British Journal of Hospital Medicine

Cardiovascular assessment for non-cardiac surgery: Updated European Guidelines (2022)

--Manuscript Draft--

Manuscript Number:	hmed.2023.0204
Full Title:	Cardiovascular assessment for non-cardiac surgery: Updated European Guidelines (2022)
Article Type:	Education and training
Corresponding Author:	Daniel Watkin, MbChB Royal Liverpool & Broadgreen Hospitals NHS Trust: Liverpool University Hospitals NHS Foundation Trust Liverpool, UNITED KINGDOM
Corresponding Author Secondary Information:	
Corresponding Author's Institution:	Royal Liverpool & Broadgreen Hospitals NHS Trust: Liverpool University Hospitals NHS Foundation Trust
Corresponding Author's Secondary Institution:	
First Author:	Daniel Watkin
First Author Secondary Information:	
Order of Authors:	Daniel Watkin
	Hugh Montgomery
	Ned Gilbert-Kawai
Order of Authors Secondary Information:	
Abstract:	The 2022 ‘Guidelines on cardiovascular assessment and management of patients undergoing non-cardiac surgery’ published in the European Heart Journal, are intended for physicians involved in the peri-operative care of patients undergoing non-cardiac surgery, in whom heart disease is a potential source of complications. Whilst extremely relevant and useful, their length (99 pages) may limit widespread reading. This article thus offers a precis of the guidelines, highlighting those that we feel are most relevant to medical staff preparing their patients for surgery.

Cardiovascular assessment for non-cardiac surgery: Updated European Guidelines (2022)

Short title: Cardiovascular assessment for non-cardiac surgery: Updated European Guidelines (2022)

Authors:

Daniel Watkin[1]

Hugh Montgomery[2]

Ned Gilbert-Kawai[1]

[1]Royal Liverpool Hospital, Liverpool Foundation Trust, Mount Vernon St, Liverpool L7 8YE

[2]Professor of Intensive Care Medicine, Centre for Human Health and Performance, University College London, London

Corresponding author: Daniel Watkin, danielwatkin@doctors.org.uk, 0151 706 2410

Additional information

Conflict of interest: None

Cardiovascular assessment for non-cardiac surgery:

Updated European Guidelines (2022)

Abstract

The 2022 'Guidelines on cardiovascular assessment and management of patients undergoing non-cardiac surgery' published in the European Heart Journal, are intended for physicians involved in the peri-operative care of patients undergoing non-cardiac surgery, in whom heart disease is a potential source of complications. Whilst extremely relevant and useful, their length (99 pages) may limit widespread reading. This article thus offers a precis of the guidelines, highlighting those that we feel are most relevant to medical staff preparing their patients for surgery.

Key words

Cardiology; Anaesthesia; Surgery; Assessment; Management

Key points

1. The incidence of cardiac complications after non-cardiac surgery depends on the interaction between the type of surgery and the circumstances under which it occurs, and patient-related risk factors.

2. Surgical interventions can be divided into those associated with low-, intermediate- and high-cardiac risk.

3. Preoperative cardiac evaluation must be tailored to the patient and surgical urgency.

4. Cardiac imaging should be performed only where results would influence management.

5. Continuing, ceasing, or interrupting dual antiplatelet therapy in those with coronary stents is complex and individualised, and interdisciplinary assessment must be made weighing risk of surgical bleeding against life-threatening stent thrombosis.

Introduction

Of the ~300 million patients undergoing major surgery worldwide annually, the prevalence of cardiovascular disease is increasing. To improve peri-operative outcomes, the European Society of Cardiology (ESC) has updated their 'Guidelines on cardiovascular assessment and management of patients undergoing non-cardiac surgery [NCS]'. Here, we provide a markedly abridged version to accompany, but not replace, them. In doing so, and to make them most relevant to those working on the medical wards, we have omitted a number of sections, including those relating to 'Specific diseases', 'Peri-operative monitoring and anaesthesia', and 'Peri-operative cardiovascular complications'. These should be referred to in the original article.

Clinical risk evaluation

The incidence of cardiac complications after NCS depends on (i) the type of surgery/procedure, and (ii) patient-related risks. Risk can be reduced by comprehensive pre-operative assessment and decision making.

Timing and type of surgery

Risk varies with the surgical intervention (Table 1), being generally greater for acute as opposed to elective procedures.

Table 1: 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 • Superficial surgery • Minor urological, orthopaedic, gynaecological procedures	• Coronary artery stenting/endarterectomy • Endovascular aortic aneurysm repair • Head and neck surgery • Hip and spinal surgery • Renal transplant • Peripheral arterial angioplasty • Major urological or gynaecological tumour	• Adrenal resection • Aortic and major vascular surgery • Duodenal and pancreatic surgery • Liver resection and bile duct surgery • Oesophagectomy • Open lower limb revascularisation, amputation • Pneumonectomy • Lung, liver transplant

		• Repair of perforated bowel • Total cystectomy
Legend: Surgical interventions can be classified as being associated with low, intermediate, and high cardiac risk (30-day risk of cardiovascular death, myocardial infarction, and stroke).		

Laparoscopy tends to cause less tissue trauma / intestinal paralysis than open surgery, however because pneumoperitoneum reduces venous return by raising intra-abdominal pressure, it doesn't necessarily reduce cardiovascular (CV) risk in patients with congenital heart disease, obesity, and cardiovascular disease (CVD). Benefits are probably greatest in elderly patients (reduced length of hospital stay, intra-operative blood loss and incidence of post-operative pneumonia/cardiac complications). In patients with high cardiovascular risk undergoing vascular or pulmonary surgical procedures, endovascular or video-assisted surgery may improve outcomes.

Patient related risk

Patient-related risk is determined by age, established cardiovascular disease or risk factors (e.g., smoking, hypertension, diabetes, dyslipidaemia, family disposition), and other comorbidities. All patients scheduled for NCS should have comprehensive pre-operative assessment including a thorough history, examination, and be given advice on smoking cessation and guideline-directed medical therapy (see 'pharmacological' section). Further cardiac evaluation must be tailored to the patient and surgical urgency as per Table 2.

Table 2: Management of patients before non-cardiac surgery

	<65 years with no CV risk factors	**≥65 years, CV risk factors, or signs of CVD**	**Established CVD**
Low risk NCS	No further tests	No further tests	No further tests
Medium risk NCS	No further tests	ECG (pre-op) Biomarkers (pre- and post-op)[a] Functional capacity assessment[b]	ECG (pre-op) Biomarkers (pre- and post-op)[a] Functional capacity assessment[b]
High risk NCS	Consider ECG, biomarkers if >45years	ECG (pre-op) Biomarkers (pre- and post-op)[a] Functional capacity assessment[b]	ECG (pre-op) Biomarkers (pre- and post-op)[a] Functional capacity assessment[b] Cardiology consultation and multidisciplinary decision making

Legend: Management of patients before non-cardiac surgery. CV, cardiovascular; CVD, cardiovascular disease; NCS, non-cardiac surgery; ECG, electrocardiogram.

[a]Biomarkers/ECG: In patients who have known CVD) or CV risk factors, it is recommended to obtain a pre-operative 12-lead ECG, and measure hs-cTn T or hs-cTn I before NCS, and at 24 and 48 hours afterwards. Consider measuring BNP levels pre-operatively.

[b]Functional capacity: Consensus guidelines recommend assessing functional capacity based on the Duke Activity Status Index (DASI) or the ability to climb two flights of stairs. Surgical risk classified as per Table 1.

Patients with murmurs, chest pain, dyspnoea, or peripheral oedema

In patients with a newly detected cardiac murmur, transthoracic echocardiography (TTE) is recommended in those with symptoms or signs of CVD. In those without evidence of CVD, TTE may be considered depending on history obtained. In patients with chest pain, dyspnoea, or peripheral oedema, further tests should include TTE and serum NT-proBNP/BNP.

Pre-operative assessment tools

Risk scores

While several risk indices exist (including the 'Revised Cardiac Risk Index' and 'Surgical Outcome Risk Tool'), no single one is specifically recommended: the decision for further pre-operative testing should be based on clinical criteria as opposed to a specific score.

Assessment of frailty

Frailty (diminished physiological reserve) is an excellent predictor of unfavourable post-operative outcomes. The simplest assessment tool is the Clinical Frailty Scale (validated against the more complex Frailty Index). Shared decision making between relevant multi-disciplinary team members, the patient and relatives is crucial. Multimodal, holistic pre-habilitation programmes, including exercise, nutrition, and psychological interventions could improve outcomes.

Functional capacity

Quantifying functional capacity is fundamental to pre-operative cardiac risk assessment. 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.

Electrocardiography and Biomarkers

All patients ≥65, and those with CV risk factors undergoing intermediate- or high-risk surgery, should have (i) a 12-lead ECG (a cheap screening tool for previous myocardial infarction [indicated by Q waves] or arrhythmias), and (ii) measurement of high sensitivity troponin pre- and post (at 24h and 48h) surgery to rule out myocardial ischaemia. Even mild increases in baseline troponin are associated with a significant increase in hospital mortality following elective NCS (6.2% versus 1.9%) and should be investigated further.

Non-invasive and invasive procedures

Routine pre-operative CV risk evaluation using TTE, stress testing and imaging, and angiography should be limited to those who would benefit in the non-surgical setting e.g., poor functional capacity or exercise tolerance, unexplained dyspnoea, a raised BNP, or previously uncharacterised murmurs (as indications for echo), and patients with a high likelihood of coronary artery disease (for stress imaging and angiography).

General risk reduction strategies

Lifestyle interventions, including the control of cardiovascular risk factors (e.g., blood pressure, dyslipidaemia, and diabetes) and smoking cessation at least >4 weeks pre-operatively is recommended prior to NCS.

Pharmacological

Surgery/anaesthesia may trigger cardiac ischaemia through mismatched oxygen supply and demand and therefore a close review of peri-operative medications is necessary.

Beta-blockers

Beta-blockers decrease myocardial oxygen consumption by reducing heart rate and myocardial contractility, are effective anti-arrhythmic agents, and inhibit neutrophil hyperactivation. Established beta-blocker therapy should generally be continued peri-operatively. Pre-operative initiation remains controversial, but bisoprolol or atenolol should be considered in patients with high CV risk profiles having high-risk surgical interventions, being initiated $\geq$1 week pre-operatively and up-titrated to achieve a resting heart rate of 60-70bpm and a systolic blood pressure >100mmHg.

Amiodarone

Amiodarone reduces the risk of post-operative atrial fibrillation by 58% following NCS, and may be more effective with beta-blocker co-prescription. However, the clinical benefits of its routine use are unclear.

Statins

Established therapy should be continued peri-operatively, but initiation in the absence of a standard indication is not recommended.

Renin–angiotensin–aldosterone system inhibitors

Data on peri-operative use of renin–angiotensin–aldosterone system (RAAS) inhibitors are inconclusive. Continuation risks intra-operative hypotension and vasopressor use, and the potential for end organ damage (kidney injury, myocardial damage, stroke). Withholding them risks post-operative hypertension. Guidance suggests withholding on the day of surgery for patients without heart failure (to prevent peri-operative hypotension), and consideration of peri-operative continuation in patients with stable heart failure. RAAS inhibitors should be restarted as soon as possible after surgery.

Calcium channel blockers (CCBs)

The effects of calcium channel blockers (CCBs) on the balance between myocardial oxygen supply and demand makes them theoretically suitable for risk-reduction strategies. However, data are few. Continuing their perioperative use in patients established on them (particularly for vasospastic angina) is suggested, omitting the dose on the morning of surgery.

Diuretics

When used to treat hypertension, transient discontinuation on the day of NCS should be considered, with resumption as soon as possible post-operatively. When used to treat heart failure, dosage should be adjusted well in advance for an optimal fluid balance for surgery, with fluid balance closely monitored post-operatively and optimised with loop diuretics or fluids. Electrolyte disturbances are

commonly associated with arrhythmias: any electrolyte abnormalities should thus be corrected pre-operatively.

Sodium-glucose co-transporter-2 (SGLT-2) inhibitors

SGLT-2 inhibitor use in patients with type 2 diabetes is increasing. In light of a small but significant associated risk of euglycaemic diabetic ketoacidosis (DKA), omission for at least 3 days pre-operatively and vigilance for euglycaemic DKA (including measurement of ketones) is recommended.

Antithrombotic agents

Management of patients taking antithrombotic agents requires multidisciplinary individualised consideration of thrombotic vs procedural bleeding risk (Table 3). It is exceedingly complex, and we advise referring to the full text for specific questions.

Table 3: Bleeding risk according to type of non-cardiac surgery.

Surgery with minor bleeding risk	Low bleeding risk (infrequent with low clinical impact)	Surgery with high bleeding (frequent or with significant clinical impact)
• Cataract or glaucoma procedures • Dental procedures (minor) • Endoscopy (without biopsy or resection) • Superficial surgery	• Abdominal surgery: cholecystectomy, hernia repair, bowel resection • Breast surgery • Complex dental procedures • Endoscopy with biopsy • Gastroscopy or colonoscopy with simple biopsy • Large-bore needle procedures (e.g., bone marrow biopsy, lymph node biopsy) • Non-cataract ophthalmic surgery • Small orthopaedic surgery (foot, hand, arthroscopy)	• Abdominal surgery: Liver biopsy • Extensive cancer surgery (e.g., pancreas, liver) • Spinal anaesthesia • Neurosurgery • Major orthopaedic surgery • Vascular organ biopsy (kidney, prostate) • Reconstructive plastic surgery • Specific interventions (lumbar puncture, endovascular aneurysm repair, polypectomy) • Thoracic surgery • Prostatectomy, bladder tumour resection

		• Vascular surgery (AAA repair, vascular bypass)
Legend: Bleeding risk according to type of non-cardiac surgery		

Single antiplatelet therapy

Risk of post-operative ischaemic events is low in patients taking aspirin monotherapy for primary prevention, and aspirin can be safely interrupted for 3-7 days. Permanent discontinuation of aspirin may be appropriate in patients with low- and moderate-risk atherosclerotic cardiovascular disease according to ESC guidance (ESC Scientific Document Group 2022).

For secondary prevention, an interruption of $\geq$ 3 days can be considered for low bleeding risk (LBR) procedures, and for $\geq$ 7 days for high bleeding risk (HBR) procedures (table 3). In patients who have had a previous percutaneous coronary intervention (PCI), peri-operative aspirin should be continued (in the absence of HBR), to reduce the incidence of post-operative myocardial infarction.

For patients on clopidogrel monotherapy for chronic coronary syndrome, interruption is recommended in patients with HBR. $P2Y_{12}$ inhibitors may also be used as a part of de-escalation strategy post PCI, acute coronary syndrome (ACS), recent stroke or peripheral arterial disease, and careful interdisciplinary evaluation of bleeding vs ischaemic risk is required. Notably, the effects of ticagrelor or clopidogrel monotherapy on haemostasis are considerably less than when coupled with aspirin.

Dual antiplatelet therapy

Dual antiplatelet therapy (i.e., aspirin+$P2Y_{12}$ inhibitor) is recommended after PCI. Around 4% of these patients undergo NCS in the first year post-PCI, with a significant risk (2-8%) of major adverse cardiac events including stent thrombosis, myocardial infarction, and cardiac death. Individualised antiplatelet therapy management should therefore be discussed between surgeon, anaesthetist, and cardiologist.

In post-PCI DAPT use, ideally delay elective NCS until full DAPT course completion (e.g., 6 months after elective PCI, 12 months post ACS PCI). For time-sensitive surgery, ideally delay for at least 1 month for elective PCI, and 3 months for emergency PCI following ACS/non-ST elevation ACS, or those with a high risk of stent thrombosis. At this point, $P2Y_{12}$ inhibitors should be interrupted (Ticagrelor 3-5 days,

clopidogrel 5 days, prasugrel 7 days), and wherever possible aspirin should continue through the peri-operative period.

When time-sensitive surgery cannot be postponed, de-escalation or shorting of DAPT is recommended. The guidelines are complicated, and we suggest referring to the full text. Aspirin should generally be continued as above. Expert advice to determine the most appropriate management is imperative.

On all occasions, consider restarting therapy as soon as possible (within 48 hours) post-surgery, according to interdisciplinary risk assessment.

Oral anticoagulants

Approximately one-in-four patients taking oral anticoagulant therapy will require a surgical or invasive procedure within two years. Peri-operative drug management depends on the surgery type, patient-related factors, and the specific anticoagulant agent. Consensus guidance is complicated, and we suggest referring to the full text and having a low threshold to seek specialist advice if unclear.

Vitamin K antagonists (VKAs)

Within this abridged text, we describe the management of warfarin given that this is the most clinically relevant VKA. Mechanical heart valves have an inherently high thrombotic risk, and anticoagulation is crucial. Consider undertaking minor surgical procedures without interruption of warfarin. Notably nuances exist dependent on the specific valve replaced (aortic/mitral) and the type of prosthesis used, so expert opinion should be sought. For major surgical procedures requiring an international normalised ratio (INR) ≤1.5, interruption of warfarin (with low molecular weight heparin [LMWH] or unfractionated heparin bridging) should also be considered (Table 4).

For patients taking warfarin for other reasons (e.g., atrial fibrillation [AF] or venous thromboembolism [VTE]), low bleeding risk procedures can be undertaken without warfarin interruption. For HBR procedures in low thrombotic risk patients, interruption for 3-5 days is necessary (until INR ≤1.5). Bridging isn't generally recommended due to increased risk of major bleeding without reduction in VTE, however in high thrombotic risk patients (e.g., recent stroke < 3 months, high risk of VTE recurrences, left ventricular apex thrombus, AF with a very high stroke risk based on CHA_2DS_2-VASc score (Gage et al. 2001), bridging may be considered with specialist advice. If the thrombotic risk is likely to decrease with time, deferral of surgery may be appropriate.

Where VKA treatment is interrupted before surgery, anticoagulation should restart (150% of the normal dose for two days) 12-24 hours following post-operatively if bleeding is controlled and gastric absorption satisfactory. After bridging therapy, anticoagulation should restart 24 hours post-operatively, and bridging continued until a therapeutic INR is achieved. In HBR procedures, therapeutic anticoagulation should be delayed for 48-72 hours following intervention.

Table 4: Management of warfarin in the peri-operative period

	Mechanical heart valve[a], or other reason for high thrombotic risk[b]	**Low thrombotic risk**
Minor or low surgical bleeding risk	Consider performing minor surgical procedures with INR in the lower level of target range or following a short interruption (3-5 days). Bridging is not recommended.	
High surgical bleeding risk	Mechanical heart valve: consider bridging with expert advice. In other high thrombotic risk patients[b] with a high bleeding risk, consider bridging with LMWH or unfractionated heparin, or deferring NCS if appropriate[c].	Consider interrupting VKA for 3-5 days. Bridging is not recommended.

Legend: Recommendations for management of warfarin therapy in patients undergoing non-cardiac surgery. AVR, Aortic valve replacement; INR, International normalised ratio; LMWH, low molecular weight heparin; NCS, non-cardiac surgery; VKA, vitamin K antagonist. Bleeding risk as per Table 3.

[a]Mechanical heart valve replacement (AVR) and any thromboembolic risk factor, or older-generation mechanical AVR, or a mechanical mitral valve replacement.

[b]Recent stroke < 3 months, high risk of VTE recurrences, left ventricular apex thrombus, atrial fibrillation with a very high stroke risk based on CHA_2DS_2-VASc (Gage et al, 2001).

[c] i.e., 3 months after stroke/venous thromboembolism.

The guidance is complicated, due differences in surgical bleeding risk and thrombotic risk dependent on the indication.

Non-vitamin K oral anticoagulants (NOACs)

These (e.g., dabigatran [Factor IIa inhibitor], apixaban, rivaroxaban, and edoxaban [Factor Xa inhibitor]) have short biological half-lives and a well-defined 'on' and 'off' action providing renal function is normal. 'Bridging' to surgery is therefore unnecessary, except in extremely high thrombotic risk states (thromboembolic event [stroke or VTE] < 3 months, or previous thromboembolic event during interruption of NOAC therapy).

Renal function must be reviewed as longer interruptions are necessary in states of chronic kidney disease. The management of NOACs peri-operatively is dependent on surgical bleeding risk (Table 5).

In general, NOACs can be restarted 6-8 hours postoperatively where rapid and complete haemostasis was attained. Where post-operative bleeding risk outweighs thrombotic risk, NOACs can be withheld for 48-72 hours (with bridging prophylactic LMWH).

Table 5: Management of NOAC therapy dependent on surgical bleeding risk

Bleeding Risk	Recommendation
Minor	Perform surgery without interruption of NOAC therapy. Procedures should be conducted at times that coincide with NOAC at trough levels (typically 12–24 hours after last administration).
Low	NOACs should be interrupted. This normally involves omission of NOAC the day prior to surgery and re-starting it the evening following surgery, however it is dependent on both the renal function and specific NOAC used.
High	NOACs should be omitted for up to five half-lives (3-5 days depending on the specific NOAC) prior to high bleeding risk procedures (e.g., spinal anaesthesia). Resumption of NOACs can be considered at 48 -72 hours post-surgery. Prophylactic LMWH may be appropriate in the interim.
Legend: Management of NOAC therapy dependent on surgical bleeding risk. Bleeding risk as per table 3. NOAC, non-vitamin K oral anticoagulants; LMWH, low molecular weight heparin.	

Reversal of anticoagulant therapy

Vitamin K antagonists

Reversal can be achieved using oral or intravenous vitamin K, prothrombin complex concentrates (PCC) or fresh frozen plasma (FFP), reducing INR over 18-24 hours, 4-6 hours, and immediately, respectively.

Non-vitamin K antagonist oral anticoagulants

Manage bleeding with symptomatic and supportive measures. Seek haematological advice early: specific reversal agents include Idarucizumab (Praxbind) for Dabigatran, and Andexanet Alpha for Xa inhibitors. In their absence, PCC, recombinant factor VIIa and haemodialysis may offer benefit.

Heparin

The anticoagulant effects of unfractionated heparin or LMWH are usually negated within 4-8 hours of stopping treatment. Protamine sulphate can immediately reverse the action of unfractionated heparin, however the anti-Xa activity of LMWH will not be completely neutralized (maximum 50%).

Peri-operative thromboprophylaxis

Mortality from peri-operative VTE has declined over the past few decades. It is now thought that peri operative VTE should be regarded as a markers of increased mortality risk, rather than as a causal factor.

Thromboprophylaxis should be considered in patients with Caprini VTE risk stratification scores ≥ 5 based on a number of surgical and patient related factors (Caprini 2010). Generally, thromboprophylaxis should be given pre- and post-operatively until hospital discharge. Extended post-

operative thromboprophylaxis should be considered for orthopaedic procedures (hip and knee arthroplasty).

Patient blood management

Major surgery is associated with a high risk of blood loss, and even mild anaemia is associated with increased morbidity/prolonged hospital admission.

Correcting pre-operative anaemia

Haemoglobin should be measured pre-operatively for intermediate- and high-risk NCS. Most causes of anaemia can be diagnosed and corrected in the 2-4 weeks preoperatively. Iron deficiency (the cause of anaemia in ~50% cases), should be addressed, and oral or intravenous iron prescribed.

Reduction of intra-operative blood loss

This begins with pre-operative management of antiplatelet/anticoagulant medication. Intra-operatively minimally invasive surgical techniques and judicious diathermy use should be considered, with cell salvage for operations with anticipated blood loss ≥ 500mLs. Tranexamic acid should be considered in cases of major bleeding

Conclusions

Both surgical and patient-related factors determine the risk of cardiac complications after non-cardiac surgery. Individualised pre-operative assessment, including a comprehensive history and examination must be utilised, and appropriate strategies used to reduce the risk of peri-operative morbidity and mortality.

References:

Caprini, J. A. 2010. Risk assessment as a guide for the prevention of the many faces of venous thromboembolism. The American Journal of Surgery, 199(1): S3-S10.

ESC Scientific Document Group. 2022. 2021 ESC Guidelines on cardiovascular disease prevention in clinical practice. European Journal of Preventive Cardiology, 29(1): 5-115.

Gage, B. F., Waterman, A. D., Shannon, W., Boechler, M., Rich, M. W., & Radford, M. J. 2001. Validation of clinical classification schemes for predicting stroke: results from the National Registry of Atrial Fibrillation. Jama, 285(22): 2864-2870.

Table 1: 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 • Superficial surgery • Minor urological, orthopaedic, gynaecological procedures	• Coronary artery stenting/endarterectomy • Endovascular aortic aneurysm repair • Head and neck surgery • Hip and spinal surgery • Renal transplant • Peripheral arterial angioplasty • Major urological or gynaecological tumour	• Adrenal resection • Aortic and major vascular surgery • Duodenal and pancreatic surgery • Liver resection and bile duct surgery • Oesophagectomy • Open lower limb revascularisation, amputation • Pneumonectomy • Lung, liver transplant • Repair of perforated bowel • Total cystectomy
Legend: Surgical interventions can be classified as being associated with low, intermediate, and high cardiac risk (30-day risk of cardiovascular death, myocardial infarction, and stroke).		

Table 2: Management of patients before non-cardiac surgery

	<65 years with no CV risk factors	**≥65 years, CV risk factors, or signs of CVD**	**Established CVD**
Low risk NCS	No further tests	No further tests	No further tests
Medium risk NCS	No further tests	ECG (pre-op) Biomarkers (pre- and post-op)[a] Functional capacity assessment[b]	ECG (pre-op) Biomarkers (pre- and post-op)[a] Functional capacity assessment[b]
High risk NCS	Consider ECG, biomarkers if >45years	ECG (pre-op) Biomarkers (pre- and post-op)[a] Functional capacity assessment[b]	ECG (pre-op) Biomarkers (pre- and post-op)[a] Functional capacity assessment[b] Cardiology consultation and multidisciplinary decision making

Legend: Management of patients before non-cardiac surgery. CV, cardiovascular; CVD, cardiovascular disease; NCS, non-cardiac surgery; ECG, electrocardiogram.

[a]Biomarkers/ECG: In patients who have known CVD) or CV risk factors, it is recommended to obtain a pre-operative 12-lead ECG, and measure hs-cTn T or hs-cTn I before NCS, and at 24 and 48 hours afterwards. Consider measuring BNP levels pre-operatively.

[b]Functional capacity: Consensus guidelines recommend assessing functional capacity based on the Duke Activity Status Index (DASI) or the ability to climb two flights of stairs. Surgical risk classified as per Table 1.

Table 3: Bleeding risk according to type of non-cardiac surgery.

Surgery with minor bleeding risk	Low bleeding risk (infrequent with low clinical impact)	Surgery with high bleeding (frequent or with significant clinical impact)
• Cataract or glaucoma procedures • Dental procedures (minor) • Endoscopy (without biopsy or resection) • Superficial surgery	• Abdominal surgery: cholecystectomy, hernia repair, bowel resection • Breast surgery • Complex dental procedures • Endoscopy with biopsy • Gastroscopy or colonoscopy with simple biopsy • Large-bore needle procedures (e.g., bone marrow biopsy, lymph node biopsy) • Non-cataract ophthalmic surgery • Small orthopaedic surgery (foot, hand, arthroscopy)	• Abdominal surgery: Liver biopsy • Extensive cancer surgery (e.g., pancreas, liver) • Spinal anaesthesia • Neurosurgery • Major orthopaedic surgery • Vascular organ biopsy (kidney, prostate) • Reconstructive plastic surgery • Specific interventions (lumbar puncture, endovascular aneurysm repair, polypectomy) • Thoracic surgery • Prostatectomy, bladder tumour resection • Vascular surgery (AAA repair, vascular bypass)
Legend: Bleeding risk according to type of non-cardiac surgery		

Table 4: Management of warfarin in the peri-operative period

	Mechanical heart valve[a], or other reason for high thrombotic risk[b]	**Low thrombotic risk**
Minor or low surgical bleeding risk	Consider performing minor surgical procedures with INR in the lower level of target range or following a short interruption (3-5 days). Bridging is not recommended.	
High surgical bleeding risk	Mechanical heart valve: consider bridging with expert advice. In other high thrombotic risk patients[b] with a high bleeding risk, consider bridging with LMWH or unfractionated heparin, or deferring NCS if appropriate[c].	Consider interrupting VKA for 3-5 days. Bridging is not recommended.

Legend: Recommendations for management of warfarin therapy in patients undergoing non-cardiac surgery. AVR, Aortic valve replacement; INR, International normalised ratio; LMWH, low molecular weight heparin; NCS, non-cardiac surgery; VKA, vitamin K antagonist. Bleeding risk as per Table 3.

[a]Mechanical heart valve replacement (AVR) and any thromboembolic risk factor, or older-generation mechanical AVR, or a mechanical mitral valve replacement.

[b]Recent stroke < 3 months, high risk of VTE recurrences, left ventricular apex thrombus, atrial fibrillation with a very high stroke risk based on CHA_2DS_2-VASc (Gage et al, 2001).

[c] i.e., 3 months after stroke/venous thromboembolism.

The guidance is complicated, due differences in surgical bleeding risk and thrombotic risk dependent on the indication.

Table 5: Management of NOAC therapy dependent on surgical bleeding risk

Bleeding Risk	Recommendation
Minor	Perform surgery without interruption of NOAC therapy. Procedures should be conducted at times that coincide with NOAC at trough levels (typically 12–24 hours after last administration).
Low	NOACs should be interrupted. This normally involves omission of NOAC the day prior to surgery and re-starting it the evening following surgery, however it is dependent on both the renal function and specific NOAC used.
High	NOACs should be omitted for up to five half-lives (3-5 days depending on the specific NOAC) prior to high bleeding risk procedures (e.g., spinal anaesthesia). Resumption of NOACs can be considered at 48 -72 hours post-surgery. Prophylactic LMWH may be appropriate in the interim.
Legend: Management of NOAC therapy dependent on surgical bleeding risk. Bleeding risk as per table 3. NOAC, non-vitamin K oral anticoagulants; LMWH, low molecular weight heparin.	