Coronary artery stenting in elderly patients: where are we now

With the increase of the elderly population, the number of these patients undergoing percutaneous coronary intervention (PCI) has increased considerably. The elderly are, given the presence of comorbidities and frailty, at higher risk of mortality and morbidity following PCI. However, the elderly appear to derive significant benefits in terms of quality of life and might derive greater benefits from revascularization compared with younger patients. PCI is clearly effective in old age, but a careful approach to patient selection is essential to obtain better outcomes. In this qualitative review, we sought to examine the role and the risks of PCI in the older patients and the strategies to lower the adverse events in this particular set of patients.

Keywords: acute coronary syndrome • elderly • percutaneous coronary intervention

The world has never seen an aged population as currently exists globally. The increase in life expectancy has raised the average age of the population by increasing the number of surviving older people. Currently, 21% of the population in the more developed regions is aged 60 years or over, and by 2050 almost 33% of the population is projected to be 60 years or over [1].

The increasing age also places the population at risk of cardiovascular disease and is a powerful predictor of death and other major adverse cardiovascular events (MACE) in patients with coronary artery disease (CAD) [2-5]. Despite the improvement in percutaneous interventions and medical therapy, CAD remains the leading cause of morbidity and mortality among the elderly and its prevalence and severity increases with advancing age [6].

Evidence from trials of coronary revascularization has shown that patients at high risk derive greater benefit from revascularization than patients at low risk [7-9]. Thus, older patients, presenting more cardiovascular risk factors and higher risk of subsequent cardiovascular events, might derive greater benefit from revascularization [9,10]. However, community studies have shown that elderly patients are less likely to undergo percutaneous coronary intervention (PCI) and those that undergo coronary revascularization are typically treated less aggressively.

Despite the efforts made in the last updates, the current guidelines still do not take fully into account the complexity in the management and treatment of older patients, based on observational studies, post hoc analysis or randomized clinical trials in which they are frequently excluded for the presence of comorbidities requiring multiple medications or because of functional or cognitive limitations [11,12]. In recent years, the growing statistical importance of the older patients with CAD in the whole population and the development of new technologies and evidence based periprocedural medications made the PCI in this set of patients more feasible, increasing the amount of published data regarding this challenging field in interventional cardiology. In a cohort study conducted in Denmark, 3792 elderly patients (>80 years old) were treated with PCI and the annual proportion increased from 224 (5.4%) in 2002 to 588 (10.2%) in 2009 [13]. In the SCAAR trial, a total of 144,039 patients undergoing...
Review Donahue & Briguori

a PCI for the first time between January 1990 and December 2010 were analyzed; patients aged >75 years in 1990 were 5.8%, in 2000 were 15.9% and currently represent 28% of the whole PCI population [14]. The 2011 guidelines for PCI acknowledge that older adults constitute a growing proportion of patients considered for PCI. In one series examining trends over 25 years, the proportion of patients undergoing PCI who were 75–84 years of age doubled and those older than age 85 years increased fivefold [11]. Despite these data support a more aggressive attitude, the limit between benefit and harm is often vague. The management and the adoption of the most beneficial therapeutic strategy in the elderly with CAD represents one of the current challenges for interventional cardiologists.

In this qualitative review, we sought to examine the role of PCI in elderly patients with stable coronary disease and acute coronary syndromes (ACS) and the strategies to lower adverse events in this particular set of patients. Where not differently specified, elderly patients has been defined as patients aged over 75 years.

Frailty & increased PCI-related risk in the elderly

Predicting risk in the elderly may be problematic given their highly variable health, social and cognitive status. Age is an independent risk factor for adverse outcomes in many conditions and is usually included in risk scores. However, the assessment of frailty represents comprehensively the vulnerability typical of the elderly and is emerging as a superior predictor when compared with chronological age. Frailty, denoting a multidimensional syndrome characterized by increased vulnerability and decreased physiologic reserves, is also known to be associated with an increase in long-term mortality in patients with cardiovascular disease [15,16]. Singh et al. found that 66% of patients >65 years of age undergoing PCI are either frail or have intermediate frailty and that the inclusion of measures of frailty, comorbidity and quality-of-life (QOL) status improves risk stratification and predicts adverse outcomes and mortality better than the traditional cardiovascular risk scores, based on traditionally assessed cardiovascular risk factors [16].

Frailty in this setting increases the potential for complications and may limit the scope for symptomatic improvement. CAD in elderly patients is more extensive than in younger patients with a higher prevalence of three-vessel and left main CAD; nevertheless, two reasons make these patients less likely to undergo PCI: lower procedure success rates; and worse short-term prognosis [17,18]. Often the feasibility of performing PCI in elderly patients causes concern; operators must take into account a more extensive and diffuse pattern of atherosclerosis in the arterial beds, increased vascular stiffness and endothelial dysfunction [19]. Severe coronary calcification, which may lead to coronary dissections, stent underexpansion or the need for more invasive procedures such as rotational atherectomy, while peripheral vascular disease with a tortuous aorto-iliac system and often subclavian vessels, make coronary approaches difficult and may significantly affect access for interventional procedures.

Moreover, because of their frailty and comorbidities, elderly patients undergoing a percutaneous intervention run an increased risk of procedure-related complications, which are associated with higher mortality rates. In three large registries, the authors observed that in-hospital mortality was up to five-times higher in the most elderly group compared with those aged <80 years [20–22]. Despite these considerations, in current practice, up to 25% of all PCI are performed in patients over the age of 75 years and 12% are performed in those aged over 80 years, and this number has increased sharply over the past decade [20,21].

Stable angina

The prevalence of angina in population-based studies increases with age in both sexes, from 5 to 7% in women aged 45–64 years to 10 to 12% in women aged 65–84 years, and from 4 to 7% in men aged 45–64 years to 12 to 14% in men aged 65–84 years [23]. However, diagnosis of CAD is often difficult in the elderly because of the presence of atypical symptoms and common coexisting conditions, including the limited capacity to exercise and their high prevalence of baseline ECG changes that render exercise test data less reliable.

For choosing the optimal treatment strategy in the individual patient, both the complexity of CAD and concomitant comorbidities have to be taken into account. Therefore, cautious risk stratification is an essential aspect of this clinical decision-making process. A variety of risk scores has been developed to further stratify CAD patients, and to give additional information whether a patient should undergo PCI, coronary artery bypass graft (CABG) or optimal medical therapy (OMT) alone. Sinning et al. demonstrated that the combination of the SYNTAX score and the EuroSCORE as a combination of angiographical and clinical risk factors is beneficial in selecting the appropriate revascularization strategy for the individual patient and to further improve outcomes, especially in high-risk patients such as elderly patients [24]. Older patients with multivessel disease are more often referred to PCI than CABG, but age should not be the
sole criterion for the choice of type of revascularization. Although a slight advantage of surgical over percutaneous revascularization might exist for elderly patients with multivessel coronary disease, especially if diabetic [25–27]; surgical revascularization should remain an option only for a selected population of highly functioning elderly patients with few comorbidities.

In the prespecified analysis of clinical outcomes by age from the COURAGE trial [28], given the known limitations of the study, OMT was as effective in stable CAD patients aged <65 years as in patients aged >65 years, and PCI, when added to OMT, did not prevent ‘hard’ clinical outcomes such as death or myocardial infarction (MI) during long-term follow-up. In addition, older patients were angina-free at 60 months of follow-up with similar rates for those treated with PCI (80%) and OMT (73%).

In the randomized TIME trial, the authors compared an invasive strategy versus OMT in 303 patients aged 75 years and older with stable angina [29] and found a reduction in the risk of MACE in the invasive arm, which was largely driven by the reduction in rate of rehospitalization. Patients managed medically had a twofold increased risk of an adverse cardiovascular outcome compared with those undergoing myocardial revascularization. At a 4-year follow-up, an invasive strategy resulted in decreased MACE and improved QOL compared with a conservative strategy of OMT. However, the invasive strategy was associated with a trend toward increased mortality [30].

The Alberta Provincial Project for Outcome Assessment and Coronary Heart Disease Study [31] strengthened the evidence that elderly patients experience the largest absolute risk reductions associated with CABG or PCI compared with younger patients. Among the 6181 patients aged 70 years or older, the improvements in health status observed with coronary revascularization were similar or greater than those seen in patients aged <70 years.

These findings illustrating the benefits of an aggressive revascularization strategy in elderly patients are confirmed by the analysis of the German ALKK registry based on the data of 35,534 consecutive patients (7645 [21.5%] were aged between 75 and 84 years, and 744 [2.1%] patients were older than 85 years) undergoing elective PCI in which the authors found no differences in intra-procedural complications during elective PCI between younger and elderly patients. Although in-hospital major adverse cardiac and cerebrovascular events were somewhat higher in the elderly, the overall event rate was low [32].

Notwithstanding the positive results emerging from nonrandomized studies, the higher in-hospital mortality rates associated with revascularization, particularly in patients older than 75–80 years, raises some concerns and the indication for PCI in very elderly patients still remains questionable. Since PCI is mainly performed for pain relief and not for a higher life expectancy, this should be recommended only after careful consideration of patient preferences and desired outcomes, functional capacity and QOL, as well as therapeutic alternatives.

The importance of improvements in health status and QOL in influencing decision-making in this patient group tends to grow compared with the importance of survival end points. Especially as patients get older, it is reasonable that their objective may be to live better rather than longer.

**Acute coronary syndrome**

Age is one of the most important predictors of risk in ACS. The prevalence of ACS-related complications such as heart failure, bleeding, stroke, renal failure and infections increases markedly with age and patients aged >75 years have at least double the mortality rate of those <75 years [33]. The elderly are at particular risk of bleeding; it is therefore essential to dose the antithrombotic therapies, particularly in relation with renal function.

In the setting of ACS, the American College of Cardiology/American Heart Association guidelines recommend that the elderly patient’s candidacy for intervention is evaluated with similar standards to those used for younger patients in deference to the wishes of the patient and his family [34]. Although it has been widely demonstrated that routine early invasive management yields superior outcomes in patients >65 years of age with ACS [35–37], in current clinical practice these patients are less likely to undergo invasive procedures than younger patients [38–42].

Elderly patients have been historically excluded from ACS randomized trials because of their comorbidities and potentially high mortality rates. Therefore, evidence has been extrapolated from studies of younger patients, which precludes extending the study findings to the population that experiences the most morbidity and death from ACS.

In the treatment of older patients, one should prioritize relief of symptoms treating the culprit lesion and avoidance of bleeding complications. Moreover, a complete revascularization in patients with multivessel CAD, neither significantly influences the rate of repeat revascularizations, nor acute and 12 months total adverse events [43–45].

**Non-ST-elevation MI**

Non-ST-segment elevation ACS (NSTE-ACS) is the most common presentation of acute ischemic heart
disease in elderly patients; in European registries of NSTE-ACS, 27–34% of patients are aged >75 years [46]. There has been considerable debate about the optimal therapy for elderly patients in this set of patients. Landmark randomized trials and registries demonstrated that compared with younger patients, elderly patients with unstable angina or non-ST-elevation MI had a markedly increased rate of adverse ischemic outcomes and that an early coronary angiography and revascularization (<48 h after hospital admission) leads to better in-hospital and long-term outcomes [47–50]. This strategy had a greater absolute benefit for the reduction of death or nonfatal MI in older patients than in younger patients, and both the absolute and relative benefits increased with increasing age. Of note, the early invasive strategy may increase major bleeding among patients older than 75 years of age [49].

Damman et al. analyzed the impact of the initial management strategy on the 5-year risk of cardiovascular death or MI, according to the patients’ age categories in the FRISC II, ICTUS and RITA 3 trials and found that, in patients with NSTE-ACS, the long-term benefit of the routine invasive strategy over the selective invasive strategy was evident for patients aged 65–74 years (hazard ratio [HR]: 0.72; 95% CI: 0.58–0.90) and those aged ≥75 years (HR: 0.71; 95% CI: 0.55–0.91), but not in those aged <65 years (HR: 1.11; 95% CI: 0.55–1.38) [51].

In the Elderly ACS trial, 313 patients ≥75 years of age with NSTE-ACS were randomly allocated to an early aggressive strategy or an initially conservative strategy [52]. Patients with an initially conservative treatment experienced significantly more ischemic events during index admission and within 1 year, a 20% difference in the rates of major adverse cardiac and cerebrovascular events between the early aggressive and the initially conservative cohorts was observed. Moreover, patients with elevated troponin levels on admission randomized to an early aggressive approach had a significant 57% reduction of the primary end point rate.

PCI in very old patients (>85 years) appeared to be safe in the study conducted by Rana et al. [53]. In this registry, the authors showed that, in 294 patients over the age of 85 years undergoing PCI for ACS, 1-year mortality rates were 17.7%. In elderly patients who underwent revascularization during the index admission, there was a larger absolute reduction in mortality at 6 months compared with patients <70 years of age (7 vs 1.8%, respectively).

**ST-elevation MI**

Management of MI in the elderly presents special challenges compared with younger patients. Delays in the emergency activation are common among older adults, often due to atypical symptoms and/or lack of symptom recognition [54]. Treatment may also include delay or lack of reperfusion, increased risk of antithrombotic therapy and presence of comorbidity and renal impairment, which require dosing adjustment.

The decision of reperfusion strategies to be made must depend on the availability of resources for reperfusion in each practice. Overall, thrombolysis is not commonly utilized in the elderly age group in contemporary practice [55,56]. The leading reasons center on concerns regarding increased bleeding, intracranial hemorrhage and higher in-hospital mortality. Primary PCI (PPCI) is particularly attractive in the elderly, since it offers the advantage of high successful reperfusion rates in this very high-risk population, avoiding the risks of bleeding associated with fibrinolytic therapy. Considerable evidence from registries and subanalysis of randomized trials conducted in the last two decades indicates that PPCI is superior to fibrinolytic therapy in the elderly, reducing recurrent ischemia, reinfarction, stroke and death [57–62] and shows up to five-times higher mortality when compared with younger patients [63].

In a meta-analysis of 22 randomized trials comparing PPCI with fibrinolysis, de Boer et al. showed a mortality reduction favoring primary PCI in all age strata, as well as reductions in the risk of repeat MI and stroke [64].

So far, three randomized trials have assessed the efficacy of primary PCI versus fibrinolysis in the elderly. A small study evaluating 87 patients aged ≥75 years showed that PPCI was superior to thrombolysis with streptokinase revealing a decrease of the composite end point of death, re-infarction or stroke at 1 year (13 vs 44%; p = 0.001) [65]. In the Senior PAMI trial [66], which randomized 481 patients ≥70 years old, although PPCI did not reduce the primary end point of 30-day death or disabling stroke, it was superior among patients 70–80 years old to thrombolytic therapy at reducing the combined end point of death, disabling stroke or re-infarction, a secondary end point (7.7 vs 17.0%; p < 0.01). Moreover, a nonsignificant trend towards a higher mortality rate in patients >80 years old was allocated to PPCI (19 vs 16%). The TRIANA study, including 266 patients aged ≥75 years, reported a trend toward reduction in the 30-day composite end point of death, re-infarction or disabling stroke with PPCI (18.9 vs 25.4%; p = 0.21). Recurrent ischemia was encountered less commonly in primary PCI-treated patients (0.8 vs 9.7%; p = 0.001) [67]. Of note, both the Senior PAMI and TRIANA trials were terminated before completion because of slow recruitment. The results of the main trials comparing primary percutaneous intervention versus fibrinolysis are summarized in Table 1.
Lowering risk & improving outcomes of PCI in the elderly

Frailty and the presence of significant comorbidities such as renal insufficiency, multiorgan dysfunction and extensive vascular disease may explain the increased mortality rates in elderly patients undergoing PCI. Over the last 10 years, new therapeutic tools, including devices and medications, have been developed to reduce periprocedural complications. General recommendations to improve outcomes in elderly patients undergoing PCI are depicted in Figure 1.

Risk stratification

To achieve better outcomes in patients undergoing PCI, it is essential for interventionists to perform a careful case selection and the decision on how to manage the single older patient should include the patient's pre-illness mental status, physical condition, patient wishes and QOL and be based on the estimated ischemic and bleeding risk, estimated life expectancy, and risks and benefits of revascularization [16]. Frailty stratification predicts a patient's risk of death and need for institutional care and, as aforementioned, should be included in the risk models for the elderly. In their study, Graham et al. expanded the use of a simple frailty assessment tool such as the Edmonton Frail Scale to a group of elderly patients with ACS. Higher Edmonton Frail Scale scores were associated with increased comorbidity, longer lengths of stay, decreased procedure use and, after adjusting for baseline risk factor differences using a burden of illness variable, with increased mortality [68].

Bleeding

Periprocedural bleeding and vascular complications are associated with worst clinical outcome, prolonged hospital stay and increased short- and long-term mortality, especially in elderly patients with ACS [69–72] who are at highest risk for bleeding after PCI. The reduced glomerular filtration rate (GFR) with the consequent
reduction in renal drug elimination and the altered hemostatic state with a tendency towards increased bleeding in response to antithrombotic agents in the elderly, makes the choice of the antithrombotic therapy paramount in avoiding this complication. The selection of vascular access in the elderly represents equally a crucial point in prevention of bleeding and worse outcomes.

**Antiplatelet therapy**
Aspirin should be prescribed well before revascularization and thereafter lifelong, at low (≤100 mg/day) doses. Clopidogrel, given its ease of use, friendly therapeutic window and low cost, should be considered as the receptor P2Y12 blocker of choice. Prasugrel is a third-generation oral thienopyridine with more potent platelet P2Y12 inhibitory effects than clopidogrel. *Post hoc* analyses from the TRITON-TIMI 38 trial clarified that, in patients older than 75 years, prasugrel has no net clinical advantage over clopidogrel as the ischemic benefit is offset by the risk of bleeding [73]. Although the use of prasugrel in patients ≥75 years of age is generally not recommended, according to the EMA, a reduced 5-mg prasugrel maintenance dose may be considered in the elderly. The safety and efficacy of a 5-mg dose of prasugrel in elderly patients with NSTE-ACS...
medically treated has been evaluated in the TRILOGY-ACS trial [74]. The authors did not observe any differences in ischemic and bleeding outcomes between reduced-dose prasugrel and clopidogrel 75 mg/day in the elderly cohort.

Ticagrelor is the first member of a new class of potent reversible P2Y$_12$ receptor antagonists that do not require metabolism and have direct action on the P2Y$_{12}$ receptor. In a substudy of the PLATO trial, the clinical benefit of ticagrelor over clopidogrel in patients with ACS with respect to the composite of cardiovascular death, MI and stroke; MI; cardiovascular death; stent thrombosis or all-cause mortality, was not significantly different between patients aged ≥75 years and those aged <75 years. No increased risk of major bleeding complications with ticagrelor versus clopidogrel was observed in patients aged ≥75 years or patients aged <75 years [75].

Notwithstanding the trend towards a clinical benefit, treatment with glycoprotein IIb/IIIa inhibitor (GPI) in elderly patients with ACS who undergo PCI is still controversial. Although guidelines do not suggest dose modifications based on age, careful patient selection is mandatory and dosing adjustment based on GFR is necessary for small-molecule GPIs (tirofiban and eptifibatide), which are cleared renally. An increase in minor bleeding should be expected when using GPIs in patients 75 years of age and older, but the potential treatment benefit may surpass the slightly increased risk for minor access site bleeding complications. Broadened use of vascular closure devices in this specific patient population may lower the rate of such complications.

**Access site**

The elderly are at particular risk of access-related complications mainly because of the higher prevalence of native vascular disease and a greater susceptibility to the antithrombotic therapy during and after PCI. The radial approach, abolishing almost totally the access site bleeding, is associated with a lower rate of bleeding and similar procedural success rates compared with the femoral approach [79]. Since elderly patients have significantly higher baseline risk of arterial access complication [80], the reduced rates of lower local vascular complications may be beneficial for this group.

These benefits appear to be pronounced among experienced radial operators and in patients with ACS [81–83]. Multiple studies have also shown an association between transradial PCI and reduced mortality [84,85], but the mechanisms underlying this benefit are unclear. Moreover, time-to-ambulation is significantly reduced with the radial approach, which helps eliminate or reduce the risk of venous thrombosis and pulmonary embolism among elderly patients.

**Prevention of contrast-induced nephropathy**

The presence of multiple comorbidities, including chronic kidney disease (CKD), and more complex lesions, requiring greater amounts of contrast medium during procedures, increases the risk of contrast-induced nephropathy (CIN) that has been associated with adverse outcomes and early and late mortality following PCI [86].

The best approach to prevent CIN is to identify patients at risk using risk scores [87,88], to minimize the amount of administered contrast media and provide adequate periprocedural hydration according to the current guidelines recommendations [12]. The use of nephrotoxic drugs should be suspended for at least 2 days prior to contrast media exposure, while OMT before exposure to contrast media should include statins, β-blockers and angiotensin-converting enzyme inhibitors or sartans.

In CKD patients with diffuse atherosclerosis, performing diagnostic and interventional procedures separately and scheduling staged PCI in multivessel disease patients reduces the total volume exposure to contrast media. The risk of CIN increases significantly when the ratio of contrast volume to GFR exceeds 3.7 [89].

Although serum creatinine is a marker of renal function, it does not represent an ideal marker of acute kidney injury [90]. For this reason, new biomarkers, such as cystatin C and neutrophil gelatinase-associated lipocalin, which allow an earlier and more accurate diagnosis of acute kidney injury, have been identified [91,92].
Procedural issues
Stent choice should include a comprehensive evaluation of the risk of restenosis, thrombosis, bleeding and patient’s compliance. Bare-metal stents may be considered the device of first choice in elderly patients undergoing PCI, given the primary goal of minimizing the risk of bleeding and the presence of a health status often requiring multiple diagnostic and therapeutic invasive procedures. On the other hand, the high prevalence of CKD, diabetes and complex lesions in this set of patients should make the operators adopt a more effective strategy, in order to reduce the risk of repeat revascularization and implanting drug-eluting stents (DES).

Data from large registries demonstrated that patients receiving DES had significantly better clinical outcomes including mortality, MI and repeat revascularization than those who received bare-metal stents, without an associated increase in major bleeding or stroke [93–95]. These results are consistent even in patients requiring more challenging procedures like chronic total occlusion [96] and small vessel lesions [97]. In the randomized XIMA trial enrolling 800 octogenarian stable patients, DES implantation were associated with a lower incidence of MI and target vessel revascularization, without an increased incidence of major bleeding [98].

Especially in the elderly, the bleeding risk correlates with the duration of dual antiplatelet therapy (DAPT) [99]. Although the optimal duration of DAPT is still lacking scientific ground, in DES trials, as recommended by guidelines, prolonged DAPT intake for at least 12 months was mandatory. Results from recent randomized trials comparing 3 versus 12 months of DAPT among patients with low-risk profile CAD treated with zotarolimus-eluting stents, suggest the noninferiority for short- vs long-term DAPT with no significant difference in any of the individual components of the primary end point (cardiovascular death, MI, stent thrombosis, target vessel revascularization or bleeding) [100,101]. Moreover, in the PARIS registry, most adverse events occurred while patients were taking DAPT and cardiac events after DAPT cessation depended on the clinical circumstance and reason for cessation and attenuates over time; physician-guided discontinuation was associated with a substantially lower MACE risk, while disruptions due to bleeding or noncompliance were associated with a substantially increased risk. Patients who had temporary DAPT interruption lasting up to 14 days did not have an increased rate of thrombotic events [102]. Trials evaluating early struts coverage using the optical coherence tomography imaging demonstrated a low percentage of uncovered struts 3 months after DES implantation, adding new implication on DAPT duration [103].

As previously stated, in patients with culprit-only multivessel disease, the revascularization approach should be envisioned. Previous studies have noted that older patients who were completely revascularized undertook a much higher risk, such as acute or subacute thrombosis, sudden death or bleeding [93,104] and no differences in acute and 12 months total events between completely or incompletely revascularized subjects [43–45].

Lesion preparation and poststenting optimization should be parsimoniously pursued, as these may indeed have a detrimental impact on periprocedural events.

Coronary bifurcations should be approached with a conservative stance, unless a large side branch does compromise itself causing symptoms or instability [105]. Thus, a provisional stenting strategy should be pursued in most coronary bifurcation lesions. Moreover, diffuse stenting should be avoided and spot stenting adopted instead, to minimize the risk of stent thrombosis.

Stent delivery through calcified lesions may be difficult and stent may be underexpanded due to high resistance of the calcified plaques. The use of rotational atherectomy is particularly useful in the case of very tight calcified lesions that may resist dilatation at low balloon inflation pressures, or cause coronary rupture at the highest possible balloon pressure.

Future perspective
With the growth of the elderly population, the proportion of these patients undergoing PCI is increasing considerably. Although the development of new therapeutic tools including devices and medications has improved the outcome in elderly patients, this remains less favorable than in younger patients.

To date, evidence regarding PCI in the elderly allow us to confirm that these patients would benefit from a more invasive strategy both in the stable and ACS settings, but given the increase of this population, the need for specifically designed randomized trials may become crucial in the future. In the next years, evidence-based guidelines should be adapted for elderly patients with multimorbidity and the stratification with new risk scores including disease-specific risk, comorbidity and frailty should be common practice. It has been demonstrated that the radial approach is effective in reducing bleeding complications, but future studies should focus specifically on the role of the radial approach in the setting of bivalirudin-based treatment regimens.

In the elderly, as in the other high-risk subgroups, therapeutic strategies and the degree of invasiveness should be tailored as much as possible and a careful and comprehensive approach to patient selection is paramount to obtain the best outcomes.

Finally, the correct duration of DAPT in patients undergoing PCI is still controversial. A better understanding of the relation between struts coverage and adverse events and the development of DES requiring a
more reasonable DAPT duration in the elderly is of the utmost importance.

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Executive summary

Increased percutaneous coronary intervention-related risk in the elderly

- Coronary artery disease (CAD) represents the leading cause of morbidity and mortality among the elderly patients and its prevalence and severity increases with advancing age.
- The elderly might derive greater benefit from revascularization compared with younger patients but, given the presence of a higher risk for in-hospital mortality and morbidity due to a precarious health status, they are less likely to undergo percutaneous coronary intervention (PCI).

Elderly with chronic coronary

- In choosing the optimal treatment strategy for the individual patient, a cautious risk stratification represents an essential aspect of this clinical decision-making process; both the complexity of CAD and concomitant comorbidities have to be taken into account.
- Evidence from clinical trials suggest that an invasive strategy results in decreased rates of major adverse cardiovascular events and an improved quality of life compared with a conservative strategy of optimization of medical therapy.

Elderly presenting acute coronary syndrome

- Elderly patients have been selectively excluded from acute coronary syndrome (ACS) randomized trials. Therefore, evidence has been extrapolated from studies of younger patients, which precludes extending the study findings to the population that experiences the most morbidity and death from ACS.
- In patients with non-ST-segment elevation ACS, an early coronary angiography and revascularization leads to better in-hospital and long-term outcomes.
- Considerable evidence from registries and randomized trials indicate that primary PCI is superior to fibrinolytic therapy in the elderly patients with ST-elevation myocardial infarction.

How to improve outcomes of PCI in the elderly

- New therapeutic tools have been developed to reduce periprocedural and long term complications:
  - The use of risk scores that include the evaluation of frailty, comorbidities and quality of life;
  - It is essential to tailor antithrombotic therapy, bivalirudin in ACS patients is effective in reducing bleeding rates;
  - The radial approach, abolishing almost totally the access site bleeding, is associated with a lower rate of bleeding compared with the femoral approach and similar procedural success rates;
  - The best approach to prevent contrast-induced nephropathy is to identify patients at risk using risk scores, to minimize the amount of administered contrast media and provide adequate periprocedural hydration;
  - Drug-eluting stents significantly improve clinical outcomes including mortality, myocardial infarction and repeat revascularization compared with those who received bare-metal stents, without an associated increase in major bleeding.

References

Papers of special note have been highlighted as:
• of interest; •• of particular interest

Demonstrated that the inclusion of the measures of frailty, comorbidities and quality of life improves the discriminating ability of the risk model derived from routine cardiovascular risk factors.

- The TIME trial was the first prospective randomized treatment trial in elderly patients with chronic symptomatic coronary artery disease. At 4-year follow-up, an invasive strategy resulted in decreased major adverse cardiovascular events and improved quality of life compared with a conservative strategy of optimization of medical therapy.
Coronary artery stenting in elderly patients: where are we now

Review


• This meta-analysis of the FRISC II–ICTUS–RITA-3 trials shows that long-term reduction in the composite of cardiovascular death or myocardial infarction with routine invasive strategy compared with a selective invasive strategy is mainly seen in patients aged ≥65 years.

• The results of this study complement those previously found in the Senior PAMI trial suggesting that primary percutaneous coronary intervention may offer clinical advantage over fibrinolytic therapy as manifested by the trends towards improvements in the combined end point of death, reinfarction and stroke at 30 days in the oldest patients.


Coronary artery stenting in elderly patients: where are we now

Review


Review

Donahue & Briguori


