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CONSENSUS DOCUMENT
Patient care

Cardiovascular diseases, prevention, and management of complications in older adults and frail patients treated for elective or post-traumatic hip orthopaedic interventions: a clinical consensus statement of the ESC Council for Cardiology Practice (CCP), the European Association of Preventive Cardiology (EAPC), the Association for Acute CardioVascular Care (ACVC), the Association of Cardiovascular Nursing & Allied Professions of the ESC (ACNAP), the ESC Working Group on Aorta and Peripheral Vascular Diseases (WG APVD), and the ESC Working Group on Thrombosis (WG T)

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Abstract

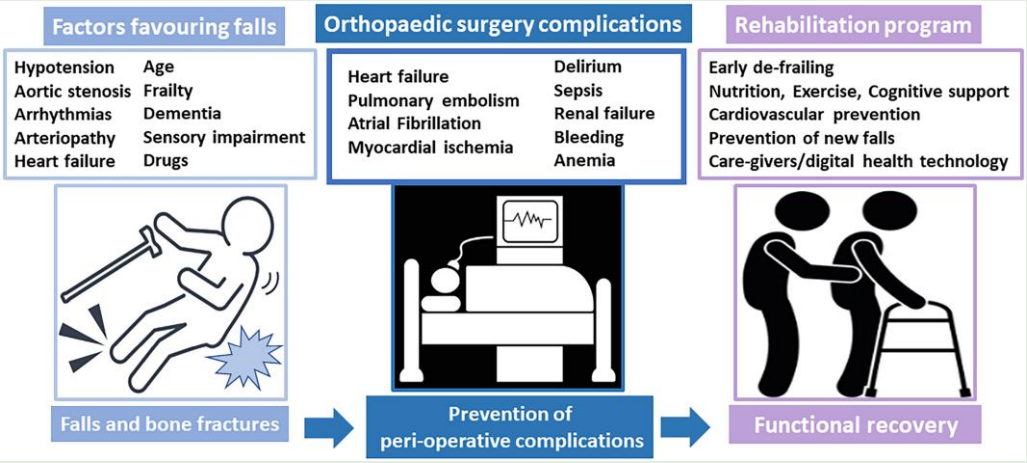
Due to the aging population, focusing on healthy aging has become a global priority. Cardiovascular diseases (CVDs) and frailty, characterized by increased vulnerability to adverse stress and health events, interact synergistically in advanced age. In older adults, hip fractures are a frequent dramatic 'life-transition' event. Conditions such as arrhythmias, orthostatic hypotension, heart failure, peripheral artery disease, and adverse drug reactions may facilitate falls and thus bone fractures in older adults. Cardiovascular complications or the worsening of previous CVDs may increase the degree of frailty and disability following this surgery. The close relationship between older age, CVDs, frailty, and orthopaedic surgery leads to the need to focus on the various phases of interventions in a multidisciplinary approach. This document aims to provide practical support to prevent cardiovascular complications in older and frail patients undergoing hip procedures by suggesting specific assessments and interventions. In particular, in pre-operative care, the focus should be on the assessment and management of concomitant CVD and frailty, while immediate peri- and post-operative care should highlight specific concerns for anaesthesia, prevention, and management of thrombotic complications, specific nursing needs, including the prevention of infections and delirium, and the establishment of an integrated rehabilitation program focusing on CVDs and the risk of new falls, with a positive role for care-givers. Furthermore, by optimizing the 'hip surgery pathway' the objective is to help avoid the deterioration of health and loss of independence that often result from this surgery through the correct management of cardiovascular patients in this peculiar context.

Lay summary

Hip fractures and orthopaedic surgery are common dramatic events that trigger a sequence of adverse outcomes in older adults. This clinical consensus statement aims to provide practical support to prevent cardiovascular complications and avoid deterioration of health and loss of independence in older adults and/or frail patients undergoing hip surgery, suggesting specific assessments and interventions and optimizing:

- The prevention and correct management of cardiovascular complications in the pre- and peri-operative care.
- The support for frailty and the specific needs of older patients in this specific clinical context.

Graphical Abstract



Keywords

Orthopaedic interventions • Hip surgery • Non-cardiac surgery • Falls • Older adults • Frailty • De-frailing • Cardiovascular disease • Rehabilitation • Prehabilitation • Elderly

Introduction

Due to the epidemiological trend in aging, a primary goal for the 'WHO-Decade of Healthy Ageing 2020–2030' is to preserve successful aging in the general population.[1]

The main cause of morbidity and mortality in older adults are cardiovascular diseases (CVDs). Frailty, a multidimensional and multisystem condition characterized by decreased functional reserves and increased vulnerability to stress and acute adverse events,[2] synergistically interacts with heart conditions, with a behaviour characterized by a two-way mutual enhancement.[2]

Hip fractures are a major 'catastrophic' adverse event in older age, frequently leading to disability and higher mortality.[3] This dramatic sequence of events may be, in turn, due to and worsened by frailty and cardiac complications.[4,5] The just-depicted close relationship between older age, CVDs, frailty, risk of falls, and orthopaedic surgery leads to the need to focus on the various steps of interventions in a multidisciplinary approach.[6]

This document complements the European Society of Cardiology (ESC) guidelines for the management of non-cardiac surgery.[7] The experts of the Consensus were chosen after asking the six ESC constituent bodies involved in the topics and included after the approval of the Associations/Councils/Working Groups and by direct invitation to international experts. Clinical Consensus Statements were shared and approved by all the authors. In particular, the specific needs of older patients that may arise during the pre-, peri-, and post-operative

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periods are addressed to prevent or minimize cardiovascular complications and to safely complete, including improving recovery time, this life-threatening surgery.

Connection between CVDs and risk of fall or hip fracture

Syncope

Every syncope may lead to falls and bone fractures in older adults. The 2018 ESC guidelines define syncope as transient loss of consciousness due to cerebral hypoperfusion, characterized by a rapid onset, short duration, and spontaneous complete recovery.[8]

In addition to the first peak in the incidence and prevalence of syncope occurring in young subjects, the second peak occurs in patients above the age of 65 years. In the Framingham study, a sharp rise in syncope incidence has been shown after the age of 70 years (5.7 events/1000 person-years in age 60–69 years, 11.1 in age 70–79 years).[9,10]

Syncope may be related to a cardiac disease, to reflex syncope, or to orthostatic hypotension. The latter two forms seem to be more frequent in older people (in patients >75 years, reflex syncope: 36%; orthostatic hypotension: 30%).[11]

Besides true syncope, every unwitnessed unexplained fall should be considered as a syncope.[12,13]

In addition to cardiovascular drugs, such as anti-hypertensive drugs, polypharmacy, psychotropics (i.e. neuroleptics and antidepressants), dopaminergic drugs, and many others increase the risk of syncope and falls.[6,14]

Orthostatic hypotension may be due to inadequate venous return from hypovolemia (due to, for example, dehydration) or venous pooling, or to autonomic nervous failure from a structural or functional impairment of the autonomic nervous system, as in Parkinson's disease, amyotrophic lateral sclerosis, diabetic neuropathy, and amyloidosis.

The clinical features that may suggest a diagnosis of orthostatic hypotension are a history of an episode of syncope while or after standing, or standing after exertion, or the finding of post-prandial hypotension.[8] Many tests used to confirm the diagnosis should be performed with caution in the older adults and may not be feasible in a patient with a hip fracture confined to bed.[8]

Education and teaching to avoid triggering events and to maintain adequate hydration, causative drug interruption and, whenever possible, teaching physical counter-pressure manoeuvres may help to reduce relapses of orthostatic hypotension syncope also in the older adults.[15]

Anti-hypertensive treatment

Hypertension is highly prevalent in older adults and is associated with increased morbidity and mortality even in patients with advanced age. However, there is concern of potential iatrogenic problems, first of all arterial hypotension, when treating hypertension in older adults.[16,17] Due to the potential for orthostatic hypotension, an evaluation during standing should be part of the standard clinical visit in older patients treated with anti-hypertensive drugs.[2,6,17] Older patients with multimorbidity, frailty, and polypharmacy tend to develop iatrogenic hypotensive episodes more than younger ones, suggesting that a personalized treatment and a careful balance between positive and negative drug effects are needed during the acute or sub-acute phase of surgery.[2,15,17]

Arrhythmias

Older age is associated with increased cardiac fibrosis, cardiac chamber hypertrophy or enlargements, cardiac diseases, and multi-morbidity leading to increased prevalence of arrhythmias. Arrhythmias and conduction disorders may provoke syncope *per se*, or may facilitate syncope and falls in older patients with altered cardiac compliance, in patients with orthostatic hypotension or with frailty.[6,18]

The more frequent arrhythmias associated with falls are brady-arrhythmias, asystole, and tachy-brady forms of atrial fibrillation.[19,20] The prevalence of frailty in patients with atrial fibrillation ranges from 4.4 to 75.4%, while the prevalence of this arrhythmia in the frail population ranges from 48.2 to 75.4%.[21] Frailty is associated with sarcopenia, sensory impairment, cognitive disorders and balance impairment which may facilitate falls during an arrhythmic episode. Patients with atrial fibrillation have an about doubled prevalence of falls compared with those without it, with a high prevalence of non-accidental falls.[22,23]

Aortic stenosis

Although arrhythmias could certainly cause hypotension in patients with aortic stenosis, syncope is usually ascribed to a circulatory imbalance. In aortic stenosis, syncope occurs during exercise and in any condition in which it is likely that left ventricular systolic pressure increases afterload more than can be offset by pre-load reserve. Thus, cardiac output fails to increase or even decreases.[24]

Aortic stenosis with syncope occurs on average in patients with smaller heart chambers and/or stiffer left ventricles, resulting in lower stroke volume. This condition can worsen in the early post-operative period.[25]

Besides haemodynamic challenges leading to syncope, a relationship between aortic calcifications and osteoporosis has been described,[26–28] together with evidence of a reciprocal regulation between the calcification in the arterial vasculature and skeleton.[29] In symptomatic, severe aortic stenosis patients who underwent transcatheter aortic valve replacement, patients with a history of fracture displayed smaller body mass index, increased frailty, a higher prevalence of stroke history and osteoporosis.[30]

Chronic heart failure

In heart failure patients, nearly 40% of adults experienced a fall within 1 year,[31] being Type 2 diabetes, slowness, and exhaustion predictors of falls. Older adults with heart failure had 14% greater odds of falling[32] with four-fold increased risk of fracture requiring hospitalization compared with patients with other CVDs.[33] Heart failure is also associated with factors that may contribute to accelerated bone loss and subsequent fractures. It is known that increased levels of aldosterone are linked to urinary calcium and magnesium excretion, hyperparathyroidism, and diminished bone mineral density. Another important relationship is the association between heart failure, hyponatremia, and increased risk of falls and fractures.[33]

Moreover, medical therapy of heart failure, including angiotensin-converting enzyme inhibitors, angiotensin II receptor blockers, angiotensin receptor-neprilysin inhibitors, loop diuretics, and β-blockers, may potentiate the risk of falls.[34–37] Hot weather or reduced oral fluid intake associated with diminished thirst can contribute to hypotension, particularly in older patients with structural heart disease.

Peripheral artery disease

Peripheral artery disease (PAD) is a frequent condition in older adults, as its prevalence reaches 20% in octogenarians.[38] In older patients hospitalized for non-cardiovascular conditions, undiagnosed PAD can be detected in almost 20%.[39] Among patients managed for knee arthroplasty, 4.6% had an incidentally detected PAD, mostly located on superficial femoral or popliteal arteries.[40]

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Some authors report subclinical PAD, identified by an ankle-brachial index <0.9 associated with hip fractures.[41] Patients with PAD are at increased risk of falls, as this condition is associated with decreased walking speed, step length, stride length, cadence, and hip extension, as soon as the first steps.[42–44] Additionally, patients with intermittent claudication have gait disturbances with a higher risk of falls.[45] Furthermore, several studies showed that PAD was associated with the presence of osteoporosis and osteoporotic fractures.[46,47] Indeed, the history of CVD, including PAD, has been found to be associated with decreased bone mineral density.[48] Yet, PAD must be considered as a common, often undiagnosed comorbidity in patients at risk of falls and hip fractures.

In addition, PAD is considered an independent risk factor of peri-operative myocardial infarction and injury after total knee or hip arthroplasty.[49] In a recent series of older patients with proximal femur fracture, PAD was associated with mortality at 6 months.[50] Taking all these into consideration, PAD screening can be proposed for risk stratification in patients attending elective total hip arthroplasty.[51]

Finally, patients with PAD present muscular impairment, sarcopenia, neuropathy and frequently frailty.[2,52,53] All these consequences, aggravated by ischaemia when walking, can impede rehabilitation after hip surgery.

Care of older patients during the acute and post-acute phases

The role of the cardiologist in the pre-, peri-, and post-operative co-management of older patients (≥65 years) undergoing urgent or elective hip surgery is to address the cardiovascular conditions that can cause complications or impede functional recovery (see *Bullet points 1* and *Bullet points 2*, see Figure in Supplementary material online, *Data*). In vulnerable older patients, the union of specific skill-sets in a multidisciplinary team with cardiologists, orthopaedists, anaesthesiologists, intensivists, and geriatricians ('orthogeriatric service') is advisable.[54]

Bullet points 1—Clinical consensus statement: care of older patients during the acute phase of hip surgery

- A multidisciplinary co-management of older patients undergoing urgent or elective hip surgery to address the cardiovascular conditions is advisable.
- The concomitant management of cardiovascular diseases (CVDs) should follow the 2022 ESC guidelines on cardiovascular assessment and management of patients undergoing non-cardiac surgery.[7]
- The decision to intervene on severe or unstable forms of ischaemic or valvular heart disease with coronary revascularization or valve replacement procedures prior to hip surgery must be weighed against the risks of delaying hip surgery >24–48 h.
- It is advisable to take into consideration the risk of surgical bleeding in patients undergoing PCI for which dual antiplatelet therapy will be required.
- It is advisable to search for the presence of severe anaemia, tachyarrhythmias, acute heart failure, aortic valve stenosis, sepsis, pulmonary embolism and stroke.
- Focus on frailty in older adults undergoing hip surgery (see *Box 2*).
- Focus on infectious endocarditis prevention.

Bullet points 2—Clinical consensus statement: care of older patients during the post-acute phase of hip surgery

- Focus on the potential occurrence of orthostatic hypotension due to age, comorbidities, non-adequate fluid intake and the haemodynamic deconditioning in the immediate post-acute phase.
- Nursing management requires a multidisciplinary approach with sarcopenia and delirium (see *Table 1*) being two clinical conditions that must be carefully observed in the immediate post-acute phase.
- Focus on an Integrated Rehabilitation Programme (see *Table 2*).
- Include family members and/or care-givers support in the patient's care pathway. After returning home, a particular attention regarding CVDs may be focused on possible occurrence, or worsening of symptoms related to atrial fibrillation, heart failure decompensation and hypotension (which may lead to falls).
- Soon after discharge potential digital-health technology interventions to monitor CVD complications may be established.
- Soon after discharge the patients need a more intense support, therefore it is advisable to adapt the home environment and care according to the general management of frailty in cardiology.[2]

Pre-operative care

Prognostic implications of CVD

Hip surgery is broadly classified as an intermediate-risk procedure, although it can be reclassified as high-risk depending on the patient's profile and acuity.[7] CVD is highly prevalent in the patient population undergoing hip surgery, and it is associated with a small increase in post-operative mortality (pooled odd ratio [OR] 1.14; 95% confidence interval [CI] 1.03–3.78)[55] and a larger increase in non-fatal major adverse cardiac events (OR 2.85, 95% CI 1.32–7.14),[56] with certain forms of CVD posing substantially higher risks. In particular, heart failure has been associated with a twofold increase in hospital mortality (adjusted OR 2.15; 95% CI 2.09–2.22) in a vast dataset of 21 560 996 non-cardiac surgeries.[57] These patients are at risk for haemodynamic instability and volume overload that could deteriorate to acute decompensated heart failure,[7,58,59] irrespective of preserved or reduced ejection fraction.[60]

Clinical assessment of CVD

CVD may be known or it may be elicited as a new diagnosis during the pre-operative assessment. In the 2022 ESC guidelines on cardiovascular assessment and management of patients undergoing non-cardiac surgery, a standard evaluation of CVD symptoms and signs is recommended, complemented in older patients (≥65 years) undergoing intermediate or high-risk non-cardiac surgery with an expanded evaluation of functional capacity, an ECG, a measurement of high-sensitive troponin (hsT), and brain natriuretic peptide.[7] It is advisable to evaluate clinically for arrhythmias in patients hospitalized for a hip fracture due to syncope.

Even minimal elevation in hsT forecasts up to three-fold increases in major adverse cardiac events.[61] Additional examinations may be indicated depending on the results of these assessments, such as echocardiography, pharmacological stress testing, or coronary angiography.[7] Incidental echocardiographic findings were common in octogenarians pre-hip surgery but rarely impacted management.[62] For obvious

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reasons, 6-min walk and exercise stress testing are not feasible in these patients (see Assessment and management of frailty for advice about the assessment of frailty).

Concomitant management of CVDs

Medical treatment of CVDs should follow the 2022 ESC guidelines on cardiovascular assessment and management of patients undergoing non-cardiac surgery.[7] While widespread initiation of β-blockers shortly before non-cardiac surgery has been discouraged following the findings of increased mortality, stroke, and hypotension in the POISE trial,[63] it is worth highlighting observational evidence that emergency hip fracture surgery may be a potentially high-yield indication for β-blockade owing to the massive catecholamine release in this setting.[64] The decision to intervene on severe or unstable forms of ischaemic or valvular heart disease—namely with coronary revascularization or valve replacement procedures—prior to hip surgery must be weighed against the risks of delaying surgery >24–48 h after multidisciplinary discussion. Another consideration is the risk of surgical bleeding in patients undergoing percutaneous coronary interventions (PCI) for which dual antiplatelet therapy will be required. This risk may be justified in acute coronary syndromes, although it is rarely so in patients with stable coronary artery disease.

As for aortic stenosis, peri-operative, 30-day, and one-year unfavourable event rates seem to be higher in patients undergoing hip fracture repair when aortic stenosis is left untreated.[65]

Data are lacking on the heterogeneity of the patients with aortic stenosis (critical vs. severe stenosis, left ventricular function, presence or not of coronary artery disease).

In time-sensitive, high-risk/intermediate-risk non-cardiac surgery, in the presence of a low-risk valve procedure, the Heart Team is recommended for evaluation of valve replacement following the 2022 ESC guidelines on cardiovascular assessment and management of patients undergoing non-cardiac surgery.[7] Balloon valvuloplasty as an alternative option to a strictly monitored non-cardiac surgery intervention is feasible in patients at high risk for valve procedures and intermediate/high risk for non-cardiac surgery.[7]

Impact of operative delays

A contentious issue is whether delaying hip surgery to perform additional cardiac tests, or even interventions, will adversely affect the patient's potential for operative success and functional recovery. The HIP ATTACK showed no difference in short-term mortality or incidence of complications with accelerated (median 6 h) as compared with standard care (24 h) surgical timing.[66] Delaying surgery further (>48 h) was associated with increased mortality in a systematic review of 16 studies involving 25 349 patients,[55] although the extent to which this is confounded by patient complexity and multi-morbidity remains unknown.

The clinical consensus statement suggested check list for CVD assessment before hip surgery is provided in *Box 1*.

Assessment and management of frailty

Frailty is a syndrome of age-related multi-system impairments that diminish physiologic reserves and predispose to disproportionate risks of adverse events in the face of stressors[2]—as in hip surgery. One of the cardinal impairments is sarcopenia, and by extension, osteosarcopenia, characterized by reduced muscle and bone mass and quality. The clinical consequences are far-ranging including impaired mobility, falls, fractures, disability, and mortality. Chronic inflammation and inactivity are key drivers for the development of osteosarcopenia, and also for the development of CVD, explaining the bi-directional links between frailty and CVD. According to the ESC Consensus Document on Frailty in Cardiology, it is advised to screen/assess for frailty patients with ≥70 years of age and any acute or chronic CVD.[2]

Many of the usual frailty tests, such as 5-m gait speed or five sit-to-stands (as used in the Essential Frailty Toolset), are based on lower extremity strength and balance,[67] hence not often feasible in these hip surgery patients. Advised alternatives are handgrip strength measured using a portable dynamometer,[68] muscle mass measured using the clinical computerized tomography images,[69] and a gradation of self-reported disability and vitality as measured by the Clinical Frailty Scale.[70] Screening of cognitive function, social support, mood, and nutrition can also be performed using questionnaires, and biomarkers such as haemoglobin and albumin. The Nottingham Hip Fracture Score encompasses many of these frailty domains and has been well validated.[71] Future iterations of frailty assessment tools will integrate digital biomarkers such as actigraphy from wearable devices and sensors[72] (see *Box 2*).

'De-frailing' interventions aimed at reducing the degree of frailty and enhancing the speed of recovery may be implemented before elective procedures,[73] during the index hospitalization,[64] or soon after surgery. These multi-faceted interventions typically combine one or more of the following early mobilization, rehabilitation, or prehabilitation (when feasible), protein-rich oral nutritional supplementation, cognitive stimulation, delirium monitoring, and polypharmacy reconciliation (see *Box 2*). Ideally, interventions are to be individualized to the specific deficits identified during a comprehensive geriatric assessment, with the active involvement of geriatricians and allied healthcare professionals. Notably, cardiac rehabilitation interventions are particularly well suited to frail older adults given their beneficial effects on functional status and quality of life.[74]

Box 1 Clinical consensus statement—Check list before surgery

- Is a cardiovascular disease the cause of fall leading to a hip fracture? If so, does it need to be resolved urgently and/or to be closely monitored after surgery?
- Consider specific issues in patients with known cardiovascular disease.
  - peri-operative management of antithrombotic drugs—short interruption of some cardiovascular drugs (e.g. diuretics, RAAS inhibitors, SGLT2 inhibitors).
  - fluid management in heart failure patients.
  - identify the potential need for cardiovascular postoperative follow-up or monitoring.
  - pre- and postoperative management plan for cardiovascular diseases.
  - preventive measures and optimization of guideline recommended therapy.
- Consider evaluation for frailty.
- Consider evaluation for risk of delirium.
- Is it possible to target frailty for treatment before intervention and /or schedule interventions soon after surgery?

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Box 2 Clinical consensus statement—focus on frailty in the acute phase of hip surgery

- When common tests to evaluate frailty cannot be used in hip surgery patients, advised alternatives are:
  - handgrip strength measured using a portable dynamometer,
  - muscle mass measured using the clinical CT images, and
  - a gradation of self-reported disability and vitality as measured by the Clinical Frailty Scale.
- It is advisable to screen for cognitive function, social support, mood, and nutrition using questionnaires and biomarkers such as haemoglobin and albumin and to use the Nottingham Hip Fracture Score which includes various frailty domains.
- 'De-frailing' multifaceted interventions focused on prehabilitation (when feasible) or early mobilization, protein-rich oral nutritional supplementation, cognitive stimulation, and polypharmacy reconciliation may be implemented before elective procedures, during the index hospitalization, or soon after surgery.

Box 3 Clinical consensus statement

Main concerns in the peri-operative phase

- Conditions of the skin and musculoskeletal system before and during surgery
- Maintenance of hydration with avoidance of hypovolemia and hypotension to prevent kidney damage
- Careful monitoring of fluid intake to avoid hypervolaemia and keep a neutral fluid balance
- Avoidance of nephrotoxic drugs or combinations of drugs with high risk of nephrotoxicity
- Monitoring of body temperature with active heating of the patient when indicated
- Careful monitoring of Haemoglobin with consideration of transfusion for Haemoglobin <8 g/dL
- Optimal pain control with individualized multimodal prevention and treatment of pain
- Regular SpO_2 and respiratory rate assessments with arterial blood gas analysis when percutaneous oximetry is not possible.

Main concerns in the immediate post-operative period

- Daily assessment of caloric intake with full enteral nutrition started as soon as possible.
- Prevention and management of postoperative delirium (see *Table 1*).
- Use of pulmonary expansion techniques, such as respiratory physiokinesis exercises, incentive spirometry or, when indicated, non-invasive ventilation in case of high risk of pulmonary complications.
- Proper antithrombotic prophylaxis.

Peri-operative care

Several points (summarized in *Box 3*) may be advised during the peri-operative and immediate post-operative period.

Indirect challenges of hip surgery on the cardiovascular system may be due to various factors, including relevant loss of blood with severe anaemia and complex blood transfusion management, particularly threatening in older adults, common iatrogenic complications due to polypharmacy, and sudden worsening of a pre-existing heart diseases. Moreover, the threat to the cardiovascular system may be related to thromboembolic events also due to rare cement or fat embolism, or both acute infections and sepsis and post-operative prosthetic infections.

In the ESC 2022 Guidelines on cardiovascular assessment and management of patients undergoing non-cardiac surgery, awareness and surveillance for peri-operative myocardial infarction is indicated in patients treated with intermediate- or high-risk orthopaedic procedures, together with a systematic work-up to identify pathophysiology and define therapy of the ischaemic event.[7] In particular, it is advisable to search the presence of severe anaemia, tachyarrhythmias, acute heart failure, aortic valve stenosis, sepsis, pulmonary embolism, and stroke.

Anaesthesia

The choice of anaesthesia must be individualized based on the characteristics of the patient, to avoid post-operative delirium and lead to a normal functional recovery.[75,76] There is currently insufficient evidence to recommend one anaesthetic technique over another to limit peri-operative risk in frail older adults,[77] with some studies showing a benefit on pulmonary complications with the use of neuraxial anaesthesia or other loco-regional anaesthesia techniques compared with general anaesthesia, especially in older and frail patients or patients with chronic obstructive pulmonary disease.[78–80] General anaesthesia is preferred in case of: anticoagulant drugs, haemodynamic instability or non-cooperative patients.[81] Careful dosing is needed to avoid overdose, adverse haemodynamic effects, and an inadequate level of narcosis. EEG-based/EEG-derived monitoring is useful during sedo-analgesic procedures in order to reduce post-operative delirium. Unjustified prolongation of the operating term must be avoided and an early neurological evaluation is needed to assess any new damage to the peripheral nerves due the peri-operative positioning.[77,79,81]

Infective endocarditis prevention

A patient undergoing orthopaedic surgery may be at risk for infective endocarditis. Recommendations that may apply to a peri-operative phase of surgery (including orthopaedic surgery) are strict cutaneous hygiene, disinfection of wounds, curative antibiotics for any focus of bacterial infection, rigorous infection control measures for at-risk procedures, limitation of infusion catheters and invasive procedures, and stringent adherence to care bundles for central and peripheral cannulas.[82]

Post-operative care

The 30- and 90-day mortality after elective total knee arthroplasty is 0.10% (95% CI, 0.07% to 0.14%) and 0.19% (95% CI, 0.15% to 0.23%), respectively, due to patient selection, perioperative care and a healthy-population effect.[83] Patient populations differ for elective vs. urgent and emergent, post-traumatic orthopaedic surgery, with a 4–7 times increased mortality and major cardiovascular complications in urgent or emergency conditions.[84,85] Therefore, quality measurement and ways to prevent cardiovascular complications and improve post-operative risk should consider surgical acuity.

Myocardial injury after non-cardiac surgery is of concern, especially among older patients with baseline CVD undergoing urgent or emergent

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Table 1 Usual multi-component approach to prevent the onset of delirium

Component	Suggested intervention
Parameters	Monitoring of vital parameters
Laboratory test	Perform routine diagnostic laboratory tests to detect any metabolic abnormalities
Hydratation/Oxygen	Ensuring adequate hydration and supplemental oxygen, if necessary, to maintain saturation >90%
Immobilization	Reduction of immobilization and bed rest (support and encourage mobilization by nurses and physiotherapist to the bathroom and to the table for meal intake).
Bladder catheters	Remove bladder catheters by post-operative day 2 after assessment of residual, unless otherwise advised
Bowel function	Monitor the patient's bowel elimination and use laxatives if necessary
Sleep	Encourage non-pharmacological sleep intervention; if possible, avoid benzodiazepines in the first step and if already in use, do not discontinue them abruptly
Pain control	Monitor and control pain with validated scales, if possible, avoid drugs (e.g. opioids) that could increase the occurrence of delirium
Environment	Encourage an appropriate environment and reduce acoustic noise, especially at bedtime and at night. Set up an appropriate care setting, with environmental aids (calendar, clock)
Family members/care-givers	Involve family members and/or care-givers to support the patient's care pathway

procedures. The incidence of myocardial injury after non-cardiac surgery with systematically measured hsT post-hip surgery can reach 18% based on data from the HIP ATTACK study and a systematic review.[86] The prognosis of this condition post-hip surgery is concerning.[87,88]

At this regard, recent data showed that, in a time window extending from 2000 to 2019, the hip fracture population changed its characteristics. Female gender became progressively more common, and the prevalence of hypertension, Type 2 diabetes, coronary artery disease, arrhythmia, and neoplasms increased.[89] Accordingly, in the long-term, patients with hip fractures are at higher risk of myocardial infarction than the general matched population.[90] Also, the Rochester Epidemiology Project showed that in the first 7 days after hip fracture surgical procedure, the incidence of myocardial infarction and of subclinical myocardial ischaemia were 10.4 and 3.7%, respectively.[91] In-hospital mortality is significantly higher in those with than in those without myocardial infarction (12.5 vs. 3.5%), with coronary angiography often demonstrating multivessel coronary artery disease.[92] One-year mortality was 35.8% in subjects with myocardial infarction. At the 1-year follow-up, mortality was associated not only with peri-operative myocardial infarction, but also with male gender, heart failure, and dementia; patients who—before the event—lived at home and had higher haemoglobin levels showed a better survival.[91]

The incidence of peri-operative atrial fibrillation after orthopaedic surgery is between 3 and 6%.[93,94] Among all cases of peri-operative atrial fibrillation, one out of five is associated with orthopaedic procedures.[95] Peri-operative atrial fibrillation is promoted by transient factors operating on a pre-existing and/or surgery-induced substrate.[96,97] Age, a history of atrial fibrillation, left ventricular diastolic and systolic dysfunction, and hypertension are the most common predisposing factors.[97] Also, a time to surgery longer than 48 h and the need for >2 units of packed red blood cells in the emergency or in the recovery room were found to be associated with arrhythmia development.[98] New episodes of atrial fibrillation are usually distributed between the first and the third post-operative day.[99] After the hip fracture surgery, in a population with a mean age of 83.8 years, 1-year mortality was significantly higher if atrial arrhythmias were observed in the first 7 days after the procedure (45 vs. 21%; HR = 2.1, 95% CI: 1.4–3.1).[94] These results were strengthened by those of the POISE trial, which showed that peri-operative atrial fibrillation was associated with a worse 1-year vascular outcome. In particular, after orthopaedic surgery, stroke incidence and mortality were 5.6 and 23.8%, respectively.[95] According to the 2024 ESC Guidelines for the management of atrial fibrillation[100] long-term oral anticoagulant therapy should be considered in patients with post-operative atrial fibrillation at elevated thromboembolic risk.

During peri-operative treatment it is necessary to modify various therapies or pharmacological dosages based on the haemodynamic variations during the surgical phase. It is advisable to optimize therapy, often reintroducing lower doses of drugs when resuming treatments for heart failure or anti-hypertensive treatments, before discharge from the hospital and/or in agreement with the rehabilitation team.

Nursing from surgery to discharge

The evaluation of the patient from admission to discharge must continue throughout the hospitalization.[101] The main objectives of the post-operative period concern early mobilization and prevention of complications.[102] Advanced age, increased frailty and impaired organ function put these patients at high risk of complications. Among the most significant are cognitive dysfunction, cardiac complications, and post-operative infections. To improve the quality of care it is necessary to standardize dedicated monitoring protocols, using appropriate rating.[103] The vulnerability of older hip fracture patients may last for several days after surgical repair. Sarcopenia and delirium are two clinical conditions that must be carefully observed. Among the screening and assessment tests to evaluate any onset of sarcopenia is the Barthel Scale, which is significantly reduced in these patients.[104]

Prevention of delirium

Delirium is one of the most common complications in older patients undergoing hip surgery. Pre-operative frailty is closely related to post-operative delirium[105] with an increased incidence in more older patients, emergency surgery procedures, longer operative time, and larger transfusion volumes.[106] Patients with post-operative delirium have significantly higher incidence of major adverse cardiac events and mortality.[107,108] Older age, polypharmacy, cognitive deficits and

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Table 2 Components of multidisciplinary rehabilitation following hip surgery in patients with frailty and/or at high risk for cardiovascular diseases or with cardiovascular diseases (adapted from Aktaa et al.[121])

Component	Suggested intervention
Patient assessment	• Cardiovascular risk or disease clinical evaluation • Multidimensional Geriatric Assessment including evaluation of comorbidities, psycho-cognitive deterioration, physical function, functional capacity, nutritional status, sarcopenia, frailty, disability, social deprivation
Physical activity counselling	• Counselling for individual activities (and degree of supervision by the caregiver) to prevent or limit disabilities • Counselling for visual and hearing impairments, comorbidities, physical limitations, and cognitive status influencing the individual program
Exercise training prescription	• Multi-component tailored exercise prescriptions designed on existing comorbidities, frailty, nutritional and cognitive conditions and on the physical capacity and activity limitation (mainly based on grade of recovery after hip surgery) • See Supplementary material online, *Table 1*: Detailed Exercise Prescription • Expected outcomes: improving physical capacity and quality of life; reducing disability, frailty level, institutionalization
Diet/nutritional counselling	• Nutritional supplementation (high quality proteins) to be combined with strength and endurance exercise
Weight control management	• Efforts need to be done to improve sarcopenia rather than reduce body mass index, especially in patients at higher risk of cardiac cachexia
Psychosocial management	• Transition of care to long-term geriatric centres should be evaluated and managed individually
Lipid management	• It is advisable to identify individual benefit from lipid lowering medication
Blood pressure monitoring	• Decision to treat hypertension must consider the patient's clinical status, polypharmacy, and frailty.
Medication Adherence	• Confirm adherence and adjust dosage, if necessary, of medication for cardiovascular risk factors and cardiovascular disease, pain drugs, anticoagulants and others

dementia, dehydration, infections, severity of clinical condition, end of life, visual-auditory deficits, constipation, or urinary retention are among the main causes of delirium manifestations.[109] In older patients undergoing hip surgery, pre-operative cognitive impairment, morphine using, living in an institution, heart failure, total hip arthroplasty, multiple comorbidities and advanced age were more likely to sustain delirium after surgery.[110]

Some of the most effective strategies in the early management and diagnosis of these patients are screening[111,112] on a daily schedule using validated diagnostic tools, extending visitation periods by relatives and friends,[113] and a multi-component intervention that has been shown to reduce the incidence of delirium by 40% compared with standard care,[114] being particularly effective in post-orthopaedic or abdominal surgery.[115] The key elements of a multi-component approach are shown in *Table 1*.

Rehabilitation

A structured rehabilitation intervention is often needed in people undergoing surgically treated hip fracture, with the aim to restore mobility and independence in basic functions of daily living as far as to treat complications and medical problems after surgery. For this purpose, a team with expertise on different areas (led by a doctor and including nurses, physiotherapists, dieticians, social workers and mental health specialists) develops an individual plan to be executed in a residential and/or ambulatory setting. This 'multidisciplinary rehabilitation', as compared with usual care (orthopaedic or medical only), results in fewer cases of 'poor outcome' (death or deterioration in residential status) in the short-term, with low-certainty evidence for reduction of mortality and poorer mobility in the medium-term (12 months).[116]

It is advisable to consider CVD and frailty in a modern rehabilitation program after hip surgery, in view of their role in influencing expected goals and measured outcomes. Older patients with CVD and other comorbidities are not precluded from completing rehabilitation, with the main predictor of functional recovery being pre-operative functional status.[117–121] The components to be advised in an integrated rehabilitation model are summarized in *Table 2*.

Role of the care-givers

The family members and/or cares support the patient's care pathway. After returning home, particular attention regarding CVDs may be focused on possible occurrence, or worsening of symptoms related to atrial fibrillation, heart failure decompensation and hypotension which may lead to new falls. Care-givers and patients may be involved in the home management of the above-mentioned diseases, and potential digital-health technology interventions may be established.[72] As the degree of frailty changes over time, the patients need more intense support for frailty soon after discharge, and environmental support and care should be implemented according to the general management of frailty in cardiology.[2]

Prevention and management of thrombotic complications

Management of patients on antithrombotic therapy

Besides the surgery-related risk, the comorbidities are the major determinants of the peri-operative thrombotic and bleeding risk. Antithrombotic pretreatment due to underlying CVD is common in older patients scheduled for hip surgery.[122] Older patients (≥70 years) undergoing joint arthroplasty surgery are at higher risk for peri-operative bleeding events requiring blood transfusion.[123] The enhanced risk of bleeding in patients pre-treated with antiplatelet

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therapy undergoing early hip fracture surgery must be weighed against the benefits in length of hospitalization and mortality.[124] It is advisable not to delay urgent hip surgery and to reduce the risk of peri-operative bleeding with blood pressure control and gastroprotection. It is safe to interrupt P2Y12 inhibitor treatment after one/three months from elective or urgent PCIs.[7] In the case of elective hip surgery, procedure should be deferred beyond this time period. Aspirin should be continued in the peri-operative period due to proven benefits.[7,125] Some older patients might be on a P2Y12 inhibitor-monotherapy due to post-PCIs de-escalation strategy or receive clopidogrel as an alternative to aspirin as secondary prevention strategy. Despite the relative lack of evidence about peri-operative management of antiplatelet therapy, we advise to continue single antiplatelet therapy in patients undergoing hip fracture surgery without life-threatening bleeding.

In patients on non-vitamin-K oral anticoagulant (NOAC) due to atrial fibrillation or a history of venous thromboembolism (VTE), we refer to the 2022 ESC guidelines on cardiovascular assessment and management of patients undergoing non-cardiac surgery.[7] Briefly, the length of interruption depends on the type of NOAC and renal function with no bridging.[7]

In patients with atrial fibrillation and a recent PCI, dual anti thrombotic therapy (NOAC + clopidogrel) is advised, in particular in the older subjects.[100,122] It is advisable to maintain antiplatelet therapy with clopidogrel during short peri-operative interruption of NOACs in the setting of time-sensitive hip surgery.

In patients with mechanical prosthetic valves on vitamin-K antagonists, we refer to the 2022 ESC guidelines on cardiovascular assessment and management of patients undergoing non-cardiac surgery.[7] In those patients with a low risk of thromboembolism (e.g. mechanical bi-leaflet aortic valve in patients with sinus rhythm), bridging may not be needed. On the other side, in those patients with mechanical prosthetic valves with a high risk of thromboembolism (e.g. mechanical aortic valve replacement with any thromboembolic risk factor; an older-generation mechanical aortic valve; a mechanical mitral or tricuspid valve), bridging with heparin should be considered during the peri-operative time interval.[7] There are no severe post-operative bleeding events/need for re-operation for haematoma in hip fracture patients with international normalized ratio (INR) values between 1.5 and 3.0.[126,127] Therefore, it seems reasonable to keep the INR at the lower end of the therapeutic window (e.g. ~2.0) in mechanical prosthetic valves patients undergoing hip surgery without high bleeding risk (see *Box 4*).

Box 4 Clinical consensus statement—main messages on anti-thrombotic management

- Unnecessary delay for time sensitive hip surgery should be avoided and ongoing treatments with antiplatelet agents should not delay surgery.
- Defer elective hip surgery to 1 month after elective percutaneous coronary intervention and 3 months after acute coronary syndrome to safely interrupt P2Y12 inhibitor treatment.
- Continue peri-operative single antiplatelet therapy in patients with prior percutaneous coronary intervention without excessive peri-operative bleeding risk.
- Interrupt NOAC treatment depending on NOAC type and renal function according to general guidelines.
- Interdisciplinary judgement (i.e. surgeons and cardiologist) about peri-operative interruption and post-operative continuation of antithrombotic therapy in patients at high risk of bleeding and/or high risk for thrombotic events.
- Thromboprophylaxis with NOACs or low molecular weight heparin according to risk up to 35 days.
- Careful prescription of post-operative venous thromboembolism prophylaxis, as early as possible, post-operative mobilization and short hospitalization are essential in limiting the risk.

Thromboprophylaxis in hip surgery

VTE after hip surgery is underestimated (about 1.5% at 3 months despite optimal thromboprophylaxis protocols).[128] During hospitalization, supportive measurements including mechanical prophylaxis (e.g. intermittent compression), patient care programs including post-operative mobilization, and patient training about the use of thromboprophylaxis are essential to reduce VTE risk.[7,129,130] NOACs, compared with low molecular weight heparins, have shown similar efficacy and safety after major orthopedic surgery.[131] However, additional data on older patients are needed. It is advisable that the duration of thromboprophylaxis after hip arthroplasty could be 35 days.[132–135] There is consensus that aspirin should not be used as initial VTE prophylaxis in patients undergoing total hip arthroplasty (see *Box 4*).[136]

Management of post-operative VTE/ pulmonary embolism after hip surgery

Role of post-operative monitoring

No consensus exists regarding the diagnostic approach of VTE in older patients with hip fractures. The usual tools (clinical presentation, D-dimer) are of limited value in this setting. Compression Ultrasound Scanning represents the main initial technique to detect deep vein thrombosis at the asymptomatic stage. In patients suspected of pulmonary embolism with haemodynamic instability, according to the 2019 ESC Guidelines for the diagnosis and management of acute pulmonary embolism, computerized tomography scan is indicated as well as a monitoring of right ventricular function to discuss an aggressive therapy.[137]

Thrombolysis/catheter-directed thrombolysis/inferior vena cava filters

There is a lack of evidence regarding thrombolytic therapy in patients with post-operative deep vein thrombosis/pulmonary embolism, since fracture or recent major surgery is considered contraindication in thrombolytic trials. Indeed, thrombolytic treatment is associated with a significantly increased risk of major bleeding particularly in older patients.[138] According to the 2019 ESC Guidelines for the diagnosis and management of acute pulmonary embolism, surgical embolectomy should be considered in patients on anticoagulation with massive pulmonary embolism and haemodynamic deterioration[137] and the use of an inferior vena cava filter should be considered for patients with deep vein thrombosis in whom anticoagulation is contraindicated or in case of pulmonary embolism recurrence despite anticoagulation.

Long-term anticoagulation

It is recommended to assess the patient's bleeding risk[139] to identify and treat modifiable bleeding risk factors and to individualize the duration and regimen/dose of anticoagulant treatment according to the 2019 ESC Guidelines for the diagnosis and management of acute pulmonary embolism.[137] In most of the cases, considering the high peri-operative mortality

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of VTE (17%),[140] it is advisable to initiate anticoagulation as early as possible.[141] In the absence of strong randomized controlled studies, it seems reasonable to start the initial phase of treatment (up to 10 days) with low molecular weight heparins.[141] For the subsequent three months, oral anticoagulants might be proposed, preference given to NOACs[142] (see *Box 4*).

Conclusion

A coordinated multidisciplinary approach could help in the process of care of older patients in the 'hip surgery pathway'. Specific clinical studies on older adults aimed at optimizing their management during a stressful health event such as hospitalization for orthopedic surgery are often lacking. The proposed approach (diagnostic, peri-operative, and rehabilitative interventions) includes management of specific needs that lead to an increased degree of awareness of frailty during this potentially life-transition event. Health status may be acutely challenged by cardiovascular complications or by worsening of previous CVDs in complex older patients undergoing hip surgery. This structured approach could help older adults to avoid health deterioration and loss of independence, which often complicate hip surgery.

Supplementary material

Supplementary material is available at *European Journal of Preventive Cardiology*.

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Author contribution

L.G. and S.F. gave the main contribution to the conception and design of the consensus. In particular, R.A., R.C., D.R., V.A., and L.C. focused on the diseases associated with falls; J.A., S.G., and P.S. contributed to the operative care; A.A., M.A., and M.B. contributed to the rehabilitation phase; T.G. and M.F. contributed to the thromboembolic diseases management. All the authors critically revised the manuscript for important concepts. All gave final approval and agree to be accountable for all aspects of work ensuring integrity and accuracy.

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