Preoperative Evaluation Of The Elderly

Mitchell S. King, M.D.

***Abstract*: As the population ages, an increasing number of elderly patients will need surgery. An organized medical evaluation that focuses on the patient's cardiopulmonary and nutritional status should be performed before the patient undergoes surgery. The initial history and physical examination should be performed up to 8 weeks before surgery. Follow-up examinations are then dictated by the results of the initial examination. Established guidelines to assess cardiopulmonary and nutritional status should be followed. Preoperative laboratory assessment should consist of hemoglobin and creatinine measurements and include a urinalysis and electrocardiogram. The need for additional tests is indicated by the history and physical examination. Following this assessment, therapeutic and prophylactic measures to reduce surgical morbidity and mortality can be implemented. With timely identification and management of medical disease in geriatric surgical patients, the risks of surgery can be minimized. (J Am Board Fam Pract 1991; 4:251-8.)**

With the well-noted aging of the US population and the improved health of the elderly, an increasing number of elderly patients will be candidates for surgery. At the same time, more primary care physicians will be called upon to provide presurgical medical evaluations for these patients. Physicians assessing elderly patients should be aware of the major causes of morbidity and mortality associated with surgery in this group so they can provide a sound presurgical medical evaluation.

The many physiologic changes that occur with aging increase the vulnerability of the elderly to the stresses of surgery. Some changes include decreased cardiopulmonary reserve, decreased hepatic and renal function, altered body composition, decreased gastric and gastrointestinal motility, decreased immunologic function, decreased sensory abilities, and increased susceptibility to complications from bed rest.[1-5] In addition, individual variation in physiologic function is more pronounced with aging, which increases the importance of an individualized assessment of risk or suitability for surgery.[6]

In general, studies assessing morbidity in and mortality of geriatric surgical patients have been poorly controlled for age and concomitant disease, have lacked control groups and uniformly accepted reporting criteria for age and outcome, and have suffered from selection bias.[7-11] Nevertheless, these data indicate a trend toward increased death rates of geriatric surgical patients. It is possible that many elderly patients have been denied elective surgery, only to undergo semi-elective or emergency surgery later, which would account for much of the age-related mortality. Results of a study of Djokovic and Hedley-Whyte,[12] in which outcomes of patients older than 80 years were grouped according to the American Society of Anesthesiologists classification (Table 1), point to concomitant disease as the cause of excess mortality in geriatric surgical patients and support the concept of individualized risk assessment (Table 2).

Most problems encountered in elderly surgical patients are due to cardiac, pulmonary, and infectious complications that occur in addition to the primary disease process.[11-13] A preoperative evaluation of the geriatric patient therefore would assess these areas, as well as nutrition, and include taking steps to prevent deep venous thrombosis.

The Preoperative History and Physical Examination

A geriatric patient should undergo a preoperative evaluation several weeks in advance of hospitalization. The history should include information about the patient's current condition requiring surgery, any past surgical procedures, and the patient's experience with anesthesia. The physician should inquire about any chronic medical problems, particularly those involving the heart and lungs. Medications, including over-the-

From the Oakwood Hospital Family Practice Residency Program, Dearborn, Michigan. Address reprint request to Mitchell S. King, M.D., Bon Secours Hospital, Family Practice Residency, 468 Cadieux Rd., Grosse Pointe, MI 48230.

Table 1. American Society of Anesthesiologists Physical Status Classification.

Class	Description
1	Healthy
2	Mild systemic disease; neonates; aged > 80 years
3	Severe systemic disease
4	Severe, life-threatening systemic disease
5	Moribund

counter medication, should be noted. A functional assessment should be performed, and the physician should review the patient's social supports and need for assistance upon hospital discharge. A history of smoking and alcohol use should be elicited, and the patient should be told to stop smoking 8 or more weeks before surgery.[14]

The physician should perform the physical examination of the elderly patient several weeks in advance of surgery and a prehospitalization examination closer to the time of surgery if warranted by the patient's medical status. The focus should be cardiopulmonary, i.e., signs of congestive heart failure and chronic obstructive pulmonary disease. The physician should note any signs of malnutrition and administer a baseline mental status examination, using a standardized testing format.

At the time of the preoperative evaluation, the patient can be told what to expect during hospitalization and the perioperative period, and information about the anticipated postoperative functional status can be provided. The patient's desires about code status, should complications arise, can also be addressed.

The Preoperative Cardiac Assessment

Goldman's cardiac risk profile for noncardiac surgery (Table 3) is useful to predict perioperative morbidity and mortality.[15-17] Each risk factor in the index is assigned points, and an estimation of risk is calculated based upon the number of points a patient accumulates (Table 4). In general, patients who fall into classes 3 and 4 of the cardiac risk index should be monitored intensively throughout the perioperative period, using Swan Ganz catheters to measure pulmonary arterial blood pressures, or have surgery postponed until their condition improves. The cardiac risk index may not be predictive for peripheral vascular surgery. Patients undergoing peripheral vascular surgery warrant cardiac stress testing, either an exercise electrocardiogram (ECG) or dipyridamole-thallium imaging, because of the high incidence of previously undetected coronary artery disease reported in such persons.[18-21]

Table 2. Mortality Rate by American Society of Anesthesiologists (ASA) Classification in 500 Operations in Patients Aged 80 Years and Older.

ASA Class	Mortality Rate
2	< 0.01
3	0.04
4	0.25
Overall mortality	0.062

Age greater than 70 years is a risk factor in the cardiac index. Although age alone is not a significant risk factor, with advancing age the higher prevalence of concomitant disease can increase surgical risk.

Myocardial infarction within the previous 6 months puts the patient at increased risk for cardiac morbidity. Reinfarction rate is 37 percent if surgery is performed within 3 months after myocardial infarction,[22] stabilizing at 5 percent after this 6-month period. In patients who have had a recent myocardial infarction (within 3 months), morbidity and mortality from surgery managed with intensive monitoring and blood pressure control are comparable to that of patients who had a myocardial infarction more than 6 months before surgery.[23] Some recommend that elective surgery be performed 6 or more months after myocardial infarction, semielective surgery be performed 4 to 6 weeks after myocardial infarction with intensive monitoring and blood pressure control, and emergency surgery be performed with intensive monitoring.[17] Several studies have shown that assessment of left ventricular function can help determine the prognosis and the intensity of monitoring needed for patients with a history of myocardial infarction or congestive heart failure.[24-26]

Angina, though not mentioned as a risk factor in the cardiac risk profile, poses some added risk for noncardiac surgery. Stable angina should be managed medically because the combined risks of catheterization, coronary artery bypass grafting (CABG), and surgery are greater than those of surgery alone in this patient population. The physician should evaluate and treat unstable angina preoperatively. After CABG, patients are at no

increased risk for surgery on the basis of coronary artery disease.[24,27]

A history of congestive heart failure increases the risks for postoperative pulmonary edema.[28] This complication occurs in 2 percent of patients with no history of congestive heart failure, 6 percent with a history of this disease but a normal examination, and up to 35 percent of patients with congestive heart failure apparent on examination. A preoperative radionuclide cardiogram to determine left ventricular ejection fraction can be of prognostic value and help direct perioperative care.[25,26] Congestive heart failure should be treated and the patient stabilized before surgery is performed. The physician should exercise care to prevent excessive diuresis because of the risks of intraoperative or perioperative hypotension. The patient's volume status should be monitored closely throughout the perioperative period.

Valvular heart disease confers increased risk for surgery,[15,17,28] and the physician should evaluate the severity of the patient's valvular disease preoperatively. If valve replacement is not an option or is not warranted by the severity of disease, then the patient's blood pressure and volume status should be closely monitored to allow the physician to respond promptly to the changes induced by anesthesia and the stress of surgery.

Arrhythmias, generally a marker for coronary artery disease, are a risk factor for perioperative congestive heart failure and ischemia or infarction. Further cardiac work-up is indicated in the presence of arrhythmias. Premature ventricular contractions in the absence of heart disease are not considered a risk factor.[29] Antiarrhythmic medication is warranted only for symptomatic or life-threatening arrhythmias.[30] Patients with underlying cardiac conditions (congestive heart failure or ischemia) should be stabilized preoperatively. Supraventricular arrhythmias should be controlled preoperatively, and medication for the arrhythmia should be continued in the perioperative period. Though controversial, digoxin can be used prophylactically in elderly patients undergoing pulmonary surgery who have a history of valvular disease or previous valve surgery or who have a history of paroxysmal supraventricular tachycardia.[31]

Emergency surgery increases the risks of surgery two to four times, particularly in the elderly.

Table 3. Cardiac Risk Index.*

Risk Category	Points
Aged > 70 years	5
Myocardial infarction within last 6 months	10
S_3 gallop or jugular venous distention	11
Significant valvular stenosis	3
Rhythm other than sinus or premature atrial contractions	7
Premature ventricular contractions > 5/min.	7
Poor general medical condition	3
Abdominal or thoracic aorta surgery	3
Emergency surgery	4
Total	53

*Used with permission from: Goldman L, Caldera D, Nussbaum SR, Southwick FS, Krogstad D, Murray B, et al. Multifactorial index of cardiac risk in noncardiac surgical procedures. N Engl J Med 1977; 297:845-50.

Abdominal, thoracic, and aortic surgeries pose major pulmonary risks and are also risk factors for perioperative myocardial infarction.[22]

Hypertension is another important cardiovascular consideration in the preoperative assessment.[12,32,33] Surgery can be performed if the patient's diastolic blood pressure is 110 mmHg or less and the systolic blood pressure is 200 mmHg or less. The physician should closely monitor the patient's blood pressure perioperatively. Higher blood pressures should be controlled, preferably for 2 to 4 weeks, before proceeding with surgery. The patient should continue to take blood pressure medications up to the morning of surgery. Intravenous medications may be necessary during surgery or postoperatively if the patient is not able to take oral medications. The rate of postoperative hypertension is 25 percent regardless of the degree of preoperative control.

Myocardial infarction is most likely to occur within the first 6 postoperative days, with 60 per-

Table 4. Cardiac Morbidity and Mortality as Predicted by Cardiac Risk Index.*

Class	Points	Life-Threatening Complications (%)	Cardiac Death (%)
1	0–5	0.6	0.6
2	6–12	3.0	1
3	13–25	11.0	3
4	26+	12.0	39

*Used with permission from: Goldman L, Caldera D, Nussbaum SR, Southwick PS, Krogstad D, Murray B, et al. Multifactorial index of cardiac risk in noncardiac surgical procedures. N Engl J Med 1977; 297:845-50.

Table 5. Pulmonary Function and Blood Gas Indicators of High Surgical Risk for Pulmonary Complications.

Test	Value Indicating Increased Risk
FEV_1	< 2 L
MVV	< 50% predicted
PEF	< 100 L or 50% predicted
pCO_2	≥ 45 mmHg
pO_2	≤ 50 mmHg

FEV = Force expiratory volume.

MVV = Maximal voluntary ventilation.

PEF = Peak expiratory flow.

cent of episodes occurring within 3 days of surgery. Up to 50 percent of these myocardial infarctions are painless or have atypical symptoms. The mortality rate for perioperative myocardial infarctions has been reported to approach 50 percent. An ECG should be obtained within 24 hours postoperatively and then again within 3 to 5 days.[15,22]

Postoperative hypertension and worsening congestive heart failure secondary to pain, hypoxia, or excitement can occur 30 to 60 minutes after cessation of anesthesia. Hypertension or worsening congestive heart failure secondary to fluid mobilization can occur 2 to 3 days after surgery. The physician can prevent or minimize these complications[17] by providing adequate analgesia, sedation, or diuresis in a timely manner.

Preoperative Pulmonary Assessment

The history, pulmonary examination, and an awareness of the causes of surgery-associated pulmonary morbidity help the physician identify patients at risk for pulmonary complications. The major pulmonary complications are atelectasis, pneumonia, and bronchitis. Some pulmonary risk factors predisposing a patient to these complications are obesity, cough, dyspnea, smoking, abdominal or thoracic surgery, and history of lung disease.[34-37] The most significant risk factor is the site of surgery, with abdominal and thoracic surgery having a complication rate as high as 40 percent. As a rule, the closer the surgery is to the diaphragm, the higher the risk for pulmonary complications.

The at-risk patient should have a chest radiograph, and the physician should consider pulmonary function testing and measuring arterial blood gases. Some indicators of high risk are presented in Table 5; however, there are no preoperative guidelines that absolutely define prohibitive lung function.[36,37]

The patient at risk for pulmonary complications will need some preparation for surgery to minimize the chances of their occurrence. If the patient who smokes cigarettes quits 8 weeks before surgery, the mucociliary transport mechanism will recover, the secretions will decrease, and the carbon monoxide levels in the blood will drop. Bronchodilators, if indicated by pulmonary function testing, should be prescribed to increase pulmonary function. Any pulmonary infection should be treated preoperatively. The patient should be instructed in incentive spirometry and deep-breathing exercises, as they have been shown to decrease pulmonary complications by up to 50 percent.[38] Finally, the patient should be told about and be given an opportunity to ask questions or voice concerns about the possibility of postoperative ventilator support.

Nutritional Assessment

Malnourished patients experience increased surgical morbidity and mortality.[39-41] A preoperative nutritional evaluation should assess any risk factors for malnutrition found during the history and physical examination. Social isolation, limited financial resources, poor dentition, weight loss, and chronic medical diseases, such as chronic obstructive lung disease, congestive heart failure, depression, diarrhea, or constipation, are risk

Table 6. Risk Groups for Venous Thromboembolism According to Surgical Site.*

Patient Group	Incidence of Venous Thrombosis (%)	Recommended Prophylaxis
Hip fracture or total hip replacement	40–70	Adjusted-dose hepain, warfarin, low-dose heparin
Total knee replacement	40–70	Pneumatic compression
Urologic surgery	15–20	Pneumatic compression
General and gynecologic surgery	15–20	Low-dose heparin
Neurologic surgery	15–20	Pneumatic compression

*Adapted with permission from: Heyers TM, Hull RD, Weg JG. Antithrombotic therapy for venous thromoboembolic disease. Chest 1989; 95 (Suppl 2):37S-51S.

factors commonly associated with malnutrition. In addition, many patients will not be able to eat for varying periods before and after the surgical procedures. If there are nutritional concerns, the patient's serum albumin should be measured, because serum albumin is a sensitive indicator of malnutrition.[42] If the patient's nutritional status is in further question, additional protein measurements and anthropometric data can be reviewed, and preoperative nutritional supplementation should be provided. Although the duration of supplementation needed is uncertain, it has been suggested that a minimum of 7 to 10 days of oral or intravenous supplementation is needed to result in any benefit.[43]

Table 7. Adjusted-Dose Heparin Schedule for Surgical Patients, According to the Activated Partial Thromboplastic Time (APTT) 6 Hours After Injection.*

APTT (sec)	Adjustment in Heparin Dose IU
< 27.5	+1000
28–31	+500
31.5–36	0
36.5–39	−500
> 39.5	−1000

Starting dose = 3500 IU every 8 hr

*Used with permision from: Leyvraz PF, Richard J, Bachmann F, Van Melle G, Treyvaud JM, Livio JJ, et al. Adjusted versus fixed-dose subcutaneous heparin in the prevention of deep-vein thrombosis after total hip replacement. N Engl J Med 1983; 309:954-7.

Preoperative Laboratory Screening

Laboratory assessment is a more controversial component of the preoperative evaluation. Several studies have reported that most routine preoperative laboratory tests are ordered without any indication, although selective ordering of laboratory tests for specific indications is appropriate.[44-46] A typical routine preoperative laboratory assessment consists of a complete blood count, urinalysis, prothrombin time (PT), partial thromboplastin time (PTT), chemistry profile, ECG, and chest radiograph.

No data support a routine complete blood count. A hemoglobin measurement can detect unsuspected anemia and provide a baseline measure in the event of hemorrhagic complications. A serum creatinine measurement can indicate any decline in renal function that comes with aging (using the formula by Cockroft and Gault) and thus direct the physician to avoid prescribing potentially nephrotoxic drugs.[47] The urinalysis provides a high yield at a low cost[48] and can be a prudent[49] screening tool for patients aged 60 years or older. Several studies have shown that the PT, PTT, and chemistry profile are not indicated as routine preoperative screening tests.[48,50,51] Findings from a preoperative ECG generally have little impact on clinical management[13,52] of the patient in the perioperative period, but they do assist with cardiac assessment using the Goldman criteria and can document the cardiac rhythm. An exercise ECG is not recommended for routine preoperative assessment in geriatric patients,[19] unless they are undergoing peripheral vascular surgery. Although the preoperative chest radiograph offers little to the clinical management of the patient despite the high rate of "positive" findings,[53-55] it can be indicated as part of the pulmonary assessment.

Deep Venous Thrombosis Prophylaxis

Prophylaxis against deep venous thrombosis reduces the morbidity and mortality associated with this common complication of surgery[56-58] and should be provided to the patient during the perioperative period for most surgical procedures.

Some of the risk factors associated with deep venous thrombosis include history of deep venous thrombosis or pulmonary embolus, lower extremity orthopedic surgery, malignancy, obesity, congestive heart failure, cerebrovascular accident, immobilization, and surgery lasting longer than 30 minutes. The site and type of surgery also are important in determining the level of risk for occurrence of deep venous thrombosis (Table 6).[58-60]

The most commonly recommended drugs for preventing deep vein thrombosis are warfarin and heparin (low dose and adjusted dose). Intermittent pneumatic compression stockings are also commonly used. The method chosen is determined by the type of surgery and risk status of the patient. Low-dose heparin or intermittent pneumatic compression is recommended for moderate-risk patients and should be considered for low-risk patients. Warfarin is recommended for patients undergoing orthopedic hip surgery or for hip fracture and should be considered for high-risk patients. Adjusted-dose heparin is also

effective in patients undergoing total hip replacement surgery (Table 7).[61] Intermittent pneumatic compression should be used with neurosurgical procedures.[59,60,62]

Prophylaxis for deep venous thrombosis begins preoperatively. Intermittent pneumatic compression stockings are usually put on while the patient is on the operating table and are kept on until the patient can walk. Administration of low-dose heparin (5000 U subcutaneously every 8 to 12 hours) should begin 2 hours before surgery and continue until hospital discharge. Warfarin is generally administered the day before surgery and continued until hospital discharge. Adjusted-dose heparin can begin 2 days before surgery, to arrive at the correct dose of heparin required, and is continued, along with monitoring the PTT and adjusting the dose, until hospital discharge. For high-risk patients, postoperative screening for asymptomatic deep venous thrombosis can help determine the need for extended anticoagulant therapy.[63]

Conclusion

Though surgery in the geriatric patient can involve increased risks, these increased risks do not result from age, but from the presence of concomitant disease. If physicians perform careful preoperative assessments, focusing on the cardiopulmonary and nutritional status of the patient, they can make appropriate management decisions to minimize these risks. Prophylactic steps can be taken to minimize the chances of complications, and physicians can thus improve the chances for a successful outcome for the geriatric surgical patient.

References

1. Berman R, Haxby JV, Pomerantz RS. Physiology of aging. Part 1: normal changes. Patient Care 1988; 22:20-36.
2. *Idem*. Physiology of aging. Part 2: clinical implications. Patient Care 1988; 22:39-66.
3. Boss GR, Seegmiller JE. Age-related physiological changes and their clinical significance. West J Med 1981; 135:434-40.
4. Harper CM, Lyles YM. Physiology and complications of bed rest. J Am Geriatr Soc 1988; 36: 1047-54.
5. Kennedy RA. Physiology of aging. Clin Geriatr Med 1985; 1:37-59.
6. Williams ME. Clinical implication of aging physiology. Am J Med 1984; 76:1049-54.
7. Colapinto ND. Is age alone a contraindication to major cancer surgery? Can J Surg 1985; 28: 323-6.
8. Del Guercio LR, Cohn JD. Monitoring operative risk in the elderly. JAMA 1980; 243:1350-5.
9. Linn BS, Linn MW, Wallen N. Evaluation of results of surgical procedures in the elderly. Ann Surg 1982; 195:90-6.
10. Mohr DM. Estimation of surgical risk in the elderly: a correlative review. J Am Geriatr Soc 1983; 31: 99-102.
11. Palmberg S, Hirsjarvi E. Mortality in geriatric surgery with special reference to the type of surgery, anesthesia, complicating diseases, and prophylaxis of thrombosis. Gerontology 1979; 25:103-12.
12. Djokovic JL, Hedley-Whyte J. Prediction of outcome of surgery and anesthesia in patients over 80. JAMA 1979; 242:2301-6.
13. Seymour DG, Pringle R, Maclennan WJ. The role of the routine pre-operative electrocardiogram in the elderly surgical patient. Age Ageing 1983; 12: 97-104.
14. Warner MA, Offord KP, Warner ME, Lennon RL, Conover MA, Jansson-Schumacher U. Role of preoperative cessation of smoking and other factors in postoperative pulmonary complications: a blinded prospective study of coronary artery bypass patients. Mayo Clin Proc 1989; 64:609-16.
15. Goldman L, Caldera D, Nussbaum SR, Southwick FS, Krogstad D, Murray B, et al. Multifactorial index of cardiac risk in noncardiac surgical procedures. N Engl J Med 1977; 297:845-50.
16. Jeffrey CC, Kunsman J, Cullen DJ, Brewster DC. A prospective evaluation of cardiac risk index. Anesthesiology 1983; 58:462-4.
17. Weitz HW, Goldman L. Noncardiac surgery in the patient with heart disease. Med Clin North Am 1987; 71:413-32.
18. Boucher CA, Brewster DC, Darling RC, Okada RD, Strauss HW, Pohost GM. Determination of cardiac risk by dipyridamole-thallium imaging before peripheral vascular surgery. N Engl J Med 1985; 312:389-94.
19. Carliner NH, Fisher ML, Plotnick GD, Garbart H, Rappaport A, Kelemen MH, et al. Routine preoperative exercise testing in patients undergoing major noncardiac surgery. Am J Cardiol 1985; 56: 51-8.
20. Hertzer NR, Beven EG, Young JR, O'Hara PJ, Ruschhaupt WF 3d, Graor RA, et al. Coronary artery disease in peripheral vascular patients. A classification of 1000 coronary angiograms and results of surgical management. Ann Surg 1984; 199:223-32.
21. Jain KM, Patil KD, Doctor US, Peck SL. Preoperative cardiac screening before peripheral vascular operations. Am Surgeon 1985; 51:77-9.
22. Steen PA, Tinker JH, Tarhan S. Myocardial reinfarction after anesthesia and surgery. JAMA 1978; 239:2566-70.
23. Rao TL, Jacobs KH, El-Etr AA. Reinfarction following anesthesia in patients with myocardial infarction. Anesthesiology 1983; 59:499-505.

24. Foster ED, Davis KB, Carpenter JA, Abele S, Fray D. Risk of noncardiac operation in patients with defined coronary disease: the Coronary Artery Surgery Study (CASS) registry experience. Ann Thorac Surg 1986; 41:42-50.
25. Lazor L, Russell JC, DaSilva J, Radford M. Use of multiple uptake acquisition scan for the preoperative assessment of cardiac risk. Surg Gynecol Obstet 1988; 167:234-8.
26. Pedersen T, Kelbaek H, Munck O. Cardiopulmonary complications in high-risk surgical patients: the value of preoperative radionuclide cardiography. Acta Anaesthesiol Scand 1990; 34:183-9.
27. Mahar LJ, Steen PA, Tinker JH, Vlietstra RE, Smith HC, Pluth JR. Perioperative myocardial infarction in patients with coronary artery disease with and without aortic coronary artery bypass grafts. J Thorac Cardiovasc Surg 1978; 76:533-7.
28. Goldman L, Caldera D, Southwick F, Nussbaum S, Murray B, O'Malley T, et al. Cardiac risk factors and complications in noncardiac surgery. Medicine 1978; 57:357-70.
29. Kennedy HL, Whitlock JA, Sprague MK, Kennedy LJ, Buckingham TA, Goldberg RJ. Long-term follow-up of asymptomatic healthy subjects with frequent and complex ventricular ectopy. N Engl J Med 1985; 312:192-7.
30. Goldman L. Cardiac risks and complications of noncardiac surgery. Ann Intern Med 1983; 98:504-13.
31. Chee TP, Prakash NS, Desser KB, Benchimol A. Postoperative supraventricular arrhythmias and the role of prophylactic digoxin in cardiac surgery. Am Heart J 1982; 104:974-7.
32. Goldman L, Caldera DL. Risks of general anesthesia and elective operation in the hypertensive patient. Anesthesiology 1979; 50:285-92.
33. Marin DE, Kammerer WS. The hypertensive surgical patient. Surg Clin North Am 1983; 63: 1017-33.
34. Garibaldi RA, Britt MR, Coleman ML, Reading JC, Pace NL. Risk factors for postoperative pneumonia. Am J Med 1981; 70:677-80.
35. Latimer RG, Dickman M, Day WC, Gunn ML, Schmidt CD. Ventilatory patterns and pulmonary complications after upper abdominal surgery determined by preoperative and postoperative computerized spirometry and blood gas analysis. Am J Surg 1979; 122:622-31.
36. Tisi GM. Preoperative evaluation of pulmonary function. Am Rev Respir Dis 1979; 119:293-310.
37. *Idem*. Preoperative identification and evaluation of the patient with lung disease. Med Clin North Am 1987; 71:399-412.
38. Celli BR, Rodriguez KS, Snider GL. A controlled trial of intermittent positive pressure breathing, incentive spirometry, and deep breathing exercises in preventing pulmonary complications after abdominal surgery. Am Rev Respir Dis 1984; 130:12-5.
39. Bistrian BR, Blackburn GL, Hallowell E, Heddle R. Protein status of general surgical patients. JAMA 1974; 230:856-60.
40. Dempsey DT, Mullen JL, Buzby GP. The link between nutritional status and clinical outcome: can nutritional intervention modify it? Am J Clin Nutr 1988; 47:352-6.
41. Warnold I, Lundholm K. Clinical significance of preoperative nutrition status in 215 noncancer patients. Ann Surg 1984; 199:299-305.
42. Leite JF, Antunes CF, Monteiro JC, Pereira BT. Value of nutritional parameters in the prediction of postoperative complications in elective gastrointestinal surgery. Br J Surg 1987; 74:426-9.
43. Weiss SM. Nutritional aspects of preoperative management. Med Clin North Am 1987; 71:369-75.
44. Blery C, Charpak Y, Szatan M, Darne B, Fourgeaux B, Chastang CL, et al. Evaluation of a protocol for selective ordering of preoperative tests. Lancet 1986; 1:139-41.
45. Charpak Y, Blery C, Chastang C, Kemmoun RB, Pham J, Brage D, et al. Usefulness of selectively ordered preoperative tests. Med Care 1988; 26: 95-104.
46. Johnson H Jr, Knee-Ioli S, Butler TA, Munoz E, Wise L. Are routine preoperative laboratory screening tests necessary to evaluate ambulatory surgical patients? Surgery 1988; 104:639-45.
47. Cockroft DW, Gault MH. Prediction of creatinine clearance from serum creatinine. Nephron 1976; 16:31-41.
48. Turnbull JM, Buck C. The value of preoperative screening investigations in otherwise healthy individuals. Arch Intern Med 1987; 147:1101-5.
49. US Preventive Services Task Force. Screening for asymptomatic bacteruria, hematuria and proteinuria. In: Fisher M, editor. Guide to clinical preventive services: an assessment of the effectiveness of 169 interventions. Baltimore: Williams & Wilkins, 1989:155-9.
50. Eisenberg JM, Clarke JM, Sussman SA. Prothrombin and partial thromboplastin times as preoperative screening tests. Arch Surg 1982; 117:48-51.
51. Kaplan EB, Sheiner LB, Boeckmann AJ, Roizen MF, Beal SL, Cohen SM, et al. The usefulness of preoperative laboratory screening. JAMA 1985; 253:3576-81.
52. Goldberger AL, O'Konski M. Utility of the routine electrocardiogram before surgery and on general hospital admission. Critical review and new guidelines. Ann Intern Med 1986; 105:552-7.
53. Boghosian SG, Mooradian AD. Usefulness of routine preoperative chest roentgenograms in elderly patients. J Am Geriatr Soc 1987; 35:142-6.
54. Charpak Y, Blery C, Chastang C, Szatan M, Fourgeaux B. Prospective assessment of a protocol for selective ordering of preoperative chest x-rays. Can J Anesthesiol 1988; 35:259-64.
55. Hubbell FH, Greenfield S, Tyler JL, Chetty K, Wyle F. The impact of routine admission chest x-ray films on patient care. N Engl J Med 1985; 312:209-13.
56. Borow M, Goldson H. Postoperative venous thrombosis: evaluation of five methods of treatment. Am J Surg 1981; 141:245-51.
57. Collins R, Scrimgeour A, Yusef S, Peto R. Reduction in fatal pulmonary embolism and venous thrombosis by perioperative administration of subcutaneous heparin. Overview of results of randomized trials in

general, orthopedic and urologic surgery. N Engl J Med 1988; 318:1162-72.
58. Oster G, Tuden RL, Colditz GA. A cost-effectiveness analysis of prophylaxis against deep vein thrombosis in major orthopedic surgery. JAMA 1987; 257:203-8.
59. Prevention of venous thrombosis and pulmonary embolism. NIH Consensus Development. JAMA 1986; 256:744-9.
60. Merli GJ, Martinez J. Prophylaxis for deep vein thrombosis and pulmonary embolism in the surgical patient. Med Clin North Am 1987; 71:377-97.
61. Leyvraz PF, Richard J, Bachmann F, Van Melle G, Treyvaud JM, Livio JJ, et al. Adjusted versus fixed-dose subcutaneous heparin in the prevention of deep-vein thrombosis after total hip replacement. N Engl J Med 1983; 309:954-7.
62. Hyers TM, Hull RD, Weg JG. Antithrombotic therapy for venous thromboembolic disease. Chest 1989; 95(Suppl 2):37S-51S.
63. Barnes R, Nix ML, Barnes CL, Lavender RC, Golden WE, Harmon BH, et al. Perioperative asymptomatic venous thrombosis: role of duplex scanning versus venography. J Vasc Surg 1989; 9:251-60.