



I Guidelines For Perioperative Evaluation

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SUPPORT

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Guidelines for Perioperative Evaluation

1. Definition of the problem

A) Purpose of these guidelines:

Knowledge of surgical interventions is being transferred surprisingly fast to medical practice. New technological resources and the technical refinement of medical teams increase the confidence of physicians and patients. Consecutive successes associated with a lower rate of postoperative complications increase the number of surgery candidates. With less invasive, faster and more efficient technologies becoming available, cases that were once considered inoperable are now being operated. Consequently, a growing number of interventions are being performed in a population that is progressively older and of higher risk.

Now it is necessary to organize the knowledge of the phenomena that occur before, during and after a surgical intervention. This task demands a great effort when one considers the enormous variability of the characteristics of patients in these conditions and the difficulty to establish common criteria and references for observation and comparison, the basic methodology for the accumulation of scientific knowledge. For this area of knowledge, some authors proposed the name **Perioperative Evaluation**.

The goals of these guidelines are:

- Refine and unify the terminology used by the entire multidisciplinary team, including the patients and their family;

- Establish new routines, change indication for surgery according to the information obtained during the perioperative evaluation;

- Do not provide clearance for surgery but inform the patient of the possible risks. Based on these data, personal experience, knowledge of the other side of the story, the underlying disease, its risks and the risk attributable to the surgery itself, the surgeon can decide with the patient and their family if the risk/benefit ratio favors the intervention.

- Data or scientific evidences are not always available to allow all the different situations to be analyzed. As customary in medical practice, minute analysis of the patient and problem and the common sense of the team must prevail.

- The surgical intervention does not finish when the patient is bandaged or leaves the operating room. The concept of the word *perioperative* includes the need for a postoperative surveillance whose intensity is determined by the individual level of risk of the patient.

B) Methodology and Evidence:

The participants of these guidelines were chosen among health sciences specialists with hands on and academic experience, thus being characterized as clinical researchers. The basics of perioperative evaluation and the current recommendations were established in order to decrease perioperative complications. Unfortunately, we have not yet eliminated the stress caused by surgery or all its consequences, but the reader will notice that there is much that can be done for the surgery to run smoothly and have a successful outcome without hurting scientific truth. The adopted methodology and evidence levels were the same as those used in earlier documents by the Brazilian Society of Cardiology.

Recommendations:

- The guidelines must be based on evidences;
- Class division must be used when applicable;
- Degrees of recommendation must be used when applicable, according to the levels of evidence;

Degree or Class of Recommendation:

- **Class I:** Conditions for which there is evidence for and/or general agreement that the procedure/therapy is useful and effective.

- **Class II:** Conditions for which there is conflicting evidence and/or a divergence of opinion about the usefulness/efficacy of performing the procedure/therapy.

Class IIa: Weight of evidence/opinion is in favor of usefulness/efficacy.

Class IIb: Usefulness/efficacy is less well established by evidence/opinion.

- **Class III:** Conditions for which there is evidence for and/or general agreement that the procedure/therapy is not useful/effective and in some cases may be harmful.

Levels of Evidence:

- **A:** Sufficient evidence from multiple randomized trials or meta-analyses;

- **B:** Limited evidence from single randomized trial or non-

randomized studies;

- C: Evidence only from case reports and series;
- D: Expert opinion or standard of care.

2. General Approach to the Patient

A) History

Medical history investigation by talking with the patient or family member is the first step in a perioperative evaluation. It should be done in a comfortable environment and at least one week before an elective surgery so that medications that decrease perioperative risk can be introduced or those that interfere with surgery can be discontinued, thus increasing surgical success. On the other hand, talking with the patient or family member right before emergency interventions can reveal important information that will help the surgeon decide if the patient should be sent to the ICU after surgery or if there are coexisting clinical conditions that can influence the early postoperative period.

Medical history investigation consists of the following essential actions:

- Minute investigation of the past surgical or anesthetic history of the patient that can lead to potentially preventable complications and allergies or the existence of comorbidities;
- Investigation of the clinical condition of the patient and the need to compensate for coexisting diseases;
- Determination of what medications are being taken and if they interfere with surgery;
- The surgeon's opinion on the urgency and risk of the procedure;
- Degree of anxiety and doubts of the patient and their family regarding the procedure and its risks;

B) Physical examination

Physical examination is useful during the perioperative risk assessment process and it should not be limited to

the cardiovascular system. The objectives are: to identify preexisting or potential heart disease (risk factors), define the severity and stability of the heart disease and identify comorbidities, if any.

Patients with heart disease whose general condition is compromised by other conditions such as neurological diseases, renal failure, infections, liver abnormalities, malnourishment or pulmonary dysfunction are at higher risk of cardiac complications since these conditions exacerbate surgical stress.¹

The incidence of ischemic heart disease in patients with peripheral arterial disease is high and it is a predictive factor for perioperative complication. Information obtained upon physical examination such as changes in pulse rate or carotid bruit should be investigated. On the other hand, jugular vein distension signaling high central venous pressure (CVP) indicates that the patient may develop pulmonary edema after surgery.^{2,3} Finding the third heart sound (S3) during perioperative evaluation indicates a bad prognosis with increased risk of pulmonary edema, myocardial infarction or cardiac death.⁴

The presence of bilateral lower limb edema must be analyzed together with the presence of jugular vein distension. If the amplitude of the pulse wave of the internal jugular vein reveals high CVP, then heart disease and pulmonary hypertension are at least partially responsible for the patient's edema. If CVP is not high, then the edema is probably caused by something else such as liver disease, nephrotic syndrome, chronic venous insufficiency or some medication. The presence of edema and unknown CVP is not a definite sign of heart disease.⁶ If heart murmurs are present, the physician should be able to distinguish organic from functional murmurs, determine if they are significant or not and determine their origin. The origin will indicate if endocarditis prophylaxis or assessment of valvular lesion severity is necessary.

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Table 1 - Physical examination and risk of perioperative complications

Sign	Sensitivity (%)	Specificity (%)	Likelihood ratio for a positive result
S3 predictive of pulmonary edema	17	99	14.6
S3 predictive of AMI or cardiac death	11	99	8.0
High CVP predictive of pulmonary edema	19	98	11.3
High CVP predictive of AMI or cardiac death	17	98	9.4

Source: modified from McGee, 2001 4. S3: third heart sound; CVP: central venous pressure; AMI: acute myocardial infarction. Likelihood ratio for a positive result: the values indicate the extent to which a diagnostic test will increase the pre-test probability of a target condition, allowing one to estimate that the likelihood of something occurring is high (values greater than 10), moderate (values greater than 5 and lower than 10), low (values ranging from 2 to 5) and insignificant (values ranging from 1 to 2).⁵

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C) Comorbid Diseases

I. Thyroid diseases

Thyroid disease is a very common clinical condition. In endemic areas, goiter affects 15 to 30% of the adult population. In addition to the technical difficulties of managing the airways of the patient with goiter, the hormonal imbalance may be a considerable source of morbidity and mortality.¹ Tetraiodothyronine (T4) represents 80% of thyroid hormone production and 40% of it is converted by peripheral organs to triiodothyronine (T3), which is five times more active. Another 50% of the T4 produced by the thyroid is converted to 3,5-triiodothyronine (rT3), which does not have biological activity. Only 0.2% and 0.3% of the circulating T3 and T4 respectively are in the free and biologically active form while the remaining is bound to plasma proteins (albumin, transthyretin and thyroid-binding globulin). T3 and rT3 are converted by the liver, kidneys and CNS into inactive compounds. Severe systemic diseases, trauma and drugs may block the peripheral conversion of T4 to T3 leading to the euthyroid sick syndrome in critically ill patients, a physiological mechanism that conserves energy in critical situations.

I. 1. Hypothyroidism

It is estimated that 5 out of every 1000 patients have hypothyroidism and the prevalence of subclinical hypothyroidism is three times greater. Hypothyroidism is 10 times more common in women than in men and may

be due to iatrogenic causes (radioactive iodine therapy or surgical resection) or autoimmune thyroiditis (Hashimoto's), among others. In addition to the signs and symptoms (Table 2), TSH and free T4 and T3 must be determined to confirm the diagnosis.

Complications during the perioperative period are rare when hypothyroidism is subclinical, light or moderate. Special attention should be given to the severe cases since complications are more likely to occur.¹⁻⁶

Table 2 - Relevant clinical manifestations of hypothyroidism during perioperative evaluation

Hypothermia
Myocardial depression
Slow respiratory rate and difficulty in weaning from mechanical ventilation
Slow heart rate
Altered baroreceptor response
Hypotension or hypertension
Angina, myocardial infarction
Hypovolemia
Anemia
Hypoglycemia
Hyponatremia (syndrome of inappropriate antidiuretic hormone secretion)
Abdominal distension
Decreased hepatic metabolism of drugs

Recommendations: ¹⁻⁶

Class I, Level of evidence D.

- Assess all the risk factors of the patient;
- Do not worry about subclinical hypothyroidism when TSH < 10mU/dl;
 - Elective surgery should only take place when the thyroid function of the patient is normal;
 - Patients < 45 years should be given the full L-thyroxine dose which is usually from 1.6 to 2.2 mcg/kg or from 100 to 200 mcg per day. It takes from 4 to 6 weeks of treatment for TSH levels to normalize;
 - Patients > 45 years should start with a 25-50 mcg/day dose to be increased at every two-week intervals;
 - Coronary patients should start with a 15 mcg/day dose to be increased weekly until TSH normalizes;
 - Do not postpone surgery in patients with light hypothyroidism but start oral hormone replacement therapy;
 - Hypothermia prophylaxis, cardiovascular monitoring and hydrocortisone administration (100 mg at every 8 hours for 24 hours since adrenal insufficiency may occur) must be done in hypothyroid patients submitted to surgery;
 - The half-lives of T4 and T3 are 7 and 1.5 days respectively.

Thus, a patient who is taking T4 does not need to take it on the day of surgery while the patient who is taking T3 does;

- Radiograph the cervical region to determine if goiter is going to interfere with tracheal intubation.

Recommendations for patients with severe hypothyroidism or myxedema coma undergoing urgent surgeries:¹⁻⁶

Class I, Level of evidence D.

- Administer 200-500 mcg of L-thyroxine or 40 mcg of intravenous T3 or 10-25 mcg of T3 at 8-hour intervals before surgery. This should correct hemodynamic and electrocardiographic changes. Divide the dose into 50% of T4 and 50% of T3 during the perioperative period;
- Maintenance dose should be 40 to 100 mcg of T4 or 10 to 20 mcg of T3 given intravenously at 24-hour intervals;
- Administer 100 mg of hydrocortisone at 6-hour intervals for a long period;
- Start hormone replacement therapy by digestive route using the doses listed above as soon as possible.

I. 2. Hyperthyroidism:

Thyrotoxicosis affects 2% of women and 0.2% of men. Clinical and subclinical hyperthyroidism prevalence in the USA is 0.2 and 1% respectively. The most common causes are: Graves’ disease, toxic nodular goiter, several types of thyroiditis and iatrogenic causes. Clinical manifestations with perioperative repercussions are listed in Table 3. Adrenergic effects are high risk factors for complications such as cardiac arrhythmias (10 to 15% being atrial fibrillation). They are associated with an increased number or sensitivity of beta-adrenoreceptors. Hyperthyroidism mortality is associated with cardiovascular events.¹⁻⁶

Table 3 - Clinical manifestations of hyperthyroidism with perioperative repercussions

Cardiovascular	Increased cardiac inotropism and chronotropism with decreased systemic vascular resistance Left ventricular hypertrophy Higher incidence of angina, heart failure, arrhythmias and embolic events
Blood	Anemia, thrombocytopenia, neutropenia, increased factor VIII levels Decreased levels of vitamin K-dependent coagulation factors, bleeding.
Gastrointestinal	Inadequate medication absorption
Metabolic	Hypercalcemia, hypoalbuminemia, ketoacidosis Increased medication clearance Glucose intolerance, weight loss and protein catabolism
Pulmonary	Myopathy with respiratory failure
Endocrine	Increased cortisol production and clearance

Laboratory tests should be done to confirm diagnosis. TSH levels should be low and free T4 levels should be normal (subclinical hyperthyroidism) or high. Many conditions can raise total T4 because of increased thyroxine-binding globulin levels, yet they do not affect free T4 which is the biologically active substance: pregnancy, cirrhosis, acromegaly, Cushing’s syndrome, lithium, contraceptives, propranolol, amiodarone and iodinated contrasts. A patient must be treated for hyperthyroidism before being submitted to elective surgery.

Specific complications may occur in cases of thyroidectomy: patients with large goiters may present complications during intubation and extubation (up to 35% of these patients present some degree of tracheal obstruction), recurrent laryngeal nerve injury, tracheomalacia and edema of the glottis. Hypocalcemia may occur in 20% of the cases up to 36 hours after thyroidectomy and calcium must be replaced intravenously during this phase. Only 3% of the patients become permanently hypocalcemic and need to take oral calcium for life.

Recommendations:¹⁻⁶

Class I, Level of evidence D.

- Antithyroid medications: the most common are propylthiouracil (PTU) and methimazole. They inhibit the synthesis of thyroid hormones by preventing iodide oxidation and organification. When used in high doses, PTU has the additional advantage of inhibiting the peripheral conversion of T4 to T3, therefore it is used more often during the perioperative period. The standard dose is 100 mg at 8-hour intervals and the maximum dose is 400mg at 8-hour intervals. Methimazole doses vary from 10 to 120 mg in a single daily dose. The dose should be reassessed at 4-6-week intervals. Adverse effects are rarely severe: skin rash, fever, itching and arthralgia, transient elevation of liver enzymes and leucopenia. More severe and less frequent complications that require discontinuation of medication are agranulocytosis (0.5%), severe hepatitis, lupus-like syndrome and thrombocytopenia;

- Beta-blockers: They are only used to control adrenergic signs and symptoms. They do not affect hormone levels. Propranolol is used most often at 10 to 80 mg at 6-8-hour intervals (1 mg intravenously during surgery). Esmolol can be given during surgery at a loading dose of 500 mcg/kg for 1 minute and a maintenance dose of 25-300mcg/kg/min.

Recommendations for urgent or emergency surgeries:¹⁻⁶

Class I, Level of evidence D.

- Antithyroid medications – PTU in high doses is the medication of choice (1000 to 1200 mg divided in 3 doses per day);
- Beta-blockers – intravenous is the preferred route of administration;
- Iodine – can be used for a maximum of 10 days since the inhibition of iodine organification (Wolff-Chaikoff effect) is transient and after this time an escape phenomenon occurs and hyperthyroidism worsens. The most commonly used agent is Lugol’s iodine. It contains 5% iodine and 10% potassium

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iodide. The dose varies from 0.1 to 0.3 ml at 8-hour intervals (3 to 5 drops);

- Iodinated contrasts – Sodium ipodate and iopanoic acid are used for compensation. They present two advantages: there is less escape and the peripheral conversion of T4 to T3 is inhibited. The dose is 500mg at 8-hour intervals;
- Corticosteroid – must be given when hyperthyroidism is not compensated during and after surgery because of elevated peripheral degradation of cortisol. The induction dose is 100mg followed by 100mg at 8-hour intervals for the first 24 hours;
- Anesthesia – pay special attention to increased metabolism of anesthetic agents and intubation difficulty due to goiter;¹
- Thyroid storm – is associated with mortality rates varying from 20 to 30%. Given the sudden nature of the signs and symptoms, treatment should begin right away even if laboratory tests have not yet confirmed the condition. Table 4.

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II. Renal Impairment

Patients with renal failure are more prone to perioperative complications, increased hospital stay, greater costs during hospital stay and higher morbidity than those without renal failure.^{1,2} Preoperative creatinine > 2.0 mg/dL is among the

risk factors found in prognostic models for cardiovascular complications after non-cardiac surgeries. Even moderate chronic renal failure (creatinine between 1.5 and 3.0 mg/dL or glomerular filtration rate between 30 and 60 ml/min) is a risk factor for cardiac and non-cardiac complications after surgery, doubling the mortality rate of these patients in relation to patients with normal renal function.^{1,2} Patients on peritoneal dialysis or hemodialysis must undergo dialysis before surgery to avoid hypervolemia, correct electrolyte and acid-base disturbances and reduce the likelihood of uremic bleeding. Immunosuppression in patients with kidney transplant must be carefully adjusted by the nephrologist before and after surgery to avoid an acute rejection episode and nephrotoxicity.

Acute renal failure (ARF) occurs in the postoperative period in 1-30% of the cases, depending on the type of surgery, with a mortality rate of roughly 50%. ARF prevention during the perioperative period depends on identifying risk factors for its onset (especially preoperative renal failure), avoiding nephrotoxic medications, keeping adequate hydration and avoiding hypotension. Attempts to prevent ARF with diuretics and vasoactive amines are not effective. "Renal dose" dopamine does not prevent renal failure and does not reduce the need for dialysis and ARF mortality rate. Potentially nephrotoxic medications should be avoided or used properly, that is, corrected for renal function. Aminoglycoside antibiotics, amphotericin B, radiological contrast agents and non-steroidal anti-inflammatory agents are examples of nephrotoxic substances commonly used in the perioperative period. The effects of anti-inflammatory agents with cyclooxygenase-II-selective inhibition properties in renal function are not different from the effects caused by the non-selective anti-inflammatory agents and their use should be avoided in patients at risk of anti-inflammatory-associated nephrotoxicity (old age, history of renal failure, heart failure, dehydration, concomitant use of angiotensin-converting enzyme inhibitor, diuretics or other nephrotoxic agents).³⁻⁶

The risks for postoperative complications are well defined in renal failure patients and all patients with preoperative creatinine greater than 1.5 mg/dL should be assessed by a nephrologist. Always bear in mind that creatinine is not a very sensitive marker for renal function. Therefore, creatinine below 1.5 mg/dL does not necessarily mean that renal function is normal, especially among the elderly and those with reduced muscle mass. Perioperative assessment is an opportunity to be in contact with the patient and the clinical and surgical teams and plan actions that will prevent the deterioration of renal function and later retard the progression of chronic renal failure.

Table 4 - Treating thyroid storm⁶

Supportive care	Specific treatment
Hydration	Loading PTU dose: 1000 mg by digestive route
Cooling	Maintenance PTU dose: 200mg at 6-hour intervals by digestive route
Respiratory support	Loading hydrocortisone dose: 300mg intravenously
Metabolic control	Maintenance hydrocortisone: 100mg at 8-hour intervals.
Inotropic agents	Lugol's iodine given orally or intravenous iodine: 1g at 8-hour intervals
	If necessary: plasmapheresis, dialysis or cholestyramine to remove hormones from the circulation

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III. Blood disorders

Many blood disorders can increase the morbidity and mortality rates of individuals submitted to non-cardiac surgeries. Anemia is a condition that leads to an overload of the cardiovascular system, increasing cardiac output. Individuals with cardiovascular diseases are less tolerant of anemia as its presence can aggravate underlying myocardial ischemia and heart failure. Instructions regarding blood transfusions in the perioperative period are limited but its benefits and risks should nevertheless be questioned.¹ In order to decide if the patient needs to receive a blood transfusion, the physician must weigh the duration of anemia, intravascular volume, extent of surgery, likelihood of massive bleeding and presence of associated conditions, such as pulmonary diseases, heart failure, myocardial ischemia and peripheral or cerebral vascular disease. Always bear in mind that one unit of RBC (red blood cells) increases hemoglobin by approximately 1g/dL and hematocrit by 3%.¹

Recommendations for RBC transfusions:²

- Symptomatic individuals should receive enough blood to minimize their symptoms; *Class I, Level of evidence D*;
- Hemoglobin below 7.0 g/dL in patients with acute anemia; *Class I, Level of Evidence A*.
- In cases of acute coronary disease, hemoglobin should be kept around 9.0 and 10.0 g/dL; *Class I, Level of Evidence D*.

There are many other blood conditions that should be taken into account during perioperative assessment for non-cardiac surgery and many of them require the presence of a hematologist in the multidisciplinary team that cares for the patient. Patients with platelet count equal to or above 50,000/mm³ usually tolerate surgeries well, do not bleed in excess and do not require platelet transfusion.²

Recommendations for platelet transfusion:

Class I, Level of Evidence B.

- Platelet count below 50,000/mm³;
- Platelet count below 100,000/mm³ if surgery is neurological or ophthalmologic.

Recommended perioperative procedures for noncardiac surgeries in patients with other blood conditions

III. 1. Sickle-cell disease (SS/SC/ S β thal)

Class I, Level of Evidence C.

- Increase hemoglobin to 10 g/dL by RBC transfusion. If hemoglobin \geq 9 g/dL, ask a specialist;
- Monitor hematocrit, peripheral perfusion and oxygenation before surgery;
- Monitor blood pressure, heart rhythm and rate, oxygenation and body temperature during surgery, avoiding hypothermia;
- Monitor hydration, oxygenation and body temperature after surgery.³

III. 2. Primary antiphospholipid syndrome

Class I, Level of Evidence C.

- Perioperative thrombosis prophylaxis in patients taking anticoagulant medications;
- Postoperative thrombosis prophylaxis in patients who are not taking anticoagulant medications;⁴

III. 3. Congenital thrombophilia

Class I, Level of Evidence C.

- Perioperative thrombosis prophylaxis in patients taking anticoagulant medications;
- Postoperative thrombosis prophylaxis in patients who are not taking anticoagulant medications. Doses will vary according to the type of congenital thrombophilia.⁴

III. 4. Hemophilia

Class I, Level of Evidence B.

- Perform laboratory tests to determine if inhibitors are present;
- During surgery, correct the coagulation factor deficiency by infusion of the specific factor;
- After surgery, maintain the plasma levels of the lacking factor for as long as necessary. Infusion time will vary according

to type and classification of surgery (minor/major);

- Keep plasma levels of the lacking factor under strict control with the aid of laboratory tests.⁵

III. 5. Von Willebrand Disease

Class I, Level of Evidence B.

- During surgery, correct the plasma level of the lacking factor with factor VIII/von Willebrand factor concentrates;
- After surgery, factor VIII and von Willebrand factor levels and activities will vary according to type and classification of surgery;
- Depending on the type of surgery and results of the DDAVP test, consider using this medication.⁶

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IV. Adrenal Insufficiency

The increase in cortisol levels during acute stress is an important protective response. However, metabolic stress caused by surgery can precipitate acute adrenal insufficiency in individuals with clinical and subclinical disorders that affect the hypothalamic-pituitary-adrenal axis (HPA) and the results may be catastrophic, leading to multiple complications and even death.

Physical stress increases adrenocorticotrophic hormone (ACTH) levels and cortisol secretion. Increased cortisol, noradrenalin and adrenalin levels characterize the hormonal changes induced by stress. These changes are minimal when surgical stress is low and rises progressively as surgical stress increases from moderate to severe, lasting no more than 24 hours in surgeries without complications. The HPA axis is most activated by surgery, recovery from anesthesia

and extubation, raising the cortisol levels which normalize within 24 to 48 hours.¹ Increased corticosteroid requirement may lead individuals with impaired adrenal activity and reserves to develop acute adrenal insufficiency (AAI). Therefore, it is essential to identify these individuals early and establish an adequate perioperative plan in order to avoid complications.

IV. 1. Signs and Symptoms of Adrenal Insufficiency (AI)

- Hypotension and hemodynamic shock (that may be resistant to vasopressors) with multiple organ failure;
- Hypoglycemia;
- Tachycardia;
- Electrolyte disturbances: hyponatremia, hyperkalemia (in primary adrenal insufficiency), hypercalcemia, acidosis;
- Decreased cardiac contractility;
- Anemia, eosinophilia and neutropenia;
- Nausea, emesis, weakness, orthostatic hypotension, dehydration, abdominal or flank pain (acute adrenal hemorrhage), fatigue, weight loss;
- Vitiligo, skin color changes, hypogonadism, hypothyroidism.

AI should be suspected when hypotension and unexplained, refractory or hypovolemic shock occur during or after surgery, or when there is discrepancy between the condition of the patient and severity of the disease, high fever without apparent cause (negative cultures) or refractory to antibiotic therapy, unexplained mental changes, apathy or depression without a specific psychiatric disorder. These cases should be regarded and treated as acute AI and confirmed later. *Class I, Level of Evidence C.*

IV. 2. Identification of patients at risk of AI

- Patients with an already established AI diagnosis.²
- Patients at risk of AI³ and patients with relative AI (limited adrenocortical reserve):
 - Pituitary tumors (macroadenomas);
 - Radiotherapy in the pituitary region;
 - Previous pituitary surgery;
 - Postoperative period of surgery for Cushing's disease, bilateral adrenalectomy or unilateral adrenalectomy if the other adrenal is compromised;
 - Chronic corticosteroid use (>7.5 mg of prednisone or equivalent for more than 30 days or > 20 mg for more than two weeks);
 - Patients with type I diabetes mellitus or autoimmune diseases (Hashimoto's disease, ovarian or primary testicular failure, hypoparathyroidism, vitiligo);
 - Patients with suggestive clinical features (skin darkening, weakness, fatigue, nausea, emesis, depression, hypotension, electrolyte disturbances, hypoglycemia, fever);

Recommendations:

- Confirm the diagnosis with tests that are appropriate for patients at risk of AI. It is advisable to have an endocrinologist involved; *Class I, Level of Evidence B.*
- If tests are necessary to confirm AI, use dexamethasone as it does not interfere with the tests; *Class I, Level of Evidence C.*
- If untreated hypothyroidism and AI coexist, replace AI hormones first; *Class I, Level of Evidence C.*
- Mineralocorticoid supplementation is not necessary since corticosteroid supplementation doses for surgical stress have mineralocorticoid activity *Class I, Level of Evidence C.*
- If it is impossible to confirm the diagnosis before surgery, the following corticosteroid supplementations are recommended; *Class IIa, Level of Evidence D.*

IV. 3. Corticosteroid supplementation doses:^{4,6}

Recommendations:

- High corticosteroid supplementation doses are not necessary to prevent acute AI;
- High doses may increase the likelihood of complications such as hypertension and diabetic decompensation; *Class IIa, Level of Evidence C.*

A. Mild surgical stress:

- Double or triplicate corticosteroid dose in patients with established AI and chronic users. Bear in mind that adrenal suppression may occur rapidly with high doses or even after a long time of corticosteroid discontinuation (up to 48 months) *Class IIa, Level of Evidence C.*
- If the oral route in fasting subjects is not possible, administer 50mg of intramuscular or intravenous hydrocortisone right before surgery followed by 25mg of hydrocortisone twice daily or equivalent (dexamethasone 0.75mg twice daily). Reduce to the regular dose after 24 hours or as soon as stress is over; *Class IIa, Level of Evidence C.*
- Patients who have not been diagnosed with AI but it is highly suspected, proceed with treatment for AI; *Class IIb, Level of Evidence C.*

B. Moderate surgical stress:

- Administer 25mg of intramuscular or intravenous hydrocortisone or equivalent at 8-hour intervals on the day of surgery. Reduce the dose daily by 50% until the regular dose is reached; *Class IIa, Level of Evidence C.*

C. High surgical stress:

- Administer 50mg of intramuscular or intravenous hydrocortisone or equivalent at 6-hour intervals on the day of surgery and maintain this dose until the metabolic stress is over. Metabolic stress usually lasts 48 hours following surgeries without complications (infections or other intercurrents). Then reduce the dose daily by 50% until the regular dose is reached; *Class IIa, Level of Evidence C.*

D. Cushing's syndrome special situation:

- It is advisable for an endocrinologist to be involved;
- Start corticosteroid therapy as soon as the patient arrives at the ICU or on the day following surgery;
- In these cases, some groups will only replace hormones if there are signs or symptoms of acute AI or laboratory tests confirming the need for hormone replacement therapy;

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V. Obesity

Overweight and obesity prevalence is increasing worldwide at alarming rates. Prevalence increased by 50% from the 1980's to today. It is estimated that roughly 40% of the adult Brazilian population presents excess weight (body mass index – BMI - > 25kg/m²) and that 8.9% of the men and 13.1% of the women are obese. Prevalence tends to increase with age.

Severity of obesity can be characterized by degrees:

Obesity grade 1: BMI 30-34.9 kg/m²

Obesity grade 2: BMI 35-39.9 kg/m²

Obesity grade 3: BMI ≥ 40 kg/m²

V. 1. Surgical risk associated with obesity:

- Surgical risk increases with severity of obesity, especially regarding the respiratory (airways and lungs) and cardiovascular systems;
- Difficulties in establishing surgical risk in obese individuals: physical examination is hindered by obesity (cardiac and

pulmonary auscultation, abdominal palpation);

- Clinical history may result in underestimation of symptoms (great functional limitation) and surgical risk, especially among those with obesity grades 2 and 3;
- Risk scores do not contemplate obesity as an independent risk factor;
- Difficult intubation;
- Hypoxemia by hypoventilation, restrictive lung disease, postoperative atelectasis, central and obstructive sleep apnea, hypercapnia;
- Risk of aspiration of gastric content;
- Underdiagnosed decompensated congestive heart failure and precipitation of myocardial ischemia;
- Thromboembolic events;
- Difficulty to determine blood pressure and access veins;
- Sensitivity to opioids and sedative agents;
- Surgical wound infection;
- Rhabdomyolysis;
- The risks associated with comorbidities commonly found among the obese: hypertension, diabetes, cardiovascular disease, ventricular hypertrophy.

V. 2. Preoperative assessment according to BMI and surgery classification

A. Obesity of any grade and low-risk surgery:

- Same assessment as that for nonobese individuals; *Class IIa, Level of Evidence D.*

B. Obesity grades 1 and 2 and intermediate or high-risk surgery:

- Complete medical history and physical examination;
- Clinical assessment of obstructive sleep apnea; *Class I, Level of Evidence B.*
- ECG; *Class IIa, Level of Evidence B.*
- Fasting glucose; *Class IIa, Level of Evidence B.*
- Creatinine determination if the patient is diabetic, hypertensive or has a history of renal disease; *Class IIIb, Level of Evidence C.*
- Polysomnography in selected patients; *Class IIIb, Level of Evidence C.*
- Resting and overnight non-invasive oximetry if apnea score is intermediate or high in the clinical scoring system or if diagnosis of sleep apnea has been confirmed by polysomnography; *Class IIb, Level of Evidence D.*
- Echocardiographic assessment of diastolic function if there are signs or symptoms that suggest CHF; *Class IIb, Level of Evidence D.*

C. Obesity grade 3 and intermediate or high-risk surgery:

- Electrocardiogram; *Class IIa, Level of Evidence B.*
- Fasting glucose; *Class IIa, Level of Evidence B.*

- Creatinine determination if the patient has diabetes, hypertension or a history of renal disease; *Class IIa, Level of Evidence C.*

- Echocardiographic assessment of diastolic function; *Class IIa, Level of Evidence D.*

- Resting and overnight oximetry; *Class IIb, Level of Evidence D.*

Observations:

- Additional tests such as coagulation studies, noninvasive tests for cardiac ischemia, chest x-ray and pulmonary function tests are not mandatory and should not be done routinely during the preoperative assessment of obese individuals. Additional tests are selected according to medical history. *Class IIa, Level of Evidence B.*

- Restrictive and mixed bariatric surgeries are considered intermediate-risk surgeries.

V. 3. Recommendations to reduce risk:

- Smoking cessation 6 weeks before surgery;¹ *Class I, Level of Evidence B.*

- Respiratory physiotherapy; *Class IIa, level of Evidence D.*

- If patient has sleep apnea confirmed by polysomnography or if apnea risk score is high, consider using a CPAP during the preoperative period in patients who do not use it and do not discontinue its use in patients who do; *Degree of Recommendation IIa, Level of Evidence B.*

A. Intraoperative recommendations:

- Monitor blood pressure with an inflatable cuff that is appropriate for obese individuals or in a different location (forearm) adjusted for obese patients;² *Class I, Level of Evidence B.*

- Induce anesthesia with the patient in the reverse Trendelenburg position; *Class IIa, Level of Evidence B.*

- The use of sevoflurane general anesthesia results in faster extubation and a better initial recovery period *Class IIa, Level of Evidence B.*

- Perform pre-oxygenation in the sitting or elevated head position; *Class IIa, Level of Evidence B.*

- Use the rapid-sequence induction of anesthesia with application of cricoid pressure during intubation; *Class IIa, Level of Evidence B.*

- Make sure that the stretcher that can accommodate obese patients and watch out for pressure sores; *Class IIa, Level of Evidence D.*

- Invasive pressure monitoring should be done whenever necessary; *Class IIIb, Level of Evidence D.*

B. Postoperative recommendations:

- CPAP in cases of confirmed sleep apnea;³ *Class I, Level of Evidence B.*

- Use oximetry to monitor oxygenation in patients with hypoxemia before and during surgery and suspect of respiratory

system diseases (sleep apnea, alveolar hypoventilation); *Class IIa, Level of Evidence B.*

- High risk patients with comorbidities, patients who had failure on postoperative airway extubation program, patients who suffered complications during surgery or super obese patients ($BMI > 70 \text{ kg/m}^2$) should remain in the ICU after surgery;⁴ *Class IIa, Level of Evidence C.*

- Maintain normal blood volume; *Class IIa, Level of Evidence D.*

- Perform continuous oximetry during recovery from anesthesia (*Class IIb, Level of Evidence C*), determine oxygen saturation after recovery from anesthesia (if it is normal it does not need to be measured again) and perform overnight oximetry (in cases of intermediate or high-risk surgeries); *Class IIb, Level of Evidence D.*

- All patients submitted to intermediate or high-risk surgeries are to undergo respiratory physiotherapy; *Class IIa, Level of Evidence D.*

- Deep vein thrombosis (DVT) prophylaxis:

- Encourage ambulation and use prophylactic heparins; *Class I, Level of Evidence B.*

- When indicated, both the low-molecular-weight heparin and unfractionated heparin can be used in regular regimens.⁵ If patient's weight $> 100 \text{ kg}$, consider monitoring factor Xa activity; *Class IIa, Level of Evidence B.*

- Higher doses (40mg of enoxaparin at 12-hour intervals) result in less thromboembolic events and can be useful;⁶ *Class IIa, Level of Evidence B.*

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D) Additional tests

The request for additional tests in medicine is controversial. Technological advances increase the types of tests available exponentially. Physicians need to be familiar with the attributes of a test, its indications, advantages, disadvantages, cost, availability and risks before requesting it. However, one must always remember that medical history and physical examination continue to be essential instruments in clinical diagnosis.

I. Electrocardiogram (ECG):

The ECG can detect arrhythmias, conduction defects, ischemia or myocardial necrosis, overloaded chambers, digitalis intoxication or suggest electrolyte disturbances. It is also important to have a baseline ECG to assess changes that occur during the perioperative period.¹

High risk electrocardiographic changes include severe arrhythmias (third-degree atrioventricular block, symptomatic ventricular arrhythmias with underlying heart disease, supraventricular tachycardia with high heart rate), medium risk ECG changes include the presence of pathological Q waves and low risk ECG changes include ventricular hypertrophy, left bundle-branch block, ST segment abnormalities and T wave abnormalities.²

On the other hand, routinely using a test with a limited specificity for some diseases may lead to false-positive results in patients who do not present heart diseases. For example, ST segment and T wave abnormalities may be found both in normal individuals as in patients with coronary artery diseases.³ Electrocardiographic changes usually worry the surgical team and prompts a visit to the specialist. Surgeries of individuals with varying electrocardiographic changes are cancelled more often than those of individuals with normal ECGs.⁴

Recommendations for requesting an ECG:^{5,6}

Class I:

- All patients older than 40 years or all patients with a history of and/or physical examination abnormalities that suggest cardiovascular disease regardless of age;
- Patients with a recent episode of ischemic chest pain or considered to be at high risk after algorithmic assessment;
- Patients with diabetes;

Class IIa:

- Asymptomatic obese patients;

Class III:

Guidelines

- Routinely request an ECG for asymptomatic individuals who will be submitted to low-risk surgeries.

II. Recommendations for requesting a chest x-ray:^{5,6}

- Request a chest x-ray for patients with a history of chest-related abnormalities or those with chest-related abnormalities detected during the physical examination; *Class I, Level of Evidence D.*

III. Recommendations for requesting full blood count (FBC):

Class I, Level of Evidence D.

- Request a FBC for all patients older than 65 years;
- Request a FBC when anemia is suspected during physical examination or when chronic diseases associated with anemia are present;
- Request a FBC for all patients who will be submitted to moderate/high-risk surgeries if a need for transfusion is anticipated;

IV. Recommendations for requesting hemostasis / coagulation tests:

Class I, Level of Evidence D.

- Request test for all patients on anticoagulation therapy;
- Request test for all patients with liver failure;
- Request test for all patients with coagulation disorders;
- Request for all patients who will be submitted to intermediate or high-risk surgeries;

V. Determination of serum creatinine:

Class I, Level of Evidence D.

- Determine serum creatinine in all patients older than 40 years;
- Determine serum creatinine in all patients with kidney disease, diabetes mellitus, hypertension, liver failure and/or heart failure and whose serum creatinine has not been determined in the last 12 months.
- Determine serum creatinine for all patients who will be submitted to intermediate or high-risk surgeries;

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E) Perioperative evaluation algorithms

An algorithm for perioperative evaluation of cardiovascular risk of noncardiac surgeries should cover the following stages in sequence:¹

- The clinical conditions of the patient;
- Cardiovascular functional capacity;
- The intrinsic risk associated with surgery;
- The need to use invasive or non-invasive cardiovascular diagnostic methods;
- Alternative strategies if risk is high;
- Optimization of pharmacological treatment;
- The need for additional therapeutic measures that reduce cardiovascular morbidity and mortality;
- The need for global cardiac monitoring during the perioperative period;
- The need for instructions and follow-ups after the perioperative period;

There are many perioperative evaluation algorithms in literature that can be used and some cover the items above only partially. All of them have positive and questionable points. In order to illustrate, we will discuss one of the algorithms, the one from the American College of Physicians (ACP), its advantages and disadvantages:²

I. Advantages of the ACP algorithm:

- Most of the variables used are well associated with perioperative cardiac events in many studies;
- It has been validated in Brazil by a study performed in the Clinical Hospital of University of São Paulo Medical School. In this study, the probability of cardiac events is 61.1%, 11.6% and 2.2% for Class II-III, Class I (intermediate risk) and Class I (low risk) respectively. This study shows that this algorithm presents a better post-test probability when compared with other indices.³
- It uses many clinical variables allowing for a better stratification;
- It stratifies stable heart disease (intermediate risk) and unstable heart disease (high risk);
- It covers the information obtained in an electrocardiogram;
- It covers some noncardiac clinical variables and emergency surgeries;
- It covers the type of surgery and there is a grading system for vascular and nonvascular surgeries;
- The criteria for requesting a non-invasive test to investigate myocardial ischemia are well defined. These criteria are based on the pre-test probability of the examination and of its positive predictive value⁴ and not on a negative

predictive value like most algorithms. Therefore, patients are better selected.

II. Disadvantages of the ACP algorithm

- Low risk and intermediated risk surgeries are not differentiated;
- It does not cover functional capacity;

III. Final considerations

- Algorithms are not to be used in patients who need emergency surgery intending to postpone surgery but only to quantify risk and suggest strategies that minimize it;
- The algorithm that this guideline recommends is the ACP's algorithm;²
- Some cases are far beyond the scope of an algorithm so other data must be used to assess the surgical risk/benefit

ratio;

- The algorithm is a guideline for perioperative evaluation and it does not replace the attending physician's opinion. When the physician does not agree with the algorithm's results, this fact must be stated in the perioperative evaluation. For instance, patients with reduced functional capacity who will be submitted to non-vascular high risk surgeries, may have their risk underestimated by the ACP's algorithm.

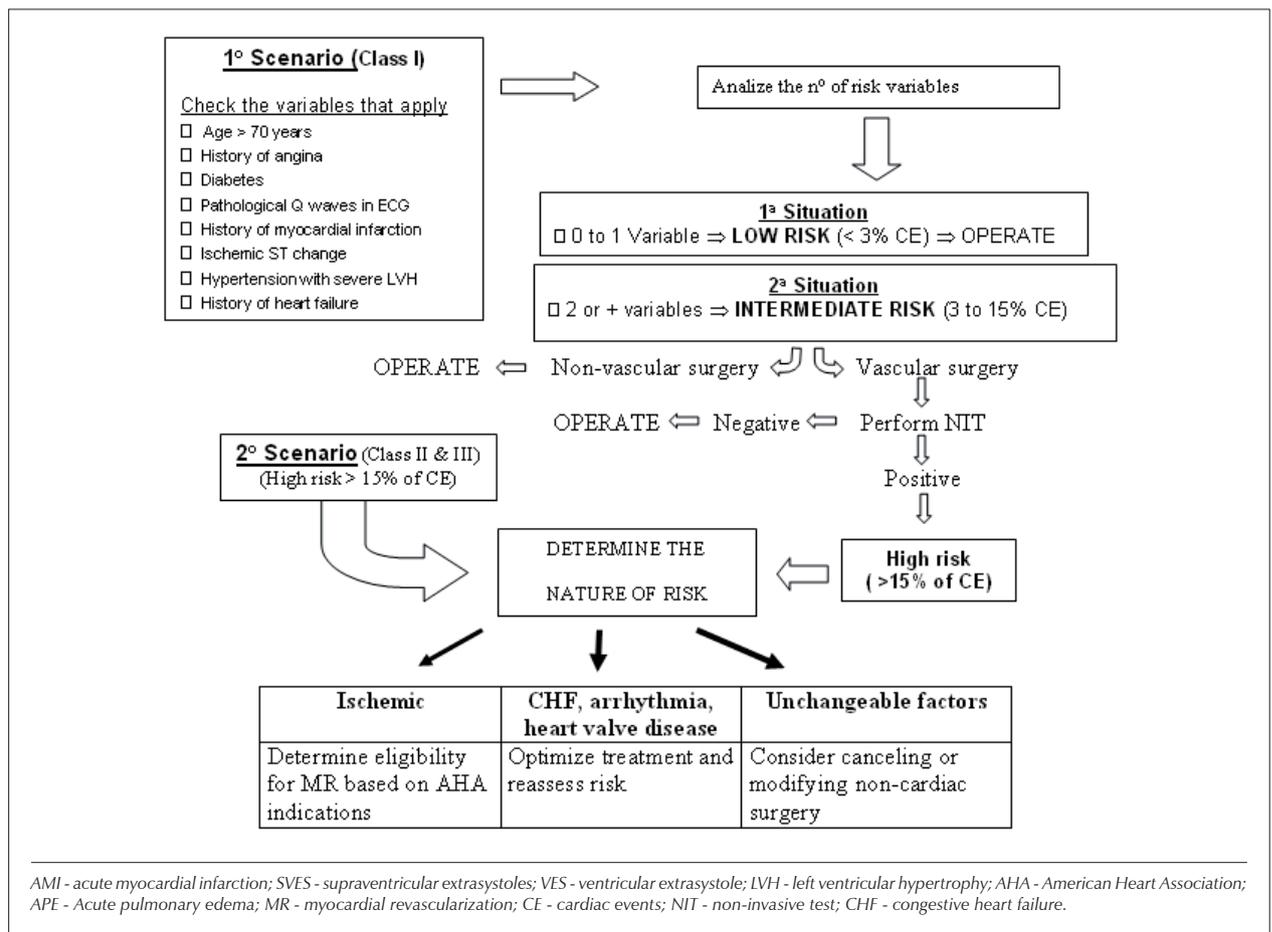
Perioperative evaluation algorithm from the American College of Physicians

- Total score:
 - Class I = 0-15 points
 - Class II = 20-30 points
 - Class III = > 30 points

1º step: attribute points according to the following findings:

- AMI < 6m (10 points) or
- AMI > 6m (5 points)
- Class III angina (10 points) or
- Class IV angina (20 points)
- APE in the last week (10 points) or
- Previous history of APE (5 points)
- Suspected critical aortic stenosis (20 points)
- Non-sinus rhythm or SR w/ SVES in ECG (5 points) or >5 VES in ECG (5 points)
- PO2 < 60, pCO2 > 50, K < 3, U > 50, C > 2.3 or bedridden (5 points)
- Age > 70 years (5 points)
- Emergency surgery (10 points)

2º step: Define if the patient is in the 1º or 2º scenario below:



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3. Specific assessment

A) Coronary Artery Disease (CAD)

I. Patients with known CAD

It is essential to clearly distinguish the surgical risk of each specific CAD condition in order to prevent and reduce the morbidity associated with perioperative events. Around four decades ago, perioperative risk assessment of coronary disease patients consisted exclusively of determining the time elapsed between an ischemic cardiovascular event and surgery date.^{1,2} Today we weigh not only the time elapsed but also all the factors that are known to be relevant in the prognosis of patients with CAD, regardless of perioperative context, such as symptoms of angina or heart failure, electrocardiographic signs of ischemia, degree of ischemia, ischemic threshold and coronary anatomy in pertinent cases.^{3,4}

There are no proven benefits of routinely and indiscriminately requesting additional tests, especially functional tests and coronary cineangiography for patients with diagnosed CAD. A careful investigation of the medical history of a patient associated with diagnostic tests that focus on the circulatory system, such as resting electrocardiogram and chest x-ray, is often enough to determine the surgical risk of CAD patients.

II. Patients with risk factors for CAD

There are no evidences to recommend functional tests for all patients with risk factors for CAD. However, it is essential to assess this population with a higher degree of clinical suspicion and vigilance, analyze the electrocardiogram carefully, attempt to estimate the functional capacity of these individuals (to avoid trusting perceived symptoms in individuals that can be very debilitated by other diseases) and weigh the invasiveness of surgery. It is equally important to assess the nature of the surgery proposed, especially in cases of vascular procedures,

since the disease that lead to surgery not only shares the same physiopathology as CAD (atherosclerosis) but also indicates the severity of the disease. If many risk factors for CAD are present, a functional test can be requested to asses myocardial ischemia as suggested by some algorithms from the American Heart Association, American College of Cardiology¹ and American College of Physicians.²

References:

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B) Hypertension

Stage 3 hypertension (systolic blood pressure \geq 180 mmHg and diastolic blood pressure \geq 110 mmHg) must be controlled before surgery but when stages 1 and 2 hypertension without metabolic or cardiovascular changes are found, there is no benefit of postponing surgery.¹

Patients with some degree of autonomic disorder, including hypertension, are more susceptible to hypotension during induction of anesthesia and surgery than patients with normal blood pressure. This is particularly true for patients who take angiotensin-converting enzyme (ACE) inhibitors before surgery. In most of the patients, this may be associated with reduced intravascular volume. Thus, it is crucial to avoid hypovolemia in the perioperative period. The withdraw of these medications before surgery may cause an hypertensive response or heart failure. Impaired autoregulation of brain blood flow in hypertensive individuals make their brains more vulnerable to blood pressure variations.

Increasing knowledge on the pathophysiology and therapeutics of hypertension and the development of new anesthetics and muscle relaxants with minimal hemodynamic effects have contributed to minimize the occurrence of complications during the perioperative period of hypertensive patients. The use of central-acting sympatholytic agents (clonidine) can improve the hemodynamic stability of hypertensive patients to some degree during anesthesia and reduce anesthetic requirement. When clonidine is used during the perioperative period of hypertensive patients, it significantly reduces variations in blood pressure and heart rate and isoflurane and narcotic requirements.²

In individuals with known CAD, blood pressure changes during surgery have already been associated with ischemic ECG changes. Many studies show that the introduction of beta-blockers during the preoperative period allows for a better control of major blood pressure oscillations and ischemic episodes during the perioperative period. Furthermore, beta-blockers reduce in-hospital mortality rates and incidence of cardiovascular complications in patients with CAD or at risk of CAD submitted to surgery.^{3,4} During surgery, it is critical to monitor the hemodynamics of hypertensive patients in order to detect blood pressure changes and signs of ischemia as soon as possible. Hypertension is not only a risk factor for CAD but it is also associated with ventricular hypertrophy, a known independent cardiovascular risk factor. This aspect must be taken into account when doing the perioperative management of the blood volume of hypertensive patients with changes in ventricular geometry and artery elasticity, especially elderly patients.⁵

Recommendations:

- If blood pressure is high and there is time enough time before surgery to reduce it with proper medications, do so; *Class I, Level of Evidence D.*
- If blood pressure is high and there is not enough time before surgery to reduce it with proper medications, administer a cardioselective beta-1 receptor blocker with rapid onset (esmolol) to keep the blood pressure from rising during intubation. Clonidine can be used when esmolol is contraindicated; *Class I, Level of Evidence C.*
- The antihypertensive medication (including ACE inhibitors) must be continued during the perioperative period, including on the day of the procedure. *Class I, Level of Evidence D.*
- If the patient's potassium level is low, intravenous administration of potassium is recommended; *Class I, Level of Evidence D.*
- The reintroduction of antihypertensive medication, preferably the one that the patient was using before surgery, should be done as soon as possible. *Class I, Level of Evidence D.*
- Volume management should be rigorous during the perioperative period. *Class I, Level of Evidence C.*

References:

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C) Congestive Heart Failure

Patients with signs and symptoms of decompensated heart failure must be considered at high risk of perioperative cardiovascular complications.¹⁻³ Such patients need careful treatment in order to optimize their hemodynamic balance and ensure a safer surgery. The use of pharmacological and dietary resources to improve the clinical status of the patient is very valuable but does not cancel the pathophysiological effects of the underlying disease. Fluid administration must be done with caution during and after surgery. Regarding anesthetic agents, prefer those that cause less myocardial depression.

When clearly symptomatic patients (NYHA functional classes III and IV) are submitted to urgent surgeries, they must be monitored closely during the postoperative period, preferably in the ICU. The use of flow-directed pulmonary artery catheter is indicated for this group to monitor hemodynamic parameters during and after surgery. Although there are no evidences that this practice improves survival rate, it allows for a better management of fluids and vasoactive agents in these circumstances.⁴

Recommendations:

Class I, Level of Evidence D

- Assessment of patients with CHF symptoms must focus on determining its etiology and the patients functional class (NYHA);
- Treatment must be optimized before surgery and patient must continue to take medications during the entire perioperative period (including the day of surgery);
- Anesthetic agents that depress myocardial contractility must be avoided in patients with CHF;
- Volume management must be rigorous. Invasive monitoring can be useful during the intraoperative and early postoperative periods of patients with severely depressed cardiac function.
- Careful evaluation of the fluid and electrolyte balance must be done.

References:

Guidelines

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D) Valvular Heart Disease

Patients with valvular heart diseases are at high risk of developing infective endocarditis when they are submitted to procedures that can introduce bacteria into their blood. If a heart murmur is present, correct patient assessment is critical to verify if an organic valvular lesion is present, which would, in general, suggest the need for infective endocarditis prophylaxis.

Although the risks of anesthesia and surgery have decreased significantly in the last decades, complications still occur during the perioperative period of patients with valvular heart disease submitted to non-cardiac surgeries: decompensated heart failure which may result in cardiogenic shock, myocardial infarction, thromboembolic phenomena, arrhythmias and infections.

In general, patients with valvular heart disease whose functional capacity is more compromised, that is, functional class III or IV, are at high risk of surgery and anesthesia and more likely to experience complications when they are submitted to non-cardiac surgeries.^{1,2} Preoperative treatment optimization and control of heart rate and blood volume reduce the likelihood of cardiac complications.

In the specific case of patients with symptomatic aortic stenosis (AS), there is a very high risk of acute pulmonary edema or sudden death. So, whenever possible, heart valve surgery should precede non-cardiac surgery.^{3,4} Balloon valvuloplasty is not recommended for patients with degenerative AS as an alternative to surgical treatment given the bad results obtained with this technique.

Mitral stenosis (MS) continues to be the most common valvular disease in Brazil. Tachycardia and excessive fluid infusion during the perioperative period causes a sudden reduction in diastolic loading and increased preload and both should be avoided. Assessment of valve anatomy by Doppler echocardiography can identify the ideal candidates for balloon valvuloplasty preceding non-cardiac surgery among extremely symptomatic patients and those with a significantly reduced mitral valve orifice.⁵

The perioperative morbidity of patients with aortic (AR) and mitral (MR) valve regurgitation submitted to non-cardiac surgery is associated with pulmonary congestion. Presence of pulmonary rales and third heart sound (S3) indicate that controlling heart failure will be critical for a positive surgical

outcome. The use of cardiotoxic, diuretic and vasodilating agents can help reduce the preload and postload besides improving cardiac contractility.

Patients with heart valve prostheses need to receive prophylaxis for infective endocarditis and those with mechanical prostheses require special attention regarding anticoagulation.⁶ When submitting patients taking anticoagulants and antiplatelets to major surgeries, it is recommended to suspend the use of anticoagulant therapy for at least 5 days. However, high risk patients such as those with mechanical mitral valve prosthesis, Bjork-Shiley valve, Star-Edwards prosthesis, history of embolic or thrombotic events (last 12 months) or at least 3 risk factors (atrial fibrillation, history of embolism, hypercoagulation, mechanical prosthesis and ejection fraction < 30%) must be treated with low-molecular-weight or intravenous heparin after reduction of prothrombin time – INR below 1.5.

Recommendations:

- Patients with valvular heart disease should be referred to a cardiologist before surgery; *Class I, Level of Evidence D*.
- Patients with valvular lesion, especially aortic stenosis, with indication for corrective surgery, should have their heart disease corrected before being submitted to non-cardiac surgery whenever possible; *Class I, Level of Evidence C*.
- Control of blood volume and electrolytic disorders must be given special attention during the entire perioperative period; *Class I, Level of Evidence D*.
- When appropriate, prophylaxis of infective endocarditis should be done; *Class I, Level of Evidence D*.
- The level of anticoagulation must be well adjusted in order to avoid hard-to-control bleeding. The use of heparins should follow current guidelines; *Class I, Level of Evidence C*.

References:

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E) Cardiac Arrhythmias and Conduction Disorders

I. Cardiac arrhythmias

Older patients have higher demand for surgery and the incidence of cardiac arrhythmias and chronic degenerative diseases also increases with age. The physician must verify if symptoms related to disorders of heart rhythms are present and if there is associated structural heart diseases.

Isolated extrasystoles can be caused by the emotional stress, coronary heart disease or varying degrees of myocardial diseases.^{1,2}

The presence of ventricular extrasystole, even repetitive forms such as paired ventricular extrasystoles or nonsustained ventricular tachycardia, does not lead to increased rates of cardiovascular complications, as long as they are asymptomatic. If symptoms or a structural heart disease associated with residual myocardial ischemia and reduced contractility is present, therapeutic measures must always be taken to decrease the likelihood of cardiovascular complications.^{1,2} Patients with isolated extrasystoles, whether atrial or ventricular, without evidence of structural cardiomyopathies should only be submitted to a resting electrocardiogram and do not require further diagnostic investigation.

Patients with permanent atrial fibrillation should only undergo surgery if their heart rate can be controlled to remain below 90bpm since some types of surgery can increase heart rate, which, in its turn, will reduce the systolic efficiency of the cardiac output.^{1,2}

Bear in mind that metabolic disorders, hypoxemia and drug toxicity can affect heart rhythm.

In urgent/emergency situations, where it is impossible to further investigate the rhythm disturbance, use a beta-blocker preventively if there are no contraindications.

Refer for cardiologist assessment:

- Patients with symptoms that are associated with:
 - Low output or syncope, structural heart disease associated with compromised left ventricular systolic function and/or myocardial ischemia. *Class I, Level of Evidence D.*
 - Tachyarrhythmia in patients with ventricular preexcitation syndrome with sudden onset and termination, without clinical findings or adequate treatment *Class I, Level of Evidence D.*
 - Tachyarrhythmias, regardless of structural heart disease, in patients with well-defined, frequent and recent symptoms of tachycardia episodes of sudden onset and termination; *Class IIa, Level of Evidence D.*
 - Low output or syncope in elderly patients with a resting heart rate below 50 bpm *Class IIa, Level of Evidence D.*
- In the absence of symptoms:
 - In patients with permanent atrial fibrillation to assess control of heart rhythm *Class IIa, Level of Evidence D.*
 - In patients with very frequent ventricular arrhythmias or repetitive ventricular arrhythmias associated with structural heart disease. *Class IIa, Level of Evidence D.*

II. Atrioventricular and intraventricular conduction disorders

Atrioventricular and intraventricular conduction disorders are less common than cardiac arrhythmias secondary to the origin of the impulse and although they can be suspected during clinical examination, they are diagnosed with the aid of an electrocardiogram. These disorders do not usually cause complications during the perioperative period. Dangerous situations would have already been diagnosed and treated, for example, with a pacemaker.

Patients with asymptomatic, mild atrioventricular blocks such as first-degree AV block, Mobitz type I second-degree AV block during sleep, bundle branch or bifascicular AV block do not need to undergo complex testing and can be cleared for surgery. Their risk of complications is very low.^{1,2}

Refer for cardiologist assessment:

- Patients with AV blocks:
 - Severe AV blocks: Type II second-degree AV block, 2:1 AV block, paroxysmal or permanent complete AV block or AV dissociation; *Class I, Level of Evidence D.*
 - Mild AV block in the resting ECG but with symptoms that suggest low output or syncope; *Class IIa, Level of Evidence D.*
- Intraventricular blocks:
 - Trifascicular block; *Class IIa, Level of Evidence D.*
 - Bifascicular block in the resting ECG but with symptoms that suggest low output or syncope; *Class IIa, Level of Evidence D.*

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F) Implantable Pacemakers and Cardioverter-Defibrillators

Artificial cardiac stimulation has advanced significantly in recent years with the development of an array of new implantable devices that are capable of monitoring and responding to abnormal heart rhythms. People often wonder if electrocautery and other equipment will cause electromagnetic interference with pacemaker function.

I. Individuals with conventional single- or dual-chamber pacemakers:

I.1. Pacemakers implanted in the last 60 days:

Most leads found in the pacemakers of today have an

active fixation element, that is, a device that allows them to be actively fixed in the endocardium. These leads are rarely displaced but sometimes a spontaneous lead displacement may occur during this period. The location where the generator was implanted is recovering from surgery, therefore, inflammatory phenomena, hematoma, edema, rejection and even subclinical infection may occur during this phase. Bear in mind that microorganisms originating in other body foci or introduced by surgeries of any kind can attach to the pacemaker and leads and cause an infection. Complications of the pacemaker surgery in addition to those of the proposed surgery must be thoroughly contemplated. If possible, elective surgery should only be done two months after pacemaker surgery in order to minimize the risk of complications.

I.2. Almost dead pacemaker batteries:

Pacemakers whose batteries are almost dead should be replaced by modern units before elective surgeries because such devices may behave strangely when submitted to certain events that may happen during elective surgery.

I.3. Safe cardiac stimulation:

These patients need to see their pacemaker physicians before being submitted to elective surgeries for a complete assessment of the stimulation system. The physician will determine if the pacemaker settings need to be changed, issue a document with warnings for the surgeon and anesthesiologist and describe the behaviors that the pacemaker may display during surgery.

Usually, the biggest concern involves those patients who will be submitted to major surgeries with the use of electrocautery. In these cases, a safety procedure should be done always in a pacemaker check-up clinic and by a certified pacemaker physician. If electrocautery^{1,2,3} cannot be substituted by ultrasonic scalpel, the document must contain at least the recommendations listed in below:

- Continuous cardiac monitoring with ECG monitor and pulse oximetry (heart rhythm monitoring is possible even during electrocautery);
- Use bipolar electrocautery. If bipolar is not available, use monopolar electrocautery but place the grounding pad far from the pacemaker and make sure to use a conducting gel;
- Ground the electrocautery device properly by connecting it to a good grounding wire;
- Limit the use of the electrocautery probe as much as possible and to very short periods and always monitor the ECG or heart rate;
- If bradycardia or tachycardia occur during electrocautery (because of electromagnetic interference), place a magnet over the pacemaker every time the electrocautery probe is used. Note that if the magnet is placed correctly, the pacemaker stimulates the heart with a fixed heart rate;
- Avoid using arrhythmogenic agents during anesthesia (sympathomimetic and/or atropine-like agents);
- Avoid volume overload and if possible, keep the patient

in the slightly elevated reclined position;

Remind the patient to return to the pacemaker check-up clinic after the postoperative recovery period so that the original settings can be restored and the pacemaker reassessed.

II. Individuals with multisite cardiac resynchronization devices:

More leads in the heart undeniably increase the likelihood of complications due to external interferences on the stimulation system. Most stimulation leads used in the venous system of the left ventricle are unipolar, thus more susceptible to external interferences, especially those caused by electrocautery.

III. Patients with Implantable Cardioverter-Defibrillators (ICDs):

The behavior complexity and diversity of these devices, the risk of severe arrhythmias during surgery and the possibility of electrocautery causing electromagnetic interferences lead us to recommend the presence of the pacemaker physician and the necessary equipment to program the ICD in the surgery room so that it can be adjusted during surgery if necessary and according to the metabolic needs of the patient. Antitachycardia function must be disabled and the patient properly monitored. As this function is disabled, the physician needs to be ready to respond to a high-risk arrhythmia with an external defibrillator and antiarrhythmic medications. It is not unusual for the pacemaker physician to have this type of patient stay in the ICU during the early postoperative period so that they can be closely monitored, specially while the antitachycardia function is not working.

IV. Emergency electrical cardioversion or defibrillation

During the perioperative period, patients with a pacemaker or implantable cardioverter-defibrillator may have complications that require an electrical cardioversion or defibrillation. Although the generators can theoretically withstand the shocks, in practice it is advisable to avoid them whenever possible. When indispensable, some cautions must be taken⁴ to preserve the pacemaker or defibrillator, the leads and the lead-heart interface, as described below:

- Internal cardioversion is preferred in patients with internal ICD since it uses less energy, biphasic pulse and internal safety resources of the device itself;
- Prefer cardioverters that come with adhesive pads. Place them anteroposteriorly, according to the polarity informed by the manufacturer. Avoid the standard placement of the pads (between the base and tip of the heart – parallel to the leads) since the myocardium may be injured by the tip of the lead.
- Attach the pads as far as possible from the generator and leads;
- Use as little energy as possible. Modern cardioverters delivering biphasic shocks should be preferred;

- Place a magnet over the generator of the pacemaker (not over that of the ICD because if a magnet remains over them for more than 30 seconds, it can disable the antitachycardia function). This attitude leads to two different responses: the sensing circuit of older pacemakers invariably shuts down when a magnet is placed over them and become asynchronous. Conversely, modern rate-responsive devices are programmable and can have different behaviours. Thus, placing a magnet over the generator does not necessarily protect the device during a cardioversion.

- Verify the sensing and pacing thresholds after the procedure. Consider reassessing the device in 24 hours and monitor the patient during this time.

V. Recommendations:

1. In the preoperative period:

- Determine if the patient uses a single or dual chamber pacemaker, resynchronizer, defibrillator or multiple prostheses; *Class I, Level of Evidence D.*

- Check the identification card, radiological identification number or hospital records to determine what type of device the patient is using; *Class I, Level of Evidence D.*

- Determine if the patient depends on the pacemaker by reviewing previous assessments, asking the patient if they had syncope or dizziness before the implant or decreasing the timing of the device to the lowest rate and observing if an escape focus occurs and its stability; *Class I, Level of Evidence D.*

- Determine the function of the pacemaker. This requires a specific previous assessment of the device and adjusting the settings. If it is impossible to adjust its settings, check if there is an effective pacemaker pacing artifact (that generates pacing) in the ECG; *Class IIb, Level of Evidence D.*

2. In the intraoperative period:

- All patients must be monitored by continuous ECG and plethysmography (or auscultation, pulse palpation or ultrasound) regardless of the type of anesthesia; *Class I, Level of Evidence C.*

- Electrocautery: follow the recommendations listed in item 13; *Class I, Level of Evidence D.*

- Radiofrequency ablation: place the grounding pads far from the generator and leads and do not allow the ablation catheter to touch the pacemaker's leads *Class I, Level of Evidence C.*

- Lithotripsy⁵: do not focus the lithotripsy beam toward the pacemaker and leads. Turn off atrial stimulation when using ECG-triggered lithotripsy; *Class IIa, Level of Evidence D.*

- Cardioversion or defibrillation: follow the recommendations listed in item IV; *Class I, Level of Evidence D.*

3. In the postoperative period:

Class I, Level of Evidence D.

- Heart rate and rhythm must be continuously monitored during the postoperative period;

- Cardioversion/defibrillation equipment and resources for cardiac stimulation must be available;

- If the functions of the pacemaker were changed for surgery, reprogram it back to its usual settings as soon as possible.

References:

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G) Transplants

Organ transplant comprehends many different clinical situations that range from the transplant of lifeless structures, such as corneas, to vital organs, such as heart and liver, without which it is impossible to keep an individual alive for days or even hours, even if proper equipment is used.

Since this is a very heterogeneous group of patients, there is no single perioperative assessment protocol for all the different types of transplant surgeries. Additionally, there is a lack of prospective and controlled studies in this area. The available assessment methods usually reflect the opinion of specialists and are based more on comorbidities than on the disease that required the transplant.¹⁻⁵

Recommendations:

- Use non-invasive methods to determine if kidney and liver transplant candidates with risk factors for coronary artery disease have ischemic heart disease; *Class IIa, Level of Evidence D.*

- When revascularization is indicated for patients with coronary artery disease, it should precede transplant surgery; *Class IIa, Level of Evidence D.*

- Investigate if liver transplant candidates have pulmonary hypertension before submitting them to liver transplant; *Class IIa, Level of Evidence D.*

- Transplant indication must be reassessed if there is severe comorbidity with unfavorable short-term prognosis; *Class I,*

Level of Evidence D.

References:

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H) Heart disease and pregnancy

Morbidity and mortality rates of pregnant women submitted to surgery are above average because these surgeries are needed by women with acute conditions or whose clinical condition worsened and is not responding to medications. Fetal prognosis is associated with the mother's prognosis and depends on the gestational period in which surgery takes place. Surgery performed in the first trimester of pregnancy is more associated with higher risks of teratogenesis and miscarriage in the last trimester with a higher risk of preterm birth.¹

Sometimes the symptoms are hard to distinguish, so additional testing is common and necessary. Treatment strategy should not be determined by test results alone during pregnancy. Electrocardiograms, echocardiograms and sometimes dynamic electrocardiograms (Holter monitor) are the most common tests performed in pregnant women suspected of heart disease. They are usually enough to confirm a diagnosis and determine cardiac risk in non-cardiac surgeries.

All physicians should be aware of the normal changes caused by pregnancy in heart tests so that these changes can be distinguished from changes caused by cardiac anomalies, such as the presence of Q waves in the D3 lead, AQRs left axis deviation and ventricular repolarization changes in the electrocardiogram. In Doppler echocardiogram, there can be an exacerbation of the transvalvular or intramyocardial gradient of obstructive lesions, increased diameters of the cardiac chambers or tricuspid regurgitation.

Recommendations on additional tests:²

- Resting or dynamic ECG and Doppler echocardiogram do not pose any risk for mother or fetus. *Class I, Level of Evidence D.*
- Chest x-ray should not be used routinely during pregnancy *Class I, Level of Evidence C.*
- Myocardial scintigraphy is not advised because the fetus can be exposed to ionizing radiation. If absolutely necessary, use technetium-99m and thallium-201 scintigraphy; *Class IIb, Level of Evidence C.*
- Gallium-67 scintigraphy is always contraindicated during pregnancy; *Class I, Level of Evidence C.*
- When hemodynamic studies are needed, make sure to protect the abdomen. *Class I, Level of Evidence C.*
- Nuclear magnetic resonance is not contraindicated during pregnancy *Class I, Level of Evidence C.*

Recommendations for surgeries in pregnant women:

- Delaying indication for surgery and surgery itself are the main causes for morbidity and mortality;
- The second trimester of pregnancy is the safest for the mother and fetus;
- Conventional surgical techniques should not be modified because of pregnancy;
- Serial assessment of fluid and electrolyte balance and hematocrit and hemoglobin levels;
- The pregnant uterus should not be allowed to compress the inferior vena cava during surgery;
- An efficient analgesia prevents preterm birth;
- Gastrointestinal decompression prevents emesis and aspiration;
- Insure efficient pre-oxygenation before induction and intubation;
- Prevent paralytic ileus;
- Avoid using too much crystalloid solution in the intraoperative infusion;
- Avoid using solutions containing glucose when delivery is imminent to reduce the risk of neonatal hypoglycemia;
- Insert a Foley catheter to prevent build up of urine in the bladder;
- Maintain the standard antibiotic therapy;
- Pay special attention to lower limb edema as it increases the risks of phlebitis caused by prolonged inactivity and postoperative thromboembolism;
- Do not encourage early ambulation to avoid preterm birth;
- Administer vaginal progesterone to prevent premature labor (250mg/day);

Prevention of thromboembolism

Susceptibility to thrombosis during pregnancy is higher

because of a combination of factors: blood stasis and hypercoagulation due to an increase in coagulation factors and reduction in fibrinolysis and fibrinolytic proteins.³ Other factors may also contribute to an increased risk of thromboembolism such as obesity, lengthy hospital stays, weeks of pregnancy, parity and surgical interventions.

The decision to use anticoagulant agents to prevent thromboembolism during pregnancy will depend on the risk-benefit analysis of each case⁴ as the risk of thromboembolism depends on the clinical condition of patient. Pregnant women with chronic atrial fibrillation, history of thromboembolism, intracavitary thrombus and dilated cardiomyopathy⁵ are considered at moderate risk while those with mechanical prostheses are considered at high risk.⁵

Recommendations:

- Heparin is the anticoagulant of choice for pregnant women as it does not cross the placental barrier and is not harmful to the fetus;⁵ *Class I, Level of Evidence A.*

- Although still controversial, preoperative anticoagulation therapy for high risk patients is 12UI/kg/hour of non-fractionated intravenous (iv) heparin controlled by activated partial thromboplastin time (1.5 times the relation of PTTs) or 1mg/kg/day of low-molecular-weight heparin (enoxaparin) at 12-hour intervals. For patients at moderate risk, the recommendation is 10,000 UI of subcutaneous non-fractionated heparin at 12-hour intervals or subcutaneous low-molecular-weight heparin (enoxaparin) at 40mg/day. Suspend the use of non-fractionated heparin 4 hours before surgery and low-molecular-weight heparin 18 hours before surgery, reintroducing them 6 hours after surgery.⁵ *Class IIb, Level of Evidence C.*

References:

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I) Dental procedures

The incidence and severity of odontogenic bacteremia increase significantly in the presence of infective foci such as periodontal and endodontic infections, yet they can be caused even by simple actions, such as toothbrushing and chewing.¹

Therefore, dental assessment before surgical procedures should be done routinely in patients with or without heart disease in order to reduce perioperative complications.

There is controversy regarding the use of local anesthetics with vasoconstrictors in heart disease patients. Local anesthetics with vasoconstrictors increase the quality and duration of analgesia and reduce bleeding.² Local anesthetics without vasoconstrictors last very little, are rapidly absorbed (high toxic potential), do not kill pain adequately, which may lead to hemodynamic changes and even cardiac arrhythmias, and promote slight vasodilation, which, in turn, increases bleeding. Lidocaine with epinephrine is the most common local anesthetic used worldwide.²

Epinephrine or other vasoconstrictors are contraindicated in cases of untreated repetitive ventricular arrhythmia or supraventricular tachycardia with rapid ventricular response and should be used with caution in paced patients.³ Vasoconstrictor use is also contraindicated in patients with unstable angina and the hospital may be the most appropriate place for dental treatment in this population.³ Use epinephrine with caution in patients with hypertrophic cardiomyopathy.³

The use of epinephrine in patients with uncontrolled hypertension has been associated with a statistically insignificant but nevertheless slight increase in systolic and diastolic blood pressure.³ Vasoconstrictors may also be contraindicated in patients with a recent history of myocardial infarction, patients with severe congestive heart failure, uncontrolled hyperthyroidism³ and drug addiction.

Recommendations:

- Patients on optimal medication therapy for heart disease can safely undergo dental procedures and do not require special care; *Class I, Level of Evidence D.*

- The use of anesthetics with vasoconstrictors should be avoided during acute phases of coronary events, cardiac arrhythmias with rapid ventricular response, hyperadrenergic states or left ventricular outflow obstruction; *Class I, Level of Evidence D.*

- Pacemakers and automatic internal cardiac defibrillators are not affected by high or low rotation speed drills, amalgam mixer, electrical pulp testing, laser, electric toothbrushes, endodontic ultrasound and radiography. There are specific recommendations for electrocautery (see item 3F); *Class I, Level of Evidence C.*

I. Dental procedures in patients on anticoagulation therapy

Patients with INR < 3.0 can receive any type of dental care that does not cause too much trauma (single tooth or multiple teeth extraction, alveoloplasty, biopsy, frenectomy) without having to discontinue anticoagulation therapy, as long as hemostatic measures are taken. This includes: atraumatic surgery, sutures that close wounds properly, application of direct pressure to avoid or stop bleeding, use of topical hemostatic agents such as thrombin, gelatin sponge, oxidized regenerated cellulose, synthetic collagen, local compression with gauze soaked in tranexamic acid for 30 to 60 minutes

and use of other antifibrinolytic agents before and after surgery.^{3,4}

Oral antifibrinolytic therapy should start 24 hours before surgery. The recommended dose of ϵ -aminocaproic acid is 200mg/kg at 6-hour intervals for up to 8 days (starting 24 hours before surgery). Tranexamic acid is more potent than ϵ -aminocaproic acid and the recommended dose is from 25 to 30mg/kg at 8-hour intervals for the same period (starting 24 hours before surgery and lasting 7 days after surgery). Another alternative to prevent bleeding episodes without discontinuing anticoagulation therapy is to rinse the mouth with 10ml of a 4.8% aqueous solution of tranexamic acid (4 times per day, rinse for 2 minutes at a time) starting after surgery and for the next 7 days. The mouth can also be rinsed with a ϵ -aminocaproic acid solution.⁵

Follow the recommendations given for non-dental surgeries for procedures that cause much bleeding.

Recommendations:

- Warfarin should not be discontinued in patients who are not at high risk of bleeding; *Class I, Level of Evidence D*.
- Patients at high risk of bleeding should stop warfarin and the procedure could be done when INR is under 1.5. If the patient is at high risk of thrombosis, heparin should be given thereafter, discontinued 4 hours before surgery, reintroduced as soon as possible after the procedure and maintained until INR > 2.0; *Class I, Level of Evidence D*.
- Patients submitted to dental treatments that cause local bleeding can rinse their mouths with aqueous solutions of tranexamic or ϵ -aminocaproic acid without the need to discontinue anticoagulation therapy; *Class I, Level of Evidence D*.

II. Dental procedures and prevention of infective endocarditis

In this situation, the physician should consider the patient's susceptibility to infective endocarditis and the likelihood of the procedure contaminating the blood with a microorganism that is capable of causing infective endocarditis.

The dental procedures that are most likely to cause bacteremia are: subgingival placement of antibiotic fibers or strips, teeth extraction, dental implants or reimplants, endodontic and periodontal procedures, placement of orthodontic bands and procedures that cause significant bleeding. High-risk patients should always receive antibiotic prophylaxis when submitted to these procedures.

Patients undergoing hemodialysis using arteriovenous fistulas require antibiotic prophylaxis.³ Patients with vascular stenting should take antibiotics after dental procedures for 4 to 6 weeks.^{3,6}

Subjects with dental infections who are submitted to organ transplantation should be treated with antibiotics before and after the procedure.

The therapeutic options to prevent infective endocarditis are listed in item 5E.

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4. Additional perioperative assessment

A) Shortcut for non-invasive testing

Moderate-risk patients who will be submitted to vascular surgeries should always have a non-invasive test to detect myocardial ischemia (*Class I, Level of evidence D*). Thus, functional tests are not indicated for low-risk patients since there would be no additional benefits, nor are they indicated for high-risk patients since these usually require an invasive stratification.

Perioperative assessment of myocardial ischemia should be done with imaging tests. Myocardial perfusion imaging with exercise-induced stress (preferred over stress with dipyridamole or dobutamine when there are no contraindications) and stress echocardiogram are very accurate tests, have a high negative predictive value and can be compared.

Exercise electrocardiography is not as accurate as imaging tests and has limitations in patients with resting electrocardiographic changes, such as bundle branch blocks, ventricular hypertrophy and ventricular repolarization changes. However, in a select group of patients who manage to reach 85% of the expected heart rate, the test has a high negative predictive value and allows the functional capacity to be objectively assessed.¹⁻⁴

Patients who have been submitted to some sort of functional test in the previous two years and whose symptoms have not changed do not need to repeat the test. The same

applies to patients who have been submitted to complete myocardial revascularization in the previous 5 years and remain clinically stable.

Recommendations for requesting non-invasive tests

Class I

- Indicated for patients with intermediate clinical predictors and who will be submitted to vascular surgeries;

Class IIa

- Indicated when at least two of the three items below are present:

1. Presence of angina functional classes I or II, history of myocardial infarction or pathological Q wave, previous or compensated heart failure, diabetes mellitus or renal failure;

2. Low functional capacity: less than 4 METs;

3. High-risk surgeries: peripheral vascular surgeries or aortic surgery, lengthy surgeries with considerable blood loss or shifts in body fluids;

Class IIb

- Indicated for patients who have not undergone functional testing in the previous two years and who have

1. Coronary artery disease or

2. At least two risk factors for CAD (hypertension, smoking, dyslipidemia, diabetes mellitus, positive family history);

Class III

- In patients who are not candidates for myocardial revascularization and whose non-cardiac surgical plan cannot be changed because of the results of a functional test.

References:

1. Eagle et al .ACC/AHA Guideline Update on Perioperative Cardiovascular Evaluation for Noncardiac Surgery 2002.
2. Grayburn PA, Hillis LD. Cardiac events in patients undergoing noncardiac surgery: shifting the paradigm from noninvasive risk stratification to therapy. *Ann Intern Med* 2003;138(6):506-11.
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B) Importance of analyzing resting LV function

Left ventricular function can be assessed by transthoracic echocardiography, nuclear ventriculography or by contrast ventriculography. Usually, two-dimensional echocardiography is the test of choice since it also allows the assessment of the structure and dynamics of the valves or the presence of ventricular hypertrophy. Routine preoperative assessment of left ventricular function is questionable although the clinical

context of each case needs to be taken into account.¹⁻⁵

Recommendations:

Class I

- Clinical suspicion of aortic stenosis; *Level of Evidence B*;

Class IIa

- Patients with CHF without previous assessment of ventricular function; *Level of Evidence D*;

- Grade III obesity; *Level of Evidence D*;

- Preoperative assessment of liver transplant; *Level of Evidence D*;

Class IIb

- Detection of valvular heart disease; *Level of Evidence B*;

Class III

- Routinely for all patients; *Level of Evidence D*.

References:

1. Halm EA, Browner WS, Tubau JF, Tateo IM, Mangano DT. Echocardiography for assessing cardiac risk in patients having noncardiac surgery. *Ann Intern Med* 1996;25:433-441.
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C) Exercise electrocardiogram

The importance of doing an exercise electrocardiography during perioperative evaluation is to objectively determine the functional capacity, identify if severe ischemia and arrhythmias are present and estimate cardiac risk and long-term prognosis.

An important limitation of this test in perioperative evaluation for non-cardiac surgery is the fact that 30 to 50% of the patients referred to the cardiologist for preoperative

evaluation for major or vascular surgeries cannot achieve a sufficient load during exercise to assess cardiac reserve.¹⁻³

A prospective study assessed 204 patients with coronary disease or at risk of coronary disease who were submitted to non-cardiac surgeries that required general anesthesia. All of them had been submitted to exercise electrocardiography preoperatively while taking the standard medication. ST segment depression ≥ 1 mm was considered an independent predictor of postoperative cardiac events. The positive predictive value of the test was only 20%.⁴

Perioperative exercise electrocardiography is an inexpensive, easy to perform and highly reproducible test, and although it is inferior to imaging tests, it is adequate to the reality of many towns in Brazil⁵.

Recommendations for requesting a perioperative exercise electrocardiogram:

Class IIa

- Indicated when the two factors below are present:

1. Presence of intermediate clinical predictors of risk: angina functional class I or II, history of myocardial infarction or pathological Q wave, previous or compensated heart failure, diabetes mellitus or renal failure;
2. High-risk surgery: aortic or peripheral vascular surgeries, lengthy surgeries with considerable blood loss or shifts in body fluids;

Class IIb

- Indicated for patients without a functional assessment in the previous two years and

1. Known to have coronary artery disease
2. With at least two risk factors for CAD (hypertension, smoking, dyslipidemia, diabetes mellitus, positive family history);

Class III

- In patients who are not candidates for myocardial revascularization and whose non-cardiac surgical plan cannot be changed because of the results of a functional test;

- Routinely for all patients.

References:

1. Von Knorring J, Lepantalo M: Prediction of perioperative cardiac complications by electrocardiographic monitoring during treadmill exercise testing before peripheral vascular surgery. *Surgery* 1986; 99: 610-613.
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D) Myocardial scintigraphy with pharmacological and non-pharmacological stress

In the perioperative context, indications for scintigraphy and its interpretations are the standard ones. Exercise should be preferred to pharmacological stress. Pharmacological stress can be used in cases of physical disabilities.

Pharmacological stress should also be used in patients who will be submitted to vascular surgeries since it is difficult for them to exercise because of the disease. Patients with aortic aneurysms should not be submitted to dobutamine or exercise stress whereas dipyridamole should be avoided in the presence of bilateral carotid stenosis greater than 70%.

E) Dobutamine stress echocardiography

Stress echocardiography is accurate in identifying patients with coronary artery disease, it is safe and plays an important role in predicting cardiac events.^{1,2} Dobutamine and exercise stress echocardiographies present similar diagnostic accuracies and are more accurate than dipyridamole stress echo.³ If dobutamine stress echo does not reveal the presence of residual ischemia in a patient with a history of myocardial infarction, the prognosis is good and the likelihood of another myocardial infarction is low after non-cardiac surgery.⁴

The use of dobutamine stress echocardiography to assess perioperative risk is already well documented in literature, with a positive predictive value ranging from 21 to 95% and a negative predictive value ranging from 93 to 100% for cardiac events in patients submitted to non-cardiac surgeries.⁵ The results usually influence the clinical course of action, for example, the patient may be submitted to coronary cineangiography before elective surgery or myocardial revascularization before or after elective surgery.

L'Italien et al.⁶ assessed how clinical markers influenced long term cardiac risk assessment in patients submitted to vascular surgery. The evidences indicate that low-risk patients will not benefit from non-invasive tests unless their functional capacity is low (<4 METs) and they are candidates for high-risk surgeries (*Level of Evidence B*). On the other hand, patients with 3 or more minor clinical predictors should be considered intermediate-risk patients. (*Level of Evidence D*) All patients with intermediate risk for cardiac events and low functional capacity (<4 METs) and those with good or excellent functional capacity (>4 METs) who will be submitted to high-risk surgeries (*Level of Evidence B*) must undergo stress echocardiography. Consider doing a coronary cineangiography in patients with major clinical predictors for cardiovascular events. (*Level of Evidence B*).

References:

1. Mathias W Jr, Arruda A, Santos FC, Arruda AL, Mattos E, Osorio A Campos O, Andrade JL, Carvalho AC. Safety of dobutamine-atropine stress echocardiography: a prospective experience of 4033 consecutive studies. *J Am Soc Echocardiogr* 1999; 12: 785-791.
2. Chuah SC, Pellikka PA, Roger VL, McCully RB, Seward JB. Role of Dobutamine stress echocardiography in predicting outcome in 860 patients with known or suspected coronary artery disease. *Circulation* 1998; 97: 1474-1480.
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4. Bigi R, Cortigiani L, Mariani PR, Bax JJ. Sustained favorable long-term prognosis of negative stress echocardiography following uncomplicated myocardial infarction. *Am J Cardiol* 2002; 90: 149-152.
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Recommendations for stress echocardiography / stress myocardial perfusion scintigraphy:

Class I

- Indicated for intermediate-risk patients who will be submitted to vascular surgeries;

Class IIa

- Indicated when at least two of the following factors are present:

1. Presence of intermediate clinical predictors of risk: angina functional class I or II, history of myocardial infarction or pathological Q wave, previous or compensated heart failure, diabetes mellitus or renal failure;
2. Low functional capacity: below 4 METs;
3. High-risk surgeries: peripheral vascular or aortic surgeries, lengthy surgeries with considerable blood loss or shifts of body fluids;

Class IIb

- Indicated for patients who have not been submitted to functional assessment in the previous two years and

1. Known to have coronary artery disease
2. With at least two risk factors for CAD (hypertension, smoking, dyslipidemia, diabetes mellitus, positive family history);

Class III

- In patients who are not candidates for myocardial

revascularization and whose non-cardiac surgical plan cannot be changed because of the results of a functional test;

- Routinely for all patients.

F) Holter monitor

The Holter monitor can be used to assess arrhythmias or to identify silent ischemia by ST segment analysis. Its routine use in the perioperative context is not recommended. It is used only in specific cases based on the clinical condition and specific symptomatology of the patient.

G) Coronary cineangiography

The objective of doing a coronary cineangiography during the preoperative assessment of a non-cardiac surgery is to better assess and stratify myocardial ischemia and propose intervention strategies to reduce perioperative cardiac risk. Indications for this test in the perioperative period are the same as those of clinical practice. It should not be done routinely in perioperative assessments.

In cases where non-cardiac surgery is urgent, indication for this test can be postponed, considering the global risk and benefit.

Recommendations for coronary cineangiography:

Class I

- High-risk non-invasive test;
- Presence of major clinical predictors;
- High-risk acute coronary syndrome;
- Positive non-invasive test with proven ischemia and LV dysfunction;

Class IIa

- Low- or moderate-risk non-invasive test with preserved ventricular function;

Class III

- Patients who are not candidates for myocardial revascularization;

5. Steps to reduce surgical risk

A) Perioperative medication therapy

I Beta-blockers

Over the last 20 years, beta-blockers went from belonging to a class of medications that should be perioperatively discontinued to becoming one of the main pharmacological aids used to clinically control and reduce perioperative risk. It was believed that beta-blockers could blunt an appropriate hemodynamic response to surgical stress. This concept has been refuted by important evidences regarding their safety.¹ There are two main randomized studies that established the beneficial impact of perioperative beta-blocker use: one included some individuals at risk of

cardiovascular complications, even if the risk was low, with at least two risk factors for CAD² and the other one selected a population of moderate and high risk patients with ischemia detected by stress echocardiogram undergoing vascular surgeries.³

Mangano found a 65% reduction of cardiovascular mortality at 2-year follow-up and reduced cardiovascular morbidity in the group treated with beta-blocker (17% versus 32%, $p=0.008$). The greatest benefit occurred mainly in the first 8 months of follow-up.² In another study, Poldermans demonstrated a 91% reduction in the rates of nonfatal myocardial infarction and death from cardiac causes within the 30 days that followed surgery in patients pretreated with beta-blockers (3.4% versus 34%, $p<0.001$).³

Perioperative indication of beta-blockers to patients at low or moderate risk of cardiovascular complications who will be submitted to non-cardiac surgeries has been criticized because of the limitations of the clinical assays.

The objective is to control heart rate to approximately 60 bpm. betablockers should be introduced at the moment of the preoperative evaluation and continued until 7 days after surgery. It is important to emphasize that if the beta-blocker has not been introduced prior to surgery, it can be done intravenously during surgery.

Recommendations for perioperative beta-blocker use:

Class I

- High-risk (ACP Classes II and III) and CAD patients; *Level of Evidence A.*

Class IIb

- Two or more cardiovascular risk factors (>65 years, hypertension, smoking, diabetes and total cholesterol >240mg/dl);² *Level of Evidence B.*

Class III

- Patients with contraindication to beta-blockers; *Level of Evidence B.*

II. Statins

In a recent study in Brazil, 98 patients submitted to elective vascular surgeries were randomized to receive atorvastatin (20mg) or placebo. At 6-month follow-up, there was a 68% reduction in the rate of major cardiovascular events in the atorvastatin group.⁴ This reduction was not influenced by baseline cholesterol levels or beta-blocker use (similar between the groups).

Later, another study also investigated the benefits of using statins to reduce the perioperative mortality of vascular surgeries. A total of 2816 patients with a mortality rate of 5.8% were assessed retrospectively.⁵ The mortality rate in the statin group was 4.5 times lower than that in the non-statin group (OR 0.22 CI: 0.10 – 0.47). This study included patients who had undergone surgery as far back as 1991, a time when perioperative beta-blocker use had not yet been well established. The rate of beta-blocker use among survivors was higher, which could lead to an overestimation of the beneficial effects of statins.

Recommendations for perioperative statin use:

Class I

- Patients undergoing vascular surgeries; *Level of Evidence B.*

- Patients with known CAD or those who already use statins; *Level of Evidence D.*

Class IIb

- High-risk patients (ACP Classes II and III); *Level of Evidence D.*

III. Alpha-agonistas

In order to moderate catecholamine response to surgery and anesthesia and thereby decrease the risk of myocardial complications in CAD patients, some authors studied the effects of these drugs, especially clonidine, in the perioperative context. The results are conflicting.

IV. Aspirin

Acetylsalicylic acid (AAS) is a potent antiplatelet agent. Its ability to reduce morbidity and mortality rates of CAD patients is well known.

Recommendations:

- Patients on lifelong AAS therapy should not discontinue its use before surgery except in cases of neurological surgery or transurethral prostatectomy;⁶ *Class I, Level of Evidence B.*

- Consider reducing the dose of patients taking higher doses of AAS (325 mg); *Class IIa, Level of Evidence D.*

References:

1. Goldman L. Cardiac risks and complications of noncardiac surgery. *Ann Intern Med* 1983; 98:504-513.
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6. Burger W, Chemnitius JM, Kneissl GD, Rucker G. Low-dose aspirin for secondary cardiovascular prevention-cardiovascular risks after its perioperative withdraw versus bleeding risks with its continuation- review and meta-analysis. *J Intern Med* 2005; 257: 399-414.

B) Myocardial revascularization

Myocardial revascularization can be indicated before non-cardiac surgery to reduce perioperative cardiovascular risk.^{1,2} Most of the patients submitted to myocardial revascularization with angioplasty or surgery already had an indication for the procedure. The interval, that is, the amount of time elapsed between both procedures is an important factor, even in cases of angioplasty.³⁻⁵ On one hand, there is a risk of intracoronary thrombosis when this interval is too short and intrastent restenosis when this interval is too long. On the other hand, there is a risk of hemorrhagic complications associated with the use of potent antiplatelet agents such as clopidogrel. Finally, bear in mind that patients who received a drug-eluting stent should take clopidogrel for more time than those who received bare-metal stents given the risk of late stent thrombosis.

Recommendations for myocardial revascularization (surgical or percutaneous) before non-cardiac surgeries:

Class I

- Angioplasty should only be done when there is proof of artery-related ischemia. It should not be done when it is based exclusively on anatomical findings; *Level of Evidence A*.

- Patients with indication of myocardial revascularization, regardless of perioperative context who are scheduled to undergo elective non-cardiac surgeries; *Level of Evidence D*;

- Evidence of extensive ischemic areas, low ischemic threshold and high- risk coronary anatomy (lesion of the left coronary artery and triple-vessel disease with ventricular dysfunction); *Level of Evidence D*;

Class IIa

- Patients without high-risk functional or anatomical markers for perioperative cardiac complications but with indication of myocardial revascularization before major non-cardiac surgeries (vascular, intraperitoneal or intrathoracic surgeries); *Level of Evidence D*;

Class IIb

- Patients without high-risk functional or anatomical markers for perioperative cardiac complications but with indication of myocardial revascularization before surgeries other than major vascular, intraperitoneal or intrathoracic surgeries; *Level of Evidence D*;

Class III

- Patients in need of emergency, non-cardiac surgery regardless of symptom severity or degree of coronary artery obstruction; *Level of Evidence D*;

- Patients with diseases that require non-cardiac surgeries and greatly increase the risk of general complications during the perioperative period of myocardial revascularization, such as intestinal neoplasias with considerable bleeding, severe dyspeptic symptoms, intra or extracavitary infections, head injury or brain tumors that may bleed; *Level of Evidence D*;

- Patients with bad prognoses because of severe non-cardiac illness who may be submitted to palliative surgeries such as gastrostomy, gastric/intestinal bypass, tracheotomy, etc.; *Level of Evidence D*.

Recommendations regarding safe intervals between myocardial revascularization and non-cardiac surgery:

Class I

- After surgical myocardial revascularization:

- Ideal interval: 30 days; *Level of Evidence D*.

- Minimum interval: depends on the clinical condition of the patient; *Level of Evidence D*.

- After balloon angioplasty without stenting:

- Ideal interval: 14 days; *Level of Evidence B*.

- Minimum interval: 7 days; *Level of Evidence B*.

- After angioplasty with stenting:

- Ideal interval: 6 weeks; *Level of Evidence B*.

- Minimum interval: 14 days; *Level of Evidence B*.

- After angioplasty with drug-eluting stenting:

- Ideal interval: not established; *Level of Evidence D*.

- Minimum interval: 30 days;⁶ *Level of Evidence D*.

References:

1. Eagle K., Rihal CS., Mickel MC., Holmes DR., et al. Cardiac Risk of Noncardiac Surgery- Influence of Coronary Disease and Type of Surgery in 3368 Operations. *Circulation* 1997; 96: 1882-1887.
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C) Venous thromboembolism prophylaxis

Adequate prophylaxis for each patient depends on knowing their risk factors. Among surgery candidates there are the

Guidelines

additional risks of surgery itself¹ (Table 5).

The risk factors for venous thromboembolism (VTE) are: old age, prolonged immobilization or paralysis, previous venous thromboembolism, cancer and its treatments, major surgeries (especially those that involve the abdomen, pelvis and lower limbs), obesity, trauma (especially in the pelvis and lower limbs), peripheral venous disease, cardiac dysfunction, stroke, central venous catheters, inflammatory bowel disease, nephrotic syndrome, pregnancy and estrogen use.

I. Classification of VTE risk according to patient and surgery characteristics:

- Low risk: minor surgery, patient under 40 years and without risk factors.
- Moderate risk:
 - Minor surgery and patient with risk factors;
 - Major surgery, patient between 40 and 60 years and without risk factors;
 - Major surgery, patient under 40 years and without risk factors;
- High risk:
 - Major surgery, patient above 60 years or with risk factors;
 - Major surgery, patient above 40 years or with risk factors;
- Very high risk:
 - Major surgery, patient above 40 years, previous VTE, cancer or hypercoagulation;
 - Patient with many risk factors;

II. Recommendations for the perioperative prophylaxis of venous thromboembolism¹

1. Low risk:

- Early mobilization; *Class I, Level of Evidence C.*

2. Moderate risk:

- Heparin 5000IU subcutaneously at 12-hour intervals, starting

1 to 2 hours before surgery; *Class I, Level of Evidence A.*

- Enoxaparin 20mg subcutaneously at 24-hour intervals, starting 1 to 2 hours before surgery; *Class I, Level of Evidence A.*
- Compression stockings: start immediately before surgery until outpatient follow-up or intermittent pneumatic compression (IPC) – start immediately before surgery until hospital discharge; *Class I, Level of Evidence A.*

3. High risk:

- Heparin 5000IU subcutaneously at 8-hour intervals, starting 1 to 2 hours before surgery *Class I, Level of Evidence A.*
- Enoxaparin 40mg subcutaneously at 24-hour intervals, starting 1 to 2 hours before surgery; *Class I, Level of Evidence A.*
- IPC – start immediately before surgery until hospital discharge *Class I, Level of Evidence A.*

4. Very high risk:

- Enoxaparin 40mg subcutaneously at 24-hour intervals, starting 1 to 2 hours before surgery plus IPC or compression stockings; *Class I, Level of Evidence C.*
- Heparin 5000IU subcutaneously at 8-hour intervals, starting 1 to 2 hours before surgery plus IPC or compression stockings; *Class I, Level of Evidence C.*
- Warfarin in selected patients – start with 5 mg/day on the day of surgery or on the next day and adjust the dose to keep INR between 2 and 3. *Class IIa, Level of Evidence C.*

5. Elective hip arthroplasty

- Enoxaparin 40mg subcutaneously 12 hours before or 12 to 24 hours after surgery or 20mg subcutaneously 4 to 6 hours after surgery; then 40mg/day on the days following surgery; *Class I, Level of Evidence A.*
- Warfarin: adjust dose to keep INR between 2 and 3; start administration before surgery or immediately after surgery; *Class I, Level of Evidence A.*
- Heparin subcutaneously at 8-hour intervals, loading dose of 3500IU ± 500IU per dose to keep aPTT above normal; *Class*

Table 5 - Incidence of deep vein thrombosis (DVT) and pulmonary thromboembolism (PTE)

Surgeries/patients	DVT distal (%)	DVT proximal (%)	PTE clinical (%)	PTE fatal (%)
Low risk	2	0.4	0.2	0.002
Moderate risk	10-20	2-4	1-2	0.1-0.4
High risk	20-40	4-8	2-4	0.4-1.0
Very high risk	40-80	10-20	4-10	0.2-5
Elective hip or knee arthroplasty				
Hip fracture surgery				
Trauma	40-80	10-20	4-10	0.2-5
Acute spinal cord injury				
Major gynecological surgeries				
Major urological surgeries				

Ila, Level of Evidence A.

- Prophylactic measures associated with IPC or compression stockings *Class IIa, Level of Evidence C.*
- Prophylaxis should last at least 7 days. *Class I, Level of Evidence A.*

6. Elective knee arthroplasty

- Enoxaparin 40 mg subcutaneously 12 hours before or 12 to 24 hours after surgery, or 20 mg subcutaneously 4 to 6 hours after surgery, then 40 mg/day on the days following surgery; *Class I, Level of Evidence A.*
- Warfarin: adjust dose to keep INR between 2 and 3. Start before surgery or immediately after surgery; *Class I, Level of Evidence A.*
- IPC – start immediately before surgery until hospital discharge; *Class I, Level of Evidence B.*
- Prophylaxis should last at least 7 to 10 days; *Class I, Level of Evidence A.*

7. Hip fracture surgery

- Enoxaparin 40 mg subcutaneously 12 hours before or 12 to 24 hours after surgery or 20mg subcutaneously 4 to 6 hours after surgery, then 40 mg/day on the days following surgery; *Class I, Level of Evidence B.*
- Warfarin: adjust dose to keep INR between 2 and 3. Start before surgery or immediately after surgery; *Class I, Level of Evidence B.*
- Heparin 5000IU subcutaneously at 8-hour intervals, starting 1 to 2 hours before surgery; *Class IIa, Level of Evidence B.*

8. Neurosurgery

- IPC with or without compression stockings; *Class I, Level of Evidence A.*
- Heparin 5000IU subcutaneously at 8-hour intervals starting 1 to 2 hours before surgery; *Class IIa, Level of Evidence A.*
- Enoxaparin 40mg subcutaneously/day after surgery; *Class IIa, Level of Evidence A.*
- IPC or compression stockings associated with prophylactic enoxaparin or heparin; *Class I, Level of Evidence B.*

9. Trauma

- Enoxaparin 30 mg subcutaneously at 12-hour intervals starting 12 to 36 hours after the trauma if the patient is hemodynamically stable; *Class I, Level of Evidence A.*
- IPC or compression stockings if enoxaparin is contraindicated (risk of bleeding); *Class I, Level of Evidence C.*
- Inferior vena cava filter if there is proven DVT and contraindication of anticoagulation therapy; *Class I, Level of Evidence C.*

10. Acute spinal cord injury

- Enoxaparin 30mg subcutaneously at 12-hour intervals; *Class I, level of Evidence B.*
- IPC or compression stockings associated with prophylactic enoxaparin or heparin or if anticoagulation therapy is contraindicated right after the lesion; *Class IIa, Level of Evidence B.*
- Continue enoxaparin therapy during rehabilitation or use full anticoagulation with warfarin (INR between 2 and 3); *Class I, Level of Evidence C.*

11. Gynecological surgeries

- 11.A. Small interventions for benign diseases
- Early mobilization; *Class I, Level of Evidence C.*
- 11.B. Major for benign diseases without risk factors
- Heparin 5000IU subcutaneously at 12-hour intervals; *Class I, Level of Evidence A.*
 - Enoxaparin 40 mg subcutaneously at 24-hour intervals or IPC before surgery and at least many days after surgery; *Class I, Level of Evidence C.*
- 11.C. Major cancer surgeries
- Heparin 5000IU subcutaneously at 8-hour intervals; *Class I, Level of Evidence A.*
 - Heparin 5000IU subcutaneously at 8-hour intervals associated with IPC or compression stockings to provide additional protection; *Class I, Level of Evidence C.*

12. Urological surgeries

- 12.A. Low-risk or transurethral surgery
- Early mobilization; *Class I, Level of Evidence C.*
- 12.B. Major or open-cavity surgery
- Heparin 5000IU subcutaneously at 8-hour intervals, 1 to 2 hours before surgery; *Class I, Level of Evidence B.*
 - Enoxaparin 40mg subcutaneously at 24-hour intervals, starting 1 to 2 hours before surgery; *Class I, Level of Evidence B.*
 - IPC – start immediately before surgery until hospital discharge; *Class I, Level of Evidence B*
 - Compression stockings – start immediately before surgery until outpatient follow-up; *Class I, Level of Evidence B.*
- 13.C. High-risk patients
- IPC or compression stockings associated with prophylactic enoxaparin or heparin; *Class I, Level of Evidence C.*

III. Patients already taking anticoagulation therapy because of a previous VTE

The perioperative treatment of patients with a history of VTE or recurrent VTE taking anticoagulation therapy depends on weighing the combined risks of the disease and anticoagulation therapy. Discontinuing anticoagulation therapy in the first month after an acute event seems to be associated with a very high risk of recurrence (40% in a one-month interval). A lower risk of recurrence has been reported when anticoagulation is discontinued between the second

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and third months following an acute event (10% in a two-month interval).² Suspension of oral anticoagulation therapy is associated with a much lower risk of VTE (15%/year) in patients on lifelong oral anticoagulation therapy because of a history of recurrent VTE, inherited thrombophilia or cancer.³ Table 6 contains recommendations for anticoagulation management before and after surgery. Today, it is common practice to use full-dose low-molecular-weight heparin instead of full-dose intravenous heparin in the perioperative period of patients with a history of VTE.^{4,5}

References:

1. Geerts W, Heit J, Clagett P, Pineo G, Colwell C, Anderson F, Wheeler B. Prevention of Venous Thromboembolism. *Chest* 2001; 119: 132S-175S.
2. Kearon C, Hirsh J. Management of anticoagulation before and after elective surgery. *N Engl J Med* 1997; 336:1506-11.
3. Hull RD, Carter CJ, Jay JM, et al. The diagnosis of acute, recurrent, deep-vein thrombosis: a diagnostic challenge. *Circulation* 1983; 67:901-6.
4. Hewitt RL, Chun KL, Flint LM. Current Clinical Concepts in Perioperative Anticoagulation. *Am Surg* 1999 Mar.;65(3):270-3.
5. Hirsh J, Fuster V, Ansell J, Halperin JL. American Heart Association/ American College of Cardiology Foundation Guide to Warfarin Therapy. *Circulation* 2003; 107:1692-1711.

D) Perioperative anticoagulation therapy

The management of patients under anticoagulation therapy in the perioperative period depend on their individual risk of having thromboembolic events if therapy is discontinued and of bleeding if therapy is maintained. Perioperative anticoagulation is associated with a 3% increase in severe bleeding. There is consensus that INR < 1.5 is not associated with perioperative bleeding. Thus, it is important to adjust anticoagulation therapy properly in order to minimize thrombotic and hemorrhagic events.¹

I. Risk of thromboembolism:

- High-risk patients: venous thromboembolism in the last 3 months, mechanical valvular prostheses, atrial fibrillation (only if the patient has a history of stroke, many risk factors for stroke or valvular disease) and hypercoagulable states (Factor V Leiden, proteins C and S deficiencies) with recurrent or recent thrombosis.
- Intermediate-risk patients: atrial fibrillation without history of stroke and with only one risk factor for stroke (age >65 years, diabetes mellitus, hypertension, heart failure)
- Low-risk patients: venous thromboembolism before the last 3 months, recent atrial fibrillation without risk factors for stroke, hypercoagulable states without thrombotic complications and a history of recurrent thrombosis.

II. Procedures with low risk of bleeding:

- Ophthalmic surgery: cataract, trabeculectomy, vitreoretinal surgery;
- Dental procedures: hygiene, single extraction, restoration, endodontic and prosthetic procedures.

III. Recommendations:²

1. Patients at low risk of thromboembolism:

- Discontinue warfarin 4 days before surgery; wait for INR to return to almost normal values (<1.5); *Class IIa, Level of Evidence C.*
- Non-fractionated (NFH) or low-molecular-weight heparin (LMWH) prophylaxis can be used before surgery if indicated; *Class IIa, Level of Evidence C.*
- Non-fractionated or low-molecular-weight heparin prophylaxis can be used after surgery if the type of procedure indicates its use and simultaneously reintroduce warfarin; *Class IIa, Level of Evidence C.*

2. Patients at high risk of thromboembolism:

- Discontinue warfarin 4 days before surgery and wait for INR to normalize; *Class IIa, Level of Evidence C.*
- Start full-dose NFH or LMWH when INR < 2.0; *Class IIa, Level of Evidence C.*
- Discontinue intravenous NFH 5 hours before surgery and

Table 6 - Recommendations for the management of pre and postoperative coagulation therapy in patients taking oral anticoagulation because of a history of VTE^{2*}

Indication	Before surgery	After surgery
Acute VTE – month 1	IV heparin # (suspend 6h before)	IV heparin # (restart 12h after major surgery or later if there is risk of bleeding);
VTE – month 2 and 3	prophylactic sub-Q LMWH in inpatients ^β	IV heparin (until INR=2.0 with warfarin)
VTE – after 3 months	prophylactic sub-Q LMWH in inpatients ^β	Sub-Q LMWH
VTE recurrent £	prophylactic sub-Q LMWH in inpatients ^β	Sub-Q LMWH

*Class I, Level of Evidence C. *IV heparin refers to intravenous heparin in therapeutic doses and LMWH Sub-Q refers to the use of subcutaneous low-molecular-weight heparin in prophylactic doses to prevent VTE in high-risk patients. # Consider using an inferior vena cava filter when acute VTE occurred within the previous two weeks or when there is a high risk of bleeding with i.v. heparin. ^β hospitalization is not recommended for this reason alone. £ Patients who require long-term oral anticoagulation therapy because of a high risk of recurrence but whose last VTE episode occurred more than 3 months before surgery.*

subcutaneous NFH or LMWH 12 to 24 hours before surgery; *Class IIa, Level of Evidence C.*

- Simultaneously reintroduce full-dose NFH or LMWH and warfarin after surgery until INR is within therapeutic range; *Class IIa, Level of Evidence C.*

3. Patients at intermediate risk of thromboembolism:

- The management of these patients can follow the recommendations for patients with low or high-risk at the physician’s discretion. *Class IIa, Level of Evidence C.*

4. Procedures with low risk of bleeding:

- The procedure can be done when INR is around 2.0. Discontinuation of anticoagulation therapy is not necessary; *Class IIa, Level of Evidence C.*

- If INR > 3.0, discontinue anticoagulation therapy one or two days before surgery and reintroduce it the night after surgery; *Class IIa, Level of Evidence C.*

5. Urgent procedures:¹

- Vitamin K and fresh plasma can be used to reverse anticoagulation. Avoid high doses of vitamin K as it may inhibit anticoagulation later on;

References:

1. Machado FS. Perioperatório do paciente em uso de anticoagulante. In: Machado FS, Martins MA, Caramelli B. Perioperatório: procedimentos clínicos. 1ed, São Paulo, Ed Savier; 2004.p105-9.
2. Ansell J, Hirsh J, Poller L, Bussey H, Jacobson A, Hylek E. The Pharmacology and Management of the Vitamin K Antagonists: The Seventh ACCP Conference on Antithrombotic and Thrombolytic Therapy. Chest 2004; 126(3): 214-15.

E) Endocarditis prophylaxis:

Antibiotic prophylaxis will depend on the preexisting heart disease and type of procedure.^{1,2}

I. Preexisting heart disease:

- High risk: Valvular prostheses, previous infective endocarditis, cyanotic congenital heart diseases and surgical arteriovenous shunts.

- Intermediate risk: other congenital heart diseases, rheumatic valvular heart diseases or of other etiologies, hypertrophic cardiomyopathies, mitral valve prolapse with regurgitation.

II. Surgical procedure

Surgical procedures that require antibiotic prophylaxis are those that are associated with a high incidence of transient bacteremias: dental treatment (tooth extraction and periodontal or endodontic procedures), digestive tract surgeries, (sclerotherapy for esophageal varices, esophageal dilation, endoscopic retrograde cholangiography and surgeries of the biliary tract or intestinal mucosa), respiratory tract (tonsillectomy, adenoidectomy, rigid bronchoscopy and surgeries of the respiratory mucosa) and urinary tract (prostate surgery, cystoscopy and urethral dilation).

III. Recommendations for the antibiotic prophylaxis of infective endocarditis¹⁻³

(See table below)

IV. IE prophylaxis is NOT recommended for:

- Interatrial communication (IAC) alone;
- Corrected IAC, interventricular communication (IVC) or patent ductus arteriosus (PDA) and without residual shunt;
- Previous myocardial revascularization surgery;

Dental, respiratory tract and esophageal procedures		
Situation	Antibiotic	Regimen
General	Amoxicillin or Ampicillin	2g or 50mg/Kg OA/1 hour BP or 2g (IM/IV) or 50mg/kg 30 minutes BP
Allergic	Clindamycin or Cephalexin Azitromicin / claritromicin	600mg or 20mg/Kg OA/1 hour BP or IM 30 minutes BP 2g or 50mg/Kg OA/1 hour BP 500mg 1 hour BP
Gastrointestinal (except esophagus) and genitourinary procedures		
High risk	Ampicillin + Gentamicin	2g (IM/IV) or 50mg/Kg 30 min BP + 6 hours later 1g or 25mg/kg (or Amoxicillin 1g OA) 1.5mg/Kg (up to 120mg) IM/IV 30 min BP
High risk and allergic	Vancomycin + Gentamicin	1g or 20mg/kg IV (infusion in 1 hour) 30 min BP + 1.5mg/Kg (up to 120mg) IM/IV 30 min BP
Moderate risk	Amoxicillin or Ampicillin	2g or 50mg/Kg AO 1hour BP or 2g (IM/IV) or 50mg/kg 30 min BP
Moderate risk and allergic	Vancomycin	1g or 20mg/kg IV (infusion in 1 hour) 30 min BP

IM - intramuscular; IV - intravenous; OA - oral administration; BP - before procedure.

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- Mitral valve prolapse without regurgitation;
- Innocent heart murmurs;
- Patients with pacemakers or ICDs;
- History of Kawasaki disease or rheumatic fever without valvular dysfunction.

References:

1. Dajani AS, Taubert KA, Wilson W et al. Prevention of Bacterial Endocarditis. Recommendations by the American Heart Association. *Circulation* 1997;96:358-66.
2. Durack DT. Prevention of infective endocarditis. *N Engl J Med* 1995;332:38-44.
3. Dajani AS, Bawdon RE, Berry MC. Oral amoxicillin as prophylaxis for endocarditis: what is the optimal dose? *Clin Infect Dis* 1994;18:157-160.

F) Glycemic control

Until not long ago, physicians accepted mild and moderate hyperglycemia in patients who would be submitted to surgical stress because they believed that some hyperglycemia could benefit the patient by nourishing nerve and blood cells. Therefore, it was normal practice to keep perioperative glycemia slightly elevated to avoid possible acute complications of hypoglycemia. Today we know that hyperglycemia can be detrimental to the clinical outcomes of operated patients, especially regarding infections.¹ Furthermore, hyperglycemia directly or indirectly causes endothelial dysfunction, increased thrombogenesis, impaired healing because of decreased collagen synthesis, water and electrolyte disturbances with osmotic diuresis, immune system changes and so on. Studies have shown that glucose level upon hospital admission is an independent predictor of prognosis after acute coronary syndrome, ischemic stroke and myocardial revascularization regardless of a history of diabetes.² The negative effects of hyperglycemia support the indication of doing an adequate glycemic control during the perioperative period.

I. Preoperative period

A strict glycemic control is recommended, particularly in the week preceding surgery. Ideally, glucose and glycosylated hemoglobin should be within normal levels. Oral hypoglycemic agents should be discontinued up to 72 hours before surgery, depending on the half life of the agent, and replaced by enough regular subcutaneous insulin to keep glucose level within the normal range. Oral hypoglycemic agents are only reintroduced after adequate hemodynamic and respiratory stability have been achieved and perfect functioning of the digestive system has been established. The objective is to maintain preoperative preprandial glycemia between 80 and 120 mg/dL.³

Recommendations:

- Screen all patients and respective medical records for risk factors of diabetes mellitus (DM); *Class I, Level of Evidence*

D.

- Patients older than 45 years, overweight or with symptoms that suggest DM should be at least submitted to a fasting glucose test; *Class I, Level of Evidence D.*

- Glycemia < 100 mg/dL: Patient can undergo surgery without any special preoperative measure; *Class I, Level of Evidence D.*

- Glycemia between 100 and 125 mg/dL: patient should have a creatinine test done in the previous 12 months, baseline electrocardiogram and be more attentive to blood pressure control. After surgery, consider referring the patient to an endocrinologist; *Class I, Level of Evidence D.*

- Glycemia > 125 mg/dL or has diagnosed DM: patient should have a creatinine test done in the previous 12 months, baseline electrocardiogram and be more attentive to blood pressure control including screening for dysautonomia (blood pressure and heart rate while sitting and after standing for 3 minutes). After surgery, consider referring the patient to an endocrinologist; *Class I, Level of Evidence D.*

- Glycemia > 220mg/dL, consider postponing surgery until better glycemic control is achieved; *Class I, Level of Evidence D.*

- Best times to discontinue oral medications before (*Class I, Level of Evidence D*):

Biguanides: 24 to 48 hours before surgery

Sulfonylureas: of 1^a generation – 48 to 72 hours before surgery; of 2^a and 3^a generation – on the day of surgery;

Glitazones: 24 to 48 hours before surgery;

Thiazolidinediones: on the day of surgery;

Acarbose: 24 hours before surgery;

Glinides: on the day of surgery;

Insulin NPH: patient may take the normal bedtime dose the night before surgery; on the morning of surgery, administer 1/3 to 2/3 of the normal dose, depending on what time the surgery will be done.

- If glycemic control is too hard to achieve, consider working with an endocrinologist.

II. Intra and postoperative periods

Hyperglycemia and insulin resistance are common findings in patients submitted to surgical stress given the metabolic changes that occur, such as increased secretion of substances involved in glucose counterregulation and decreased secretion of insulin by pancreatic beta cells.⁴ Adequate control of hyperglycemia before surgery may reduce the rate of nosocomial infections in diabetic patients.⁵ Van den Berghe et al.⁶ prospectively studied 1548 patients in an intensive care unit (ICU) specialized in postoperative care of which 63% had undergone cardiac surgery and 87% were not diabetic. These patients randomly received standard treatment (intervene only if glycemia > 215 mg/dL) or intensive treatment (glycemia kept between 80 and 110 mg/dL). This study was terminated early because mortality in the ICU, especially due to multiple organ failure with a proven septic focus, was significantly lower in the intensive treatment group (4.6% versus 8.0%; $p < 0.04$).

Intrahospital mortality and incidence of morbidities, such as sepsis, acute renal failure and polyneuropathy were also significantly lower in the intensive treatment group. Even though the rate of hypoglycemic episodes was much higher in the intensive treatment group, not one of the episodes was followed by hemodynamic instability or convulsions. Intravenous insulin infusion during surgery has some advantages over subcutaneous administration: it reduces the blood glucose fluctuations seen with injections, corrects glycemia faster and allows easier avoidance of hypoglycemia and adjustment of insulin concentration. A separate dextrose and electrolyte infusion can be used to prevent hypoglycemia and hypokalemia. Postoperative recovery should be done in a place where intensive monitoring is effective and intra and postoperative capillary or arterial blood glucose levels are monitored with nomograms created based on the experience of the service and patient profiles.

Recommendations:

- If surgery will last more than one hour or if patient is of high risk (ACP Classes II and III), capillary blood glucose level should be determined at induction of anesthesia; *Class IIa, Level of Evidence D*.
- Intravenous insulin infusion to all type I diabetics regardless of surgery classification and to all type II diabetics submitted to surgeries that last more than one hour or when their glycemia is out of control; *Class IIa, Level of Evidence D*.
- Control glycemia strictly with regular insulin in an infusion pump to keep capillary insulin between 80 and 110mg/dL; determine capillary glucose level as often as needed. If glycemia rises above 110mg/dL, it is advisable to determine serum potassium level and monitor it at least daily; *Class IIa, Level of Evidence B*.
- Transition from insulin pumps to oral medication can be done outside the ICU. Target glycemia remains the same (between 80 and 110mg/dL). Consider endocrinologist follow-up. Capillary blood glucose level should be determined one hour after discontinuation of insulin pump and at least three times per day before meals or at 6-hour intervals in fasting patients; *Class IIa, Level of Evidence B*.

References:

1. Van den Berghe G, Wouters P, Bouillon R, Weekers F, et al. Outcome benefit of intensive insulin therapy in the critically ill: Insulin dose versus glycemic control. *Crit Care Med* 2003;31(2):359-66.
2. Umpierrez GE, Isaacs SD, Bazargan N, You X, Thaler LM, Kitabchi AE. Hyperglycemia: na independent marker of in-hospital mortality in patients with undiagnosed diabetes. *J Clin Endocrinol Metab* 2002;87:978-82.
3. American Diabetes Association: Standards of medical care for patients with diabetes mellitus (Position Statement). *Diabetes Care* 2001; 24(1):S33-S43.
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G) Considerations on anesthesia and surgery

I. Choosing the anesthetic technique

The objective of choosing the anesthetic technique is to improve the long-term outcome of the patient. The development of the “fast track” technique, where the patient remains in the hospital for less time, reflected in anesthesiology and resulted in the development of practices that protect the myocardium and promote early recovery from anesthesia.

Many studies tried to show the superiority of one technique over another. In a meta-analysis that included 9559 patients of 141 clinical studies, Rodgers et al.,¹ demonstrated that the use of regional anesthesia reduced the 30-day mortality rate by 30%, deep vein thrombosis by 44%, pulmonary embolism by 55%, need of blood transfusion by 50%, pneumonia by 39%, respiratory depression by 59%, myocardial infarction by 33% and renal failure by 43%. In another meta-analysis of 17 studies of which 11 were chosen randomly, totaling 1173 patients, Beattie et al.² demonstrated that the use of epidural analgesia for more than 24 hours is associated with a statistically significant ($p < 0.05$) reduction of postoperative myocardial ischemia and a trend towards reduced mortality ($p < 0.09$).

The use of regional anesthesia presupposes a greater hemodynamic stability and is associated with excellent intra and postoperative analgesia. Chronic obstructive pulmonary disease increases the risk of perioperative mortality by 5 to 13 times and abdominal procedures are associated with higher risk for respiratory complications. Studies point toward the advantages of neuraxial blockade over general anesthesia in patients at high risk of respiratory complications. Thus, regional anesthesia instead of general anesthesia helps reduce postoperative morbidity and mortality.

Recommendation:

- Whenever possible, prefer neuraxial blockade to general anesthesia. *Class IIa, Level of Evidence A*.

II. Choosing the anesthetic agent

Induction of anesthesia should always be done slowly to avoid hemodynamic instability and coronary and brain ischemia. Substituting midazolam by propofol or etomidate, fentanyl by low doses of sufentanil and not using muscle relaxants that require renal elimination in patients whose creatinine clearance is compromised allow early extubation (within 4 hours) and minimize the risk of myocardial ischemia occurring during recovery of anesthesia with adequate analgesia and sedation.

Etomidate is the agent of choice for patients with hemodynamic instability or reduced cardiovascular reserve because of its reduced hemodynamic effects. Propofol has been associated with intraoperative hypotension.

Recommendation:

- Always prefer fast-acting and short-lasting anesthetics and anesthetics whose residual effects are minimal. *Class I, Level of Evidence B.*

III. Management of body temperature

Intraoperative hypothermia is associated with an increased response to stress, hypertension and coronary ischemic events. Two clinical studies show an association between non-intentional hypothermia and postoperative myocardial ischemia in patients submitted to vascular and non-vascular events. A significantly higher number of electrocardiographic changes were found in patients whose temperature dropped below 35°C. The incidence of unstable angina, cardiorespiratory arrest and myocardial infarction was lower in patients who remained normothermic.³

Recommendation:

- Maintain normothermia during the perioperative period to prevent cardiac events. *Class I, Level of Evidence A.*

IV. Nitroglycerin during surgery

Nitroglycerin is more of a vein than an artery vasodilator with coronary dilating properties. However, no study has yet demonstrated that perioperative infarction can be prevented with intravenous nitroglycerin.⁴

Recommendation:

- Intraoperative nitroglycerin should only be used to control blood pressure of coronary artery disease patients, not to prevent perioperative ischemia. *Class I, Level of Evidence C.*

V. Catheters

1. Pulmonary artery catheter

Pulmonary artery catheter allows better intraoperative management of heart disease patients submitted to non-cardiac surgeries. However, according to the evidence found in literature, its practice is not associated with less perioperative cardiovascular complications.

Two prospective studies that assessed pulmonary artery catheter found an increased incidence of non-cardiac events and no decrease in the rate of cardiovascular complications in this population. The first was a non-randomized, prospective study of 4059 patients submitted to major elective surgeries, excluding abdominal aortic surgeries, which found a greater incidence of non-cardiac events, such as pulmonary embolism and stroke, and longer hospital stay among patients with pulmonary artery catheter.⁵ The second was a randomized,

prospective study that included 1994 high-risk patients submitted to non-cardiac surgeries which found no benefit using perioperative pulmonary artery catheter. As a matter of fact, its use was associated with a higher incidence of pulmonary embolism.⁶

Perioperative use of pulmonary artery catheter has a well-established role in high-risk vascular surgeries, especially in surgeries for abdominal aortic aneurysms. Patients with severe ventricular dysfunction (functional classes III and IV) who will undergo surgeries that may cause great variations in blood volume or pressure can benefit from invasive hemodynamic monitoring.

Recommendations:

- Surgery for abdominal aortic aneurysm; *Class IIa, Level of Evidence D.*
- Patients with decompensated heart disease who will undergo major surgery; *Class IIa, Level of Evidence C.*
- Patients with myocardial dysfunction who will undergo major surgery; *Class IIb, Level of Evidence C.*

2. Invasive pressure monitoring

The recommendations regarding invasive pressure monitoring in the perioperative period of non-cardiac surgeries are the same as those for monitoring and providing intensive care for critically ill patients.

In the perioperative context, indication for invasive pressure monitoring depends on patient and type of surgery. It is indicated for patients with heart disease, hemodynamic instability, respiratory insufficiency, increased intracranial pressure and polytrauma and during the intra and early postoperative periods of prolonged and major surgeries, such as cardiac surgeries, craniotomies, thoracic surgeries and abdominal surgeries.

There is a peculiar situation in which invasive pressure monitoring can be useful and should be considered: in patients with permanent pacemakers. In this specific population, electrocautery can affect intraoperative electrocardiographic monitoring while invasive pressure monitoring is reliable.

Recommendations:

- Patients with heart disease, hemodynamic instability and/or undergoing major surgery; *Class I, Level of evidence D.*
- Patients with permanent pacemakers; *Class IIb, Level of Evidence D.*

VI. Intra-aortic balloon pump

There are few data in literature on the use of an intra-aortic balloon pump in the perioperative period of non-cardiac surgeries and its use is limited to specific situations.

Its use could be beneficial in patients with a very high perioperative cardiac risk: patients with acute coronary syndrome, ischemic ventricular dysfunction or severe coronary artery abnormalities (involving multiple arteries or bifurcation lesion) who will be submitted to major non-cardiac surgery,

including intrathoracic and intra-abdominal surgeries.

Recommendation:

- Patients at high cardiac risk and high-risk non-cardiac surgeries; *Class IIb, Level of Evidence D.*

References:

1. Rodgers A, Walker N, Schug S, et al. Reduction of postoperative mortality and morbidity with epidural or spinal anaesthesia: results from overview of randomised trials. *Bmj* 2000; 321:1493.
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3. Sea F. Perioperative maintenance of normothermia reduces the incidence of morbid cardiac events. A randomized clinical trial. *JAMA* 1997; 277: 1127-34.
4. Coriat P. Prevention of intraoperative myocardial ischemia during noncardiac surgery with intravenous nitroglycerin. *Anesthesiology* 1984; 61:193-196.
5. Polanczyk CA, Rohde LE, Goldman L, et al. Right heart catheterization and cardiac complications in patients undergoing noncardiac surgery: an observational study. *JAMA* 2001; 286(3): 309-14.
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H) Perioperative monitoring

I. Monitoring the ST segment

The usefulness of monitoring the ST segment during the perioperative period is controversial. Many of the concepts applied in this context are based on those of conventional stress electrocardiography and the Holter monitor. In other words, if the accuracy of predicting myocardial ischemia based on ST segment changes observed in those situations is limited, the same applies to perioperative monitoring. Yet some additional specific considerations deserve to be mentioned. Studies that assessed changes in the ST segment during the perioperative period were not methodologically uniform (number of leads, monitoring duration, human or automated analysis) and did not use the same criteria to diagnose ischemia.¹ Bear in mind that in addition to proven accuracy variations among the different automated ST segment analyses², this variation is even greater when the automated ST segment analysis is compared with that of an observer in the surgery room. In one of the reported series, the medical team who was assisting the patients identified only 20% of the changes detected by automated ST segment analysis.¹

In addition to the well-known factors that admittedly limit ST segment analysis, some specific characteristics of the perioperative scenario can interfere with ST segment

analysis such as hypothermia, hypokalemia, hypocalcemia and hypomagnesemia, besides artifacts and noise caused by electrocautery, proximity to the operating table and so on.

Yet, automated ST segment analysis should still be considered a helpful tool in the perioperative assessment of high-risk patients for whom the positive predictive value of findings is higher and has prognostic implication^{3,4}, even if there is not enough evidence to recommend its routine use since the existing studies have not assessed the impact of therapies based on ST segment changes. It is important to remember that most of these changes do not occur during surgery but after surgery. The greatest prognostic correlation is seen when lasting changes appear in the postoperative period.^{4,5} Some data suggest that the specificity of ST segment changes seen in the perioperative period is low, therefore the technique offers no advantage to patients who do not have clinical or surgical predictors of high risk.⁶

Recommendation:

- Monitor the ST segment of high-risk patients during the perioperative period; *Class IIB, Level of Evidence C.*

References:

1. London MJ, Hollenberg M, Wong MG, Levenson L, et al. Intraoperative myocardial ischemia: localization by continuous 12-lead electrocardiography. *Anesthesiology* 1988; 69:232-241.
2. Slogoff S., Keats AS, David Y, Igo SR. Incidence of perioperative myocardial ischemia detected by different electrocardiographic systems. *Anesthesiology* 1990; 73:1074-1081.
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II. Perioperative AMI

Acute myocardial infarction is the most feared cardiac complication in the perioperative period of non-cardiac surgeries, with an incidence of roughly 1 to 1.8% and mortality of 23 to 40-50%.¹⁻³ The existence of comorbidities and restrictions to the use of standard antithrombotic and

antiplatelet agents for unstable ischemic heart disease is an important prognostic factor and probably indicates a poor prognosis. Although the clinical consequences of perioperative myocardial infarction are extremely severe, most times its diagnosis is not evident or requires much suspicion and monitoring. The diagnostic criteria (compatible pain, electrocardiogram and markers of myocardial necrosis) are subject to changes that are inherent to the surgical context.

The most characteristic symptom, precordial thoracic pain, is absent either because of analgesics and/or traces of anesthetics or because the medical team associates it with more obvious etiologies, such as incisional or positional pain. Painless perioperative myocardial infarction rates have been reported by some case series to be of 50%¹, and sometimes as high as 61%². The clinical picture usually indicates cardiac insufficiency and arrhythmias with pulmonary congestion or low output, manifested by altered states of consciousness, gastrointestinal symptoms, hypotension or worsening renal function. Roughly 64% of the patients who suffer a perioperative myocardial infarction have one or more of these manifestations.²

Electrocardiographic changes are usually compatible with myocardial infarction, yet they are not pathognomonic of myocardial infarction. Nonspecific ECG changes during the perioperative period are extremely common but nonspecific for myocardial ischemia. They are often due to postoperative electrolyte disturbances, effects of medications, hypothermia or systemic inflammatory response syndrome.⁴ These changes are more plausible when they are supported by past ECGs, clinical context and biomarker assays (CKMB, troponin etc.).

Finally, the use of biomarker assays to confirm myocardial necrosis may redefine the diagnostic criteria of perioperative myocardial infarction. CK-MB fraction specificity is low in the perioperative context,⁵ and the biological meaning of altered CK-MB not accompanied by other myocardial infarction evidence, such as compatible clinical picture or electrocardiographic change, remains to be explained. Yeager et al. named this finding "chemical myocardial infarction." Survival rate and patterns of subsequent myocardial infarction and coronary intervention at 4-year follow-up were similar between patients with chemical MI and control group.³ There are no means to determine whether such findings are false-positive CK-MB results or dependent on methodology. The use of troponin assay in the diagnostic and prognostic assessment of patients with unstable ischemic heart disease is growing. Troponin assays improve the accuracy of the diagnosis and prognosis, especially when it is found to be elevated in the perioperative period of non-cardiac surgeries.⁶ Another case series found the positive predictive value of troponin for acute myocardial infarction or death from cardiac causes in the perioperative period of vascular surgery to be 62%, with a specificity of 93%, while the positive predictive value of CK-MB was only 22%.⁵ Recently, the importance of elevated troponin alone was reiterated by data that show that even discrete elevations or elevations that do not reach the cutoff value for MI diagnosis are relevant.

Patients with an unquestionable diagnosis of perioperative acute myocardial infarction must be treated aggressively,

preferably with early and invasive stratification of risk, before being discharged. This practice is critical to control the alarming short and long-term morbidity and mortality.

Any change in the electrocardiogram or elevation of troponin in patients with moderate and high cardiac risk must be further investigated before hospital discharge. Invasive or non-invasive stratification of patients whose only sign is elevated troponin is a choice that depends on the specific assessment of a cardiologist.

Recommendations:

- Patients with an estimated moderate or high perioperative cardiac risk of ischemic nature must be continuously monitored in semi-intensive or intensive care unit. Electrocardiogram and troponin assay must be done daily until the third day after surgery since most events occur in this period. *Class I, Level of Evidence A.*

- If troponin testing is not available, it should be substituted by a CK-MB/CK curve (8/8 hours). *Class I, Level of Evidence B.*

References:

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6. Urgent surgery

When an urgent surgery is indicated, it is believed that the benefits of prompt intervention outweigh the inherent risks of the procedure. Yet, this does not justify a neglectful preoperative assessment since urgent surgeries carry a 2 to 5 fold increase in cardiac complication rates.¹ The high risk is due to insufficient time and conditions to assess the patient satisfactorily, and, of course, because of the reason and associated comorbidities that motivated the intervention. Knowledge of the patient's family history of cardiovascular

disease and a couple of diagnostic findings can be enough to help the physician make optimal use of monitoring and therapeutic resources during and after surgery. Furthermore, most acute ischemic syndromes happen between surgery and the fourth day after surgery, therefore the time the patient spends in the ICU after surgery can be put to good use.

Recommendations regarding monitoring:

- ECG daily (in addition to those done before surgery) until the third postoperative day; *Class I, Level of Evidence C.*
- Myocardial injury markers: Biomarker assays (troponin) should be done daily until the third day after surgery; *Class I, Level of Evidence A.*
- Swan-Ganz catheter: given the controversies regarding the use of this catheter, its use should be restricted to hemodynamically unstable patients immediately before surgery or those at high risk of instability; *Class IIb, Level of Evidence B.*
- Monitor the ST segment in the intra and early postoperative periods with at least 2 precordial leads (V4 and V5) in CAD patients; *Class IIb, Level of Evidence C.*
- Transthoracic echocardiogram: given the short time available before an urgent procedure for this type of test, it should not be requested routinely but in special situations where diagnostic doubts exist, such as hypertrophic cardiomyopathy and/or valvular disease.^{2,3} Recommendations and Levels of Evidence are the same as those of item 4B;
- Intra-aortic balloon pump: given the scarcity of literature

data on this device, its use should be restricted to the extremely severe situations described in item 5GV.

Recommendations regarding therapy:

- Beta-blockers: recommendation for its perioperative prophylactic use in urgent noncardiac surgeries is based on studies of elective surgeries that show reduced acute myocardial infarction, death and post-discharge events. The Recommendations and Levels of Evidence are the same as those of item 5A1;
- Nitrates: contraindicated for the prophylaxis of ischemia;⁴ *Class III, Level of Evidence C.*

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