

Preoperative clinical problems and short hospital stay : the cardiovascular patient

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We are actually dealing with an evermore aging population with important associated comorbidities.

Preoperative evaluation of high-risk patients (particularly the cardiovascular patient) by the anesthesiologist is beneficial because he will be able to identify potential medical problems, and propose the adequate screening and treatment. This approach could minimize the number of last minute cancellations and postoperative complications, therefore decreasing total cost and hospital stay.

On the other hand, the increasing development in outpatient surgery (or at least morning admission) will also concern cardiovascular patients and we, as anesthesiologists, must evaluate if they are good candidates for day case surgery.

I. PREOPERATIVE EVALUATION

A. Evaluation of cardiac morbidity for noncardiac surgery

Cardiac complications including myocardial infarction (MI) and congestive heart failure (CHF) are the most important cause of perioperative death after noncardiac surgery (1).

1. Coronary artery disease is the key point of cardiovascular risk. Acute MI is observed in 3 to 5 % of patients at risk.

The exact pathophysiologic mechanism is not entirely clear. One of the mechanisms involves a coronary plaque rupture, which leads to platelet aggregation and thrombus formation in about half of perioperative MI. The other mechanism is consistent with a prolonged imbalance between myocardial oxygen supply and demand in the setting of coronary artery disease. Perioperative MI generally occurs 1 to 4 days after surgery, frequently under the form of an early-occurring non-Q-wave MI. Asymptomatic perioperative troponin elevation may identify patients who are at increased risk of mortality in the first 6-24 months postoperatively.

The preoperative evaluation is facing 2 problems : to provide the good preoperative care for patients with known coronary artery disease, and to detect potential coronary artery disease in asymptomatic patients.

Management of patients with coronary artery disease should focus on a thorough preoperative clinical evaluation including : review of the medical and surgical history, physical examination and an evaluation of the patient's functional capacity, before any complementary exams. Assessment of clinical risk variables and if necessary non-invasive testing should be included in the second step. Finally, a pharmacologic perioperative strategy should be considered in order to reduce the cardiac risk.

1. Medical history

To be remembered is the Canadian Cardiovascular Society classification of angina :

- I for vigorous exercise (sport)
- II for moderate exercise (household activities)
- III for minimal exercise (personal activities)
- IV at rest (and during sleep)

But with subclinical disease, restricted activity, autonomic neuropathy (diabetes mellitus, uremia) and in the transplanted heart, angina may be absent.

The clinical predictors of increased perioperative cardiovascular risk have to be checked and have been defined by the ACC/AHA Guideline Update for Perioperative Cardiovascular Evaluation for Noncardiac Surgery (2). They will be discussed in the risk stratification part.

2. Evaluation of the functional capacity

The functional capacity is expressed in metabolic equivalent (MET) levels. Multiples of

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Table 1
The Duke Activity Status Index

<p>1 MET</p> <p style="text-align: center;">↓</p> <p>4 METs</p>	<p>* Can you take care of yourself ? * Eat, dress, or use the toilet ?</p> <p>* Walk indoors around house ? * Walk a block or two on level ground at 3,2 to 4,8 km/h ? * Do light work around the house like dusting or washing dishes ?</p>	<p>4 METs</p> <p style="text-align: center;">↓</p> <p>Greater than 10 METs</p>	<p>* Climb a flight stairs or walk up a hill ? * Walk on level ground at 6,4 km/h ? * Run a short distance ? * Do heavy work around the house like scrubbing floors or liftin or moving heavy furniture? Participate in moderate recreational activities ? * Golf, bowling, dancing, doubles tennis, or throwing a baseball or football ? * Participate in strenuous sports like swimming, singles tennis, football, basketball, or skiing ?</p>
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the baseline MET value are used to express aerobic demands for specific activities.

The *Duke Activity Status Index* provides a questionnaire to determine patient's functional capacity (table 1) (3).

Previously reported data have demonstrated good cardiac outcomes for surgical and non-surgical patients who can manage > 5 METs (1 MET = VO₂ 3.5 ml/kg/min) (VO₂ = oxygen consumption). A poor functional capacity status has been defined as a patient unable to meet a 4 Mets demand and has been associated with perioperative and long-term cardiac risks after a wide range of surgeries (4). Simple questions are : are you able to climb a flight of stairs, walk up a hill or walk on level ground at 6-7 km/h, activities that require at least 4 METs.

The *stair climbing test* has also been used as a predictor of postoperative cardiopulmonary complications after high-risk surgery such as thoracotomies (5). Girish and Colleagues evaluated 83 patients, scheduled for high-risk surgeries (thoracotomy, sternotomy, and upper abdominal laparotomy) by the stair climbing test (6). The primary outcome was cardiopulmonary complications within 30 days after surgery. Pulmonary complications were nearly 3 times as common as cardiac complications (30 % vs. 11 %, respectively). The number of stairs climbed was the strongest predictor of complications but did not predict perioperative mortality. No patients who could climb 7 flights of stairs had any postoperative complication, whereas 8 of 9 patients, unable to climb even 1 flight, had a complication. 4 flights of stairs were defined as a good exercise capacity with a specificity of 77 % and a sensitivity of 71 %.

3. Risk stratification by clinical variables

The ACC/AHA guidelines for perioperative cardiovascular evaluation for noncardiac surgery

were first edited in 1996 and later updated in 2002. The full version of the update is available on the ACC website (<http://www.acc.org/clinical/topic/topic.htm>). These guidelines remain a reference in these settings even if some authors have also proposed simplifications and alternatives.

The guidelines recommend consideration of 3 major factors, in sequence :

- 1) *clinical predictors*, 2) *functional capacity*, 3) *surgery-specific risk*.

clinical predictors :

major

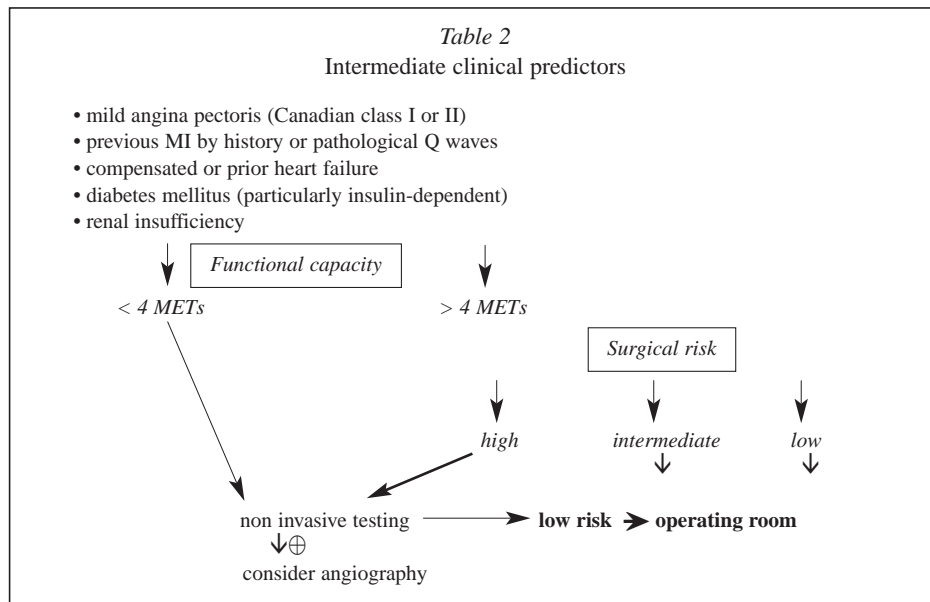
- unstable coronary syndromes :
 - acute MI (documented MI less than 7 days previously)
 - recent MI (more than 7 days but less than 1 month before surgery)
 - unstable or severe angina (Canadian class III or IV)
- decompensated heart failure
- significant arrhythmias :
 - high-grade atrioventricular block
 - symptomatic ventricular arrhythmias with underlying heart disease
 - supraventricular arrhythmias with uncontrolled ventricular rate
- severe valvular disease

intermediate

- mild angina pectoris (Canadian class I or II)
- previous MI by history or pathological Q waves
- compensated or prior heart failure
- diabetes mellitus (particularly insulin-dependent)
- renal insufficiency

minor

- advanced age
- abnormal ECG (left ventricular hypertrophy, left bundle-branch block, ST-T abnormalities)
- rhythm other than sinus



- low functional capacity
- history of stroke
- uncontrolled systemic hypertension

surgery-specific risk :

high (reported cardiac risk often greater than 5 %)

- emergent major operations, particularly in the elderly
- aortic and other major vascular surgery
- peripheral vascular surgery
- anticipated prolonged surgical procedures associated with large fluid shifts and/or blood loss

intermediate (reported cardiac risk generally less than 5%)

- carotid endarterectomy
- head and neck surgery
- intraperitoneal and intrathoracic surgery
- orthopedic surgery
- prostate surgery

low (reported cardiac risk generally less than 1%)

- endoscopic procedures
- superficial procedures
- cataract surgery
- breast surgery

A stepwise Bayesian strategy that relies on assessment of clinical markers, prior coronary evaluation and treatment, functional capacity, and surgery-specific risk is then proposed and leads to an algorithm for cardiac testing.

The stepwise strategy is summarized :

Step 1 : What is the urgency of noncardiac surgery?

Emergency surgery does not allow time for preoperative cardiac evaluation. Postoperative risk stratification and risk factor management may be appropriate for patients who have not been assessed.

Step 2 : Has the patient undergone coronary revascularisation in the past 5 years ?

If so and in the absence of recurrent symptoms and signs of ischemia, further testing is not necessary.

Step 3 : Has the coronary patient had a coronary evaluation in the past 2 years ?

If the results were normal, it is not necessary to repeat testing unless new symptoms of ischemia since the last cardiac evaluation.

Step 4 : Does the patient have a major clinical predictor of risk (unstable coronary syndrome, decompensated heart failure...)?

The surgery has to be cancelled until the problem has been identified and treated.

Steps 5, 6, 8 : Does the patient have intermediate clinical predictors of risk ?

See table 2.

Step 7 : Does the patient have minor or no clinical predictors of risk ?

Additional testing must be only considered on an individual basis for patients with a poor functional capacity who are scheduled for high-risk surgery.

Step 8 : The results of non-invasive testing can be used to determine the need for additional preoperative testing and treatment.

Table 3

<i>Clinical predictors</i>	<i>Functional capacity</i>	<i>Surgical risk</i>
Major 4 points	Poor 2 points	High 2 points
Intermediate 2 points	Moderate or better 0 point	Intermediate 1 point
Minor 0 point		Low 0 point

These guidelines also confirm that preoperative revascularization is rarely necessary solely to reduce risks associated with noncardiac surgery unless an independent indication exists to reduce long-term cardiovascular mortality.

Stinson has proposed an **abbreviation of the ACC/AHA algorithm** (7).

The same assignments are utilized : 1) *clinical predictors*, 2) *functional capacity*, 3) *surgery-specific risk*. A point score, easier to memorize, is proposed, see table 3.

The total score of the 3 columns is added. A point score of 4 or more would suggest the need for further cardiac evaluation. A patient with 3 points or less could safely proceed to surgery.

Lee and colleagues described another scheme of clinical risk assessment, **the revised cardiac risk index (RCRI)** (8). After identifying the following *six* variables in 2893 patients, they tested them in another clinical setting in 1422 patients :

- high-risk surgical procedure (intraperitoneal, intrathoracic, suprainguinal vascular reconstruction)
- history of ischemic heart disease (excluding previous revascularization)
- history of congestive heart failure
- history of stroke or transient ischemic attack
- preoperative insulin therapy
- preoperative serum creatinine levels > 2.0 mg/dl

The performances of prior risk-prediction indexes were compared by use of receiver-operat-

ing characteristic curve (ROC) analysis, the RCRI being superior to other risk-prediction indexes, see table 4.

4. Risk stratification by diagnostic testing

What are the places of 2 usual preoperative tests : 12-lead ECG and resting left ventricular (LV) function ?

The ACC/AHA guidelines have a clear position for both tests.

The *resting 12-lead ECG* does not identify increased perioperative risk in patients undergoing low-risk surgery. Recommendations are :

1) Class I (evidence and general agreement that therapy is useful and effective) : a recent episode of chest pain or ischemic equivalent in clinically intermediate or high-risk patients scheduled for an intermediate or high-risk surgery

2) Class IIa (opinion/evidence in favour of usefulness and efficacy) : asymptomatic persons with diabetes mellitus

3) Class IIb (usefulness/efficacy is less well established by evidence/opinion) : patients with prior coronary revascularization

4) Class IIb : asymptomatic male more than 45 years old or female more than 55 years old with 2 or more atherosclerotic risk factors (diabetes mellitus, hypercholesterolemia, hypertension, smoking, obesity, family history of coronary artery disease, peripheral vascular disease).

Table 4

Major cardiac event rates by the revised cardiac risk index

Class	Events/patients(n/n)	Event rate (95% CI) (%)
I (0 risk factor)	2/488	0.4 (0.05-1.5)
II (1 risk factor)	5/567	0.9 (0.3-2.1)
III (2 risk factors)	17/258	6.6 (3.9-10.3)
IV (≥ 3 risk factors)	12/109	11.0 (5.8-18.4)
ROC curve area 0.806*		
Versus original cardiac risk index (Goldmann <i>et al.</i> , 1977) (ROC curve area, 0.701) and American Society of Anesthesia classification (ROC curve area, 0.706)		

The *resting LV function* has not been found to be a consistent predictor of perioperative ischemic events. Recommendations are :

- 1) Class I : patients with current or poorly controlled heart failure (except if there is a recent evaluation)
- 2) Class IIa : patients with prior heart failure and patients with dyspnea of unknown origin.
- 3) Class III (evidence and general agreement that the procedure is not useful and effective) : as a routine test for LV function in patients without prior HF.

The ACC/AHA guidelines recommend that additional non-invasive testing must be considered for patients with intermediate clinical predictors of risk and either poor functional capacity, or a high level of surgery-specific risk. They also recommend additional testing on an individual basis for patients with minor or no clinical predictors and a poor functional capacity, scheduled for high-risk surgery.

The type of non-invasive cardiac stress test is often institutionally dependent: availability and operator's experience are important factors. The most commonly used tests are exercise ECG, myocardial perfusion imaging and stress echocardiography.

Exercise ECG is of little diagnostic value in patients with ECG abnormalities at rest (left bundle-branch block, pacemaker, preexcitation syndrome or ST-segment depression more than 1 mm at rest) or unable to exercise. Several drugs can also influence the results, including digoxin, β -blockers for example. In a previous meta-analysis, sensitivity of exercise ECG was 68% and specificity, 77%, but in patients without high risk of extensive coronary artery disease, the sensitivity was only 45% and in women, the test is even less sensitive than in men (9). A more accurate approach, improving test accuracy, would be, for example, the use of the Duke treadmill score calculated as : $\langle \text{duration of exercise in minutes} - 5 \times (\text{the maximal net ST-segment deviation during or after exercise in millimetres}) - 4 \times (\text{treadmill angina index}) \rangle$.

The angina index is assigned a value of 0 if angina is absent, 1 if typical angina occurs and 2 if angina is the reason the patient stopped exercising.

The Duke treadmill score: low risk (≥ 5 points), reflecting longer exercise times and little or no ST-segment deviation ; intermediate (-10 to +4 points) ; high (≤ -11 points).

Myocardial perfusion imaging : the use of single-photon-emission computed tomography

(SPECT) to reconstruct anatomical slices of discrete thickness has improved sensitivity to 88 % with a specificity of 77%. The diagnostic performance of technetium-based agents is similar to that of thallium, but false positive results are an important problem. Attenuation artefacts can produce apparent perfusion defects and experience of the reader is crucial. Stress perfusion studies (SPS) use dobutamine, adenosine, dipyridamole and the diagnostic is similar to that obtained with exercise scintigraphy. Concomitant use of β -blockers or antianginal medications may compromise sensitivity. The cost of SPECT is another important aspect.

Stress echo : can involve exercise or pharmacologic agents to provoke ischemia such as dobutamine. The sensitivity is 76 % in a previous meta-analysis. A recent meta-analysis of six non-invasive tests found a sensitivity of 85 % for predicting perioperative death and non-fatal MI (10). The specificity is 70 % to 88 %, from different studies. The overall accuracy of dobutamine stress echocardiography (DSE) and SPS were similar, DSE showed a positive trend towards better diagnostic performance and might be the best test in situations where there is valvular or left ventricular dysfunctions.

In a recent study, Labib *et al.* founded that in patients undergoing a preoperative DSE (n = 429), failure to achieve target heart rate was frequent (16 %) because many patients received β -blockers. Perioperative MI occurred more frequently in patients with positive tests (9,4 % vs. 1,8 %), but with similar frequency in the negative-maximal group (1,8 %) and negative submaximal groups (1,6 %). An important and surprising finding was that patients with resting wall motion abnormalities appeared to be at increased risk for perioperative events even without inducible ischemia (11).

In a provocative article, Grayburn and Colleagues reminded that the goal of risk stratification is to reduce risk (12). First, any test must be accurate, it should have a high positive and negative predictive value and result in a change in risk from the pretest likelihood. Second, risk stratification is most helpful when it influences outcome (cancellation of surgery, alternative or prophylactic treatment such as revascularization). Third, the harms-benefit tradeoff of risk stratification must be favourable. They found that myocardial perfusion imaging and DSE add little to the clinically defined risk index in most patients and that positive test results lead to further evaluation (coronary angiography) which is costly and may delay surgery unnecessarily. They also stated that a specific peri-

operative pharmacologic therapy (β -blockers) renders preoperative non-invasive testing unnecessary. Several comments have been made after this article, showing that it is premature to eliminate non-invasive testing in clinically high-risk patients (13).

Boersma and Colleagues, in a rational approach, have previously suggested that empirical β -blocker therapy in low-risk patients, scheduled for major vascular surgery, may obviate the need for preoperative non-invasive testing and that higher-risk patients with a negative result during pharmacologic stress test can proceed to surgery with perioperative β -blockers (14). In their study, patients with a RCRI less than 3 had a cardiac risk less than 2 %, as long they received perioperative β -blockers. DSE results were unhelpful and did not modify this low risk. An incidence of perioperative death and MI of 6,5 %, 10 %, and 16 % was found in patients with respective scores on a RCRI of 3, 4, and 5 who were treated with perioperative β -blockers but had signs of ischemia on preoperative DSE. Patients with at least 5 abnormal segments on DSE did not benefit from β -blockers and needed cardiac catheterization and revascularization. Finally, in a multivariate model of clinical and DSE variables, the following factors were independently associated with outcome: age (70 years or older), CHF, previous cerebrovascular accident, abnormal findings on DSE at rest and with stress, and perioperative β -blocker therapy.

Existing evidence supports a more restrictive use of preoperative non-invasive cardiac testing for patients at high risk (RCRI \geq 3) or with limited functional capacity. In addition, for high-risk patients scheduled for noncardiac surgery, coronary artery bypass grafting or percutaneous coronary revascularization are appropriate if they are indicated independently of the need for noncardiac surgery.

5. Pharmacologic perioperative strategy

Large randomized controlled trials (RCTs) have shown that the use of **β -blockers** reduces mortality in patients with coronary artery disease in the absence of surgery and in patients with hypertension and CHF. Their use for prevention of secondary cardiac outcomes after major noncardiac surgery is now evidence but a study by Nass *et al.* demonstrated that only 30 % of patients scheduled for vascular surgery with coronary artery disease risk factors were actually treated (15).

Postulated mechanisms by which β -blockers may exert beneficial effect are : 1) an improved

myocardial oxygen supply-demand relationship (decreased heart rate, contractility and left ventricular wall tension and increased diastolic filling time), 2) plaque stabilization via reduction of shear forces and possibly antiplatelet, antineutrophilic and antioxidant effects, 3) antiarrhythmic properties.

Stevens *et al.* reviewed all RCTs of drugs, including β -blockers, used for prevention of myocardial ischemia, MI and cardiac death in noncardiac surgery (16). They reported for all studies the risk reduction and numbers-needed-to-treat (NNT). β -blockers (most frequently, metoprolol) were tested in 11 trials with 866 patients. The risk of intraoperative ischemia (10 trials) decreased from 20,2 % to 7,6 % (NNT 8). For postoperative ischemia (5 trials), the risk decreased from 27,9 to 15,2 % (NNT 8). β -blockers reduced also the risk of MI from 5,2 to 0,9 % (NNT 23) but prestudy prevalence of MI ranged from 0 to 52 % and when 2 studies (with high MI prevalence of 32 and 52 %) were excluded, the effect of β -blockers was no longer significant. No effect on mortality could be demonstrated but in another meta-analysis, Auerbach and colleagues found in 5 trials a reduction of mortality in high-risk patients undergoing major noncardiac surgery (NNT 2,5 to 8,3) (17).

The most common adverse effect was bradycardia, which occurred in 24,5 % of patients receiving β -blockers.

Few patients have absolute contraindications to β -blockers (major conduction disease, severe asthma). Careful titration of β_1 -selective agents (metoprolol, atenolol, bisoprolol) is tolerated in many patients presenting reactive airway disease, diabetes mellitus or peripheral vascular disease. Patients with compensated CHF may tolerate β -blockers, if they are introduced gradually before surgery.

Whereas perioperative cardioprotection is effective with β -blockers, some questions must be addressed.

1) Which patients need β -blockers in noncardiac surgery ? Outcome is most likely to improve in higher-risk patients undergoing major surgical procedures, but for some patients myocardial revascularization should be considered first.

2) Are there differences between agents ? β_1 -selective agents are preferred. Secondary prevention studies have not documented differences in outcomes between different β -blockers except for an adverse association in agents with intrinsic sympathomimetic activity (18).

3) Over what time period should it be given

and what is the optimal dose? Preoperative oral therapy could allow assessment of tolerance to therapy and could take advantage of cellular-level effects but there are no data showing that acute β -blocker therapy is less effective or less safe. A recent study, on cost-effectiveness of 5 different perioperative β -blockade strategies in vascular surgery, based on decision analytic model, has been conducted (19). Perioperative death and MI were associated with a net increase of cost. All of the strategies involving acute perioperative β -blockade were associated with a net cost savings and increase in efficacy, although less than the strategy involving preoperative oral titration (bisoprolol for 7 days).

Resting heart rate is an imprecise marker of β -blockers efficacy, which is most accurately assessed by response to exercise or direct adrenergic challenge. Intraoperatively, some patients may need additional intravenous (IV) administrations. In low-to moderate-risk patients, β -blockers must be continued for the first week postoperatively, but for patients undergoing vascular surgery, therapy will have to be continued at least for 14 to 30 days postoperatively.

A dose of 5 to 10 mg bisoprolol (1 or 2x daily) or 25 to 50 mg oral atenolol can be administered, but caution is necessary for atenolol in patients with renal insufficiency. If necessary, a perioperative IV dose of esmolol can be administered.

Concerning β -blockers, the most important message is to avoid the withdrawal of therapy in patients chronically treated and to promote the use of β -blockers perioperatively in order to reduce in-hospital mortality (20).

In the same meta-analysis that for β -blockers, Stevens *et al.* studied the role of α_2 -agonists (clonidine and mivazerol) in 6 trials of 2614 patients. α_2 -agonists decreased the risk of intraoperative ischemia from 32,8 % to 19,4 % (NNT 7). Their effects on postoperative ischemia and MI were not significant, but α_2 -agonists significantly decreased the risk of cardiac death from 2,3 to 1,1 % (NNT 83).

Calcium channel blockers (CCB) are not widely used in the perioperative setting. In the meta-analysis of Stevens *et al.*, only 3 trials were considered with 121 patients, with no evidence of any benefit. In another meta-analysis by Wijeyundera and Beattie, 11 studies including 1007 patients were considered (21). CCB reduced by half perioperative ischemia (relative risk (RR) 0,49 ; confidence intervals (CI) 0.30-0,80) and the incidence of supraventricular arrhythmia (RR

0,52 ; CI 0,37-0,72). The effects of CCB on heart failure, MI or mortality were not significant. Larger outcomes RCT might be undertaken because previous large RCT have demonstrated that patients chronically treated with CCB do not have any improvement of cardiovascular outcomes and may experience adverse events.

The role of inhibitors of 3-hydroxy-3-methylglutaryl coenzyme A (**statins**) has been highlighted recently in 2 studies. Poldermans *et al.* examined, in a retrospective study (2816 patients), the association between statin therapy and perioperative mortality in patients undergoing major vascular surgery (22). 5,8 % patients died during surgery or during the first 30 postoperative days. The risk of perioperative mortality among statins users was reduced 4,5 times compared to nonusers. β -blocker therapy was also significantly less common in patients who died (19 %) than in controls (36 %) and the risk of perioperative mortality among β -blocker users was reduced 2,3 times compared to nonusers. The effect of statins on perioperative mortality was similar in β -blocker or aspirin users and nonusers. Lindenauer *et al.* examined the association between treatment with lipid-lowering medications and in-hospital mortality following major noncardiac surgery in a retrospective study of 780,591 patients (23). Lipid-lowering therapy was defined as drug use during the first 2 hospital days. 9,9 % patients received lipid-lowering medications perioperatively and this was associated with a reduction of mortality (2,13 vs. 3,05 %). The NNT to prevent a postoperative death was 85 and varied from 186 among patients at lowest risk to 30 among those with a RCRI of 4 or more. RCTs are required to confirm both studies suggesting that preoperative statins are associated with a reduction in perioperative mortality and that their continuation is indicated perioperatively.

Antiplatelet agents are used in the prevention of major adverse cardiovascular events for patients with coronary artery disease including MI, percutaneous coronary intervention, and acute coronary syndrome. A growing number of patients on antiplatelet therapy are undergoing surgical procedures, the potential risks and benefits must be evaluated.

Perioperative risk of **aspirin** use is an increase of bleeding events and as reported in general surgical, gynaecologic and urologic operations but without an increase in transfusion requirements. No clinically relevant bleeding has been reported for cardiovascular, vascular and orthopedic surgery and epidural anesthesia. The postoperative efficacy

of aspirin has been explored in RCTs and the American College of Chest Physicians recommends aspirin in patients having peripheral vascular grafts, carotid endarterectomy. Efficacy in improving surgical outcomes and in preventing adverse cardiovascular events has been demonstrated (24) and therefore aspirin in low doses must generally not be stopped. In specific types of surgery, e.g. neurosurgery, in which even a minor bleeding leads to severe complications, aspirin should be stopped at least 5 days preoperatively.

A recent coronary stenting is another issue. Kaluza *et al.* reported that patients, whose stent was placed before the noncardiac surgery, had a high risk for both bleeding complications and cardiac complications (25). Another retrospective study by Wilson *et al.* confirms an increased risk of postoperative cardiac complications and death, but the absolute risks for cardiac complications (3,9 %) and bleeding due to aspirin or thienopyridines were lower than previously estimated. The authors suggested that noncardiac surgery should be delayed six weeks after stent placement, by which time stents are generally endothelialized, and a course of antiplatelet therapy to prevent stent thrombosis has been completed (26).

2. Cardiac heart failure

In patients with previous CHF, physical examination, evaluation of functional capacity and current treatment must be noted. The evaluation of the resting LV function is a class I indication for patients with current or poorly controlled heart failure, and a class IIa indication for patients with prior heart failure and patients with dyspnea of unknown origin.

All preoperative medications must generally be taken as usual by the patient.

A study on a subgroup of the Cardiac Insufficiency Bisoprolol Study II (CIBIS II) has analyzed 165 patients undergoing surgery with moderate to severe heart failure and with a LVEjection fraction ≤ 35 %. Mortality was not different between placebo- and bisoprolol-treated groups. Compared to coronary artery disease, perioperative β -blocker therapy had little effect on perioperative complications in patients with CHF undergoing surgery (27).

Angiotensin-converting enzyme inhibitors (ACEIs) and angiotensin II receptor antagonists can cause a severe hypotension, at the induction of anesthesia, in hypovolemic patients specifically in those receiving diuretics. Both medications inhibit

angiotensin II, a potent vasoconstrictor, that can counterbalance such an hypotensive effect. In hypertensive patients, incidence of hypotension is frequent. In patients with CHF, ACEIs administration until the day of surgery does not seem to result in a higher incidence of perioperative hypotension (28).

B. The hypertensive patient

Numerous recordings of blood pressure in a nonstressful environment are necessary before concluding to an untreated hypertension.

In the ACC/AHA guidelines, uncontrolled hypertension is only a minor clinical predictor and a moderate or well-controlled hypertension is definitively not a clinical risk factor.

Howell *et al.* have performed a meta-analysis of 30 observational studies and demonstrated a statistically significant relationship between hypertension and perioperative cardiac outcomes (29). The association was of little evidence when the arterial pressure was less than 180 mmHg systolic or 110 mmHg diastolic. Patients with higher pressures than 180 mmHg systolic or 110 mmHg diastolic were more prone to perioperative ischemia, arrhythmias and cardiovascular lability but there was no clear evidence that deferring surgery reduced perioperative risk. β -blockers and α_2 -agonists are the best choices in this situation.

A recent onset of severe hypertension may lead to a delay of elective surgery in case of suspected renal artery stenosis, pheochromocytoma, hyperaldosteronism.

All medications must be given to the patient until morning of surgery with a careful use of long acting ACEIs, because of the risk of hypotension and also because no rebound is seen after withdrawal.

C. The valvular patient

For the ACC/AHA guidelines, severe valvular disease is a major clinical risk predictor.

Symptomatic regurgitant valve disease is usually better tolerated and may be stabilized preoperatively with intensive medical therapy, except for reduced LV function, when the hemodynamic reserve is limited.

Severe aortic stenosis poses the greatest risk for noncardiac surgery, if severe and symptomatic, elective noncardiac surgery must be postponed until after valve replacement.

Preoperative surgical correction of mitral valve disease is not indicated before noncardiac surgery, unless the valvular condition should be corrected to prolong survival and prevent complications, unrelated to the proposed noncardiac surgery.

Endocarditis prophylaxis should also be considered and for patients with oral anticoagulation, a careful management must be anticipated (30). For minimally invasive procedures, the recommendation is to briefly reduce the international normalized ratio to the low or subtherapeutic range and restore the normal dose of oral anticoagulation immediately after the procedure. Perioperative heparin therapy is recommended for patients in whom the risk of bleeding with oral anticoagulation is high and the risk of thromboembolism without anticoagulation is also high (i.e., mechanical valve in the mitral position, recent thrombosis or embolus, or three or more of the following factors: atrial fibrillation, previous embolus at any time, mechanical prosthesis, and LV ejection fraction less than 30 %).

D. Carotid artery lesion

Having surgery increases the risk of stroke. After identifying more than 1450 patients with ischemic stroke and a matched control of patients, stroke patients have been found to have a higher incidence of surgical procedures within one month of their stroke (31).

Two large RCTs have been conducted and published in 1998: the European Carotid Surgery Trial (ECST) and the North American Symptomatic Carotid Endarterectomy Trial (NASCET). They proved that in *symptomatic* patients with over 70 % carotid stenosis, identified by angiograms, benefit from carotid endarterectomy was unequivocal, despite a 6 % perioperative risk of stroke or death. Only six patients needed to be treated to prevent one stroke in 2 years. For symptomatic patients in NASCET with 50 to 69 % carotid endarterectomy stenosis, the number needed to be treated to prevent stroke was 15 but in ECST, the 8 % perioperative risk nullified the net benefit.

A large RCT has also been published recently in *asymptomatic* patients, the Asymptomatic Carotid Surgery trial (ACST) (32). The results are that in asymptomatic patients younger than 75 years of age with a 70 % or more carotid stenosis on ultrasound, even in patients on aspirin, antihypertensive and statin therapy, endarterectomy

halved the net-5 year stroke risk from about 12 % to 6 % (including the 3 % perioperative hazard).

Halm *et al.* has reviewed the medical records of 2124 patients, who underwent carotid endarterectomy, from 6 hospitals (33). Two thirds of patients had asymptomatic carotid stenosis. The risk of death, stroke, and MI was directly related to degree of comorbidity, and patients with high comorbidity had more than twice the odds of death or stroke. The effect of comorbidity on the risk of adverse outcomes was most consistent among asymptomatic patients. High comorbidity and its associated greater risk of perioperative complications is therefore a critical mitigating factor that would cause the risks of carotid endarterectomy to outweigh its benefits for asymptomatic patients.

When a carotid stenosis is detected, medical comorbidities, life expectancy, operative risk and also the type of surgery must be taken into account before any decision.

E. Arrhythmias

Most patients with a history of cardiac arrhythmia or treated for arrhythmias can undergo almost any surgical procedure without contra-indication.

It has been demonstrated that asymptomatic ventricular arrhythmias, including nonsustained ventricular tachycardia, were not associated with an increase in cardiac complications after noncardiac surgery or an increased risk of nonfatal MI or cardiac death (34). However, presence of an arrhythmia, in the preoperative setting, should provoke a search for underlying cardiopulmonary disease, ongoing myocardial ischemia or MI, drug toxicity, or metabolic disturbances.

Patients with intra-ventricular conduction delays but no history of advanced block (third-degree and type II second-degree atrioventricular blocks) are not at increased risk for developing a complete atrioventricular block in the perioperative period.

For patients with implantable pacemakers, type of device, initial indication, pacemaker dependency, battery status and magnet's response should be checked. If devices are under regular follow-up with good residual battery capacity when last checked, a routine preoperative check may be unnecessary (35). Implanted cardioverter defibrillators should be programmed *off* immediately before surgery, if electrocautery is planned, then

programmed *on* postoperatively to prevent unwanted discharge.

II. RELATION BETWEEN POSTOPERATIVE CARDIAC AND NONCARDIAC COMPLICATIONS

Some studies have shown that pulmonary and cardiac complications after elective abdominal surgery and hip fracture repair are equally important in terms of mortality and length of stay.

Patients with multiple complications had also the poorest outcomes (36, 37).

A recent retrospective study (3970 patients) has established the link between cardiac and noncardiac complications in patients undergoing elective major noncardiac surgery (orthopedic, intrathoracic, vascular and abdominal procedures). Patients, who experienced a cardiac complication, were at increased risk of developing another complication as well as prolonged perioperative length of stay (38). The author found that patient, with a first postoperative complication that was cardiac (MI, pulmonary edema, or serious arrhythmia), had a sixfold greater odds of a subsequent noncardiac complication. Patients, whose first complication was noncardiac, had five times the risk of a subsequent cardiac complication.

These findings have several implications: first, they confirm that patients with combined cardiac and noncardiac complications fare least well and have longer hospital stays; second, they raise the possibility that complications can be linked.

This fact emphasizes the need for cardiac risk stratification and more prevention of postoperative complications but also the need of a preventive global strategy of care.

This strategy must therefore involve a preoperative plan regarding diabetes mellitus, chronic obstructive pulmonary disease (COPD), which are frequent in cardiovascular patients. For example, postponement of elective surgery should be recommended for patients who have clinical findings consistent with a COPD exacerbation.

III. AMBULATORY SURGERY

Is the cardiovascular patient a good candidate for ambulatory surgery ?

A survey among Canadian anesthesiologists showed that medical conditions with extreme grades of severity (such as Canadian class III and

IV of angina or CHF) are associated with majority opinion that ambulatory anesthesia is unsuitable (39). The majority of the anesthesiologists were willing to propose ambulatory surgery to patients with low-grade or remote symptoms (i.e., angina class II, CHF class I, MI occurring more than six months before surgery and asymptomatic valvular disease).

A study, about contributing factors to a prolonged stay after ambulatory surgery on 17,638 patients, has found that of 13 preexisting medical conditions (hypertension, angina, MI, dysrhythmia, valvular heart disease, CHF, smoking, asthma, chronic obstructive pulmonary disease, gastroesophageal reflux, diabetes mellitus, obesity, history of cerebrovascular attack), only CHF showed an association with length of stay (11 % longer than patients without CHF). Patients with CHF had a higher than average incidence of intraoperative (11 %) and postoperative cardiovascular events (2,1 %) (40).

That outpatient surgery is no longer restricted to young, healthy patients, seems now to be evident. Higher risk patients (including cardiovascular patients) may be considered acceptable candidates for ambulatory surgery if their systemic diseases are well controlled and their medical condition is optimized preoperatively.

IV. CONCLUSION

To decrease hospital stay in the cardiovascular patient, the preoperative clinical evaluation is an important key point. The Anesthesiologist must perform careful review of patient's medical history, physical examination and assessment of functional activity with a subsequent risk stratification also including clinical predictors and surgery-specific risk.

The use of preoperative non-invasive testing must be restricted to high-risk patients or with a limited functional capacity.

β -blockers have been proved to bring a perioperative cardioprotection and more importantly, their withdrawal has to be avoided. All medications, including statins, aspirin and antihypertensive drugs, must be given until the day of surgery, except in a few cases.

For ambulatory surgery, the cardiovascular patient is an acceptable candidate, if he is appropriately selected (with stable systemic diseases), screened and prepared.

References

1. Mangano D. T., Browner W. S., Hollenberg M., *et al.*, Association of perioperative myocardial ischemia with cardiac morbidity and mortality in men undergoing noncardiac surgery: The Study of Perioperative Ischemia Research Group, *N. ENGL. J. MED.*, **323**, 1781-1788, 1990.
2. Eagle K. A., Berger P. B., Calkins H., *et al.*, ACC/AHA guideline update for perioperative cardiovascular evaluation for noncardiac surgery-executive summary. A Report of the American College of Cardiology/American Heart Association Task Force on Practice Guidelines (Committee to update the 1996 Guidelines on Perioperative Cardiovascular Evaluation for Noncardiac Surgery), *ANESTH. ANALG.*, **94**, 1052-1064, 2002.
3. Hlatky M. A., Boineau R. E., Higginbotham M. B., *et al.*, A brief self-administered questionnaire to determine functional capacity (the Duke Activity Status Index), *AM. J. CARDIOL.*, **64**, 651-654, 1989.
4. Reilly D. F., McNeely M. J., Doerner D., *et al.*, Self-reported exercise tolerance and the risk of serious perioperative complications, *ARCH. INTERN. MED.*, **159**, 2185-2192, 1999.
5. Brunelli A., Monteverde M., Al Refai M., *et al.*, Stair climbing test as a predictor of cardiopulmonary complications after pulmonary lobectomy in the elderly, *ANN. THORAC. SURG.*, **77**, 266-270, 2004.
6. Girish M., Trayner E., Damman O., *et al.*, Symptom-limited stair climbing as a predictor of postoperative cardiopulmonary complications after high-risk surgery, *CHEST*, **120**, 1147-1151, 2001.
7. Stinson D. K., An abbreviation of the ACC/AHA Algorithm for Perioperative Cardiovascular Evaluation for Noncardiac Surgery, *ANESTH. ANALG.*, **97**, 295-296, 2003.
8. Lee H. L., Marcantonio E. R., Mangione C. M., *Derivation and Prospective Validation of a Simple Index for Prediction of Cardiac Risk of Major Noncardiac Surgery*, *CIRCULATION*, **100**, 1043-1049, 1999.
9. Lee H., Boucher C. A., *Noninvasive Tests in Patients with Stable Coronary Artery Disease*, *N. ENGL. J. MED.*, **344**, 1840-1845, 2001.
10. Kertai M. D., Boersma E., Bax J. J., *A meta-analysis comparing the prognostic accuracy of six diagnostic tests for predicting perioperative cardiac risk in patients undergoing major vascular surgery*, *HEART*, **89** (11), 1327-1334, 2003.
11. Labib S. B., Goldstein M., Kinnunen P. M., *et al.*, Cardiac events in patients with negative maximal versus negative submaximal dobutamine echocardiograms undergoing noncardiac surgery: importance of resting wall motion abnormalities, *J. AM. COLL. CARDIOL.*, **44** (1), 82-87, 2004.
12. Grayburn P. A., Hillis L. D., *Cardiac events in patients undergoing noncardiac surgery: shifting the paradigm from non-invasive risk stratification to therapy*, *ANN. INTERN. MED.*, **138**, 506-511, 2003.
13. Frost S. D., Michota F. A., *Risk Stratification for Noncardiac Surgery*, *ANN. INTERN. MED.*, **140**, Issue 1,W-1, 2004.
14. Boersma E., Poldermans D., Bax J. J., *et al.*, Predictors of cardiac events after major vascular surgery: role of clinical characteristics, dobutamine echocardiography, and β -blocker therapy, *JAMA*, **285**, 1865-1873, 2001.
15. Nass C. M., Allen J. k., Jermyn R. M., *et al.*, Secondary prevention of coronary artery disease in patients undergoing elective surgery for peripheral arterial disease, *VASC. MED.*, **6**, 35-41, 2001.
16. Stevens R. D., Burri H., Tramer M. R., *Pharmacologic myocardial protection in patients undergoing noncardiac surgery: a quantitative systematic review*, *ANESTH. ANALG.*, **97**, 623-633, 2003.
17. Auerbach A. D., Goldman L., *β -blockers and reduction of cardiac events in noncardiac surgery: Scientific review*, *JAMA*, **287**, 1435-1444, 2002.
18. London M. J., Zaugg M., Schaub M. C., *et al.*, Perioperative β -Adrenergic Receptor Blockade, *Physiologic Foundations and Clinical Controversies*, *ANESTHESIOLOGY*, **100**, 170-175, 2004.
19. Fleisher L. A., Corbett W., Berry C., *et al.*, Cost-effectiveness of different perioperative β -blockade strategies in vascular surgery patients, *J. CARDIOTH. VASCULAR ANAESTHESIA*, **18**, 7-13, 2004.
20. Lindenauer P. K., Fitzgerald J., Hoople V., *et al.*, The potential preventability of postoperative myocardial infarction: underuse of perioperative beta-adrenergic blockade, *ARCH. INTERN. MED.*, **174** (7), 762-766, 2004.
21. Wijjensundera D. N., Beattie W. S., *Calcium channel blockers for reducing cardiac morbidity after noncardiac surgery: a meta-analysis*, *ANESTH. ANALG.*, **97**, 634-641, 2003.
22. Poldermans D., Bax J. J., Kertai M. D., *et al.*, Statins are associated with a reduced incidence of perioperative mortality in patients undergoing major noncardiac vascular surgery, *CIRCULATION*, **107**, 1848-1851, 2003.
23. Lindenauer P. K., Pekow P., Wang K., *Lipid-lowering therapy and in-hospital mortality following major noncardiac surgery*, *JAMA*, **291**, 2092-2099, 2004.
24. Merritt J. C., Bhatt D. L., *The efficacy and safety of perioperative antiplatelet therapy*, *J. THROMB. THROMBOLYSIS*, **17**, 21-27, 2004.
25. Kaluza G. L., Joseph J., Lee J. R., *et al.*, Catastrophic outcomes of noncardiac surgery soon after coronary stenting, *J. AM. COLL. CARDIOL.*, **35**, 1288-1294, 2000.
26. Wilson S. H., Fasseas P., Orford J. L., *et al.*, Clinical outcome of patients undergoing non-cardiac surgery in the two months following coronary stenting, *J. AM. COLL. CARDIOL.*, **42**, 234-240, 2003.
27. Bohm M., Maack C., Wehrlein-Grandjean M., *Effect of bisoprolol on perioperative complications in chronic heart failure after surgery (Cardiac Insufficiency Bisoprolol Study II)*, *Z. KARDIOL.*, **92**, 668-676, 2003.
28. Colson P., Ryckwaert F., Coriat P., *Renin angiotensin system antagonists and anesthesia*, *ANESTH. ANALG.*, **89**, 1143-1155, 1999.
29. Howell S. J., Sear J. W., Foex P., *Hypertension, hypertensive heart disease and perioperative cardiac risk*, *BR. J. ANAESTH.*, **92**, 570-83, 2004.
30. *Proceedings of the American College of Chest Physicians 5th Consensus on Antithrombotic Therapy*, *CHEST*, **114**, 439S-769S, 1998.
31. Wong G. Y., Warner D. O., Schroeder D. R., *et al.*, Risk of surgery and anesthesia for ischemic stroke, *ANESTHESIOLOGY*, **92**, 425-432, 2000.
32. MCR Asymptomatic Carotid Surgery Trial (ACST) Collaborative Group, *Prevention of disabling and fatal strokes by successful carotid endarterectomy in patients without recent neurological symptoms: randomised controlled trial*, *LANCET*, **363**, 1491-1502, 2004.
33. Halm E. A., Chassin M. R., Turhim S., *Revisiting the appropriateness of carotid endarterectomy*, *STROKE*, **34**, 1464-1476, 2003.
34. Mahla E., Rotman B., Rehak P., *et al.*, Perioperative ventricular dysrhythmias in patients with structural heart disease undergoing noncardiac surgery, *ANESTH. ANALG.*, **86**, 16-21, 1998.
35. Senthuran S., Toff W. D., Vuylsteke A., *Implanted cardiac pacemakers and defibrillators in anaesthetic practice*, *BR. J. ANAESTH.*, **88**, 627-31, 2002.
36. Lawrence V. A., Hilsenbeck S. G., Mulrow C. D., *et al.*, Incidence and hospital stay for cardiac and pulmonary complications after abdominal surgery, *J. GEN. INTERN. MED.*, **10**, 671-678, 1995.
37. Lawrence V. A., Hilsenbeck S. G., Noveck H., *Medical*

- complications and outcomes after hip fracture repair*, ARCH. INTERN. MED., **162**, 2053-2057, 2002.
38. Lawrence V. A., *The relation between postoperative cardiac and noncardiac complications : pathophysiological dominoes or doubles tennis ?*, AM. J. MEDICINE, **115**, 580-581, 2003.
39. Friedman Z., Chung F., Wong D. T., *Ambulatory surgery adult patient selection criteria: a survey of Canadian Anesthesiologists*, CAN. J. ANESTH., **51**, 437-443, 2004.
40. Chung F., Mezei G., Tong D., *Pre-existing medical conditions as predictors of adverse events in day-case surgery*, Br. J. ANAESTH., **83**, 262-270, 1999.