PERIOPERATIVE MANAGEMENT OF ADULT CARDIAC PATIENTS FOR NON-CARDIAC SURGERY – SLOVENIAN GUIDELINES

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Introduction

It is important that anaesthesiologist plays a significant role in management of cardiac patients for non-cardiac surgery. The cardiovascular systems of patients who undergo non-cardiac surgery are influenced by multiple stress factors. A previously stable patient may decompensate perioperatively, leading to significant morbidity and mortality. Elderly population with its associated health concerns is expanding rapidly. The prevalence of cardiovascular disease increases with age. Elderly people require surgery four times more often than the rest of the population. It is estimated that number of patients undergoing surgery will increase by 25% by 2020, and for the same time period the eldrly population will increase by > 50%.

Around 230 million patients undergo anaesthesia for major surgery in the world every year. Seven million develop severe complications associated with these surgical procedures from which one million die (200.000 in Europe). Lee et al. studied 4315 patients undergoing elective non-cardiac surgical procedures. They observed that 2.1% of patients suffered major

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cardiac complications, including cardiac death and myocardial infarction. When applied to the population in the European Union member states these figures translate into 150.000-250.000 life-threatening cardiac complications due to non-cardiac surgery annually. So European Society of Cardiology and endorsed by the European Society of Anaesthesiology have published the Guidelines for pre-operative cardiac risk assessment and perioperative cardiac management in non-cardiac surgery.

Guidelines should help physicians to make decisions in their daily practice. Guidelines aim to present recommendations based on available relevant clinical evidence on the topic.

Clinical practice over Europe may vary widely. This implies that european guidelines should be adapt to the specific local situation.

The data used may come from multiple randomized clinical trials or meta-analyses, single randomized trial or large non-randomized studies, retrospective studies or expert opinion statements. Cardiac complications after non-cardiac surgery depend on risk factors that are patient-related, surgery related and organization-related. Pre-operative evaluaton requires multidisciplinary approach from anaesthesiologist, cardiologist, internist, surgeon, primary physician. The goal of the consultation is the optimal care of the patient.

Preoperative assessment of cardiac patients for noncardiac surgery

Perioperative cardiac complications, such as myocardial infarction, cardiac arrest, congestive heart failure, unstable angina, cardiac arrhythmias, are a major cause of perioperative morbidity and mortality in patients undergoing major non-cardiac surgery. After major surgery, the incidence of cardiac death varies between 0.5% and 1.5% and of nonfatal cardiac complications 2% and 3.5%. Mortality of perioperative myocardial infarction is 40%.

Cardiac evaluation prior to noncardiac surgery is often performed by cardiologist who is to provide clinical information to the anesthesiologist and surgical team in terms of following:

- The current medical status of the patient.
- The patient's clinical risk profile for surgery.
- Recommendations regarding the management of cardiac problems during the perioperative period.

The main purpose of preoperative cardiac evaluation is to identify high-risk patients and determine which patients warrant further cardiac testing and risk reduction strategies that may improve short- and long-term outcomes after major surgery.

The European and updated American guidelines for preoperative cardiac risk assessment and perioperative cardiac management in noncardiac surgery were released by European Society of Cardiology (ESC) in 2009 and American College of Cardiology and American Heart Association (ACC/AHA) in 2007. Both guidelines are based on current evidence-based medicine together with expert opinion and result in algorithm of decision making. The guidelines suggest stepwise approach to a problem. Integrating factors such as acuity and severity of cardiac risk factors together with functional capacity of the patient and the type of planned surgery results in a final decision.

1. First step is to assess **urgency of surgical procedure**. If urgent, no testing is advised.
2. The next step is to identify **unstable cardiac conditions**: unstable angina pectoris, acute heart failure, significant cardiac arrhythmias, symptomatic valvular disease, recent myocardial infarction (30 days) and residual myocardial ischemia. If these present, immediate evaluation and treatment of a cardiac disease prior to surgery is needed, with cardiologist involved.
3. The third step is to **classify surgical procedure** according to risk for development adverse cardiac events. Low risk procedures (< 1% risk) are breast, dental, eye, gynecological, urological surgery etc. Medium risk (1-5% risk) are most of abdominal, head and neck, neurological, orthopedic, thoracic procedures, as well as carotid surgery and peripheral angioplasty. High risk procedures (> 5% risk) are aortic and major vascular surgical procedures. In general, patients undergoing any type of vascular surgery are at a greater risk than any other type of surgery. Vascular disease is strongly associated with concomitant coronary heart disease due to the same pathogenesis. In low-risk procedures, no further testing is required.
4. The fourth step is to assess **functional capacity** of patient. This is crucial step for most cases in preoperative evaluation. Functional capacity is measured in metabolic equivalents (MET). 1 MET is the resting oxygen consumption of a 70 kg 40-years-old man. Functional capacity is determined based on the ability to perform activities of daily living. Poor functional capacity (less than 4 METs - inability to climb 2 flights of stairs or run a short distance) is associated with higher rate of cardiac complications after surgery. In these patients the number of cardiac risk factors together with surgery related risk should be considered for further management. Patient with good (> 4 MET) functional capacity can go to surgery without testing.

5. **Clinical risk factor** determination is the next step. Guidelines use the Revised Cardiac Risk Index, described by Lee. Risk factors included in index have been identified in studies as independent predictors of adverse cardiac events, and they are: stable ischemic heart disease, compensated heart failure, cerebrovascular disease, insulin dependent diabetes mellitus, preoperative creatinine higher than 170 μmol/L and high-risk non cardiac surgery. ACC/AHA guidelines include first 5 of them as »cardiac risk factors« and allow non-insulin dependent diabetes as a risk factor as well; ESC guidelines use term »clinical risk factors« for the same factors. In patients with poor functional status undergoing high-risk surgery with up to 2 clinical risk factors, no additional testing prior to surgery is recommended, only risk reductive pharmacological measures. If there are ≥ 3 clinical risk factors, non-invasive stress testing is recommended. It may be considered also for patients with 2 risk factors and high- or intermediate risk surgery. Further management of a patient is guided by results of non-invasive testing. If there is extensive myocardial ischemia induced by stress testing, decision about prophylactic revascularization prior to noncardiac surgery is to be made individually as a result of multidisciplinary consultation.

Recent ACC/AHA and ESC guidelines note that continued emphasis should be given to preoperative clinical risk stratification, with non-invasive testing indicated only *when its results would lead to a substantial change in medical management.* In the past, referring the low-risk patients for stress testing was the leading cause of inappropriate referrals for these tests. Preoperative noninvasive testing should provide information on left ventricular (LV) dysfunction, myocardial ischemia and valve pathology, all major determinants of adverse postoperative outcome. Echocardiography for LV assessment is not predictive for adverse outcome, as it cannot detect severe underlying ischemic heart disease. Exercise testing (treadmill or bicycle) is preferred method for detecting ischemia, but it cannot be applied to all patients. Alternatives are myocardial perfusion imaging and stress echocardiography.

Not included in risk stratification, but mentioned in the guidelines, some other factors are developing. It has been shown that high preoperative NT-proBNP and CRP are strong and independent predictors of major cardiovascular event in non cardiac surgery. Predictive power of current clinical risk index could be strengthened by them.

Based on risk stratification of a particular patient, **risk-reductive strategies** are recommended prior to surgery: pharmacological (β-blockers, ACE

inhibitors and statins) and preoperative myocardial revascularization.

For preoperative β-blocker therapy, continuing debate on the usefulness and safety is going on, especially after results of POISE study were reported in 2007. β-blockers were associated with reduced perioperative myocardial infarction rate and cardiac death, but this benefit was offset by an increase in total mortality and stroke. Many other studies were published on this topic, with different populations of patient selection, types of surgery studied and different agents and protocols used. ESC and ACC/AHA guidelines recommend β-blockers to be continued perioperatively if patient is already receiving them and for patients with high cardiac risk based on multiple cardiac risk factors and stress-induced myocardial ischemia. It is reasonable also for patient at intermediate risk undergoing high- or intermediate-risk surgery. It is recommended to initiate therapy gradually with low starting dose and titration to target resting heart rate 60-70 bpm with systolic blood pressure over 100 mmHg. This requires starting treatment optimally 30 days or at least 1 week before surgery. Respond to a treatment should be carefully followed up.

Statins are also recommended as perioperative risk reductive therapy because of their pleiotropic effects, which are improved endothelial function, enhanced stability of atherosclerotic plaques, decreased oxidative stress and anti-inflammatory properties. Guidelines recommend statins for high-risk surgery and to be continued perioperatively if patient already receiving them.

ACE inhibitors seem to have beneficial effect on postoperative outcome, therefore they are recommended for cardiac stable patients with left ventricular dysfunction for intermediate and high risk surgery, maybe also for low-risk surgery.

For *myocardial revascularization* prior to noncardiac surgery, indications are the same as for non operative setting. It has not been demonstrated to improve survival and lower rate of nonfatal myocardial infarction after non-cardiac surgery, even with high-risk surgery, if patients are well managed perioperatively with β-blockers and optimal heart rate control. In perioperative setting it is useful for patients with left main disease, with 3-vessel disease, particularly if the ejection fraction is abnormal and for selected patients wit 2-vessel disease and proximal stenoses of main coronary arteries. There are no differences in method used - percutaneous or surgical.

Other interventions are to be considered as a result of preoperative stress testing:

- Delaying surgery because of unstable symptoms.
- Optimization of medical therapy before surgery.

- Involving additional specialists in the patient's perioperative care.
- Modification of intra/postoperative monitoring.
- Modification of postoperative care.
- Modification of surgical procedure.

Studies on implementation of guidelines have shown that in practice less than half residents in USA demonstrate approach advised in guidelines and that only one of each five patients underwent noninvasive testing when indicated. Reasons could be out-of-date guidelines, lack of awareness, agreement, or self-efficacy, lack of outcome expectancy, inertia on previous practice, external barriers such as lack of time, insufficient time or staff. Guidelines give recommendations to general groups of patient, but one must consider each patient individually. For example, assessment of functional capacity based on clinical performance of patient with claudications could be misleading. On the other hand, delaying surgery, even if not urgent, could worsen patient surgical condition. If myocardial revascularization is to be considered, at least 4 weeks of delaying noncardiac surgery is expected in a case bare metal stent or surgical revascularization is performed or even 1 year if drug-eluting stent is inserted. Some other additional factors which can have influence on perioperative course have to be considered as well, such as antiplateled therapy. Surgery related risks are also institutional- and surgeon-dependent. For most of laparoscopic procedures, there is still no agreement if this is low or intermediate risk surgery.

Preoperative evaluation of patients is a team work, including anesthesiologists, cardiologists, surgeons and primary care physicians. To implement guidelines in practice, organization of preoperative management at institutional level has to be adjusted. Anesthesiologist involved has to be experienced and familiar with all types of surgical procedures. Cardiologist has to be familiar with perioperative cardiovascular patophysiology and specificities of perioperative period. Surgeon has to be aware of patient's condition, his risk profile and willing to change surgical plan if necessary. There could be constant members of the team (analogy to acute pain service) or decisions are left to team involved in particular patient care. To organize the entire process of preoperative evaluation, timeframe for cardiac testing or titration of pharmacological therapy as well as priority related to nonsurgical patients waiting for the same test have to be considered as well. It is important also, who of the team is in charge to follow up the patient through the preoperative assessment to ensure optimal and timely fashion noncardiac surgery with as low risk as possible.

Pre-operative cardiac risk assessment and perioperative cardiac management in non cardiac surgery in patients with valvular heart disease, heart failure and ischaemic heart disease

Heart disease is a potential source of complicatios during non-cardiac surgery. More specifically, cardiac complications can arise in patients with ischaemic heart disease, heart failure and valvular heart disease. In urgent cases surgery patient-specific or surgical-specific factors dictate the strategy, and do not allow further cardiac testing or treatment. In elective cases all these diseases need preoperative evaluation and if needed, management.

Before non-cardiac surgery it should be clarified if the patient is unstable. Unstable cardiac conditions are:

- Unstable angina pectoris
- Recent myocardial infarction (within 30 days) and residual myocardial ischemia
- Acute heart failure
- Symptomatic valvular heart disease
- Significant cardiac arrhythmias.

These conditions should be treated appropriately prior to surgery. This usually leads to cancellation or delay of the surgical procedure.

Valvular heart disease

Patients with valvular heart disease (VHD) are at higher risk of perioperative cardiovascular complications during non-cardiac surgery. Echocardography should be performed in patients with known or suspected VHD, to assess it severity and consequences. In the presence of severe VHD it is recommrnded that a clinical and echocardiographic evaluation be performed and, if needed, treatment before non-cardiac surgery.

Aortic stenosis

Aortic stenosis (AS) is the most common VHD in Europe, particulary among elderly. Severe AS constitutes a well established risk factor for perioperative mortality and myocardial infarction. Severe AS is defined as aortic valve area < 1.0 cm^2, mean pressure gradient > 40 mmHg and jet velocity > 4 m/s. In the case of elective non-cardiac surgery, the presence of symptoms is a key for decision making.

In symptomatic patients (dyspnea, stenocardia, syncopa) aortic valve replacement should be considered before elective surgery. In patients who

are not candidates for valve replacement, balloon aortic valvuloplasty or transcatheter valve implantion is a reasonable therapeutic option before surgery.

In asymptomatic patients non-cardiac surgery of low to intermediate risk can be safely performed.

Mitral stenosis

Mitral stenosis (MS) is the most frequent valvular complication of rheumatic fever. Given the decrease in the prevalence of rheumatic heart diseases, MS has become the least frequent single left-side valve disease. However, it still accounts for ~10% of left-sided valve disease in Europe and it remains frequent in developing countries.

Non-cardiac surgery can be performed at relatively low risk in patients with non-significant MS (valve area > 1,5 cm^2) and in asymptomatic patients with significant MS (valve area < 1,5 cm^2) and systolic pulmonary artery pressure < 50 mmHg. Pre-operative surgical correction of MS in these patients is not indicated.

In asymptomatic patients with significant MS and systolic pulmonary artery pressure > 50 mmHg and in symptomatic patients (progressive dyspnea on exertion, exertional presyncope) the risk related to the non-cardiac operation is significantly higher, and these patients may benefit from percutaneous mitral commissurotomy or surgical repair particulary before high-risk surgery.

In patients with MS it is very important to ensure control of heart rate to avoid tachycardia, which may cause pulmonary oedema due to reduction in diastolic filling period. Strict control of fluid overload is needed. Development of atrial fibrillation may cause serious clinical deterioration. With the high risk of embolisem, anticoagulation control is important.

There are other VHD which generally do not independently increase the risk of cardiovascular complication during non-cardiac surgery.

Mitral regurgitation is very common VHD and has many causes, the two most common being mitral valve prolaps and functional mitral regurgitation that complicates postinfarction left ventricular remodeling.

Valvular abnormalities that may result in **aortic regurgitation** include bicuspid aortic, rheumatic fever, infective endocarditis, collagen vascular diseases, and degenerative aortic valve disease. Abnormalities of the ascending aorta, in the absence of valve pathology, may also cause aortic regurgitation, such as may occur with longstanding uncontrolled hypertension, Marfan syndrome, idiopathic aortic dilation.

At high risk of cardiovascular complications are only those patients with mitral or aortic regurgitation who are symptomatic and those who are asymptomatic with severely impaired left ventricular ejection fraction (< 30%). These patients may benefit from optimization of pharmacological therapy (ACE inhibitors, beta blockers, diuretics). In aortic regurgitation attention to volume control and afterload reduction is recommended. Slow heart rates are not recommended.

Patients who have undergone surgical correction of VHD and have a **prosthetic valve** can undergo non-cardiac surgery without additional risk, when there is no evidence of valve or ventricular dysfunction. In these patients, endocarditis prophylaxis is recommended and modification of the anticoagulation regimen to be considered in the perioperative period.

Heart failure (HF)

Acute heart failure is one of unstable cardiac conditions that at least postpone elective non-cardiac operation. Patients with acute HF need intensive pharmacological treatment (diuretics, vasodilatators, adrenergic agonists...). Special attention should be given to the patient's volume status. Perioperative management is similar in patients with HF who have preserved left ventricular ejection fraction as in patients with reduced ejection fraction. After stabilization of the patient non-cardiac operation is possible.

Chronic heart failure is one of clinical risk factors for non-cardiac operation. An attempt should be made to optimize pharmacological therapy before surgery. This may be of particular importance for beta blockers, which are recommended in the perioperative period in all high-risk patients. If a heart failure patient is not receiving a beta blocker, such therapy should be initiated early enough before elective surgery to ensure optimal dose uptitration. Another group of drugs which are very important in primary treatment in chronic heart failure patients are ACE inhibitors (or ARBs in patients intolerant of ACE inhibitors). Unless contra-indicated or not tolerated, they should be given in optimal doses in all patients with symptomatic heart failure and an left ventricular ejection fraction < 40%. In these patients who are in a stable clinical condition, it seems reasonable to continue ACE inhibitors during the perioperative period under close monitoring. ACE inhibitor withdrawal may be considered only when they are prescribed for hypertension.

The perioperative use of ACE inhibitors, beta blockers, statins, and aspirin is independently associated with a reduced incidence of in-hospital morta-

lity in patients with LV dysfunction who are undergoing major non-cardiac vascular surgery.

Post-operative heart failure is very common complication in non-cardiac operation. The diagnosis is often difficult to make since it often presents atypically and may have a different aetiology compared with the non-surgical setting. Special attention should be given to the patient's volume status since high-volume infusion is often needed in the intra- and immediate post-operative setting. Fluid overloading may cause decompensation of chronic heart failure or development of de novo acute heart failure. Patients with heart failure have significantly higher risk of hospital readmission after surgical procedures.

Ischaemic heart disease

Unstable coronary syndromes (unstable angina pectoris, recent myocardial infarction) usually leads to cancellation or delay of the non-cardiac operation. These patients should be referred for coronary angiography to asses the therapeutic options. Treatment options should be discussed in multidisciplinary team, involving all perioperative care physicians, because interventions might have implications specific surgical procedures. Depending on the outcome of this discussion, patients can proceed for coronary artery intervention, namely CABG, balloon angioplasty, or stent placement with the initiation of dual antiplatelet therapy if the index surgical procedure can be delayed, or directly for operation if delay is incompatible with optimal medical therapy.

In patients with **chronic ischemic heart** disease it is very important to clarify next questions:

- what is the ischemic threshold ie, the amount of stress required to produce ischemia,
- what is the patients ventricular function and
- is the patients on his optimal medical regimen.

First of all we should consider functional capacity of the patient. If an asymptomatic patient has moderate or good functional capacity, > 4 MET, he could proceed to non-cardiac surgery. In patients with poor functional capacity we should consider the risk of the surgical procedure and the number (frequency) of clinical risk factors. In these patients it seems reasonable to do some non-invasive tests (stress ergometry, stress echocardiography, myocardial perfusion imaging, MRI, CT angiography). Patients without stress induced ischaemia, or mild to moderate ischaemia, can proceed with the

planned surgical procedure. In patients with extensive stress-induced ischaemia individualized perioperative management is recommended, taking into consideration the potential benefit of the proposed surgical procedure compared with the predicted adverse outcome. Also, the effect of medical therapy and/or coronary revascularization must be assessed, not only for immediate post-operative outcome, but also for long-term follow-up. In patients referred for percutaneous coronary artery intervention, the intiation and duration of antiplatelet therapy will interfere with the planned surgical procedure.

In patients referred for angioplasty, non-cardiac surgery can be performed within 2 weeks after intervention with continuation of aspirin treatment.

In patients with bare metal stent placement, non-cardiac surgery can be performed after 6 weeks to 3 months following intervention. Dual antiplatelet therapy should be continued for at least 6 weeks, preferably for up to 3 months. After this period, at least aspirin therapy should be continued.

In patients with recent DES placement, non-cardiac surgery can be performed after 12 months, following intervention, before which time dual antiplatelet therapy is recommended. After this period, at least aspirin therapy should be continued. Discontinuation of aspirin therapy should be considered only in those patients in which haemostasis is difficult to control during surgery.

In all patients with ischaemic heart disease statin therapy and a titrated low-dose beta blocker regimen appears appropriate prior surgery. In patients with systolic LV dysfunction also ACE-inhibitors are recommended.

Intraoperative anaesthetic management

Trauma, surgery and administration of anaesthetic drugs often affect cardiovascular physiology to great degree. Randomized studies and a meta-analysis of several randomized clinical trials in non-cardiac surgery patients, comparing outcome with regional and general anaesthetic techniques have shown little evidence of improved outcome and reduced post-operative morbidity and mortality. The importance of management in keeping adequate organ perfusion pressure is often underlined.

Cardiovascular effects of general anaesthesia

Most anaesthetic techniques reduce sympathetic tone, decrease myocardial contractility , decrease stroke volume and increased myocardial irritability. Inhalational and intravenous anaesthetics can be detrimental by senziting the myocardium to circulating cathecholamines, thereby increasing the risk of ventricular ectopy. Opioid-based anaesthetics were previously

popularized because of the cardiovascular stability associated with their use. The use of fentanyl,sufentanil or alfentanil results in less myocardial depression compared to inhaled anaesthetics. The use of high doses of opioids is associated with the need for prolonged postoperative mechanical ventilation. All inhaled volatile anaesthetic agents can depress myocardial contractility and reduce afterload. Randomized clinical trials in patients undergoing CABG surgery indicate that volatile anesthetics decrease troponin release and enhance LV function compared with propofol, midazolam or balanced anaesthetic techniques with opioids. Volatile anaesthetics have been shown in animal studies to precondition and postcondition the heart against infarction by activating specific intracellular signal transduction pathways. Ultimate evidence that the cardioprotective effects of volatile anaesthetic agents can result with better post-operative outcome remains to be established.

Cardiovascular effects of neuraxial techniques

Neuraxial anaesthetic techniques include spinal and epidural blocks. Both techniques can result in sympathetic blockade, resulting in decreases in both preload and afterload and ultimately reducing cardiac output. The decision to use neuraxial anesthesia for the high-risk cardiac patient may be influenced by the dermatomal level of the surgical procedure.

Epidural blockade that is restricted to the level of the low thoracic and lumbar region (T_5-L_4) results in a peripheral sympathetic blockade with vascular dilatation in the pelvis and lower limbs and decrease in mean arterial pressure. This decrease is compensate with a reflex increase in efferent sympathetic vasoconstriction above the level of the block, by release of catecholamines from the adrenal medulla. This increased activity may result in increased cardiac contractility and increased heart rate. Reduction in mean arterial pressure during lumbar epidural anaesthesia may increase myocardial ischemia in some patients with coronary artery disease. Activation of the sympathetic nervous system may result in myocardial ischemia and infarction. Atrial fibrillation and tachycardia are common after cardiac and thoracic surgery. Thus, sympathetically mediated decreases in myocardial oxygen supply may be a major factor of postoperative cardiac morbidity. Selective blockade of cardiac sympathetic inervation (T_1-T_5) can most easily be achieved by administrating local anaesthetics through an epidural catheter placed at an upper thoracic level, a technique commonly known as thoracic epidural anaesthesia (TEA). TEA significantly reduced incidence of supraventricular tachyarrhytmias after pulmonary resections. Cardiac sympathetic blockade by TEA dilates stenotic coronary arteries and has been

used to control pain in patients with unstable angina. The anti-ischemic and anti-anginal effects of continuous TEA are superior to those of conventional therapy in the treatment of refractory unstable angina. Postoperative myocardial infarction, respiratory and renal failure, stroke and mortality were reduced by TEA, but not by lumbar epidural analgesia. TEA containing a local anaesthetic dilates stenotic coronary arteries and increases myocardial oxygen supply, decreases myocardial oxygen consumption, decreases myocardial ischaemic events and postoperative myocardial infarction. Lumbar epidural analgesia with a local anaesthetic, on the other hand dilates arteries of the lower part of body, constricts coronary arteries and decreases myocardial oxygen supply.

In summary we can say that epidurals for major surgery offers better pain control in the postoperative period and improves patient satisfaction. In selected groups such as the patient undergoing aortic surgery, it may also influence cardiac morbidity and mortality (aortic). Other benefits are less clear. The Multicentre Australian Study of Epidural Anesthesia found no difference in outcome between patients receiving perioperative epidural analgesia and those receiving intravenous opioids.

Continuous TPB either unilaterally or bilaterally has been useful in minimally invasive cardiac surgery to provide excellent analgesia while allowing early ambulation. There is also a potential advantage of avoiding central neuraxial haemathoma with this technique. It was presented that TPB can resolve ST segment depression during general anaesthesia and thus is useful in treatment of angina pectoris.

The studies which compared TPB with TEA found no difference in analgesia. In the study of Richardson et al. was found that TPB (bupivacaine) was superior in terms of analgesia, pulmonary functions, neuroendocrine stress responses, side effects and postoperative respiratory morbidity compared to TEA (bupivacaine).

In the study of Casati and co-workers was shown that continuous thoracic paravertebral analgesia is as effective as epidural blockade in controlling a post-thoracotomy pain, but is associated with less haemodynamic effects.

In patients undergoing minimally invasive direct coronary artery bypass surgery TEA and TPB were compared. The quality of analgesia was comparable within the groups. TPB is technically easier than TEA and may be safer than TEA because no complication were seen in the TPB group.

Two recent systematic reviews have confirmed the efficacy of paraverte-

bral blockade for post-thoracotomy analgesia. Davies et al. compared TPB with TEA and confirmed that the quality of analgesia was equivalent but there were fewer side effects and complications with TPB. The Prospect group looked at all randomized trials where regional technique was used (epidural, paravertebral, intrathecal, intercostals and interpleural). Again, on the balance of equivalent or superior analgesia and less adverse events, TPB is recommended for post-thoracotomy analgesia.

Systematic reviews found no difference in analgesia with TPB techniques when compared with TEA regimens. Important side effects such as hypotension, urinary retention, nausea and vomiting, were less frequent with TPB than with TEA. Compared to the other available regional techniques such as intercostals and interpleurals TPB offers better quality, longer duration of analgesia and less side effects.

Although many clinicians believe that regional anaesthesia is safer than general anaesthesia, randomized studies comparing the two modalities have shown no difference in cardiopulmonary complications or mortality. It has been estimated that the number of patients needed for a randomized clinical trial to determine whether epidural anaesthesia and analgesia would affect mortality in patients undergoing high-risk vascular surgery would be 24 000, while enrolment of 1.2 million would be needed in a low-risk procedure. Combined epidural and general anaesthesia with analgesia for pain control may attenuate sympathetic hyperactivity, reduce the need for additional parenteral analgesia postoperatively, improve postoperative pulmonary funcion and reduce the duration of stay in the intensive care unit following surgery.

Valvular heart disease

Patients with VHD are at highr risk of perioperative cardiovascular complications during non-cardiac surgery. Severe aortic stenosis defined as with valve area <1 cm^2 associated with transvalvular gradient of 50 mmHg and with symptoms syncope, angina, dyspnea should be considered for valve replacement before elective surgery. The goals in anaesthetic management are to maintain normal blood pressure and heart rate, to maintain preload, to avoid abrupt decrease in afterload. In severe aortic stenosis central neuraxial blocks are relatively contraindicated, anaesthesiologist should consider the use of peripheral nerve blocks. Cardiopulmonary resuscitation may be problematic as chest compressions may not generate pressures great anough to overcome valve gradient.

In aortic regurgitation reduction in peripheral vascular resistance such

as that produced by neuraxial blocks promotes forward flow and reduces the regurgitation fraction. Abnormal reductions in blood pressure should be avoided because it may cause significant reduction in diastolic filling pressure with subsequent myocardial ischemia or cardiovascular collapse.

In patients with mitral stenosis is important to prevent tachycardia and fluid overload to avoid pulmonary oedema. In patients with severe mitral regurgitation and impaired LV ejection fraction < 30% non-cardiac surgery should be performed only if necessary.

Perioperative medical therapy

Preoperative evaluation of the patient's condition and introduction of optimal medical therapy is important in order to decrease perioperative cardiovascular complications. During major abdominal and vascular surgery patients are at the highest risk for developing myocardial ischemia and myocardial infarction. Regarding the patient´s condition the arterial hypertension, diabetes mellitus, hyperlipidemia and angina pectoris pose a risk for perioperative morbidity and mortality.

B-blockers

Every surgical procedure represents stress to the human organism. The excitation of the sympathetic nervous system results in an increased heart rate, myocardial contractility and myocardial oxygen consumption and it depends on the type and invasiveness of the surgery.

The main benefit for perioperative β blocker use is to improve relationship between myocardial oxygen supply and consumption and thus reduce the risk for myocardial infarction.

Published recommendations and guidelines on perioperative β blocker therapy are most often based on seven randomised multicenter studies. Considering the design of the study, type and dose of β blockers used, and duration of treatment the studies vary widely. The differences are in the number of patients enrolled in the studies, their co morbidities and type of surgery.

In the DECREASE study Poldermans and co-workers collected 112 patients with the greatest preoperative risk for myocardial infatction undergoing vascular surgery. Patients started the treatment with β blockers week before surgery and continuing 30 days after surgery had lower mortality rate and also reduced rate of myocardial infarction postoperatively.

The largest number of patients was enrolled in *POISE* study. Patients received β blockers 2-4 hours before the procedure and the treatment continued 30 days after the surgery. There was a decrease in the composite end point,

defined as death, myocardial infarction and non-fatal cardiac arrest at 30 days. However there was significant increase in total mortality and in cerebrovascular insult. Analysis revealed that the main cause of higher mortality rate and stroke was hypotension.

Before the decision to introduce β blockers in the perioperative period is accepted the patients´ underlying cardiac risk and the invasiveness of the procedures should be taken into account.

β blockers should be continued in patients who are already receiving β blockers to treat angina, heart failure or hypertension.

β blockers should be initiated before surgery in patients:

1. With known ischemic heart disease
2. In whom preoperative stress testing identifies myocardial ischemia
3. Undergoing vascular surgery having chronic heart disease.

To achieve the maximal impact the treatment onset and the choice of optimal dose of β blockers are of significant importance. The treatment should be initiated between 30 days and at least 1 week before surgery and the dose should be titrated to achieve a resting heart rate between 60-70 beats/min with systolic blood pressure > 100 mm Hg. It is recommended that the treatment starts with daily dose 2.5 mg bisoprolol or 50 mg metaprolol.

The treatment with β blockers should be considered in patients:

1. Scheduled for intermediate-risk surgery
2. Scheduled for low-risk surgery with risk factor(s) for cardiovascular complications in perioperative period.

B blockers are not recommended in patients:

1. Scheduled for low-risk surgery without risk factor(s) for postoperative cardiovascular complications
2. When dose titration is not possible or it is not possible to monitor the patient who started the treatment
3. With contraindication for treatment with β blockers

Angiotensin-converting enzyme inhibitors

Indications for angiotensin-converting enzyme inhibitors (ACE inhibitor) have spread in recent years. Beside blood pressure-lowering effect these drugs poses anti-inflammatory effect, beneficial effects on vascular endothelium and ultimately reduce the incidence of myocardial ischemia. However perioperative use of ACE inhibitors represents a risk of severe and resistant hypotension immediately after the induction of the anaesthesia. The hypotension is even more frequent and severe in concomitant ß blocker use.

This is the reason why ACE inhibitor withdrawal 24 hours before surgery is recommended when they are prescribed for hypertension and this would not

deteriorate patients' conditions. If the ACE inhibitor is prescribed for heart failure and patient's current condition is stable the treatment may continue. If the treatment with ACE inhibitor is initiated the elective surgery should be postpone until the stabilization of patient's condition is achieved.

Calcium channel blockers

Verapamil and diltiazem with their effect on heart rate are suitable drugs for reduction the perioperative risk of cardiovascular complications. In the meta-analysis the authors collected data from 11 trails suggested the significant reduction in incidence of myocardial ischemia and supraventricular tachycardia in patients who were treated with calcium channel blockers and underwent noncardiac surgery. It is recommended that the calcium channel blockers are continued in perioperative period if the patients are on regular therapy with this drug. It is also recommended to introduce the therapy with calcium channel blockers in patients who have contraindications for β blockers.

Nitrates

Perioperative use of nitroglycerine may decrease preload and expose the patients to severe hypotension. This is the reason why the initiation with this drug in perioperative period is not recommended. If nitroglycerine is prescribed for treatment of angina pectoris the drug should not be withdrawal.

Diuretics

The application of diuretics may result in detrimental imbalance in intravascular volume and serum electrolytes. If the diuretics are prescribed for hypertension they should be discontinued on the day of surgery. For heart failure treatment the diuretics are prescribed in high dose and the patient's condition should be accurately evaluated. If the treatment with diuretics is not interrupted before surgery the volume status and the serum concentration of electrolytes should be monitored carefully.

α_2 Receptor agonists

The studies showed the reduction in incidence of postoperative myocardial infarction and death in population of patients who underwent vascular operations and were treated with clonidin or mivazetrol. Even though α_2 receptor agonists are not the first line drug to avoid ischemic event they may be considered to reduce the risk of perioperative cardiovascular complications in vascular surgery patients.

Statins

Statins are frequently prescribed not only because their lipid-lowering effect but also because they also stabilize coronary plaque; this is so called their pleitropic effect. Multiple large multicenter studies have demonstrated beneficial effect of perioperative statin use. To prevent cardiovascular complications in high-risk surgery patients it is recommended to start statins 30 days or at least 1 week before surgery. After the surgery the treatment should be continued as soon as possible. It was never proved that statins increase the risk of myopathy and rhabdomyolysis. Quite the contrary it was demonstrated that the discontinuation of statins could result in a rebound effect.

Aspirin

After coronary stent placement and patients with ischemic heart disease should receive aspirin lifetime. Aspirin withdrawal in perioperative period increases the risk for ischemic event. It was proven that continued therapy with aspirin expose the patients to the increased pooperativne bleeding but this is not related to major and life threatening pooperativne complications. Aspirin should only be discontinued if the bleeding risk outweighs the potential cardiac benefit. Discontinuation should be considered only when haemostasis is difficult to control during surgery.

Anticoagulant therapy

Anticoagulation therapy is associated with increased bleeding during cardiac and non-cardiac surgery. However anticoagulation therapy should be maintained or modified in patients with high risk for thrombotic event. In patients with low risk for thrombotic event the anticoagulation therapy should be stopped. Patients treated with vitamin K antagonist could be operated safely and without increased risk for postoperative bleeding if the international normalized ration (INR) is < 1.5. After cessation of oral anticoagulation therapy patients with increased risk for thrombotic complications need bridging therapy with standard heparin or low molecular weight heparin. Vitamin K antagonists should be stopped 5 days before surgery. Regarding to the risk for thrombembolic complications therapeutic or preventive dose of standard or low molecular heparin is prescribed.

Perioperative monitoring

Introduction

For patients with accompanying heart disease the preoperative period is of great importance for a positive outcome after noncardiac surgery. Lite-

rature suggests that intensive and careful monitoring during perioperative period may help to reduce perioperative complications. Especially myocardial ischemia has been shown to be an early predictor of possible future postoperative events; in addition, it is rarely accompanied by pain during the perioperative period.

Electrocardiography

Recommendations

- Intraoperative and postoperative ST-segment monitoring can be useful to monitor patients with known ischemic heart disease, with computerized ST-segment analysis, used to detect myocardial ischemia during the perioperative period (recommendation IIa, level of evidence B).
- Intraoperative and postoperative ST-segment monitoring may be considered in patients with risk factors for ischemic heart disease who are undergoing a noncardiac surgery (recommendation IIb, level of evidence B).
- For a better detection of ischemia in the operating room a combination of multiple leads should be considered (recommendation IIa, level of evidence B).

According to literature, intraoperative and postoperative ST-segment changes in high-risk noncardiac surgery patients are associated with increased risk for cardiac events and morbidity during the perioperative period. In a review of studies between the years 1990 and 2003, Landesberg reported a sensitivity of perioperative ischemia in predicting postoperative cardiac events of 55% to 100%; the specificity was 37% to 85%, the negative predictive value was 89% to 100%. The relative risk of suffering a postoperative cardiac event, including cardiac death, in patients with ischemia was between 2.2% and 73%. Additionally, the duration of the ST-segment changes positively correlates with the incidence of the perioperative myocardial infarction.

Modern monitors in operating rooms and in ICU units normally enable a computerized real-time analysis of the ST-segment. The computerized analysis is more reliable for detecting myocardial ischemia compared to visual analysis of a physician. Moreover, ST-segment trending monitors were found to have an average sensitivity and specificity of 74% and 73%, respectively, compared with Holter ECG recordings. Since myocardial ischemic events are dynamic they may not always appear in the same lead. If a single lead is used for monitoring, there is an increased risk of missing ischaemic events. A study conducted by Landesberg et al. showed that the sensitivity for detection

of myocardial ischemia in the lead V5 was 75%. By combining the leads V4 and V5 the sensitivity increased to 90%, and even to 96%, when the standard lead II is used additionally. Ischemia during ST-segment monitoring may be a predictor of cardiac events in high-risk patients. However, it is not clear whether the ST-segment monitoring is efficient enough in patients at low risk and without signs of an ischemic heart disease.

Transoesophageal echocardiography (TOE)

Recommendations on intraoperative and/or postoperative transoesophageal echocardiography for detection of myocardial ischemia

- The use of TOE should be considered in patients who develop ST-segment changes on intraoperative or postoperative ECG monitoring (recommendation IIa, level of evidence C).
- The use of TOE may be considered in patients at high risk of developing myocardial ischemia who undergo major non-cardiac surgery (recommendation IIb, level of evidence C).

Recommendations on intraoperative and/or postoperative transoesophageal echocardiography in patients at risk of haemodynamic instability

- TOE is recommended when acute sustained severe haemodynamic disturbances develop during surgery or in the perioperative period (recommendation I, level of evidence C).
- TOE monitoring may be considered in patients at increased risk of significant haemodynamic disturbances during and after major non-cardiac surgery.
- TOE monitoring may be considered in patients with severe valvular lesions during major non-cardiac surgical procedures accompanied by significant haemodynamic stresses.

TOE has been implemented as a monitoring tool during cardiac surgery with increasing frequency. Its use in non-cardiac surgery is yet not fully understood, though. TOE is relatively non-invasive and rapidly available method. According to literature, it is more sensitive than the ST-segment monitoring in detecting myocardial ischemia. The efficiency rates relate to the experience of the physician; however automated non-stop control methods have not been developed yet. The concordance between ECG and TOE is rather weak, too. Both ST-segment changes and regional wall motion abnormalities can be present in the absence of acute ischemia. Wall motion abnormalities may be difficult to interpret in the presence of right bundle branch block, atrial fibrillation, and ventricular pacing. The prediction rate

of TOE for a heart disease is also relatively small. In a study conducted by Eisenberg and colleagues involving patients undergoing a non-cardiac surgery TOE demonstrated an OR of 2.6 (95% CI: 1.2-5.7) for predicting perioperative cardiac events.

Certainly, TOE is a good choice if acute and severe haemodynamic instability develops during or after surgery. In this case TOE enables a rapid evaluation of global and regional cardiac structure, information on left and right ventricle function and the presence of a possible cardiac tamponade or thrombi, as well as a ventricular preload estimation.

The role of TOE for monitoring patients at high risk during a non-cardiac surgery has not been extensively validated in published literature.

Undoubtedly, TOE is a very efficient method in monitoring patients with severe valvular lesions. The loading conditions change during general anaesthesia, which can pathophysiologically affect the valve defect. TOE can be of great assistance in evaluating valvular function, ventricular loading, systolic, and diastolic function (mitral insufficiency, evaluation of preload in patients with aortic stenosis); however this method needs some more validation for its routine use.

Post anaesthesia monitoring for the cardiac patients after non cardiac operations in post anaesthesia care unit

The decision to care for the cardiac patient after non cardiac surgery in a post anaesthesia care unit (PACU) or in an intensive care unit is based on several variables that influence postoperative patient's condition immediately after surgery.

Patients undergoing pulmonary or major vascular surgery in chest or abdomen are best cared for in specialised intensive care units. The patients with cardiac disease undergoing other types of surgery can be admitted to PACU if there is a prospective to discontinue mechanical ventilation and hemodynamic monitoring and support in the short term.

Preoperative variables

Planning of the location of postoperative care depends on severity of the cardiac disease and predictable risk of the planned operation. With regard to cardiac risk, cardiac patients after surgery with low or intermediate risk can be admitted to PACU.

However, elderly patients, patients with unstable ischaemic heart disease, concomitant pulmonary and/or kidney disease have greater risk for postoperative complications.

Intraoperative variables

Prolonged time of operations, fluid shifts, significant blood loss, hypothermia, episodes of tachycardia and/or hypotension, ST-segment deviation, are conditions that correlate with increased frequency of postoperative myocardial infarction or heart failure. If the surgery was of low risk, and patient was stable during the procedure, recovery is reasonably safe in the PACU.

PACU

To provide the adequate level of care, PACU must have equipment and staff to continue and safely proceed to weaning from mechanical ventilation, if it is necessary. Monitoring and haemodynamic support must be continued in the early postoperative period.

Postoperative pain management

It is well known that postoperative pain may increase sympathetic drive and delay recovery.

Neuraxial analgesia with local anaesthetics/opioids and/or α_2-agonists seems to be the most effective.

The benefit of neuraxial analgesia in patients under chronic antithrombotic therapy should be weighed against the risk of potential neuraxial haematoma formation.

Patient-controlled analgesia with i.v. opioids is an alternative for postoperative pain control.

Non-steroidal anti-inflammatory drugs and COX-2 inhibitors have the potential of promoting heart and kidney failure as well as thromboembolic events and should be avoided in patients with myocardial ischaemia.

The evidence based data from literature considering outcome of the comparable cardiac patients, whether their care immediately after surgery is taking place in ICU or PACU, is lacking. The recommendations are based on general agreement and common practice with these patients.

Postoperative pain management for cardiac patients after noncardiac surgery

Many investigations in recent years proved that control of postoperative pain not only provides a subjective patient comfort, but also blunts the neuroendocrine and metabolic responses to surgical trauma, reduces the incidence of postoperative morbidity and mortality and quickens the recovery of function that allows the patient to breathe, to cough, to move better, and to recover earlier oral food intake.

It is well known that postoperative pain may increase sympathetic drive

and delay recovery. Stimulation of the sympathetic nervous system by pain leads to an increase in blood pressure, heart rate and inotropy. The resultant increase in oxygen demand may lead to ischaemia if there is not a matched increase in supply. These changes, coupled with postoperative hypercoagulability, possibly also be influenced by the sympathetic nervous system, may affect perioperative cardiac morbidity.

Neuraxial analgesia

After major surgery in thorax or abdomen, neuraxial analgesia with local anaesthetics/opioids and/or α_2-agonists seems to be the most effective, as well as for high risk patients after ortopedic surgery.

However, cardiac patients are often on chronic antithrombotic therapy, so the benefit of neuraxial analgesia should be weighed against the risk of potential neuraxial haematoma formation.

Patient-controlled analgesia

Patient-controlled analgesia (PCA) with i.v. opioids is an alternative for postoperative pain control after major surgery. PCA is a delivery system with which patients self-administer predetermined doses of analgesic medication to relieve their pain. Since its introduction in the early 1980s, the daily management of postoperative pain has been extensively optimised.

Instillation of local anesthetics

PCA with peripheral nerve catheters results in increased postoperative analgesia and satisfaction for surgery on upper and lower extremities. Serious complications occur rarely with these catheters.Wound instillation of local anesthetics has been a proven successful pain therapy alone for peripheral surgery as well as an adjunct to intravenous analgesia after major surgery, and was proven to be safe also for cardiac patients.

Non-steroidal anti-inflammatory drugs and COX-2 inhibitors

Non-steroidal anti-inflammatory drugs and COX-2 inhibitors have the potential of promoting heart and kidney failure as well as thromboembolic events and should be avoided in patients with myocardial ischaemia. On the other hand, coadministration of paracetamol has been introduced as a method of reducing opioid dose.

In conclusion, if feasible, neuraxial analgesia has advantage over other techniques of postoperative pain therapy after major surgery for cardiac patients. If there are contraindications existing for it's use, alternative is PCA with opioids, possibly with adjunction of paracetamol. Nonsteroidal anti-in-

flammatory drugs are currently not recommended in the group of patients with cardiac disease.

For less invasive surgery cathether wound instillation of local anesthetics has been used in cardiac patients. This type of analgesia can be combined with PCA for more invasive procedures to diminish opioid use and their undesirable side effects.

Guidelines for treatment the patients with pacemaker and implantable cardioverter for noncardiac surgery

The pacemaker (PM) and implantable cardioverter (ICD) may be disturbed by different sources of electromagnetic field.

The results of electromagnetic interference (EMI) with PM or ICD are:

- Asynchronous pacing
- Inhibition
- Stimulation on upper limit
- Ventricular fibrillation
- Burns of endocardium
- Pacemaker damage
- Especially old PM with function R (the R is responsible for physiological rate adaptation) can be disturbed also because of drugs such as succinylcholine, ketamine or etomidate. The higher frequency because of function R can be caused also because of connection the patient with ventilator after the intubation.
- ICD can be switched off or it can deliver counter shocks under the influence of EMI.

Safety measures before the surgery

A shorter time before surgery (1-6 months) the ICD and PM has to be checked by cardiologist or cardiovascular surgeon who has to check:

- The type of pacemaker
- Which kind of pacing the patient has if he doesn't have the PM identification and if this type of pacing is appropriate for this patient.
- Battery status
- The degree of patient's dependence of PM
- The condition of patients heart disease (hypoxia, hypercapnia, metabolic disturbances, myocardial ischemia and electrolyte imbalance) and treat them if necessary.
- Before the surgery we have to evaluate the possibility of electromagnetic interference during the surgery.
- If there is possibility of electromagnetic interference it is necessary to

reprogram the PM:
- If the patient is dependent on PM, the PM should be switched on asynchronous pacing.
- If the R function is present, it should be switched off
- The antitachycard function should be switched off.

During the surgery

- The possible sources of EMI are monopolar electrocautery, radiofrequency ablation, electromagnetic resonance (which is forbidden in this group of patients) and lithotripsy.
- In operating room an external defibrillator, external PM, a reprogramming device and magnet must be always present.
- The electrolyte disturbances or ischemia may cause the disturbances in PM or ICD action, so we have to treat them.
- The surgeon should use the bipolar electrocautery or ultrasonic scalpel
- If the surgeon can't avoid the usage of monopolar electrocautery, it is very important that we put its grounding plate as close as possible to active tip of electrocautery and outside of electric circuit of pulse generator.
- The largest possibility of EMI is in the case where electric current direction is parallel to pacemakers lead and the smallest where the current direction is perpendicular to it. So the best placement for the ground plate is where the electric current direction is posterior-anterior.
- Surgeon should use the monopolar electrocautery only in short not rhythmic pulses and after them has to be interval of at least 10 seconds which permits PM to maintain the adequate cardiac output and the anaesthesiologist can check the heart rate on monitor.
- The surgeon should use the lowest possible energy for electrocautery.
- The use of monopolar electrocautery at procedures under waist is not so dangerous but we have to keep in mind all recommendations for this group of patients.
- For longer procedures heart rate and blood pressure should be monitored using an arterial line.
- In the case of external defibrillation the posterior-anterior electrode placement is recommended. We have to place the anterior electrode at least 15 cm away of pulse generator.
- If we put both electrodes anterior, the current direction should be perpendicular to PMs Leads. The lowest possible energy should be use for defibrillation.
- The magnet switch PM to asynchronous pacing and it is possibly dangerous for patients with their own rhythm.

- If we put magnet on ICD, we switch off the cardio version and defibrillation, the pacing is in asynchronous way.
- If it comes to PM damage, we give the patients the inotropic support and external pacing. We have to call the cardiologist immediately.
- The ICD should be switched off during the surgery. All the time the patient have to be monitored and external cardioverter and defibrillator should be present in operating room.
- In the case of ventricular fibrillation we have to remove the source of EMI. If the ICD was switched off with magnet we just remove the magnet and ICD will deliver counter shock, if doesn't come to defibrillation we have to do it external. If the ICD was reprogrammed we have to start with external defibrillation.
- In the case of radiofrequency ablation we have to avoid the direct contact of PMs Pulse generator and the catheter for ablation. The electrical circuit of radiofrequency ablation has to be away of the circuit of PM pulse generator.
- Lithotripsy: ultrasound source should be away of the PM pulse generator. If the lithotripsy is synchronised with R tooth in ECG, we have to switch off the atrial pacing.

After the surgery

- In early postoperative time we have to monitor the patient.
- The equipment for cardio version and defibrillation should be in vicinity of the patient.
- All functions we switched off before the surgery should be switched on after the surgery. ICD should be switched on already in recovery room.
- The patient with PM or ICD should be checked by cardiologist who has to estimate if the PM and ICD function is appropriate.
- Disturbances in PM and ICD function can be expected after 48 hours after surgery.

Patients with pulmonary hypertension for non-cardiac surgery

Introduction

Successful perioperative treatment of patients with pulmonary hypertension is composed of number of stages: recognition of the disease, determination of the cause, evaluation of severity of disease, risk assessment, anesthesia plan, treatment of perioperative complications.

Primary pulmonary hypertension

PPH is a rare, progressive and often fatal disease characterized by increased pulmonary vascular resistance of unknown cause.

Secondary pulmonary hypertension

It is caused by lung or heart disease, thromboembolism, CO_2 embolism during laparoscopy, air embolism in neurosurgery in the sitting position, cementing in orthopedic surgery, use of protamine, extracorporeal circulation, reperfusion syndrome, reduction of pulmonary vessels after pneumonectomy.

Symptoms and diagnosis of APH

The most common sign of disease is dispnoa and fatigue. Diagnosis is set up with cardiac auscultation, chest X-ray, electrocardiogram (ECG), doppler examination of the heart, cardiac catheterization and measurement of pressures in the heart and angiography.

Therapy

In secondary pulmonary hypertension the cause of the disease should be treated as first: bronchodilators in COPD, corticosteroids in interstitial lung disease, anticoagulants in pulmonary thromboembolism, reducing the mismatch between ventilation and perfusion, antibiotics for pneumonia, early correction of congenital heart disease, treatment of the left ventricle in left-sided heart failure.

Symptomatic treatment: administration of oxygen, the prevention of respiratory acidosis with hyperventilation, metabolic acidosis treatment, „recruitment" maneuvers, reduction of the ventilation perfusion mismatch, preventing the release of catecholamines due to stress with adequate sedation and analgesia, prevention of shivering...

In the case of right ventricular dysfunction and elevated pulmonary vascular resistance vasodilators should be administered, in right ventricular dysfunction and normal pulmonary vascular resistance inotropes should be given. Preload should be optimized and afterload of the right ventricle reduced by giving inhaled vasodilators. Drugs that are administered to reduce pulmonary vascular resistance are: magnesium, adenosine, ACE inhibitors, calcium channel blockers, milrinone/amrinone, PgI2, PGE2 (alprostadil), PDE-5 inhibitors, endothelin receptor blockers and inhaled NO. Increased perfusion pressure through the right coronary artery should be achieved with vasoconstrictors or inotropes and liquids.

Moderate reduction in right ventricular contractility is treated with dobutamine, in severe cases can be given also adrenaline. In shocked patient drug of selection is noradrenaline.

In the case of increased pulmonary vascular resistance and reduced contractility administeration of PDE-III inhibitors could be successful.

Hyperventilation and consequent increase in pH is also important, as we reduce pulmonary vascular resistance and improve oxygenation. In the operating room or intensive therapy unit we evaluated the effects of our ongoing treatment with duly monitoring.

Perioperative risk assessment

Perioperative complications occurred in 29% of such patients. The risk is higher in urgent, severe and prolonged operations. When assessing perioperative risk the type of surgery, patient's functional status, severity of pulmonary hypertension, right ventricular function and associated diseases should be taken into considerations.

Elective operations should be postponed till the patient is optimally prepared. In a patient with pulmonary heart and symptomatic heart failure elective procedures should not be performed. In such a patient the consultation with internist is essential.

In the pulmonary heart respiratory therapy, bed rest, oxygen therapy and treatment with diuretics is very important.

In the absence of left heart failure digitalis in is not recommended. Before surgery ECG, chest X-ray, arterial blood gas analysis and cardiac ultrasound should be performed. In a significant right ventricular dysfunction we should reconsider whether the operation is really necessary.

Before the operation pulmonary hypertension should be reduced as much as possible. The chronic therapy for pulmonary hypertension should not be interrupted in the perioperative period.

In major surgery the pulmonary arterial catheter should be inserted or transesophageal echocardiography should be used.

Anesthesia in patients with PAH

Etomidate is an ideal anaesthetic drug for the induction of general anesthesia.The choice of anesthetic drugs and anesthetic techniques for maintenance of anesthesia is relatively unimportant. The volatile anesthetic isoflurane and sevoflurane are recommended for patients with pulmonary hypertension, whereas they decrease the pulmonary vascular resistance. Most of the other anesthetics (except cetamine and NO2) have little effect on the pulmonary circulation.

During maintenance of anesthesia our main aim is to maintain adequate preload, systemic vascular resistance, cardiac contractility and cardiac output of the right heart. At the same time we need to prevent an increase in pulmonary vascular resistance due to hypoxia, hypercapnia, acidosis, agitation, pain and hypothermia.

Hypotension can be prevented through aggressive systemic vasoconstrictors (phenylephrine, vasopressin, noradrenaline).

The worst complication is intraoperative right ventricular failure. In this case the combination of dobutamine and milrinone is effective.

Systemic hypotension due to right ventricular failure is treated by inhaled vasodilators such as NO and inhaled iloprost.

PDE-5 inhibitors may be beneficial before surgery, because they prevent the deterioration of pulmonary hypertension and facilitate discontinuation of inhaled pulmonary vasodilators.

Conclusion

Anaesthesia in patients with pulmonary hypertension is based on the understanding of the pathophysiology of the disease and prevention of right ventricular failure with systemic hypotension.

Anesthesia for non-transplant surgery of the heart transplant recipients

Because of the increasing number of heart transplanted patients presenting for different elective and urgent nontransplant surgery it is becoming increasingly difficult to manage them exclusively by specialized teams. Presently, cardiac transplantation is performed in 3500 patients annually worldwide. The 1-year survival of the patients has increased to more than 80% and 10 years survival is around 50%. In Slovenia more than 20 patients with end stage heart failure are transplanted each year.

Although there is no ideal anesthesia, there are some general considerations related to heart transplant recipients we have to take into account:

- physiologic and pharmacologic problem of allograft denervation
- the side effects of immunosupresion therapy and the higher risk for infections
- the potential for rejecton if we reduce the immunosuppresion therapy

The transplanted heart is a denervated organ. During the harvesting, sympathetic postganglionic and parasympatetic preganglionic efferent nerves and both afferent nerves are transected. The basiline heart rate is increased to 90 – 100 beats /min., because of loss of vagal effect.

Sometimes there are 2 P waves on electrocardiogram - from native and donor atria.

Pain of myocardial ishemia is impaired. The transplanted heart does not respond on valsalva maneuver or to carotid sinus massage and there is no

tachycardia to inadequate anesthesia. The intrinsic heart mechanisem are preserved and the heart is preload dependent . The Frank-Starling mechanism is intact and contractile reserve is normal. Tachycardia in response to exercise and hemodynamic stress is blunted and it depends on circulating catecholamines. Exercise response includes increased cardiac output due to increased venous return and increase in heart rate due to increase in circulating catecholamines. α and β adrenergic receptors in the heart muscle are preserved. The drugs that act through the autonomic nervous system, like atropin and glycopyrrolate, have no or minimal effect on transplanted heart. Neostigmin can cause bradycardia by direct action on cholinergic receptors on cardiac ganglionic cells. The direct–acting myocardial drugs, like epinephrine, dobutamine, isoproterenol, norepinephrine, glucagon are effective. Therefore, the drugs with direct and indirect effects show only their direct effects on the transplanted heart. Digoxin can depress atrioventricular conduction in long term administration, but has inotropic effect. In several years after transplantation reinnervation is possible.

In the transplanted patients first degree AV block and right bundle branch are common. About 5 % of patients need a permanent pacemaker. First 6 months after transplantation the rhythm disturbances like atrial premature beats, atrial fibrillation or flutter and ectopic ventricular beats are prominent; later dysrythmias may represent a sign of rejection.

Most patients after heart transplant are on triple immunosuppresive drug regimen. The immunosupresion drugs are responsible for many side effects. Steroids are responsible for hyperglycemia, hyperlipidemia, osteoporosis. Calcineurin inhibitors (cyclosporine, tacrolimus) are nephrotoxic and responsible for hypertension in up to 70%.

Heart transplant recipients patients also have higher incidence of cholecistolithiasis, pancreatitis, peptic ulcus disease and high incidence of malignant disease.

Cardiac allograft vasculopaty is the main late cause of death. It is detectable in 20% of patients 5 years after transplantation. Possibility for silent myocardial ishemia or angina increases with time that has passed since heart transplant.

Infection is the common problem specialy in the early postoperative period. Strict aseptic technique is mandatory for all invasive procedures including intubation. The number of indwelling catheters must be kept to a minimum and removed as soon as possible.

The opportunistic infestions must be kept in mind and CMV negative blood must be used.

Checking for graft rejection is mandatory. The clinical picture includes fatigue, fever, atrial or ventricular dysrhytmias and warrants further evaluation including myocardial biopsy before elective surgery. Most rejection episodes requering treatment occur within the first year. During the surgery the balance between to much or too little of immunosupresion is difficult to acchive. The serum level of cyclosporin or tacrolimus should be monitored more offen, even daily if necesary. The transplant team must be available to discuss regarding immunosuppresion in the perioperative period.

Perioperative management

A transplant team should be contacted and consulted before any non-transplant surgery is performed.

Mandatory preoperative evaluation includs: recent electrocardiogram, chest radiograph, full, blood cell count, inflammatory markers, coagulation tests, electrolytes, blood urea nitrogen, liver function tests, CMV status, preoperative ECHO assesment.

Type of anesthetic and monitoring during surgery:

Heart transplant recipients have been managed with all types of anesthetic techniques. The anesthetic technique can be chosen according to the surgical needs.

There is some concern regard the regional spinal anesthesia, because the denervated heart is preload dependent and there is potentially exaggerated respons to hypovolemia.

Any anesthetic agent can be used, when hepatic and renal function are normal. Drugs with direct pressor and chronotropic effect, like dobutamin, isoproterenol and epinephrine must be always available for the treatment of bradycardia and hypotension. In case of tachyarytmia amiodarone or verapamil can be used. B-blockers should be avoided. If possible 12 leads ECG is required during operation and recovery. If large fluid shifts are expected another monitor is indicated: Swan-Ganz catheter, noninvasive measures of cardiac output, or transesophageal echo.

Postoperative care:

Postoperative care is similar to the care for non transplanted patients, but ECG and blood pressure monitoring are mandatory. Attention to preload, renal function, adequate immunosupression monitoring and infection prevention is important.

Recommended literature:

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