

Fabio Guarracino, Giulia Brizzi, and Rubia Baldassarri

2.1 Introduction

The anaesthesiologist has a key role in the preoperative clinical evaluation of the surgical patient. This evaluation considers the type of patient and the type of surgery the patient will undergo. Over the last 10 years, thanks to the progress of diagnostic and surgical techniques and to the technological implementation, surgery has undergone significant changes that can be summarized in a particular boost towards less invasive techniques, such as robotic surgery, and wider indications than in the past. But even the surgical patient has changed over time. In fact, the population is getting older, and the physiology of aging is accompanied by an increase in morbidity, with many older patients who are candidates for surgery and often with cardiovascular disease. Each year an increasing number of elderly patients with cardiovascular disease undergo noncardiac surgery.

Improved cardiovascular disease treatment has determined a better quality of life for cardiopathic patients over the last 10 years, and even heart failure with severe ventricular dysfunction allows a better quality of life when treated according to good practice. However, perioperative cardiovascular complications are the strongest predictors of morbidity and mortality after major noncardiac surgery, and for this reason the patients with cardiovascular disease undergoing surgery often cause concern in the preoperative evaluation and require instrumental examinations. We can also estimate that approximately 30 million patients die every year within 30 days of noncardiac surgery [1] and that myocardial ischemia is frequently the cause of death.

For these reasons periodically, scientific societies publish recommendations on the management of the cardiopathic patient undergoing noncardiac surgery. The recent ESC/ESA Guidelines [2] of 2014 provide the context for conducting an

F. Guarracino (✉) • G. Brizzi • R. Baldassarri

Department of Anaesthesia and Critical Care Medicine, Cardiothoracic and Vascular Anaesthesia and Intensive Care, Azienda Ospedaliero Universitaria Pisana, Pisa, Italy
e-mail: fabiodoc64@hotmail.com

Table 2.1 Cardiovascular risk and surgery

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

effective preoperative evaluation of the cardiopathic patient candidate for noncardiac surgery. This must include preoperative risk stratification based on assessment of the patient's functional capacity, cardiac risk factors and cardiovascular function and type of surgery (Table 2.1) the patient will undergo.

The approach must be tailored to the individual patient so that some preoperative testing will be performed independently of the type of surgery and urgency of the operation and only in patients who are likely to benefit from it. In fact the aim of the preoperative evaluation of the surgical patient is not a screening for cardiovascular disease but rather a risk stratification and an implementation of perioperative strategies that can minimize it. Therefore it should be emphasized that not every patient with cardiovascular disease requires detailed preoperative cardiac evaluation. For example, patients with stable cardiovascular disease undergoing low- or intermediate-risk surgery do not require an additional preoperative cardiac assessment, while cardiopathic patients scheduled for high-risk noncardiac surgery should undergo cardiac assessment by a multidisciplinary expert team that includes anaesthesiologists, surgeons, and cardiologists, as well as other specialists if necessary.

2.2 The Issue of Perioperative Myocardial Ischemia

Perioperative myocardial ischemia represents the most feared event of the surgical team.

Myocardial ischemia in the surgical period has its own peculiarities from a pathogenetic and physiopathological point of view. In fact, the classification

of myocardial ischemia is based on five different types of mechanism inducing ischemia, where the perioperative event is included in type 1 and type 2 [3]. Type 1 is represented by a classic acute event in which an endothelial lesion on an unstable coronary plaque leads to coronary thrombosis with vessel occlusion and arterial flow interruption. In this situation after a few minutes, we can see the typical ST elevation on the electrocardiogram (STEMI). In type 2, the mechanism does not involve endothelial lesion and platelet activation but an acute imbalance in O₂ demand/O₂ delivery at myocardial level, resulting in myocardial ischemia. In this case the electrocardiogram typically does not show the elevation of ST segment (NSTEMI).

The two above-mentioned mechanisms are both responsible for perioperative myocardial ischemic events in approximately 50% of cases. This means that half and possibly more of myocardial ischemia in the surgical patient are not related to coronary occlusion but to a coronary mismatch caused by a reduction of O₂ delivery (e.g., during hypoxemia, anaemia, haemorrhage, hypotension) or by an increased demand (e.g., due to tachycardia, hypertension, inadequate anaesthesia, postoperative pain, and suspension of beta-blocker therapy). It is interesting to notice that the two types of myocardial ischemia have different presentation times. The mismatch type has usually an early presentation, and if it causes death, it will be between the first and the third day; the ischemia due to coronary occlusion occurs later, and mortality is shifted to a few days after surgery.

It is easy to understand that the scenario of perioperative myocardial ischemia causes important perioperative issues. In particular, the consequences are relevant to the preoperative evaluation and management of the patient at risk of myocardial ischemia. Indeed, knowledge of pathophysiology helps to understand that at least half of patients do not have coronary occlusion as a mechanism of ischemia, and so, for example, they are not protected by antiplatelet agents. On the other hand, the other half of the problem makes clear that preoperative provocative cardiac tests can be completely negative without excluding the patient in question from the risk of having a myocardial ischemic event. There are also implications on postoperative monitoring. We should ask ourselves if it is worthwhile admitting the patient to intensive care on the day of surgery, as we know that the event, if it occurs, will happen after the patient is out of our observation.

Knowledge of the problem should lead to the creation of organizational models in which intensive care units are not unnecessarily occupied during the night after surgery but where there is a very careful alert system that allows the early detection of possible ischemic events [4]. Obviously, this requires a multidisciplinary approach involving anaesthesiologists, cardiologists and surgeons.

The aspects that we have discussed here regarding the mechanisms of myocardial ischemia are the basis of the knowledge necessary to understand why guidelines recommend much selectivity in requesting preoperative examinations: often the sensitivity and specificity of a provocative cardiac test are not very different from tossing a coin; often resting cardiac tests are not adequate to explore the complex world of the intraoperative period with all its possible acute physiological variations.

Table 2.2 Clinical risk factors

Ischemic heart disease (angina pectoris, myocardial infarction)
Heart failure
Stroke or transient ischemic attack (TIA)
Renal dysfunction (serum creatinine concentration >170 $\mu\text{mol/L}$ or 2 mg/dL or a creatinine clearance <60 mL/min/1.73 m ²)
Diabetes mellitus requiring insulin therapy

2.3 Preoperative Risk Stratification

Preoperative risk stratification should be performed considering the presence of risk factors in the patient for the occurrence of cardiovascular complications. Clinical risk factors, listed in Table 2.2, are derived from clinical history and clinical examination and allow risk stratification using the Revised Lee Cardiac Risk Index.

In addition to the traditional Lee cardiac risk index [5], for the preoperative evaluation, the model of the American College of Surgeons National Surgical Quality Improvement Program (NSQIP) Myocardial Infarction Cardiac Arrest (MICA) can be used, a model based on the 2007 NSQIP database. In this model, type of surgery, functional status, creatinine concentration, ASA physical status classification, and age were found to be independent predictors of perioperative myocardial infarction or cardiac arrest. The prognostic information provided by the two models is complementary. However, the predictive ability of the NSQIP MICA model was superior to the Revised Lee Cardiac Risk Index, and the risk [6] can easily be calculated at the bedside (<http://www.surgicalriskcalculator.com/miocardiacarrest>).

Assessment of preoperative functional capacity must take into account the metabolic equivalent tasks (METs) or exercise testing when needed.

2.4 Preoperative Testing: Which Exams in Which Patient [2]

2.4.1 Preoperative ECG

Every day, thousands of patients scheduled for noncardiac surgery are routinely submitted to resting ECG during the preoperative evaluation. The resting ECG has no sufficient specificity and sensitivity to diagnose congenital or acquired heart disease. For this reason, ECG is only recommended in cases where the presence of risk factors requires further investigation.

Preoperative resting ECG is not recommended in asymptomatic patients without risk factors undergoing low-risk surgery. Instead it could be performed in patients without risk factors who are about to undergo intermediate- or high-risk surgery if they are over 65.

A resting ECG should be performed only *in patients with risk factors* (Table 2.3) undergoing *intermediate- or high-risk surgery*.

Table 2.3 Recommendations for preoperative resting ECG

Patient population	2014 ESC/ESA Guidelines
Patients with risk factors scheduled for intermediate- or high-risk surgery	Recommended (I,C)
Patients with risk factors scheduled for low-risk surgery	May be considered (IIb,C)
Patients without risk factors scheduled for intermediate-risk surgery	May be considered (IIb,C)
Patients without risk factors scheduled for low-risk surgery	Not recommended (III,B)

Risk factors as listed in Table 2.5. Types of surgery as listed in Table 2.1

Table 2.4 Recommendations for preoperative resting echocardiography

Patient population	2014 ESC/ESA Guidelines
	Class of recommendation (Latin number) and level of evidence (second letter)
Asymptomatic patients	Not recommended (III)
Patients scheduled for high-risk surgery	May be considered (IIb,C)
Patients scheduled for intermediate- or low-risk surgery	Not recommended (III,C)
Patients with severe valvular heart disease	–
Patients with known or suspected valvular heart disease scheduled for intermediate- or high-risk surgery	Recommended (I,C)

Types of surgery as listed in Table 2.1

2.4.2 Preoperative Echocardiography

A routine echocardiography in a cardiopathic but clinically asymptomatic and stable patient is not necessary in the preoperative evaluation.

Routine preoperative echocardiography is only recommended in patients with known or suspected valvular heart disease scheduled for intermediate- or high-risk surgery. The Guidelines suggest that it may also be considered in patients undergoing high-risk surgery (Table 2.4).

2.4.3 Imaging Stress Testing

The Guidelines recommend preoperative cardiac stress testing only if the results are likely to modify the perioperative management. It is recommended only in patients with poor functional capacity and more than two clinical risk factors before high-risk surgery. It may be considered in patients with one or two clinical risk factors and poor functional capacity before intermediate- or high-risk surgery. Imaging stress testing is generally not recommended before low-risk surgery.

In clinically stable patients who have undergone surgical myocardial revascularization in the previous 6 years, no preoperative cardiac stress tests

should be performed. These are, however, recommended in patients with high cardiac risk scheduled for surgery in the first year after surgical myocardial revascularization.

2.4.4 Serum Biomarkers

Routine preoperative determination of serum biomarkers (brain natriuretic peptide [BNP], NT-proBNP, cardiac troponin) for risk stratification before surgery is not recommended in patients undergoing noncardiac surgery. It may be considered in high-risk patients. In particular, in these patients, the determination of cardiac troponins at 48–72 hours after major surgery may be considered, in order to monitor the possible onset of perioperative myocardial ischemia.

2.4.5 Preoperative Coronary Angiography and Myocardial Revascularization

Although many patients undergoing noncardiac surgery suffer from coronary artery disease, preoperative coronary angiography is rarely indicated. Considering the procedure-associated risk and lack of evidence that preoperative coronary revascularization improves perioperative outcome, the indications for preoperative coronary angiography are identical to those in the non-surgical setting.

There is no evidence that preoperative coronary revascularization improves perioperative outcome in asymptomatic patients or in patients with stable coronary artery disease (CAD). In general, recommendations for perioperative coronary revascularization are identical to those used in the medical field and follow the ESC Guidelines on the management of stable CAD. In accordance with these Guidelines, a routine prophylactic preoperative coronary revascularization is not recommended in patients with documented CAD scheduled for low- or intermediate-risk surgery. Prophylactic preoperative coronary revascularization could be considered in the presence of a significant stress-induced myocardial perfusion defect.

2.5 Preoperative Pharmacological Management: Medications for Heart Failure

The management of cardiac therapies in the preoperative evaluation of cardiopathic patients is an aspect of particular interest. More and more patients are taking cardio-vascular drugs and anticoagulant and antiplatelet agents.

Considering the most commonly used drugs such as beta blockers, ACE inhibitors (ACEIs) and angiotensin II (ARBs) receptor antagonists and statins, it is generally recommended to continue the home therapy in the perioperative period.

The Guidelines [2] recommend the continuation of beta-blocker therapy in the perioperative period in patients currently receiving this medication. However,

regarding preoperative initiation of beta-blocker therapy in patient in non-chronic treatment, the ESC/ESA Guidelines suggest that the preoperative start of beta blockers may be considered in patients: 1) scheduled for high-risk surgery, 2) with ≥ 2 clinical risk factors or ASA physical status ≥ 3 , and 3) with known ischemic heart disease or myocardial ischemia.

Atenolol or bisoprolol may be considered first-choice drugs if the decision for preoperative initiation of oral beta-blocker therapy is made. Neither the initiation of beta blockers in patients undergoing low-risk surgery nor the initiation of high-dose beta-blocker therapy without titration is recommended.

Therapy with ACEI and ARBs should be kept under close control in patients with chronic heart failure and left ventricular dysfunction. If necessary this therapy should be started at least a week before surgery.

A temporary interruption of ACEI or ARBs for the increased risk of severe hypotension during anaesthesia associated with this therapy may be considered in patients with arterial hypertension.

Regarding statins, Guidelines recommend perioperative continuation of chronic statin therapy with preference to statins with a long half-life or extended-release formulation. Initiation of statin therapy should be considered before vascular surgery, ideally at least 2 weeks before surgery.

2.6 Preoperative Pharmacological Management: Antiplatelet Agents and Anticoagulant Therapy

2.6.1 Antiplatelet Agents

2.6.1.1 Aspirin

The decision for or against low-dose aspirin in patients undergoing noncardiac surgery must be based on individual weighing of the perioperative risk of bleeding against that of thrombotic complications. Continuation of chronic aspirin therapy for secondary cardiovascular prevention may be considered. Its discontinuation should be considered when difficult intraoperative haemostasis is anticipated. Following percutaneous coronary intervention, aspirin should be continued for 4 weeks after bare-metal stent (BMS) implantation and for 3–12 months after drug-eluting stent (DES) implantation, unless the risk of life-threatening surgical bleeding is considered unacceptably high.

2.6.1.2 Dual Antiplatelet Therapy

More and more patients are now treated with dual antiplatelet therapy, often posing problems on management of therapy and surgical timing.

In postcoronary angioplasty patients, maintenance of P2Y₁₂ receptor antagonists should be considered for 4 weeks after the BMS implantation and 6–12 months after the DES implant (6 months in the case of a new generation stent). In a patient subjected to coronary angioplasty without a stent implant, surgery should be scheduled at least two weeks after the beginning of antiplatelet therapy.

Table 2.5 Risk factors for thromboembolic events

• Atrial fibrillation associated with heart failure, hypertension, age ≥ 75 years, diabetes, stroke, vascular disease
• Advanced age
• Female sex
• Mechanical prosthetic heart valves, recently inserted biological prosthetic heart valve
• Mitral valvular repair within the past 3 months
• Recent venous thromboembolism within past 3 months
• Thrombophilia

2.6.1.3 Anticoagulant Therapy

Before deciding for or against the perioperative administration of oral anticoagulants, the risk of life-threatening perioperative bleeding must be weighed against the potential thromboembolic risk. Discontinuation of therapy is recommended a few days before surgery in patients at low risk of thrombosis. Patients on oral vitamin K antagonists can undergo noncardiac surgery when the international normalized ratio (INR) is <1.5 .

Patients with risk factors for thromboembolic events (Table 2.5) require preoperative bridging therapy with unfractionated heparin (HFU) or low-molecular-weight heparin (LMWH). The last dose of LMWH should be administered no later than 12 hours before surgery. Depending on the type of oral vitamin K antagonists, it is recommended to stop therapy 3–5 days before surgery. For patients receiving non-vitamin K antagonist direct oral anticoagulants (NOACs), it is recommended to discontinue NOACs for 2–3 times their respective half-lives before surgery with average risk of bleeding and for 4–5 times their biological half-lives before surgery with high risk of bleeding. Due to their well-defined “on” and “off” action, preoperative bridging therapy with UFH or LMWH is usually not required.

2.7 How to Deal with Arrhythmia [2]

Changes in heart rhythm and conduction disorders can already be present and treated at home, or they can develop as a perioperative complication.

Ventricular rate control is essential in the management of perioperative atrial fibrillation and supraventricular arrhythmias. Drugs of choice are beta-blockers and calcium-channel blockers. The administration of beta-blockers is associated with an increased rate of conversion of atrial fibrillation to sinus rhythm in patients undergoing noncardiac surgery. In patients with heart failure, amiodarone represents an effective alternative.

In the case of ventricular arrhythmias, the continuation of anti-arrhythmic home therapy is always recommended.

When the ventricular tachycardia (VT) arises in the perioperative period, it needs to be promptly treated with electric cardioversion. Anti-arrhythmic drugs are recommended in patients with sustained VT.

2.7.1 Management of Patients with Pacemaker/Implantable Cardioverter Defibrillator

Patients with permanent pacemakers require increased perioperative attention because of the possible interference between device and electrocautery. Special precautions should be taken to reduce the risk of the interferences. In patients who are pacemaker dependent, the device should be set in an asynchronous or non-sensing mode by placing a magnet on the skin over the pacemaker. In patients with an implantable cardioverter defibrillator (ICD), the device should be deactivated by the arrhythmologist before surgery and adequately reactivated after the operation.

During the period of deactivation, the patient's ECG must be continuously monitored, and an external defibrillator must be available.

2.7.2 Temporary Cardiac Pacing: When and How

The indications for perioperative temporary cardiac pacing are usually the same as for permanent cardiac pacing. Temporary perioperative pacing in noncardiac surgery is recommended [2] in patients with complete heart block and in those with symptomatic asystolic episodes. Temporary perioperative pacing is not recommended in asymptomatic patients with bifascicular block, independently of the presence of first-degree atrioventricular block.

These recommendations should recall how many useless requests for temporary pacemaker positioning are made due to the lack of knowledge of evidence-based literature and Guidelines. The availability of pads for emergency transcutaneous pacing should avoid even more inappropriate requests for arrhythmological consultation.

2.8 Cardiological Consultation: A Laissez-Passer?

The need for cardiological consultation is an important aspect of the preoperative evaluation. However, this rarely modifies patient management, which means that too many are requested.

The cardiological consultation should not be considered a *laissez-passer* for cardiopathic patients either by the anaesthesiologist or the surgeons. It should only be requested in the case of known cardiopathic patients with instable clinical conditions evaluated during clinical examination or specific situations (presence of ICD or pacemaker; management of the dual antiplatelet therapy in a patient after a recent coronary revascularization) which can be significantly affected by the cardiologist's opinion. The consultation should not be requested only because the patient is cardiopathic. In most cases a cardiopathic patient undergoes a yearly follow-up with a cardiologist. In the absence of conditions of recent instability, a cardiopathic patient should be considered less problematic. On the other hand, a patient with a silent clinical history may need a more careful preoperative evaluation to identify

possible risk factors and a clinical evaluation to detect conditions needing further investigations.

The Guidelines [2] put the cardiological evaluation request of the cardiopathic patient scheduled for low- or intermediate-risk surgery in Class IIb, proving that in most cases the request is inappropriate.

Conclusions

Preoperative evaluation of patients with cardiovascular disease undergoing non-cardiac surgery must be based on a careful clinical evaluation.

Indiscriminate use of routine preoperative cardiac testing is not justified in the evidence of literature, and it is not recommended by the Guidelines, because it is resource limiting and does not improve perioperative outcome [7]. Fewer exam requests should not be considered as an underestimation of the issue; rather they should give more consideration to the capability of identifying, during the clinical evaluation, risk factors and unstable conditions which need further investigation. This can only improve the evaluation of those patients who really deserve more attention and avoid the need for inappropriate examinations and consultations.

References

1. The Vascular events In noncardiac Surgery patients cOhort evaluatioN (VISION) Writing Group, The Vascular events In noncardiac Surgery patients cOhort evaluatioN (VISION) Investigators. Myocardial injury after non cardiac surgery. A large, international, prospective cohort study establishing diagnostic criteria, characteristics, predictors, and 30-day outcomes. *Anesthesiology*. 2014;120:564–78.
2. Kristensen SD, Knuuti J, Saraste A, Anker S, Bøtker HE, De Hert S, et al. Authors Task Force Members. 2014 ESC/ESA Guidelines on non-cardiac surgery: cardiovascular assessment and management: The Joint Task Force on non-cardiac surgery: cardiovascular assessment and management of the European Society of Cardiology (ESC) and the European Society of Anaesthesiology (ESA). *European Heart Journal*. 2014;35:2383–431.
3. Landesberg G, Beattie WS, Mosseri M, Jaffe AS, Alpert JS. Perioperative Myocardial Infarction. *Circulation*. 2009;119:2936–44.
4. Biccard BM. Detection and management of perioperative myocardial ischemia. *Curr Opin Anesthesiol*. 2014;27:336–43.
5. Lee TH, Marcantonio ER, Mangione CM, Thomas EJ, Polanczyk CA, Cook EF, et al. Derivation and prospective validation of a simple index for prediction of cardiac risk of major noncardiac surgery. *Circulation*. 1999;100:1043–9.
6. Gupta PK, Gupta H, Sundaram A, Kaushik M, Fang X, Weldon J, et al. Development and validation of a risk calculator for prediction of cardiac risk after surgery. *Circulation*. 2011;124:381–7.
7. Guarracino F, Baldassarri R, Priebe HJ. Revised ESC/ESA Guidelines on non-cardiac surgery: cardiovascular assessment and management. Implications for preoperative clinical evaluation. *Minerva Anesthesiol*. 2015;8:226–33.