CLINICAL REVIEWS

Preoperative Evaluation:

The Assessment and Management of Surgical Risk

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MEDICAL CONSULTATION for surgical patients has received increased attention in recent years. The duties of the consultant may be arbitrarily divided into preoperative evaluation and postoperative care. Although the tasks overlap, the focus of this paper is on preoperative evaluation. In fulfilling this task the consultant identifies patient factors that could increase the risk of the operation and provides recommendations on how to minimize the surgical risk. In this practical approach to assessing and managing perioperative risk, I consider the various body systems in relation to surgical risk and conclude with some general issues pertaining to consultative medicine. For a more comprehensive coverage, there are several excellent sources,[1-4] and specific recommendations regarding medications are presented elsewhere in this issue.[5]

RISKS OF SURGERY AND ANESTHESIA

Advances in anesthesic and surgical techniques have made operative death uncommon, with the usual risk for mortality being 0–0.01 per cent; a low but increased risk, 0.01–0.9 per cent; a significant risk, 1–5 per cent; a moderate risk, 5–10 per cent; a high risk, 10–20 per cent; and a very high risk, more than 20 per cent.[3] Feigal and Blaisdell[4] have reviewed the reasons for deaths related to surgery. Surgical mortality can be classified as perioperative (deaths occurring during the operation or within 48 hours of surgery) and postoperative (deaths occurring within six weeks of surgery). Perioperative deaths occur in about 0.3 per cent of all operations, with 10 per cent occurring during induction of anesthesia, 35 per cent intraoperatively, and 55 per cent in the 48 hours following surgery. Inadequate ventilation, aspiration, arrhythmias, drug-related myocardial depression, and refractory hypotension each are responsible for about 10 to 15 per cent of the 48-hour mortality. Hypoxia may contribute to half of all anesthetic deaths. The six-week postoperative mortality is commonly related to pneumonia (about 20 per cent of the deaths), nonpulmonary infections, particularly peritonitis and gram-negative sepsis (30 per cent), cardiac arrest (15–20 per cent), pulmonary embolism (5–10 per cent), and renal failure, hypovolemic shock, inoperable cancer, and stroke (5 per cent each).

Risks may be patient-related, procedure-related, provider-related, and anesthetic-related.[2] Patient-related risk factors are discussed in detail under each organ system. Regarding age, operative mortality may increase four- to eightfold for patients more than 70 years old compared with younger patients, due largely to coexisting illnesses, decreased cardiopulmonary reserves, and a larger proportion of emergency and cancer operations with fewer procedures being elective.[4] Procedures associated with high death rates include craniotomy, heart surgery, exploratory laparotomy, and large bowel surgery. Low-risk procedures include cystoscopy, dilatation and curettage, eye surgery, oral surgery, hysterectomy, herniorrhaphy, and plastic surgery. All other operations would be considered intermediate-risk. Emergency operation roughly doubles the surgical risk.[4] Regarding provider, mortality may vary with the experience of the surgical team and with the size and the type (teaching vs.non-teaching) of the hospital. Anesthetic-related deaths are most often the result of human error; anesthetic agents themselves are rarely fatal.[2]

A widely misunderstood issue is the relative safety of spinal versus general anesthesia in the high-risk patient. From neither a cardiac nor a pulmonary standpoint can spinal anesthesia be considered safer than general anesthesia.[2-4] Spinal anesthesia can be associated with wider fluctuations in blood pressure, greater anxiety, and less airway and ventilatory control. Therefore, the concept that a patient who is too ill for general anesthesia might be "cleared if done under a spinal" should be discarded. Decisions regarding type of anesthesia are in the anesthesiologist's rather than the medical consultant's bailiwick.

A traditional method for stratifying the risks of patients undergoing surgery and general anesthesia has been the five-level classification system of the American Society of Anesthesiologists (ASA): I—normal; II—mild disease; III—severe disease limiting activity but not incapacitating; IV—severe,

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TABLE 1

Calculation of Multifactorial Cardiac Risk Index*

Variable	Points†
S3 gallop or jugular venous distention	11
Myocardial infarction in the past six months	10
Rhythm other than sinus or premature atrial contractions on last preoperative electrocardiogram	7
Age more than 70 years	5
Emergency operation	4
Intraperitoneal, intrathoracic, or aortic operation	3
Suspected critical aortic stenosis	3
Poor general medical condition‡	3

*Adapted from Goldman et al.[8]

†Operative risks, from lowest to highest, may be classified as: I (0-5 points); II (6-12 points); III (13-25 points); IV (>25 points).

‡Electrolyte abnormalities (potassium <3.0 mmol/l, or HCO_3 < 20 mmol/l), abnormal arterial blood gases (P_{O_2} < 60 mm Hg, or P_{CO_2} > 50 mm Hg), renal insufficiency (blood urea >17.85 mmol/l (BUN > 50 mg/dl), or creatinine >265 μmol/l) (>3.0 mg/dl), abnormal liver status (elevated transaminase, or physical signs of chronic liver disease), or patient bedridden.

incapacitating, a constant threat to life; V—expected to die in 24 hours.[6] However, ASA classification is subjective, a global impression rather than a systematic assessment. More useful is an organ-system approach whereby specific problems can be identified and managed.

CARDIAC RISKS AND MANAGEMENT

Risk Factors

Various authors have reviewed the cardiac risks of surgery.[2-4, 7, 8] An important step towards the objective classification of cardiac risk was the development by Goldman and coworkers[7] of a Multifactorial Cardiac Risk Index (MCRI). By prospectively evaluating 1,001 patients undergoing general anesthesia, they identified nine factors that increased the probability of a major perioperative cardiac event (Table 1). On the basis of these nine factors, patients were stratified into four risk groups, as follows: I—0 to 5 points; II—6 to 12 points; III—13 to 25 points; IV—26 or more points. For these categories, the risks of life-threatening cardiac complications (i.e., pulmonary edema, ventricular tachycardia, or myocardial infarction) and death were I—0.7 and 0.2 per cent; II—5 and 2 per cent; III—11 and 2 per cent; IV—22 and 56 per cent.

Of note, 31 of the 53 possible risk points concern areas that might be corrected preoperatively. When the patient has recently experienced a myocardial infarction, surgery might be delayed until six months have elapsed; congestive heart failure might be controlled, thereby eliminating an S3 gallop or jugular venous distention; factors contributing to poor general status might be improved; and arrhythmias could be treated. Although it remains to be shown that correction of these factors reduces the operative risk, it seems reasonable to optimize the patient's condition.

The MCRI should not be relied upon as the sole criterion for evaluating cardiac status. The outcomes predicted by the MCRI are death and life-threatening complications; a patient may still develop a lesser cardiac event, such as postoperative angina, that the MCRI was not designed to predict. The MCRI was developed in 1977 from a single data set, and subsequent validation in other settings has been limited. One study in 99 patients undergoing elective aortic procedures[9] and another in 100 geriatric patients undergoing major operations[10] revealed that the risks in these patients were underestimated by using the MCRI. Detsky and coworkers[11] have proposed modifications of the MCRI to allow more accurate prediction of cardiac complications for different surgical procedures and for different patient populations.

Coronary Artery Disease

A postoperative myocardial infarction (MI) is a feared complication because over half may be silent and the mortality rate is high.[12, 13] The risk actually continues well into the postoperative period, with the peak incidence occurring on the third day following surgery. One might therefore consider obtaining an electrocardiogram within a day of surgery and a second one between the third and fifth postoperative days in high-risk patients, such as those who are having ischemic signs or symptoms as well as those who are in MCRI class III or IV.[8] Patients with recent infarctions are at greatest risk of a postoperative MI. For the first few months following an MI, the risk of another MI resulting from surgery is around 30 per cent. If an operation is postponed for three to six months following an MI, the risk of a postoperative MI declines to 10 per cent. After six months, the risk drops to 5 per cent and remains relatively constant thereafter. Although the risk may have declined since the 1970s, when these observations were made, the standard recommendation is still to delay nonemergent surgery until at least six months following a myocardial infarction.

Who should be evaluated for coronary artery disease prior to surgery? More specifically, which patients require more than the standard history, physical examination, and electrocardiogram? The screening test most commonly considered is an exercise tolerance test (ETT). Two factors to consider in selecting candidates for a preoperative ETT are the type of operation planned and selected patient variables. Vascular operations place the greatest stress on the heart and are, in descending order of risk: those involving clamping of the aorta, such as resection of an abdominal aortic aneurysm; peripheral arterial and coronary artery bypass grafts; carotid endarterectomies. Thoracic and upper abdominal operations also pose a significant risk for patients with cardiac disease. The most important patient variables are a history of cardiac symptoms, particularly chest pain, and an abnormal electrocardiogram (ECG). Age alone (e.g., more than 40 years old) does not necessitate an ETT.[8, 14]

Although there is no consensus, one might consider an ETT before all vascular operations and before high-risk nonvascular operations. High-risk patients would include those with unstable angina, those with new ECG findings, particularly if ischemic, and those who are in MCRI class III or IV. Patients with ST-segment abnormalities on their baseline ECGs may require a thallium rather than a routine ETT. If the ETT (routine or thallium) is adequate and shows no evidence of ischemia, coronary angiography is usually not necessary. If the ETT is either positive for ischemia or cannot be adequately performed, cardiologic consultation to determine the need for angiography should be obtained.

Ironically, patients with peripheral vascular disease are at considerable risk for cardiac complications,[15] yet their claudication often precludes an adequate ETT. Some authors suggest obtaining coronary angiography before vascular surgery for any patient whose history, ECG, or ETT suggests coronary artery disease,[16,17] as well as anyone unable to perform an ETT.[16] Others have found noninvasive tests such as dipyrimadole-thallium scanning[18] or bicycle ergometry[10, 15] helpful in determining which patients unable to perform an ETT actually require angiography. These tests, however, are neither as well studied nor as widely available as the ETT.

Even when coronary artery disease is detected by preoperative angiography, its proper management has not been rigorously determined. Some vascular surgeons subject anyone with 70 per cent or greater stenosis of a single vessel to coronary artery bypass grafting (CABG) prior to their peripheral vascular procedure.[16, 17] This is a more aggressive approach than is currently recommended for nonsurgical patients, in whom CABG is reserved primarily for three-vessel or left main coronary artery disease.

Two other questions regarding surgical risk involve the patient with previous CABG and the patient with a carotid bruit. Prior CABG reduces the cardiac risk in subsequent operations to nearly normal,[8, 19] although it may be wise to delay elective procedures at least 30 days following CABG.[19] The risk of perioperative strokes is so low in patients with asymptomatic carotid bruits that angiography and endarterectomy before elective operations is not indicated.[20]

Congestive Heart Failure

Postoperative pulmonary edema occurs particularly in patients who have histories, past or present, of congestive heart failure (CHF). Risks range from 2 per cent in those with no prior history of CHF to 6 per cent in those with a history of but no current physical or roentgenographic evidence of CHF to over 30 per cent in those with a preoperative S3 gallop or jugular venous distention.[8] There are two peaks of occurrence: one immediately postoperatively and the second, 24 to 48 hours later, resulting from fluid mobilization. Like the value of using pulmonary artery catheters in nonsurgical patients, the intraoperative value of hemodynamic monitoring has not been studied in a controlled fashion. Goldman suggests that monitoring be considered for patients who are class IV on his MCRI or who are class III and have significant heart failure or aortic stenosis or have recently had a myocardial infarction.[8] Patients undergoing abdominal aortic aneurysm resection might also benefit.

Arrhythmias

Arrhythmias do not generally pose a problem for patients undergoing surgery. Premature ventricular contractions (PVCs) can be treated with lidocaine intraoperatively if they cause hemodynamic compromise or degenerate into ventricular tachycardia.[2, 8] A prophylactic lidocaine infusion is indicated only when the patient has complex ectopy (frequent PVCs, particularly if they occur in couplets or in runs) and a history of recent ischemic heart disease. Patients receiving chronic antiarrhythmic therapy can usually receive their oral dose the morning of surgery and have it restarted as soon as possible following the operation. Patients with bifascicular block are not at increased risk of advancing to complete heart block perioperatively, and temporary pacemakers are rarely necessary.[21, 22]

Supraventricular tachyarrhythmias (SVT) occur in as many as 4 per cent of patients in the postoperative period and should prompt a search for CHF, infarction, pericarditis, infection, hypoxemia, acidosis, hypokalemia, anemia, or aggravating medications, such as epinephrine.[23] Although the mortality in SVT approached 50 per cent in one series,[23] patients almost invariably died of the underlying cause rather than the SVT. The SVT resolved spontaneously in 40 per cent of the patients, responded to drugs in 47 per cent, and required countershock only 6 per cent of the time. Isolated premature atrial contractions do not generally require prophylactic therapy. However, preoperative digitalization might be considered for patients undergoing cardiac valvular surgery[24] or those who have histories of recurrent SVT.

Valvular Heart Disease

Auscultation of a cardiac murmur seldom necessitates postponement of surgery. Often, it will be an innocent flow murmur or the relatively benign

TABLE 2
Recommended Antibiotic Regimens for Prevention of Endocarditis

Site of Procedure	Standard Regimen	Regimen for Penicillin-allergic Patient
Dental, and oral/respiratory tract	Penicillin V, 2.0 g PO,* 1 hour before, then 1.0 g 6 hours after	Erythromycin, 1.0 g PO, 1 hour before, then 500 mg 6 hours after
Gastrointestinal, and genitourinary tract	Ampicillin, 2.0 g IM or IV, plus gentamicin, 1.5 mg/kg IM or IV, given ½ to 1 hour before, then 8 hours after	Vancomycin, 1.0 g IV, slowly over 1 hour, plus gentamicin, 1.5 mg/kg IM or IV, given 1 hour before; may repeat 8 hours after

*For patients with prosthetic valves, gastrointestinal/genitourinary regimen is recommended.

murmur of mitral valve prolapse or of aortic sclerosis. Hemodynamically significant aortic or mitral valve murmurs will usually become obvious after examining the intensity, duration, and radiation of the murmur and after palpating the carotid pulse. Significant stenotic or regurgitant lesions of the mitral or aortic valve are each associated with a 20 per cent incidence of new or worsening CHF in the postoperative period.[8]

Aortic stenosis (AS), however, poses the greatest operative risk. AS can be clinically suspected in the presence of a harsh murmur radiating to the carotids, diminished carotid pulsations, left ventricular hypertrophy on the ECG, and radiographic valvular calcification. If AS is suspected, preoperative echocardiography will help confirm the diagnosis. The indications for aortic valvular replacement before proceeding with other operations has not been well defined. Goldman[8] recommends that if echocardiography suggests significant AS in a patient with angina, heart failure, or syncope, preoperative cardiac catheterization should be performed and, if stenosis is severe, the valve should be replaced prior to other elective procedures. When the stenosis is not severe or when, despite critical stenosis, the patient is asymptomatic, general surgery will usually be tolerated. Patients with severe AS should be hemodynamically monitored in the perioperative period.

With most systolic murmurs, echocardiography can be postponed until after the operation. If one is uncertain about the etiology of a murmur and its potential for endocarditis, one can comply with the rather simple recommendations for antibiotic prophylaxis, relegating a more complete evaluation of the murmur to the outpatient setting.

Patients need endocarditis prophylaxis only when they both have substantial valvular heart disease and will undergo at-risk (contaminated) operations. Contaminated operations are, for the purpose of selecting antibiotics, divided into those above the diaphragm (oral and respiratory tract procedures) and those below the diaphragm (gastrointestinal and genitourinary procedures). Clean operations, such as orthopedic, ophthamologic, and plastic surgical procedures, do not require endocarditis prophylaxis, even if the patient has valvular heart disease. Recommendations for endocarditis prophylaxis[25] are summarized in Table 2. Mitral valve prolapse may be present in as many as 5 per cent of healthy people, and the requirements for endocarditis prophylaxis are unclear. In the absence of a murmur suggesting regurgitation, prophylactic antibiotics are probably unnecessary.

Hypertension

Mild hypertension is not a surgical risk factor.[26] Only as the diastolic blood pressure becomes considerably elevated, i.e., greater than 110 mm Hg, is it imperative for surgery to be delayed. The risk of uncontrolled hypertension is that of intraoperative blood pressure lability, with hypotension being as much of a threat as hypertension. In the postoperative period, hypertension occurs in 3 per cent of surgical patients, 60 per cent of whom have histories of hypertension.[27] In only 20 per cent, however, does the postoperative hypertension persist for more than three hours, and drug therapy can usually be reserved for this group. Although there is disagreement, many clinicians continue the blood pressure medications of patients receiving chronic therapy up to and following the operation.[8] The medications are given with a sip of water the morning of surgery.

If the patient is incapable of oral intake for more than 12 to 24 hours following the operation, several parenteral regimens may be effective.[8] Hydralazine can be given intravenously, 5 mg every 20 minutes, until blood pressure is controlled, followed by 10 mg every six hours. Propranolol can be given intravenously, 1 mg every 5 minutes, to a total dose of 5 mg; the required dose may be repeated every six hours. Although methyldopa will not have its onset of action for about four hours, 250 to 500 mg intravenously every six hours may be helpful in maintaining blood pressure control. Sublingual nifedipine is administered at 20-minute intervals by squeezing out the contents of a cut 10-mg capsule.[28] For rapid control of severely elevated blood pressure, nitroprusside remains the treatment of choice.

Dental Patients

Dentists are concerned about several kinds of cardiac patients.[29] First, there are patients taking anticoagulants. Usually, the anticoagulant need not be discontinued.[29, 30] Rather, the prothrombin time can be kept at less than 20 seconds, which, combined with certain practical measures such as intermittently using ice packs, eating soft foods, and avoiding hot liquids, will prevent problems with bleeding. Second, certain cardiotonic medications, such as the epinephrine used with local anesthetics and the atropine used occasionally to create a dry field, are usually safe if used in small quantities.[29, 31] Finally, endocarditis prophylaxis is administered to patients with valvular heart disease according to the recommendations stated above.

PULMONARY RISKS AND MANAGEMENT

Although pulmonary disease presents less of a risk for surgery than cardiac disease does, respiratory complications are common and potentially serious. Therefore, preoperative assessment of pulmonary status should be mastered by the medical consultant.[32, 33] Chronic obstructive pulmonary disease (COPD) is the primary risk, in part because adequate flow rates are necessary to generate an effective cough. Coughing clears airways, prevents atelectasis, and may reduce the risk of pneumonia and the requirement for prolonged ventilator support. Restrictive airway disease is much less worrisome than COPD in patients undergoing surgery. Factors that increase the chance of postoperative pulmonary complications include smoking history, obesity, age more than 60 years, duration of anesthesia more than three hours, and type of surgery, with upper abdominal and thoracic operations posing the greatest risks.[32, 34]

Whether each of these clinical factors contributes independently to surgical risk is controversial and, consequently, pulmonary function tests (PFTs) have emerged as the most reliable predictor of operative risk.[32, 35] Of these, the simple spirometric measure of the forced expiratory volume in 1 second (FEV_1) is probably as good a predictor as any. Somewhat different cutoff values for the FEV_1 are listed in the literature; roughly, surgical risk in patients with COPD can be estimated by the "one liter–two liter" rule: the operative risk is low when FEV_1 is >2,000 ml, medium when it is between 1,000 and 2,000 ml, and high when it is <1,000 ml. Patients whose FEV_1s are <1,000 ml are at considerable risk of requiring prolonged ventilatory support following major operations. Despite this, one study suggested that careful management can allow such patients to undergo necessary operative procedures.[36]

Instead of using the absolute value of FEV_1, it may be more useful to express FEV_1 as a percentage of predicted value based on the patient's height, weight, age, and gender. Although fewer studies have examined this measurement, an FEV_1 of less than 75 per cent of the predicted value may be associated with an increased rate of pulmonary complications. Finally, the FEV_1 may decline as much as 60 per cent following thoracic and upper abdominal procedures.[32] In such operations, one might estimate the postoperative FEV_1. A predicted value of less than 750 to 1,000 ml would indicate a high-risk patient.

Several other tests also have prognostic value. A maximal voluntary ventilation (MVV) of less than 50 per cent of predicted indicates serious operative risk. Arterial blood gas determinations can be obtained for high-risk patients, with an elevated P_{CO_2} identifying someone who may be difficult to wean from the ventilator. Indeed, hypercarbia is a much greater risk factor than hypoxemia.

Which patients require preoperative PFTs? Although the answer is not known, those with pulmonary symptoms, particularly dyspnea or chronic cough, and those undergoing thoracic operations are reasonable candidates. Some would also consider PFTs for patients who have long histories of cigarette smoking and those undergoing upper abdominal operations. Thoracic operations involving pulmonary resection present the most serious threat to pulmonary reserves and may require more sophisticated testing.[2, 3]

Although preoperative preparation of pulmonary patients has not been rigorously studied, certain guidelines have been suggested.[32, 33, 37] Most surgeons advise the patient to refrain from smoking for at least a week prior to surgery. However, this may not be long enough to allow recovery of small-airway function. Two months was found to be the minimum period of abstinence necessary to decrease pulmonary complications in smokers undergoing cardiac surgery.[38] When there is evidence of reversible airway disease, as manifested by wheezing on physical examination or by a 15 per cent or greater improvement in FEV_1 following bronchodilators, theophylline or an aerosolized bronchodilator should be considered in order to maximize pulmonary function. Asthmatics, i.e., patients in whom airway obstruction is predominantly reversible, are managed perioperatively much as they are in the nonsurgical setting.[39] If the patient has a purulent cough, antibiotics may be prescribed in an attempt to clear the sputum. Postoperatively, incentive spirometry every few hours and early mobilization are advisable. Intermittent positive-pressure breathing is much more costly and no more effective than incentive spirometry.[40]

HEMATOLOGIC RISKS AND MANAGEMENT

Four elements of the blood—erythrocytes, leukocytes, platelets, and clotting factors—are considered. Anemia, if severe enough, should be treated, because of the erythrocyte's role in oxygen transport. Although the level of hemoglobin necessary to avoid surgical morbidity has not been determined, transfusions are often given preoperatively to increase the hematocrit to at least 30 per cent.[41, 42] Patients with chronic anemia, however, may tolerate much lower hematocrits. In particular, those with sickle-cell anemia or chronic renal disease do not generally receive preoperative transfusions unless their hematocrit drops below 20 per cent. Anemia does not seem to impair wound healing,[42] and although it is associated with postoperative complications it may simply reflect the severity of the underlying condition necessitating surgery.[43] If possible, transfusion should take place at least 24 hours before the operation to allow regeneration of 2,3-DPG and reequilibration of the blood volume. If the operation is nonemergent and the cause of the anemia is unknown, it is preferable to determine the anemia's cause rather than simply to transfuse.

A decrease in the leukocyte count rarely interferes with surgery. Wound healing is generally unimpaired down to absolute granulocyte counts of 500.[42]

Quantitative or qualitative platelet abnormalities can result in bleeding complications. A platelet count of 100,000 or more is recommended for major surgical procedures, with at least 30,000 for minor operations.[42] Platelet transfusions can be administered if necessary. Each unit of transfused platelets will raise the platelet count about 10,000, although the response is quite variable, and a posttransfusion platelet count is recommended. Quantitative platelet dysfunction in the presence of a normal platelet count may be detected by a prolonged bleeding time. The bleeding time, however, may not correlate with the extent of surgical blood loss[44] and should not be obtained as a routine preoperative test.[45]

Common causes of platelet dysfunction include antiplatelet drugs and von Willebrand's disease. Aspirin irreversibly acetylates the platelets and should be discontinued five to seven days prior to surgery,[42] although the role of aspirin in causing significant surgical blood loss has been questioned.[44] Other nonsteroidal anti-inflammatory drugs impair platelet function only as long as they are present in the body; thus, stopping them one to two days prior to surgery is sufficient. If an operation must be performed and platelet dysfunction is suspected, a markedly elevated bleeding time might justify giving platelet transfusions. von Willebrand's disease, a congenital disorder in which platelet dysfunction is related to abnormalities in factor VIII, is best treated with cryoprecipitate[42] or possibly desmopressin.[46] A history in the patient or patient's family of spontaneous or postsurgical bleeding should lead to consideration of von Willebrand's disease.

Clotting factor deficiencies may also produce excessive bleeding. The tests most commonly used to detect coagulation problems are the prothrombin time (PT) and the partial thromboplastin time (PTT). Surgically important elevations in either test are usually the result of a drug (anticoagulant) or a disease. Endogenous circulating anticoagulants, seen in systemic lupus erythematosus and other conditions, may prolong the coagulation test times but rarely produce clinically significant bleeding.[42] Such circulating anticoagulants are diagnosed when an equal mixture of normal plasma with the patient's plasma does not correct the prolonged coagulation time.

The drug most often responsible for an elevated PT is warfarin. Since warfarin acts by interfering with hepatic production of vitamin K-dependent clotting factors, the PT will remain elevated for days following discontinuation of the drug. For elective procedures, therefore, warfarin should be stopped three or four days before the operation. If surgery cannot be delayed this long, 10 mg of vitamin K may be given initially and repeated 12 hours later. A more rapid means of reversing the effects of warfarin is the administration of fresh frozen plasma (FFP), 20 ml/kg of body weight. The advantage of FFP is that anticoagulation with warfarin can be resumed as soon as desired following surgery, whereas vitamin K will continue to interfere with warfarin's action for some days.

The disease most commonly associated with an elevated PT is liver failure. Since the synthetic capacity of the liver has substantial reserves, prolongation of the PT indicates profound hepatic dysfunction. Acute hepatitis, except for the fulminant case, is rarely to blame; rather, clotting abnormalities are the hallmark of chronic disease. Use of FFP is necessary if such patients require surgical procedures. Malabsorption of vitamin K and abnormal consumption of clotting factors (disseminated intravascular coagulation) can also occasionally produce an abnormal PT.

Heparin is the primary drug causing an elevated PTT. Because heparin acts through inhibition of certain clotting factors, its effect dissipates as soon as it is cleared from the body. Therefore, if an operation on a patient receiving heparin can be deferred six hours, stopping the drug may be all that is necessary. If an operation must be performed emergently, protamine can be administered to reverse the effects of heparin. The prototypical disease resulting in an elevated PTT is hemophilia, a congenital deficiency of factor VIII (hemophilia A) or factor IX (hemophilia B). Preparation of a hemophiliac for surgery requires specific factor replacement.

Perioperative management of patients receiving chronic anticoagulant therapy can be "tight" or "loose" depending on the indication for chronic therapy.[2, 3, 5, 47, 48] Tight control can be considered for patients for whom even brief periods off anticoagulation may be hazardous. This includes patients who have mechanical prosthetic heart valves in the mitral position, dialysis patients whose shunts have previously clotted, and persons who have demonstrated a proclivity for embolization. In such patients, warfarin can be stopped three to four days before surgery and full-dose heparin therapy begun one to two days preoperatively. The heparin can then be stopped 6 to 12 hours preceding the operation, and restarted postoperatively when the risk of surgical rebleeding is minimal. One approach is to restart heparin at half dose 12 hours postoperatively, increasing it to full dose in several days.

Loose control is reasonable for patients who have prosthetic aortic valves as well as those in whom the indication for anticoagulation is tenuous, such as persons with remote histories of transient ischemic attacks or of deep venous thrombosis. In such patients, warfarin can be stopped three to four days before surgery and restarted several days postoperatively without intercurrent heparinization. Actually, most major surgical procedures can be safely performed on patients who are taking warfarin, with the exception of operations involving the eye, the central nervous system, and the liver.[49] Conversely, most patients can probably remain safely off all anticoagulation for four or five days perioperatively,[47, 48] with the possible exceptions of the high-risk groups listed above. As mentioned, dental procedures can be safely performed without discontinuing chronic anticoagulant therapy.[29, 30]

Prophylaxis of thromboembolism can benefit certain subsets of surgical patients. Detailed recommendations have been recently published[50] and are summarized in Table 3. In brief, there are five high-risk operative categories: general surgery, orthopedic surgery, urology, gynecology, and neurosurgery. Postoperative deep venous thrombosis (DVT) occurs in around 25 per cent of patients undergoing these types of procedures (40 per cent or more in hip surgery, knee reconstruction, gynecologic cancer operations, open prostatectomies, and major neurosurgical procedures). Incidences of fatal pulmonary embolism vary with the frequency of DVT and range from 1 per cent to 5 per cent. Prophylaxis is recommended for patients more than 40 years old and for younger patients with other risk factors, such as cancer, obesity, recent immobilization, hypercoagulable states, and venous stasis. Prophylaxis is continued for five to seven days, or until the patient is ambulating.

Low-dose heparin is the standard regimen.[51] Best studied in patients over 40 years of age undergoing major elective abdominal and thoracic operations, heparin is also recommended for most gynecologic and urologic procedures. Low-dose heparin has been less beneficial in orthopedic patients undergoing elective hip surgery or knee reconstruction. For such patients, one should recommend low-dose warfarin,[52] adjusted-dose heparin,[53] dextran,[54] dihydroergotamine–heparin,[55] or external pneumatic compression.[56] In operations involving intracranial lesions, safety considerations have generally prevented the use of heparin, although one study reported that the use of low-dose heparin in 150 elective neurosurgical operations did not result in any bleeding complications.[57] Currently, however, the recommended methods for prophylaxis for intracranial procedures are physical measures, such as pneumatic compression boots.[56] Finally,

TABLE 3

Prophylaxis of Thromboembolism in Surgical Procedures

Type of Surgery	Prophylaxis*	Regiment†
General	Low-dose heparin	5,000 units SQ, *bid* to *tid*
Urology‡	Low-dose heparin	5,000 units SQ, *bid* to *tid*
Gynecology‡	Low-dose heparin	5,000 units SQ, *bid* to *tid*
Neurosurgery		
Extracranial	Low-dose heparin	5,000 units SQ, *bid* to *tid*
Intracranial	Pneumatic compression	
Orthopedic (hip surgery and knee reconstruction)	Two-step warfarin	Begin ten days before surgery, keeping PT only 2–3 sec prolonged; give about twice the preop dose after surgery to increase PT to about 1.5 times control
	Adjusted-dose heparin	Begin two days before surgery at 3,500 units *tid*. Check PTT 6 hr after morning dose, and increase or decrease heparin by 500 to 1,000 units to keep PTT in 30- to 40-sec range
	Dihydroergotamine–heparin (Embolex)	2 hr preop and *bid* postop
	Dextran-40	Give 10 ml/kg as 12 hr IV infusion on day of surgery, followed by 7 ml/kg/day as constant infusion for five days; use cautiously if history of heart failure
	Pneumatic compression	

*Indicated for all patients >40 years old and those ≤40 years old who have one or more risk factors: hypercoagulable state; stasis (heart failure, myocardial infarction, anasarca); obesity; immobilization; cancer; estrogen therapy; sepsis; history of thromboembolic events.

†Duration of prophylaxis should be five to seven days, or until ambulatory.

‡For open prostatectomies and for gynecologic cancer operations, consider stronger prophylaxis, such as one of the orthopedic regimens.

studies to date have not included vascular operations. Excessive bleeding might be at least a theoretical concern with anticoagulant regimens, and pneumatic compression might be cumbersome following revascularization of the lower limb. Therefore, advice regarding DVT prophylaxis in vascular procedures awaits further research.

ENDOCRINOLOGIC RISKS AND MANAGEMENT

Diabetes mellitus is the most prevalent endocrine disorder in surgical patients. Other than hyperglycemia itself, the most common postoperative complications in the diabetic patient are infection (wound or urinary tract) and cardiovascular events (myocardial infarction or congestive heart failure).[58, 59] The day of surgery pits the glucose-depleting effects of not eating versus the hyperglycemia resulting from operative stress.

Patients being treated with insulin as outpatients should probably receive some insulin preoperatively, but in a reduced dose. Many regimens have been proposed.[5, 58-64] One popular method is to administer half of a patient's usual morning dose of intermediate-acting insulin before surgery. Some have advocated a "no glucose – no insulin" regimen before minor procedures.[59, 60] If any insulin is given preoperatively, the patient should also be maintained on a glucose-containing intravenous infusion (e.g., D_5W at 125 ml/hr) to prevent hypoglycemia. Whatever the regimen selected, blood glucose should be determined postoperatively and short-acting insulin should be administered as needed.

Most of the proposed regimens do not result in tight intraoperative glucose control. A recent study demonstrated that the blood glucose was better regulated when preoperative administration of intermediate-acting insulin was supplemented by hourly doses of short-acting insulin.[61] The insulin was administered intraoperatively according to a formula based upon hourly determinations of blood glucose. However, it remains to be shown that such intensive management is feasible for the thousands of diabetic patients undergoing operations each year. Continuous infusion of insulin, popularized in recent years for the management of diabetic ketoacidosis, has also been advocated for tighter intraoperative control of blood glucose.[62, 63] However, this introduces into the operating room still another infusion system that requires monitoring. Furthermore, excessive infusion rates may precipitate hypoglycemia.[62]

How tightly blood sugar should be controlled in the surgical patient is an unsettled issue. Although results of animal studies suggest that poorly controlled diabetes may impair wound healing,[65] convincing human data are lacking. Certainly, there is little proof that tight control is better than moderate control.

Patients receiving chronic oral hypoglycemic therapy can usually be maintained on their oral agents, although perioperative insulin may be considered if the blood glucose exceeds 13.88 to 16.65 mmol/l (250 to 300 mg/dl). Long-acting sulfonylureas, namely chlorpropamide, should be stopped three days before surgery to avoid perioperative hypoglycemia. Shorter-acting agents can be discontinued the day prior to surgery.

The surgical considerations regarding obese patients,[66] patients with thyroid disease,[5, 67, 68] and those who require perioperative corticosteroids[5, 69] are discussed elsewhere. Obesity by itself is probably only a mild surgical risk factor, and preoperative weight loss, cessation of smoking, attention to pulmonary and cardiac function, and prophylactic heparinization may further reduce the risk.[66] Likewise, mild to moderate hypothyroidism, even when untreated, seems to be well tolerated by the surgical patient.[67, 68] The possibility of adrenal suppression should be entertained in the management of any patient who has been on steroids for a week or more in the 12 months preceding an operation, although one small study suggested that the risk may be minimal if the patient has been off steroids for more than two months.[69]

HEPATIC RISKS AND MANAGEMENT

The greatest operative risk relating to the liver occurs in patients with chronic liver dysfunction, particularly those with progressive hepatic failure. Child developed a rating system for predicting the risks of surgery in patients undergoing portosystemic shunting.[70] Some assert that Child's risk factors are prognostically useful in non-shunt operations, as well.[71] Table 4 outlines Pugh's modification[72] of Child's system. Patients with 5 to 6 points are considered low risk; with 7 to 9 points, medium risk; and with 10 to 15 points, high risk. However, Pugh developed this grading system based on a data set of only 38 patients, all of whom were operated on for bleeding varices.

Other investigators contend that clinical and laboratory features cannot accurately predict the surgical risks in patients with liver disease.[73] In a recent study involving 38 patients, investigators showed that the aminopyrine breath test predicted surgical risks better than Child's classification did.[74] This breath test, however, is not widely available. More research is needed to better define the validity of the above-mentioned criteria, to identify other potential risk factors, and to assess the generalizability of suggested criteria to various types of operations.

Preoperatively, the medical consultant should concentrate on correcting clotting and electrolyte abnormalities, reducing ascites, alleviating encephalopathy and improving nutritional status.[73, 75] Postoperative complications include pulmonary

TABLE 4

Modified Child's Index for Grading Severity of Liver Disease*

Clinical or Laboratory Feature	Points Scored for Increasing Abnormality†		
	1	2	3
Encephalopathy	None	Mild–moderate	Severe
Ascites	None	Slight	Moderate
Bilirubin	<34.2 μmol/l (<2 mg/dl)	34.2–51.3 μmol/l (2–3 mg/dl)	>51.3 μmol/l (>3 mg/dl)
Albumin	>35 g/l	28–34 g/l	<28 g/l
Prothrombin time (prolonged)	<4 sec	4–6 sec	>6 sec

*Adapted from Pugh et al.[72]
†Patients with 5 to 6 points are considered good operative risks; with 7 to 9 points, moderate risks; and with 10 to 15 points, poor risks.

events (atelectasis; pneumonia), renal abnormalities (hepatorenal syndrome; acute tubular necrosis), bleeding (wound site; gastrointestinal), encephalopathy, and impairment of wound healing.[76] The patient's volume status must be closely monitored, since liver failure predisposes to volume overload as well as to dehydration. Certain laboratory determinations (hemoglobin, prothrombin time, creatinine, electrolytes, and liver function tests) should be followed. Drugs, particularly pain medication, sedatives, and diuretics, need to be used cautiously to avoid iatrogenic deterioration.

Acute hepatitis is a relative contraindication to surgery, although the risk is not well quantitated.[71, 77] A prudent recommendation is to avoid elective surgery in patients with hepatitis, waiting until a month after liver function tests have returned to normal.[76] In chronic active hepatitis, one might consider delaying elective operations until the disease has been stable for at least three months.[76]

General anesthetics are said to be hepatotoxic, but this reputation is undeserved. Although minor elevations in transaminases are common following surgery, the cause is most likely the reduction in hepatic blood flow caused by anesthetics as well as the operation itself.[78] Some anesthetics, such as halothane and methoxyflurane, produce greater reductions in hepatic blood flow than do others. Halothane only rarely causes severe hepatic disease. The type of operation may contribute much more to postoperative hepatic dysfunction than does the type of anesthesia.[2-4] Thoracic and upper abdominal operations, in particular, may elevate transaminases in 65 per cent to 90 per cent of patients. Most perturbations in liver function tests following surgery are slight and short-lived. Patients with pre-existent liver disease, however, tend to have more frequent and more serious abnormalities.[78] Finally, although ethanol is the leading hepatotoxin in the United States, other organs may also be functionally impaired in chronic alcoholism. Surprisingly, there is a paucity of clinical research regarding the perioperative management of the alcoholic patient.[79]

RENAL RISKS AND MANAGEMENT

Surgical procedures can generally be performed safely on patients with chronic renal disease if precautions are taken to prevent acute renal failure.[80-82] The surgical complications of renal disease depend primarily on the severity of rather than the type of disease. Whether renal insufficiency is glomerular or interstitial or obstructive, it is the decline in creatinine clearance that causes concern. Likewise, in nephrotic syndrome, it is the amount of azotemia rather than the degree of proteinuria that determines the operative risk.[80] As the glomerular filtration rate approaches 25 ml/min, the complication rate rises.

Three cations deserve particular attention. Total body *sodium*, the determinant of a patient's volume status, must be meticulously managed. Excessive sodium loads can lead to hypertension, heart failure, and edema, while a sodium deficiency results in hypovolemia and declining renal function. The serum *potassium* concentration can rise to dangerous levels in renal insufficiency: it is ideally maintained at a level less than 5.0 (but greater than 3.5) mmol/l in the perioperative setting. *Hydrogen* ion is the third cation that accumulates as renal function declines. If serum bicarbonate is less than 18 mmol/l, an arterial blood gas determination should be obtained. Mild acidosis can be treated by the administration of bicarbonate combined with intraoperative hyperventilation. If any of the three cations accumulates despite conservative measures and the operation is deemed necessary, preoperative dialysis may be necessary.

Additional factors to consider include hemoglobin, free water, blood pressure, drug dosages, and excessive bleeding. Anemia becomes more common as renal function declines, yet the anemia is well tolerated. Transfusions are seldom needed when the hematocrit is more than 25 per cent.[81, 82] Hyponatremia indicates an excess in free water. Fluid restriction and the avoidance of hypotonic intravenous solutions are indicated if the serum sodium drops to 125 mmol/l or less. Hypertension in renal patients is often volume-dependent, in which case the administration of loop diuretics may suffice. The usual antihypertensive medications can also be used but, if these fail, dialysis or ultrafiltration may be necessary. Anesthetics as well as all other medications must be administered in appropriately modified doses.

Excessive bleeding is a major consideration only in patients who have uncontrolled azotemia (due to platelet dysfunction) and in those on dialysis (because of the anticoagulant present in dialysates). Platelet dysfunction can be lessened by dialysis. Additionally, preoperative infusions of cryoprecipitate, deamino-8-D-arginine vasopressin (DDAVP), or conjugated estrogens may reduce bleeding in uremic patients.[83-85] Ten bags of cryoprecipitate[83] or 0.3 μg/kg body weight of DDVAP[84] are infused immediately preoperatively. The DDVAP is administered in 50 ml of saline over a 30-minute period, with careful monitoring of blood pressure and plasma osmolarity. Conjugated estrogens are administered as daily infusions of 0.6 mg/kg for five consecutive days before surgery.[85] The effect of estrogens lasts for 14 days, that of cryoprecipitate for 12 to 18 hours, and that of desmopressin for 4 hours.

Dialysis is best avoided in the 4 hours preceding surgery. However, a lengthy dialysis-free period preoperatively can lead to hazardous levels of serum potassium. Therefore, it is recommended that patients on maintenance hemodialysis be dialyzed within 24 hours of their operations.[81, 82] Postoperatively, the most common complications in dialysis patients relate to hyperkalemia, blood pressure (too high or too low), and pulmonary (atelectasis or pneumonia) and hematologic (excessive bleeding or shunt clotting) events. Wounds generally heal well, with about a 5 per cent to 10 per cent infection rate.[81, 82] Any patient with a vascular access requires antimicrobial prophylaxis to prevent endarteritis. Recommendations are similar to those for preventing endocarditis (Table 2). Furthermore, the arm with the vascular access should not be used for intravenous lines, blood drawing, or blood pressure readings.

PROPHYLACTIC ANTIBIOTICS

The preoperative administration of antibiotics to prevent subsequent infections is usually initiated by the surgical team independent of medical consultation. However, since antimicrobial prophylaxis is used in as many as 20 per cent of surgical patients,[3] it behooves the consultant to be familiar with the indications for antibiotic use. The risk of wound infection depends largely on the type of operation.[2, 3] *Clean* operations are ones in which the gastrointestinal, genitourinary, and respiratory tracts are not entered, asepsis is maintained, and there is no inflammation. The risk of infection in a clean operation is 5 per cent. *Clean-contaminated* operations are those in which the gastrointestinal, genitourinary, or respiratory tract is entered but there is minimal spillage of its contents. Infection rates are approximately 10 per cent in such operations. *Contaminated* operations are those in which inflammation but no pus is found, major breaks in asepsis or gross spillage from a hollow viscus have occurred, or a fresh traumatic wound is repaired. The risk of infection in contaminated operations approaches 20 per cent. *Dirty* operations are those involving an abscess, purulent material, a perforated viscus, or the repair of an old traumatic wound (one more than 4 hours old). Dirty operations may result in wound infections 30 per cent of the time or more often.

Prophylactic antibiotics are generally not indicated for clean operations unless the consequences of an infection could be disastrous. For example, although insertion of a prosthetic joint or cardiac valve is a clean procedure, infections of such devices can result in major morbidity or mortality. Prophylactic antibiotics have their primary role in clean-contaminated procedures. Although antibiotics are almost always used in contaminated and dirty operations, their use in such procedures is therapeutic and not prophylactic. Recommendations are summarized in Table 5, which is adapted from a comprehensive review.[86] Current evidence does not support routine antimicrobial prophylaxis in urologic (unless the urine is infected), ophthalmologic, or clean neurosurgical procedures.

A prophylactic antibiotic is chosen on the basis of the most likely organisms involved in wound infections for a given type of operation. The primary purpose of antimicrobial prophylaxis is to prevent wound infections. Despite preoperative antibiotics, pneumonias and urinary tract infections will still occur. The most common error in prophylaxis has been in timing. To be optimally effective, antibiotics are administered just before and for one to two days after an operation. More prolonged postoperative administration is no more effective and can lead to drug toxicity and superinfection.

PREOPERATIVE LABORATORY TESTS

What tests should be obtained in managing a patient prior to surgery? Actually, few tests should be ordered solely because an operation is planned. In the absence of clinical signs, symptoms, or risk factors for a disease, routine tests are usually normal, or when abnormal are frequently ignored. Even abnormal tests that are pursued often prove to be either "false positives" or clinically unimportant. The ordering of a standard battery of preoperative tests is probably no longer justified.[4, 87, 88] Studies focusing

TABLE 5

Recommended Antimicrobial Prophylaxis for Common Surgical Procedures

	Recommended Regimen*		
Type of Surgery	Antibiotic	Preoperative	Postoperative
Gynecologic			
Cesarean section	CFZ	1 g	1 g at 6 and 12 hr
Hysterectomy	CFZ	1 g	1 g at 6 and 12 hr
Orthopedic			
Arthroplasty of joints, including replacement	CFZ	1 g	1 g *q* 6 hr (3 doses)
Open fracture reduction, routine	CFZ	1 g	1 g *q* 6 hr (3 doses)
Open fracture reduction, complex	CFZ	1 g	1 g *q* 8 hr (10 days)
Amputation, lower limb	CFX	2 g	2 g *q* 6 hr (4 doses)
General surgery			
Cholecystectomy†	CFZ	2 g	None
Colonic surgery, routine	‡	‡	None
Colonic surgery, emergency	CFX	2 g	2 g *q* 4 hr (3 doses)
Appendectomy, routine	CFX	2 g	2 g *q* 6 hr (3 doses)
Appendectomy, perforated	CFX	2 g	2 g *q* 8 hr (3–5 days)
Gastric resection§	CFZ	1 g	None
Otolaryngologic			
Incision through oral or pharyngeal mucosa	CFZ	1 g	1 g *q* 6 hr (3 doses)
Cardiothoracic and vascular			
Cardiac	CFZ	1 g	1 g *q* 6 hr (48 hours)
Thoracic	CFZ	1 g	1 g *q* 6 hr (24 hours)
Peripheral vascular	CFZ	1 g	1 g *q* 6 hr (24 hours)
Neurosurgical			
Craniotomy¶	Clindamycin	300 mg	300 mg at 4 hr (once)

*All doses are intravenous. CFZ = cefazolin. CFX = cefoxitin. For patients with beta-lactam allergy, see more detailed recommendations in Kaiser,[86] from which this table is adapted.

†Only for "high-risk" patients—i.e., those more than 60 years old, or in those with acute symptoms, jaundice, or prior biliary surgery.

‡Neomycin and erythromycin, 1 g of each orally at 1, 2, and 11 PM on the day before surgery.

§Only for "high-risk" patients—those with a bleeding or obstructed duodenal ulcer, a gastric ulcer or cancer, or morbid obesity.

¶Only for "high-risk" procedures—e.g., reexploration and microsurgery.

on specific tests have indicated that the chest roentgenogram,[89] the electrocardiogram,[90] the prothrombin time and partial thromboplastin time,[91,92] and the bleeding time[45] may not be justified as routine preoperative tests. After a cost-benefit analysis, Robbins and Mushlin concluded that only the complete blood count and the urinalysis seemed indicated for every patient.[4] Evidence for the urinalysis, however, was weak, and in one preliminary report the value of a urinalysis before low-risk procedures was questioned.[93] It has become increasingly apparent that tests should be ordered for specific clinical indications rather than because a patient enters the clinic, the hospital, or the operating room.

THE ART OF CONSULTATION

Consultation involves not only the formulation of a management plan by the consultant for a patient, but also the art of persuading the surgeon to comply with this plan. Advice is not compulsory: it can be followed or ignored. Much of the literature in consultative medicine deals more with the interactions between consultant and consultee than with the management of specific medical problems.[94-97] Such research has provided useful guidelines regarding how the medical consultant might optimize compliance with his or her advice:

1. Limit the number of recommendations to five or fewer.
2. Focus on crucial recommendations. Try to avoid diluting the management plan with trivial suggestions.
3. Be specific, especially regarding drug dosages. Recommend not only which drug to start, but the dose and the frequency of administration as well.
4. Advice regarding therapy (e.g., starting or stopping drugs) is more often heeded than diagnostic suggestions (e.g., ordering tests).
5. Labor-intensive advice, i.e., that which requires the surgeon to do something himself (look at a smear; perform a procedure; etc.) is poorly heeded. If such tasks must be performed, the medical consultant should consider doing them personally.
6. Oral communication with the surgeon may enhance compliance.
7. Follow-up visits and notes further improve compliance.

There is also an art to communicating one's assessment and plan. A three-stepped approach—"Dx/Rx/Prx" (diagnosis, treatment, prognosis)—is suggested. Regarding *Dx*, or diagnosis, the consultant creates a problem list. This list is a table of contents for anyone caring for the patient and is particularly useful to the anesthesiologist and the surgeon. The consultant may uncover pertinent problems of which the operating team is unaware. Again, only important problems should be highlighted. The internist's compulsion to be complete should be harnessed so that crucial problems are not buried in a largely unread tome.

Regarding *Rx*, or treatment, the consultant offers recommendations that will diminish the surgical risks associated with the patient's problems. The emphasis here is on "diminished surgical risk." Diagnostic tests that could be done after hospital discharge, treatment that in the long term may be beneficial but that is not crucial for this operation, patient education and health promotion, all are best excluded from preoperative recommendations. They should be relegated to outpatient follow-up instead.

Regarding *Prx*, or prognosis, the consultant states the surgical and anesthetic risk of each problem. The available literature will allow more accurate assessments of the operative risks for some problems than for others. Where research is meager, the consultant will have to substitute his or her judgment. Even when certain problems have objective criteria by which to assess operative risks, research is lacking regarding how to quantitate the overall risk in the presence of multiple problems. What is the cumulative risk of a patient with cardiac, pulmonary, and liver disease? Furthermore, at what point does the total risk become prohibitive?

Although preoperative consultation has been practiced for a long time, the emphasis on better evaluating medical problems in terms of operative and anesthetic consequences and on communicating the consultant's recommendations in an effective manner is more recent. Medical educators must now decide how best to transmit this growing body of knowledge to housestaff and students. The experience of consultative services in several teaching hospitals has been published.[3, 4, 98, 99] An understanding of what is commonly seen will facilitate curriculum development. A knowledge of the literature will also reveal the many areas in which further research is needed. The science and the art of preoperative evaluation will improve most rapidly through the joint efforts of those involved in patient care, education, and clinical research.

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