2022 ESC Guidelines on cardiovascular assessment and management of patients undergoing non-cardiac surgery

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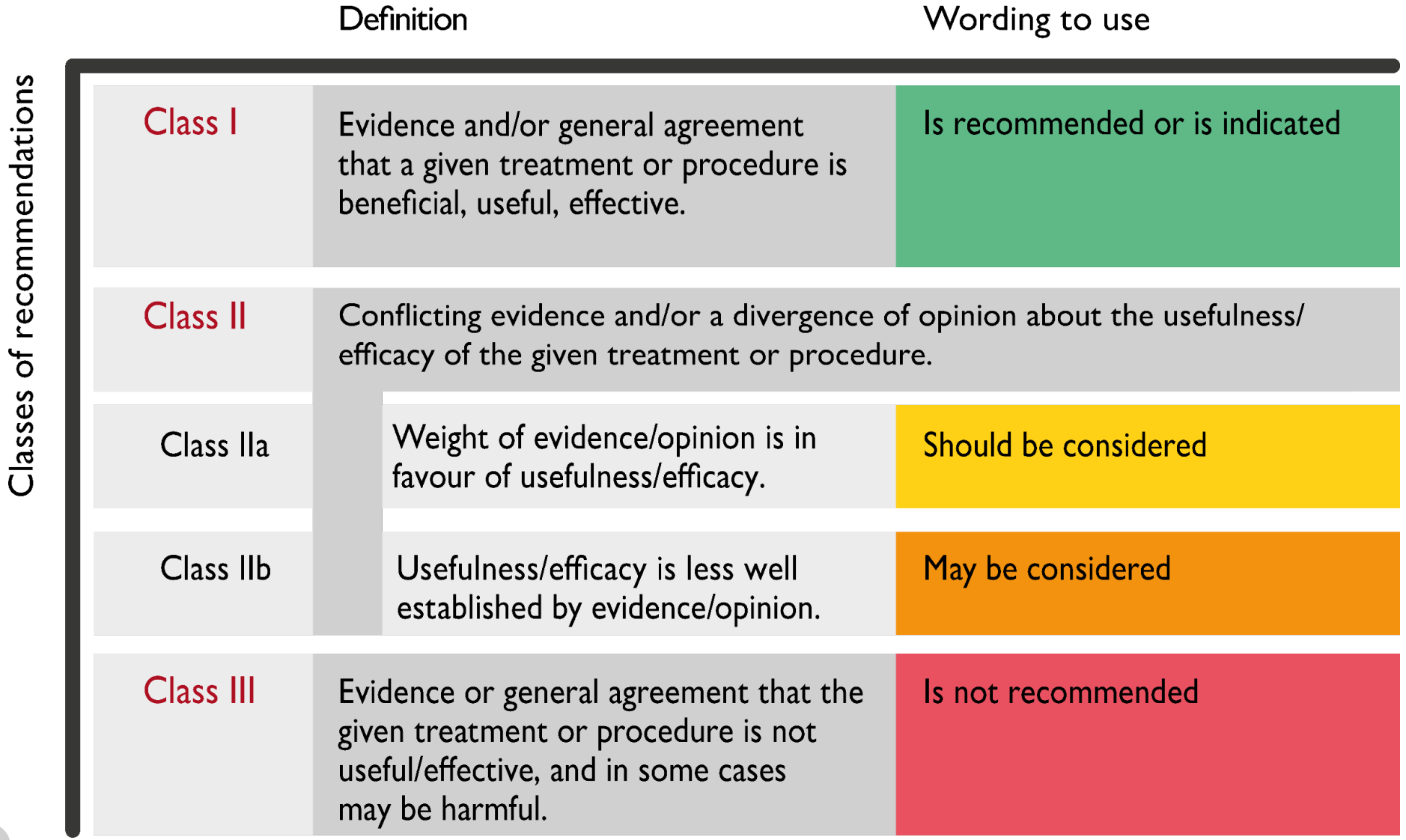
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ESC subspecialty communities having participated in the development of this document:

Associations: Association for Acute CardioVascular Care (ACVC), Association of Cardiovascular Nursing & Allied Professions (ACNAP), European Association of Cardiovascular Imaging (EACVI), European Association of Percutaneous Cardiovascular Interventions (EAPCI), European Heart Rhythm Association (EHRA), Heart Failure Association (HFA).
Councils: Council of Cardio-Oncology, Council on Valvular Heart Disease.
Working Groups: Adult Congenital Heart Disease, Aorta and Peripheral Vascular Diseases, Cardiovascular Pharmacotherapy, Cardiovascular Surgery, Thrombosis.
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ESC Classes of recommendations



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Level of evidence A	Data derived from multiple randomized clinical trials or meta-analyses.
Level of evidence B	Data derived from a single randomized clinical trial or large non-randomized studies.
Level of evidence C	Consensus of opinion of the experts and/or small studies, retrospective studies, registries.

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What is new (1)

Recommendations	Class
Clinical risk evaluation — Patients scheduled for non-cardiac surgery	
In all patients scheduled for NCS, an accurate history, and clinical examination are recommended.	I
It is recommended to perform a pre-operative risk assessment, ideally at the same time as the NCS is proposed.	I
If time allows, it is recommended to optimize guideline-recommended treatment of CVD and CV risk factors before NCS.	I
Endovascular or video-assisted procedures should be considered for patients with high CV risk undergoing vascular or pulmonary surgery.	IIa

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What is new (2)

Recommendations	Class
Clinical risk evaluation — Patients <65 years without signs, symptoms, or history of CVD	
In patients with a family history of genetic cardiomyopathy, it is recommended to perform an ECG and TTE before NCS regardless of age and symptoms.	I
In patients 45–65 years of age without signs, symptoms, or history of CVD, ECG, and biomarkers should be considered before high-risk NCS.	IIa

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What is new (3)

Recommendations	Class
Clinical risk evaluation — Pre-operative assessment in patients with a newly detected murmur, chest pain, dyspnoea, or peripheral oedema	
In patients with a newly detected murmur *and* symptoms or signs of CVD, TTE is recommended before NCS.	I
In patients with a newly detected murmur suggesting clinically significant pathology, TTE is recommended before high-risk NCS.	I
In patients with a newly detected murmur, but without other signs or symptoms of CVD, TTE should be considered before moderate and high-risk NCS.	IIa
If a patient scheduled for elective NCS has chest pain or other symptoms suggestive of undetected CAD, further diagnostic work-up before NCS is recommended.	I

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What is new (4)

Recommendations	Class
Clinical risk evaluation — Pre-operative assessment in patients with a newly detected murmur, chest pain, dyspnoea, or peripheral oedema (continued)	
If a patient in need of acute NCS also has chest pain or other symptoms suggestive of undetected CAD, a multidisciplinary assessment approach is recommended to choose the treatment with lowest total risk for the patient.	I
In patients with dyspnoea and/or peripheral oedema, an ECG and an NT-proBNP/BNP test is indicated before NCS, unless there is a certain non-cardiac explanation.	I
In patients with dyspnoea and/or peripheral oedema and elevated NT-proBNP/BNP, TTE is recommended before NCS.	I

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What is new (5)

Recommendations	Class
Clinical risk evaluation — Patient information	
It is recommended to give patients individualized instructions for pre-operative and post-operative changes in medication, in verbal and written formats with clear and concise directions.	I
It should be considered to set up a structured information list (e.g. a check list to help with common issues) for patients with CVD or at high risk of CV complications scheduled for NCS.	IIa

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What is new (6)

Recommendations	Class
Preoperative assessment tools — Frailty and physical capacity	
In patients ≥70 years old, being scheduled to undergo intermediate- or high-risk NCS, frailty screening should be considered using a validated screening tool.	IIa
Adjusting risk assessments according to self-reported ability to climb two flights of stairs should be considered in patients referred for intermediate- or high-risk NCS.	IIa
Preoperative assessment tools — Transthoracic echocardiography	
TTE is recommended in patients with poor functional capacity and/or high NT-proBNP/BNP, or, if murmurs are detected before high-risk NCS, in order to undertake risk-reduction strategies.	I
TTE should be considered in patients with suspected new CVD or unexplained signs or symptoms before high-risk NCS.	IIa
TTE may be considered in patients with poor functional capacity, abnormal ECG, high NT-proBNP/BNP, or ≥1 clinical risk factor before intermediate-risk NCS.	IIb
To avoid delaying surgery, a FOCUS exam performed by trained specialists may be considered as an alternative to TTE for pre-operative triage.	IIb

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What is new (7)

Recommendations	Class
Preoperative assessment tools — Stress imaging	
Stress imaging should be considered before high-risk NCS in asymptomatic patients with poor functional capacity, and prior PCI or CABG.	IIa
Preoperative assessment tools — Coronary angiography	
CCTA should be considered to rule out CAD in patients with suspected CCS or biomarker-negative NSTE-ACS in case of low-to-intermediate clinical likelihood of CAD, or in patients not suitable for non-invasive functional testing undergoing non-urgent, intermediate-, and high-risk NCS.	IIa

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What is new (8)

Recommendations	Class
General risk-reduction strategies — Cardiovascular risk factors and lifestyle interventions	
Smoking cessation more than 4 weeks before NCS is recommended to reduce post-operative complications and mortality.	I
Control of CV risk factors, including blood pressure, dyslipidaemia, and diabetes, is recommended before NCS.	I
General risk-reduction strategies — Pharmacological treatment	
For patients on diuretics to treat hypertension, transient discontinuation of diuretics on day of NCS should be considered.	IIa
It should be considered to interrupt SGLT-2 inhibitor therapy for at least 3 days before intermediate- and high-risk NCS.	IIa

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What is new (9)

Recommendations	Class
General risk-reduction strategies — Antiplatelets	
For patients undergoing high bleeding risk surgery (e.g. intracranial, spinal neurosurgery, or vitroretinal eye surgery), it is recommended to interrupt aspirin for at least 7 days pre-operatively.	I
In high-risk patients with a recent PCI (e.g. STEMI patients or high-risk NSTE-ACS patients), a DAPT duration of at least 3 months should be considered before time-sensitive NCS.	IIa
General risk-reduction strategies — Anticoagulants	
When an urgent surgical intervention is required, it is recommended that NOAC therapy is immediately interrupted.	I
In non-minor bleeding risk procedures in patients using a NOAC, it is recommended to use an interruption regimen based on the NOAC compound, renal function, and bleeding risk.	I

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What is new (10)

Recommendations	Class
General risk-reduction strategies — Anticoagulants (continued)	
In minor bleeding risk surgery and other procedures where bleeding can be easily controlled, it is recommended to perform surgery without interruption of OAC therapy.	I
In patients using NOACs, it is recommended that minor bleeding risk procedures are performed at trough levels (typically 12–24 h after last intake).	I
LMWH is recommended, as an alternative to UFH, for bridging in patients with MHVs and high surgical risk.	I
For patients with mechanical prosthetic heart valves undergoing NCS, bridging with UFH or LMWH should be considered if OAC interruption is needed and patients have: (i) mechanical AVR and any thromboembolic risk factor; (ii) old-generation mechanical AVR; or (iii) mechanical mitral or tricuspidal valve replacement.	IIa
Idarucizumab should be considered in patients on dabigatran and requiring urgent surgical intervention with intermediate to high bleeding risk.	IIa

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What is new (11)

Recommendations	Class
General risk-reduction strategies — Anticoagulants (continued)	
For interventions with a very high risk of bleeding, such as spinal or epidural anaesthesia, interruption of NOACs for up to five half-lives and re-initiation after 24 h should be considered.	**IIa**
When specific reversal agents are not available, PCC or activated PCC should be considered for reversing NOAC effects.	**IIa**
If an urgent surgical intervention is required, specific coagulation tests and assessment of NOAC plasma levels should be considered to interpret routine coagulation tests and waning of anticoagulant effect.	**IIa**

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What is new (12)

Recommendations	Class
General risk-reduction strategies — Anticoagulants (continued)	
If bleeding risk with resumption of full-dose anticoagulation outweighs the risk of thromboembolic events, postponing therapeutic anticoagulation 48–72 h after the procedure may be considered, using post-operative thromboprophylaxis until resumption of full OAC dose is deemed safe.	IIb
Bridging of OAC therapy is not recommended in patients with low/moderate thrombotic risk undergoing NCS.	III
Use of reduced-dose NOAC to attenuate the risk of post-operative bleeding is not recommended.	III

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What is new (13)

Recommendations	Class
General risk-reduction strategies — Thromboprophylaxis	
It is recommended that decisions about peri-operative thromboprophylaxis in NCS are based on individual and procedure-specific risk factors.	I
If thromboprophylaxis is deemed necessary, it is recommended to choose the type and duration of thromboprophylaxis (LMWH, NOAC, or fondaparinux) according to type of NCS, duration of immobilization, and patient-related factors.	I
In patients with a low bleeding risk, peri-operative thromboprophylaxis should be considered for a duration of up to 14 or 35 days, for total knee or hip arthroplasty, respectively.	IIa
NOACs in thromboprophylaxis dose may be considered as alternative treatments to LMWH after total knee and hip arthroplasty.	IIb

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What is new (14)

Recommendations	Class
General risk-reduction strategies — Patient blood management	
It is recommended to measure haemoglobin pre-operatively in patients scheduled for intermediate- to high-risk NCS.	I
It is recommended to treat anaemia in advance of NCS in order to reduce the need for RBC transfusion during NCS.	I
In patients undergoing surgery with expected blood loss of ≥500 mL, use of washed cell salvage is recommended.	I
It is recommended to use point-of-care diagnostics for guidance of blood component therapy, when available.	I

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What is new (15)

Recommendations	Class
General risk-reduction strategies — Patient blood management (continued)	
The use of an algorithm to diagnose and treat anaemic patients before NCS should be considered.	**IIa**
In patients undergoing NCS and experiencing major bleeding, administration of tranexamic acid should be considered immediately.	**IIa**
Use of closed-loop arterial blood sampling systems should be considered to avoid blood loss.	**IIa**
Application of meticulous haemostasis should be considered a routine procedure.	**IIa**
A feedback/monitoring programme or clinical decision support system should be considered to be assessed before blood transfusion.	**IIa**
Before allogenic blood transfusion, it should be considered to obtain an extensive consent about risks associated with transfusion.	**IIa**

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What is new (16)

Recommendations	Class
Specific diseases — Coronary artery disease	
Pre-operative evaluation of patients with an indication for PCI by an expert team (surgeon and cardiologist) should be considered before elective NCS.	IIa
Specific diseases — Heart failure	
In patients with HF undergoing NCS, it is recommended to regularly assess volume status and signs of organ perfusion.	I
A multidisciplinary team including VAD specialists is recommended for peri-operative management of patients with HF receiving mechanical circulatory support.	I

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What is new (17)

Recommendations	Class
Specific diseases — Valvular heart disease	
In patients with symptomatic severe AR or asymptomatic severe AR and LVESD >50 mm or LVESDi (LVESD/BSA) >25 mm/m^2 (in patients with small body size) or resting LVEF ≤50%, valve surgery is recommended prior to elective intermediate- or high-risk NCS.	I
In patients with moderate-to-severe rheumatic MS and symptoms or SPAP >50 mmHg, valve intervention (percutaneous mitral commissurotomy or surgery) is recommended before elective intermediate- or high-risk NCS.	I
In asymptomatic patients with severe AS who are scheduled for elective high-risk NCS, AVR (SAVR or TAVI) should be considered after Heart Team discussion.	IIa

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What is new (18)

Recommendations	Class
Specific diseases — Valvular heart disease (continued)	
In patients with symptomatic severe primary MR or asymptomatic severe primary MR with LV dysfunction (LVESD ≥40 mm and/or LVEF ≤60%), valve intervention (surgical or transcatheter) should be considered prior to intermediate- or high-risk NCS, if time allows.	**IIa**
In patients with severe secondary MR who remain symptomatic despite guideline-directed medical therapy (including CRT if indicated), valve intervention (transcatheter or surgical) should be considered before NCS, in eligible patients with an acceptable procedural risk.	**IIa**
In patients with severe symptomatic AS in need of time-sensitive NCS or in whom the TAVI and SAVR are not feasible, BAV may be considered before NCS as a bridge to definitive aortic valve repair.	**IIb**

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What is new (19)

Recommendations	Class
Specific diseases — Arrhythmias	
In AF patients with acute or worsening haemodynamic instability undergoing NCS, emergency electrical cardioversion is recommended.	I
In patients with symptomatic, monomorphic, sustained VT associated with myocardial scar, recurring despite optimal medical therapy, ablation of arrhythmia is recommended before elective NCS.	I
It is recommended that all patients with CIEDs which are reprogrammed before surgery, have a re-check and necessary reprogramming as soon as possible after the procedure.	I

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What is new (20)

Recommendations	Class
Specific diseases — Arrhythmias (continued)	
If indications for pacing exist according to the 2021 ESC Guidelines on cardiac pacing and cardiac resynchronization therapy, NCS surgery should be deferred and implantation of a permanent pacemaker should be considered.	**IIa**
Ablation should be considered in symptomatic patients with recurrent or persistent SVT despite treatment, prior to high-risk, non-urgent NCS.	**IIa**
In high-risk CIED patients (e.g with ICD or being pacing-dependant) undergoing NCS carrying a high probability of electromagnetic interference (e.g. involving unipolar electrosurgery above the umbilical area), CIED check-up and necessary reprogramming immediately before the procedure should be considered.	**IIa**

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What is new (21)

Recommendations	Class
Specific diseases — Adult congenital heart disease	
In patients with ACHD, a consultation by an ACHD specialist is recommended before intermediate- or high-risk surgery.	I
In patients with ACHD, it is recommended that intermediate- and high-risk elective surgery is performed in a centre with experience in the care of ACHD patients.	I
Specific diseases — Pericardial diseases	
In patients with acute pericarditis, deferring elective NCS until complete resolution of the underlying process should be considered.	IIa
Avoiding elective NCS procedures under general anaesthesia until colchicine or the immunosuppressive treatment course for pericardial disease is completed may be considered.	IIb

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What is new (22)

Recommendations	Class
Specific diseases — Pulmonary arterial hypertension	
Inodilator drugs (dobutamine, milrinone, levosimendan), which increase cardiac output and lower pulmonary vascular resistance, should be considered peri-operatively according to the haemodynamic status of the patient.	IIa
Specific diseases — Peripheral artery disease and/or abdominal aortic aneurysm	
Routine referral for cardiac work-up, coronary angiography, or CPET prior to elective surgery for PAD or AAA is not recommended.	III

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What is new (23)

Recommendations	Class
Specific diseases — Renal disease	
In patients with known risk factors (age >65 years, BMI >30 kg/m^2, diabetes, hypertension, hyperlipidaemia, CV disease or smoking) undergoing intermediate- or high-risk NCS, it is recommended to screen for pre-operative renal disease measuring serum creatinine and GFR.	I
In patients with renal disease requiring peri-operative contrast-enhanced radiography, a balanced hydration with i.v. isotonic fluids, the use of a minimal volume of contrast media and the use of a minimal volume of contrast media and the use of low-osmolar or iso-osmolar contrast media should be considered.	IIa
If a cystatin C measurement assay is available, cystatin C measurement should be considered in patients with impaired eGFR (<45–59 mL/min/1.73 m^2) to confirm kidney disease.	IIa

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What is new (24)

Recommendations	Class
Specific diseases — Obesity	
It is recommended to assess cardiorespiratory fitness to estimate peri-operative CV risk in the obese patient, with particular attention to those undergoing intermediate- and high-risk NCS.	I
In patients at high risk of obesity hypoventilation syndrome, additional specialist investigation before major elective NCS should be considered.	IIa
Specific diseases — Diabetes mellitus	
A pre-operative assessment for concomitant cardiac conditions is recommended in patients with diabetes with suspected or known CAD and those with autonomic neuropathy, retinopathy, or renal disease and scheduled to undergo intermediate- or high-risk NCS.	I
Peri-operative monitoring and anaesthesia	
It is recommended to avoid post-operative acute pain.	I

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What is new (25)

Recommendations	Class
Perioperative cardiovascular complications	
It is recommended to have high awareness for peri-operative CV complications combined with surveillance for PMI in patients undergoing intermediate- or high-risk NCS.	I
Systematic PMI work-up is recommended to identify the underlying pathophysiology and to define therapy.	I
It is recommended to treat post-operative STEMI, NSTE-ACS, acute HF, and tachyarrhythmias in accordance with guidelines for the non-surgical setting, after interdisciplinary discussion with the surgeon about bleeding risk.	I
In patients with post-operative PE of high or intermediate clinical probability, initiation of anticoagulation is recommended without delay, while diagnostic work-up is in progress, if bleeding risk is low.	I

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What is new (26)

Recommendations	Class
Perioperative cardiovascular complications (continued)	
Post-operative oral anticoagulation for PE is recommended to be administered for a period of at least 3 months.	I
In patients with a post-operative indication for OAC, NOACs are generally recommended over VKA.	I
In patients with post-operative AF after NCS, long-term OAC therapy should be considered in all patients at risk for stroke, considering the anticipated net clinical benefit of OAC therapy, as well as informed patient preferences.	IIa
In patients with MINS and at low risk of bleeding, treatment with dabigatran 110 mg orally twice daily may be considered from about 1 week after NCS.	IIb
Routine use of beta-blocker for the prevention of post-operative AF in patients undergoing NCS is not recommended.	III

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What is new (27)

2014 Guidelines	Class	2022 Guidelines	Class
Preoperative assessment tools — Electrocardiography and biomarkers			
Pre-operative ECG is recommended for patients who have risk factor(s)d and are scheduled for intermediate- or high-risk surgery.	I	In patients who have known CVD or CV risk factors (including age ≥65 years), or symptoms or signs suggestive of CVD, it is recommended to obtain a pre-operative 12-lead ECG before intermediate- and high-risk NCS.	I
Assessment of cardiac troponins in high-risk patients, both before and 48–72 hours after major surgery, may be considered.	IIb	In patients who have known CVD, CV risk factors (including age ≥65 years), or symptoms suggestive of CVD, it is recommended to measure hs-cTn T and hs-cTn I before intermediate- and high-risk NCS, and at 24 h, and 48 h afterwards.	I

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What is new (28)

2014 Guidelines	Class	2022 Guidelines	Class
Preoperative assessment tools — Electrocardiography and biomarkers (continued)			
NT-proBNP and BNP measurements may be considered for obtaining independent prognostic information for peri- operative and late cardiac events in high-risk patients.	IIb	In patients who have known CVD, CV risk factors (including age ≥65 years), or symptoms suggestive of CVD, it should be considered to measure BNP or NT-proBNP before intermediate- and high-risk NCS.	IIa
Universal pre-operative routine biomarker sampling for risk stratification and to prevent cardiac events is not recommended.	III	In low-risk patients undergoing low- and intermediate-risk NCS, it is not recommended to routinely obtain pre-operative ECG, hs-cTn T/I, or BNP/NT-proBNP concentrations.	III

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What is new (29)

2014 Guidelines	Class	2022 Guidelines	Class
Preoperative assessment tools — Coronary angiography			
Pre-operative ICA is not recommended in cardiac-stable patients undergoing low-risk surgery.	III	Routine pre-operative ICA is not recommended in stable CCS patients undergoing low- or intermediate-risk NCS.	III
General risk-reduction strategies — Pharmacological treatment			
Transient discontinuation of ACEIs or ARBs before non-cardiac surgery in hypertensive patients should be considered.	IIa	In patients without HF, withholding RAAS inhibitors on the day of NCS should be considered to prevent peri-operative hypotension.	IIa

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What is new (30)

2014 Guidelines	Class	2022 Guidelines	Class
General risk-reduction strategies — Antiplatelets			
Consideration should be given to performing non-urgent, non-cardiac surgery in patients who have had recent DES implantation no sooner than 12 months following the intervention. This delay may be reduced to 6 months for the new- generation DES.	IIa	It is recommended to delay elective NCS until 6 months after elective PCI and 12 months after an ACS, respectively.	I
It is recommended that aspirin be continued for 4 weeks after BMS implantation and for 3–12 months after DES implantation, unless the risk of life-threatening surgical bleeding on aspirin is unacceptably high.	I	After elective PCI, it is recommended to delay time-sensitive NCS until a minimum of 1 month of DAPT treatment has been given.	I

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What is new (31)

2014 Guidelines	Class	2022 Guidelines	Class
General risk-reduction strategies — Antiplatelets (continued)			
Continuation of aspirin, in patients previously thus treated, may be considered in the peri-operative period, and should be based on an individual decision that depends on the peri-operative bleeding risk, weighed against the risk of thrombotic complications.	**IIb**	In patients with a prior PCI, it is recommended to continue aspirin peri-operatively if the bleeding risk allows.	**I**
Discontinuation of aspirin therapy, in patients previously treated with it, should be considered in those in whom haemostasis is anticipated to be difficult to control during surgery.	**IIa**	In patients without a history of PCI, interruption of aspirin at least 3 days before NCS may be considered if the bleeding risk outweighs the ischaemic risk, to reduce the risk of bleeding.	**IIb**

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What is new (32)

2014 Guidelines	Class	2022 Guidelines	Class
General risk-reduction strategies — Antiplatelets (continued)			
In patients treated with $P2Y_{12}$ inhibitors, who need to undergo surgery, postponing surgery for at least 5 days after cessation of ticagrelor and clopidogrel—and for 7 days in the case of prasugrel—if clinically feasible, should be considered unless the patient is at high risk of an ischaemic event.	**IIa**	If interruption of $P2Y_{12}$ inhibitor is indicated, it is recommended to withhold ticagrelor for 3–5 days, clopidogrel for 5 days, and prasugrel for 7 days prior to NCS.	**I**

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What is new (33)

2014 Guidelines	Class	2022 Guidelines	Class
Specific diseases — Coronary artery disease			
If PCI is indicated before semi- urgent surgery, the use of new-generation DES, BMS or even balloon angioplasty is recommended.	I	If PCI is indicated before NCS, the use of new-generation DES is recommended over BMS and balloon angioplasty.	I

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What is new (34)

2014 Guidelines	Class	2022 Guidelines	Class
Specific diseases — Arrhythmias			
Patients with ICDs, whose devices have been pre-operatively deactivated, should be on continuous cardiac monitor throughout the period of deactivation. External defibrillation equipment should be readily available.	I	It is recommended that patients with temporarily deactivated ICDs have continuous ECG monitoring, and during the peri-operative period are accompanied by personnel skilled in early detection and treatment of arrhythmias. In high-risk patients (e.g. pacemaker dependant or ICD patients), or if access to torso will be difficult during the procedure, it is recommended to place transcutaneous pacing/defibrillation pads prior to NCS.	I

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What is new (35)

2014 Guidelines	Class	2022 Guidelines	Class
Specific diseases — Hypertension			
Large peri-operative fluctuations in blood pressure in hypertensive patients should be avoided.	IIa	In patients with chronic hypertension undergoing elective NCS it is recommended to avoid large peri-operative fluctuations in blood pressure, particularly hypotension, during the peri-operative period.	I
Clinicians may consider not deferring non-cardiac surgery in patients with grade 1 or 2 hypertension (systolic blood pressure <180 mm Hg; diastolic blood pressure <110 mm Hg).	IIb	It is not recommended to defer NCS in patients with stage 1 or 2 hypertension.	III

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What is new (36)

2014 Guidelines	Class	2022 Guidelines	Class
Specific diseases — Peripheral artery disease			
Patients with PAD should be clinically assessed for ischaemic heart disease and, if more than two clinical risk factors are present, they should be considered for pre-operative stress or imaging testing.	IIa	In patients with poor functional capacity or with significant risk factors or symptoms (such as moderate-to-severe angina pectoris, decompensated HF, valvular disease and significant arrhythmia), referral for cardiac work-up and optimization is recommended prior to elective surgery for PAD or AAA.	I

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What is new (37)

2014 Guidelines	Class	2022 Guidelines	Class
Specific diseases — Diabetes mellitus			
In patients at high surgical risk, clinicians should consider screening for elevated HbA1c before major surgery and improving pre-operative glucose control.	**IIa**	In patients with diabetes or disturbed glucose metabolism, a pre-operative HbA1c test is recommended, if this measurement has not been performed in the prior 3 months. In case of HbA1c ≥8.5% (≥69 mmol/mol) elective NCS should be postponed, if safe and practical.	**I**

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What is new (38)

2014 Guidelines	Class	2022 Guidelines	Class
Peri-operative monitoring and anaesthesia			
Patients with high cardiac and surgical risk should be considered for goal-directed therapy.	IIa	In order to preserve optimal CV stability, it is recommended to apply goal-directed haemodynamic therapy in patients undergoing high-risk NCS.	I
Avoiding arterial hypotension (mean arterial pressure <60 mmHg) for prolonged cumulative periods (>30 minutes) may be considered.	IIb	In order to minimize the risk of post-operative organ dysfunction, it is recommended to avoid intra-operative mean arterial pressure decrease of >20% from baseline values or below 60–70 mmHg for ≥10 min.	I

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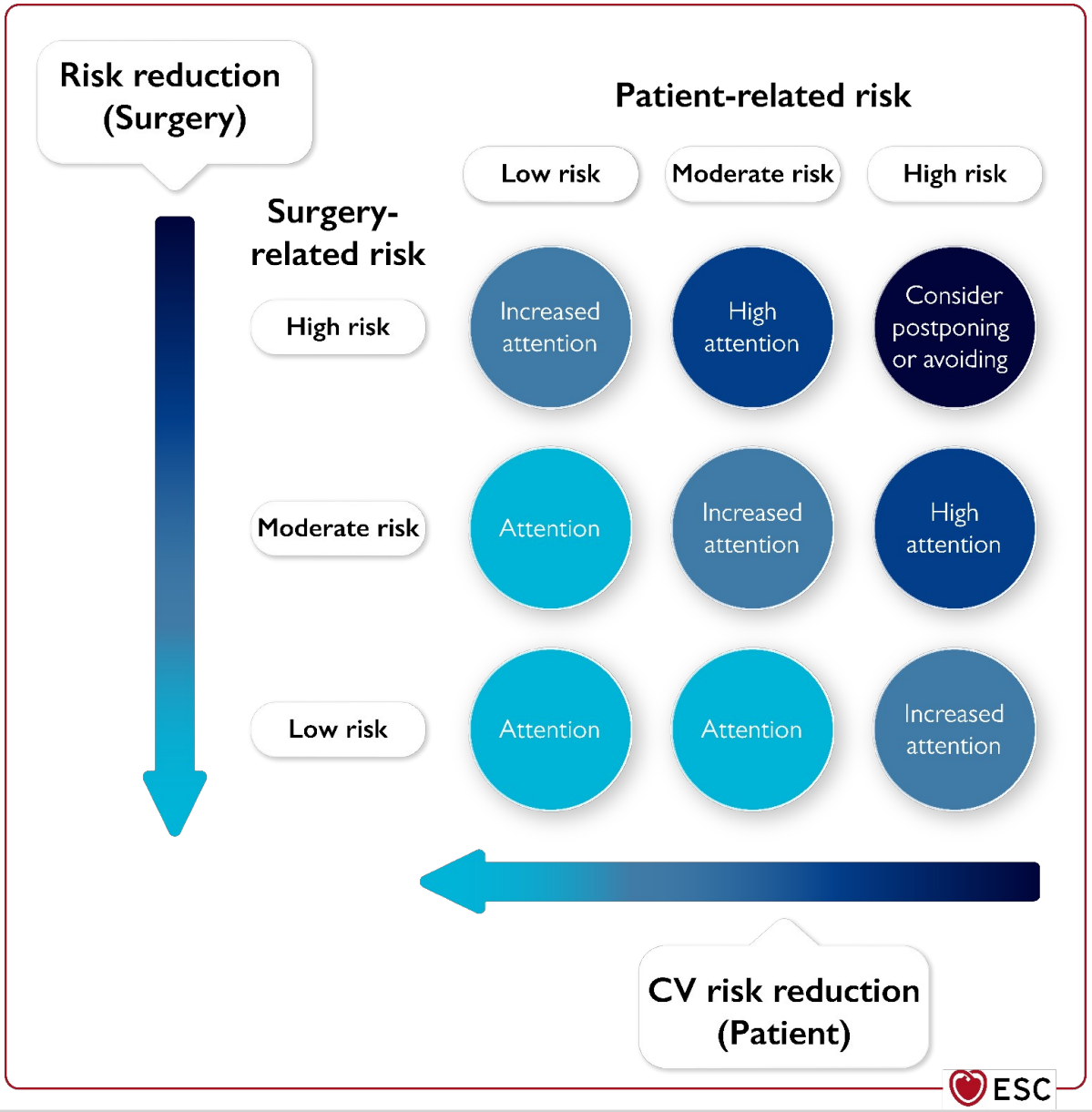
What is new (39)

2014 Guidelines	Class	2022 Guidelines	Class
Peri-operative monitoring and anaesthesia (continued)			
Avoiding non-steroidal anti-inflammatory drugs (especially cyclo-oxygenase-2 inhibitors) as the first-line analgesics in patients with IHD or stroke may be considered.	IIb	Non-aspirin NSAIDs are not recommended as first-line analgesics in patients with established or high risk of CVD.	III

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Figure 1

Total risk is an interaction of patient-related and surgery-related risk



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Surgical risk estimate according to type of surgery or intervention

Low surgical risk (<1%)	Intermediate surgical risk (1–5%)	High surgical risk (>5%)
• Breast • Dental • Endocrine: thyroid • Eye • Gynaecological: minor • Orthopaedic minor (meniscectomy) • Reconstructive • Superficial surgery • Urological minor: (transurethral resection of the prostate) • VATS minor lung resection	• Carotid asymptomatic (CEA or CAS) • Carotid symptomatic (CEA) • Endovascular aortic aneurysm repair • Head or neck surgery • Intraperitoneal: splenectomy, hiatal hernia repair, cholecystectomy • Intrathoracic: non-major • Neurological or orthopaedic: major (hip and spine surgery) • Peripheral arterial angioplasty • Renal transplants • Urological or gynaecological: major	• Adrenal resection • Aortic and major vascular surgery • Carotid symptomatic (CAS) • Duodenal-pancreatic surgery • Liver resection, bile duct surgery • Oesophagectomy • Open lower limb revascularization for acute limb ischaemia or amputation • Pneumonectomy (VATS or open surgery) • Pulmonary or liver transplant • Repair of perforated bowel • Total cystectomy

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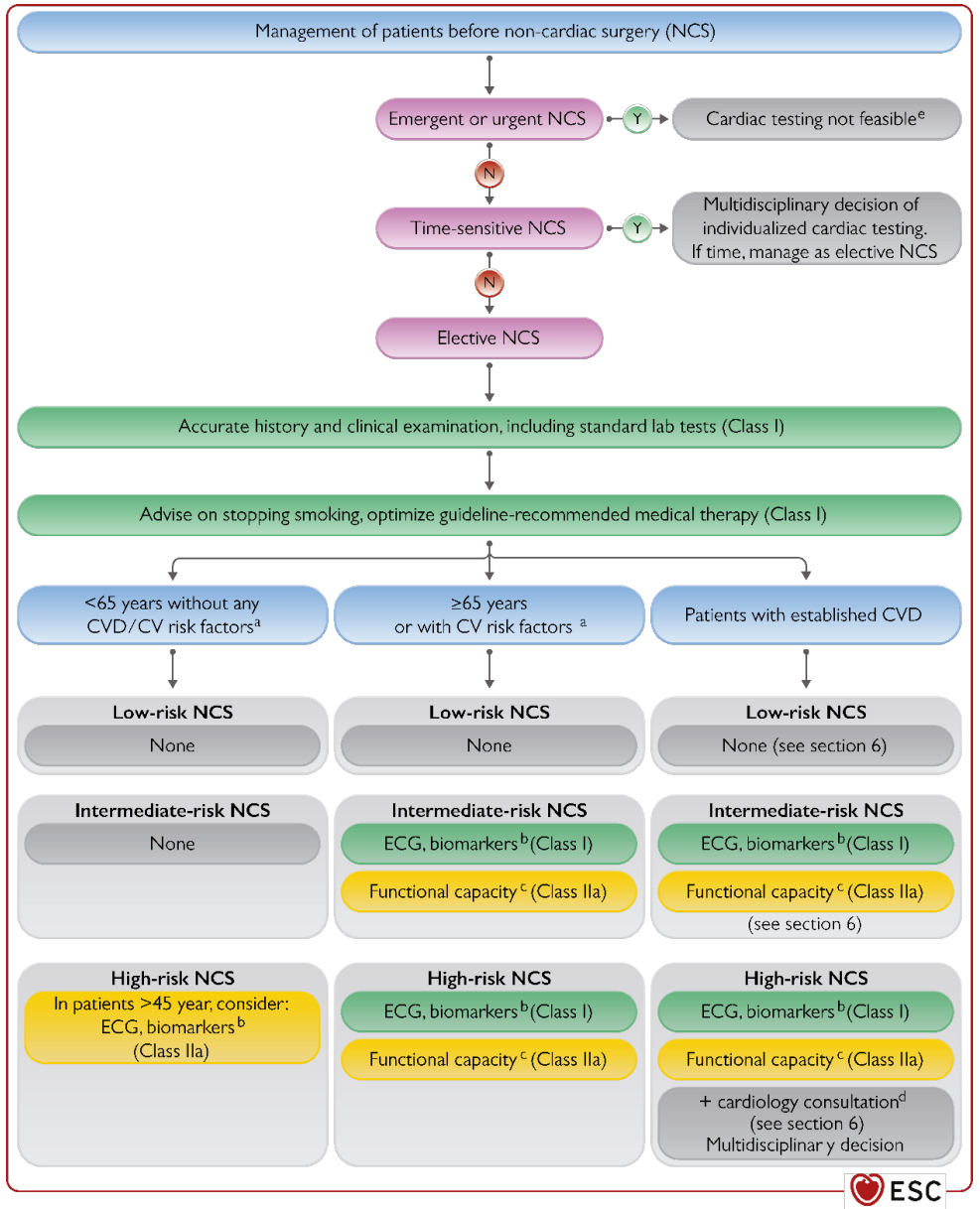
Recommendations for the selection of surgical approach and impact on risk

Recommendations	Class	Level
Endovascular or video-assisted procedures should be considered for patients with high CV risk undergoing vascular or pulmonary surgery.	IIa	B

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Figure 2

Pre-operative assessment before non-cardiac surgery



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Recommendations for all patients scheduled for non-cardiac surgery

Recommendations	Class	Level
In all patients scheduled for NCS, an accurate history, and clinical examination are recommended.	I	C
It is recommended to perform a pre-operative risk assessment, ideally at the same time as the NCS is proposed.	I	B
If time allows, it is recommended to optimize guideline-recommended treatment of CVD and CV risk factors before NCS.	I	C

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Recommendations for patients <65 years without signs, symptoms, or history of cardiovascular disease

Recommendations	Class	Level
In patients with a family history of genetic cardiomyopathy, it is recommended to perform an ECG and TTE before NCS regardless of age and symptoms.	I	C
In patients 45–65 years of age without signs, symptoms, or history of CVD, ECG, and biomarkers should be considered before high-risk NCS.	IIa	C

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Recommendations for pre-operative assessment in patients with previously unknown murmur, angina, dyspnoea, or peripheral oedema (1)

Recommendations	Class	Level
Newly detected murmur		
In patients with a newly detected murmur *and* symptoms or signs of CVD, TTE is recommended before NCS.	I	C
In patients with a newly detected murmur suggesting clinically significant pathology, TTE is recommended before high-risk NCS.	I	C
In patients with a newly detected murmur, but without other signs or symptoms of CVD, TTE should be considered before moderate and high-risk NCS.	IIa	C
Previously unknown angina		
If a patient scheduled for elective NCS has chest pain or other symptoms suggestive of undetected CAD, further diagnostic work-up before NCS is recommended.	I	C
If a patient in need of acute NCS also has chest pain or other symptoms suggestive of undetected CAD, a multidisciplinary assessment approach is recommended to choose the treatment with lowest total risk for the patient.	I	C

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Recommendations for pre-operative assessment in patients with previously unknown murmur, angina, dyspnoea, or peripheral oedema (2)

Recommendations	Class	Level
Dyspnoea and/or peripheral oedema		
In patients with dyspnoea and/or peripheral oedema, an ECG and an NT-proBNP/BNP test is indicated before NCS, unless there is a certain non-cardiac explanation.	I	C
In patients with dyspnoea and/or peripheral oedema and elevated NT-proBNP/BNP, TTE is recommended before NCS.	I	C

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Recommendations for patient information

Recommendations	Class	Level
It is recommended to give patients individualized instructions for pre-operative and post-operative changes in medication, in verbal and written formats with clear and concise directions.	I	C
It should be considered to set up a structured information list (e.g. a check list to help with common issues) for patients with CVD or at high risk of CV complications scheduled for NCS.	IIa	C

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Figure 3

Examples of questions and concerns expressed by patients

- Do I need to take any cardioprotective medication before surgery?
- Who will inform my cardiologist about my surgery?
- Do I need to pause or reduce any of my medications, and what are the risks if I do so?
- Can my heart medications cause any problems during surgery?
- Are there any interactions or contraindications between my medications and drugs given during surgery?
- Who will take care of me and how will they communicate my history and needs during my hospital stay?
- Can you give me information on how I will be monitored before, during, and after surgery?
- How will the healthcare professionals involved in my care be informed about my heart condition?



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Risk score calculators (1)

	Revised Cardiac Risk Index (RCRI) (1999)	Surgical Risk Calculator (2011)	The American College of Surgery National Surgical Quality Improvement Program (ACS NSQIP) (2013)	Surgical Outcome Risk Tool (SORT) (2014)	The American University of Beirut (AUB)-HAS2 Cardiovascular Risk Index (2019)
Variables	Ischaemic heart disease Cerebrovascular disease History of congestive heart failure Insulin therapy for diabetes Serum creatinine level ≥2 mg/dL High-risk surgery (each assigned 1 point)	Age ASA–PS grade Pre-operative dependent functional status Creatinine >1.5 mg/dL Type of surgery	Age Sex Functional status Emergency case ASA class Current steroid use Ascites within 30 days Systemic sepsis within 48h Ventilator dependence Disseminated cancer Diabetes Hypertension on treatment Congestive HF Dyspnoea Current smoker History of severe COPD Dialysis Acute renal failure Body mass index Surgery code	ASA–PS grade Urgency of surgery High-risk surgical specialty Surgical severity (from minor to complex major) Cancer Age ≥65 years or over	History of **H**eart disease Symptoms of **H**eart disease (angina or dyspnoea) **A**ge ≥75 years **A**naemia (haemoglobin <12 g/dL) Vascular **S**urgery Emergency **S**urgery (2 H, 2 A and 2 S) (each assigned 1 point)

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Risk score calculators (2)

	Revised Cardiac Risk Index (RCRI) (1999)	Surgical Risk Calculator (2011)	The American College of Surgery National Surgical Quality Improvement Program (ACS NSQIP) (2013)	Surgical Outcome Risk Tool (SORT) (2014)	The American University of Beirut (AUB)-HAS2 Cardiovascular Risk Index (2019)
Score range	Score 1; risk 6.0% (4.9–7.4) Score 2; risk 10.1% (8.1–10.6) Score ≥3; risk 15% (11.1–20.0)	Absolute risk: 0–100%	Absolute risk: 0–100%	Absolute risk: 0–100%	Low risk (score 0–1); (0.3 and 1.6%) Intermediate risk (score 2–3); (7.1 and 17%) High risk (score >3); (>17%)
Outcome	30-day MI, cardiac arrest, death	Intra-operative and 30-day MI or cardiac arrest	Serious complications and any complications at 30 days	30-day mortality	30-day death, MI, or stroke
Derivation population	1422	211 410	1 414 006	11 219	3284
Validation population	Externally validated in various surgical populations	257 385	Externally validated in various surgical populations	22 631	1 167 414
Model performance (AUC)	0.68–0.76	0.81–0.85	0.73	0.81-0.92	0.82
Interactive calculator	https://www.mdcalc.com/revised-cardiac-risk-index-pre-operative-risk	http://www.surgicalriskcalculator.com/miorcardiacarrest	https://riskcalculator.facs.org	http://www.sortsurgery.com	

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Recommendations for pre-operative assessment of frailty and physical capacity

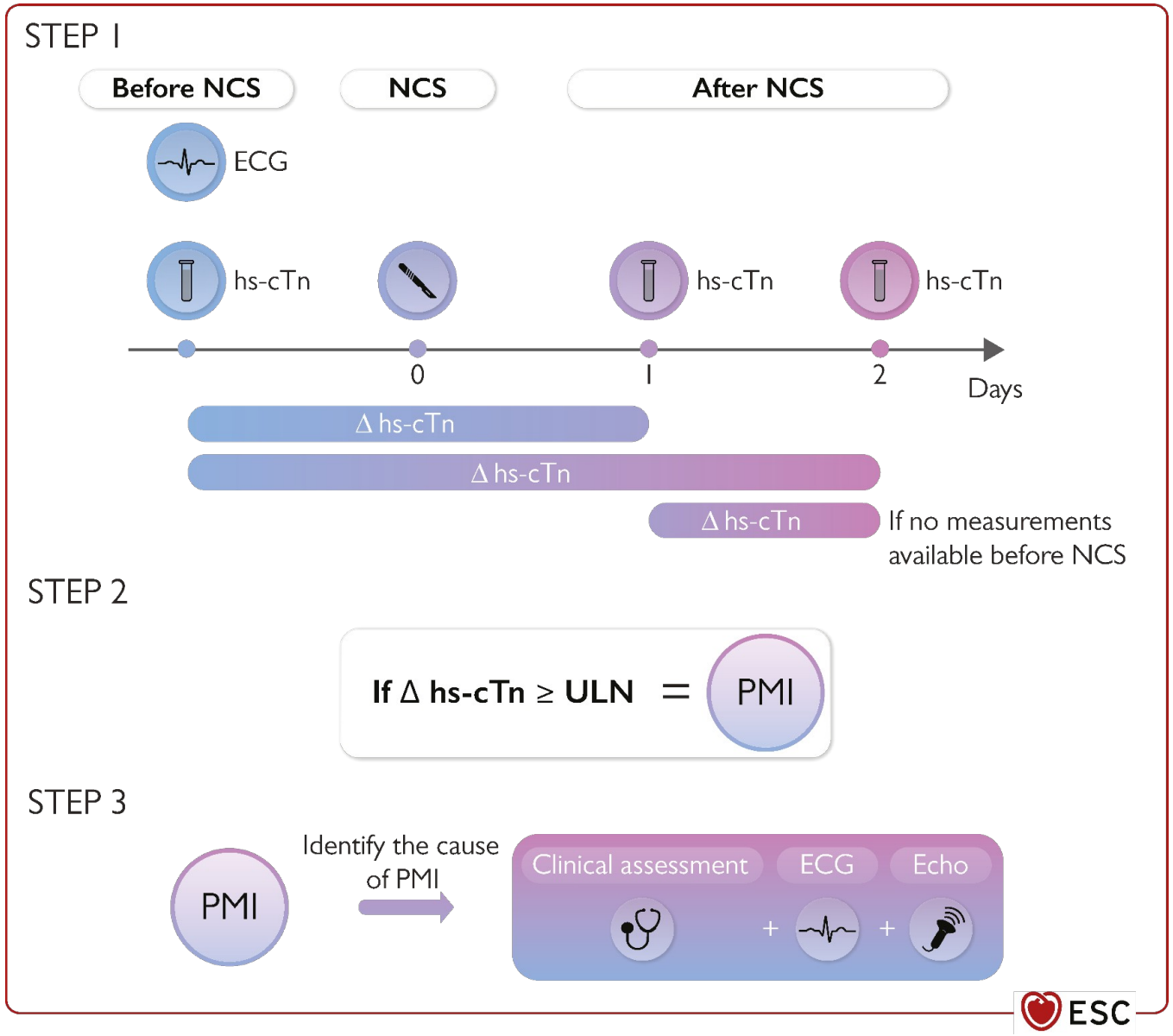
Recommendations	Class	Level
In patients ≥70 years old, being scheduled to undergo intermediate- or high-risk NCS, frailty screening should be considered using a validated screening tool.	IIa	B
Adjusting risk assessments according to self-reported ability to climb two flights of stairs should be considered in patients referred for intermediate- or high-risk NCS.	IIa	B

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Figure 4

Recommended measurements to assess and detect the risk of post-operative cardiac complications



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Recommendations for pre-operative risk assessment—electrocardiography and biomarkers

Recommendations	Class	Level
In patients who have known CVD or CV risk factors (including age ≥65 years), or symptoms or signs suggestive of CVD, it is recommended to obtain a pre-operative 12-lead ECG before intermediate- and high-risk NCS.	I	C
In patients who have known CVD, CV risk factors (including age ≥65 years), or symptoms suggestive of CVD, it is recommended to measure hs-cTn T or hs-cTn I before intermediate- and high-risk NCS, and at 24 h, and 48 h afterwards.	I	B
In patients who have known CVD, CV risk factors (including age ≥65 years), or symptoms suggestive of CVD, it should be considered to measure BNP or NT-proBNP before intermediate- and high-risk NCS.	IIa	B
In low-risk patients undergoing low- and intermediate-risk NCS, it is not recommended to routinely obtain pre-operative ECG, hs-cTn T/I, or BNP/NT-proBNP concentrations.	III	B

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Recommendations for transthoracic echocardiography

Recommendations	Class	Level
TTE is recommended in patients with poor functional capacity and/or high NT-proBNP/BNP, or, if murmurs are detected before high-risk NCS, to undertake risk-reduction strategies.	I	B
TTE should be considered in patients with suspected new CVD or unexplained signs or symptoms before high-risk NCS.	IIa	B
TTE may be considered in patients with poor functional capacity, abnormal ECG, high NT-proBNP/BNP, or ≥1 clinical risk factor, before intermediate-risk NCS.	IIb	B
To avoid delaying surgery, a FOCUS exam performed by trained specialists may be considered as an alternative to TTE for pre-operative triage.	IIb	B
Routine pre-operative evaluation of LV function is not recommended.	III	C

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Recommendations for stress imaging

Recommendations	Class	Level
Stress imaging is recommended before high-risk elective NCS in patients with poor functional capacity and high likelihood of CAD or high clinical risk.	I	B
Stress imaging should be considered before high-risk NCS in asymptomatic patients with poor functional capacity, and prior PCI or CABG.	IIa	C
Stress imaging may be considered before intermediate-risk NCS when ischaemia is of concern in patients with clinical risk factors and poor functional capacity.	IIb	B
Stress imaging is not recommended routinely before NCS.	III	C

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Recommendations for coronary angiography

Recommendations	Class	Level
It is recommended to use the same indications for ICA and revascularization pre-operatively as in the non-surgical setting.	I	C
CCTA should be considered to rule out CAD in patients with suspected CCS or biomarker-negative NSTE-ACS in case of low-to-intermediate clinical likelihood of CAD, or in patients not suitable for non-invasive functional testing undergoing non-urgent, intermediate-, and high-risk NCS.	IIa	C
Pre-operative ICA may be considered in stable CCS patients undergoing elective surgical CEA.	IIb	B
Routine pre-operative ICA is not recommended in stable CCS patients undergoing low- or intermediate-risk NCS.	III	C

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Recommendations for lifestyle and cardiovascular risk factors

Recommendations	Class	Level
Smoking cessation more than 4 weeks before NCS is recommended to reduce post-operative complications and mortality.	I	B
Control of CV risk factors, including blood pressure, dyslipidaemia, and diabetes, is recommended before NCS.	I	B

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Recommendations for pharmacological treatment (1)

Recommendations	Class	Level
Initiation		
In patients with an indication for statins, it should be considered to initiate statins peri-operatively.	IIa	C
Pre-operative initiation of beta-blockers in advance of high-risk NCS may be considered in patients who have ≥2 clinical risk factors, in order to reduce the incidence of peri-operative myocardial infarction.	IIb	A
Pre-operative initiation of beta-blocker in advance of NCS may be considered in patients who have known CAD or myocardial ischaemia.	IIb	B
Routine initiation of beta-blocker peri-operatively is not recommended.	III	A

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Recommendations for pharmacological treatment (2)

Recommendations	Class	Level
Continuation		
Peri-operative continuation of beta-blockers is recommended in patients currently receiving this medication.	I	B
In patients already on statins, it is recommended to continue statins during the peri-operative period.	I	B
In patients with stable HF, peri-operative continuation of RAAS inhibitors may be considered.	IIb	C
Interruption		
In patients without HF, withholding RAAS inhibitors on the day of NCS should be considered to prevent peri-operative hypotension.	IIa	B
For patients on diuretics to treat hypertension, transient discontinuation of diuretics on day of NCS should be considered.	IIa	B
It should be considered to interrupt SGLT-2 inhibitor therapy for at least 3 days before intermediate- and high-risk NCS.	IIa	C

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Pharmacokinetic and pharmacodynamic characteristics of antiplatelets

	ASA	Clopidogrel	Prasugrel	Ticagrelor	Cangrelor	Eptifibatide	Tirofiban
Target (type of blockade)	COX-1 (irreversible)	$P2Y_{12}$ (irreversible)	$P2Y_{12}$ (irreversible)	$P2Y_{12}$ (reversible)	$P2Y_{12}$ (reversible)	GPIIB/IIIa (reversible)	GPIIB/IIIa (reversible)
Application	Oral	Oral	Oral	Oral	i.v.	i.v.	i.v.
Time to C_{max}	0.5–1.0h	2 h (after 600 mg LD)	0.5 h (after 60 mg LD)	0.5 h (after 180 mg LD)	2 min	5 min	5 min
Prodrug	No	Yes	Yes	No	No	No	No
Bioavailability (%)	~50	~50	80	36	100	100	100
Drug interactions	NSAIDs (in particular ibuprofen + naproxen)	CYP3A4, CYP3A5, or CYP2C19 inhibitors or inducers	CYP3A4/A5 and CYP2B6 inhibitor	CYP3A4 inducers or inhibitors	None	None	None
Plasma half-life	20 min	0.5–1 h (active metabolite	0.5–1 h (active metabolite)	6–12 h	3–6 min	2.5–2.8 h	1.2–2 h
Duration of action after last dose	7–10 days	3–10 days	7–10 days	3–5 days	1–2 h	4 h	8 h
Renal clearance of the active metabolite (%)	NR	NR	NR	NR	58	~50	65
Dose regimen	o.d	o.d.	o.d.	b.i.d.	Bolus, infusion	Bolus, infusion	Bolus, infusion

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Pharmacokinetic and pharmacodynamic characteristics of oral anticoagulants

	Warfarin	Phenprocoumon	Apixaban	Dabigatran	Edoxaban	Rivaroxaban
Target (type of blockade)	VKORC1	VKORC1	FXa	FIIa	FXa	FXa
Application	Oral	Oral	Oral	Oral	Oral	Oral
Time to C_{max}	2–6 h	1.52 h ±1.52	3–4 h	1.25–3 h	1–2 h	2–4 h
Prodrug	No	No	No	Yes	No	No
Bioavailability (%)	>95	100	50	6.5	62	80–100
Drug interactions	CYP2C9, CYP2C19, CYP2C8, CYP2C18, CYP1A2, CYP3A4, vitamin K	CYP2C9, CYP2C8, vitamin K	CYP3A4 inhibitors or inductors, P-glycoprotein inhibitors or inductors	P-glycoprotein inhibitors or inductors	P-glycoprotein inhibitors	CYP3A4 inhibitors or inductors, P-glycoprotein inhibitors or inductors
Plasma half-life	36–48 h	~100 h	12 h	12–14 h	6–11 h	7–11 h (11–13 h in the elderly)
Duration of action after last dose	~5 days	~7 days	24 h	24 h	24 h	24 h
Renal clearance of the active metabolite (%)	Non-renal	Non-renal	27	85	37–50	33
Dose regimen	Adjusted according to INR	Adjusted according to INR	b.i.d.	b.i.d.	o.d.	o.d./b.i.d.

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Bleeding risk according to type of non-cardiac surgery

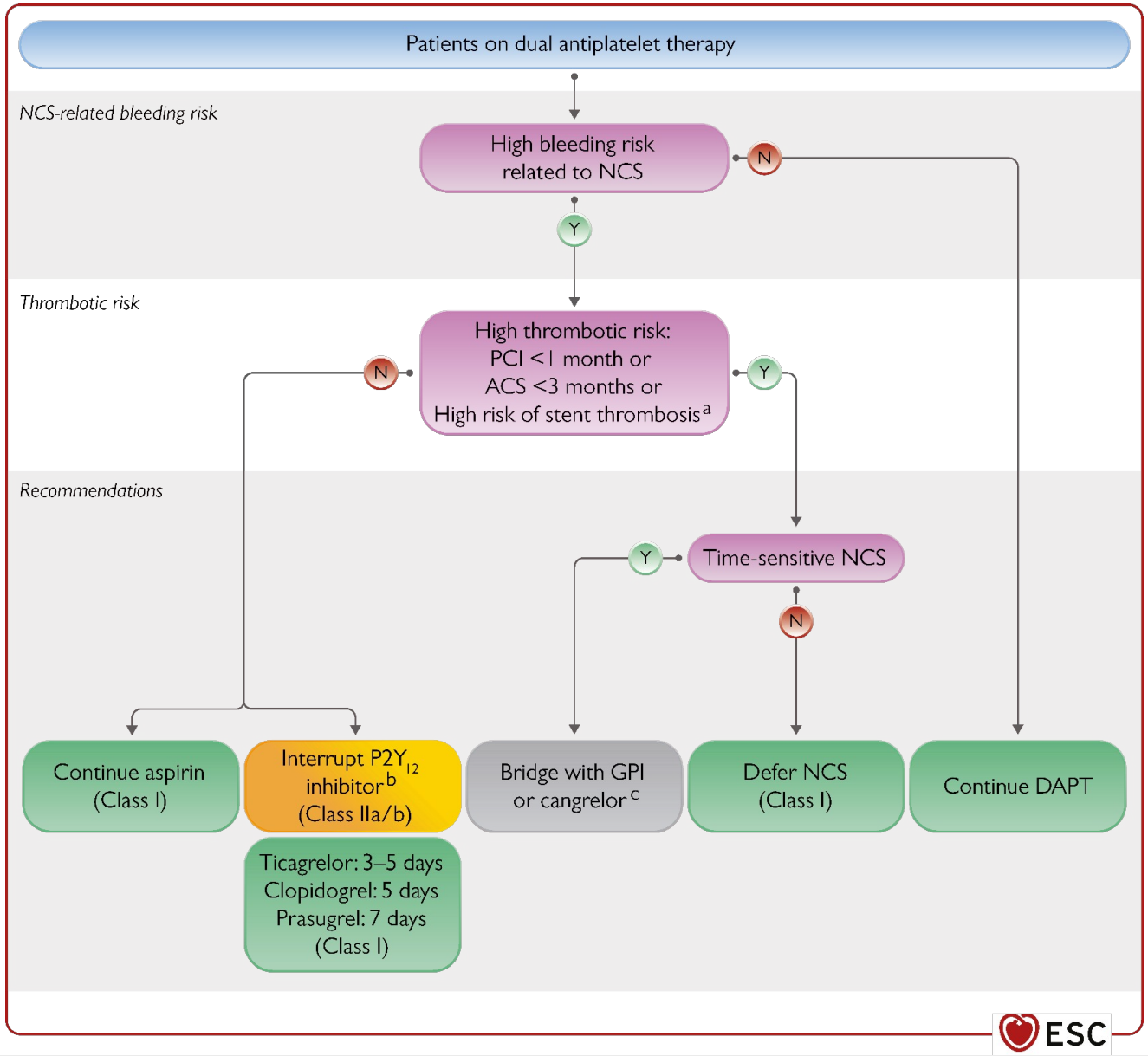
Surgery with minor bleeding risk	Surgery with low bleeding risk (infrequent or with low clinical impact)	Surgery with high bleeding risk (frequent or with significant clinical impact)
• Cataract or glaucoma procedure • Dental procedures: extractions (1–3 teeth), periodontal surgery, implant positioning, endodontic (root canal) procedures, subgingival scaling/cleaning • Endoscopy without biopsy or resection • Superficial surgery (e.g. abscess incision, small skin excisions/biopsy)	• Abdominal surgery: cholecystectomy, hernia repair, colon resection • Breast surgery • Complex dental procedures (multiple tooth extractions) • Endoscopy with simple biopsy • Gastroscopy or colonoscopy with simple biopsy • Large-bore needles procedures, e.g. bone marrow or lymph node biopsy • Non-cataract ophthalmic surgery • Small orthopaedic surgery (foot, hand arthroscopy)	• Abdominal surgery with liver biopsy, extracorporeal shockwave lithotripsy • Extensive cancer surgery (e.g. pancreas, liver) • Neuraxial (spinal or epidural) anaesthesia • Neurosurgery (intracranial, spinal) • Major orthopaedic surgery • Procedures with vascular organ biopsy (kidney or prostate) • Reconstructive plastic surgery • Specific interventions (colon polypectomy, lumbar puncture, endovascular aneurysm repair) • Thoracic surgery, lung resection surgery • Urological surgery (prostatectomy, bladder tumour resection) • Vascular surgery (e.g. AAA repair, vascular bypass)

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Figure 5

Recommendations for management of antiplatelet therapy in patients undergoing non-cardiac surgery

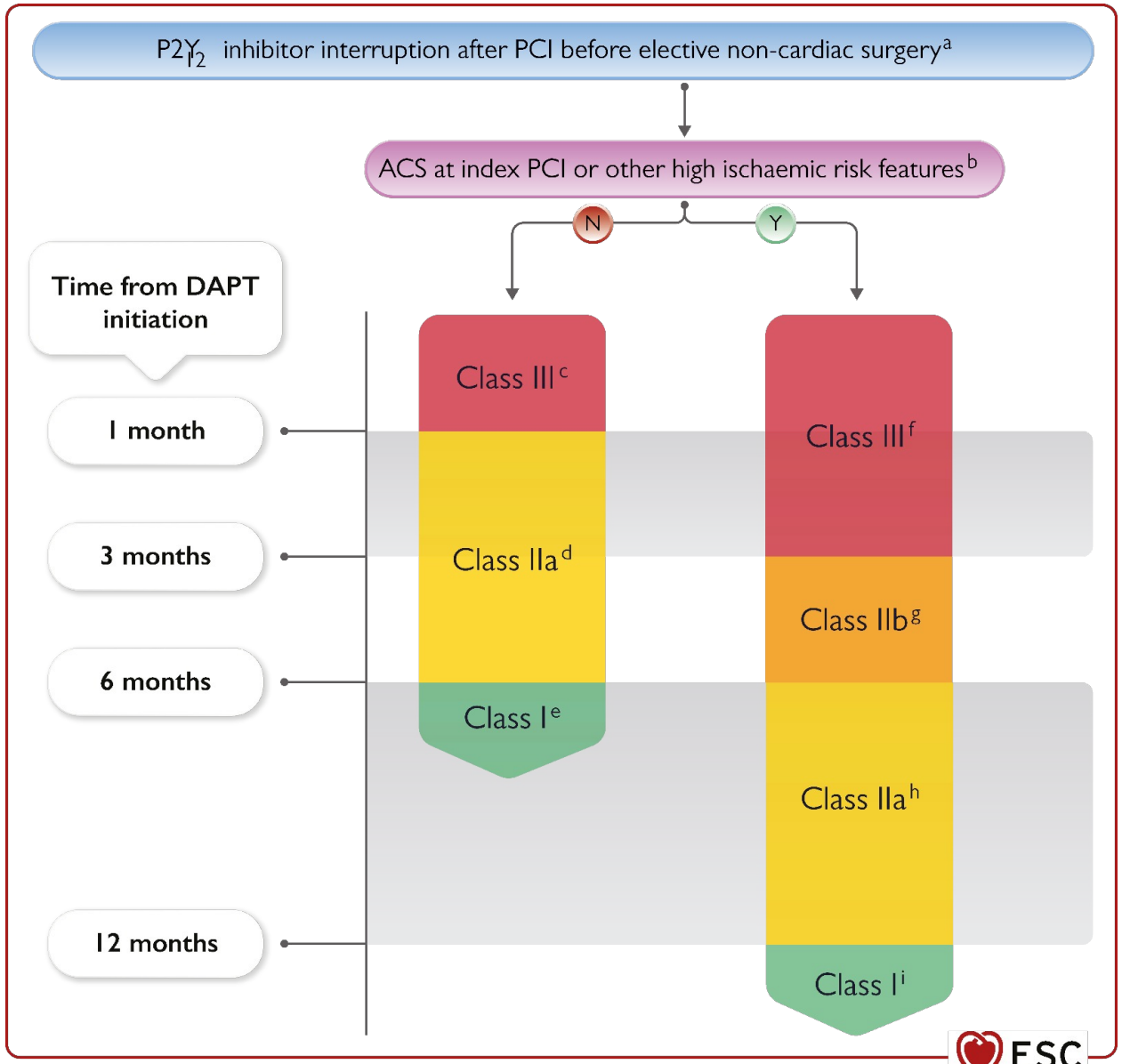


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Figure 6

$P2Y_{12}$ inhibitor interruption after percutaneous coronary intervention before elective non-cardiac surgery

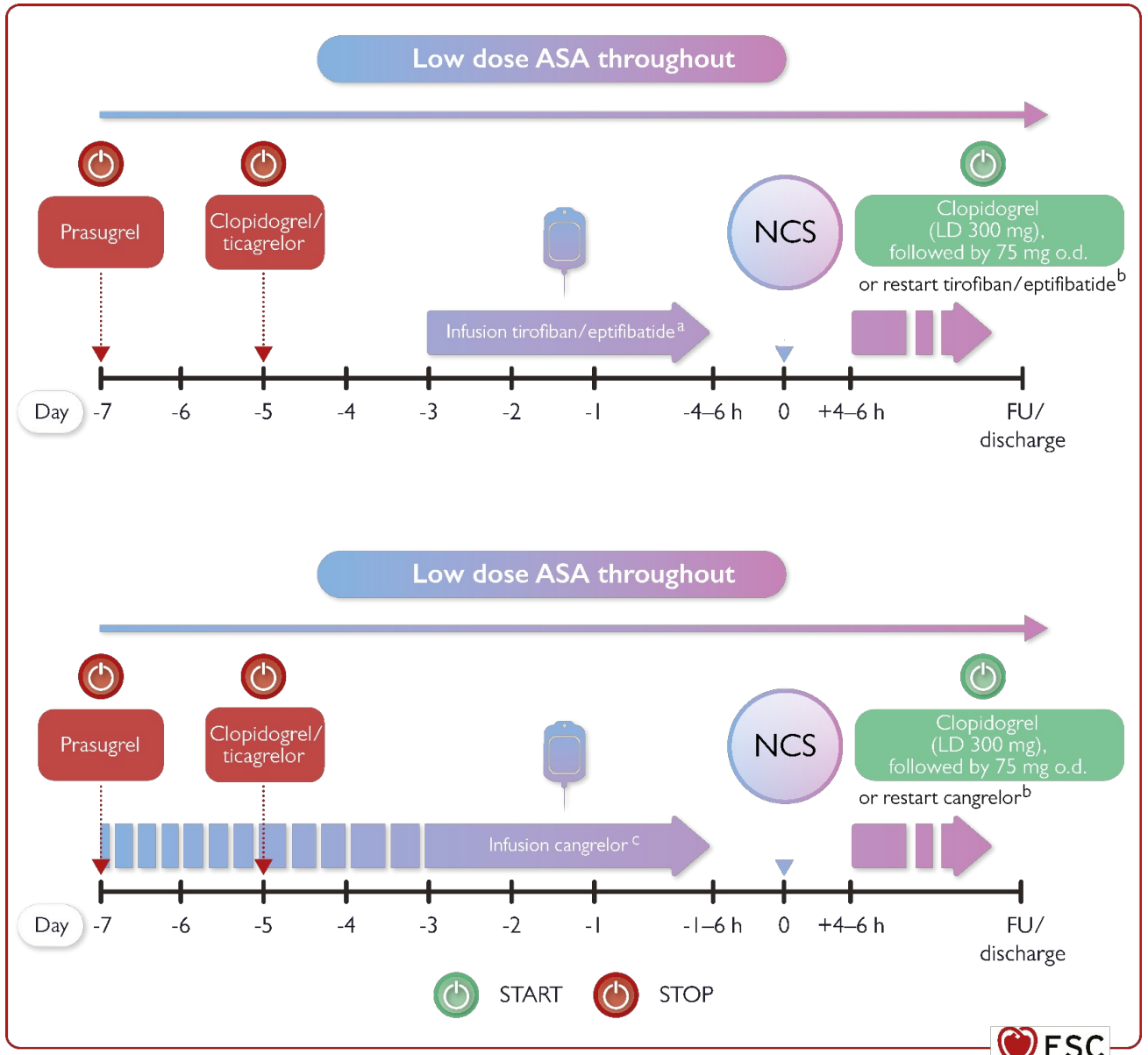


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Figure 7

Bridging with intravenous antiplatelet agents



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Recommendations for the use of antiplatelet therapy in patients undergoing non-cardiac surgery (1)

Recommendations	Class	Level
It is recommended to delay elective NCS until 6 months after elective PCI and 12 months after an ACS, respectively.	I	A
After elective PCI, it is recommended to delay time-sensitive NCS until a minimum of 1 month of DAPT treatment has been given.	I	B
In patients with a recent PCI scheduled for NCS, it is recommended that management of antiplatelet therapy is discussed between the surgeon, the anaesthesiologist, and the cardiologist.	I	C
In high-risk patients with a recent PCI (e.g. STEMI patients or high-risk NSTE-ACS patients), a DAPT duration of at least 3 months should be considered before time-sensitive NCS.	IIa	C

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Recommendations for the use of antiplatelet therapy in patients undergoing non-cardiac surgery (2)

Recommendations	Class	Level
Continuation of medication		
In patients with a prior PCI, it is recommended to continue aspirin peri-operatively if the bleeding risk allows.	I	B
Recommended time interval for drug interruption before NCS		
If interruption of $P2Y_{12}$ inhibitor is indicated, it is recommended to withhold ticagrelor for 3–5 days, clopidogrel for 5 days, and prasugrel for 7 days prior to NCS.	I	B
For patients undergoing high bleeding risk surgery (e.g. intracranial, spinal neurosurgery, or vitroretinal eye surgery), it is recommended to interrupt aspirin for at least 7 days pre-operatively.	I	C
In patients without a history of PCI, interruption of aspirin at least 3 days before NCS may be considered if the bleeding risk outweighs the ischaemic risk, to reduce the risk of bleeding.	IIb	B

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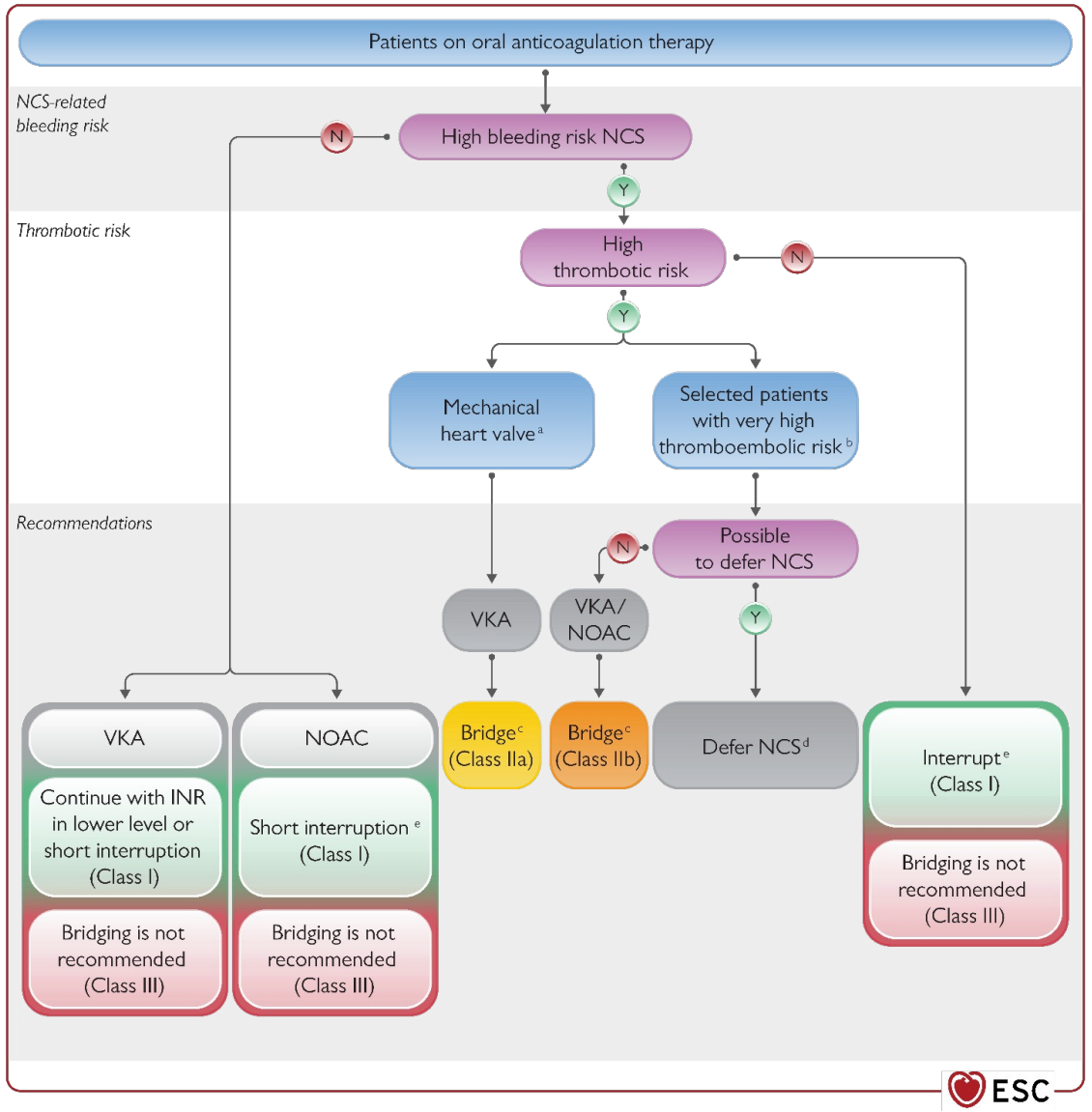
Recommendations for the use of antiplatelet therapy in patients undergoing non-cardiac surgery (3)

Recommendations	Class	Level
Resumption of medication		
If antiplatelet therapy has been interrupted before a surgical procedure, it is recommended to restart therapy as soon as possible (within 48 h) post-surgery, according to interdisciplinary risk assessment.	I	C

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Figure 8

Recommendations for management of oral anticoagulation therapy in patients undergoing non-cardiac surgery

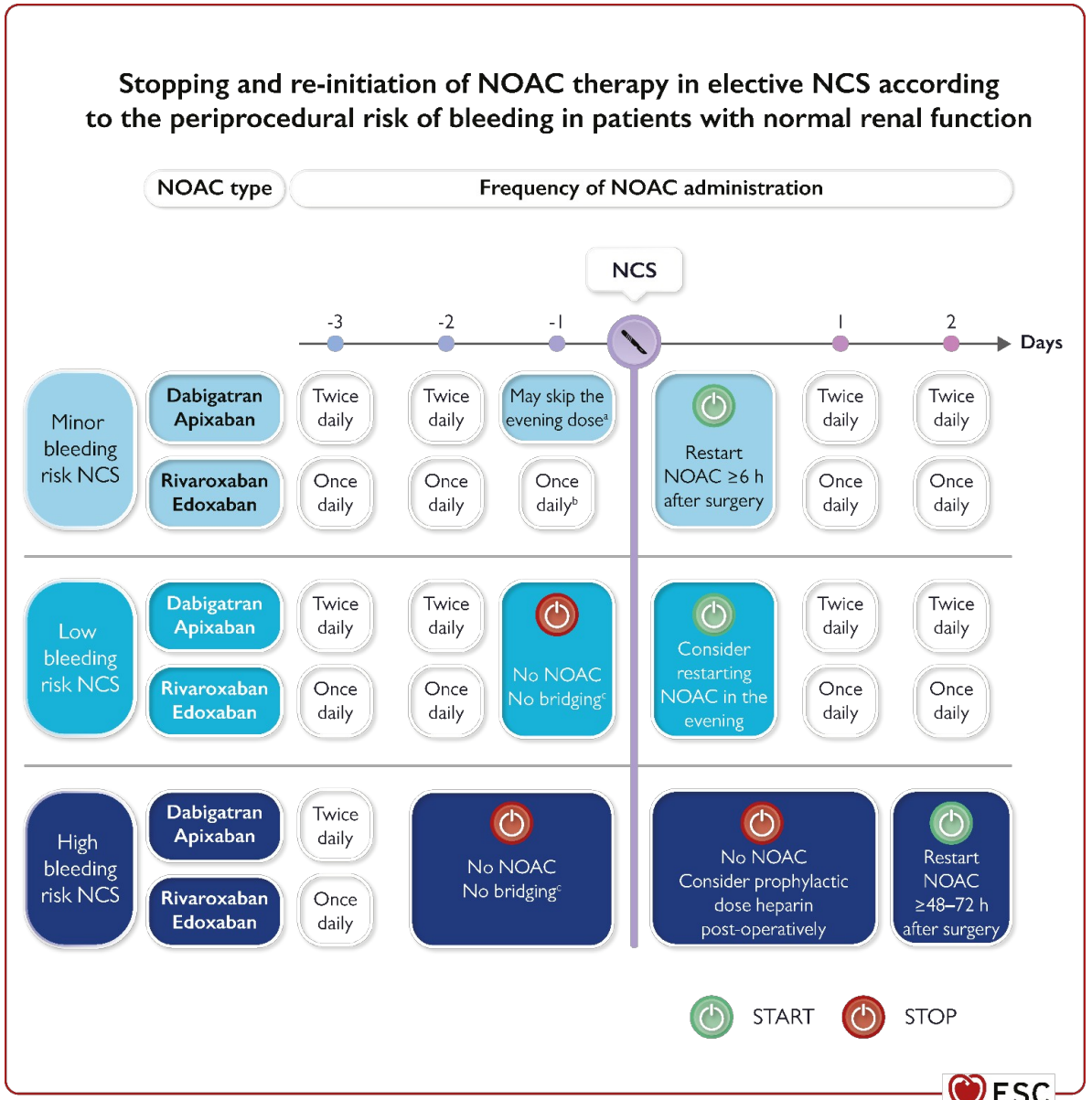


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Figure 9

Peri-operative management of non-vitamin K antagonist oral anticoagulant according to the periprocedural risk of bleeding

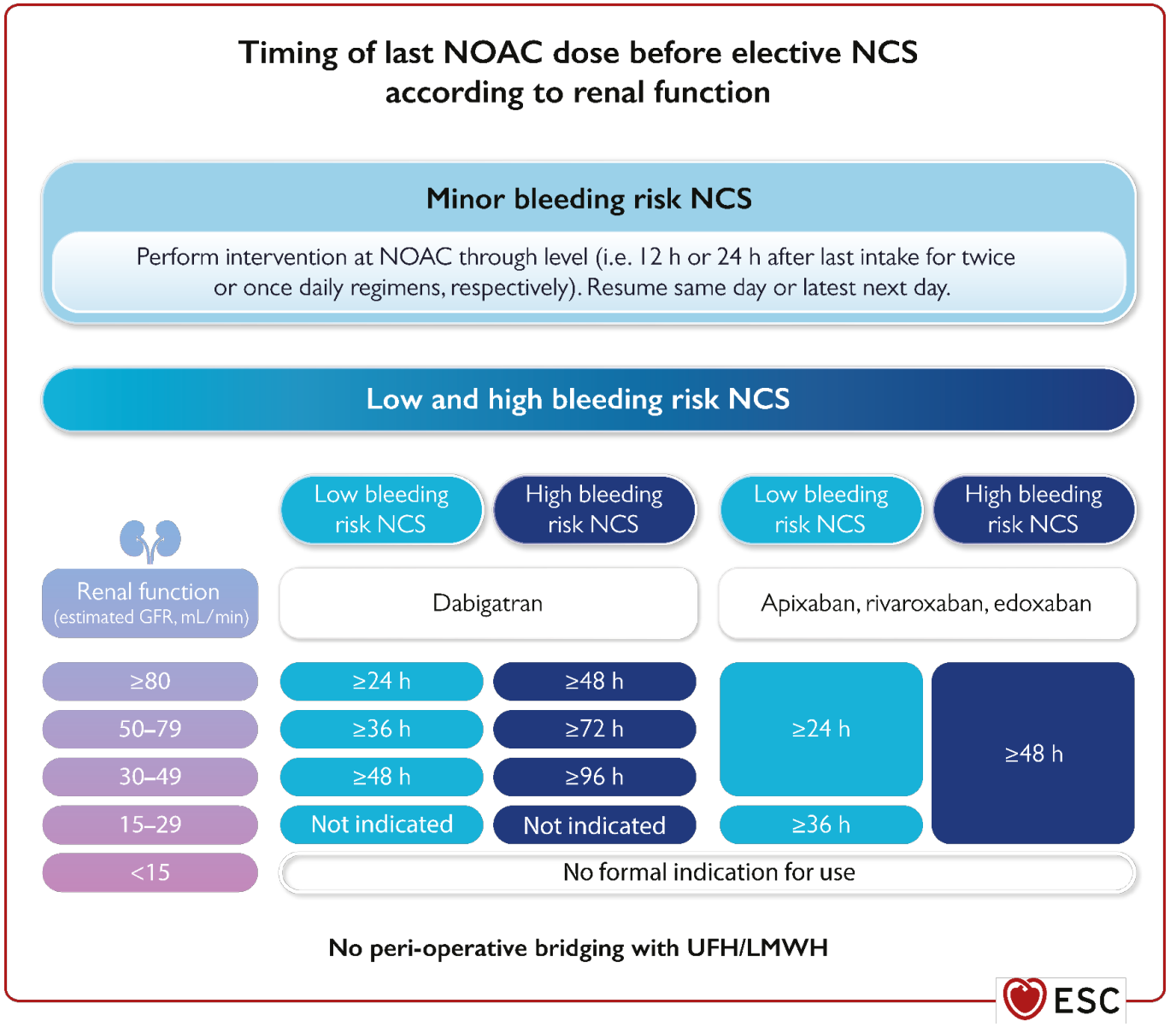


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Figure 10

Timing of last NOAC dose before elective NCS according to renal function

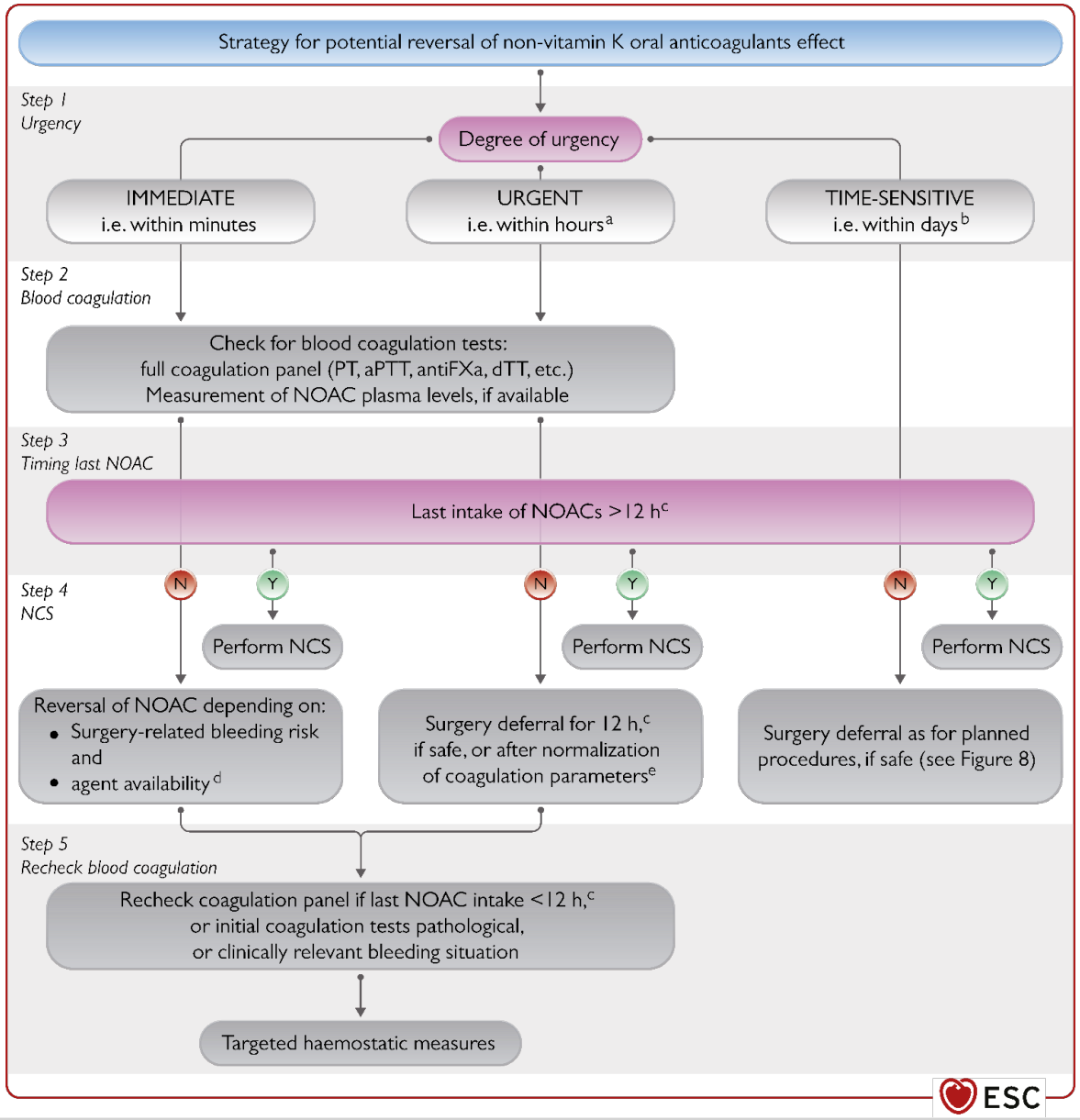


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Figure 11

Suggested strategy for potential reversal of non-vitamin K oral anticoagulants anticoagulant effect



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Recommendations for interruption and resumption of anticoagulants in patients undergoing non-cardiac surgery (1)

Recommendations	Class	Level
Interruption of anticoagulation		
When an urgent surgical intervention is required, it is recommended that NOAC therapy is immediately interrupted.	I	C
Idarucizumab should be considered in patients on dabigatran and requiring urgent surgical intervention with intermediate to high bleeding risk.	IIa	B
In non-minor bleeding risk procedures in patients using a NOAC, it is recommended to use an interruption regimen based on the NOAC compound, renal function, and bleeding risk.	I	B
For interventions with a very high risk of bleeding, such as spinal or epidural anaesthesia, interruption of NOACs for up to five half-lives and re-initiation after 24 h should be considered.	IIa	C

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Recommendations for interruption and resumption of anticoagulants in patients undergoing non-cardiac surgery (2)

Recommendations	Class	Level
Interruption of anticoagulation (continued)		
When specific reversal agents are not available, PCC or activated PCC should be considered for reversing NOAC effects.	IIa	C
If an urgent surgical intervention is required, specific coagulation tests and assessment of NOAC plasma levels should be considered to interpret routine coagulation tests and waning of anticoagulant effect.	IIa	C
Continuation of medication		
In minor bleeding risk surgery and other procedures where bleeding can be easily controlled, it is recommended to perform surgery without interruption of OAC therapy.	I	B
LMWH is recommended, as an alternative to UFH, for bridging in patients with MHVs and high surgical risk.	I	B
In patients using NOACs, it is recommended that minor bleeding risk procedures are performed at trough levels (typically 12–24 h after last intake).	I	C

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Recommendations for interruption and resumption of anticoagulants in patients undergoing non-cardiac surgery (3)

Recommendations	Class	Level
Continuation of medication (continued)		
For patients with mechanical prosthetic heart valves undergoing NCS, bridging with UFH or LMWH should be considered if OAC interruption is needed and patients have: (i) mechanical AVR and any thromboembolic risk factor; (ii) old-generation mechanical AVR; or (iii) mechanical mitral or tricuspidal valve replacement.	IIa	C
Bridging of OAC therapy is not recommended in patients with low/moderate thrombotic risk undergoing NCS.	III	B

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Recommendations for interruption and resumption of anticoagulants in patients undergoing non-cardiac surgery (4)

Recommendations	Class	Level
Start/resumption of medication		
If bleeding risk with resumption of full-dose anticoagulation outweighs the risk of thromboembolic events, postponing therapeutic anticoagulation 48–72 h after the procedure may be considered, using post-operative thromboprophylaxis until resumption of full OAC dose is deemed safe.	IIb	C
Use of reduced-dose NOAC to attenuate the risk of post-operative bleeding is not recommended.	III	C

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Recommendations on thromboprophylaxis

Recommendations	Class	Level
It is recommended that decisions about peri-operative thromboprophylaxis in NCS are based on individual and procedure-specific risk factors.	I	A
If thromboprophylaxis is deemed necessary, it is recommended to choose the type and duration of thromboprophylaxis (LMWH, NOAC, or fondaparinux) according to type of NCS, duration of immobilization, and patient-related factors.	I	A
In patients with a low bleeding risk, peri-operative thromboprophylaxis should be considered for a duration of up to 14 or 35 days, for total knee or hip arthroplasty, respectively.	IIa	A
NOACs in thromboprophylaxis dose may be considered as alternative treatments to LMWH after total knee and hip arthroplasty.	IIb	A

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Laboratory parameters for the diagnosis of absolute iron-deficiency anaemia

Parameter	Normal	Iron deficiency
Mean corpuscular haemoglobin (g/dL)	28–33	<27
Mean cellular volume (fL)	80–96	<80
Transferrin saturation (%)	16–45	<20
Ferritin (ng/mL)	18–360	<30
Reticulocytes haemoglobin (ng/mL)	18–360	<30

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Recommendations for intra- and post-operative complications associated with anaemia

Recommendations	Class	Level
It is recommended to measure haemoglobin pre-operatively in patients scheduled for intermediate- to high-risk NCS.	I	B
It is recommended to treat anaemia in advance of NCS in order to reduce the need for RBC transfusion during NCS.	I	A
The use of an algorithm to diagnose and treat anaemic patients before NCS should be considered.	IIa	C

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Recommendations for intra- and post-operative complications associated with blood loss

Recommendations	Class	Level
In patients undergoing surgery with expected blood loss of ≥500 mL, use of washed cell salvage is recommended.	I	A
It is recommended to use point-of-care diagnostics for guidance of blood component therapy, when available.	I	A
In patients undergoing NCS and experiencing major bleeding, administration of tranexamic acid should be considered immediately.	IIa	A
Use of closed-loop arterial blood sampling systems should be considered to avoid blood loss.	IIa	B
Application of meticulous haemostasis should be considered a routine procedure.	IIa	B

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Recommendations for intra- and post-operative complications associated with allogeneic blood transfusion

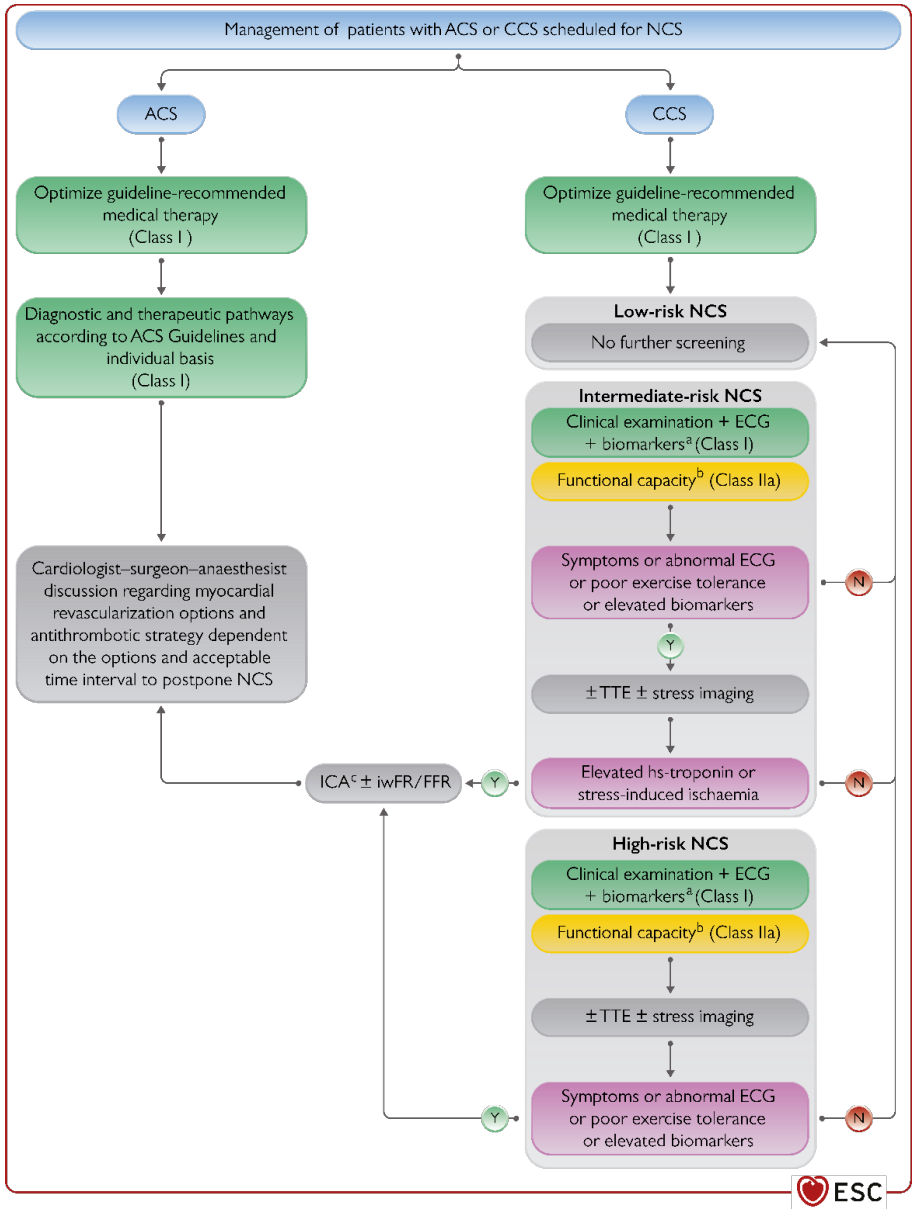
Recommendations	Class	Level
A feedback/monitoring programme or clinical decision support system should be considered to be assessed before blood transfusion.	IIa	B
Before allogenic blood transfusion, it should be considered to obtain an extensive consent about risks associated with transfusion.	IIa	C

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Figure 12

Management of patients with acute or chronic coronary syndrome scheduled for non-cardiac surgery



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Recommendations on the timing of non-cardiac surgery and revascularization in patients with known coronary artery disease (1)

Recommendations	Class	Level
Patients with CCS		
If PCI is indicated before NCS, the use of new-generation DES is recommended over BMS and balloon angioplasty.	I	A
Pre-operative evaluation of patients with an indication for PCI by an expert team (surgeon and cardiologist) should be considered before elective NCS.	IIa	C
Myocardial revascularization before high-risk elective NCS may be considered, depending on the amount of ischaemic myocardium, refractory symptoms, and findings at coronary angiography (as in the case of left main disease).	IIb	B
Routine myocardial revascularization before low- and intermediate-risk NCS in patients with CCS is not recommended.	III	B

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Recommendations on the timing of non-cardiac surgery and revascularization in patients with known coronary artery disease (2)

Recommendations	Class	Level
Patients with ACS		
If NCS can safely be postponed (e.g. at least 3 months), it is recommended that patients with ACS being scheduled for NCS undergo diagnostic and therapeutic interventions as recommended for ACS patients in general.	I	A
In the unlikely combination of a life-threatening clinical condition requiring urgent NCS, and NSTE-ACS with an indication for revascularization, the priorities for surgery on a case-by-case basis should be considered by the expert team.	IIa	C

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Peri-operative approach to patients with ventricular assist devices undergoing non-cardiac surgery

Pre-operative	Intra-operative	Post-operative
• Multidisciplinary team identified (primary surgical and anaesthesia teams, cardiac surgery, HF cardiologist, VAD personnel) • Pre-operative medical optimization when possible or necessary • Physical examination focused on the sequelae of HF • Baseline ECG, echocardiogram, and laboratory values • Manage pacemaker/ICD settings when indicated • CT examination to evaluate possible driveline interference with the operative field • Hold, bridge, or reverse anticoagulation when indicated, after VAD team consultation	• Standard American Society of Anesthesiologists monitors • Cerebral tissue oxygenation, processed electroencephalogram, arterial line with ultrasound guidance, central venous catheter if fluid shifts are expected, PA catheter only if severe pulmonary hypertension, TEE available • Monitor VAD control console • External defibrillator pads in place • Optimize pre-load, support RV function, avoid increase in afterload • Gradual peritoneal insufflations and position changes	• Standard post-anaesthesia care unit unless ICU is otherwise indicated • Extubation criteria are unchanged • Avoid hypoventilation, optimize oxygenation • Resume heparin infusion when post-op bleeding risk is acceptable

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Recommendations for management of heart failure in patients undergoing non-cardiac surgery

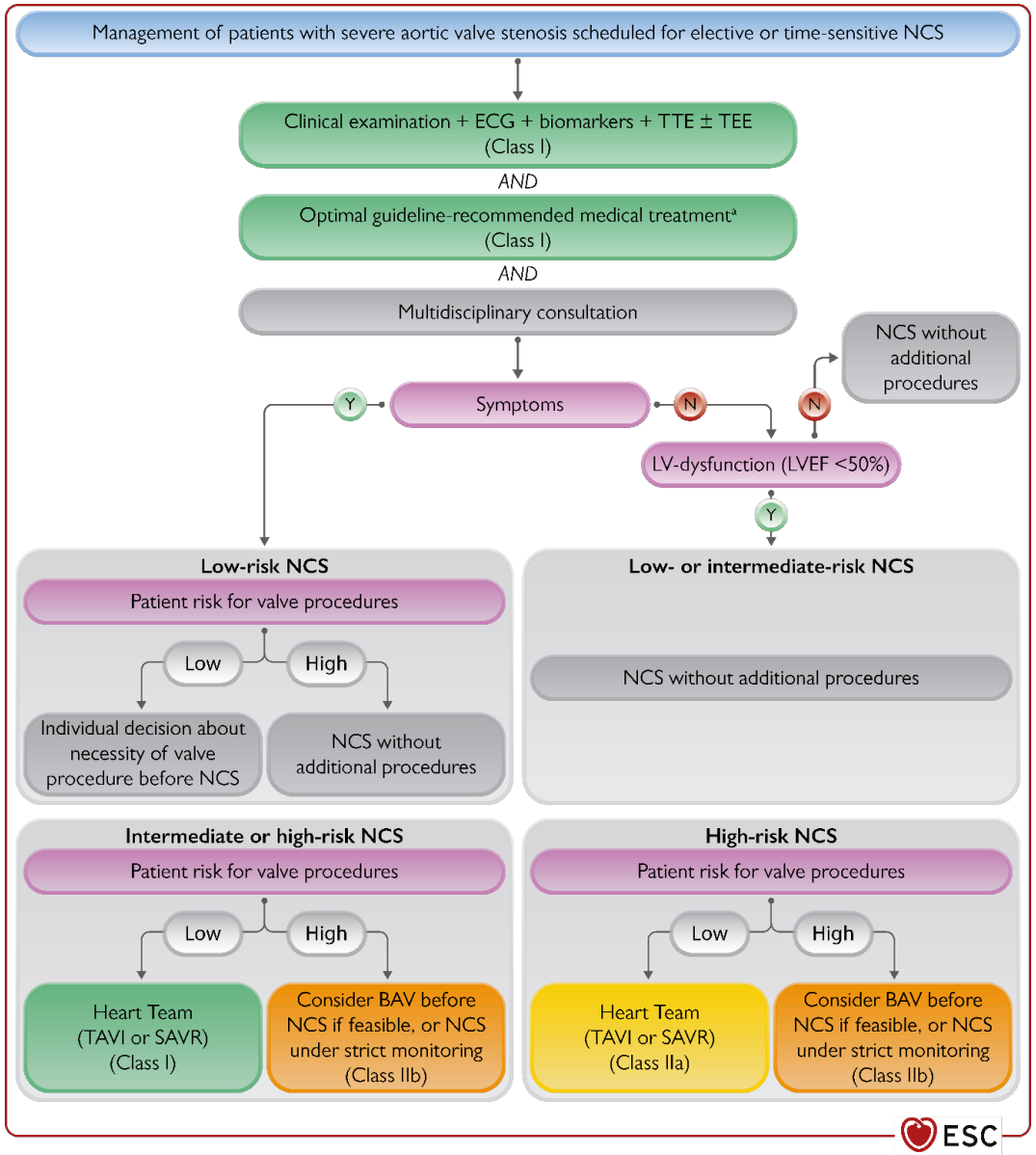
Recommendations	Class	Level
In patients with suspected or known HF scheduled for high-risk NCS, it is recommended to evaluate LV function with echocardiography and measurement of NT-proBNP/BNP levels, unless this has recently been performed.	I	B
It is recommended that patients with HF undergoing NCS receive optimal medical treatment according to current ESC Guidelines.	I	A
In patients with HF undergoing NCS, it is recommended to regularly assess volume status and signs of organ perfusion.	I	C
A multidisciplinary team including VAD specialists is recommended for peri-operative management of patients with HF receiving mechanical circulatory support.	I	C

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Figure 13

Management of patients with severe aortic valve stenosis scheduled for non-cardiac surgery

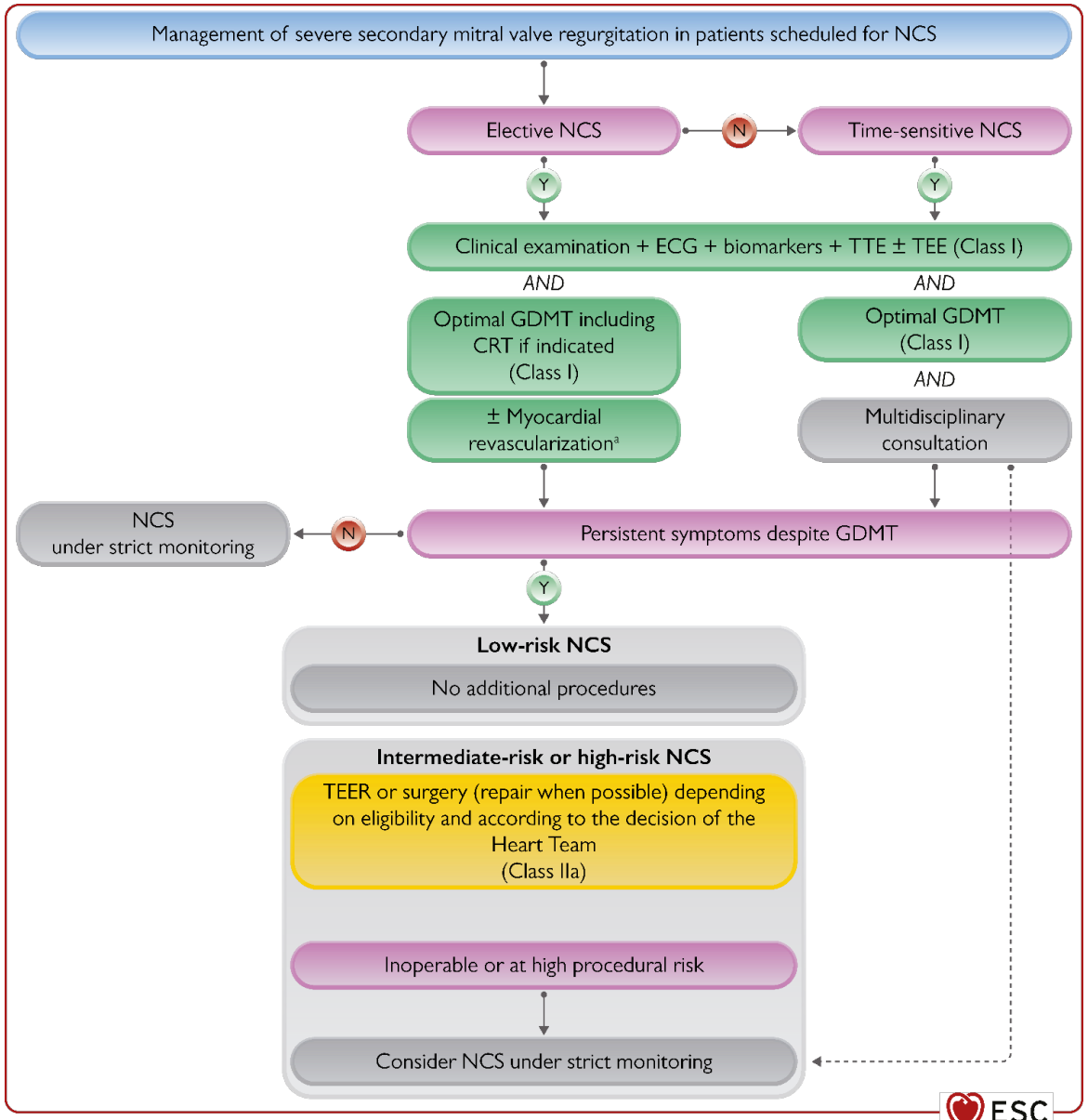


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Figure 14

Management of patients with secondary mitral valve regurgitation scheduled for non-cardiac surgery



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Recommendations for management of valvular heart disease in patients undergoing non-cardiac surgery (1)

Recommendations	Class	Level
Clinical and echocardiographic evaluation (if not recently performed) is recommended in all patients with known or suspected VHD who are scheduled for elective intermediate- or high-risk NCS.	I	C
Aortic valve stenosis		
AVR (SAVR or TAVI) is recommended in symptomatic patients with severe AS who are scheduled for elective intermediate- or high-risk NCS.	I	C
In asymptomatic patients with severe AS who are scheduled for elective high-risk NCS, AVR (SAVR or TAVI) should be considered after Heart Team discussion.	IIa	C
In patients with severe symptomatic AS in need of time-sensitive NCS or in whom the TAVI and SAVR are not feasible, BAV may be considered before NCS as a bridge to definitive aortic valve repair.	IIb	C

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Recommendations for management of valvular heart disease in patients undergoing non-cardiac surgery (2)

Recommendations	Class	Level
Aortic valve regurgitation		
In patients with symptomatic severe AR or asymptomatic severe AR and LVESD >50 mm or LVESDi (LVESD/BSA) >25 mm/m^2 (in patients with small body size) or resting LVEF ≤50%, valve surgery is recommended prior to elective intermediate- or high-risk NCS.	I	C
Mitral valve stenosis		
In patients with moderate-to-severe rheumatic MS and symptoms or SPAP >50 mmHg, valve intervention (PMC or surgery) is recommended before elective intermediate- or high-risk NCS.	I	C

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Recommendations for management of valvular heart disease in patients undergoing non-cardiac surgery (3)

Recommendations	Class	Level
Mitral valve regurgitation		
In patients with symptomatic severe primary MR or asymptomatic severe primary MR with LV dysfunction (LVESD ≥40 mm and/or LVEF ≤60%), valve intervention (surgical or transcatheter) should be considered prior to intermediate- or high-risk NCS, if time allows.	IIa	C
In patients with severe secondary MR who remain symptomatic despite guideline-directed medical therapy (including CRT if indicated), valve intervention (transcatheter or surgical) should be considered before NCS, in eligible patients with an acceptable procedural risk.	IIa	C

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Recommendations for management of known or newly diagnosed arrhythmias (1)

Recommendations	Class	Level
Supraventricular arrhythmias		
In patients with SVT controlled by medication, it is recommended that AADs are continued during the peri-operative period.	I	C
Ablation should be considered in symptomatic patients with recurrent or persistent SVT despite treatment, prior to high-risk, non-urgent NCS.	IIa	B
AF with haemodynamic instability in patients undergoing NCS		
In AF patients with acute or worsening haemodynamic instability undergoing NCS, emergency electrical cardioversion is recommended.	I	B
In AF patients with haemodynamic instability, amiodarone may be considered for acute control of heart rate.	IIb	B

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Recommendations for management of known or newly diagnosed arrhythmias (2)

Recommendations	Class	Level
Ventricular arrhythmias		
In patients with symptomatic, monomorphic, sustained VT associated with myocardial scar, recurring despite optimal medical therapy, ablation of arrhythmia is recommended before elective NCS.	I	B
It is not recommended to initiate treatment of asymptomatic PVCs during NCS.	III	C

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Peri-operative management of patients with arrhythmias

Type of arrhythmia	SVT	Idiopathic VT in structurally/functionally normal heart	VT in structural heart disease
Diagnostics	• ECG ±TTE	• ECG ±TTE	• ECG +TTE +biomarkers • ±Coronary angiography • ±Cardiac CT/MRI
Acute management	• Vagal manoeuvres • I.v. adenosine, beta-blocker, CCB • Electrical cardioversion if unstable	• Vagal manoeuvres • I.v. beta-blockers/ verapamil • Electrical cardioversion if unstable	• Treatment of underlying heart disease • I.v. betablocker (uptitration), amiodarone • Electrical cardioversion if unstable
Prevention of recurrence	• Per oral beta-blocker, CCB • Catheter ablation if recurrent despite OMT (only before high-risk NCS)	• No treatment or • Per oral beta-blocker, CCB, class I AAD • Catheter ablation in case of recurrence despite AADs or drug-intolerance before high-risk NCS	• Per oral beta-blocker, amiodarone • Catheter ablation if recurrent despite OMT

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Recommendations for management of bradyarrhythmia and patients carrying cardiac implantable devices (1)

Recommendations	Class	Level
If indications for pacing exist according to the 2021 ESC Guidelines on cardiac pacing and cardiac resynchronization therapy, NCS surgery should be deferred and implantation of a permanent pacemaker should be considered.	IIa	C
It is recommended that patients with temporarily deactivated ICDs have continuous ECG monitoring, and during the peri-operative period are accompanied by personnel skilled in early detection and treatment of arrhythmias. In high-risk patients (e.g. pacemaker dependant or ICD patients), or if access to torso will be difficult during the procedure, it is recommended to place transcutaneous pacing/defibrillation pads prior to NCS.	I	C

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Recommendations for management of bradyarrhythmia and patients carrying cardiac implantable devices (2)

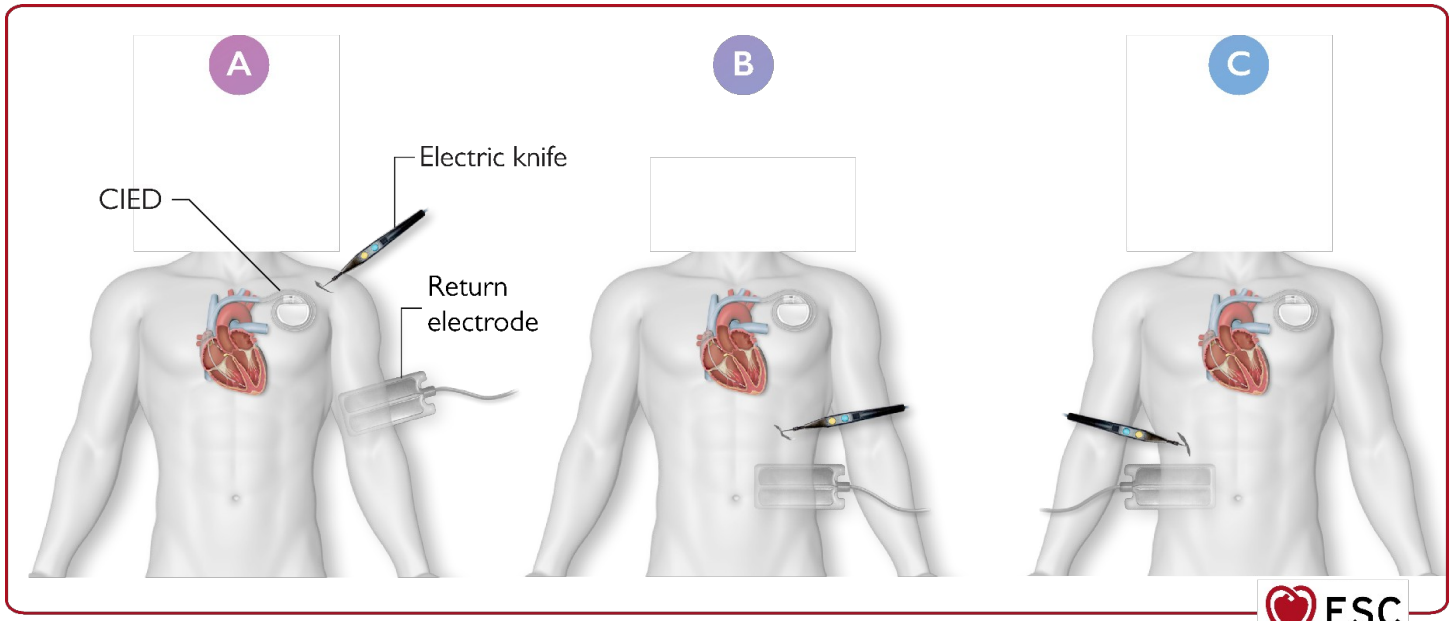
Recommendations	Class	Level
Ventricular arrhythmias		
It is recommended that all patients with CIEDs which are reprogrammed before surgery, have a re-check and necessary reprogramming as soon as possible after the procedure.	I	C
In high-risk CIED patients (e.g with ICD or being pacing-dependant) undergoing NCS carrying a high probability of electromagnetic interference (e.g. involving unipolar electrosurgery above the umbilical area), CIED check-up and necessary reprogramming immediately before the procedure should be considered.	IIa	C

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Figure 15

Optimal location of return electrode during unipolar electrosurgery in patients with cardiac implantable electronic devices, depending on the surgery site



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Risk stratification for non-cardiac surgery in adults with congenital heart disease

Minor risk	Patients with small, uncorrected defects, and no need for medication or any other treatment Patients with successfully corrected CHD with no symptoms, no relevant residua, and no need for medication
Intermediate risk	Patients with corrected or uncorrected conditions with residual haemodynamic abnormality, with or without medication
Severe risk	Patients with uncorrected cyanotic heart disease, pulmonary hypertension, other complex CHD, ventricular dysfunction requiring medication, and patients listed for heart transplantation

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Recommendations for management of patients with adult congenital heart disease undergoing non-cardiac surgery

Recommendations	Class	Level
In patients with ACHD, a consultation by an ACHD specialist is recommended before intermediate- or high-risk surgery.	I	C
In patients with ACHD, it is recommended that intermediate- and high-risk elective surgery is performed in a centre with experience in the care of ACHD patients.	I	C

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Recommendations for pericardial diseases

Recommendations	Class	Level
In patients with acute pericarditis, deferring elective NCS until complete resolution of the underlying process should be considered.	IIa	C
Avoiding elective NCS procedures under general anaesthesia until colchicine or the immunosuppressive treatment course for pericardial disease is completed may be considered.	IIb	C

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Patient-related and surgery-related factors to be considered when assessing peri-operative risk in patients with pulmonary arterial hypertension

Patient-related peri-operative risk factors in patients with PAH	Surgery-related peri-operative risk factors in patients with PAH
• Functional class >II • Reduced six-minute walk distance • Coronary heart disease • Previous pulmonary embolism • Chronic renal insufficiency • Severe right ventricular dysfunction	• Emergency surgery • Duration of anaesthesia >3 h • Intra-operative requirement for vasopressors

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Recommendations for patients with pulmonary arterial hypertension undergoing non-cardiac surgery

Recommendations	Class	Level
It is recommended to continue chronic therapy for PAH in the peri-operative phase of NCS.	I	C
It is recommended that haemodynamic monitoring of patients with severe PAH continues for at least 24 h in the post-operative period.	I	C
In the case of progression of right HF in the post-operative period in patients with PAH, it is recommended that the diuretic dose be optimized and, if necessary, i.v. prostacyclin analogues be initiated under the guidance of a physician experienced in the management of PAH.	I	C
Inodilator drugs (dobutamine, milrinone, levosimendan), which increase cardiac output and lower pulmonary vascular resistance, should be considered peri-operatively according to the haemodynamic status of the patient.	IIa	C

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Recommendations for pre-operative management of hypertension

Recommendations	Class	Level
In patients with chronic hypertension undergoing elective NCS it is recommended to avoid large peri-operative fluctuations in blood pressure, particularly hypotension, during the peri-operative period.	I	A
It is recommended to perform pre-operative screening for hypertension-mediated organ damage and CV risk factors in newly diagnosed hypertensive patients who are scheduled for elective high-risk NCS.	I	C
It is not recommended to defer NCS in patients with stage 1 or 2 hypertension.	III	C

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Recommendations for management of patients with peripheral artery disease and/or abdominal aortic aneurysm undergoing non-cardiac surgery

Recommendations	Class	Level
In patients with poor functional capacity or with significant risk factors or symptoms (such as moderate-to-severe angina pectoris, decompensated HF, valvular disease and significant arrhythmia), referral for cardiac work-up and optimization is recommended prior to elective surgery for PAD or AAA.	I	C
Routine referral for cardiac work-up, coronary angiography, or CPET prior to elective surgery for PAD or AAA is not recommended.	III	C

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Recommendations for management of patients with suspected or established carotid artery disease undergoing non-cardiac surgery

Recommendations	Class	Level
Pre-operative carotid artery and cerebral imaging is recommended in patients with a history of TIA or stroke in the previous 6 months who have not undergone ipsilateral revascularization.	I	C
For patients with carotid artery disease undergoing NCS, the same indications for carotid revascularization should be considered as for other patients with carotid stenosis.	IIa	C
Pre-operative carotid artery imaging is not recommended routinely in patients undergoing NCS.	III	C

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Recommendations for management of patients with renal disease undergoing non-cardiac surgery

Recommendations	Class	Level
In patients with renal disease requiring peri-operative contrast-enhanced radiography, a balanced hydration with i.v. isotonic fluids, the use of a minimal volume of contrast media and the use of a minimal volume of contrast media and the use of low-osmolar or iso-osmolar contrast media should be considered.	IIa	B
In patients with known risk factors (age >65 years, BMI >30 kg/m^2, diabetes, hypertension, hyperlipidaemia, CV disease or smoking) undergoing intermediate- or high-risk NCS, it is recommended to screen for pre-operative renal disease measuring serum creatinine and GFR.	I	C
If a cystatin C measurement assay is available, cystatin C measurement should be considered in patients with impaired eGFR (<45–59 mL/min/1.73 m^2) to confirm kidney disease.	IIa	C

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Recommendations for management of patients with obesity undergoing non-cardiac surgery

Recommendations	Class	Level
It is recommended to assess cardiorespiratory fitness to estimate peri-operative CV risk in the obese patient, with particular attention to those undergoing intermediate- and high-risk NCS.	I	B
In patients at high risk of obesity hypoventilation syndrome, additional specialist investigation before major elective NCS should be considered.	IIa	C

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Recommendations for management of patients with diabetes mellitus undergoing non-cardiac surgery

Recommendations	Class	Level
In patients with diabetes or disturbed glucose metabolism, a pre-operative HbA1c test is recommended, if this measurement has been not performed in the prior 3 months. In case of HbA1c ≥8.5% (≥69 mmol/mol), elective NCS should be postponed, if safe and practical.	I	B
A pre-operative assessment for concomitant cardiac conditions is recommended in patients with diabetes with suspected or known CAD and those with autonomic neuropathy, retinopathy, or renal disease and scheduled to undergo intermediate- or high-risk NCS.	I	C

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Factors that could influence peri-operative risk during cancer surgery and preventive strategies

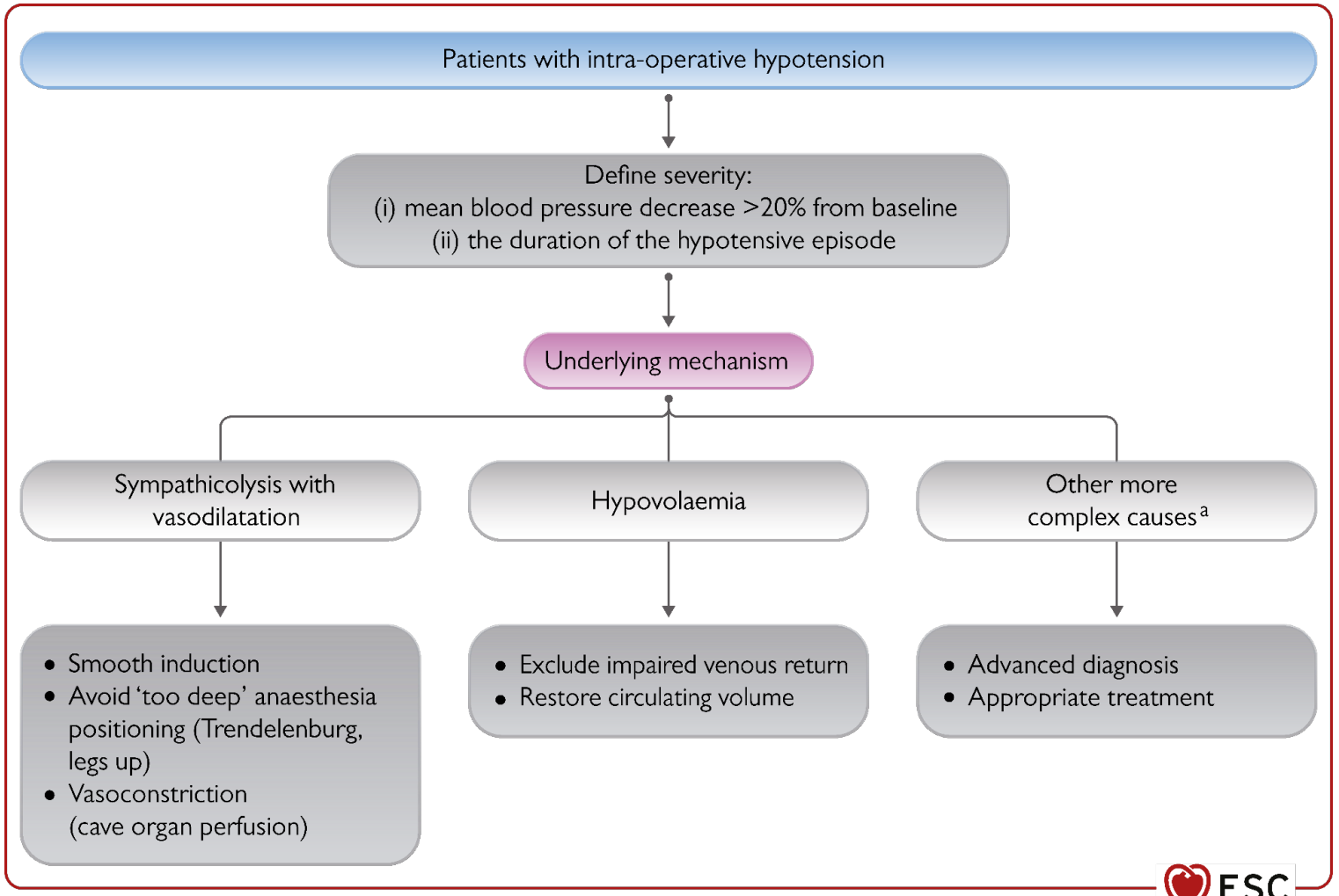
	Factors that could influence peri-operative risk during cancer surgery	Preventive strategies
Patient-related factors	• Lifestyle risk factors—smoking, obesity, sedentary lifestyle • Poorly controlled CV risk factors—hypertension, diabetes • Pre-existing CVD, including cancer therapy-related cardiovascular toxicity • Cardiac medications increasing peri-operative bleeding risk (e.g. antiplatelets and anticoagulants) • Historical primary malignancy • Current cancer type, stage, and location • Arrhythmias (due to myocardial cancer invasion, induced QT-prolongation, AF, or imbalance of autonomic nervous system)	• Optimal management of CV risk factors and CVD • Optimize preventive strategies with respect to VTE and arterial thromboembolic events • ECG monitoring for arrhythmias • Correction of all proarrhythmic conditions
Neoadjuvant cancer therapy	• Previous cardiotoxic cancer treatments (especially anthracycline chemotherapy and/or trastuzumab; immune checkpoint inhibitors, VEGFi, fluoropyrimidine and thoracic radiotherapy) • Cancer treatments increasing peri-operative bleeding risk (e.g. antiangiogenics, BTKi) • Cancer treatments increasing risk of arrhythmias	• Ensure optimal CV monitoring of neoadjuvant therapy • Optimize preventive strategies with respect to VTE and arterial thromboembolic events

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Figure 16

Pathophysiological approach to address intra-operative hypotension



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Recommendations for peri-operative monitoring and anaesthesia

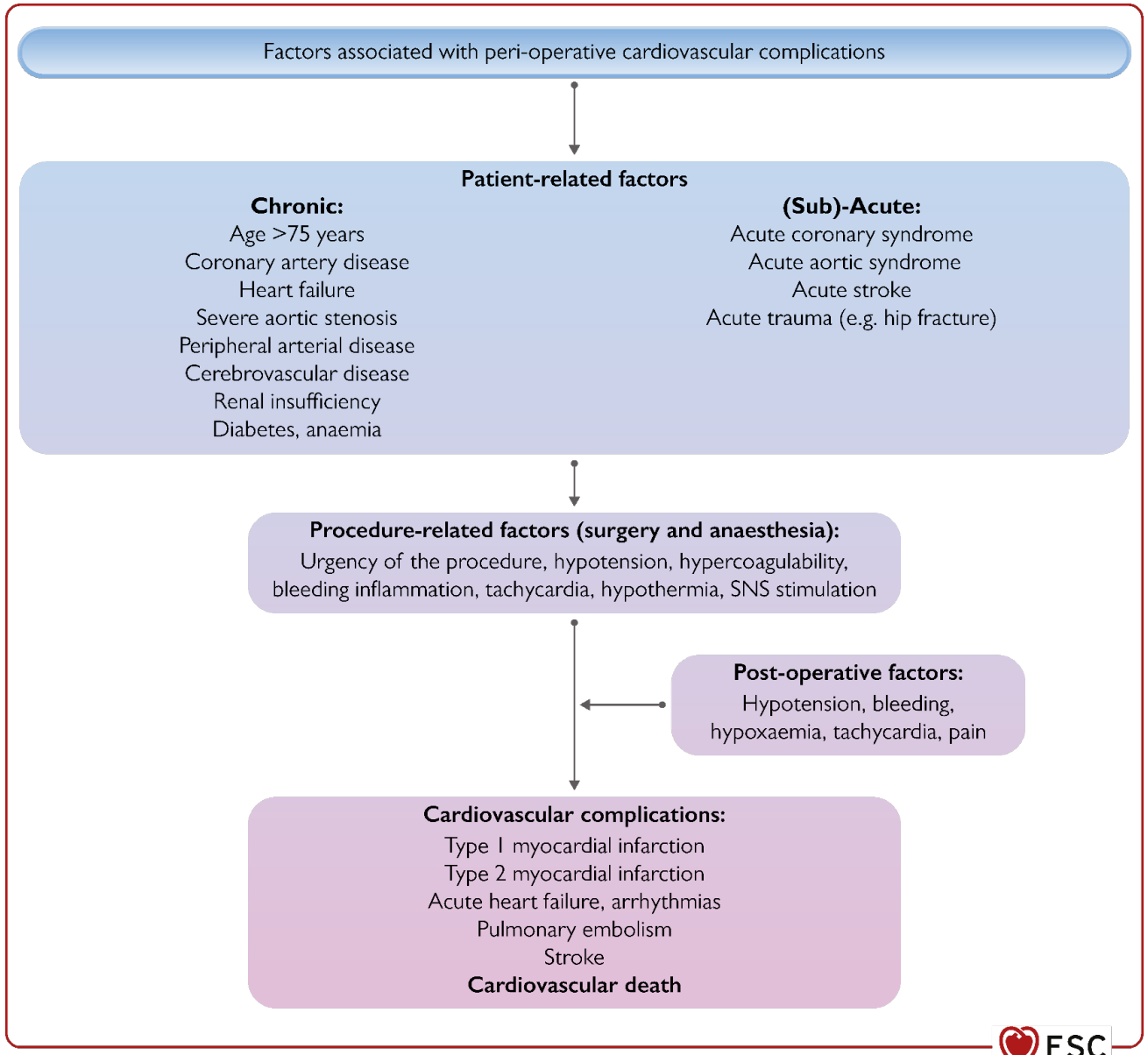
Recommendations	Class	Level
In order to preserve optimal CV stability, it is recommended to apply goal-directed haemodynamic therapy in patients undergoing high-risk NCS.	I	A
It is recommended to avoid post-operative acute pain.	I	B
In order to minimize the risk of post-operative organ dysfunction, it is recommended to avoid intra-operative mean arterial pressure decrease of >20% from baseline values or below 60–70 mmHg for ≥10 min.	I	B
Non-aspirin NSAIDs are not recommended as first-line analgesics in patients with established or high risk of CVD.	III	B

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Figure 17

Factors associated with peri-operative cardiovascular complications

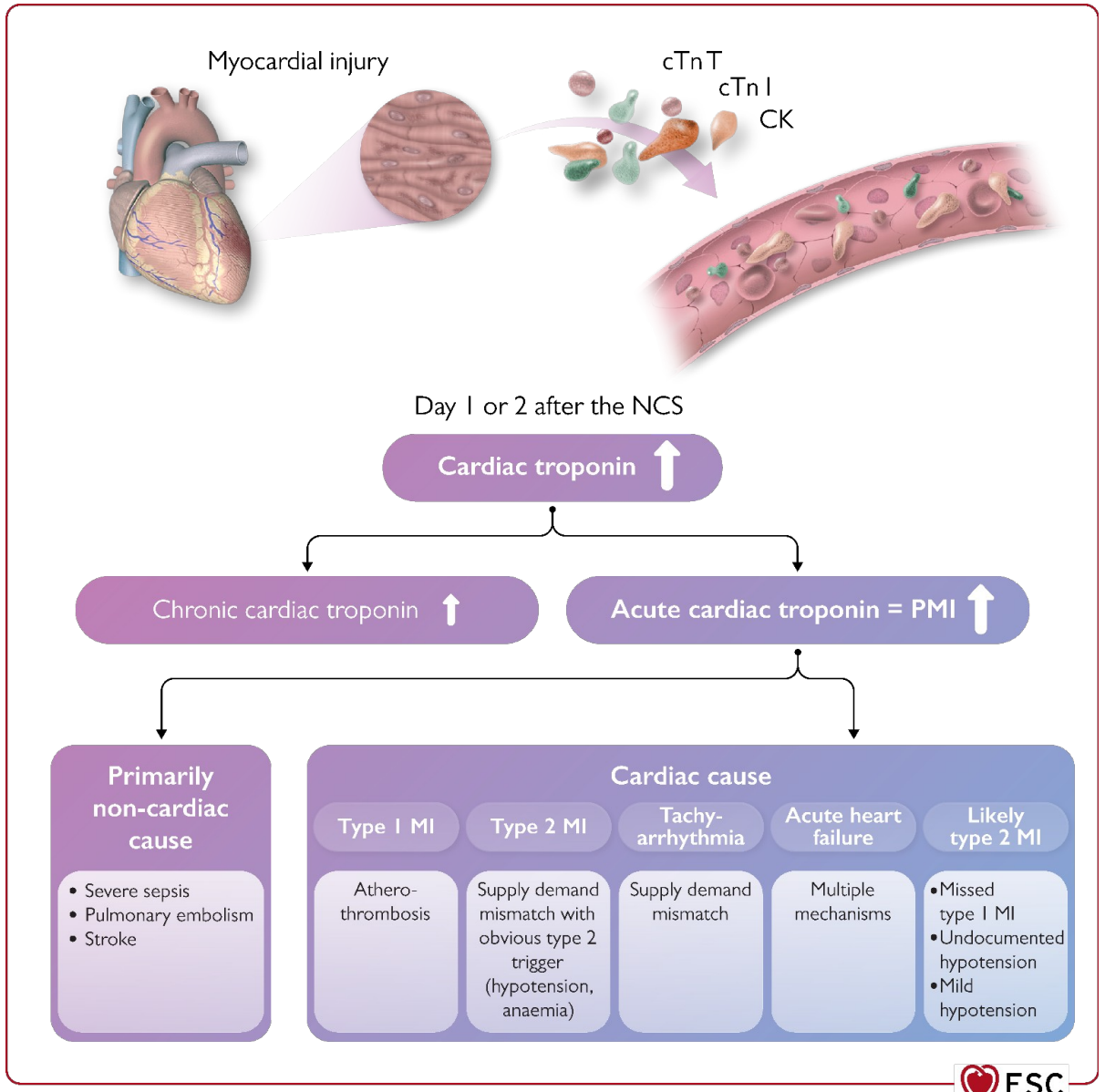


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Figure 18

Differential diagnosis of elevated post-operative cardiac troponin concentrations

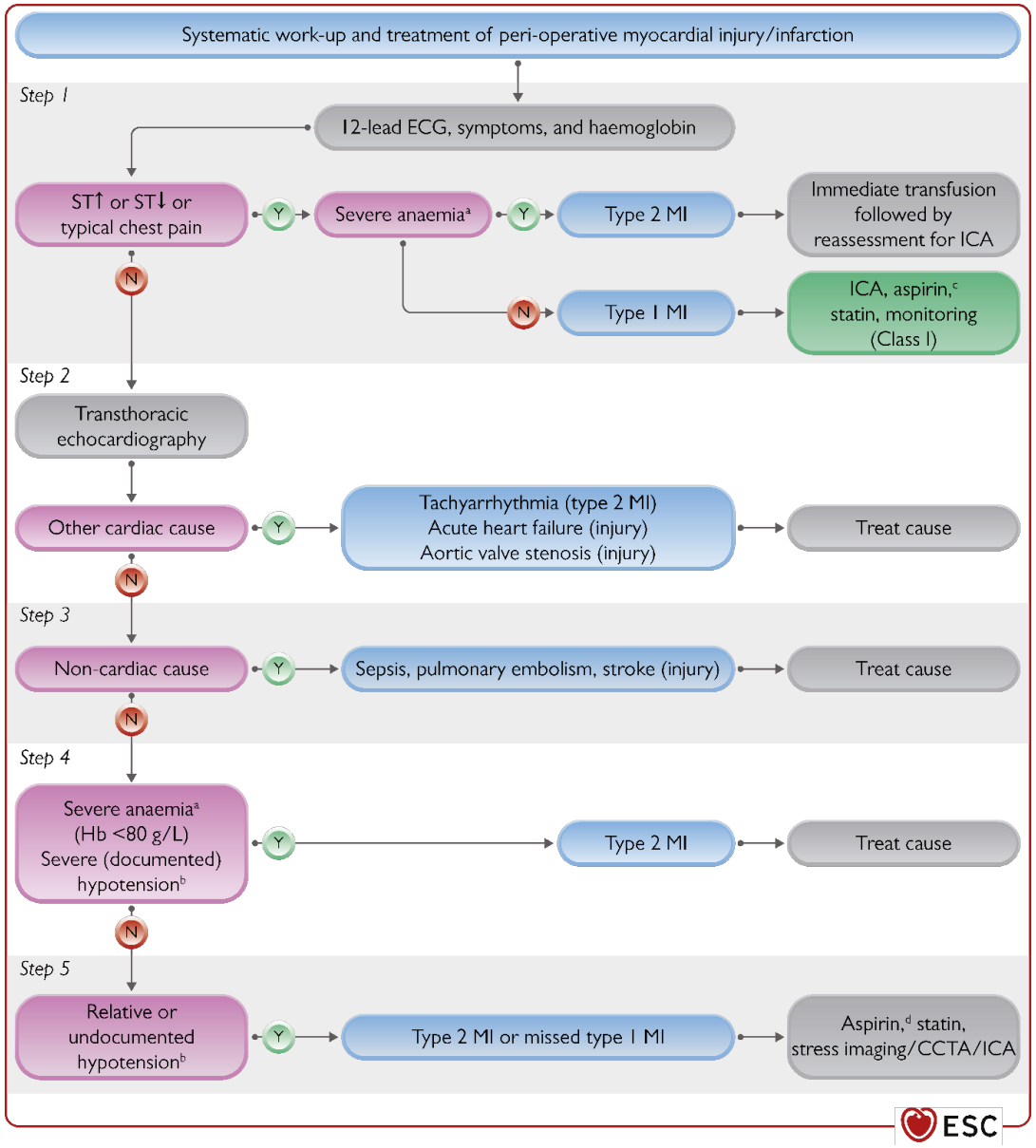


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Figure 19

Systematic work-up (aetiology) and therapy of peri-operative myocardial infarction/injury

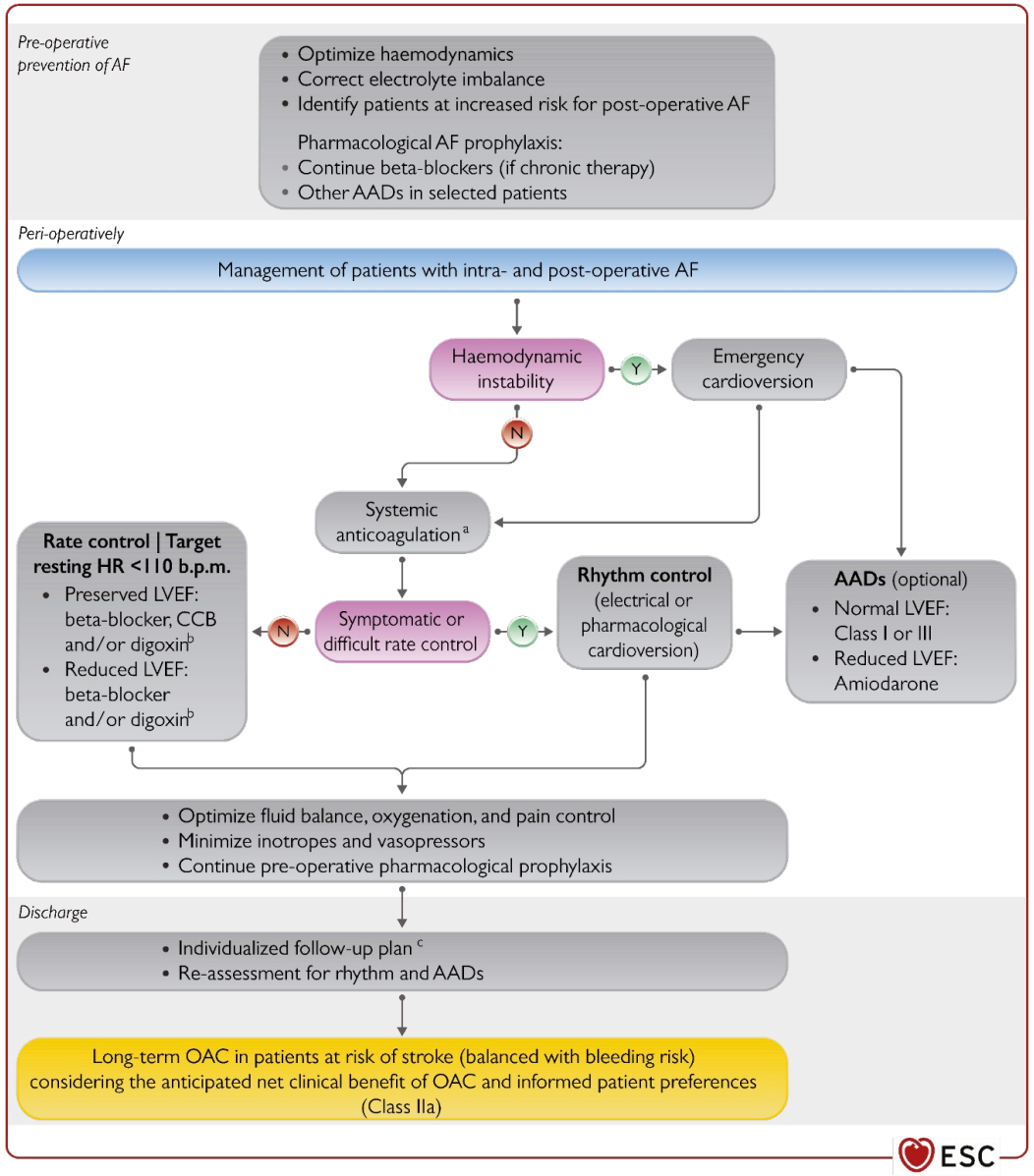


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Figure 20

Prevention and management of post-operative atrial fibrillation



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Recommendations for peri-operative cardiovascular complications (1)

Recommendations	Class	Level
It is recommended to have high awareness for peri-operative CV complications combined with surveillance for PMI in patients undergoing intermediate- or high-risk NCS.	I	B
Systematic PMI work-up is recommended to identify the underlying pathophysiology and to define therapy.	I	B
It is recommended to treat post-operative STEMI, NSTE-ACS, acute HF, and tachyarrhythmias in accordance with guidelines for the non-surgical setting, after interdisciplinary discussion with the surgeon about bleeding risk.	I	C
In patients with post-operative PE of high or intermediate clinical probability, initiation of anticoagulation is recommended without delay, while diagnostic work-up is in progress, if bleeding risk is low.	I	C
Post-operative oral anticoagulation for PE is recommended to be administered for a period of at least 3 months.	I	C

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Recommendations for peri-operative cardiovascular complications (2)

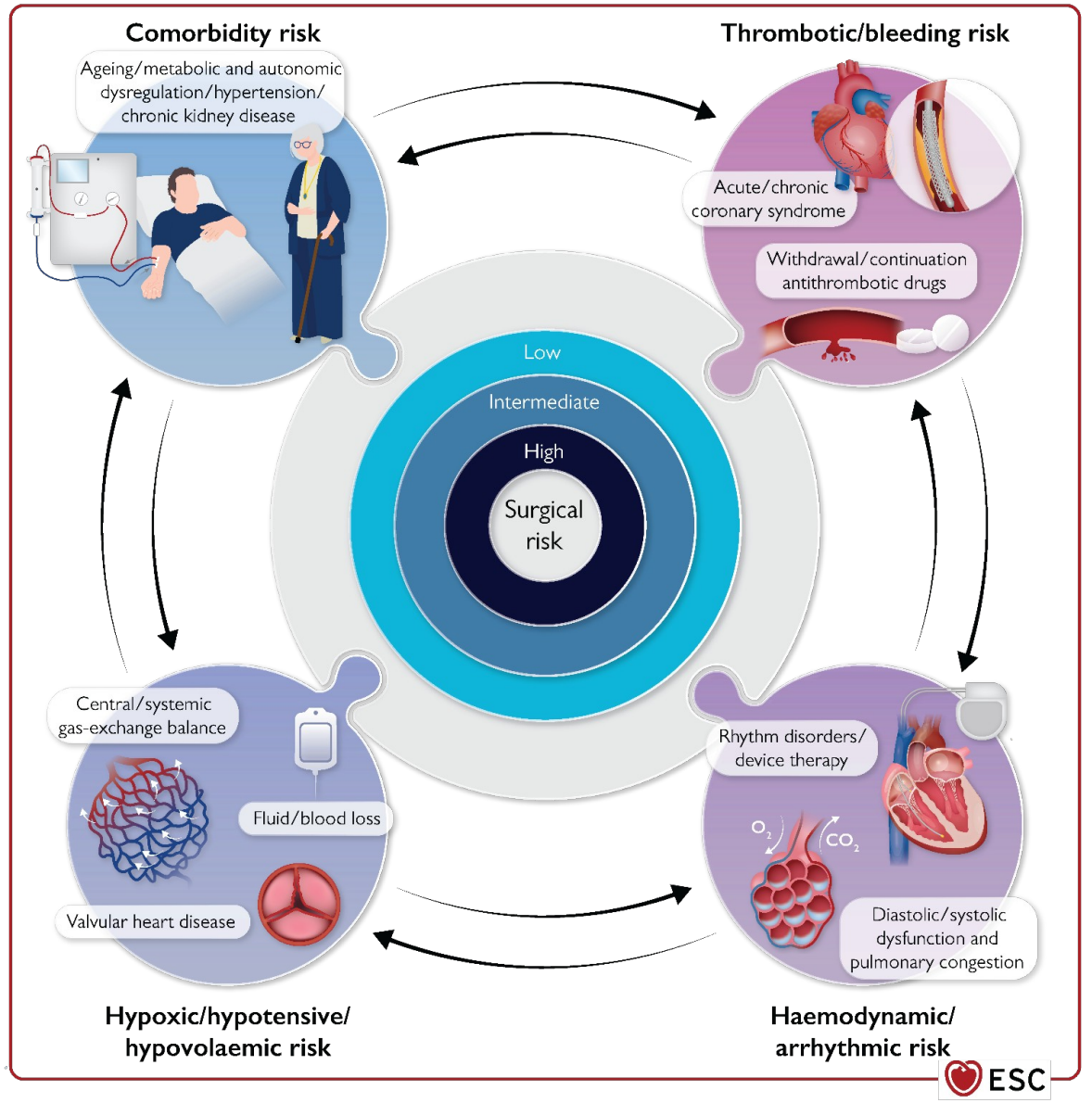
Recommendations	Class	Level
In patients with a post-operative indication for OAC, NOACs are generally recommended over VKA.	I	A
In patients with post-operative AF after NCS, long-term OAC therapy should be considered in all patients at risk for stroke, considering the anticipated net clinical benefit of OAC therapy, as well as informed patient preferences.	IIa	B
In patients with MINS and at low risk of bleeding, treatment with dabigatran 110 mg orally twice daily may be considered from about 1 week after NCS.	IIb	B
Routine use of beta-blocker for the prevention of post-operative AF in patients undergoing NCS is not recommended.	III	B

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Figure 21 Central illustration

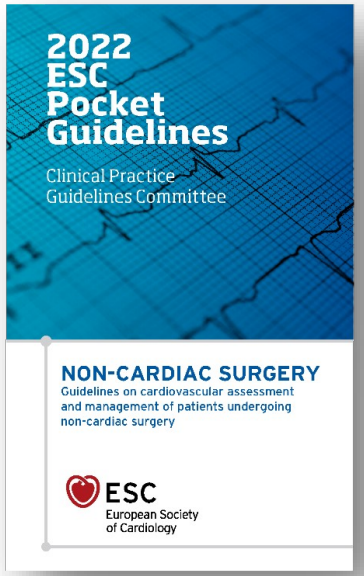
The complex interplay between the intrinsic risk of surgery and the patient risk of peri-operative cardiovascular complications



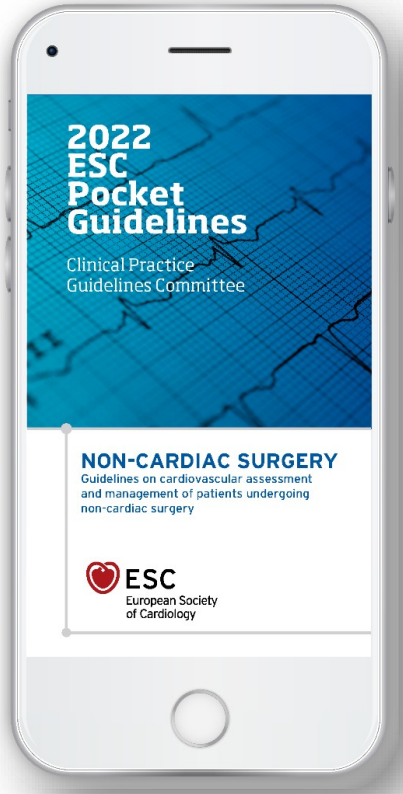
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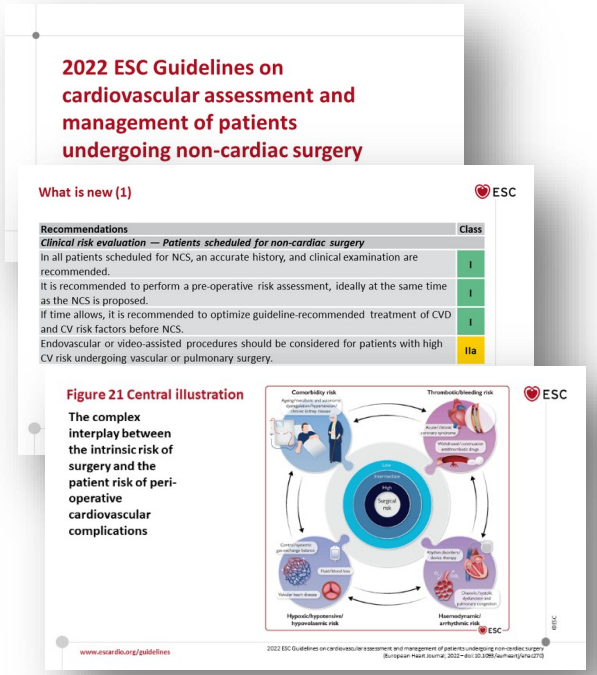
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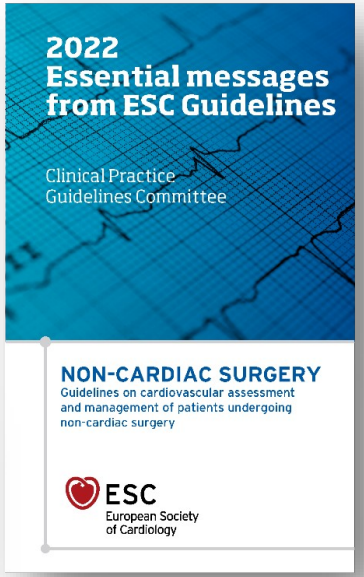
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