PERIOPERATIVE MANAGEMENT

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To
Seymour Breslow, Gerald Rosenberg,
and our families

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Preface

This book is very much a personal statement. In it we address the various factors responsible for adverse outcomes in patients who present for surgery. The belief that clear-cut mistakes in either anesthetic or surgical technique are only rarely responsible for perioperative complications is central to this text. We believe that the end-organ effects of anesthetic drugs and the neurohumorally induced changes in physiologic function induced by surgical trauma interact with preexisting disease states to produce morbid events. While this statement seems simple, it runs counter to the standard manner of care for patients in the perioperative period. Historically, anesthesiologists have focused on adverse effects associated with the various anesthetic agents and techniques, surgeons have focused on complications as a function of specific surgical procedures, and internists have attempted to correlate various preexisting medical conditions with perioperative complications. These different perspectives in most institutions result in internists medically preparing patients for surgery and attesting to their readiness, anesthesiologists assuming responsibility for intraoperative care, and surgeons operating and delivering care postoperatively. We believe that this system is flawed; not only is care fragmented, but more importantly, it does not allow the multidisciplinary approach to patient care that is necessary for an optimal perioperative outcome. Rather, internists need to better understand the effects of anesthetics and surgery and follow patients beyond the double doors leading into the operating room. Anesthesiologists need to better appreciate how specific disease states alter responses to specific anesthetics, and how different management approaches affect the postoperative course. And surgeons must learn to appreciate differences in patient responses to surgical procedures as a result of specific preexisting medical conditions, and must increase their knowledge concerning the beneficial and adverse effects of different anesthetic practices.

This text presents a multidisciplinary approach to the care of the surgical patient. The first section consists of general concepts of preoperative, intraoperative, and postoperative care. The remainder of the book addresses specific medical problems, identifies ways in which they increase perioperative risk, and discusses how these factors necessitate alterations in standard anesthetic and surgical techniques. For each disease we have outlined what we believe to be the essential patient management issues, and have critically reviewed the relevant literature from the fields of medicine, anesthesia, and surgery. Where adequate studies are not available, this is clearly indicated. This is not a "how to" book. Rather we identify ways in which perioperative events interact with preexisting disease states. It is our conviction that only through this type of approach can we improve patient outcome.

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PART ONE

PREOPERATIVE EVALUATION

CHAPTER 1

Preoperative Screening Tests

TERI A. MANOLIO

Preoperative screening tests are often ordered according to a standard checklist, with little consideration given to their indications or implications. While adequate preoperative evaluation is a necessary adjunct to a smooth perioperative course, adequacy is frequently confused with exhaustiveness. Traditional attitudes regarding preoperative tests are summarized in the 1976 edition of Collins' *Principles of Anesthesiology*:[7] "Certain laboratory procedures are necessary in the evaluation of any patient preoperatively. These procedures should be considered as screening tests and whenever a positive finding appears, it must be explored and further detailed examinations carried out." The reasons that such beliefs have been questioned, the rationale behind a more directed approach to preoperative testing, and the specifics of such an approach are the topics of this chapter.

REASONS TO LIMIT PREOPERATIVE TESTS

Accuracy of a Test and the Problem of False Positives

No diagnostic test is perfect, as everyone knows. The accuracy of a test can be defined as its ability to distinguish persons with a disease from persons without a disease. Various terms have been devised to characterize the accuracy of a test, such as its validity, reproducibility, precision, sensitivity, specificity, and predictive value. The latter three are most commonly used in the clinical setting and will be described here. Other sources offer a more detailed discussion of the clinical usefulness of a diagnostic test.[39]

The sensitivity of a test is the probability of a positive test result given that the patient has the disease being sought. It reflects the ability of the test to detect the disease correctly. Specificity is the probability of a negative test result given that the patient does not have the target disease. It reflects the ability of the test to rule out the disease correctly. These terms are more easily understood in the context of a 2 × 2 table:

	Disease present	**Disease absent**	
Test positive	a	b	a + b
Test negative	c	d	c + d
	a + c	b + d	

Sensitivity is therefore equal to:

$$\frac{\text{a (those with positive test results with disease)}}{\text{a + c (all those with disease)}}$$

Specificity is equal to:

$$\frac{\text{d (those with negative test results without disease)}}{\text{b + d (all those without disease)}}$$

Cell c represents those persons who have the disease but whose test results were negative; they are referred to as "false negatives." The false negative rate of the test can be calculated as:

$$\frac{\text{c (those with negative test results but with disease)}}{\text{c + d (all those with negative test results)}}$$

Similarly, cell b represents those persons who do not have the disease but whose test results were positive; they are referred to as "false positives." The false positive rate of the test can be calculated as:

$$\frac{\text{b (those with positive test results but without disease)}}{\text{a + b (all those with positive test results)}}$$

Note that if the test were perfect, sensitivity and specificity would be 100% and there would be *no* false positives or false negatives. Cells b and c would both be empty.

Finally, the positive predictive value of a test is defined as the probability of having the disease given that the test is positive. It is equal to:

$$\frac{\text{a (those with positive test results with disease)}}{\text{a + b (all those with positive test results)}}$$

Similarly, the negative predictive value is the probability of being free of the disease given that the test is negative, or:

$$\frac{\text{d (those with negative test results without disease)}}{\text{c + d (all those with negative test results)}}$$

In clinical medicine, we most commonly use tests for their predictive value; that is, we obtain a test to rule in disease (relying on its positive predictive value) or rule out disease (relying on its negative predictive value). Although predictive value obviously varies with the accuracy of a test (as reflected by its sensitivity and specificity), what is not so obvious is that predictive value *also varies with disease prevalence*. Any test that has less than 100% sensitivity and specificity (almost all do) will lose predictive value as disease prevalance drops. The mathematical formulation of this concept is known as Bayes' theorem, and the understanding of it is critical in using and interpreting diagnostic tests. For a more detailed discussion of Bayes' theorem, the reader is referred to Ingelfinger et al.[17]

To illustrate the concept of dependence of predictive value on disease prevalence, consider the following three situations:

1. *You have a test that is 90% sensitive and 90% specific for detecting a disease. You apply this test in 1000 members of population A, which has a 70% prevalence of the disease. The following 2 × 2 table will be generated:*

	Disease present	**Disease absent**	
Test positive	630	30	660
Test negative	70	270	340
	700	300	

Positive predictive value = 630/660 = 95.5%
Negative predictive value = 270/340 = 79.4%

2. *Next, you apply the same test to a population with a 20% prevalence of disease:*

	Disease present	**Disease absent**	
Test positive	180	80	260
Test negative	20	720	740
	200	800	

Positive predictive value = 180/260 = 68.2%
Negative predictive value = 720/740 = 97.3%

Note that your positive predictive value has dropped considerably, although the negative predictive value is increased. Also notice that the number of false positives has almost tripled (from 30 to 80).

3. *Finally, you apply the test in a population with a 2% prevalence of disease:*

	Disease present	Disease absent	
Test positive	18	98	116
Test negative	2	882	884
	20	980	

Positive predictive value = 18/116 = 15.5%
Negative predictive value = 882/884 = 99.8%

Note now that the number of false positives (98) outnumbers the true positives by more than 5 to 1, leaving a positive predictive value of only 16%. This means that only 16% of those with a positive test will actually have the disease! Negative predictive value in this instance is quite good, at 99.8%, but it is really already known (from the 2% prevalence) that 98 out of 100 persons will be disease free.

Understanding the relationship between disease prevalence and sensitivity/specificity/predictive value is crucial to the rational application of diagnostic tests. The indiscriminate use of diagnostic tests can produce far more false positives than it identifies true cases of disease, particularly when you are screening for disease that is not evident by clinical examination and thus has a low prevalence. Investigation of these false positives in the preoperative period leads to needless delay, increased costs of further testing, and, worst of all, completely unnecessary anxiety on the part of the patient.

Costs of Preoperative Testing

The effects of routine preoperative screening tests on medical care costs are difficult to estimate. In addition to the cost of performing the test, one must consider the cost of delayed surgery and prolonged hospitalization because of false positive results and the cost of further testing to establish or exclude a diagnosis. Obviously, delays and increased costs may also result from failure to order a test, perhaps leading to complications from an unidentified disease. However, evidence that routine screening tests in an asymptomatic population have a beneficial effect on patient outcome is hard to produce.[4,9,20]

Perhaps the best study of the effects of routine screening comes from a controlled trial of multiphasic screening in a British hospital.[10] In this study, patients were assigned either to have their test results routinely reported back to their attending physicians, or to have the results withheld and available only upon request. Patients in whom results were routinely reported had 32% more requests for repeat testing than did patients in whom results were only available by request. The routine reporting group also had 15% more follow-up tests not included in the screening battery, and 25% more consultations for a second clinical opinion. There was no difference between groups in length of hospital stay, and no obvious difference in patient outcome. Testing charges were 64% higher in the routine reporting group, and total hospital charges were approximately 5% higher.

Diagnostic Versus Screening Tests

All this is not to say that no preoperative tests should be performed, nor that there are not valid indications for some screening tests in almost all preoperative patients. To determine which tests are indicated, one must first discriminate between screening tests designed to detect occult or asymptomatic disease not suggested by the clinical presentation and diagnostic or confirmatory tests performed in patients with obvious signs and symptoms. The latter category, often referred to as "indicated" tests, includes those performed for the following reasons:

1. To evaluate a known condition to choose appropriate surgical therapy; for example, metastatic work-up before pulmonary resection for lung cancer
2. To evaluate a known condition to choose appropriate anesthetic therapy; for example, pulmonary function tests before deciding on type of anesthesia in patients with lung disease
3. To monitor the status of a known condition: for example, blood glucose in a diabetic or blood gases in a patient with lung disease
4. To confirm diagnosis suspected on clinical grounds; for example, chest x-ray and sputum in a patient with signs of pneumonia or urinalysis in a patient with symptoms of urinary tract infection

Screening tests, on the other hand, are tests performed without signs and symptoms to detect preclinical or asymptomatic disease. Such tests in nonsurgical patients would include periodic screening for occult blood in stools, glucose in urine, or elevated cholesterol in serum. In the preoperative period, such screening should be designed to detect occult disease that could have a direct bearing on operative risk and outcome. Robbins and Mushlin have described five criteria for useful preoperative screening tests[34]:

1. *The condition tested for must be asymptomatic and not obvious on routine history and physical examination.*

That the history and physical examination establish far more diagnoses than any laboratory test has been demonstrated repeatedly. Crombie[8] showed that 88% of diagnoses were made following a history and physical examination. Sandler showed that correct diagnoses would be made in 57% of medical outpatients following the history alone, in a further 17% following the examination, and in only another 5% following routine laboratory tests. The clinical examination performed best in patients with cardiovascular and neurologic disease and poorest in endocrine and digestive diseases.[41] Similar results were obtained by Hampton et al, who established diagnoses in 71 of 94 conditions on the basis of the clinical examination alone.[14] Therefore, the most important and useful screening test is the attentive clinical examination. Recall from the previous discussion of disease prevalence that screening tests are of necessity low in predictive value and high in false positives, because of the low prevalence of most diseases in their clinically silent forms.

2. *The condition must significantly affect the morbidity or mortality of surgery or must represent a significant risk to those associated with the patient's care.*

Conditions with a known or suspected detrimental effect on surgical outcome include anemia, ischemic heart disease, cardiac arrhythmias, chronic obstructive pulmonary disease, diabetes, chronic nephritis, urinary tract infection, clotting disorders, thrombocytopenia, nephrotic syndrome, and chronic interstitial lung disease. Conditions that put those caring for the patient at risk include tuberculosis, viral hepatitis, and HIV infections. The ethics of routine HIV testing in preoperative patients are complex and hotly debated; such a discussion is beyond the scope of this chapter. The reader is referred to Kunkel for an in-depth discussion.[22]

3. *Preoperative diagnosis must be more beneficial to management than a diagnosis established in the perioperative or postoperative period, even though detection might not necessarily affect the outcome of surgery.*

Such conditions might include glaucoma, gonorrhea, hepatitis, hypercholesterolemia, malignancy, and urinary tract infection (in procedures not involving insertion of a foreign body). Patients undergoing surgery for a specific condition whose health maintenance has been irregular or poor in the past do present the opportunity to perform some routine testing that they might otherwise go without. Whether the surgeon or other members of the perioperative team are obligated to perform such testing within the limitations of a surgical encounter is a difficult issue; one must balance the long-term interests of the patient with the short-term goals of treatment of the surgical illness. Few would argue with a urologist's obligation to test stool for occult blood after performing a prostate examination in preparation for prostatic surgery. Less clear is the responsibility, for example, to screen for cervical or colon cancer in patients without surgical illness in those organ systems. A prudent approach, dictated more by experience than by hard evidence, is to recommend to the patient that routine health maintenance be performed at regular intervals (using the guidelines of the Canadian Task Force on the Periodic Health Examination[43] or the American College of Physicians Medical Practice Committee[25] and to offer such testing as is within the abilities of the perioperative team to perform. As long as the attending surgeon makes it clear that further management of any abnormalities detected must be carried out by another health care provider (one recommended by the surgeon, if the patient so desires), reasonable care can be provided at this "therapeutic opportunity" without delay or unreasonable expense. It should be strictly borne in mind, however, that whenever such testing is performed it is the ordering physician's legal and ethical responsibility to obtain the test results, inform the patient, and provide adequate follow-up.

4. *Tests must be sufficiently specific and sensitive to allow detection of the condition.*

As discussed in the preceding section, the performance of a test must always be considered before ordering it. This is such an obvious criterion that it often goes unstated; therefore, it may also often be overlooked. While no test is perfect, many of the preoperative tests currently ordered are quite inefficient at detecting their target diseases, or are ordered for persons in whom their interpretation may be difficult. The routine electrocardiogram is a good example of a widely used screening test for coronary artery disease that has a poor sensitivity (27%) and low specificity (81%).[24] Its interpretation may be further complicated by the use of digitalis or the presence of conduction blocks or electrolyte imbalance. While this does not mean that an ECG should never be ordered to detect occult coronary disease, it does mean that use of the test must be tempered by an understanding of the patient groups in which it performs the best.

5. *Prevalance of the condition must be high enough that efficient detection of an asymptomatic patient with the condition is possible.*

Even a test with almost perfect sensitivity and specificity will be of little use if the disease sought is vanishingly rare. A good example of such a test is the partial thromboplastin time to detect an asymptomatic bleeding disorder. Such disorders (in their totally asymptomatic form) have a prevalence of about 1 per 100,000. The test is 99% sensitive and 72% specific at detecting them, but at $10 apiece, $1 million in tests must be performed to detect one case.[34] That $1 million might more reasonably be spent in other ways.

YIELD OF FREQUENTLY USED PREOPERATIVE TESTS

Recommendations for routine preoperative tests most commonly include an electrocardiogram, serum electrolytes, glucose and urea nitrogen, complete blood count with differential, and a urinalysis. Chest x-ray examinations, liver function tests, and clotting times are often added as well. Each of these tests will be dealt with in turn.

Electrocardiogram

One of the most routinely ordered and frequently abnormal preoperative tests is the resting electrocardiogram (ECG).[6] In a study of 1410 admission electrocardiograms performed on the Duke University medical service, only 360 (26%) were totally normal.[26] Many of the abnormalities found were nonspecific, however, and when study members reviewed hospital records and ECGs, only 52 patients (4%) were deemed to have useful information added by the admission ECG. Because this was a medical population, often admitted for cardiac-related complaints, the yield in preoperative patients might be expected to be even lower. Of the more than 800 patients in the Duke study who had no evidence of a cardiovascular abnormality, the ECG provided added information in only eight patients, or less than 1%. The only factors associated with an increased yield of the test were the patients being over 45 years of age and presence of a clinically evident cardiac abnormality. Moorman et al concluded that ". . . the routine admission ECG infrequently added new information to the clinical evaluation, but was useful when it did." Its estimated cost-effectiveness, while believed to be low, was comparable to that of many other accepted medical practices.

Fewer studies have addressed the use of routine ECGs in surgical patients, but one study of 1068 patients found a 19% prevalence of abnormalities, 56% of which were nonspecific repolarization abnormalities or left anterior fascicular block, which have little effect on the outcome of surgery.[12] The incidence of abnormalities was observed to increase steadily with patient age. A later series of 198 patients undergoing major noncardiac surgery showed that an abnormal preoperative electrocardiogram was independently associated with increased risk of perioperative course complicated by death, myocardial infarction, or myocardial ischemia. Both ST-T abnormalities and intraventricular conduction delays showed trends toward higher prevalence in patients with a complicated course versus those with an uncomplicated course, although only a minority of patients developed a complication.[3]

An interesting approach to decreasing the use of preoperative ECGs was developed by Paterson et al in Glasgow.[28] A simple six-item questionnaire was administered to 267 patients undergoing elective surgery and receiving preoperative electrocardiograms (see box on p. 7). Ninety-six patients (36%) gave one or more positive responses to the questionnaire, and 29 of them had a major abnormality on ECG (defined as ST depression less than 1 mm or T inversion, conduction defects, prior infarct, significant arrhythmia, or left ventricular hypertrophy). Only 5 patients with completely negative questionnaires had major abnormalities, and all were over 50 years of age. The authors recommended limiting routine ECGs to those over 50, and to those under 50 with signs or symptoms of heart disease. They estimate that adoption of these guidelines would lead to a 30% reduction in routine ECGs. It should be noted, however, that assessment of the effects of these recommendations on patient outcome, and the ability to generalize these findings to other centers, are not available.

The usefulness of the ECG in establishing a "baseline" has also been questioned. A study of 236 emergency room patients complaining of chest pain con-

Questionnaire to detect risk factors for abnormal ECG

1. Have you had any chest pain?	yes/no
2. Have you experienced breathlessness on exertion?	yes/no
3. Have you experienced breathlessness lying flat?	yes/no
4. Has any form of heart disease ever been diagnosed?	yes/no
5. Have you had rheumatic fever?	yes/no
6. Have you ever been found to have a heart murmur?	yes/no

From Paterson KR et al: The preoperative electrocardiogram: an assessment, Scott Med J 28:116-118, 1983.

cluded that a prior ECG would only have affected treatment decisions in 4.7%, and that in no case would it have helped to avoid an inappropriate discharge.[36] In the preoperative setting, 812 patients were studied who had an ECG recorded at some time in the past (mean of 24 months) followed by a routine ECG preoperatively.[30] Although 165 tracings showed new abnormalities, none of them led to delay or cancellation of surgery.[29] The probability of a new abnormality was greater in patients 60 years of age or older, in patients whose prior ECG had been obtained more than 2 years before the preoperative ECG, and in patients whose prior ECG was abnormal. Rabkin and Horne concluded that a preoperative ECG following a prior ECG had little impact on decisions related to surgical case delay and cancellation.

A problem in assessing the impact of any test such as the ECG on perioperative decisions is the difficulty of documenting its exact contribution. Rarely does a single test "make or break" a decision to operate or a choice of anesthesia, but more often it is used as contributing evidence in supporting one line of thought over another. Whether such decisions would be made in the absence of the ECG is almost impossible to assess.

Chest Radiography

The data on chest x-rays evaluations are somewhat clearer. Hubbell and colleagues looked at the prevalence of abnormalities in chest x-ray evaluations of 294 medical inpatients in a VA hospital (a population with a high prevalence of smoking and chronic obstructive pulmonary disease) and found abnormalities in 36%.[16] Nearly half of these abnormalities resulted from chronic obstructive lung disease or cardiomegaly, however, and the vast majority (81%) were considered to be chronic and stable. The investigators felt that the chest x-ray evaluation might have altered treatment in 12 of the 294 patients for whom admission films were ordered; however, only one serious disease would have been missed without the films, and the outcome in that case would not have changed.

A similar study of 6063 admission chest x-ray evaluations in patients on all services at Barnes Hospital showed 1001 (16.5%) to have a "serious" abnormality, the majority of which again resulted from cardiomegaly (50%) or chronic obstructive lung disease (34%). The prevalence of abnormalities increased steadily with patient age, from 0% in the newborn to 19 age-group to 43% in those over 70. The screening chest films were believed to add new diagnostic information in only 4% of patients, but the impact of this information on outcome could not be assessed.[40]

The use of screening chest x-ray evaluations in 10,619 patients undergoing nonacute, noncardiopulmonary surgery was studied in eight British hospitals by the Royal College of Radiologists.[35] The researchers concluded that the routine films ". . . did not seem to influence the decision to operate or the choice of anaesthetic; nor was there any evidence that preoperative chest radiography, at the levels of utilisation observed in this study, would be of much value as a baseline against which subsequent radiographs in patients with postoperative pulmonary complications could be judged."

A study of 1000 preoperative chest x-ray films in another British hospital showed only one significant new finding in 437 patients under the age of 30.[23] Of the 563 patients over age 30, 64 (11%) were felt to have significant findings. However, 44 of these findings were cardiac enlargement or emphysema. No data are given on the chronicity or stability of these findings (though the author states that most