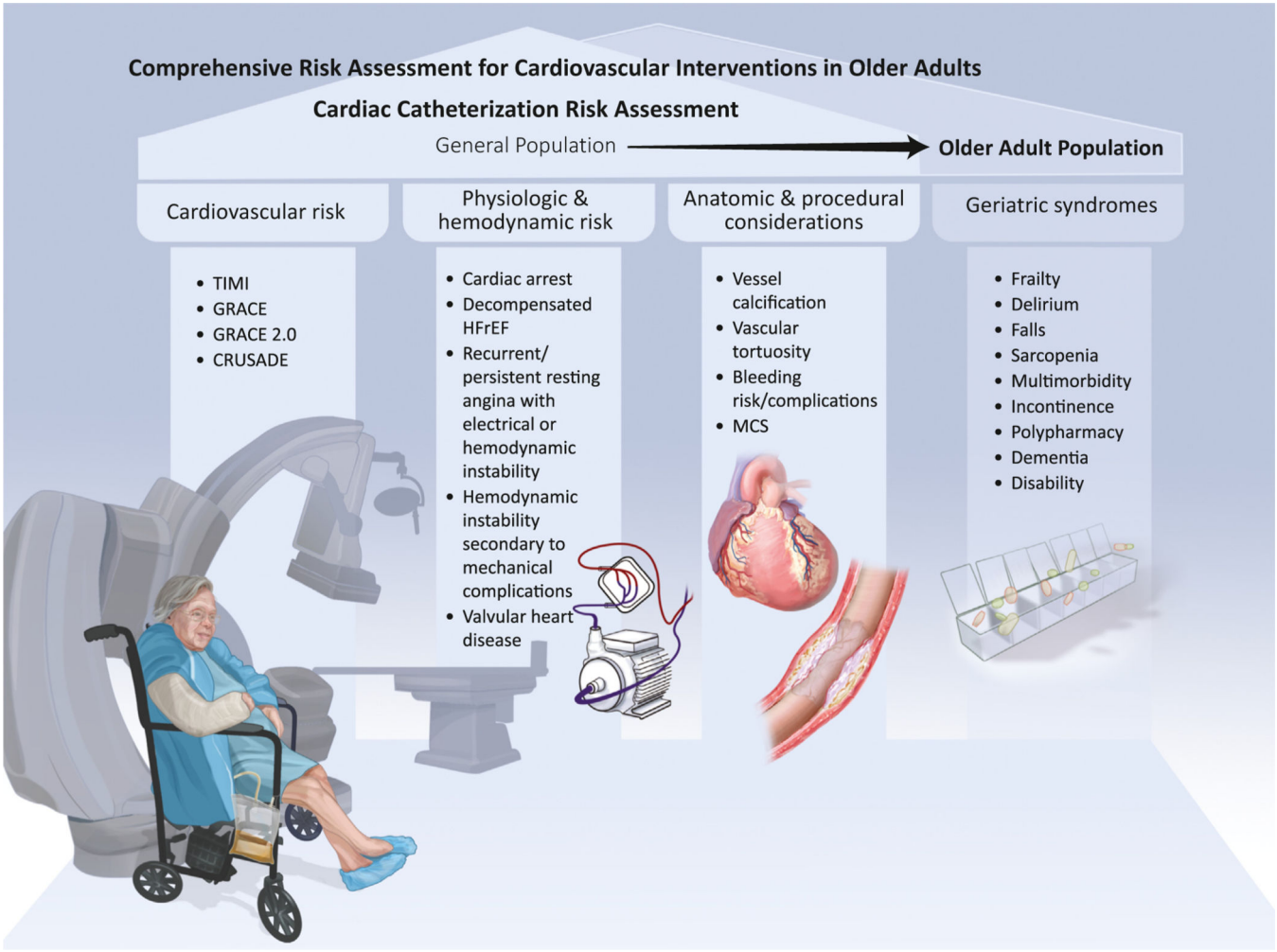
HIGHLIGHTS

- Older adults are at elevated risk for morbidity and mortality both during and after PCI.
- The risk assessment of older adults undergoing PCI currently includes 3 major pillars of risk, summarized as the cardiovascular, hemodynamic, and anatomic/procedural risks.
- We propose the addition of a fourth pillar, geriatric syndromes, given their profound impact on the periprocedural risk and outcomes of older adults.



CENTRAL ILLUSTRATION. Definitions of a Variety of Geriatric Syndromes Likely Influencing the Individual Risk of Older Adults Undergoing Percutaneous Coronary Intervention

TABLE 1

Cardiovascular Risk Assessment in Older Adults With Coronary Artery Disease

Categories of Risk	Examples of Predictors of Risk	Key Considerations in Older Adults
Demographics and clinical comorbidities[1,9,15]	Sex Race Social determinants of health Clinical comorbid conditions (cardiac and noncardiac)	• Most comorbidities more common with advanced age • Comorbid conditions may be at more advanced stages than in younger patients
Diagnostic tools	Physical exam abnormalities High-sensitivity troponin NT-proBNP Serum creatinine Cystatin C ECG Echocardiogram	• Non-ACS troponin elevations are more common in older adults[16] • ECG is more frequently nondiagnostic in older adults[17] • Cystatin C provides incremental improvement in performance of existing estimates of glomerular filtration rates in older adults[18]
Clinical presentation[9,15]	STEMI NSTEMI Unstable angina Surgical turndown	• Older adults have more late presentation and more frequent non-chest pain symptoms[19,20] • The majority of patients ≥85 y with ischemia present with dyspnea; only 40% of older patients present with typical anginal chest pain.[21]
Validated risk scores	GRACE GRACE-2 TIMI CRUSADE[23]	• Traditional risk factors may lose predictive power[22] • May label most older adults at high risk with limited discrimination • May underestimate risk at the extremes of chronological age • Do not distinguish type I from type II MI, which is more common among older patients[16] • May not predict the most important outcomes for select populations of older adults who may prioritize functional outcomes and quality of life over prolonging survival[24]

ACS = acute coronary syndrome; CRUSADE = Can Rapid Risk Stratification of Unstable Angina Patients Suppress Adverse Outcomes with Early Implementation of the American College of Cardiology/American Heart Association Guidelines; ECG = electrocardiogram; GRACE = Global Registry of Acute Coronary Events; MI = myocardial infarction; NSTEMI = non-ST-segment elevation myocardial infarction; NT-proBNP = N-terminal prohormone of brain natriuretic peptide; STEMI = ST-segment elevation myocardial infarction; TIMI = Thrombolysis In Myocardial Infarction.

TABLE 2

Hemodynamics Risk Factors in Older Adults Being Considered for Percutaneous Coronary Intervention

Categories of Risk	Key Considerations in Older Adults
Cardiogenic shock	• Exceedingly high mortality in older adults, approaching 43% in those undergoing revascularization and exceeding 50% when revascularization is not performed.[27] • Benefits of early revascularization may not be seen in older adults >75 years old.[28] • Potential benefits of improvements in health care access, shock networks, and advancement of percutaneous mechanical circulatory support devices for older adults remain to be seen.[7]
Cardiac arrest	• Incidence is increasing among older adults and older age is associated with worse outcomes.[29–31]
Acute heart failure	• Common among patients presenting with ACS and older adults are disproportionately affected with increased risk for long-term adverse events including mortality.[32,33] • Older age and multiple chronic conditions increase the risk of subsequent HF rehospitalization.[34]
VHD	• Prevalence of VHD increases with age: 0.7% in those 18–44 years old to 13.3% in those >75 years old.[35] • Severe VHD has profound hemodynamic implications influencing procedural risk and both short- and long-term outcomes, including increased mortality in those with moderate or severe valvular disease.[35–37] • Advanced age is a predictor of increased mortality in patients with severe aortic stenosis undergoing PCI.[36] • The presence of moderate or severe mitral regurgitation in patients undergoing PCI is also associated with worse intermediate-term (1-y) and long-term mortality.[38]
Recurrent/Persisting angina with or without electrical instability	• Advancing age is associated with variation in symptom presentation, including higher prevalence of nonchest pain symptoms which may be the recurrent or persisting anginal equivalent.[19] • Confusion, syncope, and stroke are also common and sometimes are the sole presenting symptom.[21] • Ongoing symptoms secondary to underlying myocardial ischemia with recurrent angina or anginal equivalent, dynamic changes on 12-lead electrocardiogram, and hemodynamic or electrical instability denote a higher risk profile in older patients attributed to a larger amount of myocardium at risk.[17]
Mechanical complications	• High mortality rates persist in patients with mechanical complications, such as papillary muscle rupture, ventricular septal rupture, or ventricular free-wall rupture.[39] • Older age is one of the strongest risk factors for mechanical complications particularly among female patients and those with hypertension, heart failure, chronic kidney disease, or during a first coronary event.[39]

ACS = acute coronary syndrome; PCI = percutaneous coronary intervention; VHD = valvular heart disease.

TABLE 3

Anatomic and Procedural Risk Factors in Older Adults Undergoing Percutaneous Coronary Intervention

Categories of Risk	Key Considerations in Older Adults
Coronary anatomic complexity	• Older adults often have high-risk coronary anatomic features: left main disease, proximal disease in the left anterior descending artery, bifurcation disease, increased number of diseased vessels, chronic total occlusion(s), severe calcification, long lesion length (>60 mm). • SYNTAX score (≥33) have favorable clinical outcomes when managed with coronary artery bypass grafting surgery as compared with PCI,[46] including specifically in older adults.[47]
Calcification	• In patients aged ≥70 y, the prevalence of coronary calcification is 67% of women and 90% of men.[48] • Can lead to inadequate stent expansion, challenging device delivery, and are prone to periprocedural complications such as no-reflow, dissection, and perforation.[49] • Options for plaque modification include rotational atherectomy, orbital atherectomy, excimer laser, and intravascular lithotripsy, though these also increase the risk for complications.
Vascular tortuosity	• Older patients have a higher rate of highly tortuous coronary vessels; tortuosity increases the risk for dissection and perforation using RA, OA, or laser atherectomy.[50] • Older females have higher prevalence of severe tortuosity of the right subclavian artery, which may lead to a higher risk of unplanned radial to femoral access site crossover and worse outcomes.[51]
MCS	• In patients with very high-risk anatomy, reduced ejection fraction, or cardiogenic shock, the use of MCS may be reasonable to support patients through PCI.[52] • Evidence for MCS in older adults remains scarce and MCS devices are associated with a higher rate of periprocedural complications such as bleeding and vascular events which may be magnified in older adults.[53] • Additional MCS complications include: infectious, neurological (stroke), hematological (thrombocytopenia, thromboembolism), and mechanical (device malfunction).[53,54] • Higher prevalence of iliofemoral PAD among older adults which may limit large bore MCS options.[55]
Bleeding	• Older adults have the highest rates of periprocedural bleeding events and, thus, derive the largest absolute benefit from bleeding avoidance strategies.[8,56] • Radial access vs femoral access reduces major bleeding and improves mortality.[8,57–59] • Older adults are less likely to undergo PCI via radial access, creating a risk-treatment paradox.[60] • Other bleeding avoidance strategies include risk stratification (CRUSADE, ABC-HBR, DAPT), use of weight- and renal-adjustment of antithrombotic agents, selecting drug-eluting stents that are known to be safe for shorter dual antiplatelet therapy duration post-PCI (Resolute Onyx, Synergy, and Xience),[61] and an initial noninvasive strategy in select patients.[61]

DAPT = dual antiplatelet therapy; MCS = mechanical circulatory support; OA = orbital atherectomy; PAD = peripheral vascular disease; PCI = percutaneous coronary intervention; RA = rotational atherectomy.

TABLE 4

Impact of Geriatric Syndromes on Percutaneous Coronary Procedure Outcomes

	First Author (Year)	Study Population	Risk Assessment	Prevalence of Geriatric Syndrome	Key Findings
Frailty/ sarcopenia	Singh, 2011[62]	Mean age 74.7 y, PCI	Fried	22%	Frailty was associated with adverse long-term outcomes following PCI
	Murali-Krishnan, 2015[63]	Mean age 62 ± 12 y, PCI	Canadian Study of Health and Aging Clinical Frailty Scale	11%	Frailty assessment had predictive value for both mortality and length of hospital stay
	Sujino, 2015[64]	Mean age 88.1 ± 2.5 y, PCI	Canadian Study of Health and Aging Clinical Frailty Scale	36%	PCI was performed less frequently in patients deemed frail, even though performing PCI may reduce in-hospital mortality
	Dodson, 2018[65]	Mean age 75.3 ± 7.7 y, PCI	Combined frailty score based on Rockwood Clinical Frailty Scale using measures of assisted/unassisted walking, cognition, ADLs	16%	More frail patients had higher risk of major bleeding when cardiac catheterization was performed
	Calvo, 2019[66]	Mean age 82.6 y, PCI	FRAIL scale	20%	The FRAIL scale was a strong predictor of mortality after PCI
	Hermans, 2019[67]	Mean age 79 ± 6.4 y, PCI	Safety Management Programme (VMS)	57%	Frail patients over 70 y treated with PCI had higher rates of short-term mortality and major bleeding
	Damluji, 2019[11]	Mean age 82.3 y, PCI	Claims-based Frailty Index	19%	While frailty should be considered, frail patients also benefit from PCI
	Yoshioka, 2019[68]	Mean age 84.6 ± 3.8 y, PCI	CFS	49%	Frailty influenced short- and mid-term prognoses after PCI
	Anand, 2020[69]	Mean age 79 y, PCI	CFS	20%	Using CFS enhances the predictive value of the GRACE score for mortality risk after myocardial infarction in older patients
	Shing Kwok, 2020[70]	Mean age 64.5 y, PCI	Hospital Frailty Risk Score	5%	High and intermediate frailty puts patients at an increased probability of in-hospital mortality, bleeding, prolonged length of hospital stay, and increased cost following PCI
	Nishihira, 2021[71]	Median age 84.5 y, PCI	Frailty scale modeled after Dodson et al[65] and Rockwood Clinical Frailty Scale	28%	Frailty was associated with major bleeding, in-hospital mortality, and mid-term mortality after undergoing PCI
	Kanwar, 2022[72]	Mean age 74.8 ± 6.4 y, PCI	Fried or Rockwood Clinical Frailty Scale, depending on cohort, Seattle Angina Questionnaire, Short Form 36, and a single-item question on self-reported health	19%–20% depending on cohort	Increased frailty and worse QOL had significant association with long-term survival
Functional status	Mori, 2021[73]	75 y of age and older, PCI	Functional status scale defined by decline of at least 1 of ADLs measured (bathing, dressing, chair rise, walking)	43% patients declined by 1 ADL	There was a lower risk of decline in functional status for patients who underwent PCI compared to AMI.
Cognitive impairment/ dementia	Mutch, 2011[74]	Mean age 67.3 y, PCI	Hospital abstract data or ICD-9-CM diagnoses	5%	Patients who underwent PCI had lower rates of dementia compared to CABG
	Chanti-Katterl, 2014[75]	Mean age 76.3 y, PCI	ICD-9 codes	3%	Patients with dementia were less likely to receive diagnostic cardiac catheterization, and thus were less likely to undergo PCI

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First Author (Year)	Study Population	Risk Assessment	Prevalence of Geriatric Syndrome	Key Findings
Scott, 2018[76]	Mean age 65.5 ± 8.7 y, PCI	Consortium to Establish a Registry for Alzheimer's Disease Auditory Verbal Learning Test, Trail Making Tests (parts A and B), Digit Symbol Substitution Test, Controlled Oral Word Association Test, CERAD Semantic Fluency test, Grooved Pegboard test	52%	8%–13% of patients 3 mo after they underwent PCI experienced cognitive decline
Levine, 2020[77]	Mean age 82.3 y, PCI	Modified Telephone Interview for Cognitive Status	19%	Patients with cognitive impairment are less likely to undergo PCI after AMI

ADL = activities of daily living; GRACE = Global Registry of Acute Coronary Events; PCI = percutaneous coronary intervention; QOL = quality of life.