CONTINUING MEDICAL EDUCATION

Preoperative Risk Assessment—From Routine Tests to Individualized Investigation

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SUMMARY

Background: Risk assessment in adults who are about to undergo elective surgery (other than cardiac and thoracic procedures) involves history-taking, physical examination, and ancillary studies performed for individual indications. Further testing beyond the history and physical examination is often of low predictive value for perioperative complications.

Methods: This review is based on pertinent articles that were retrieved by a selective search in the Medline and Cochrane Library databases and on the consensus-derived recommendations of the German specialty societies.

Results: The history and physical examination remain the central components of preoperative risk assessment. Advanced age is not, in itself, a reason for ancillary testing. Laboratory testing should be performed only if relevant organ disease is known or suspected, or to assess the potential side effects of pharmacotherapy. Electrocardiography as a screening test seems to add little relevant information, even in patients with stable heart disease. A chest X-ray should be obtained only if a disease is suspected whose detection would have clinical consequences in the perioperative period.

Conclusion: In preoperative risk assessment, the history and physical examination are the strongest predictors of perioperative complications. Ancillary tests are indicated on an individual basis if the history and physical examination reveal that significant disease may be present.

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Patients undergo preoperative assessment before elective surgery (under general and/or regional anesthesia) so that any patient-specific risks can be detected and minimized. Any additional test that might be performed, aside from clinical history-taking and physical examination, yields a potential gain in information that must be weighed against its cost and the fact that the information obtained may be irrelevant. Over the past decade, there has been a trend toward reducing the amount of routine preoperative testing (1, 2, e1), both because screening tests have been found to have a low predictive value for perioperative complications (2–10, e1, e2) and because the findings may be ignored preoperatively, despite their potential importance and the physician's obligation to know and act upon them (11).

Growing attention to the financial side of medicine has markedly increased the pressure for economic productivity in surgery, as in other medical fields (12). The resulting shift toward outpatient preoperative evaluations has lessened the opportunity for extensive risk assessment, because the available time is shorter and often not optimally exploited.

In 2010, as a result of these developments, the German Societies of Anaesthesiology and Intensive Care Medicine (*Deutsche Gesellschaft für Anästhesiologie und Intensivmedizin*, DGAI), Internal Medicine (*Deutsche Gesellschaft für Innere Medizin*, DGIM), and Surgery (*Deutsche Gesellschaft für Chirurgie*, DGCH) published joint recommendations on the preoperative evaluation of adult patients for elective, non-cardiac surgery (13), based on the existing scientific data and expert opinion. These recommendations do not meet the formal criteria for guidelines; the underlying consensus-finding process corresponds to that of a level S2k guideline (e3).

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Preoperative risk assessment

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TABLE 1

Search strategy and inclusion/exclusion criteria for the literature search

Group A search terms	Group B search terms	Group C search terms
<ul style="list-style-type: none"> – preoperative – preoperative evaluation – preoperative risk – preoperative assessment – non-cardiac surgery 	<ul style="list-style-type: none"> – anamnesis – electrocardiography – laboratory testing – chest X-ray – echocardiography – lung spirometry – ultrasound 	<ul style="list-style-type: none"> – perioperative risk – mortality – outcome

Included: reviews; prospective, randomized controlled trials from single or multiple centers; retrospective analyses; cohort studies.

Excluded: case reports, case studies, abstracts, comments, conference decisions, letters to the editor, editorials.

Studies identified: 741, of which 23 were included.

Aside from these recommendations, a number of nationwide recommendations exist concerning individual aspects of preoperative risk assessment (e4–e7). The European Society of Anaesthesiology (ESA) has issued a European guideline for preoperative assessment (e8), which, however, takes a fundamentally different approach from that of the German recommendations. It includes evidence-based recommendations for the management of specific diseases and conditions (including diabetes mellitus, coagulopathies, anemia, obesity, alcoholism, allergies, and old age), but no recommendations about preoperative testing. For such matters, the ESA refers to the guideline material issued in the United Kingdom by the National Institute of Health and Clinical Excellence (NICE) (e1, e5). When the German recommendations were published, they were the only ones that had been developed anywhere with the joint participation of the relevant medical and operative specialty societies.

In this review, we present not only the contents of the joint recommendations in their current version, but also the further scientific evidence about preoperative risk assessment that has emerged since they were published. As this new evidence calls forth important questions in some areas of preoperative risk assessment, an update of the joint recommendations is now planned.

The prevailing practice of preoperative risk assessment was the subject of a nationwide survey of

German anesthesiology departments in 2011 (14). Another such survey was carried out in early 2013 to assess the acceptance and implementation of the current German recommendations in routine clinical practice (e9).

Learning objectives

Readers of this CME article should be able to identify the key components of preoperative risk evaluation and know what diagnostic tests are indicated on an individual, patient-specific basis. This article also provides an overview and an evaluation of the current modes of preoperative risk assessment, based on selected articles from the literature.

Methods

The recent studies presented here were retrieved by a selective search in the Medline and Cochrane Library databases for the period January 2009 to September 2013. We searched for publications that dealt with the utility of various testing methods for surgical risk assessment. Preference was given to studies with risk-adjusted patient populations. The key words and inclusion/exclusion criteria for the literature search are given in *Table 1*. The search employed combinations of terms from groups A, B, and C.

The timing of preoperative risk assessment

To lessen surgical risk effectively without the need for excessive revision of existing operating schedules, risk assessment should be carried out a sufficiently long time before surgery, but no more than six weeks beforehand. The best time for risk assessment is, generally speaking, the moment when the operation is judged to be indicated. Nevertheless, six months after publication of the joint recommendations, it was found that the “premedication” discussion was held at the time of indication in only 12.1% of cases (14). This discussion was most commonly held the day before surgery, in 63.4% of cases (14).

History and physical examination

To detect all previously unknown or inadequately treated medical conditions that might affect the perioperative risk, a precise history should be obtained directly from the patient, with particular attention to any history of a bleeding disorder; a physical examination should also be performed (1, 15–17). Historytaking and physical examination should both be carried out

European guidelines

The European guidelines include evidence-based recommendations for the management of specific diseases and conditions, but no recommendations about preoperative testing.

The timing of preoperative risk assessment

Risk assessment should be carried out a sufficiently long time before surgery, but no more than six weeks beforehand.

TABLE 2

History and physical examination

History	
General information	age, height, weight
Current medications	e.g., anticoagulants, anti-angina drugs, analgesics
Past surgical and anesthetic history and any associated problems or complications	e.g., bleeding tendency, protracted awakening from anesthesia, allergic reactions, transfusion reactions
Cardiopulmonary reserve	e.g., physiologic reserve, MET (<i>Table 5</i>), exercise
Allergies and intolerances	e.g., local anesthetics, non-steroidal anti-inflammatory drugs, antibiotics
Organic disease / potential evidence of organic disease	
Heart/circulatory system	e.g., arterial hypertension, arrhythmia, congenital heart defect, angina pectoris, coronary heart disease, dyspnea
Lungs/respiratory system	e.g., chronic obstructive pulmonary disease (COPD), asthma, pneumonia
Vascular system	e.g., varicose veins, arterial occlusive disease, thrombosis, embolism
Liver and biliary pathways	e.g., hepatitis, jaundice, cirrhosis, gallstones
Kidneys	e.g., renal failure, dialysis, kidney stones
Esophagus/stomach/intestines	e.g., reflux, gastritis, ulcer, strictures, digestive disturbances
Metabolism	e.g., diabetes mellitus, gout
Thyroid gland	e.g., hyperthyroidism
Skeletal system	e.g., scoliosis, arthritis, restricted range of motion
Musculature	e.g., myasthenia, familial muscle disease, malignant hyperthermia
Nervous system, mental function	e.g., epilepsy, depression
Eyes	e.g., cataract, glaucoma
Ears	e.g., hearing impairment, hearing aid
Oral and maxillofacial area	e.g., loose teeth, dentures, bridges, crowns
Female reproductive system	e.g., known or possible pregnancy
Substance consumption	e.g., tobacco, alcohol, illicit substances
Bleeding history	
1) Have you ever been diagnosed as having a clotting disorder? 2) Have you ever had bleeding of any of the following types: a) nosebleed for no apparent reason? b) bruises or very small hematomas under the skin for no apparent reason? c) bleeding into the joints, soft tissues, or muscles? d) prolonged bleeding after a cut or scrape? 3) Have you ever had prolonged or unusually intense bleeding after a tooth extraction? 4) Have you ever had unusually intense bleeding during or after an operation? 5) Are you known to have a problem with wound healing? 6) Does anyone in your family have an increased bleeding tendency? 7) Have you taken any medications that can affect the blood clotting system in the past two weeks? 8) Are you now taking any painkillers or anti-rheumatic drugs? 9) For women: Do you have unusually intense or prolonged menstruation (>7 days)?	
Physical examination	
Respiratory pathway	e.g., size of oral opening, visibility of uvula and palate, mobility of cervical spine, condition of teeth, thyromental distance, upper-lip-biting test, neck circumference
Heart	e.g., heart sounds, heart murmurs, skipped beats, heart rate and rhythm, blood pressure
Lungs	e.g., respiratory sounds, dullness to percussion, cyanosis
Cardiopulmonary reserve	e.g., if the history is unclear: stress test—doctor and patient climb stairs together
Potential signs of heart failure	e.g., physiologic reserve (by history and/or stress test), dyspnea, edema, signs of venous congestion

TABLE 3

Recommended indications for preoperative laboratory testing based on known or suspected pre-existing illness of organ systems (modified from [13])

Known or suspected illness of:				
Laboratory test	Heart/lungs	Liver	Kidney	Blood
Hemoglobin	+	+	+	+
Leukocyte count				+
Platelet count		+		+
Sodium, potassium	+	+	+	+
Creatinine	+	+	+	+
ASAT, bilirubin, aPTT, INR		+		

ASAT, aspartate aminotransferase; aPTT, activated partial thromboplastin time; INR, international normalized ratio

TABLE 4

Cardiac risk ratings for various types of surgery (modified from [13])

Cardiac risk	Type of surgery
High	– aortic surgery – major peripheral arterial surgery
Intermediate	– intrathoracic and intraabdominal procedures (including via laparoscopy/thoracoscopy) – carotid surgery – prostate surgery – orthopedic surgery – head and neck surgery
Low	– superficial procedures – endoscopic procedures – breast surgery – cataract surgery

thoroughly according to a standardized scheme (Table 2). The Professional Association of German Anaesthesiologists (*Berufsverband Deutscher Anästhesisten e.V.*) has issued a history-taking form that it recommends for this purpose. If this initial evaluation yields no evidence of any conditions significantly affecting the perioperative risk, then, as a rule, no further testing is needed.

The initial survey of 2011 revealed that preoperative physical examinations were generally not regularly performed (37%) (14). Two years after the recommen-

dations were published, the physical examination appeared to have become more common: in early 2013, an additional 25.7% of anesthesiologists surveyed confirmed that, since publication of the recommendations, they performed a history and physical examination more commonly or always. 39.1% said that they also ordered fewer ancillary tests (e9).

Laboratory tests

There is no reason to perform laboratory testing routinely in all cases, or because of the patient's age as the sole indication. The main reasons not to do so are the high prevalence of abnormal laboratory values with no relevance to perioperative risk and the (unnecessary) expense of such testing (18). Although laboratory findings tend to deviate from the norm more frequently with increasing age (19, 20), there is still no correlation between the number of abnormal laboratory findings and the outcome of surgical treatment, even in elderly patients (aged 70–100) (21). Even tests of the conventional clotting parameters, including the activated partial thromboplastin time (aPTT), the international normalized ratio (INR), and the platelet count, are inadequate for the detection of the more common coagulopathies (congenital and acquired disorders of platelet function and von Willebrand disease); they are, therefore, less useful than a standardized bleeding history (22, 23). Laboratory tests of coagulation should be performed only if indicated by a specific drug history (treatment with coumarin derivatives or heparin) or a positive bleeding history (obtained with a standardized questionnaire) (Table 2). This strategy has been validated once more in a study of 11 804 patients who underwent neurosurgical procedures (24).

Despite this rule, preoperative laboratory testing may exceptionally be indicated in the following situations:

- when preoperative diagnostic or therapeutic measures might alter homeostasis to a clinically significant extent (e.g., measurement of the serum potassium level after a preoperative bowel prep);
- when the operation to be performed necessitates such testing (e.g., in surgeries with expected high blood loss);
- when the patient is taking drugs that can significantly alter laboratory values (e.g., antibiotics that elevate the serum creatinine or hepatic transaminase levels);
- in the presence of severe organ dysfunction (e.g., renal failure).

History

A precise history, including bleeding history, and a physical examination are the basis for the decision of any previously unknown or inadequately treated medical conditions that might affect the perioperative risk.

Laboratory tests

There is no reason to perform laboratory testing routinely in all cases, or because of the patient's age as the sole indication.

If organic disease is known or reasonably suspected on the basis of the history and/or physical examination, the laboratory tests listed in *Table 3* are recommended.

Preoperative blood sugar measurement can detect previously unknown or inadequately treated diabetes mellitus or abnormal glucose tolerance (impaired fasting glucose, IFG). Each of these entities is a major perioperative risk factor that cannot always be reliably detected by history and physical examination alone (25, 26). Therefore, fasting blood sugar measurement is now recommended before high-risk procedures (surgery of the aorta and major peripheral arteries) (*Table 4*), when other cardiac risk factors are present (*Box*), and for overweight patients (body mass index >30 kg/m²).

The survey of anesthesiology departments mentioned above revealed that, up to the date of the survey, laboratory testing was often performed either routinely (43.2%) or because of the patient's age (52.8%) (14). A chance thus presents itself to economize on preoperative risk assessment without compromising patient safety.

12-channel ECG

Preoperative ECG alone yields no additional information when used as a screening method in elderly patients or as an additional test in patients with a history of stable heart disease, nor does it improve outcomes (6, 27). ECG is, therefore, recommended only for:

- patients with no signs or symptoms of heart disease who are about to undergo procedures carrying a high cardiac risk (*Table 4*);
- patients with more than one cardiac risk factor (*Box*) who are about to undergo intermediate-risk procedures (*Table 4*);
- patients with clinical manifestations of cardiac ischemia, arrhythmia, valvular heart disease, congenital cardiac anomalies, or congestive heart failure, and persons who have undergone the implantation of an automatic implantable cardiac defibrillator (AICD).

On the other hand, patients with cardiac pacemakers who are asymptomatic and keep their regularly scheduled pacemaker follow-up appointments do not need an ECG before surgery (*Figure*).

Nonetheless, the potential significance of the ECG remains a matter of debate. In a prospective, single-center study of 345 patients about to undergo aortic surgery, arterial bypass grafting, or laparotomy, those who had no

BOX

Cardiac risk factors*

- congestive heart failure
- coronary heart disease (CHD)
- peripheral arterial occlusive disease (PAOD)
- cerebrovascular insufficiency
- diabetes mellitus
- renal failure

*modified from (13)

history of cardiac ischemia but had an abnormal ECG sustained a larger number of significant cardiac events than patients with normal ECGs (10). A further study involving 1363 patients revealed that an abnormal preoperative ECG was an independent predictor (odds ratio [OR], 2.8; $p = 0.005$) of perioperative complications (hypo- or hypertension, hemodynamically relevant arrhythmias); other independent predictors were age, the invasiveness of the procedure, and a prior history of renal disease or anemia (2). Yet another study dealt with the predictive value of ECG abnormalities for the occurrence of perioperative cardiac events (PCE: significant arrhythmia [treated or untreated], acute coronary syndrome, acute congestive heart failure, cardiac arrest, pulmonary thromboembolism, or cardioembolic cerebral ischemia) in 660 patients (28). On univariate analysis, PCE were significantly more common in patients with abnormal ECGs than in those with normal ECGs (16% vs. 6.4%; $p < 0.001$). Multivariate analysis, however, identified only prolongation of the QT interval as a predictor of PCE ($p < 0.001$, OR 1.04). A retrospective cohort analysis of 70 996 patients revealed no association between survival rates and preoperative ECG findings (29). Thus, the value of a preoperative ECG is not yet fully clear. Moreover, the relevance of the family history to the risk of perioperative cardiac complications has not yet been studied.

Chest X-ray

The sensitivity of anteroposterior chest X-rays for cardiopulmonary disease is low (8, 30); thus, they should only be obtained if there is clinical suspicion of

Cardiac risk factors

- Congestive heart failure, coronary heart disease (CHD), peripheral arterial occlusive disease (PAOD), and cerebrovascular insufficiency
- Diabetes mellitus
- Renal failure

Patients with cardiac pacemakers

Patients with cardiac pacemakers who are asymptomatic and keep their regularly scheduled pacemaker follow-up appointments do not need an ECG before surgery.

Recommendation
about whether to order
a preoperative
12-channel ECG
(modified from [13]).
AICD, automatic
implantable cardiac
defibrillator

FIGURE

a condition that could affect decision-making in the perioperative period, e.g., pneumonia or a relevant anatomical abnormality.

(Doppler) echocardiography

The predictive value of echocardiography for perioperative cardiac complications remains unknown. A small number of studies have identified certain abnormal echocardiographic findings (left ventricular hypertrophy, systolic dysfunction, moderate or severe mitral regurgitation, an abnormal dobutamine stress test) as predictive factors for relevant cardiac complications after non-cardiac surgery (31–33). Nonetheless, the overall prognostic value of echocardiography is limited; it cannot predict cardiac complications with any degree of accuracy (34). Preoperative echocardiography is indicated for patients with dyspnea of new onset and for those who have congestive heart failure with worsened symptoms over the past 12 months. It seems reasonable at present to consider echocardiography for patients with previously undiagnosed (or unevaluated) heart murmurs who are about to undergo procedures carrying a moderate or high cardiovascular risk (Table 4) (35).

Ultrasonography of the cervical vessels

Patients with symptomatic carotid stenosis or a prior stroke or transient ischemic attack are at elevated risk

(OR 1.6–2.9 [e10, e11]) of a perioperative cerebrovascular event (36). Ultrasonography of the cervical vessels should be performed preoperatively in such patients, and in any patient about to undergo major arterial surgery (13, 37). The literature contains no evidence of a correlation between asymptomatic carotid murmurs and perioperative cerebrovascular events (38). There is thus no evidence-based recommendation for perioperative ultrasonography in patients with asymptomatic carotid murmurs.

Pulmonary function tests

According to a small number of studies, abnormal findings on pulmonary function tests are valid predictors for pulmonary complications after surgical procedures that do not involve the lungs (39–40, e12). Other studies, however, did not show pulmonary tests to be useful for either the prevention of pulmonary complications or their detection (e1, e13–e15). Thus, patients about to have extrathoracic surgery should undergo pulmonary function testing only if they have a known or suspected pulmonary disease of new onset.

Extended cardiac testing

Positive criteria for extended preoperative cardiac testing include:

- acute, symptomatic heart disease
- cardiac risk factors

Chest X-ray

The sensitivity of anteroposterior chest X-rays for cardiopulmonary disease is low; thus, they should only be obtained if there is clinical suspicion of a condition that could affect decision-making in the perioperative period.

(Doppler) echocardiography

The predictive value of echocardiography for perioperative cardiac complications remains unknown.

- diminished physiologic reserve
- the cardiac risk profile of the intended operation.

In patients with acute, symptomatic heart disease, the evaluation and treatment of the cardiac problem take priority, and all non-emergency surgical procedures must be postponed.

According to the current evidence, non-invasive cardiac stress tests (stress ECG, dobutamine stress echo-cardiography) are indicated only for patients with three or more clinical risk factors (*Box*) and diminished or unknown physiologic reserve (<4 metabolic equivalents [MET]) (*Table 5*) before high-risk surgery. Non-invasive cardiac stress tests should also be considered for patients in this group who are about to undergo any operation carrying an intermediate or high cardiac risk (*Table 4*). On the other hand, such testing is not indicated for patients without clinical risk factors, even if their physiologic reserve is diminished (<4 MET).

Discussion

The presentation of testing modalities and interdisciplinary recommendations in this article reflects the current state of scientific evidence and expert opinion. Adaptation to specific clinical situations may be necessary in individual cases. Moreover, these recommendations are neither complete nor final; as further evidence accumulates, they will have to be re-evaluated and updated at regular intervals.

Recent articles have addressed the potential value of additional laboratory testing for surgical risk assessment, particularly the preoperative measurement of pro-B natriuretic peptide (pBNP) and of the hemoglobin concentration (e16–e19). In a review of 97 studies (2001–2011) that addressed the issue of additional preoperative testing and its effects on perioperative management and/or morbidity and mortality (e1), it was pointed out that many of these studies were conducted primarily on elderly patients with multiple pre-existing medical conditions. In some of the studies, the preoperative ancillary test results were found to be correlated with treatment outcomes; these correlations, however, do not confirm the usefulness of testing for risk stratification. Rather, they are consistent with the unsurprising fact that patients with serious comorbidities tend to do worse.

Multiple recent studies of preoperative testing have led to the conclusion that the strongest predictors of perioperative complications are the patient's pre-existing illnesses, as revealed by a thorough history,

TABLE 5

Metabolic equivalents (MET) of various activities*

MET	Activity
1	reading, watching television
	eating, getting dressed
2–3	walking on level ground at 3–4 km/h
	light housework
4	climbing a few stairs
	walking on level ground at ca. 6 km/h
	running (short distances)
	heavy household chores
	moderately strenuous sports (golf, dancing)
>10	highly strenuous sports (tennis, soccer)

*modified from (e24)

and the nature of the operation to be performed (2, 21, 24). Further studies have shown that routine testing does not increase perioperative patient safety (e2, e20–e23). Thus, unless the history and physical examination furnish a specific reason for additional testing, no such testing should be performed. In the future, preoperative evaluation will be optimized by the implementation of these concepts in clinical practice, and by the ongoing incorporation of new scientific evidence in the recommendations as it comes to light.

Conflict of interest statement

The authors declare that no conflict of interest exists.

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Pulmonary function tests

Patients about to have extrathoracic surgery should undergo pulmonary function testing only if they have a known or suspected pulmonary disease of new onset.

Criteria for extended cardiac testing

- Acute, symptomatic heart disease
- Cardiac risk factors
- Diminished physiologic reserve
- The cardiac risk profile of the intended operation

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The state of the evidence

The strongest predictors of perioperative complications are the patient's pre-existing illnesses, as revealed by a thorough history, and the nature of the operation to be performed.

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Question 1

Which of the following is an indication for preoperative laboratory testing of coagulation status?

- a) any type of heart failure
- b) type 1 diabetes
- c) treatment with coumarin derivatives
- d) age over 75 years
- e) cigarette smoking

Question 2

Before which of the following types of surgery should a fasting blood sugar be obtained?

- a) aortic surgery
- b) head and neck surgery
- c) orthopedic surgery
- d) endoscopic surgery
- e) breast surgery

Question 3

What is the longest permissible interval between peri-operative risk assessment and surgery?

- a) 2 weeks
- b) 3 weeks
- c) 4 weeks
- d) 5 weeks
- e) 6 weeks

Question 4

Light housework has what metabolic equivalent?

- a) 2 to 3
- b) 4 to 5
- c) 6 to 7
- d) 8 to 9
- e) 10 to 11

Question 5

A patient who is to undergo surgery has a cardiac pacemaker. He says he has had no problems in his regular pacemaker follow-ups. What should be performed as part of the preoperative risk assessment?

- a) long-term ECG
- b) stress echocardiography
- c) 12-channel ECG
- d) no ECG
- e) stress ECG

Question 6

Which of the following is an indication for a preoperative chest X-ray?

- a) forthcoming plastic surgery of the nasal septum
- b) clinical suspicion of pneumonia
- c) chronic sinusitis
- d) diabetes mellitus
- e) allergy

Question 7

What study should patients with symptomatic carotid stenosis undergo preoperatively?

- a) head MRI
- b) upper abdominal ultrasonography
- c) ultrasonography of the cervical vasculature
- d) cardiac catheterization
- e) long-term ECG

Question 8

Which of the following is considered a cardiac risk factor in preoperative risk assessment before high-risk procedures?

- a) Crohn's disease
- b) age over 65 years
- c) scoliosis
- d) renal failure
- e) psoriasis

Question 9

Which of the following laboratory tests, performed as part of a preoperative risk assessment, may yield evidence of renal disease?

- a) serum sodium concentration
- b) leukocyte count
- c) activated partial thromboplastin time
- d) platelet count
- e) aspartate aminotransferase

Question 10

Which of the following types of surgery carries a high cardiac risk?

- a) breast surgery
- b) prostate surgery
- c) carotid surgery
- d) aortic surgery
- e) cataract surgery

CONTINUING MEDICAL EDUCATION

Preoperative Risk Assessment—From Routine Tests to Individualized Investigation

Andreas B. Böhmer, Frank Wappler, Bernd Zwissler

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