PERIOPERATIVE CARE

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FROM THE EDITOR

Perioperative Medicine: A Fundamental Facet of Our Identity

For most of us, being a hospitalist at the outset consisted chiefly, if not exclusively, of a commitment to excellence in the care of hospitalized patients for whom we served as the attending of record. As with many things in life, as a specialty we have come to realize over time that this was an overly simplistic view, and that for most of us there are at least two other, not necessarily mutually exclusive, central pillars of our professional existence. The second of these 'foundations of hospital medicine' is a commitment to patient safety and systems improvement; while the third is involvement in the care of the perioperative patient.

As Geno Merli articulates in this special supplement to *The Hospitalist*, despite the central and growing role of most hospitalists as practitioners of perioperative medicine, many of us did not receive fully adequate training in perioperative and consultative medicine during our residencies. I occasionally reflect wryly on my own experience as a senior resident a decade ago, when I spent two weeks dutifully trekking between preoperative consultations, predictably mumbling a few things about "Goldman criteria" and "avoiding hypotension" in overlong and rambling consult notes. Fortunately, as Sylvia McKean points out beautifully in this supplement, we have much more than that to offer our perioperative patients and surgical colleagues. Much of what we have come to know has been learned via on-the-job training and the school of hard knocks, and the path from perioperative point A (the conclusion of our formal training) to point B (where we are today) for many of us can be summed up rather well by the line from the old Grateful Dead song: "What a long, strange trip it's been."

As Merli goes on to discuss, if nature abhors a vacuum, the emergence of hospitalists as leaders both as practitioners and educators in the perioperative medicine arena was perhaps inevitable, and in any event is a very natural fit. In many of our academic centers, presumably especially those where general internal medicine had failed to establish vigorous perioperative/consultative medicine services, a fairly subtle but inexorable passing of the baton of perioperative medicine has occurred from 'traditional' GIM faculty to hospitalists. (This is not to suggest, of course, that traditional internists do not continue to maintain expertise, including healthy research agendas, in some centers.)

While our youth as a discipline is a double-edged sword, there are many positives inherent in this, as have been well outlined elsewhere. This is probably nowhere more true than in the area of perioperative medicine. Our willingness to work collaboratively in multidisciplinary teams is clearly something that perioperative care is well suited to, and the symbiotic relationship that so many hospital medicine and orthopedic groups have developed and continue to cultivate is merely the most obvious example of this. Likewise, our deeply-rooted commitment to patient safety and systems improvements, if channeled appropriately, seems ripe with the promise of better outcomes for patients undergoing surgery. The entire realm of surgical co-management, which in a relatively short time appears to be moving from a mildly abstract idea to an irresistible tide, seemingly demands a rapidly expanding specialty to slake its potentially insatiable appetite. Once again, hospital medicine is poised to deliver.

While historically perioperative medicine took place largely within the confines of the hospital, along with patchy use of primary care physicians to perform outpatient evaluations prior to some elective surgical procedures, recent years have seen the emergence of dedicated preoperative evaluation clinics. Although still very much a nascent phenomenon, in some centers these clinics have become tightly integrated into the perioperative culture in rather short order, and have become extremely useful to surgeons, anesthesiologists and hospitalists alike (not to mention patients). The hospitalist-run preoperative clinic at the Cleveland Clinic (summarized by Amir Jaffer and Daniel Brotman in this supplement) sees an average of 60+ patients per day, and a commonly heard refrain from surgeons upon being told that there are no urgent slots available is "then how can I perform surgery on this patient?!" Lest it be concluded that such a clinic is only practical in large centers with high surgical volume, Jeff Dichter and colleagues share their more modest but still successful and important experience with a community-based preop clinic.

If hospital medicine has quickly become one of the biggest stakeholders in perioperative medicine, what challenges remain for us? Perhaps the greatest of these is to advance a meaningful research agenda, something we are dabbling in at present, but need to address head on. I think back fairly often to Lee Goldman's observation in his keynote lecture at the 2002 SHM Annual Meeting, that hospital medicine's ultimate success as a specialty will be tied closely to our ability to generate a solid research output. Perioperative medicine is one area where we have a golden opportunity to contribute meaningful research, which needs to include multidisciplinary and multicenter investigations. Specific issues that we might tackle, in no particular order, include the following (among others):

- Further elaboration of the role of statins in perioperative risk reduction
- How 'tight' should blood glucose control be in non-cardiac, non-ICU surgical patients?
- Clarification of the role for investigating and intervening on high-grade, asymptomatic carotid stenosis prior to non-cardiac surgery
- Refinement of identification of those patients who will (and will not) benefit from non-invasive car-

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diac risk stratification in the era of periop beta blockade

- A host of issues regarding perioperative medication administration, including but not limited to those raised by Mercado and Ling in this issue
- Additional work on the prevention of postoperative delirium
- More studies investigating outcomes with co-management, including higher-risk patients (e.g., cardiothoracic and vascular)
- Novel strategies to reduce perioperative risk

Other challenges abound for hospitalists involved in perioperative care, some of which include achieving 'separate but equal' partnerships with those surgeons and surgical services we enter into co-management arrangements with; keeping surgeons involved in timely fashion both pre- and postoperatively in these same relationships, and the need for tact when historic perioperative relationships are altered because of the perceived availability and expertise of hospitalists. None of these, of course, are insurmountable, and overall this is an invigorating and somewhat heady time to be practicing perioperative medicine. We hope that you enjoy this supplement, and that it provides not only a state-of-the-art review of some of the most commonly encountered clinical topics in this area, but also food for thought. Your comments, criticisms and suggestions are welcomed.

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EDITORIAL

The Hospitalist as Perioperative Expert: An Emerging Paradigm

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The role of the hospitalist as consultant and co-manager with the surgical team is beginning to evolve in the United States. The concepts of this movement began 20 years ago with academic general internists providing pure medical consultative services for the surgical patient as an area of their expertise (1,2,3). Textbooks, peer reviewed articles, and courses sponsored by physicians or national societies flourished over this time period. In addition, during this time period every medicine residency not only required but provided training in the perioperative care of the surgical patient. Over time, however, medical residency training programs underwent drastic changes in curriculum design, with a greater emphasis on outpatient care. These changes required a re-shuffling of available training time, which resulted in medical consultation becoming an expendable experience. In fact, a national survey of hospitalists' perceptions of their residency programs revealed that training in perioperative medical consultation was underemphasized. The importance of training in the skills of perioperative medical consultation was rated at a mean of 4.6 +/- 0.7 (1= very unimportant, 5 = very important) while the adequacy of emphasis in residency training was rated 3.4 +/- 1.1 (1 = very inadequate, 5 = very adequate) $p = < 0.001$ (4). Seventy-nine percent of hospitalists surveyed had less than one month of training ($p= < 0.00001$).

So why am I emphasizing the inadequacies of training in this area of medical practice? The method behind my madness is two-fold. First, hospitalists must become the experts in the perioperative care of the surgical patient. Second, hospital medicine should assume the lead educational role for this area of expertise in medical residency training programs. It has become crystal clear that the development of a team approach to the care of complex surgical patients will impact length of stay, use of resources, and most importantly provide better patient care. What better group of physicians to embrace this as part of their repertoire of care than those already dedicated to hospital work—i.e., hospitalists?

This team approach must be spearheaded by the hospitalist, who will coordinate the assessment and management of surgical patients with anesthesiology, surgery, nursing, and pharmacy services. William Mason made the first connection between surgery and internal medicine in his paper presented at the Massachusetts Medical Society meeting and subsequently published in the New England Journal of Medicine (5). He emphasized that the interaction between a surgeon and internist in perioperative care resulted in greater accuracy of diagnosis and far better treatment of this patient population. Macpherson et al began the co-management movement in 1994 with their article entitled "An internist joins the surgery service: Does co-management make a difference?" (6). The study concluded that the addition of an internist to the cardiothoracic surgery service at a tertiary care teaching center was associated with decreased length of stay, lower in-hospital mortality and less use of laboratory and radiological studies (6). More recently Huddleston and colleagues have completed a prospective, randomized, controlled trial of 526 patients undergoing total hip or knee arthroplasty (7). They compared a co-management hospitalist-orthopedic team to standard postoperative care by orthopedic surgery with medical consultation. The measures of effectiveness were length of stay, postoperative medical complications, health care provider satisfaction, and inpatient costs. This is the beginning of the process to expand this model to less established areas such as neurosurgery, urology, otolaryngology, gynecology, and cancer surgery (8).

There is no question that this new model will add work to the already busy hospitalist's schedule. I must emphasize that hospitalists will not become the house staff for surgery. This will be a team approach to care; but like all new endeavors it will take an organizational structure with defined roles, responsibilities, and measurable outcomes for improvement in care. By developing an expertise in perioperative medical care, hospitalists can also design a curriculum which can become the basis for attractive rotations for medical students and residents in this area.

I believe in the phrase "*Carpe Diem*." This is the window of opportunity for hospitalists across the country to claim a vital area of patient care that needs a fresh approach to management.

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Preoperative Cardiovascular Risk Evaluation

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Cardiovascular complications account for a large percentage of adverse events in the perioperative period, resulting in significant morbidity and mortality. A critical role of the preoperative consultant is to carefully evaluate the patient for potential complications, recommending diagnostic or therapeutic interventions where indicated to reduce this risk.

Several cardiac risk indexes have been published to help stratify patients undergoing noncardiac surgery into increasing risk categories. In 1977, Goldman and colleagues published the first validated multivariate index to assess cardiac risk (Table 1)(1). This index was later modified by Detsky and colleagues to include angina pectoris and remote myocardial infarction (MI) (Table 2)(2). More recently, the American College of Cardiology/American Heart Association (ACC/AHA) and the American College of Physicians (ACP) have published clinical practice guidelines on perioperative cardiac risk management (3, 4). Although these guidelines vary slightly in their recommendations, they both organize patients into three risk groups (high, intermediate, and low). This evaluation, combined with the type and urgency of the surgical procedure, forms the cardiac risk assessment.

General Approach

Preoperative cardiac risk assessment entails stratifying patients on the basis of clinical predictors of cardiovascular risk, functional capacity, and surgery-specific risk.

Table 1. Goldman's Cardiac Risk Index

Risk Factor	Points
History	
Age > 70 years	5
MI < 6 months	10
Physical Examination	
S_3 gallop or jugular venous distention	11
Clinically significant aortic stenosis	3
EKG	
Rhythm other than sinus, or pulmonary artery catheters on EKG	7
>5 premature ventricular contractions/min	7
Clinical Status	3
PO_2 < 60 or PCO_2 > 50	
Potassium < 3.0 meq/dL	
HCO_3 < 20 meq/dL	
Blood urea nitrogen > 50 mg/dL or creatine > 3.0	
Abnormal aspartate transaminase	
Chronic liver disease	
Bedridden from noncardiac causes	
Type of Surgery	
Peritoneal, thoracic, or aortic	3
Emergency	4
Scoring and Interpretation	
Class I: 0–5 points; low risk	
Class II: 6–12 points; intermediate risk	
Class III: 13–25 points; high risk	
Class IV: >26 points; very high risk	

Goldman L. Caldera DL, Nussbaum SR, et al. Multifactorial index of cardiac risk in noncardiac surgical procedures. *N Engl J Med.* 1977;297:845-50.

Table 2. Detsky Cardiac Risk Index

Risk Factor	Points
MI < 6 months	10
MI > 6 months	5
Canadian Cardiovascular Society angina	
Class III	10
Class IV	20
Unstable angina within the past 6 months	10
Alveolar pulmonary edema	
< 1 week	10
Ever	5
Critical aortic stenosis	20
Arrhythmia	
Rhythm other than sinus, or pulmonary artery catheters	5
> 5 premature ventricular contractions/min	5
Poor medical status	5
Age > 70 years	5
Emergency operation	10

Scoring and Interpretation

Risk Class	Likelihood Ratio of a Cardiac Complication*
Class I (0–15 pts):	0.42
Class II (16–30 pts):	3.58
Class III (>30 pts):	14.93

*Cardiac complication defined as myocardial infarction, pulmonary edema, ventricular tachycardia, ventricular fibrillation, and cardiac death.

Detsky AS, Abrams HB, McLaughlin JR, et al. Predicting cardiac complications in patients undergoing noncardiac surgery. *J Gen Intern Med.* 1986;1:211-9.

Clinical Predictors

Major clinical predictors of cardiac risk include acute coronary syndromes (ACSs), decompensated congestive heart failure (CHF), significant arrhythmias, and severe aortic valvular disease. In general, patients with any of these risk factors should be managed in a similar fashion to the nonoperative setting. Patients with recent ACSs undergoing elective noncardiac surgery should have coronary angiography to assess whether revascularization is indicated. Patients with decompensated CHF, severe valvular heart disease, or clinically significant arrhythmias should be medically stabilized before undergoing nonemergent surgery.

Minor clinical predictors include advanced age, abnormal ECG, poor functional capacity, history of stroke, and uncontrolled hypertension. Patients with these predictors can generally proceed directly to surgery without intervention. However, those with poor functional status who are undergoing a high-risk procedure may benefit from noninvasive testing (3).

While there is consensus among the major guidelines on management of patients with major and minor clinical predictors, the evaluation of patients at intermediate risk is less straightforward. Intermediate clinical predictors include mild angina pectoris (Canadian class I or II), compensated CHF, diabetes mellitus, chronic renal insufficiency, and prior MI (> 1 month). These patients should be stratified further on the basis of surgery-specific risk and functional capacity.

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Preoperative Cardiovascular Risk Evaluation (continued)

Functional Status

A patient's ability to exercise has been shown to be a reliable predictor of future cardiac events. Functional capacity is normally expressed in metabolic equivalent (MET) levels. One MET is defined as the oxygen consumption (VO_2) of a 70-kg, 40-year-old man in a resting state (3.5 mL/kg per minute). Functional status can be categorized as excellent (> 7 METs), moderate (4 to 7 METs), or poor (< 4 METs). The Duke Activity Status Index contains questions that can be used to estimate a patient's functional capacity (5). For example, climbing a flight of stairs with a bag of groceries, jogging, or walking on level ground at 4 miles per hour corresponds to at least 4 METs. Since poor functional status is associated with an increased risk of noncardiac surgery, the ACC/AHA guidelines recommend noninvasive testing in all patients at intermediate risk with poor functional status who are undergoing moderate- to high-risk procedures (3, 6). The ACP, however, based on the absence of convincing randomized data, favors a stricter approach and recommends noninvasive testing only for patients at intermediate risk undergoing vascular surgery (4).

Type of Surgery

The surgical procedure contributes to a patient's cardiac risk (Table 3) (3). For example, patients undergoing major vascular surgery are considered to be at highest risk for cardiac complications, as these procedures are lengthy and tend to have large intravascular volume shifts with hemodynamic fluctuations. In addition, patients requiring surgery for peripheral vascular disease share many of the same risk factors as those patients with coronary artery disease. Intermediate-risk procedures include orthopedic, urologic, and thoracoabdominal surgery, and low-risk procedures include endoscopy; breast biopsy; and cataract, dental, and dermatologic surgery. Low-risk procedures typically do not require preoperative intervention; however, patients identified to be at increased cardiac risk on a long-term basis should be counseled and referred back to their primary physician for risk reduction after the surgery.

The preoperative consultant often does not have the benefit of making a formal assessment before surgery. Emergency operations, such as major trauma, perforated viscus, and symptomatic aortic aneurysms, carry such high mortality that even cursory cardiac evaluations are not possible. Emergency procedures are two to five times more likely to cause cardiac complications than elective procedures (7).

Table 3. Cardiac Risk Stratification for Noncardiac Surgical Procedures

High Risk (mortality > 5%)
Aortic surgery
Peripheral vascular surgery
Emergent major operations, particularly in the elderly
Anticipated prolonged surgical procedures with large fluid shifts or blood loss
Intermediate Risk (mortality 1%–5%)
Intrathoracic and intraperitoneal surgery
Carotid endarterectomy
Head and neck surgery
Orthopedic surgery
Open prostatic surgery
Low Risk (mortality <1%)
Endoscopic procedures
Cataract surgery
Superficial procedures and biopsies
Transurethral prostate surgery

Eagle KA, Berger PB, Calkins H, et al. ACC/AHA guideline update for perioperative cardiovascular evaluation for noncardiac surgery: executive summary: a report of the American College of Cardiology/American Heart Association Task Force on Practice Guidelines (Committee to Update the 1996 Guidelines on Perioperative Cardiovascular Evaluation for Noncardiac Surgery). *J Am Coll Cardiol*. 2002;39:542-53.

Coronary Artery Disease Evaluation

As described in the ACC/AHA guidelines, preoperative cardiac evaluation is rarely necessary in patients who have had coronary revascularization in the past five years and who remain asymptomatic. In addition, further testing is not recommended in patients who have had a favorable coronary evaluation in the past two years and who have not had new coronary ischemic symptoms (3). All other patients should have their clinical risk assessed, along with diagnostic and treatment recommendations.

Noninvasive Testing

Exercise stress testing allows for an objective assessment of a patient's functional status, while at the same time helping to identify clinically significant myocardial ischemia that would increase perioperative cardiac risk. As noted, patients who can achieve a level of exercise of greater than 7 METS without ischemia are low risk, whereas patients who have ischemia induced by less than 4 METS of exercise are high risk. This is supported by data from the Coronary Artery Surgery Study (CASS), as patients with limited exercise capacity had an annual mortality greater than 5% per year, whereas those with excellent exercise capacity had an annual mortality of less than 1% per year on 4-year follow-up (7). The mean sensitivity and specificity of exercise testing for obstructive coronary artery disease is 68% and 77%, respectively (8). For three-vessel or left main coronary artery disease, the sensitivity is approximately 86% (9). Exercise stress testing has limitations, however, especially in patients with an abnormal resting ECG and in those unable to exercise.

Patients unlikely to reach their physiologic target heart rates should undergo stress imaging with agents that increase myocardial perfusion (vasodilators) or increase myocardial oxygen demand. Numerous studies have examined the role of perioperative thallium imaging (with

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either dipyridamole or adenosine). Stress imaging using dipyridamole-thallium has high sensitivity and specificity for detecting three-vessel or left main coronary disease (approximately 90%) and thus can accurately identify patients who have significantly increased cardiac risk. The test also has a high negative predictive value, accurately identifying those patients at low risk for coronary events (10, 11). The test is most useful when applied to patients at intermediate clinical risk, as patients with a high or low pretest probability for coronary artery disease are unlikely to benefit from further testing (12).

There are fewer data available regarding dobutamine stress echocardiography in the preoperative setting. However, it appears that the test has similar characteristics to dipyridamole-thallium imaging in patients at intermediate cardiac risk. A normal test result, defined as the absence of a new or worsening wall motion abnormality, has a negative predictive value of 93% to 100% (13).

Management of Preoperative Cardiovascular Conditions

Hypertension

Hypertension is the most common cardiovascular disease managed in the preoperative period, occurring in approximately 30% of patients undergoing surgery. Patients with severe hypertension (defined as a diastolic blood pressure > 110 mm Hg) may be at increased risk for complications, including myocardial ischemia/infarction, stroke, and renal failure (14). Patients with mild-to-moderate hypertension (diastolic blood pressure < 110 mm Hg) do not have increased cardiac risk, provided end-organ complications such as congestive heart failure or renal failure are not present (3, 15).

The ACC/AHA Guidelines recommend that stage 3 hypertension (systolic blood pressure > 180 or diastolic blood pressure > 110) should be controlled before surgery. Control can be established over days to weeks in nonemergency cases or more rapidly with parental agents when surgery cannot be delayed (3).

Congestive Heart Failure

Patients with poorly controlled CHF are at high risk for postoperative complications (3). These patients need to be aggressively treated with diuretics and afterload-reducing agents before surgery. Patients with left ventricular systolic dysfunction who are well compensated do not appear to have an increased mortality risk (1). In patients with new symptoms suggestive of heart failure, echocardiography should be obtained before surgery to help differentiate among systolic dysfunction, diastolic dysfunction, and valvular heart disease. However, routine assessment of left ventricular function in patients with a known history of CHF is not indicated.

Valvular Heart Disease

Valvular disease may pose significant management challenges during the perioperative period. As described in several cardiac risk indices, significant aortic stenosis carries a high surgical risk (1). Patients with symptomatic aortic stenosis should have elective noncardiac surgery delayed or canceled until valve replacement surgery can be done. Although patients with asymptomatic aortic stenosis generally have a low complication rate, efforts should focus on assessing the valvular disease first, especially if the patient is undergoing an elective procedure. Balloon valvuloplasty may be an acceptable alternative to valvular surgery in patients who are poor surgical candidates. However, clinical studies in this patient population are lacking.

Patients with mitral valve stenosis are at increased risk for atrial arrhythmias and heart failure. Severe cases should be managed either with valvuloplasty or surgery, independent of noncardiac surgery. Patients with aortic and mitral regurgitation are important to identify during the preoperative evaluation, as these patients need to be medically optimized and given bacterial endocarditis prophylaxis when indicated (16).

Arrhythmias and Conduction Abnormalities

Arrhythmias or cardiac conduction disturbances detected during the preoperative evaluation should prompt further investigation to rule out underlying cardiopulmonary disease, metabolic derangements, or drug toxicity. Electrolyte evaluation may be indicated, especially in patients receiving diuretics or other medications with known renal or cardiac toxicity. Benign rhythm and conduction disturbances (e.g., sinus arrhythmia, first-degree atrioventricular block) do not require further workup.

Patients with intraventricular conduction delays and no history of advanced heart block do not need any further intervention. Patients with high-grade conduction abnormalities that meet criteria for permanent pacemaker placement should have this performed prior to surgery. If surgery cannot be delayed, a temporary transvenous pacemaker should be placed. Therapy for symptomatic or hemodynamically compromising arrhythmias (e.g., rapid atrial fibrillation) should be instituted and the patient stabilized before proceeding to surgery.

Interventions To Reduce Cardiac Risk Pulmonary Artery Catheters

Pulmonary artery catheters are often used in critically ill patients and in those at high risk for perioperative cardiac complications. This practice stems from the belief that invasive physiologic monitoring can help refine treatment and improve patient outcomes (17). Evidence to this effect, however, has been lacking. A recent randomized, controlled trial of 1994 high-risk surgical patients found no significant difference in outcomes between patients managed with standard therapy versus patients managed with a pulmonary artery catheter (in-hospital mortality 7.8% in the pulmonary artery catheter group vs. 7.7% in the standard therapy group).

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Preoperative Cardiovascular Risk Evaluation (continued)

There was, however, a higher rate of pulmonary embolism in the catheter group than in the standard therapy group (8 vs. 0 events)(18). Based on this information and a large body of inconclusive data, pulmonary artery catheters should not be used routinely in patients undergoing high-risk surgery.

Coronary Artery Bypass Surgery

There are no randomized controlled trials assessing the merits of prophylactic coronary artery bypass surgery on lowering the risk of noncardiac surgery. That being said, patients who have successfully undergone coronary artery bypass grafting (CABG) have complication rates similar to those patients without angiographic evidence of coronary artery disease (13, 19-21).

Retrospective data from the CASS registry revealed that patients undergoing major noncardiac surgery who have a history of significant coronary artery disease (with no history of bypass surgery) had a mortality rate of 2.4%. Similar patients who had successful bypass surgery had a mortality rate of 0.9%. Patients without a history of coronary artery disease had a mortality rate of 0.5%. However, these data did not account for the mortality from the bypass surgery itself (2.3%)(22). Since the risk of bypass surgery generally exceeds the risk of major noncardiac surgery, decisions on bypass surgery should not be done solely on the basis of lowering risk. However, if the patient's long-term outcome is likely to be improved by CABG then revascularization should be considered before noncardiac surgery.

Preoperative Coronary Angioplasty

Patients who undergo successful percutaneous transluminal coronary angioplasty are at low risk for cardiac complications. However, as with CABG there are no prospective data revealing that prophylactic coronary revascularization with angioplasty before noncardiac surgery reduces the incidence of perioperative cardiac events. Until more data become available, the indications for angioplasty in the perioperative setting are identical to those for angioplasty in the nonsurgical setting (23). Patients who have undergone successful angioplasty before noncardiac surgery should have their surgery delayed for at least several days, allowing for plaque stabilization (3). If a coronary stent is placed, patients should ideally wait at least 1 month, allowing for the stent to endothelialize and for the patient to receive four full weeks of dual antiplatelet therapy with aspirin and clopidogrel.

Beta-Blockers

Several observational studies and randomized, controlled trials have shown that beta-blockers reduce the incidence of perioperative ischemia and myocardial infarction. One study examined the use of atenolol in 200 high-risk patients (defined as having two or more cardiovascular risk factors) undergoing noncardiac surgery. Atenolol produced a 15% absolute reduction in the combined end point of myocardial infarction, unstable angina, myocardial revascularization, congestive heart failure, or death at six months and reduced mortality at both six months and two years (24).

Another trial examined the use of bisoprolol in an even higher risk group (patients with a segmental wall motion abnormality on dobutamine stress echocardiography) undergoing vascular surgery. The patients were randomized to receive either bisoprolol or routine ECG monitoring. The results were significant in that there was only a 3.4% event rate (two nonfatal MIs) in the bisoprolol group, compared with a 34% event rate (nine nonfatal MIs and nine cardiac deaths) in the control group (25). Based on these data, beta-blockers should be recommended for all high-risk patients undergoing noncardiac surgery. Patients who are at intermediate risk may also derive a benefit from beta-blockade, particularly if they have a known history of hypertension, coronary artery disease, or coronary artery disease equivalent (e.g., diabetes mellitus). Ideally, patients should be started on treatment days to weeks before noncardiac surgery with the dose titrated to achieve a resting heart rate of 50 to 60 beats/minute. In patients who are intolerant of beta-blockers, alpha-2 agonists have been shown to reduce the risk for postoperative coronary events; however, the data supporting their use is less convincing (26).

Statins

Patients receiving lipid-lowering HMG-CoA reductase inhibitors (statins) have been shown to have significant cardiac risk reduction in primary and secondary prevention trials. Several observational studies have also shown this to be true for patients undergoing high-risk noncardiac surgery. One large observational study showed an adjusted odds ratio for in-hospital death in the statin group of 0.71 (95% CI, 0.67 to 0.78), a significantly reduced mortality compared with patients undergoing noncardiac surgery who did not receive a statin (27).

A randomized trial examined 100 patients undergoing vascular surgery who were treated with either atorvastatin (20 mg) or placebo for 45 days, regardless of serum cholesterol level. Surgery was generally performed 30 days after randomization, and patients were followed for 6 months. During follow-up, the primary end points (nonfatal MI, ACS, cardiac death, and stroke) occurred in only four of the patients in the atorvastatin group compared with 13 patients in the placebo group (28). The beneficial effects of statins in these trials occurred independent of the risk reduction provided by beta-blockers. Based on these data, it appears that statins should also be considered in all high-risk patients undergoing noncardiac surgery.

Conclusion

The preoperative evaluation offers the opportunity to assess both a patient's short- and long-term cardiac risk. The clinical indications for preoperative cardiac testing and treatment should generally follow those for the nonoperative setting. However, information specific to the patient, the surgical procedure, and the clinical setting should ultimately guide diagnostic and treatment recommendations.

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Preoperative Cardiovascular Risk Evaluation (continued)

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Practical Tips and Avoiding Pitfalls While Implementing Perioperative Beta-Blocker Guidelines

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Although the science of identifying patients who are at highest risk for perioperative cardiac events (e.g., myocardial infarction (MI), unstable angina, congestive heart failure, and cardiac death) is well developed, the evidence to support how best to care for high-risk patients was--until recently--sparse and conflicting (1, 2). The emergence of a strong literature supporting the efficacy and effectiveness of perioperative beta-blockade to reduce the cardiac risks of surgery (3-5) has helped partially resolve the conundrum posed by virtually all guidelines addressing perioperative care of patients with known coronary disease or substantial risks for atherosclerosis: Although preoperative testing algorithms uncover coronary disease, none support preoperative revascularization unless the patient requires it outside of surgery (1, 2).

In the past nine years, a substantial number of well-designed clinical studies have outlined the potential benefits of perioperative adrenergic blockade. Virtually all have demonstrated a substantial reduction in risk when applied effectively in appropriate patients. However, a parallel literature is pointing out how current systems of care are ill-equipped to deliver this important new therapy to appropriate patients. This paper describes several potential solutions to the organizational or other obstacles to effective implementation.

Perioperative Adrenergic Blockade: Evidence for Efficacy and Effectiveness

The earliest studies in this area of inquiry examined the effectiveness of beta-blockers in reducing perioperative ischemia, which poses a three- to eight-fold higher risk for subsequent cardiac events. Strong evidence of their potential for reducing "hard" clinical outcomes (e.g., mortality, myocardial infarction) began with Mangano's 1997 study (15), and was further buttressed by results from Poldermans in 1999 (16) as well as recent observational studies in 2001 and 2002 (17, 18). As a group, these studies suggest that use of beta-blockers provided a relative reduction in risk between 30% and 90%. The sole negative study, a trial of beta-blockers in patients undergoing elective total knee replacement, showed a benefit of similar magnitude (relative risk reduction, 0.33), although this did not reach statistical significance--largely as a result of low overall event rates in the study population (19). Results from all these papers were part of a 2003 meta-analysis, which estimated that the number of patients needed to treat (NNT) to prevent one perioperative cardiac event or death was approximately 30; a figure similar to the 25 to 50 we calculated in our 2001 paper (3).

A parallel literature has evaluated the efficacy of alpha-2 adrenergic agents (e.g., clonidine, mivazerol). Although their route of action differs physiologically from that of the beta-1 blockers in the studies described above, they provide a similar level of sympatholysis and seem effective at preventing perioperative MI and death, albeit at a higher NNT (20).

Both literatures have substantial shortcomings that clinicians should keep in mind. First, no single study of either agent has had a sample size adequate to definitively determine differences in mortality. Next, both groups of studies have focused on surgeries with higher risk (e.g., vascular surgery), making it somewhat difficult to extrapolate to lower-risk procedures, such as laparoscopic or one-day surgery. Differences between protocols in published studies leave important questions unanswered, such as: Which patients should I target? What is the optimal time to begin these agents and when should they be stopped? Which drug should I use? How can I implement a practical and effective strategy at my hospital, based on this evidence?

Perioperative Adrenergic Blockade: Gaps in Administering Effective Care

Although there has been reasonably strong evidence for the efficacy of perioperative beta-blockade for almost eight years, use of these agents has not been widely incorporated into practice. A study from a large academic hospital in Massachusetts suggested that less than one half of eligible patients were receiving beta-blockers at their site. These authors suggested that improving adherence to evidence-based selection criteria would save between 40 and 70 lives annually (7). Nineteen ninety-seven ACP guidelines favored using beta-blockers "in appropriate patients" and both the 1997 published version and the 2002 Web update to the AHA/ACC perioperative cardiac risk management guidelines made similar recommendations (1, 2). Recent publications have made clearer recommendations in this regard, (4, 17, 18) but did not make substantial comments about practical tips for implementation of effective practices.

The need to effectively address these known gaps in care, which are akin to those seen in underuse of beta-blockers and aspirin in medical patients with myocardial infarction, is clear, and likely to become more acute. The LeapFrog group, a consortium of health care purchasers that seeks to compel quality change by selecting high-quality providers for its members, has recently added perioperative beta-blockade in vascular surgery patients to its list of key indicators (http://www.qualityforum.org/txNQFprojectsummarysafepractices.pdf). Public reporting of surgical outcomes and adverse events is also on the horizon, making it even more important for health care systems and hospitals to provide an environment where physicians can provide uniform and effective evidence-based care.

Step 1: Know the Clinical Goals of Perioperative Beta-Blockade

The effective use of perioperative adrenergic blockade requires each physician, hospital, or health care system to know the key clinical practices required for perioperative adrenergic blockers to be used effectively.

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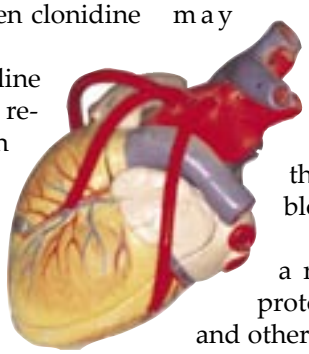
Choose an Agent

While clonidine has substantial advantages in terms of ease of dosing in patients unable to take oral medications (e.g., patch), there are practical arguments for choosing beta-blockers over clonidine in all but a few patients.

First, there are fewer and fewer "hard" contraindications to short-term use of beta-blockade, particularly cardioselective beta-blockers. A recent meta-analysis of beta-blocker use in patients with lung disease suggested that use of beta-1 blockers in the short term neither worsened symptoms nor increased inhaler use (21). A similar analysis evaluating the safety of beta-blockers in patients with diabetes suggested that the benefit of beta-blockers far outweighs the risks for masking hypoglycemic symptoms (22). Thus, it appears that the only remaining contraindications to beta-blocker use are documented intolerance to the drug and unremediated conduction system disease, and even clonidine may be difficult to use safely in these patients.

Second, alpha-2 agonists are not first-line therapy for hypertension or for prevention of recurrent ischemic events in patients with known coronary artery disease. Because the use of perioperative beta-blockade often leads to long-term therapy, approaches that use beta-blockers will provide a more direct segue into appropriate lifelong therapy.



Identify Patients Early and Start Agents before Surgery

Identify patients: There are several published algorithms that suggest strategies for identifying patients who require perioperative beta-blockade (1, 3). In general, these algorithms incorporate clinical factors known to be associated with coronary disease risk (e.g., smoking, hypercholesterolemia), a known history of coronary disease, and the type of surgery being planned. These factors are based on those used in previous studies of perioperative beta-blockers, as well as broadly accepted definitions of "at-risk" patients.

Having a clinical algorithm in place is only one part of effective practice: You also need to give yourself enough time to dose-titrate beta-blockers and identify patients at highest risk. Highest-risk patients in whom beta-blockade alone is not enough--patients with unstable coronary disease or other worrisome features, such as aortic stenosis (23) or congestive heart failure--provide ample opportunity for careful clinical thought, clear communication with anesthesia and surgical colleagues, and frank discussions with the patient about surgical risks and benefits. Identification of these patients and appropriate triage will require more time and forethought, however.

Start early: Evidence is clear that preinduction (e.g., before anesthesia begins) administration of adrenergic blockers is a crucial step in effective clinical practice, but how long beforehand is an open question. The study by Mangano began beta-blockers in the preanesthesia holding area (24); others began agents as long as one month beforehand (on average)(16). It makes good clinical sense to try to develop an approach that will begin agents as long in advance as possible, with the intent of giving physicians the opportunity to titrate agents to an effective heart rate before surgery. However, "last-minute" identification and administration even on the day of surgery is likely to be effective, but gives far less margin for error if highest-risk patients are found immediately before surgery.

Clinical Goal: Achieve Sympatholysis after Surgery and Continue for as Long as You Can

One of the most crucial practices in effective use of perioperative beta-blockers is titration so that a target heart rate is achieved. The target heart rate tends to differ slightly among study protocols, but was generally less than 70 beats/min. In fact, lack of aggressive dose titration may have played a part in the one negative study we mentioned previously. While it is a simple clinical concept, how to achieve adequate heart rates--from the beginning to the end of therapy-- requires substantial consideration in the implementation phase of a perioperative beta-blocker protocol.

The duration of therapy after surgery is a relatively open question, as some studies used protocols that treated patients in the hospital only and others continued beta-blockers for a month or longer. In general, longer treatment with beta-blockers seems to extend the protective benefit of adrenergic blockade. This is consistent with most clinicians' practice, in which the vast majority of patients who require beta-blockade at the time of surgery are either receiving the agents already or would benefit from taking them on a lifelong basis (e.g., history of coronary artery disease or hypertension). In these patients, beta-blockers should be continued indefinitely. In patients who do not require lifelong beta-blocker therapy, treatment for up to 30 days is likely to provide optimal benefit.

Step 2: Know Thy Systems, and Know Them Well

In the end, "the rubber meets the road" during implementation of any quality initiative. While there is ample literature describing the broad principles of quality improvement in the in-patient setting, it is important to point out systems issues that make implementation of perioperative beta-blockade guidelines or protocols unique. The specific approach you take at your hospital will differ somewhat, but some common issues and possible solutions are described below.

How do patients get from home to the operating room and back again? At the outset, work very hard to understand how patients get from home, to the surgeon's and anesthesiologists's office, to your hospital, and back home. Do you have multiple preoperative clinics? Do you have several clinical sites where operations are performed? Do you have a large, referral-based patient population? How many surgical patients, and what kind, does your hospital medicine group care for? Understanding these systems issues will define the challenges and opportunities you face early in your planning process.

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Who are the critical personnel? Because surgical patients are often seen by multiple physicians (e.g., surgeon, anesthesiologist, internists) during a single hospitalization, it will be important to identify interested and motivated personnel from each of these physician groups. Similarly, it will be important to enroll help from nursing, pharmacist, or nonphysician provider groups who care for surgical patients throughout your hospital. Keep the group as small as possible but broad-based, motivated, and composed of thought leaders and clinical practice leaders. Hospitalists are uniquely positioned to bring these groups together, especially if they have preexisting co-management or standardized consultation agreements with surgeons. Recognize that your institution's priorities may reach beyond these arrangements, however, and seek to include as many active and interested personnel as practical.

How can I reduce complexity and make caregivers' lives easier while implementing my guideline? While recognizing the key clinical practices in perioperative beta-blockade, keep in mind the goal of your program is both to improve care and to make the system work more efficiently. To this end, try to adhere to a precept of taking away one (or optimally two) steps when adding a task to an already overburdened set of clinical providers. For example, avoid systems that necessitate "double documentation" (e.g., documenting heart rate on vitals flow sheet and dose-titration sheet) or that add to work without subtracting it from somewhere else (e.g., discharge prescription for beta-blockers is preprinted on initial order set).

Step 3: Tailor Your Clinical Care Practices to Your Systems

1. *Find the common pathway that all patients must take to get to the operating room.* If your hospital has a single preoperative clinic, make your strongest effort there; if you have multiple preoperative clinics or providers, consider beginning your beta-blocker protocol in the preanesthesia area on the day of surgery. While "academic detailing" is on occasion an effective approach to increasing adherence to guidelines, it is prone to recidivism over time and is labor intensive.

2. *Maintain continuity of beta-blockade during hospitalization.* Once patients begin the beta-blocker protocol, make sure that they stay on it during hospitalization. This is particularly crucial on the operative day, when patients transition from home to the preanesthesia area, to the operating room, to the postanesthesia area, and then to their hospital bed; each of these transitions is a potential "dropped handoff." A single order set for all patients that is not altered and that follows the patient across phases of care may achieve this goal in hospitals without computer order entry systems.

3. *Maintain continuity of beta-blockade beyond hospitalization.* Some nuances of this step depend on how long you choose to treat patients who are not receiving beta-blockers on a long-term basis, but effectively continuing beta-blockade for 30 days or for a lifetime requires a system that accurately discriminates between those two groups of patients. This goal may be achieved by specifying a "stop date" in the order set mentioned above, with an additional category for patients who are already on long-term therapy (or in whom long-term therapy is deemed appropriate at the outset).

4. *Establish a protocol for dose titration.* As we described, making sure patients' heart rates are in a target range is key; how to do this in practice depends entirely on your local systems. In our teaching hospital, this responsibility is falling to the house officers, using a preprinted "suggested" dose titration algorithm. At other sites, nurses, pharmacists, or physician's assistants or nurse practitioners may serve this role.

5. *Decide how to deal with NPO patients, or "how I learned to stop worrying and give IV metoprolol off telemetry."* While most centers are reluctant to approve administration of IV beta-blockers in patients not on telemetry, the evidence base for this reluctance is scanty and based almost entirely on data from patients with acute coronary syndromes. Several sites, including our own, have been using an unmonitored floor IV metoprolol protocol without incident; we hope to publish these results in the next year or so. Other approaches would be to minimize the number of truly NPO patients through educational efforts (at our center, only patients on continuous nasogastric suction or those with perforated viscera are considered truly NPO), or by using clonidine patches selectively and rapidly transitioning to beta-blockers as soon as possible.

Conclusion

Although the effectiveness of perioperative beta-blockers appears well supported by available evidence, numerous aspects of how to utilize current evidence in practice have yet to be fully elucidated. Some of these questions can be answered by amalgamating evidence from the studies themselves; others must be approached using methods provided by the long years of evidence supporting the use of beta-blockers in other settings.

The greatest challenge for hospitals and health care systems will be how to implement guidelines that ensure all patients are treated appropriately. Knowing your sites and systems well, and tailoring your guidelines so that the key clinical practices are addressed completely, will greatly facilitate the success of your efforts.

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Estimating and Reducing Perioperative Pulmonary Risk for Non-Cardiothoracic Surgery

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Introduction

More than 28 million Americans undergo surgery each year in the United States at an economic burden of $300 billion annually; it is predicted the number of Americans undergoing surgery annually will increase to 40 million per year over the next three decades (1). Traditionally, preoperative evaluations have focused primarily on estimation of the risk for postoperative cardiac complications; however, it is becoming increasingly clear that postoperative pulmonary complications (PPCs) significantly impact morbidity and mortality. PPCs are as common as cardiac complications and can result in longer hospital stay (2, 3). Additionally, postoperative pulmonary complications were one of 6 independent predictors of decreased long-term survival among elderly patients undergoing noncardiac surgery (4). The other predictors included renal complications, history of cancer, neurologic disease, advanced age, and American Society of Anesthesiologists' (ASA) class >2. Thus, a thorough preoperative evaluation should include an evaluation of risk factors for PPCs and an effort to minimize this risk.

Recent studies have better elucidated risk factors for PPCs; these may be divided into procedure- and patient-related risk factors (Table 1). Procedure-related risk factors most strongly influence the development of PPCs. In this review, we summarize the risk factors for PPCs, indications for specific laboratory testing, and strategies to reduce the development of PPCs. We restrict our discussion to non-cardiothoracic surgery.

Case scenario

A 75-year-old male veteran presents with weight loss, lower abdominal discomfort, and hem-positive stools. He is transferred to the general surgery service after the discovery of a near obstructing colonic mass, which on biopsy is an adenocarcinoma. He has a previous history of abdominal surgery. You are asked to perform a preoperative evaluation in preparation for open colectomy.

What procedure-related risk factors contribute to the estimation of this patient's PPC risk?

Surgical site

The surgical site is the most influential risk factor in predicting PPCs. The closer the incision is to the diaphragm, the higher the risk for PPCs. Cardiothoracic procedures, open abdominal aortic aneurysm repairs, and

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Table 1. Patient- and procedure-related risk factors for postoperative pulmonary complications

Procedure-related risk factors	Surgical site: • Esophageal surgery • Thoracic surgery • Upper abdominal surgery • Aortic surgery • Head and neck surgery
	Pancuronium (Long-acting neuromuscular blocker)
	General anesthesia
	Surgery lasting > 3 hours
	Emergency surgery
Patient-related risk factors	Chronic obstructive pulmonary disease • Sputum production • Wheezing on exam • Maximum laryngeal height <4 cm
	ASA class >2
	Poor exercise capacity
	Cigarette use
	Obstructive sleep apnea
	Age > 70

upper abdominal procedures confer the highest risk (5, 6). Procedures associated with the lowest risk include: ophthalmologic, ear, nose, mouth, extremity (e.g. nonvascular surgery related to the humerus, wrist, hip, or knee), urogenital, and spine and back (e.g., laminectomy) surgeries. PPCs are minimal, even among high risk patients undergoing these low risk procedures.

Type of anesthesia

Debate has long existed regarding the risks attributable to general or neuraxial anesthesia. Spinal or epidural anesthesia (neuraxial blockade) can attenuate the sympathetic stress response to surgery (7). In a large meta-analysis of 9,559 patients who were randomly assigned to neuraxial blockade (plus or minus general anesthesia) versus general anesthesia alone, patients in the neuraxial blockade group had a 39% reduction in postoperative pneumonia and a 59% reduction in respiratory depression (8). Additionally, a statistically significant decrease occurred in deep venous thrombosis, pulmonary embolism, myocardial infarction, renal failure, and overall 30-day mortality. Despite these favorable outcomes, this meta-analysis does not provide the definitive answer. Many of the trials in this meta-analysis were performed prior to 1990 and differences in current anesthetic technique make it difficult to draw firm conclusions (9). Additionally, many of the trials had a study size < 50. Pending further study, however, we consider general anesthesia to be a PPC risk factor.

Another anesthesia-related risk factor associated with PPCs is the use of pancuronium, a long-acting neuromuscular blocking agent, which increases the risk of neuromuscular blockade and subsequent hypoventilation following surgery (10).

Other surgical factors

Surgery duration ≥3 hours (11, 12) and emergency surgery (5, 6) are both associated with an increased risk of PPCs. Whether a laparoscopic procedure versus an open procedure is associated with decreased PPC risk is less clear, although the benefits of a quicker recovery time and a less conspicuous scar make it an appealing option. Less deterioration in pulmonary function testing occurs, although whether differences in clinical outcomes occur remains unresolved (13).

This patient is awaiting an open colectomy, a high risk procedure. Given his history of prior abdominal surgery, the anticipated duration of surgery is approximately three hours. Decisions regarding surgical and anesthesia techniques are clearly beyond the expertise of the medical consultant; however, knowledge of these risk factors can improve collaboration among the medical consultants and operative teams.

The patient has COPD and a 40 pack year smoking history. He drinks three cans of beer/day. He has difficulty walking due to severe osteoarthritis involving his knees and requires a walker and assistance going to the bathroom and dressing. He notes a worsening cough with yellow sputum over the past one week.

What are the pertinent patient-related risk factors?

Traditional risk factors for PPCs include poor overall general health status, current tobacco use, COPD, and advanced age.

Poor overall general health status

Several available indices estimate overall heath status. A common classification is the American Society of Anesthesiologists' Physical Status Classification (ASA Class), originally developed to estimate all-cause perioperative mortality (14). Assignment of class is subjective and takes into account the patient's comorbidities and functional status, with Class 1 describing a normal healthy patient and class 5 describing a critically ill patient in whom survival greater than 24 hours is not expected. ASA Class > 2 is associated with an odds ratio of 1.7- 3.2 for developing PPCs (15).

Objective testing of functional status can also add helpful information, although this may not be feasible in the acute hospital setting. In one report, researchers directed 83 patients before high-risk surgeries to "climb as far as possible at your pace using the railing only for balance" (16). The primary outcome was cardiopulmonary complications within 30 days of surgery. Twenty-five percent of patients experienced a postoperative complication; pulmonary complications were nearly three times as common as cardiac complications. The inability to climb at least two flights of stairs had a positive predictive value of 80% for postoperative cardiopulmonary complications. Eighty-nine percent of patients unable to climb one flight of stairs developed a cardiopulmonary complication. In another study, poor self-reported exercise predicted an increased risk for in-hospital perioperative serious complications, though not specifically PPCs. Nonetheless, the feasibility of obtaining this information during the preoperative assessment is appealing; thus, we recommend evaluating self-reported exercise tolerance during the preoperative assessment (39).

Current tobacco use

Cigarette smoking increases tracheobronchial secretions and airway reactivity while also inhibiting mucociliary clearance. Current cigarette use, usually defined as smoking within two weeks of the operation, increases the risk of PPCs, even in the absence of chronic obstructive pulmonary disease (15). Current cigarette use is associated with an odds ratio of 1.9 for developing PPCs (17). A > 40 pack-year tobacco history also independently predicts PPCs (18).

Chronic obstructive lung disease

Chronic obstructive pulmonary disease (COPD) is a well-established risk factor for PPCs, although it is difficult to precisely estimate its contribution due to variable criteria and differences in study designs across multiple studies. It is associated with an odds ratio of 4.7 for developing PPCs (15).

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Estimating and Reducing Perioperative Pulmonary Risk for Non-Cardiothoracic Surgery (continued)

Specific elements of the history and physical exam of patients with COPD predict PPCs. Chronic sputum production predicts PPCs, particularly following upper abdominal surgery (11, 19). A unique but not well-known physical exam finding predictive of PPCs is a maximum laryngeal height of ≤ 4cm (18). The distance between the top of the thyroid cartilage and suprasternal notch is laryngeal height; maximum laryngeal height is measured in end-expiration. The significance of a maximum laryngeal height of ≤ 4cm suggests lung field hyperexpansion.

Advanced age

Advanced age is a controversial risk factor. Its contribution to the development of PPCs is difficult to precisely assess due to multiple comorbidities that may accompany advanced age. In general, the odds ratio associated with advanced age is 1.9- 2.4, with advanced age defined as age ≥ 70 years; however, clinicians should not deny surgery based solely on advanced age alone (15).

Obesity

Obesity is often cited as a risk factor; however most studies do not adequately control for comorbidities. Despite reduced lung volumes and the potential for worsening ventilation/perfusion mismatch in the perioperative period, obesity has not been shown to increase risk of PPCs. In a systematic review, PPC rates were similar for non-obese patients (7.0%) and obese patients (6.3%)(17).

Obstructive sleep apnea (OSA)

The pathophysiologic basis of OSA suggests a potential for airway management complications in the perioperative period, including severe hypoxemia, CO2 retention, and the need for re-intubation.

Gupta et al retrospectively evaluated patients with OSA undergoing hip or knee replacement compared with a group of matched control patients (20). Patients with OSA had a higher incidence of serious complications, which included cardiac events and complications requiring ICU transfer or urgent respiratory support such as intubation or application of CPAP (24% versus 9%, respectively; p value 0.004). Most complications occurred in the first 24 hours following surgery. Given the increased incidence of in-hospital events requiring urgent respiratory support in the postoperative period, we consider OSA to be a PPC risk factor. In minor, outpatient, non-ENT procedures, however, OSA does not increase the risk for unplanned hospital admissions (21).

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Table 2. Risk index for predicting postoperative pneumonia*

Risk Factor	Points
Procedure-related	
Type	15
AAA repair	14
Thoracic	10
Upper abdominal	8
Neck	8
Neurosurgery	3
Vascular	
Emergency surgery	3
General anesthesia	4
Patient-related	
Age	
≥80 y	17
70-79 y	13
60- 69 y	9
50- 59 y	4
Functional status	
Totally dependent	10
Partially dependent	6
Weight loss > 10% in past 6 months	7
History of COPD	5
Impaired sensorium	4
History of CVA	4
Blood urea nitrogen	
<8 mg/dL	4
22-30 mg/dL	2
≥30 mg/dL	3
Steroid use for chronic condition	3
Current smoker within 1 year	3
Preoperative blood transfusion > 4 units	3
Alcohol intake > 2 drinks/d in past 2 weeks	2

Total points	*Risk of pneumonia (%)*
0-15	0.24
16-25	1.19
26-40	4.0
41-55	9.4
>55	15.8

* Reprinted with permission from Arozullah AM, Khuri SF, Henderson WG, Daley J, et al. Development and validation of a multifactorial risk index for predicting postoperative pneumonia after major noncardiac surgery. Ann Intern Med. 2001; 135: 847-57.

Risk indices

In the past four years, researchers have expanded the traditional list of risk factors and advanced the field of preoperative pulmonary assessment with the development of the first validated multifactorial risk indices, akin to the impact of the original Goldman Cardiac Risk Index (22). (See Tables 2 and 3.) Arozullah et al derived and validated risk indices for predicting postoperative respiratory failure and postoperative pneumonia using a large database of veterans undergoing noncardiac surgery (5, 6). The postoperative pneumonia risk index confirmed the importance of surgical site in close proximity to the diaphragm. In the postoperative pneumonia risk index, high risk procedures also included neck surgery, neurosurgery, and vascular surgery. The authors noted that the risk index also highlighted patient-specific factors related to immune status, neurologic status, and fluid status. The impact of age was more pronounced than suggested by previous studies, with an odds ratio of 3.6 and 5.6 for patients ≥ 70 years and ≥ 80 years, respectively. The postoperative respiratory failure index included similar variables. As this was a predominantly elderly, male veteran population, it may be difficult to extrapolate these findings to other patient populations. Additionally, preoperative spirometry results and high body mass index were not evaluated, and the contribution of COPD may have been underestimated. Nonetheless, these risk indices are landmark achievements in the field of preoperative pulmonary assessment and are important in their ability to more precisely estimate PPC rates.

Table 3. Risk index for predicting postoperative respiratory failure*

Risk Factor	Points
Procedure-related	
Type	
AAA repair	27
Thoracic	21
Neurosurgery, upper abdominal, or peripheral vascular	14
Neck	11
Emergency surgery	11
Patient-related	
Albumin (< 30g/L)	9
BUN (>30 mg/dL)	8
Partially or fully dependent functional status	7
History of COPD	6
Age (years)	
≥70	6
60-69	4

Total points	*Risk of respiratory failure (%)*
<10	0.5%
11-19	2.2%
20-27	5.0%
28-40	11.6%
>40	30.5%

* Reprinted with permission from Arozullah A, Daley J, Henderson W, Khuri S. Multifactorial risk index for predicting postoperative respiratory failure in men after noncardiac surgery. Annals of Surgery. 2000; 232:243-253.

This patient's risk factors for PPCs are many and include: surgical site, history of COPD, tobacco use, dependent functional status, productive cough, and an abnormal lung exam. His high risk is confirmed by the risk index for predicting postoperative pneumonia, which estimates his PPC risk as at least 9%.

Which routine laboratory tests are helpful in addition to the history and physical exam?

Chest radiograph The distinction between obtaining chest radiographs to help answer specific clinical questions versus obtaining screening chest radiographs in healthy presurgical patients is often blurred. In this particular patient, a chest radiogram is a necessary part of his initial clinical evaluation. In otherwise healthy patients awaiting surgery, however, routine screening with chest radiograph rarely adds useful information to the preoperative evaluation or affects perioperative management. As an example, in a meta-analysis of 14,390 preoperative chest radiographs, while authors identified abnormalities in 10% of routine preoperative chest radiographs, only 1.3% of the abnormalities were unexpected, and 0.1% of cases resulted in a change in perioperative management (23).

Advanced age, multiple co-morbidities, and ASA Class ≥ 3 with underlying pulmonary disease predict an increased likelihood of an abnormal chest radiogram (24). We recommend obtaining a screening preoperative chest radiogram prior to elective major surgery in patients with multiple comorbidities, especially underlying cardiac or pulmonary disorders. Routine preoperative screening chest radiograph in low risk procedures, for example, cataract surgery with local anesthesia in conjunction with intravenous sedation, is not indicated, unless a patient needs an evaluation for an active cardiopulmonary process.

Arterial blood gas analysis Small studies have identified hypercarbia as a predictor for increased PPCs; however, most studies did not determine if hypercarbia added information to that obtained by clinical evaluation (12, 15). There is no threshold value for CO_2 or P_a0_2 at which surgery is prohib-

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ited; thus, routine blood gas analysis is not necessary in determining fitness for surgery.

Serum blood work: albumin and blood urea nitrogen Hypoalbuminemia and elevated blood urea nitrogen (BUN) are independent risk factors for increased PPCs (5, 6). While these tests are not indicated in the healthy patient awaiting surgery or even in stable patients with multiple comorbidities awaiting low-risk procedures, serum albumin and BUN can assist in estimating risk in patients with multiple comorbidities awaiting higher risk procedures.

Spirometry Spirometry may identify and assess the degree of airway obstruction. Whether spirometric values add incrementally to the estimation of pulmonary complication risk when compared to clinical variables remains unclear. Earlier studies suggested that a decreased FEV_1 predicted an increased risk of PPCs among patients undergoing abdominal surgery; thus, recommendations for routine preoperative spirometry prior to abdominal surgery became commonplace.

Most studies, however, have not directly compared the usefulness of clinical variables to spirometry (25). In a case-control study of abdominal surgery patients, abnormal results of lung examination (decreased breath sounds, prolonged expiration, rales, wheezes, or rhonchi), abnormal chest radiograph, cardiac morbidity, and overall comorbidity predicted PPCs (26). One study did find that an FEV_1 of 0.9 ± 0.2 in smokers undergoing abdominal surgery predicted the development of bronchospasm; however, this complication was easily treated, did not confer significant morbidity, and did not prolong hospitalization (27).

In conclusion, spirometry rarely adds additional predictive information to clinical variables. Even among patients with severe COPD, no threshold FVC or FEV_1 level exists below which one should deny surgery. It is useful in evaluating patients with asthma or COPD who may not be at their baseline and are undergoing medication titration or in evaluating patients with unexplained dyspnea.

This patient was deemed a high surgical risk for PPCs based on previous clinical information. His albumin was 2.0 mg/dl, creatinine 1.8, and BUN 38. Chest radiogram showed hyperinflation, normal cardiac silhouette, and no infiltrates. Spirometry was not obtained primarily because it would not have altered his management.

What interventions may reduce his PPCs risk?
Preoperative interventions

Smoking cessation The optimal time period to discontinue smoking prior to surgery is at least 8 weeks before surgery (15, 28). In fact, some studies actually suggest a paradoxical increase in PPCs for patients who stop smoking less than 8 weeks before surgery; one theory suggests that mucus hypersecretion is still present but ineffective cough reflex remains (28, 29). The validity of this paradoxical increase, however, is questionable due to several methodological flaws in these largely retrospective studies.

Thus far, only one preoperative smoking cessation intervention trial exists. In that report, 108 men undergoing hip or knee arthroplasty were randomly assigned to either an intervention group or control group six to eight weeks prior to surgery, continuing until 10 days after surgery (30). Patients in the intervention group received weekly teaching on smoking cessation and were given nicotine replacement. Control group patients received usual standard care. The intervention group had fewer overall complications versus the control group (18% versus 52%, respectively, p= 0.0003), with wound complications comprising the largest subset. There were no differences seen in the PPC rate; however, few PPCs developed in either group, confirming previous studies that knee and hip arthroplasty confer a low risk of PPCs. Nonetheless, this study supports the recommendation to start smoking cessation at least 8 weeks prior to elective noncardiac surgery.

Preoperative total parenteral nutrition (TPN) Malnutrition and hypoalbuminemia predict the development of PPCs and are logical targets for intervention. However, the optimal strategy for nutritional supplementation is not known. The Veterans Administration sponsored a multi-site randomized trial comparing perioperative total parenteral nutrition (TPN) to no TPN in 395 malnourished patients undergoing laparotomy or noncardiac thoracotomy (31). There were no differences in the rates of major complications or in 90-day mortality. Additionally, non-significant trends existed for higher rates of pneumonia (8.3% versus 4.4%) and respiratory failure (6.8% versus 5.4%) in the TPN group. However, severely malnourished patients who received TPN had no increase in infectious complications versus control patients and also had fewer noninfectious complications (e.g. cardiovascular, gastrointestinal, and renal complications, and pulmonary embolus). This area requires further research. The authors suggest that TPN may be beneficial in only the severely malnourished patient.

Intraoperative interventions The goals of intraoperative interventions, that fall under the direction of anesthesiologists and surgeons, extend beyond that of reducing PPCs. Thus, the goal of this section is primarily descriptive and informational for the general internist.

As discussed in the previous section, neuraxial blockade, when compared to general anesthesia alone, results in a 39% reduction in postoperative pneumonia and 59% reduction in respiratory depression (8). Another potential risk reducing anesthesia- intervention is avoiding pancuronium, a long-acting neuromuscular blocker (10). Limiting procedure duration to < 3 hours is associated with decreased risk (11, 12).

Postoperative interventions

Lung expansion maneuvers. Lung expansion maneuvers improve alveolar inflation and minimize atelectasis. Lung expansion maneuvers include chest physiotherapy (deep

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breathing exercises with cough, suctioning, percussion and vibration, and/or postural drainage), incentive spirometry, intermittent positive pressure breathing (IPPB), and continuous positive airway pressure (CPAP). Incentive spirometry, deep breathing exercises, and IPPB decrease PPCs by approximately 50% in patients undergoing abdominal surgery (32, 33). No single method is clearly superior (32-34). CPAP may be more efficacious than traditional methods (32-34) and requires minimal patient effort; however, it is more expensive than incentive spirometry or deep breathing exercises. Patient discomfort and gastric discomfort limit its use. In general, any lung expansion modality is better than no intervention; and maximum reduction in PPC risk occurs when education in lung expansion maneuvers is initiated preoperatively (35).

Postoperative nasogastric tube placement. In a meta-analysis of controlled studies of selective versus routine nasogastric decompression after elective laparotomy, selective nasogastric decompression was associated with lower rates of pneumonia and atelectasis when compared to routine nasogastric decompression (odds ratio 0.49, $p<0.0001$ and odds ratio 0.46, $p<0.001$, respectively). Therefore, limiting postoperative nasogastric tube placement to patients with a clinical indication represents another potential intervention for reducing PPC risk (36).

Postoperative analgesia. Postoperative epidural analgesia, when compared to traditional parenteral opioid analgesia, decreases PPC rates. For example, among 915 high risk patients undergoing major abdominal surgery, respiratory failure occurred less often in the group that received intraoperative and postoperative epidural local anesthestic than in the group receiving postoperative patient-controlled intravenous opioid (23% versus 30%, respectively; 0=0.02) (37). A meta-analysis also confirmed that postoperative epidural analgesia reduced postoperative pulmonary morbidity (38).

His physicians started antibiotics for treatment of his COPD exacerbation, an aggressive bronchodilator regimen, and preoperative education in lung expansion maneuvers. Due to his extremely poor nutritional status, preoperative TPN was started. He received postoperative epidural analgesia. Due to the potential for increased PPCs, he did not receive a routine postoperative nasogastric tube.

Summary

PPCs contribute significantly to perioperative morbidity and mortality. We have discussed risk factors for PPCs and potential interventions to reduce risk. Procedure-related risk factors include upper abdominal, thoracic, and aortic surgery, prolonged surgery, general anesthesia, and pancuronium use. Patient-related risk factors include COPD, cigarette use, advanced age, poor general health status, OSA, and hypoalbuminemia. Risk indices exist for predicting postoperative pneumonia and postoperative respiratory failure. Laboratory and spirometric testing add minimally to a risk assessment based on clinical evaluation. The evidence base supports specific interventions to reduce risk among high-risk patients. In the preoperative period, airflow limitation should be minimized, smoking cessation initiated at least 8 weeks prior to surgery, and education in lung expansion maneuvers begun. Intraoperative risk reduction strategies include: minimizing duration of surgery < 3 hours, avoiding pancuronium, and considering neuraxial blockade versus general anesthesia. Clinicians may recommend a number of strategies to reduce risk among high-risk patients in the postoperative period: lung expansion maneuvers, continuation of CPAP in patients with OSA, postoperative epidural analgesia in place of traditional parenteral opioid analgesia, and limiting postoperative nasogastric tube placement to patients with a clinical indication.

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Postoperative Management of Diabetes Mellitus

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The relationship between moderate hyperglycemia and the microvascular complications of diabetes is now well-established. Whether near-normal ("physiologic") glycemic control will further reduce the risk for these complications is not yet established. Furthermore, diabetes mellitus is associated with adverse outcomes in hospitalized patients, especially related to cardiovascular and surgical outcomes. Data are accumulating that intensification of glycemic control in hospitalized patients may reduce the risk for adverse medical outcomes, including mortality. It is not yet clear whether the putative benefits relate entirely to glycemic control or whether some of the benefits may be related to direct benefits of insulin therapy. Furthermore, there are several published regimens available for managing dysglycemia in diabetic and nondiabetic patients. However, there are no clearly established regimens that work in all situations. At present, most data are derived from postsurgical and critical care patients.

This article will review the current state of guideline development, summarize some of the more robust data that suggest favorable effects of glycemic control and insulin use in hospitalized patients, and provide information on options for insulin protocols. The various glucose-lowering strategies that may be implemented in a variety of hospital-based management situations will be discussed. The intent is to provide a rationale for managing dysglycemia and provide suggestions for strategies that may be applicable to hospital-based physicians in a variety of working environments.

Table 1. Putative Relationships Among Hyperglycemia and Poor Outcomes in Hospitalized Patients (adapted from Clements el al, reference 1).*

Hyperglycemia and Immune Function
Neutrophil/monocyte dysfunction: Impaired phagocytosis, chemotaxis, bacterial killing, impaired respiratory burst

Hyperglycemia and Cardiovascular Disease
Cellular damage: Impaired ischemic preconditioning, impaired coronary flow, cell death/apoptosis
Hemodynamic changes: Altered blood pressure, increased catecholamines, increased QTc intervals

Hyperglycemia and Thrombosis
Factors favoring thrombosis: Increased PAI-1, decreased t-Pa, increased platelet aggregation

Hyperglycemia and Inflammation: Increased Cytokine Concentrations
(IL-6, IL-18, TNFα, NF-κB)

Hyperglycemia and Endothelial Dysfunction
Impaired vascular reactivity
Increased reactive oxygen species

Hyperglycemia and the Brain
Increased neuronal damage

Hyperglycemia and Oxidative Stress
Increased reactive oxygen species

*IL = interleukin; NF-κB = nuclear factor kappa B; PAI = plasminogen activator inhibitor; t-Pa = tissue plasminogen activator; TNF = tumor-necrosis factor.

Background Consensus and Technical Issues Documents

Interest in the topic of inpatient glycemic control is increasing. Major organizations are becoming driving forces to acquire data and drive clinical practice to affect outcomes. Two consensus-type documents provide extensive background material and are recommended to readers of this review (1, 2).

The American Diabetes Association recently published a technical review, which is a comprehensive summary (including 449 references), of the current state of glucose control in hospitalized patients (1). This comprehensive review looks at the evidence supporting the concept that intensifying glucose control in the hospital setting improves outcomes in diabetic (and other hyperglycemic) patients. A brief review of this article's contents will be helpful to understanding the current state of the issues surrounding glucose control in hospitalized patients. The magnitude of the problem is described by showing that the prevalence of diabetes in hospitalized patients as reported in a number of studies (using a variety of criteria to diagnose diabetes) was between 12.4% to 25%. The relationship between hyperglycemia and poor outcomes is uncertain. However, several putative relations are considered, including those items summarized in Table 1. The article then reviews key clinical studies that suggest an association between adverse outcomes and associated evidence that glucose lowering results in more favorable outcomes. Finally, there is a review of medical nutrition therapy, oral agent use, and insulin use with benefits and risks of several glucose-lowering approaches.

The American Association of Clinical Endocrinologists is in the process of developing strategic ventures in the area. A summary of one of these ventures, a supporting consensus conference, has been published in *Endocrine Practice* (2). Summaries of many of the key studies and options for insulin algorithms are available in that supplement. Official guideline statements and future publications as a result of these efforts will change the landscape and provide important information for hospitalists who manage patients with hyperglycemia.

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Postoperative Management of Diabetes Mellitus (continued)

Rationale for Glucose Management in Hospitalized Patients

The recent meta-analysis of Pitta and colleagues (3) that reviewed 35 trials of insulin therapy in hospitalized patients showed a 15% decrease in short-term mortality overall. The benefits were most obvious with insulin therapy in surgical intensive care units (ICUs) (42% reduction in mortality). Reduction in mortality was also shown when glucose control was the target (29%), the analyses were limited to diabetic patients (27%), and when patients with acute myocardial infarction (MI) were analyzed (16%; *P* = NS). These results are consistent with benefits of insulin therapy and glucose control in ICUs; however, there are few data on the typical hospital setting and a paucity of randomized trials. Pitta and coworkers note that "no randomized trials of insulin therapy in the medical intensive care unit were identified." This meta-analysis nicely summarizes the current state of the art. Although there are few randomized trials, there are several settings in which intensifying glucose control—especially with insulin protocols—has been associated with favorable outcomes. Three studies in particular deserve comment. Although one of these studies was done in post-MI patients, the information from this acute setting is relevant to the issues of intensive glucose control in the hospitalized patient.

Table 2. Insulin Infusion Protocol

Protocol of Van den Berghe et al

Test	BG Result	Action
Measure glucose on entry to ICU	> 220 mg/dL 110–220 mg/dL < 110 mg/dL	Start insulin, 2–4 U/h Start insulin, 1–2 U/h Do not start insulin; continue BG monitoring every 4 h
Measure glucose every 1–2 h until within the normal range	> 140 mg/dL 110–140 mg/dL Approaching normal range	Increase insulin by 1–2 U/h Increase insulin dose by 0.5–1U/h Adjust insulin dose by 0.1–0.5 U/h
Measure glucose every 4 h	Approaching normal range Normal Declining steeply 60–80 mg/dL 40–60 mg/dL <40 mg/dL	Adjust insulin dose by 0.1–0.5 U/h Insulin dose unchanged Reduce insulin by half; check BG more frequently Reduce insulin dose; check BG within 1 h Stop insulin infusion, ensure adequate baseline BG intake and check BG with 1 h Stop insulin infusion, ensure adequate baseline glucose intake, administer glucose per 10-g IV boluses and check BG within 1 h
BG = blood glucose; IV = intravenous.		

Post-MI Patients

The first of these studies performed by Malmberg and colleagues comprised patients who were hospitalized in a coronary care unit after acute MI (4-7). This study, called Diabetes and Insulin-Glucose Infusion in Acute Myocardial Infarction (DIGAMI), evaluated 620 diabetic patients who had an acute MI. Three-hundred and six patients were randomized to a treatment regimen comprising insulin infusion during hospitalization followed by a multiple insulin injection regimen for 3 months after discharge. At baseline, both groups had mean blood glucose concentrations greater than 275 mg/dL. Blood glucose concentrations during the hospitalization were lower by 24 hours in the insulin infusion group (173 ± 59) than in the conventionally treated group (211 ± 74). Blood glucose levels varied widely in both groups (insulin infusion group, 116 to 232 mg/dL; non-insulin infusion group, 137 to 284 mg/dL). The primary outcome of mortality rates was 29% lower in the insulin infusion group at 1 year (18.6% vs. 26.1%; *P* = 0.027). This reduction in mortality persisted; at a mean 3.4-year follow-up, the insulin infusion group still had lower mortality (33% vs. 44%; *P* = 0.011).

Intensive Care Unit Patients

Van den Bergh and colleagues from Belgium have evaluated the effects of very intense glycemic control in a surgical ICU setting by comparing intensive insulin therapy with conventional treatment (8, 9). (Their approach in the conventional treatment group was typical of the approach currently used in many surgical ICUs). In patients enrolled in the aggressive intravenous insulin protocol (Table 2), they aimed for near normoglycemia with blood glucose values in the range of 80 to 110 mg/dL. In the conventional arm of the protocol, insulin was administered only if blood glucose levels exceeded 220 mg/dL. The protocol was applied to anyone who had hyperglycemia, and thus was not limited to patients with diabetes mellitus. In this study of 1,548 subjects, the intensively treated patients had improved ICU survival, improved hospital survival, and reduced length of stay. In unpublished data, they have also noted that the intensively treated group had better long-term rehabilitation and were more likely to care for themselves after 12 months. This group has made a diligent effort to determine if the improved outcomes were the result of a direct effect of insulin on glycemic control or the result of other effects of insulin. The risk for death was correlated with glycemic control with a 75% (95% CI, 45% to 205%) increase of death for every 50-mg/dL increment increase in blood glucose.

However, insulin was associated with reductions in other markers of inflammation. In a statistical analysis including such markers, when effects of insulin on C-reactive protein were added to the model, the effects of glycemic control and insulin dose disappeared. These researchers

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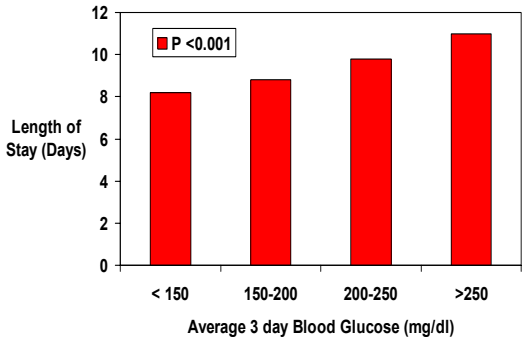
note that ongoing studies will evaluate variables in coagulation, fibrinolysis, and measures of endothelial function in critically ill (e.g., septic) patients. Their data clearly suggest that glycemic control is a favorable measure for improved outcome and insulin is the best way to achieve this outcome. In spite of the suggestion that the actual effects may be mediated through other mechanisms, their data can be used to support more intensive glycemic control in the ICU setting.

Figure 1. Association between mean blood glucose and length of stay in post-CABG patients from the Portland Study (adapted from ref. 12, 13)

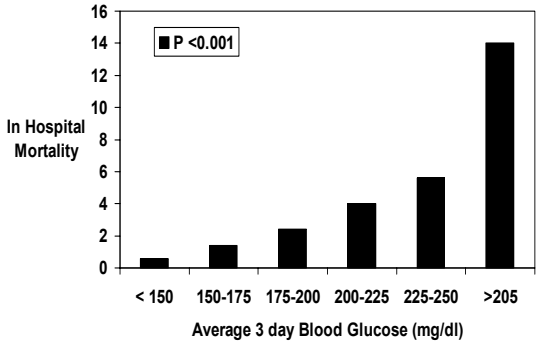


Post-Coronary Artery Bypass Graft Surgery

The Portland Diabetic Project has been carried out over the past 17 years and has reported multiple outcomes following coronary artery bypass graft (CABG) surgery (10-14). This is a prospective, nonrandomized, interventional study designed to assess the effect of intensifying glycemic control on diabetic patients who have undergone open-heart surgical procedures. More than 3,800 patients have been treated with continuous intravenous insulin protocols. From 1987 to 1991, this group used subcutaneous R insulin administered every 4 hours to maintain blood glucose concentrations below 200 mg/dL. Beginning in 1991, intravenous insulin infusion protocols were initiated with progressively decreasing glycemic targets. From 1991 to 1998, the target blood glucose range was between 150 to 200 mg/dL; in 1999, the range changed to 125 to 175 mg/dL; and in 2001, it changed again to 100 to 150 mg/dL. Analysis of the first 48 hours of glucose concentrations has shown that there is a relationship between the mean glucose concentration and the risk for sternal wound infections.

There is a more than twofold risk of sternal wound infections for mean blood glucose concentrations greater than 200 mg/dL compared with those less than 200 mg/dL. There is a progressive decline in the risk for sternal wound infections to mean blood glucose concentrations below 175 mg/dL, with little evidence of further reduction below that level. However, the risk for sternal wound infections in diabetic patients with mean blood glucose below 175 mg/dL is similar to that in nondiabetic subjects. Analysis of mean blood glucose data also show that mean blood glucose is independently predictive of mean length of stay (Figure 1). One hospital day is added for every mean 3-day 50-mg/dL increment increase in blood glucose level. Finally, mortality is reduced in patients with lower blood glucose levels; most of this effect is in patients who have had CABG surgery (Figure 2).

Figure 2. Association between mean blood glucose and in-hospital mortality from the Portland Study (Adapted from references 12, 13)



There are several other studies that show associations between hyperglycemia and adverse outcomes and/or suggest favorable effects of reducing hyperglycemia in hospitalized patients with regard to overall outcomes (morbidity and mortality) as well as length of stay (15-27). Analyses in many of these studies are confounded by the fact that both diabetic and nondiabetic patients with the most marked hyperglycemia also have the greatest number of comorbid conditions. Therefore, it is not always clear whether some of the adverse outcomes associated with hyperglycemia are the result of other disease processes. However, there are multiple potential mechanisms by which hyperglycemia may contribute to adverse outcomes (Table 1), and few data to suggest that intensifying glucose control entails particular risk. Whereas the risk for hypoglycemia is tangible, the actual risk appears to be quite low with proper attention to glucose-lowering regimens. Although theoretically high doses of insulin might be associated with adverse outcomes, this contention is not currently supported by study data. In fact, insulin itself may have favorable effects on some of the mechanisms associated with adverse outcomes in diabetic patients (28).

Approaches to Managing Glucose in Hospitalized Patients

Overview of Approaches to Intravenous and Subcutaneous Insulin Use

Glucose control always needs to consider the following variables:

- Need for both "basal" and "bolus" insulin
- Level of hyperglycemia
- Prior insulin (or oral glucose lowering agent) requirements
- Types and quantities of nutrient intake (IV, enteral)
- Contributors to insulin resistance/counterregulation

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Postoperative Management of Diabetes Mellitus (continued)

(e.g., sepsis, obesity, pressor use, glucocorticoid use)
- Risks for hypoglycemia

No single insulin intravenous or subcutaneous insulin algorithm has been able to prospectively predict exact insulin requirements. Most intravenous insulin infusion protocols start with predetermined insulin administration rates that take some of these variables into account. However, most functional protocols have built-in strategies that rapidly increase (or decrease) insulin requirements to compensate for any inadequate or excessive insulin given at baseline or throughout the protocol (Table 2). Subcutaneous insulin protocols are generally used for patients not hospitalized in ICUs. The strategies for insulin administration with published protocols have even greater variability and are often dependent on institution-specific approaches. The variables that affect insulin requirements are the same as those outlined above. Physiologic insulin secretion comprises basal insulin secretion in the postabsorptive state with very rapid (two-phase) insulin secretion with acute nutrient intake. The ideal subcutaneous insulin regimen should mimic this physiologic response as closely as possible. In addition, inadequate basal or bolus insulin requires compensation with additional insulin, often called "coverage" or "correction" insulin dosing.

Early subcutaneous insulin protocols almost exclusively used short-acting crystalline (regular or R) insulin with a sliding-scale regimen. Thus, insulin was not administered until after hyperglycemia had occurred. Such regimens may work in patients who have sufficient basal insulin and only postprandial hyperglycemia, but this is not a very common situation in hospitalized patients with established diabetes.

Use of "correction" insulin only is strongly discouraged. More appropriate insulin regimens include a combination of basal and bolus insulin in which both are given in anticipation of increasing insulin needs and only using coverage insulin to compensate for hyperglycemia that results from inadequate insulin administration. Although individual basal and bolus requirements vary widely, the hospitalist should start with the assumption that one half of the total insulin requirements will be in the form of basal insulin and that the other half will be in the form of bolus insulin. In patients who are NPO, relative basal insulin requirements will be higher. In patients on glucocorticoids, the relative bolus insulin requirements may be higher. Thus, no single algorithm applies to every situation, as evidenced by the wide variety of proposed insulin regimens (each accompanied by a series of caveats and modifiers) recently described by experienced clinicians in the American Association of Clinical Endocrinologists consensus conference (1, 2).

The following general proposals represent a distillation of published protocols (29-34) and the experience of the author (35-38) and his endocrine colleagues at the Cleveland Clinic Foundation:

Patients on traditional insulin regimens before hospitalization. In patients receiving insulin before hospitalization, initial doses of "basal" insulin (intermediate-acting insulins, such as N, L, UL; or long-acting insulin, insulin glargine) may generally be started safely at doses that constitute at least one half the patient's preadmission basal insulin. For example, a patient taking a total of 60 units of N insulin daily (and a corresponding dose of R insulin or short-acting insulin analogue) should be started on 30 units of N insulin in divided doses even while NPO. The regimen should increase rapidly back to the patient's baseline if necessary to achieve satisfactory glycemic control. For patients on crystalline insulin (or short-acting insulin analogues), these bolus insulins should be started as soon as the patient begins to eat. Doses can be estimated based on what percentage of caloric intake the patient is able to ingest compared with baseline (for example, if patient is eating half their usual intake, then half the usual dose of insulin generally is satisfactory). "Sliding-scale" insulin dosing is not appropriate as the only way to control hyperglycemia but is often the only way to achieve adequate glycemic control during the stages of changing nutrition, activity, and medications. Any requirement for sliding-scale insulin should be added into the doses of either basal (if all glucose concentrations are elevated) or the appropriate premeal bolus insulin.

For patients receiving premixed insulin before hospitalization, these regimens should be broken down into their components and basal and bolus insulin adjusted accordingly. For example, if a patient has satisfactory glycemic control on a regimen of premixed 70/30 (N/R) at doses of 20 units BID, the regimen should begin as 28 units of basal insulin and 12 units of bolus insulin, and the recommendations outlined above could be applied.

Patients not receiving insulin before hospitalization. Basal and bolus insulin schedules are appropriate for patients who have not been on insulin before hospitalization. If preoperative glycemic control was satisfactory and the patient was not on any glucose-lowering agents, then insulin requirements are generally lower than for patients on insulin or oral glucose-lowering agents before hospitalization. Basal insulin (intermediate- or long-acting insulins) should typically start in the range of 0.1 to 0.3 units/kg. Similarly, when the patient starts to eat, small doses of short-acting insulin may be given before meals, beginning at doses of 0.02 to 0.1 units/kg. As in the above regimen, sliding-scale insulin may be added to the predetermined meal bolus estimate. If sliding-scale insulin is required consistently, then these dosages should be incorporated into the basal or premeal boluses as appropriate. If preoperative glycemic control was suboptimal and/or the patient was on oral glucose-lowering agents (which were withheld during the hospitalization), then correspondingly higher doses of insulin may be necessary. The effects of sulfonylureas, short-acting insulin secretagogues, and carbohydrase inhibitors wane quickly, and insulin dosages will need to compensate for the effects of withholding these agents. The effect of metformin wanes over a period of days to weeks, and that of thiazolidinedione wanes over a period of weeks to months.

Patients on intensive insulin regimens before hospitalization. For patients receiving multiple doses of intermedi-

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ate-acting insulin or daily (or BID) doses of insulin glargine, basal insulin dosages can be restarted at one half to two thirds the prior basal insulin dosages and be rapidly increased back to usual basal doses. Most of these patients are on established premeal doses of R or short-acting insulin analogues based on consistent dietary intake or on regimens in which the premeal dose of insulin is based on carbohydrate intake. In the case of fixed premeal insulin dosages, it is often quite easy to calculate the carbohydrate-to-insulin ratio and apply it to the premeal boluses. For patients who already give insulin dosages based on CHO carbohydrate counting, the same ratio that was used before hospitalization is a good starting point for initiating bolus insulin therapy. As in both scenarios above, a sliding scale for hyperglycemia may need to be added to bolus insulin. Usually, these doses of "coverage" insulin need to be added into the basal insulin.

Table 3. Selected Subcutaneous Insulin Protocol (Trence, Kelly, Hirsch; Reference 33)

Blood Glucose Monitoring: □ before meals and at bedtime. □ _____hrs after meals . □ 2–3 AM

Goal Premeal BG = _____ (80–150 mg/dL for most patients)

	Breakfast	Lunch	Dinner	Bedtime
Prandial Insulin Orders	Give_____units of: □ Lispro (Humalog®) □ Aspart (Novolog®) □ Regular	Give_____units of: □ Lispro (Humalog®) □ Aspart (Novolog®) □ Regular	Give_____units of: □ Lispro (Humalog®) □ Aspart (Novolog®) □ Regular	
Basal Insulin Orders	Give_____units of: □ NPH □ Lente □ Ultralente □ Glargine	Give_____units of: □ NPH □ Lente □ Ultralente □ Glargine	Give_____units of: □ NPH □ Lente □ Ultralente □ Glargine	Give_____units of: □ NPH □ Lente □ Ultralente □ Glargine

Suggested lag time for prandial insulin:

Aspart/Lispro: 0–15 minutes before eating

Regular: 30 minutes before eating

For BG < 60 mg/dL

A. If patient can take PO, give 14 grams of fasting acting carbohydrate (4 oz fruit juice/non diet soda, 8 oz nonfat milk, or 3–4 glucose tabs)

B. If patient cannot take PO, give 25 mL of D50 as IV push

C. Check finger capillary glucose q 15 minutes and repeat above if BG<80 mg/dL)

- **Premeal "correction dose" algorithm for Hyperglycemia: to be administered in addition to schedule insulin dose to correct premeal hyperglycemia**

  □ Lispro

  □ Aspart

□ Low dose algorithm (For patients requiring ≤ 40 units of insulin/day	
Premeal BG	**Additional Insulin**
150–199	**1 unit**
200–249	**2 units**
250–299	**3 units**
300–349	**4 units**
> 349	**5 units**

□ Medium dose algorithm (For patients requiring 40–80 units of insulin/day	
Premeal BG	**Additional Insulin**
150–199	**1 unit**
200–249	**3 units**
250–299	**5 units**
300–349	**7 units**
> 349	**8 units**

□ Low dose algorithm (For patients requiring > 80 units of insulin/day	
Premeal BG	**Additional Insulin**
150–199	**2 unit**
200–249	**4 units**
250–299	**7 units**
300–349	**10 units**
> 349	**12 units**

□ Individualized algorithm .	
Premeal BG	**Additional Insulin**
150–199	
200–249	
250–299	
300–349	
> 349	

General Insulin Dosing Recommendations:

A. Patients with Type 1 Diabetes

This patient must have insulin to prevent ketosis. Even if the patient is not eating, he/she will need at least basal insulin (NPH/Lente/Ultralente/Glargine) to prevent ketosis

1. When admitting a patient with type 1 diabetes, continue the basal insulin that they were taking at home at the same dose. If the patient will be NPO, use an insulin drip rather prandial insulin will need to be reduced. Many hospitalized patients are under significant metabolic stress (infection, glucocorticoids, etc) and may require larger doses of prandial insulin despite eating less.
2. If a patient is newly diagnosed, the usual daily insulin requirements is 0.5–0.7 units/kg/day. Half or 50% should be given as basal insulin and the remainder as prandial insulin.

B. Patients with type 2 diabetes

1. If patient is using insulin at home, continue the outpatient regimen and adjust as needed.
2. If the patient has not been using insulin previously, the usual total daily insulin requirement is 0.4–1.0 units/kg/day.

Note: Individual insulin doses vary widely and adjustments should be made based on the bedside and laboratory glucose levels.

Optional bolus regimens for intensive insulin therapy. Postmeal insulin administration: Since eating patterns may be erratic in hospitalized patients because of delayed meals and transition diets (e.g., clear liquid, mechanical soft), postmeal administration of short-acting insulin may be an option. This works best if the bolus insulin is an insulin analogue. The dose of insulin is based on total carbohydrates ingested according to the carbohydrate-to-insulin ratio previously determined. If blood glucose concentrations are elevated before the meal, then the "coverage" insulin may be given before the meal or at the time of the postmeal insulin administration.

Diabetic patients on intensive insulin regimens may monitor blood glucose concentrations one to two hours after a meal. If postprandial glucose concentrations are elevated, they will need additional insulin in the postprandial state. Postprandial monitoring and insulin administration is less common in hospitalized patients, but consideration may be given to this approach in selected circumstances. Additional insulin is generally given if postmeal blood glucose concentrations are above individually established values (e.g., 140 to 200 mg/dL).

Insulin pump therapy: Insulin pumps are usually discontinued during surgery and in the early postoperative period. During the time

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the pump is off, patients may be given basal insulin in the form of glargine at doses approximately equal to their usual basal insulin. (Note: If the patient uses a lower basal rate at night, glargine should be estimated at this lower basal rate to reduce the risk for nocturnal hypoglycemia.) If the patient is on a "fixed" bolus regimen (i.e., not adjusting for CHO intake), then boluses need to be correspondingly reduced if the patient is not eating. If the patient is on an insulin schedule that incorporates CHO counting, this same ratio may be used even if the patient is not eating the usual quantity. If caloric intake is uncertain, postmeal use of insulin (as described above) may be used.

Nurses are generally not familiar with insulin pump operation. Therefore, pumps should not be restarted until the patient is able to perform the insertion of the infusion sets and pump programming procedures. Nurses should be instructed in how to put the pump in "suspend" mode in the event that a hypoglycemic reaction renders the patient incapable of doing so.

Published subcutaneous insulin administration protocols. Many of the published protocols for subcutaneous insulin use in hospitalized patients had a "one-size-fits-all" approach. From among the many protocols published in the reviewed literature, one of the most useful is that developed collectively by the diabetes treatment group at the University of Washington headed by Dr. Irl Hirsch (Table 3). This author generally agrees with this approach but provides the following considerations to modify this protocol:

- In selected patients, a small "correction" dose of insulin may be given at bedtime to control marked hyperglycemia. If such a dose is given, a blood sugar test at 0200 to 0300 hours should be ordered.
- The "correction" dose of insulin may be applied to R insulin for patients already receiving it. It creates additional work for nursing staff to give patients two types of premeal insulin with little evidence of efficacy.
- In the author's experience, the recommended starting dose of insulin for newly diagnosed diabetic patients is too high and may be associated with an unacceptable risk for hypoglycemia in some patients.

Insulin administration for "continuous" nutrient intake. Many authors recommend only short-acting insulin (R) for patients who are on continuous tube-feedings. Some do recommend incorporating some basal insulin on an every-12-hour basis. The author and his colleagues have used premixed insulin (e.g ,70/30) given on an every-8-hour schedule with much success over the past decade. A "correction" or "coverage" insulin with R insulin is given every 4 hours for blood glucose values greater than 150 mg/dL. Every 24 hours, the total dose of R "coverage" was added in equally divided doses to the 70/30 insulin doses. For patients who have progressively increasing nutrient intake, the 70/30 dose can be increased in anticipation, based on the estimated insulin requirements for the new nutrient load. If tube-feeding is discontinued, then the 70/30 insulin is withheld but R coverage is continued.

Hypoglycemia rarely occurs with this protocol during tube-feeding. If hypoglycemia (blood glucose < 60 mg/dL) occurs, the feeding rate may be increased until the next insulin dose, at which time the dose of 70/30 should be decreased. If hypoglycemia occurs because tube-feeding has stopped, it may be treated with D50W via bolus or a continuous infusion of D5W or D10W until tube-feeding is resumed.

Use of oral agents in perioperative management of hospitalized patients. In general, oral glucose lowering agents are discontinued in the immediate preoperative state. There is a very limited role for oral glucose-lowering agents in postoperative patients. The following commentary was described by the author in a summary article published a few years ago and is still generally true:

"Oral glucose lowering agent use in the postoperative state is usually limited to selected patients. This includes patients who have been on such agents prior to surgery, who have only mild elevations of blood glucose, who are able to ingest oral medications or who do not have significant comorbid conditions (or significant risk for such conditions) that may be contraindications to use of such agents (Table 3). Sulfonylureas and other insulin secretagogues (e.g. meglitinides, nateglinide) will lower glucoses acutely. The risk for hypoglycemia is slightly less with the nonsulfonylurea agents. Efficacy and side effects limit the use of carbohydrase inhibitors for hospitalized patients. The glucose lowering effects of biguanides and thiazolidinediones usually do not provide glucose lowering effects that are rapid enough for hospitalized patients naïve to these medications. For patients who have been on a biguanide or thiazolidinedione prior to admission, these agents are often restarted in the postoperative period when oral intake of medications is possible and hepatic and renal function are stable."

Summary

The variety of insulin infusion protocols highlights the fact that there are a number of ways to treat the perioperative patient. Each of the protocols is characterized by a need for frequent blood glucose monitoring and adjustments in insulin. The transition from intravenous insulin to subcutaneous insulin does not lend itself to ready use of protocols. However, the need to start basal subcutaneous insulin before discontinuing intravenous insulin should be standard operating procedure. Subcutaneous insulin protocols that apply to all patients are also not easy to write. However, the following characteristics are necessary for any protocol to be successful:

1. administration of basal insulin
2. administration of bolus insulin that is adjusted in anticipation of caloric needs
3. correction boluses to avoid marked hyperglycemia
4. adding up the amount of insulin given in the correction boluses and incorporating this into the basal or bolus insulin as appropriate

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Postoperative Management of Diabetes Mellitus (continued)

There is a clear need for more data on the importance of trying to achieve blood glucose concentrations in hospitalized patients whether they are hospitalized for surgical or nonsurgical disease. These data are needed to help standardize (via protocol) effective ways to deliver subcutaneous insulin, as well as to determine whether the improved outcomes demonstrated for patients after CABG and in ICUs can be documented and quantified in other hospital settings. The burgeoning use of hospitalists to manage such patients affords a unique opportunity to address some of these questions.

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Perioperative Management of Hypertension

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Hypertension affects an estimated one billion persons worldwide. In the United States, blood pressure (BP) is not well controlled in two thirds of the 65 million adults with hypertension. Approximately 23 million U.S. patients are anesthetized annually (1). Hypertension is therefore commonly encountered in the perioperative setting.

In the perioperative period, the hypertensive patient is more likely to die from hypertension-associated comorbid conditions than from elevated BP (2). Optimal perioperative management requires a clear understanding of the pathophysiology and rational treatment of hypertension.

Principles of Management

Hypertension increases cardiovascular risk and is a major risk factor for left ventricular hypertrophy, coronary artery disease, congestive heart failure, and renal and cerebrovascular disease (3). It is also closely associated with diabetes. All of these conditions increase risk for adverse postoperative cardiovascular outcomes (4).

Perioperative myocardial ischemia greatly increases the risk for in-hospital, 6-month, and 2-yr mortality. Even a single 1-min episode of ischemia, detected on Holter electrocardiographic monitoring, increases the risk for mortality up to two years (5).

Hypertensive patients are prone to perioperative myocardial ischemia. Each 10-mm Hg increase in admission systolic BP is associated with a 20% increased risk for postoperative myocardial ischemia (6).

Hypertensive patients have labile BP during anesthesia. Hypertension is associated with elevated peripheral resistance and anesthetic agents lead to systemic vasodilatation, reducing BP. During surgery, both normotensive and hy-

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Table: Perioperative Management of Antihypertensive Medications

Drug Class	Perioperative Concerns	Suggested Approach
Diuretics	Hypokalemia	1. Potassium supplementation. 2. Consider holding 24-hrs prior to surgery if BP is well controlled. 3. Check electrolytes prior to induction of anesthesia
Aldosterone antagonists	Hyperkalemia	Check electrolytes
Beta blockers	Abrupt discontinuation is associated with rebound hypertension and ischemia.	1. Continue in the perioperative period. 2. Use IV formulations.
Clonidine	Abrupt discontinuation is associated with rebound hypertension.	1. Taper and discontinue preoperatively, or 2. Switch to transdermal patch
Calcium channel blockers	Increase postoperative blood loss and transfusion requirements after surgery for hip trauma.	Benefits outweigh potential risks; continue for BP control
Angiotensin converting enzyme inhibitors and angiotensin II receptor blockers	Some reports of hypotension with induction of anesthesia, others report no change in BP.	1. Benefits outweigh potential risks; continue for BP control. 2. If BP is well controlled; can hold dose on the morning of surgery.

Perioperative Management of Hypertension (continued)

pertensive patients reach a similar BP nadir (7, 8). For hypertensive patients with high preinduction BP, this means a greater absolute decrease in BP. Conversely, BP rises during intubation due to sympathetic stimulation.

Intraoperative hypotension predicts postoperative cardiac complications in hypertensive patients. Preoperative admission BP level does not correlate well with adverse cardiac outcomes or postoperative elevation of BP (7, 8).

Postoperative uncontrolled hypertension is predicted by a history of severe elevation of BP and vascular surgical procedures (8). Vascular procedures require frequent use of fluid challenges and are associated with a decrease in renal blood flow. This can lead to postoperative salt and water overload with elevated BP.

Preoperative Evaluation

Preoperative evaluation of the hypertensive patient begins with a *careful history and examination* to assess target organ damage and to detect clues to secondary causes of hypertension. Duration of hypertension, severity, highest recorded BP, and the level of control are directly relevant to perioperative management. Outpatient records of BP measurement are invaluable.

Evaluation of the current *antihypertensive medication regimen* (Table) and use of over-the-counter medications and herbs is critical. In patients with a history of severe hypertension, it is important to continue medications before surgery to avoid rebound hypertension.

Restrictive inpatient formularies with drug substitutions often create challenges to management of hospitalized hypertensive patients. Addition or change in oral antihypertensive medications can take as long as six weeks before maximum BP lowering can occur. As a result, in the postoperative period, the effect of outpatient medication begins to wear off before the new medication takes effect. Patients can take their "home medications" to the hospital and resume them in the postoperative period. However, this approach is a source of medication errors and cannot be recommended for all patients. If a prolonged postoperative stay and restriction of oral intake is anticipated, the patients can be switched to medications with available parenteral formulations, such as enalapril, metoprolol, labetalol, and clonidine.

Patient with Elevated BP before Surgery

Elevated preoperative BP is a frequent reason for stat medical consultations. These patients may have previously undiagnosed or inadequately treated hypertension. Secondary causes of hypertension, such as renal artery stenosis, primary hyperaldosteronism, or pheochromocytoma, should also be considered. Patients with previously controlled BP may have elevated readings due to rebound hypertension, anxiety, stress, or white coat effect. The initial BP reading can also be inaccurate due to improper measurement.

Patients with BP below 180/110 mm Hg can proceed to surgery with careful perioperative management. Management of patients with persistent elevation of BP higher than 180/110 mm Hg is unclear. Several guidelines recommend delaying surgery (3, 9). Howell and colleagues' (10) proposal, based on an extensive review of the literature (Figure), is to proceed with surgery if there is no target organ damage or risk factors other than elevated BP (2, 10). In most instances, the decision has to be individualized, weighing the risk for delaying surgery and canceling operating room time against the risk for adverse outcomes for the patient.

Postoperative Hypertension

The causes of postoperative hypertension differ, based on timing after surgery and anesthesia (11). *Early postanesthesia hypertension* results from reversal of anesthesia with a resulting increase in peripheral resistance. Volume overload from fluid administered during surgery may play a role. Pain- and hypothermia-induced sympathetic stimulation as well as hypoxia and hypercarbia contribute to increased BP.

During the *late postanesthesia* period (24 to 48 hours after surgery), BP is elevated as a result of mobilization of fluid from the extravascular to the intravascular compartment. Discontinuation of epidural anesthesia reduces peripheral vasodilatation. The effects of stopping long-term antihypertensive medications become prominent. Pain, hypercarbia, hypoxia, and bladder distention all contribute to elevated BP.

Severe postoperative hypertension can cause progressive target organ damage as well as hemorrhage from suture lines and vascular anastomoses, constituting a hypertensive emergency. The overall clinical condition of the patient rather than the BP level should dictate further management. When acute BP lowering is necessary, the mean arterial pressure should not be reduced greater than 25% and BP should not be reduced below 160/100 mm Hg.

Identification and treatment of pain, anxiety, hypoxia, hypercarbia, and bladder distention often control BP without requiring antihypertensive therapy. Diuresis with intravenously administered furosemide can reduce volume expansion and help maintain the efficacy of other antihypertensive medications. Use of PRN hydralazine should be avoided because it causes reflex tachycardia, increasing

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Perioperative Management of Hypertension (continued)

myocardial oxygen demand and leading to myocardial ischemia. Hydralazine also has a long and unpredictable half-life and can cause prolonged hypotension. Resume preoperative antihypertensive medications as soon as possible. If parenteral agents are required, drugs from the same class as outpatient medications can be more effective.

Postoperative Hypotension

Postoperative hypotension is a predictor of myocardial morbidity in hypertensive patients. Before surgery, intravascular volume depletion can result from inadequate fluid intake or diuresis. After surgery, hemorrhage, fever, and inadequate volume replacement contribute to volume depletion. Peripheral vasodilatation can also reduce BP and is caused by spinal anesthesia or inhalational anesthetics, such as halothane (7, 8). These anesthetic agents can also reduce myocardial contractility by 25% (7). Perioperative myocardial infarction causes myocardial depression, leading to hypotension. Sepsis and pulmonary embolism in the postoperative period are other causes of hypotension. Nonspecific lowering of BP after surgery has also been described (12).

Pheochromocytoma

Modern-day management with proper preoperative preparation has 0% to 3% perioperative mortality for pheochromocytoma resection (13).

Preoperative Period

Outpatient preparation is safe and effective. Preoperative cardiac echocardiography helps determine the presence and severity of catecholamine-mediated hypertrophic or dilated cardiomyopathy. It is particularly useful in managing postoperative hypotension and pulmonary edema. Excess catecholamines are associated with a vasoconstrictive, hypertensive, and hypovolemic state (13). Adequate hydration and BP control are essential (12).

Preoperative alpha-adrenergic blockade controls hypertension and allows expansion of blood volume. Criteria for adequate blockade include BP below 160/90 mm Hg for at least 24 hours before surgery and presence of orthostatic hypotension with orthostatic BP above 80/45 mm Hg. Phenoxybenzamine, a long-acting, nonselective alpha-blocker, is effective in controlling the effect of excess catecholamines (12). Its side effects include tachycardia requiring the use of beta-blockers, somnolence, and nasal congestion. Doxazosin is a selective alpha$_1$-adrenergic blocker with once-daily dosing. It is associated with less tachycardia and appears to have a nearly ideal profile for preoperative preparation. Doxazosin-treated patients have less-severe postoperative hypotension (14).

Calcium-channel antagonists relax the arteriolar smooth muscle, reducing catecholamine-mediated peripheral resistance. They effectively control BP while avoiding overshoot and orthostatic hypotension (15). Long-acting nifedipine, without alpha-blockers, is effective and safe for preoperative preparation (15). Other agents used selectively include metyrosine and magnesium sulfate.

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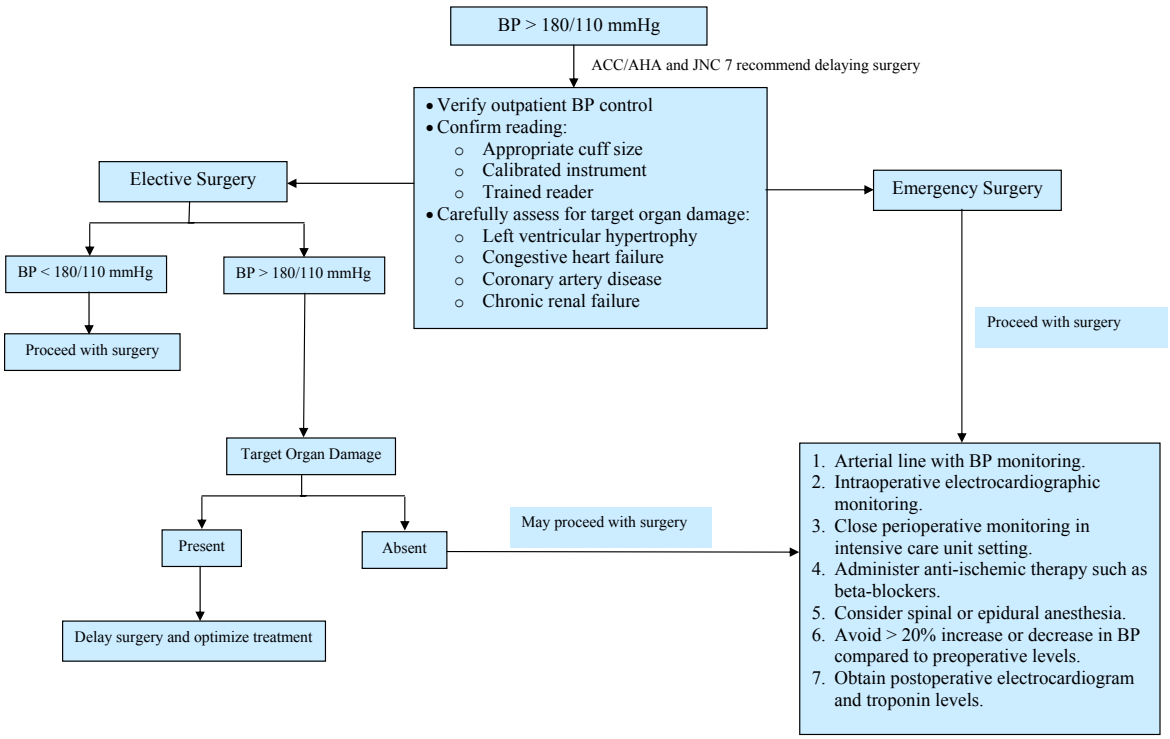
Fig: Management of Patients with Elevated BP before Surgery



Perioperative Management of Hypertension (continued)

Intraoperative Period

Laparoscopic surgery is the preferred procedure. Compared with the traditional abdominal approach, it is associated with less hypotension, less blood loss, 4.4-days shorter hospitalization, and better cosmetic outcomes but has no impact on the duration of surgery or the occurrence of hypertensive episodes (15).

Intraoperative monitoring with an arterial line and central venous catheter is essential. Pulmonary artery catheterization may be necessary (13, 14). Thiopental and propofol are used for induction of anesthesia. Vecuronium and atracurium are used for neuromuscular blockade. Isoflurane, enflurane, and sevoflurane are used for maintenance of anesthesia. Combined regional and general anesthesia is also used (13).

Intraoperative hypertensive surges resulting from catecholamine release from pheochromocytoma are caused either by pneumoperitoneum during laparoscopy or by manual manipulation. Paradoxical overactivity of the sympathetic nervous system in these patients (15), resulting from such stimuli as intubation and skin incision, predisposes them to hypertensive crises. Systolic BP can increase to levels as high as 250 mm Hg (15). Phentolamine, a parenteral alpha-adrenergic antagonist, is particularly useful in treatment (14).

Hypotension after tumor removal is common. Suppression of catecholamine output from the contralateral adrenal gland, down-regulation of adrenergic receptors, and prolonged effects of preoperative adrenergic blockade contribute to hypotension. A large volume of fluid and colloid replacement along with vasopressors is often required for treatment (13).

Postoperative Period

Hypoglycemia in the postoperative period results from rebound hyperinsulinism as the inhibitory effects of catecholamines on insulin secretion is eliminated (13). Hypotension can be persistent. Hypertension after surgery can result from residual effects of catecholamines, residual tumor, fluid overload, underlying essential hypertension, or inadvertent ligation of the renal artery (12). Adrenal steroid replacement is indicated for patients undergoing bilateral adrenalectomy. Postoperative follow-up with measurement of plasma metanephrines is recommended at 6 and 12 months.

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Controversies and New Directions in the Management of Venous Thromboembolism in the Perioperative Setting

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Venous thromboembolism (VTE), which comprises deep venous thrombosis (DVT) and pulmonary embolism (PE), is a major cause of death and disability in hospitalized populations. Autopsy studies of hospitalized patients have demonstrated that massive PE is the cause of death in 5% to 10% of all hospital deaths (1-2). Today, these patients may be at even greater risk for VTE than in the past because of their more advanced age, greater prevalence of cancer and intensive cancer therapy, more extensive surgical procedures, and prolonged stays in the critical care unit. For the surgical patient, VTE has been well documented as a common, serious, and in some cases fatal complication in the postoperative period. Although general VTE prophylaxis guidelines for surgical patients exist, many clinicians struggle with individual application, fear of complications, and the general limitations of existing prevention approaches.

Despite such recommendations, physicians continue to underuse prophylactic regimens to prevent VTE. Anderson and colleagues showed that 44% of university hospitals routinely use VTE prophylaxis compared with 19% of community hospitals (4). More striking was the fact that only 32% of the patients in this study who were at risk for VTE received any prophylaxis at all. In contrast, Stratton and colleagues found that most surgical patients receive some form of prophylaxis, but often not the recommended approach based on randomized trial evidence (5). More recent registry data confirm that surgical patients are more likely to receive protection than medical patients, but there is still much improvement to be made. The REITE registry, a prospective registry initiated in Spain in March 2001, collected data from patients with objectively confirmed DVT and/or PE (6). Registry analysis found 68% of the surgical

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The Failure-to-Prevent Syndrome

Fatal postoperative PE is uncommon, and overall rates of fatal PE in the surgical population have declined in recent years. Yet, prevention of nonfatal VTE events remains an important objective as these outcomes are associated with considerable acute morbidity, substantial resource utilization, and long-term sequelae adding further suffering and cost. In addition, patients who develop acute VTE in the surgical setting will probably require therapeutic anticoagulation with its potential for serious bleeding complications. The Agency for Healthcare Research and Quality has published a systematic review of safety interventions entitled "Making Health Care Safer: a Critical Analysis of Patient Safety Practices" (3). Appropriate VTE prophylaxis in at-risk patients is the highest-ranked safety practice, a recommendation based on the irrefutable evidence that VTE prophylaxis reduces adverse patient outcomes while reducing overall costs.

Table 1
Levels of VTE Risk in Surgical Patients with Recommended Prophylaxis Strategies

Level of Risk	*Recommended Prevention Strategy*
Low	
Minor surgery in patients <40 years No additional VTE risk factors	No specific recommendation or aggressive mobilization
Moderate	
Minor surgery in patients with additional VTE risk factors Surgery in patients 40 to 60 years without additional risk factors (Drugs should be started 2 hours before surgery then daily thereafter)	LDUH 5000 U q12 Enoxaparin 40mg daily Dalteparin 5000 U daily Graded compression stockings Intermittent pneumatic compression
High	
Surgery in patients >60 years, or age 40 to 60 years with additional risk factors (Drugs should be started 2 hours before surgery then daily thereafter)	LDUH 5000 U q8 Enoxaparin 40 mg daily Dalteparin 5000 U daily Intermittent pneumatic compression
Very High	
Surgery in patients >60 years with additional risk factors Hip^ or knee*arthroplasty, hip fracture surgery Spinal cord injury⁺ or major trauma (Drugs should be started 2 hours before surgery in very high risk abdominal surgery; orthopedic patients should begin drugs 12 to 24 hours after surgery)	Dalteparin 5000 U daily^ Enoxaparin 40 mg daily^ Enoxaparin 30 mg q12^*⁺ Fondaparinux 2.5mg daily^* +/– mechanical compression and graded compression stockings

LDUH = low-dose unfractionated heparin.

patients receiving some form of prophylaxis. DVT-FREE, a prospective registry of 5451 patients with symptomatic VTE enrolled at 183 sites in the United States between October 2001 and April 2002, found that among the hospitalized patients enrolled, only 42% were receiving any form of prophylaxis (7). Among those receiving prophylaxis, two thirds were surgical patients; a surprising 20% were receiving aspirin to prevent VTE. The American College of Chest Physicians (ACCP) specifically urges that aspirin not be used for VTE prophylaxis due to questionable efficacy and greater risk for hemorrhagic complications (8).

Ultimately, it is recommended that all surgical patients be assessed for VTE risk and for those found to be at risk to receive the most effective and safe strategies available (Table 1). Protocols with standardized risk assessment models using computer order systems have been shown to improve VTE prophylaxis rates (9).

Retrievable Inferior Vena Cava Filters

Technology has improved the inferior vena cava filter (IVCF) such that it is now smaller and less thrombogenic. In addition, the IVCF is easier to insert percutaneously and in some instances is retrievable (i.e., nonpermanent) and can be placed at the bedside. This has led to a broadening of the indications for IVCF placement and a marked concurrent increase in the number of IVCF placements over the past two decades. According to the National Hospital Discharge Survey, the number of patients who had an IVCF placed increased from 2000 in 1979 to 49,000 in 1999. Stein and colleagues found that in 1999, almost 20% of IVCF placements occurred in patients who were presumably at high risk for PE but did not have DVT or PE listed as a discharge code (10). Although many of the indications for IVCF placement are a matter of opinion, IVCF placement is generally recommended in patients with symptomatic VTE if 1) anticoagulants are contraindicated, 2) PE has recurred despite adequate anticoagulation, or 3) PE is so severe that a recurrence would be fatal. Permanent IVCF placement for VTE prophylaxis is not recommended due to increased rates of DVT and postthrombotic syndrome (11). However, the availability of nonpermanent filters has generated significant interest in such devices as early prophylaxis against PE in high-risk surgical patients.

Nonpermanent filters can be divided into temporary and optional filters. Temporary filters are attached to a catheter or guidewire that protrude externally. The design mandates filter removal, increases the risk for infection, and severely limits applicability. Optional filters are more versatile because they can be retrieved percutaneously (usually within a two-week window) or they can be left in place as a permanent filter should the clinical situation require it. Recent reports demonstrate that optional filters can also be repositioned percutaneously several times to extend the temporary dwell time beyond the typical 14-day period (12). Animal studies using new optional filters with elastic hooks and unique retrieval systems have been successfully removed following dwell times up to three months without the need for repositioning (13).

Several authors have investigated the efficacy and safety of retrievable IVCF use to prevent VTE in trauma patients (14-16). Combining these studies, 102 out of 154 prophylactic filters were removed with a retrieval success rate of 96%. There was only one major complication, and no PE was reported. The ideal patient group for a prophylactic IVCF would be one with a high risk of PE despite adequate pharmacologic prophylaxis or in those whom drug-based prophylaxis is contraindicated. Although multisystem trauma patients would seem to be ideal candidates, existing literature suggests that such a strategy (even if proven safe) would likely be cost-prohibitive. Brasel and colleagues reported that the combination of biweekly duplex scanning coupled with LMWH and then insertion of an IVCF only in those patients who had proximal DVT and could not be anticoagulated incurred charges of $100,000 per patient per PE prevented (17). It has been estimated that if only 1% of the trauma population in this country received a permanent IVCF, it would cost over $900 million dollars (18). Furthermore, the ACCP does not endorse prophylactic IVCF placement because it is not clear that outcomes are improved. On average, 29% of patients with a permanent IVCF have such complications as improper placement, migration, angulation of the filter, caval stenosis or filter narrowing, caval occlusion, air embolism, penetration of the caval wall, lower extremity edema, and sequelae of venous stasis (19). Despite this, the Eastern Association of Trauma Surgery has created practice guidelines supporting the use of prophylactic optional IVCF placement in younger multisystem trauma patients who cannot receive LMWH prophylaxis at 36 hours after injury.

More research is needed on the use of retrievable filters, both from an acute standpoint and long-term outcomes if they become permanent. However, there are several indications for optional filters that may be reasonable in the perioperative setting. Patients that develop postoperative VTE with a temporary contraindication (approximately 14 days) to anticoagulation should be considered for an optional filter as opposed to a permanent filter, with the goal of removing the filter once anticoagulation can resume. Patients who have had a recent VTE episode (<4 weeks) and require major surgery should be considered for an optional filter to protect them from recurrence, even if a narrow window off anticoagulation can be provided. This is particularly true in the setting of a very recent thrombus (<2 weeks), because even a short window (6 to 12 hours) off anticoagulation can lead to clot propagation and PE. Finally, patients at very high risk for perioperative VTE with PE rates in the 2% to 5% range in the absence of prophylaxis who cannot receive standard anticoagulant prophylaxis may be appropriate for IVCF placement on a selected basis.

New Anticoagulants

Anticoagulants for the prevention and treatment of VTE have been used on a widespread basis for about 50 years. Initially, only unfractionated heparin (UFH) and oral vitamin K antagonists were available. Low-molecular-

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weight heparin (LMWH) was introduced in Europe in the early 1980s but did not achieve widespread use for VTE prevention and treatment until about 10 years later. Over the past decade, the pace of development has accelerated with the introduction of several new anticoagulants. At the forefront of these new anticoagulants are the direct thrombin inhibitors (DTIs) and the selective indirect factor Xa inhibitor, fondaparinux.

The first DTI was recombinant hirudin, which was introduced in the United States in 1999 for treatment of heparin-induced thrombocytopenia (HIT). This was subsequently followed by argatroban, also labeled for HIT treatment, and bivalirudin, which is currently being used for elective percutaneous coronary interventions. The most anticipated DTI was ximelagatran, an oral pro-drug of melagatran. This agent had been studied in orthopedic patients for prevention of VTE and was shown to be at least as effective as warfarin therapy after total knee arthroplasty without the need for anticoagulation monitoring (20). Consequently, ximelagatran may have been particularly useful for extended out-of-hospital prophylaxis in high-risk patients. In addition, ximelagatran was compared with enoxaparin for acute treatment of VTE in a phase III trial and was found similarly safe and effective (21). The enthusiasm for an oral agent that did not require anticoagulation monitoring and could replace conventional treatment was extremely high. Unfortunately, this past September the Food and Drug Administration (FDA) unanimously denied approval of ximelagatran in the United States over safety concerns related to increased cardiovascular events. It is unclear when, if ever, this particular DTI will reach the market.

Fondaparinux was approved by the FDA in 2001 for prevention of VTE in major orthopedic surgery. Four large phase III trials comparing fondaparinux with enoxaparin found a 55% relative risk reduction in VTE with fondaparinux but significantly more major hemorrhage (P = 0.008) (22-25). A recent phase III trial in hip fracture patients studied extended (3 weeks) out-of-hospital VTE prophylaxis with fondaparinux compared with placebo (26). This study reduced both venographic (35% vs. 1.4%, $P < 0.001$) and symptomatic VTE (2.7% vs. 0.3%, P = 0.02) with fondaparinux without an increase in major bleeding events. Fondaparinux has also been studied for the prevention of VTE in abdominal surgery patients and was found to be at least as effective as dalteparin without a significant difference with respect to bleeding (27). Finally, weight-adjusted fondaparinux was found to be at least as effective as LMWH and UFH for treatment of DVT or PE (28-29). It remains unclear whether there is really an efficacy advantage over LMWH with fondaparinux in the prevention of VTE or whether it is related to timing and intensity of the dose. There is no commercially available reversing agent for fondaparinux, which has been a concern among surgeons especially in the setting of neuraxial anesthesia or patients with renal impairment. However, fondaparinux does not appear to cause HIT, as the synthetic pentasaccharide is too small to form the platelet factor 4 complex that leads to antibody development. Thus, there may be advantages to using fondaparinux, particularly in orthopedic patients where the incidence of HIT is higher.

Idraparinux is another pentasaccharide in development. It has a half-life of 130 hours, and as a result, it can be given subcutaneously on a once-weekly basis. A phase II trial compared several doses of idraparinux to warfarin for treatment of proximal DVT. It was found to be effective across all the dose ranges and had a clear dose response for major bleeding (30). Based on these results, a phase III trial is currently planned at the safest dose with respect to bleeding. Anticoagulants with a long half-life are attractive because of the need for infrequent dosing. However, reversal agents will be needed in the setting of major hemorrhage or if urgent surgery is required. Heparinases can degrade pentasaccharides, although there are none currently available for commercial use. Recombinant factor VIIa is being investigated as a potential reversing agent for idraparinux (31).

Many additional new anticoagulant agents are in the advanced stages of development, such as NAPc2, DPC 906, and soluble thrombomodulin (32). However, for any new anticoagulant to gain wide acceptance, it must have a risk–benefit ratio equal to or better than that of the established strategies with a similar cost. Extending prophylaxis and treatment out of the hospital will be a continuing theme, and novel anticoagulants that are easy to administer (oral), do not require monitoring, and can be effectively reversed will be rapidly embraced.

Special Patient Populations

The introduction of LMWH was a turning point in the contemporary treatment of thrombotic disorders. Until 1987, the only parenteral anticoagulant available was UFH. However, this agent has unfavorable binding affinities that result in unpredictable pharmacokinetic and pharmacodynamic properties. LMWH has more consistent and predictable anticoagulant activity and has replaced UFH for most clinical indications. LMWH can be administered subcutaneously once daily without laboratory monitoring, and clinical trial evidence shows that LMWH is at least as effective as and is safer than UFH. However, LMWH has not been well studied in several important patient populations (including two groups that are common in the perioperative setting--those with morbid obesity [>150 kg] and those with severe renal insufficiency [creatinine clearance < 30 cc/minute]), thus leaving questions about efficacy, safety, and appropriate dosing.

Obesity is an increasing health risk for Americans, occurring in at least a third of both men and women. Obesity is an independent risk factor for thrombosis, and VTE is common in obese populations. LMWH has theoretic advantages in obese patients as a result of superior subcutaneous bioavailability. However, even LMWH at standard fixed doses may not be sufficient to prevent VTE in morbidly obese patients. Frederikson and colleagues demonstrated a strong negative correlation between total body weight and heparin activity (as measured by anti-Xa assay) with fixed doses of

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enoxaparin (33). This relationship has also been observed in obese patients who are critically ill (34). These data suggest that weight-adjusted doses may be more appropriate than fixed doses for VTE prophylaxis in morbidly obese patients. Scholten and colleagues performed a nonrandomized prospective study in 481 obese patients undergoing gastric bypass surgery. In addition to multimodal therapy with mechanical compression stockings, enoxaparin 40 mg every 12 hrs was found to be superior to enoxaparin 30 mg every 12 hours with respect to postoperative DVT (0.6% vs 5.4%, respectively; $P = 0.01$) and did not cause an increase in bleeding complications (35). Yet, a smaller randomized study ($n = 60$) involving nadroparin (5700 IU vs. 9500 IU) in bariatric surgery failed to show a benefit with escalated doses in preventing postoperative DVT (36). It should be noted that heparin activity does correlate with enoxaparin dose even in nonobese patients (37). Using data from the MEDENOX trial, the efficacious prophylactic dose for enoxaparin (40 mg daily) calculates to a 0.5 mg/kg dose. Similarly, a prospective, open-label trial involving tinzaparin at two doses (75 and 175 units/kg) given to otherwise healthy, obese volunteers (100 to 160 kg) and compared with historical nonobese controls concluded that tinzaparin dosing for prophylaxis should be dosed on the basis of body weight alone, independent of the presence of obesity (38).

These studies support the notion that prophylactic LMWH doses (like treatment doses) should be weight-adjusted in all patients regardless of whether they were obese. Although expert consensus generally recommends a heparin concentration range of 0.1 to 0.6 IU/mL (by chromogenic anti-Xa assay) to prevent development of VTE, the optimal heparin activity needed for VTE prophylaxis remains unproven and can vary according to the agent used. Without additional data, firm recommendations are difficult. However, clinicians should consider escalating the standard recommended doses of LMWH in morbidly obese patients (i.e., 0.5 mg/kg for enoxaparin) in the setting of thromboprophylaxis with or without adjunctive use of mechanical compression devices or anti-Xa monitoring.

Contemporary VTE treatment trials of LMWH generally use weight-adjusted doses without any ceiling for obese patients. However, few patients with a total body weight greater than 150 kg and a body mass index (BMI) greater than 50 kg/m^2 were actually included. The relationship of intravascular volume and total body weight is not linear, and there is a concern that dosing based on actual body weight could lead to overdosing. Yet, post hoc analysis of cardiovascular patients using full weight-adjusted doses of LMWH and UFH found no differences in hemorrhage rates between obese and normal-weight groups (39). Similarly, anti-Xa activity is not significantly increased when LMWH is administered to obese patients based on total body weight (40-41). Given the lack of clinical trial data for VTE treatment with LMWH in obese patients, it would still be reasonable to monitor anti-Xa levels in such patients. Dose reduction should be considered if the anti-Xa level remains excessive 4 hours after the subcutaneous LMWH dose.

LMWH is cleared by the kidneys, and impaired renal function prolongs elimination of the drug. It is important to remember to use creatine clearance, not a static creatinine value, as the measure of renal function. An 82-year-old woman that weighs 50 kg with a creatine level of 1.0 has creatine clearance of 32 cc/min. Patients with severe renal insufficiency may be at increased risk for bleeding with standard doses of LMWH. Post hoc analysis of cardiovascular trials using full weight-adjusted doses of LMWH and weight-adjusted and activated partial thromboplastin time (aPTT)–monitored UFH found significant increases in bleeding rates in patients with renal impairment in both heparin groups (39). A recent retrospective analysis using full weight-adjusted doses of LMWH and weight-adjusted and aPTT–monitored UFH confirms this finding (42). A total of 620 patients with creatine clearance rates below 60 cc/min were studied. Of these, 331 received anticoagulation therapy with UFH, 250 with enoxaparin, and 39 received both. The major bleeding rates were 26.3 per 1000 patient-days for UFH and 20.7 per 1000 patient-days for enoxaparin. Major bleeding complications were similarly increased for both UFH and enoxaparin therapy across categories of worsening renal insufficiency. These data suggest that patients with renal impairment are at increased risk for bleeding and that no specific heparin strategy is inherently safer than the other. It should be emphasized that although UFH has a dual clearance mechanism and may not be as prone to accumulation as LMWH in the setting of renal insufficiency, UFH has greater adverse effects on platelet function and capillary permeability with respect to bleeding. There is no compelling evidence that UFH should be the "default" choice in the setting of renal impairment.

Large contemporary randomized trials of LMWH have generally excluded patients with significant renal impairment. However, sufficient pharmacokinetic and clinical data are available to make dosing recommendations. Pharmacokinetic studies confirm that LMWH anti-Xa activity is strongly correlated with creatine clearance (43). For enoxa-

Table 2
FDA Dosing Guidelines for Enoxaparin in Renal Insufficiency (Creatine Clearance < 30 cc/min)

Prophylaxis in the medically ill patient: 30 mg daily
Inpatient treatment of deep venous thrombosis with or without pulmonary embolism: 1 mg/kg daily
Outpatient treatment of deep venous thrombosis without embolism: 1 mg/kg daily

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parin, the relationship between anti-Xa activity and creatine clearance is linear in both single- and multiple-dose studies, with significantly increased anti-Xa levels in patients with a creatine clearance less than 30 cc/min (44-46). Sanderink and colleagues demonstrated a 39% decrease in anti-Xa clearance and a 35% increase in anti-Xa exposure with multiple prophylactic doses of enoxaparin in patients with a creatine clearance below 30 cc/min compared with those with a creatine clearance above 31 cc/min (47). These studies have led to revised FDA dosing guidelines for enoxaparin in the setting of renal insufficiency (Table 2). It is important to note that the pharmacokinetic effect of impaired renal function may differ among LMWHs, and no such dosing guidelines exist for other LMWHs or for UFH. Moreover, fondaparinux is currently contraindicated in patients with renal impairment. Also, it should be emphasized that the dosing recommendations derived from the kinetic studies have not been validated in randomized trials. The 30 cc/min cut-point for adjusted renal dosing cannot be viewed dogmatically, as patients with creatine clearance less than 10 cc/min may be expected to react differently than those with higher degrees of renal function. Thus caution should be exercised in all patients with renal impairment in the setting of anticoagulation, and monitoring heparin activity remains the safest approach, particularly in the perioperative setting.

Table 3
Neuraxial blockade of the patient receiving anticoagulants

Preoperative LMWH	
Fixed-dose prophylaxis	Needle placement 10 to 12 hours after last LMWH dose
Full weight-adjusted doses (enoxaparin 1 mg/kg q12 or dalteparin 200u/kg daily)	Needle placement >24 hours after last LMWH dose
Postoperative LMWH	
Twice-daily fixed doses	Begin 12 to 24 hours after surgery
Single-daily fixed doses	Begin 6 to 8 hours after surgery with subsequent dose at least 24 hours after the last dose
Continuous epidural analgesia	Do not pull catheter within 2 hours of LMWH dose
Postoperative vitamin K antagonists	
Continuous epidural analgesia	The catheter should be pulled with an INR <1.5

INR = international normalized ratio; LMWH = low-molecular-weight heparin.

Neuraxial Anesthesia

The ACCP recommends special caution when using anticoagulant prophylaxis in all patients undergoing neuraxial anesthesia or analgesia (8). Neuraxial blockade has several advantages, including superior analgesia, reduced blood loss and need for transfusion, decreased incidence of VTE and nosocomial pneumonia, and improved joint mobility following knee arthroplasty (48). However, there is a rare but finite risk for perispinal hematoma when neuraxial blockade is used concomitantly with anticoagulant drugs. Bleeding into the enclosed space of the spinal canal can produce spinal cord ischemia and subsequent paraplegia. A 1997 FDA public health advisory reported 41 patients who developed perispinal hematoma after receiving enoxaparin around the time of neuraxial blockade. Some patients had preexisting spinal abnormalities, and 31% had received additional hemostasis-inhibiting medications. The vast majority of cases (over 85%) occurred in major elective orthopedic joint replacements.

Most patients who develop perispinal hematomas have more than one risk factor for local or systemic bleeding. These factors include the presence of an underlying hemostatic disorder, anatomical or vascular vertebral column abnormalities, traumatic needle or catheter insertion, repeated insertion attempts, insertion in the presence of high levels of an anticoagulant, continuous use of epidural catheters, concurrent administration of medications known to increase bleeding, high anticoagulant dosage, older age, and female gender (relative to the effect on renal function). The American Society of Regional Anesthesia endorses the use of LMWH concurrently with neuraxial blockade as long as appropriate caution is taken (Table 3).

It is important that all patients going for surgery undergo a standardized preoperative assessment that includes questions about bleeding disorders. Patients with known bleeding disorders should generally not receive neuraxial blockade. In addition, patients receiving other anticoagulants at the time of surgery (ibuprofen, aspirin, clopidogrel, herbal supplements) should avoid neuraxial blockade. Anticoagulant prophylaxis should be delayed in patients who have a traumatic tap during initial placement of the spinal needle. With concurrent use of epidural analgesia and anticoagulant prophylaxis, all patients should be monitored carefully and frequently for signs and symptoms of cord compression.

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Perioperative Medication Controversies

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Introduction

Perioperative medication management is an inexact science. Perioperative practices are often guided by anecdote, trial and error, and sometimes by either small studies or reports of patient outcomes. Rarely, there are randomized trials to guide therapy. In this article we discuss some of the current controversial perioperative medication issues and possible management strategies.

Antiparkinsonian Agents

As the population ages, hospitalists will be required to manage more patients with Parkinson's disease perioperatively. A major challenge with the medication management of these patients is that almost none of the antiparkinson medications are available in a parenteral form. Most practitioners advocate continuation of these medications until the morning of surgery followed by rapid initiation postoperatively. This avoids both return of parkinsonian symptoms, as well as prevents a levodopa withdrawal syndrome. The syndrome is uncommon, but serious, and is characterized by symptoms similar to neuroleptic malignant syndrome (1).

Some practitioners advocate a preoperative decrease in the dose of levodopa to the minimum tolerated dose to help prevent the syndrome. Unless the patient is expected to have a prolonged NPO period postoperatively, we feel that this is unnecessary, and risks worsened overall control of symptoms.

If the patient cannot resume oral medications within the first several hours postoperatively (due to altered consciousness, dysphagia, or upper GI abnormality) and the lower gastrointestinal tract is functional, levodopa can be delivered via a weighted feeding tube or via jejunostomy tube. A levodopa and carbidopa solution can be made by pulverizing then dissolving 4 tablets of regular carbidopa/levodopa 25/250 strength in 1 liter of water with 1 gram of vitamin C to produce a 1 mg/ml solution of levodopa. The solution should be kept in a dark bottle to protect it from light and should be refrigerated. The solution remains stable for 24 hours (2).

For parkinsonian patients who cannot take oral medications for a prolonged period postoperatively, benztropine can be used (0.5 – 1.0 mg I.M. or I.V. bid) to help limit symptoms. Consideration can also be given to the use of a combination of rectal domperidone (available in Canada) with subcutaneous apomorphine. Apomorphine is a powerful dopamine D1 and D2 agonist. Domperidone is a peripheral D2 antagonist, which blocks the peripheral side effects of apomorphine (3). The perioperative use of apomorphine and domperidone has been well described by Galvez-Jimenez and Lang as a very effective strategy for severe Parkinson's disease patients who require surgery for gastrointestinal disorders and must be NPO for a prolonged period (4). The therapy requires initiation of the domperidone 3 days preoperatively, followed by initiation of the apomorphine soon postoperatively and continued subcutaneously every 1-2 hours, with domperidone q6h until oral intake is re-established. It is suggested that the patient undergo preoperative test dosing and titration so that the approximate apomorphine dose required for maximal symptom relief with minimal side effects is known (4). An alternative to domperidone is trimethobenzamine (Tigan), at 300 mg tid (5). Serotonin receptor antagonists such as ondansetron are contraindicated when apomorphine is in use because of the risk of severe hypotension and syncope when the two drugs are combined (5).

A significant problem for some Parkinson's disease patients is postoperative delirium and psychosis. This can be triggered by various analgesics and anesthetics as well as by perioperative use of anticholinergic agents, alteration of usual antiparkinsonian medication, metabolic abnormalities, or by infection. Anticholinergic medications such as metoclopramide or promethazine can provoke mental status changes; ondansetron or nasogastric suctioning can be tried instead for nausea or vomiting. If confusion or delirium develops, haloperidol and_fluphenazine can worsen symptoms. Instead, try the atypical antipsychotic quetiapine (5). If the patient is NPO, ziprasidone (Geodon) can be used.

Unfortunately, the anticholinergic medication and benztropine may be the only I.V. alternatives available for a patient who is NPO. In that case, the practitioner must decide if parkinsonian tremor and stiffness are more important to treat than the mental status/degree of confusion. For patients who are taking their oral medications, keep in mind that selegiline combined with opioids, but especially meperidine, can result in a life threatening reaction which resembles the neuroleptic malignant syndrome (2). Some anesthesiologists recommend stopping selegiline a few days preoperatively to avoid the possibility of this type of drug interaction. This reaction can also rarely occur with SSRI's and tricyclic antidepressants (5).

Other common issues postoperatively in parkinsonian patients are worsening of dysphagia with a related increased risk of aspiration pneumonia, a worsened respiratory restrictive defect due to stiffening of respiratory muscles, and prolonged recovery period because of decreased ability to participate in physical therapy.

With diligent medical care via optimization of medication management, attention to positioning, swallowing function, oxygenation, and physical therapy, these patients can enjoy improved swallowing outcomes.

To Stress Dose Or Not To Stress Dose?

The first report of a postoperative death from adrenal insufficiency was made in 1952. It described the case of

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Perioperative Medication Controversies (continued)

a steroid dependent patient whose steroids were stopped 2 days preoperatively and who died of hypotension following a major orthopedic procedure (6). It has subsequently been learned that patients with normal adrenal function have an increased secretion of cortisol perioperatively. Patients who have been on prolonged steroid therapy have a blunted perioperative secretion of cortisol, and are thus thought to be at possible risk of stress induced hemodynamic instability. Since the initial report in 1952, use of stress dose steroids have been the standard of care in the perioperative setting. In reviewing the literature, it appears that perioperative hypotensive crises due to adrenal insufficiency are rare, but it is impossible to know what the true occurrence rate is since it may be under recognized and/or under reported. For example, a report in 1976 by Kehlet revealed only 57 reports worldwide of adrenal insufficiency related perioperative hypotension. (6)

Many questions persist regarding appropriate perioperative steroid use, however. How much steroid use causes HPA suppression? Is continuation of the usual daily steroid dose enough? How large must the surgery be to necessitate stress dose steroid use? How much is enough? Multiple studies have been conducted to answer these questions, but most of them have been flawed by inadequate controls, statistical analysis, lack of blinding or randomization, or lack of strict clinical parameters. Even the definition of hypoadrenal symptoms varies greatly from study to study, making metaanalysis difficult. A well done review by Brown and Buie (6) found two studies in which perioperative steroids were held completely. Two of 104 patients required re-initiation of steroids for hypotension unresponsive to intravenous fluids. Glowniak and Loriaux (7) conducted a double blind study in which patients were randomized to either their usual steroid dose or stress dose steroids before major surgery. There was no difference between the groups with regard to hemodynamic status, thus no evidence of adrenal crisis. Although this study lends credence to the idea that continuing a patient's usual steroid dose on the morning of surgery should be enough to prevent stress induced adrenal insufficiency, the number of patients in the study was small and validation of the results with a larger study would be needed to help change the tide of current practice.

Although it is an option to perform ACTH testing in patients preoperatively, it is not always available or practical depending on the clinical setting. Furthermore, some studies have found that patients who have had evidence of HPA axis suppression on ACTH stimulation testing have had subsequent normal clinical courses perioperatively without the use of supplemental steroids. Conversely, ACTH testing showing normal adrenal function is not always reliable (8).

A variety of studies have attempted to discern what dose of steroid and for what duration would result in HPA axis suppression. Based on studies showing abnormal responsiveness to ACTH after only three to five days of prednisone, practitioners should consider patients to be at risk for HPA axis suppression after five days of prednisone at 20mg or its equivalent. For doses just above the physiologic range, HPA axis suppression takes at least one month to develop. After cessation of steroids, it takes as much as one year to recover from the effects of long term steroid use, but shorter courses are associated with a much quicker recovery (9). Given these facts regarding ACTH testing, and given that 1-2% of patients in some studies did have significant hemodynamic compromise related to perioperative adrenal insufficiency (6), we recommend the use of perioperative stress dosing.

Although many of the studies have been difficult to use in evidence-based management of perioperative steroids, there is enough evidence to create some practice tenets:

- Prednisone doses of less than 5 mg/day or its equivalent do not result in HPA axis derangement and do not require use of perioperative steroids.
- Patients who have had more than one week of glucocorticoid therapy at a predisone dose of at least 20 mg/day or its equivalent in the past 6-12 months may be adrenally insufficient, and consideration should be given to using stress dose steroids suitable for the level of surgery.
- Patients on chronic alternate day steroid therapy usually do not have HPA axis suppression and can continue their usual steroid dose perioperatively.
- Patients on prednisone doses of 5 mg/day or more have much variability in degree of adrenal suppression, which may be related to individual differences in the rate of steroid metabolism. (10) Consider stress dosing of steroids in these patients based on the length and degree of physical stress of the proposed surgical procedure (see below).
- Patients on more than 20 mg/day of prednisone or the equivalent should be assumed to be adrenally insufficient, and should receive full stress doses of steroids perioperatively (see below).

Based on the stress and extent of the surgery:

- For minor surgeries under local anesthesia, 25 mg of hydrocortisone immediately preoperatively can be used. If the patient is on more than 7 mg/day of prednisone or its equivalent, though, this represents more steroid than 25 mg of hydrocortisone, so the patient can simply utilize his/her usual dose of steroids.
- For moderate stress surgeries, Axelrod advises 50 mg of hydrocortisone preoperatively (9). Other practitioners have advocated hydrocortisone amounts ranging from 100-125 mg for one to two days, although there are no randomized trials to support any particular method of dosing. We recommend q8 to q 12 hour dosing.
- For large surgeries (i.e. cardiac, aortic, or large intra-abdominal procedures), full stress doses can be used. Maximal adrenal cortisol production has recently been reported as 200 mg of cortisol per day (11), although some have found this to be as high as 300-500 mg/day (2). Maximal stress dosing

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of hydrocortisone at 75-100 mg q8 hours for 24-48 hours should be adequate (9). The dose can be decreased by 50% per day after that, with return to the patient's usual steroid dose.

- If the patient is still under significant physical stress (i.e., sepsis), do not taper the stress dosing until the patient is clinically stable.

Although some studies advocate holding stress dose steroids unless the patient has documented HPA axis suppression or unless the patient is on large doses of steroids, it is ultimately up to the clinician to decide whether stress dosing is right for the patient or not. In support of stress dosing, no studies have shown clearcut wound healing problems or increased rates of wound infections due to stress dose steroids, and although rare, postoperative adrenal crisis is a real entity. If the clinician chooses to hold perioperative steroids, we recommend watching for clinical signs and symptoms of adrenal insufficiency.

Angiotensin Converting Enzyme Inhibitors

There has been increasing evidence that chronic use of ACE inhibitors (ACEI) increases the probability of hypotension at induction of anesthesia or during the intraoperative period. In balancing acceptable blood pressure control against hypotensive episodes in the operating room, clinicians remain uncertain whether or not to withhold ACE inhibitors preoperatively. Fortunately, these hypotensive episodes are readily corrected with IV saline and, if needed, vasoconstrictive agents.

In the renin-angiotensin system (RAS), renin catalyzes the conversion of angiotensinogen to angiotensin I. That, in turn, is converted to angiotensin II by angiotensin converting enzyme (ACE). The direct actions of angiotensin II include initial and rapid vasoconstriction, and later, an appropriate increase in intravascular volume via stimulation of sodium and water reabsorption. RAS activation is primarily triggered by decreased effective circulating volume. The restoration of the effective circulating volume diminishes the stimulation of the RAS. In patients treated with ACE inhibitors, the hypotensive effect may additionally be due to decreased venous return and diminished reflex tachycardia (11).

Blood pressure is sustained by three vasopressor systems: the sympathetic nervous system, the RAS, and vasopressin. Anesthesia generally diminishes sympathetic tone. Diminished venous return ensues and leads to decreased circulating volume. In patients not treated with ACE inhibitor agents, the RAS would be activated and counterbalance this effect. However, in cases where ACE inhibition is present (and thus RAS inactivated), blood pressure may decrease significantly as angiotensin II is unavailable for the immediate vasoconstrictive effect. (11)

Several studies in the 1990's demonstrated a concerning increase in incidence of hypotension at induction of anesthesia and in the intra operative period. A small randomized study (n=51) concluded that 70% to 100% of the ACEI treated group suffered hypotensive episodes (12). The group that had the ACEI held the day prior suffered a significantly decreased chance of hypotension (18%-21%). A much larger prospective study on cardiopulmonary bypass patients (n=4301) demonstrated a significantly higher incidence of postoperative vasopressor infusion use in patients chronically on ACEI compared to those on other anti-hypertensive agents (7.7% vs. 4.0%; p=0.0001) (13). This study also identified age, opioid anesthesia, poor LV function, and congestive heart failure as independent risk factors for their outcome measures. A third study (n=41) which randomized cardiopulmonary bypass patients by their anti-hypertensive regimen, ACEI vs. others, found no remarkable difference in the patients' need for vasopressor support or their hemodynamic stability (14). However, the ACEI treated group received significantly less of the same anesthesia agents compared to the other group. None of these studies reported any quantified risk of pre-induction hypertension in patients whose ACEI were withheld.

Based on these limited data, it appears that the risk of intraoperative hypotension in some cases may exceed that of pre-and intra operative hypertension. It remains unclear how often holding ACEI preoperatively results in postoperative hypertension. At this time, we recommend routine continuation of ACEI use perioperatively, except in patients shown to clearly be at risk for intraoperative hypotension (advanced age, systolic dysfunction, use of diuretics). This is based on the fact that it is unclear how holding ACEI preoperatively will affect postoperative blood pressure con-

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trol, and based on the fact that several trials show that ACEI-induced hypotensive episodes can be readily corrected with fluid resuscitation and vasoconstrictive agents. Thus, risk of hypotensive episodes translating into any morbidity is quite low in the controlled settings of the operating room. Novel agents such as vasopressin agonist have been shown to be effective for those few refractory cases of hypotension (21, 22). Anesthesiologists as a group do not yet have a consensus regarding perioperative use of ACEI. It is important to note that this discussion pertains only to patients taking ACEI for hypertension. Those taking ACEI for indications other than hypertension (i.e., those with systolic dysfunction and diabetic nephropathy) are not at risk for elevated blood pressure perioperatively and thus should have their ACEI routinely withheld preoperatively.

Immunosuppressive Agents

Immunosuppressive agents are becoming more widely used for conditions such as rheumatoid arthritis and inflammatory bowel diseases. In our preoperative evaluations of patients on these agents, our concerns include wound healing and postoperative infections. This is balanced against the sustained control of the underlying disease, for which the immunosuppressive agents are prescribed. Consensus is lacking as to the perioperative management of these agents. We will focus on the common agents for rheumatoid arthritis, methotrexate (MTX), etanercept, and infliximab.

MTX is the oldest agent in this group and thus the most studied. Earlier small studies suggested an increased risk in post-operative complications in patients who were continued on MTX compared to those who were not (15, 16). In the 1990's, other small prospective and retrospective studies supported a contrasting view. These papers concluded that there was no increased incidence of postoperative complications in patients who continued their MTX treatment through surgery (17, 18). A recent larger and better-designed trial seems to confirm that continued MTX use does not increase risk of post-operative complications (19). This trial involved 388 patients and was a prospective randomized trial. 88 patients continued on their MTX (Group A), 72 discontinued it (Group B), and 228 were never on it and served as a control group (Group C). In this study, Group A actually had a lower rate of complications compared to Group B or C (Group A: 2% vs. Group B and C, respectively, 15% and 10.5%; $p<0.003$). 8% of patients in Group B and Group C had a disease flare at six weeks, compared to no flare in Group A.

No other studies measured the rate of disease flares. There has been very little published evidence regarding the safety or risk of perioperative use of etanercept or infliximab. A recent retrospective analysis was carried out on patients with Crohn's disease undergoing abdominal surgery. Patients in this study were on 1 or more immunosuppressive agents, including corticosteroids, azathioprine, 6-MP, MTX, and infliximab (20). The study concluded, via univariate logistic regression, that preoperative use of steroids, infliximab or other immunosuppressive agents was not associated with increased rate of septic or non-septic complication rates. This paper reported no significant increase in postoperative complications (septic or total) from steroid and infliximab use, when analyzed with a multivariate model. Other supporting literature on infliximab and its safety in surgical patients has been in abstract form only.

In our opinion, it is prudent to continue MTX and infliximab in patients with no other predisposing factors for postoperative infection. In patients who are at high risk, including those with diabetes mellitus and malnutrition, consider discontinuing MTX perioperatively but probably for no more than two weeks before and after the surgery to minimize the risk of disease flare. There is no available evidence regarding etanercept to make any recommendations; we would extrapolate our suggestions on MTX and infliximab to other common immunosuppressive agents.

Conclusion

At present, there are as many questions as answers regarding the use of the above medications, and others, in the perioperative setting. In particular, many newer medications are especially poorly studied in this setting. Some general principles are useful:

- Medications without known withdrawal syndromes when stopped abruptly, and not essential for stability of a serious medical condition, may be held perioperatively.
- If medications are continued perioperatively, vigilance for adverse reactions is appropriate.
- Potential drug interactions may occur between chronic medications and anesthetics or other drugs introduced in the perioperative period.
- Above all, every patient's medication regimen must be individualized to his or her overall clinical needs.

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Preventing Surgical Site Infections

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Background

An appropriately feared complication of operations, surgical site infections (SSIs) are infections are associated with high economic costs and significantly worse clinical outcomes (1). Defined as infections of the superficial incision site, deep incision space, or organ space, SSIs add additional cost ranging from $2,700 to $26,000 per episode according to CDC's National Nosocomial Infections Surveillance System. Patients who develop an SSI have hospital lengths of stay (LOS) in excess of seven days longer and are 60% more likely to spend time in the intensive care unit than are patients without an SSI. A patient with an SSI is five times more likely to be readmitted to the hospital and is twice as likely to die (2).

Unfortunately, surgical site infections are common. Among healthcare-acquired infections, SSIs rank second only to urinary tract infections in frequency, making them more common than bloodstream infections and nosocomial pneumonia (3). There are approximately 30 million operations annually in the U.S. and an SSI complicates 2-5% of clean extra-abdominal sites. The rate is much higher for intra-abdominal operations, approaching 20% (1). Because most SSIs begin within two hours of contamination, the perioperative period is the most crucial for development of an SSI (4). By offering clinical expertise in the practice guidelines that reduce the risk of SSIs, hospital medicine programs can help patients and hospital systems lower morbidity, mortality, and costs associated with this complication. Adherence to best practices will likely require coordinated, multidisciplinary process improvement.

Several important interventions fall directly under the control of the anesthesia and surgical teams, such as administering perioperative oxygen, ensuring perioperative normothermia, and avoiding shaving of the surgical site. In coordinated quality improvement efforts, members of the operative team should assume direct responsibility for the performance of these measures. But the performance of two important interventions in this decisive period is likely to be significantly enhanced by the presence of focused hospitalist surgical co-management: antimicrobial prophylaxis and perioperative glycemic control (Table 2).

Antimicrobial Prophylaxis

Studies overwhelmingly show a marked reduction in the relative risk of SSIs with the use of antibiotic prophylaxis (1). In June 2004, the National Surgical Infection Prevention Project (NSIPP) published an advisory statement on antimicrobial prophylaxis in which it outlined three performance measures for quality improvement in prevention of SSIs:

1. The proportion of patients who have parenteral antimicrobial prophylaxis initiated within one hour before surgical incision
2. The proportion of patients provided with a prophylactic antimicrobial agent that is consistent with currently published guidelines, and
3. The proportion of patients whose prophylactic antimicrobial therapy is discontinued within 24 hours after the end of surgery (5)

Pooled data suggest that attention to timing makes a favorable difference in SSI rates (1). Fully administering the appropriate antibiotic within 60 minutes of incision ensures that serum and tissue drug levels exceed the MICs of the most likely contaminating organisms. Dosing the antibiotic immediately prior to the start of surgery also provides the best opportunity to extend therapeutic levels for the duration of the surgery. The fact that anesthesia and surgical teams are in the most practical time-space positions to apply this measure underscores the multi-disciplinary and process-level efforts necessary to reduce SSI rates.

When it comes to the choice of antimicrobial and the duration of its use, hospitalists may find themselves in superior positions of impact. Familiarity with recommendations of the NSIPP advisory statement (summarized in Table 2) promotes evidence-based selection of antibiotic prophylaxis based on patient-specific factors: type of operation and presence of true drug allergies (5). Compared with other members of the surgical co-management team, hospitalists are more likely to be aware of relevant patient-specific risk factors such as the likelihood of colonization with methicillin-resistant *Staphylococcus aureus* (MRSA). For example, in patients colonized with MRSA, hospitalists might consider vancomycin as the alternative agent for prophylaxis. Free access to the NSIPP advisory statement is available at http://www.journals.uchicago.edu/CID/journal/issues/v38n12/33257/33257.html.

Antimicrobial prophylaxis after wound closure is unnecessary; published evidence demonstrates the non-inferiority of single

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Table 1. Multidisciplinary Approach for Reduction of Surgical Site Infections

	Operative Team	Hospitalist
Antimicrobial	Timing of Antibiotic (within 60 minutes before surgical incision)	1. Selection of Antibiotic* 2. Discontinuation of Antibiotic within 24-hrs of end of surgery
Non-antimicrobial	1. Peri-operative supplemental oxygen 2. Peri-operative normothermia 3. Avoid shaving surgical site	Peri-operative normoglycemia

* For guidance in selecting appropriate antibiotic, use Table 3 of NSIPP Advisory Statement. Bratzler D, Houck PM, Surgical Infection Prevention Guidelines Writers Workgroup. Antimicrobial prophylaxis for surgery: an advisory statement from the National Surgical Infection Prevention Project. Clin Infect Dis. 2004 Jun 15;38(12):1706-15. Epub 2004 May 26.

Table 2. Adapted From NSIPP Advisory Statement

Summary of the Surgical Infection Prevention Guideline Writers Workgroup consensus positions.

Principle	Consensus Position
General dosing	
Antibiotic timing	Infusion of the first antimicrobial dose should begin within 60 min before the surgical incision.[a]
Duration of prophylaxis	Prophylactic antimicrobials should be discontinued within 24 h after the end of surgery.
Screening for ß-lactam allergy	For those operations for which cephalosporins represent the most appropriate antimicrobials for prophylaxis, the medical history should be adequate to determine whether the patient has a history of allergy or serious adverse antibiotic reaction. Alternative testing strategies (e.g., skin testing) may be useful for patients with reported allergy.
Antimicrobial dosing	The initial antimicrobial dose should be adequate based on the patient's body weight, adjusted dosing weight, or body mass index. An additional antimicrobial dose should be provided intraoperatively if the operation is still continuing 2 half-lives after the initial dose.
Antibiotic selection, by procedure	
Abdominal or vaginal hysterectomy	Cefotetan therapy is preferred; cefazolin or cefoxitin are alternatives. Metronidazole monotherapy is also used.[c] If the patient has a ß-lactam allergy, use clindamycin combined with gentamicin or ciprofloxacin[d] or aztreonam; metronidazole with gentamicin or ciprofloxacin;[d] or clindamycin monotherapy.
Hip or knee arthroplasty	Use cefazolin or cefuroxime. If the patient has a ß-lactam allergy, use vancomycin or clindamycin.
Cardiothoracic and vascular surgery	Use cefazolin or cefuroxime. If the patient has a ß-lactam allergy, use vancomycin or clindamycin.
Colon surgery	For oral antimicrobial prophylaxis, use neomycin plus erythromycin base or neomycin plus metronidazole. For parenteral antimicrobial prophylaxis, use cefotetan, cefoxitin, or cefazolin plus metronidazole. If the patient has a ß-lactam allergy, use clindamycin combined with gentamicin, ciprofloxacin, or aztreonam, or use metronidazole combined with gentamicin or ciprofloxacin.[d]

[a] When fluoroquinolone or vancomycin are indicated, infusion of the first antimicrobial dose should begin within 120 min before the incision.

[c] Metronidazole monotherapy is included in the Practice Bulletin of the American College of Obstetricians and Gynecologist as an alternative to ß-lactams for patients undergoing hysterectomy, although it may be less effective as a single agent for prophylaxis.

[d] A single 750-mg dose of levofloxacin may be substituted for ciprofloxacin.

dose prophylaxis when compared with multiple dose prophylaxis (5). Furthermore, prolonged use of antimicrobial prophylaxis is associated with the emergence of resistant organisms (6-8). By ensuring that the duration of prophylaxis does not exceed 24 hours past the end of the operation, hospitalists can make valuable contributions to public health and cost containment.

Non-antimicrobial Prophylaxis

Several non-antimicrobial measures also significantly reduce SSI rates. Those that fall outside the domain of the hospitalist and into the direct purview of the operative team include high levels of inspired oxygen, maintenance of perioperative normothermia, and use of clippers rather than a razor when hair removal is necessary. The risk of SSIs is directly related to tissue oxygenation. Bacterial infectivity is enhanced and cellular immunity is compromised in

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Preventing Surgical Site Infections (continued)

hypoperfused, poorly oxygenated tissue (9). The practice of administering perioperative supplemental oxygen (at least 80% FIO2 in intubated patients) reduces the risk of SSI by nearly one-half (1). For non-intubated patients, oxygen at 12 L/min by non-rebreathing face mask applied intra-operatively and for at least 2 hours following surgery leads to similar reductions of SSI rates. Besides being effective, this intervention is inexpensive, has no recognized adverse effects, and carries the added benefit of significantly reducing post-operative nausea and vomiting (4).

Hypothermia also predisposes the surgical wound to infection. Even mild perioperative hypothermia (i.e. core temperature 35-36.5°C) typically occurs in the absence of specific measures to prevent net heat loss. Perioperative hypothermia is the combined result of exposure and anesthetic-induced thermo-dysregulation, with redistribution of core body heat to the periphery (4). Even mild hypothermia causes vasoconstriction, yielding diminished perfusion with secondary fall in tissue oxygen tension which especially impairs phagocytosis and oxidative killing by neutrophils (10). Hypothermia also blunts scar formation, which further diminishing wound integrity. Active warming of the patient to maintain a core temperature near 36.5°C constitutes the intra-operative standard of care and is effective at reducing the risk of SSIs by as much as two-thirds (1).

Hyperglycemia, an established independent risk factor for an array of adverse outcomes in hospitalized patients, is also an independent risk factor for SSIs across a range of surgical patients (1). Short-term hyperglycemia depresses immune function through nonenzymatic glycosylation of immunoglobulin and by impairing normal leukocyte performance (11). Among diabetic cardiac surgery patients, reduction of hyperglycemia with an intravenous insulin infusion lowered the incidence of deep sternal wound infection by as much as two-thirds (12). While the value of achieving glycemic targets has already been established for a variety of important endpoints and across a range of inpatient populations, hospitalists should stay tuned. As high quality studies emerge proving that glycemic control lowers SSIs among non-cardiac surgical subpopulations, hospitalists may increasingly be relied upon to achieve strict glycemic targets.

By recognizing and coordinating practices known to reduce SSIs, hospitalists can elevate the level of care provided for surgical patients. At the same time, hospitalists can help lower costs and keep the hospital system mindful of public health goals, such as prevention of antimicrobial resistance. While individual hospitalists have key roles to play, the overall approach to SSI reduction calls for a coordinated, multidisciplinary team approach with process and system-level efforts.

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The Comprehensive Role of the Hospitalist as Medical Consultant: A Case Discussion

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Educational Objective: To understand the value added by the hospitalist in the perioperative care of the surgical patient

Key Questions:

1. What ethical issues, if any, need to be addressed?
2. What should be recommended before surgery to reduce the likelihood of perioperative complications?
3. How does knowledge of the hospital add value to the consultation?
4. How does the hospitalist's approach differ from that of a traditional medical consultant?

Consultation Summary: 67-year-old man for preoperative risk assessment for total knee replacement

The patient, an avid golfer, had markedly reduced his golf game because of chronic knee pain. The patient was determined to have a left total knee replacement (TKR), despite the fact that he was at high risk from a cardiovascular perspective. Neither his primary care physician nor his cardiologist could change his mind—he reported that he would rather die than not play golf—but they were able to convince him and his wife to travel to Boston for surgery.

The patient's extensive cardiac history included congestive heart failure 8 years earlier, followed by three-vessel coronary artery bypass grafting (CABG) and three post-CABG angioplasties. His last exercise tolerance test and cardiac catheterization were performed to evaluate unstable angina 6 months before anticipated surgery. At that time, two stents were placed into his left main coronary artery, and symptoms were partially relieved. He subsequently had no change in his chronic nocturnal angina (slight shortness of breath, jaw and throat discomfort). During the summer following stent placement, he underwent cardioversion for atrial fibrillation. At that time, ejection fraction was 55% to 60%. He had chronic severe hypertension, with readings 180–220s/120s, that was very difficult to control until spironolactone was added. Renal angiography ruled out renal artery stenosis. Associated vascular disease included a stroke with right-sided residual weakness 8 years before the currently requested surgery and chronic, less-frequent calf claudication.

Other notable medical problems were a 20-year history of type 2 diabetes that was well controlled on insulin, glaucoma, a recurrent feeling of laryngeal fullness (globus) secondary to gastroesophageal reflux disease, and urticaria. His initial allergic symptoms were attributed to an acute immunologic reaction, possibly due to new drugs (diuretics, sulfa, and/or angiotensin-converting enzyme inhibitors) that resulted in generalized urticaria and laryngeal constriction. Extensive workup for an underlying abnormality of complement, autoimmune disease, and monoclonal antibody were negative. He had no peripheral eosinophilia. He rarely drank alcohol and had discontinued cigarette smoking 25 years ago.

His medication list included bumetanide, spironolactone, enalapril, labetalol, nifedipine, verapamil, a nitroglycerine patch, clonidine transdermal patch, atorvastatin, colesevelam, aspirin, omeprazole, docusate, insulin lispro at mealtime, ranitidine, cetirizine, temazepam, ferrous sulfate, levobunolol eye drops, and monthly IM B12 injections. He had a recent decrease in verapamil dosage secondary to a slow pulse of 23 beats/min noted at the time of arthroscopic knee surgery.

This patient experienced throat closing with sulfa, latex, hydrochlorothiazide, and furosemide. He developed the same symptoms with red wine and shell fish. He and his health care proxy confirmed his wishes for life-sustaining interventions.

His physical examination revealed a mildly plethoric elderly gentleman ambulating slowly with a cane, left arm blood pressure 160/72 mm Hg, right arm blood pressure 152/72 mm Hg, pulse 56 beats/min, respiratory rate 16 breaths/min, jugular venous pressure approximately 7 cm H_2O, clear lungs, distant breath sounds, soft S4, protuberant abdomen without organomegaly or tenderness, 1+ pitting edema, right-sided hemiparesis, normal attention and memory, and localized dermatitis surrounding a clonidine patch.

Question 1: Should this high-risk patient be allowed to undergo an elective surgical procedure? His local cardiologist and primary care physician had encouraged him to postpone surgery in the hopes that he would change his mind.

The ethical dilemma in this case is conflict between patient autonomy and doing the right thing by the patient.

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His local physicians solved the problem by referring him to a tertiary care facility that treats high-risk patients. Adherence to guidelines of clinical ethics requires an understanding of the medical facts, patient preferences, his family views, and opinions of the local physicians who know him best (1). Factors external to this patient, such as legal liability, surgical expertise, and the capability of the hospital, also have to be considered. The attending orthopedist was well-known to the hospitalist as a superb surgeon whose credentials included board certification in internal medicine. Gathering information about this patient's diagnosis, prognosis, treatment options, and quality of life with and without the TKR involved speaking with the patient, family, primary care physician, local cardiologist, and his orthopaedic surgeon. Although the hospitalist would care for the patient for a brief period, the preoperative visit established a patient-physician relationship that was critical in the perioperative period. The ethical dilemma was resolved after discussion with all parties. The hospitalist confirmed with the attending surgeon that he was willing to perform the surgery and agreed that it was reasonable to proceed and respect the patient's wishes despite the increased risk.

Question 2: Is there anything that can be done beforehand to reduce the risk for postoperative complications?

The patient appeared to be euvolemic at the bedside. Routine preoperative testing was notable for hematocrit 34%, creatinine 1.9 mg/dL, an electrocardiogram demonstrating left bundle-branch block, and a chest radiograph showing cardiomegaly without congestive heart failure. Communication with his outside physicians confirmed that these test results were consistent with past results. His HgA_{1C} level was in the normal range.

According to the ACP and ACC/AHA guidelines on clinical predictors of increased cardiovascular risk for patients undergoing nonvascular surgery, he was high risk (5%) for postoperative complications of myocardial infarction, congestive heart failure, and/or death (2, 3). Indications for preoperative cardiac consultation include the patient undergoing cardiac, thoracic, or vascular surgery and/or the hospitalist needing help in interpreting an abnormal study to determine whether an intervention or medical management is appropriate. It is important to remember for cardiac interventions that roughly 82% to 90% of patients receive stents; and this may approach 100% in the future for arteries currently considered to be too small, tortuous, or calcified. Stent placement requires treatment involving at least 30 days of clopidogrel, followed by 1 to 2 weeks off clopidogrel. Patients receiving clopidogrel have a prohibitive risk of major bleeding complications during surgery, and it is thus contraindicated. However, the delay caused by this regimen is often not practical for many patients requiring surgery. The hospitalist reconciled the medication list produced by this patient with his physicians, specifically confirming that he had completed the clopidogrel regimen from the recent stent placement. The orthopedic procedure was nonvascular, intermediate risk, and elective.

The local referring cardiologist did not recommend preoperative cardiac testing because of the patient's recent cardiac catheterization, stable angina, and lack of treatment options (4, 5). The hospitalist decided that additional preoperative cardiology consultation at the Boston hospital was redundant and would not influence clinical decision-making. Both the cardiologist and primary care physician stressed epidural rather than general anesthesia due to the need for him to take all of his medications. Bumetanide was withheld on the day of surgery to avoid volume depletion, but spironolactone was continued to maintain control of his blood pressure. This information was verbally communicated to the attending surgeon and anesthesiologist also involved in the preoperative assessment.

It would be reasonable to ask his Boston allergist for specific recommendations relating to anticipated narcotic administration after surgery. Narcotics as a class generally have the ability to nonspecifically and nonimmunologically directly trigger degranulation of mast cells. Some patients develop hives associated with the use of narcotics. These drugs can also aggravate preexisting conditions, including chronic urticaria. This patient had one of two options. His surgeons could prescribe morphine/codeine drugs and be prepared to switch to alternative agents if symptoms develop. Alternatively, they could maintain the patient on continuous antihistamines that would allow him to tolerate medications that would otherwise cause symptoms. The latter option was chosen.

The local cardiologist stated that the patient "never cried wolf" about angina and in fact was very knowledgeable and compliant with his medications. This key piece of information led to the recommendation that the patient should be in charge of his complex medical regimen in the hospital to avoid delays due to the use of nonformulary medications, the potential incorrect dosages ordered by residents unfamiliar with his medications, or missed medication administration due to a variety of factors in the hospital setting.

The usual recommendations regarding adjusting the insulin dosage on the day of surgery and maintaining euvolemia were made.

Question 3: How does knowledge of the hospital influence recommendations?

Based on the hospitalist's knowledge of the capabilities of the different services in the hospital and hospital critical pathways that might be applied in patient care, specific recommendations would be made regarding deviations from the TKR pathway and the service (medicine versus surgery, ICU versus monitored bed) to which this high-risk patient should be transferred after surgery. During patient triage, it is important to remember that most complications do not occur in the operating room and may occur 2 to 3 days after surgery. The best service is that which will appropriately manage acute problems. High-risk patients are more likely to have a life-threatening cardiovascular complication than an orthopedic complication. The key for the hospitalist con-

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sultant is determining which patients are truly high risk and knowing the capabilities of each service. For this patient, the medical service could fine-tune his cardiac regimen during his hospital stay and the orthopedic surgical service might follow as a consultant. TKR is straightforward, especially now with the devices used for knee immobilization.

A knowledge of the TKR critical pathway would be helpful in making recommendations relating to timing of checking postoperative blood work (hematocrit, electrolytes, renal function) and to what hematocrit would be acceptable in this patient who has nocturnal angina with a chronic hematocrit of 34%. The consultant should stress the importance of the patient not becoming more anemic after surgery or having decreased blood pressure due to volume depletion. More frequent monitoring of the hematocrit should be recommended, especially if any decline is noted from usual levels. For example, a decline to 30% in the recovery room might be expected to decrease further to unacceptably low levels in this patient at high risk for cardiovascular complications. A prophylactic transfusion or re-measuring the hematocrit later that evening would be a reasonable deviation from the TKR critical pathway.

Question 4: How does the hospitalist's approach differ from that of a traditional medical consultant?

Traditional medical consultants usually do not focus on hospital processes when making specific recommendations relating to high-risk patients, nor do they have the availability to co-manage these patients, see them in the recovery room, or respond to the concerns of the patient or family members. The hospitalist focuses on the entire hospital course from admission, anticipating problems during hospitalization, and preparing for discharge. Hospitalists can also take the lead in communicating with referring primary care physicians with regard to preferred extended care facilities after discharge and in ensuring that they know results of testing and receive discharge information. In this particular patient, the hospitalist might recommend a beeper page from the recovery room and perform a brief postoperative check. This check would include review of all medications and a triage decision depending on how the patient did during surgery, keeping in mind that complications may surface several days later.

Ideally, hospitalists can bridge performance gaps in the following areas: venous thromboembolism prophylaxis, optimal dosing of perioperative β-blockers, tight glucose control in the surgical patient, pain assessment and treatment, prevention of infection, identification and prophylaxis of substance abuse, and early correction of abnormalities leading to renal insufficiency and fluid overload states.

The severity of complications in the elderly (deconditioning, falls, and delirium) may be lessened with measures to improve the hospital setting, timely correction of metabolic abnormalities, reviewing narcotic and medication use, elimination of tethers such as Foley catheters, and involvement of family members in the orientation process. Prevention, appropriate use of resources, including consultants, and addressing end-of-life issues are value added by the hospitalist as the medical consultant.

Effective and timely communication with primary care physicians and medical specialists requires time and availability but is central to what hospitalists do to enhance continuity of care during transfer from one physician to another. The Joint Commission on Accreditation of Health Care Organizations (JCAHO) has recognized the importance of communication in establishing patient safety goals for hospital accreditation. 2005 Critical Access Hospitals' National Patient Safety Goals include medication reconciliation and falls as new goals and requirements. Hospitalists can take leadership roles in ensuring that their hospitals reach these new goals in caring for surgical patients in the perioperative period.

Hospitalists are invested in making the hospital run more safely and efficiently. They may play a role in developing co-management models for selected surgical patients and/or identifying geographic locations in the hospital that have both medical and surgical nursing. Additional studies are needed to determine how hospitalists affect quality of care in their role as medical consultants.

Hospitalist Medical Consultation Checklist

Preoperative Evaluation

- Ethical issues (if any)
- Communication with primary care physician, medical specialists previously involved in care
- Medication reconciliation
- Code status, health care proxy
- Specific recommendations to optimize condition of patient before surgery
- Specific recommendations to minimize perioperative complications

Hospital Course

- Targeted history and physical
- Venous thromboembolism prophylaxis--identifying who is primarily responsible
- Perioperative β-blockade according to blood pressure, heart rate
- Tight glucose control
- Early identification and correction of metabolic disturbances
- Optimization of fluid status
- Recommendations regarding transfusion (factoring patient comorbid conditions)
- Assessment and treatment of pain
- Daily medication review
- Surgical infection prevention with antibiotics (initiation, appropriate antibiotics, cessation)
- Substance abuse (identification, prophylaxis, arrange for counseling)
- Smoking cessation (patch, counseling)
- Nutritional status, dietary recommendations

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Hospitalist Co-management of Surgical Patients: A Partnership with Potential

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The practice of a surgeon and an internist working together to care for complex postoperative surgical patients has been adopted as a cornerstone of many hospital medicine programs across the country. In fact, this has been highlighted as the practice most likely to lead to accelerated expansion of the hospital medicine movement over the next 5 to 10 years. The concept, however, is not new. In private practice settings, internists have commonly written orders on postoperative patients and accepted nursing calls about nonsurgical issues, even when these patients were hospitalized under the care of the surgeon. In academic settings, a more traditional consultative role has historically been maintained by the internist, who leaves recommendations for the surgical team, but does not write orders or expect to be involved in the minute-to-minute management of the patient. The hospital medicine movement has created a cadre of physicians focused on hospital quality, safety, and efficiency who have greater availability, and greater interest in the inpatient management of surgical patients. Simultaneously, the medical complexity of today's surgical patient and a need for accountability for safety, quality, and efficiency on the part of the surgeon has resulted in demand for more consistent involvement in the care of surgical patients by internists. As a result, the sometimes casual relationship between surgeon and internist is evolving into a formal partnership to co-manage and, hopefully, improve the care of surgical patients.

What is Co-management?

Surgical co-management is a mutually negotiated relationship between a surgeon and an internist in which the internist directly manages a part of the patient's care that would not be expected in a traditional consultative role. This could include anything from a model where a hospitalist writes orders that he feels are appropriate, but still acts primarily as a consultant, to models where the hospitalist actually accepts the primary care responsibility of the patient, with the surgeon only managing "surgical issues." The latter model seems least complex from an operational standpoint, but it represents the most radical change from the traditional consult model, and sometimes does not suit the needs of the participants. The needs of co-management participants are likely to vary across different practice settings. As a result, no single model of co-management will be universally applicable. Regardless of the type of model, the key to a successful program is formalizing the relationship based on mutually agreed upon goals, and having a clear understanding of individual roles and responsibilities.

Why abandon the "traditional consult model"?

Surgeons are becoming increasingly busy and more highly subspecialized, and patients are becoming increasingly elderly and medically complex. Against this backdrop, a surgeon often finds himself without the time or expertise to tend to the many issues that arise in hospitalized patients. In a traditional model, internal medicine consultants leave recommendations about how to manage many of a patient's issues, but the surgeon may not become aware of these recommendations in a timely fashion, or may not understand the relative importance or urgency of the given recommendations. Furthermore, it is not uncommon for some of the recommendations (or the follow-up issues that they generate) to be outside of the surgeon's perceived area of expertise.

As an example, consider a case in which a hospitalist is asked to assist in the management of a 72 year old woman who is postop day 1 after surgical repair of a hip fracture. The patient has type 2 diabetes, and her blood glucose has been in the high 200's despite her usual home insulin regimen. The hospitalist writes several recommendations in the chart, including a change in her insulin program to include a newer, long-acting agent. The orthopedist does not return to the chart until 6 hours later. She sees the recommendations, and begins to copy them onto the order sheet, until she realizes that she is not familiar with the type of insulin that the hospitalist recommended. So, she substitutes a form of insulin with which she is more familiar, hoping it is similar. Later, the orthopedist is called because the patient is hypoglycemic, and the hospitalist is called back for assistance. The hospitalist, in this case, is leaving recommendations that he could easily implement himself to a subspecialty surgeon who lacks the resources to correctly implement them. It is becoming clear that, as surgeons get busier, they do not want hospitalists to *advise* them on how to manage their patients. Rather, they want to form a relationship with someone they trust, who can actually *manage* medical issues for them. One of the strengths of the hospitalist is his ability to comfortably manage a wide range of medical problems in a hospitalized patient. It is clear that the traditional consultation model fails to fully realize this benefit.

Traditional consult models also fail to provide the consultant with a sense of ownership of the patient. If hospitalists embrace patients as their own in a co-management relationship, it is our perception that they are more likely to attend to interventions that increase *quality of care* for these patients. For example, it is easy for the surgeon to ignore the recommendation for perioperative beta-blockers, as she may not understand the implication of this treatment, or she may simply not be comfortable initiating this medication. The hospitalist might feel strongly that the medication would be beneficial, and would be able to easily initiate and monitor this therapy. Moreover, the hospitalist is more likely to create a system to assure that all appropriate patients are treated with beta-blockers to prevent adverse cardiovascular events. The transition from inpatient to outpatient care for a postoperative patient provides another example of an area likely to benefit from hospitalist input. The traditional

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consultant may not communicate directly with the patient's primary doctor about follow-up issues, and the surgeon's discharge summary might lack important details about important medical issues that arose in the hospital. Involvement of a hospitalist might lead to better systems of communication in this critical time period. In the era of increasingly complex surgical patients, busier surgeons, and accountability for quality and safety, the traditional consultative models fall short.

The University of Michigan Hospitalist/Orthopedic Co-management Service

Hospitalist co-management programs are popping up all across the country. Based on our own institution's experience, we feel that many of the models being used are under-developed. That is, many of them have resulted as a mechanism for surgeons and internists to avoid "stepping on one another's feet", as opposed to the development of a new care delivery system that is focused on improving efficiency, quality of care, and communication amongst caregivers.

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Table 1.
Difficulties experienced in early implementation of a co-management service, and the lessons learned.

Early difficulties	Key lessons learned
Efficiency: • The hospitalist's attention to medical issues actually created more work for the ortho PA's who were already overworked. • The ortho PA's resented the repetition of rounding twice. • These inefficiencies were recognized by the ortho "workers" (PA's and residents), which created reluctance to participate in the co-management model.	**Efficiency:** • For this type of relationship to be successful, there must be recognizable benefits for all clinicians (not just patients), and efficiency is important to the surgical team. • In order for this type of relationship to offer efficiency to the surgeon, there will need to be a substantial time investment on the part of the hospitalist. • Both the surgical contact person and the hospitalist need to be able to invest more time than in the traditional consult model in order to improve on it.
Organizational: • It was difficult to change the surgeon's deeply entrenched preoperative referral patterns to allow appropriate patients to be seen preoperatively. • The ortho PA's found it difficult to trust that the hospitalist would do some of the work that they had traditionally done.	**Organizational:** • "Hardwiring" a system that requires changes in referral patterns and changes in routine is a difficult process that requires hard work, constant attention, and active management. • Trust is key to any relationship, and often takes time to establish.
Investment: • Even though the hospitalist provided a high level of service, implementation of the co-management relationship required significant changes for the surgeons. • Problems with efficiency, even if seemingly minor, limited the level of investment from those that suffered from the inefficiencies.	**Investment:** • Co-management relationships are most likely to be fruitful when they are formed with surgeons who are highly invested in them, and who have an understanding of what the implementation will require.
Communication: • Early efforts to reduce the time requirements for rounding for the ortho PA's improved their perceived efficiency but created more gaps in communication and resulted in some miscommunications.	**Communication:** • Improved communication is one of the critical difference between the co-management model and the traditional model of care (and it is especially important in this model where the hospitalist is "doing" more and "recommending" less). • Efforts at efficiency that reduce the time that members of the two teams spend together will mandate better formalized communication strategies, and these are likely to be more time-intensive for the hospitalist.

Box 1. Inclusion criteria for the University of Michigan Hospitalist/Orthopedic Co-management Service

Any one of the following conditions:

- Age >75
- Diabetes, treated with oral medications or insulin (not diet controlled)
- Congestive heart failure
- Coronary artery disease
- Cerebrovascular disease (e.g. h/o TIA or stroke)
- Chronic renal insufficiency (e.g. SCr > or = 2) or dialysis patients
- Chronic obstructive pulmonary disease
- Immunosuppressed patients (on chronic steroids or other immunosuppressive meds, or those with AIDS or other immunocompromising illness)
- Morbid obesity with BMI > 35 or known obstructive sleep apnea
- Poorly controlled hypertension (BP not currently well controlled, or BP requiring > 2 meds for control)
- Anticoagulant treatment
- Dementia

The University of Michigan Hospitalist/Orthopedic Co-management Service was designed to more consistently incorporate the services of a hospitalist into the care of patients with medical comorbidities undergoing elective joint reconstruction surgery. The program was developed as a collaboration between the academic hospital medicine group and two orthopedic surgery attendings who expressed interest in such an effort.

The service is unique in that the co-management process (at least for elective cases) begins with the orthopedist recognizing that a patient has an important medical comorbidity at the time when surgery is first offered. Box 1 shows our suggested inclusion criteria. At that time, the patient is given an appointment in the Internal Medicine Preoperative Clinic where a complete evaluation is performed by the hospitalist, with emphasis on perioperative optimization of all medical issues. Patients subsequently admitted for surgery are assigned to a separate co-management service. Patients on the co-management service are uniquely identified in the hospital's service census system allowing for easy identification, tracking, and evaluation.

The co-management service is different from the traditional consult model in that the hospitalist attending actually rounds every weekday on all of the co-management patients. Rounds are performed with one of the Orthopedic PA's after that PA has rounded with the Orthopedic team. This provides a high level of communication between the internist and the orthopedists, as the PA understands the orthopedic concerns, and also rounds with the medicine attending to remain aware of medical issues. This PA shuttles back and forth from the floors, outpatient surgical clinics, and the operating room. She communicates with the surgical attendings and assists with follow-up of issues identified during morning rounds. When medical issues arise, the hospitalist is paged, writes orders, orders tests, and follows-up on those results, sometimes using the Orthopedic PA to assist with these tasks. The hospitalist communicates closely with the PA, who is able to pass on information to other members of the orthopedic team. Some of the features of our co-management arrangement with the Orthopedists are outlined in Box 2.

Table 1 summarizes some of the early difficulties we experienced while piloting this service, and some of the lessons we have learned. In a system where the hospitalist will be more involved in the minute-to-minute care of postoperative patients, good communication and clear delineation of responsibility are the most important lessons. We now routinely communicate with the orthopedic PA in the afternoon, providing them with important updates. This communication assures that all members of the team understand each patient's active issues. Working through the issues in Table 1 has resulted in a robust, collaborative model.

The goals of surgical co-management:

In 2004, Huddleston and colleagues published the results of a large study of a Hospitalist/Orthopedic Co-management Service (1). In short, this study showed that patients who were co-managed by a hospitalist experienced fewer minor inpatient complications, but did *not* experience fewer major inpatient complications. The co-managed patients did not experience a significantly shortened length-of-stay. Of interest, though, orthopedists and nurses favored the co-management model over the traditional consult model.

These results are exactly what one might have expected, and they likely underestimate the importance of the co-management relationship. It would have been surprising if co-managed patients would have had a significantly lower occurrence of major inpatient complications or a shortened length of stay. In a highly-respected, high-volume surgical institution, major inpatient complications would be expected to be rare and not necessarily easily prevented. Length of stay would be expected to be short, driven by efficient protocols and practices. Therefore, although we expect that the hospitalist's involvement will result in the provision of excellent clinical care, we think the benefits that a hospitalist brings to perioperative management will be broad and potentially challenging to measure.

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Quality

Hospitalists have a short but robust tradition of being quality-improvement champions. There are several quality practices that are proven to result in improved outcomes in surgical patients. Appropriate use of prophylaxis for deep vein thrombosis, prevention of cardiovascular events with beta-blockers, and perioperative control of diabetes are just a few examples. Often, these are outside of the focus or expertise of the surgeon, and institutions have sometimes struggled to achieve these goals for their patients. The hospitalist is unique in having the interest and skills to manage these issues and build robust systems to ensure compliance with well established practices. In addition, the hospitalist's presence on the surgical team allows for constant evolution of systems and practices as new evidence arises. We suspect that future research on surgical co-management will have more striking results if the investigators define some specific quality indicators that they hope to improve, and focus their interventions appropriately.

Surgical productivity

In addition to improving quality, co-management programs should strive to improve the productivity of the surgeons. From a hospital administrator's perspective, encouraging efficient practice to appropriately reduce patients' length-of-stay will always be a financial priority. If a co-management program can increase a hospital's capacity to serve patients (by improving throughput), and at the same time allow surgeons to perform a larger number of operations (by assisting with management of complex patients on the wards), it would merit financial support. The importance of surgical productivity should not be underestimated. If surgeons operate more, that translates into financial gain for the surgeons and the hospital. In addition, it is expected that the hospitalist's documentation of medical comorbidities and complications will allow hospitals to capture higher billing than that based on historically less-complete surgical documentation alone.

Research and Education

There are numerous perioperative questions that need to be addressed in clinical trials. The systems and relationships of a surgical co-management model that are developed to enhance efficiency and quality of care might also facilitate clinical research in this area. As hospitalists expand their perioperative involvement to multiple subspecialty surgical services, they will be defining a diverse, high-risk perioperative patient population that might be appropriate for such research.

Also, educational efforts (i.e. co-teaching) could result in better education of internal medicine and subspecialty surgery residents. In some internal medicine training programs, the experience provided in perioperative medicine is limited, despite the fact that it will be a substantial part of practice for hospitalists and many general internists. In addition, many believe that the ability to manage complex hospitalized patients is under-emphasized in the training of subspecialty surgeons. The co-management model may offer opportunities for subspecialty surgeons and hospitalists to collaborate to improve resident training.

Conclusion

In this age of increasingly complex and elderly patients and subspecialization of surgeons, there is a growing need for hospitalist/surgeon co-management systems of care. The barriers to the implementation of co-management systems include the inefficiencies inherent in coordinating multiple clinicians, the difficulty of changing existing practice patterns, and the need for better communication within these systems. These barriers can be overcome by creating structured interactions amongst the clinicians involved to assure clarity of individual roles and encourage a high level of communication.

The co-management model of care is an opportunity for the hospitalist to lead the surgical team to higher standards of quality, safety, and efficiency. Future research will need to examine the impact of co-management on targeted quality indicators, longer-term outcomes, surgical productivity, and financial issues, in addition to short-term patient outcomes. We believe that this research will show that co-management benefits surgeons, hospitals, and most importantly, patients.

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Box 2. Features of the University of Michigan Hospitalist/Orthopedic Co-management Service

- The Orthopedic Service remains the primary service from a billing/medicolegal perspective
- The Orthopedic Service is expected to write admission/postop orders
- The Orthopedic Service is expected to accept "1st calls" from the nurses about urgent issues, although the internist is available to assist whenever needed
- The Hospitalist Service is expected to round on all co-managed patients every weekday, and on selected patients as needed on weekends
- The Hospitalist Service is expected to actively manage medical problems under its purview
- A hospitalist is available in-house 24/7/365 to assist with complex issues after hours
- The Hospitalist Service will assist with discharge arrangements and communication about medical issues to follow-up physicians

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Partnering for Optimal Patient Care: Medical and Surgical Comanagement

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The topic of comanaging surgical patients engages hospitalists in an interesting debate. What role does a hospitalist have in the care of surgical patients? Should they leave recommendations? Should they leave recommendations and get the initial evaluation underway for the patient while the surgeon is in the operating room? Should hospitalists do the consult, order the tests and follow-up on the results? In this latter case, if the hospitalist is doing all of that anyway, should they simply take the surgical patients primarily onto their service?

Unfortunately, currently available literature does not settle the debate. As a result, anecdotes tend to rule the day. Traditionally, according to Geno Merli, MD:

> "The principal providers of medical consultation for the surgical patient have been internists, family practitioners, cardiologists, and pulmonary physicians. The model for the medical consultant's roles and responsibilities in the care of this patient population has been to provide the surgeon with an assessment of medical problems and concise recommendations on the management of patients in the perioperative period. (1) Sometimes, the surgeon retains full responsibility for carrying out the recommendations. Alternatively, the consultant serves as a comanager for all medical problems. A point of demarcation between these 2 models of consultation is the hospital setting. In community hospitals, the comanager model is the predominant practice, whereas in academic medical centers, the pure consultant approach is used." (2)

There is only one published study specifically discussing a trial designed to explore the impact of a surgical-hospitalist partnership on care using a pure comanagement model. (3) Prior to this publication, the literature describing the concept of comanagement had nothing to do with blending the practices of the internal medicine and surgical worlds. Rather, these publications describe the results and ethics of partnerships between ophthalmologists and optometrists. A MEDLINE search of [(surgery or orthopedic surgery) and (geriatrics or internal medicine)], limited to the English language and published in AIM journals, resulted in 105 entries. Only two articles specifically discuss partnerships between medical physicians and surgeons. (3,4) The vast majority of non-ophthalmology articles describing partnerships in care for surgical patients documented improved clinical outcomes with a geriatrician and orthopedic surgeon interface. (5-12) These models were reported specifically in urgent hip fracture surgical populations.

So what is the bottom-line of this small number of studies? Well, partnerships are either neutral or yield better outcomes, never worse. None of the settings were the same, nor were any of the models identical. However, patients benefited from the synergistic efforts and collective knowledge of medical and surgical specialties working together. But is any of this generalizeable to what we do as hospitalists? Are we working for the surgeons, doing the surgeons' work? Or are we doing the patient's work, attending to the patient's needs? Are patients under a comanagement model of care receiving the best of both worlds? Are they getting the best technical and postoperative care from specially trained surgeons and the best medical and coordination of care from providers who specialize in the care of hospitalized patients? The literature does not answer these questions for us. The realization that there is no real answer in the published literature does not help our growing practices. How are we to navigate these interprofessional relationships while waiting for good studies to be done?

Crossing the Quality Chasm: Any group of hospitalists contemplating a model of comanagement with surgeons, or those frustrated by current interprofessional interactions with surgeons should "test" their model against the aims and design principles for the 21st Century of Health Care as set forth by the Institute of Medicine in the Crossing the Quality Chasm Report (20). The report identifies key dimensions in which today's health care system functions at far lower levels than

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Text Box: Definitions of the Six Arms set forth by the IOM report *Crossing the Quality Chasm* (20)

- **Safe**—avoiding injuries to patients from the care that is intended to help them
- **Effective**—providing services based on scientific knowledge to all who could benefit and refraining from providing services to those not likely to benefit (avoiding underuse and overuse, respectively).
- **Patient-centered**—providing care that is respectful of and responsive to individual patient preferences, needs, and values and ensuring that patient values guide all clinical decisions.
- **Timely**—reducing waits and sometimes harmful delays for both those who receive and those who give care.
- **Efficient**—avoiding waste, including waste of equipment, supplies, ideas, and energy.
- **Equitable**—providing care that does not vary in quality because of personal characteristics such as gender, ethnicity, geographic location, and socioeconomic status.

(From "Crossing the quality chasm: A new health care system for the 21st century". National Academy Press, 2001.)

it could and should, and proposes 6 aims for improvement. Health care should be *safe, effective, patient-centered, timely, efficient, and equitable.* (See Text Box [pg. 54] for definitions of the 6 Aims of the Quality Chasm Report.) How might comanagement improve the opportunity for the healthcare system to achieve these Quality Chasm aims?

1. **Safe:** The more one does of the same thing, or cares for patients with the same diagnosis, the better the outcomes for the patient. The main safety outcomes that have been measured in this type of volume-dependent literature include mortality and readmission. These findings can be found in both the surgical and hospital medicine literature. (13) In addition, there is a suggestion that postoperative complications can be lower when patients are comanaged by their orthopedic surgeon and hospitalist. (3) Although not specifically studied to date, this volume-related experience in perioperative care among hospitalists working within a comanagement model may also help decrease postoperative medical complications.
2. **Effective**: Ethically, health care providers of all types should work within their scope of practice. We should do what we are trained to do. In the comanaged perioperative setting, patients have the opportunity to benefit from the best of both worlds. If surgeons do what they are trained to do, and hospitalists do the same, the patient should truly benefit. It is impossible to keep up with all of the burgeoning medical literature. Just as a surgeon would not expect the hospitalist to remember the latest regarding mesh, cement or prosthetic implants, surgeons cannot be expected to keep up with the medical literature surrounding cardiac disease
3. **Patient-centered**: Genuine patient-centeredness requires attentiveness, availability and thorough communication. Hospitalists are in the best position to provide patient-centered care regardless of presence or absence of a surgeon.
4. **Timely**: Hospitalists pride themselves on being very available to address nursing staff and patient concerns. In the setting of the postoperative period when the surgeon may be in the operating room and hence not readily available to address acute patient concerns, a hospitalist can respond to the acute medical issues as they arise to avoid harmful delays in care. Expecting the patient to wait for the surgeon or expecting the surgeon to scrub out of another case to deal with an issue on the floor would not fit the definition of timely care. Not only can hospitalists reduce the waits that medical patients experience, but can equally do so for the medical needs of a surgical patient.
5. **Efficient**: Previous research has demonstrated efficiency of hospitalists measured by reduction in length of stay for medical patients. (13-19) While the one trial directly evaluating the impact of a comanagement model in the care of orthopedic patients had rather neutral findings in this regard, other ongoing studies are demonstrating the same efficiency gains in sicker surgical patient populations.
6. **Equitable**: Regardless of ethnicity, gender, age or insurance status, patients must receive care known to be best practice. Hospitalists have a track-record as providing care equitably from the inception of the growing specialty. Many practices started by readily providing care for patients with out a physician or for the uninsured.

Table 1. **Standard Care and Comanagement Care**

Aspects of Patient Care	All Care	Standard Care	Comanagement Care
Care team			
Composition of orthopedic surgery team	Orthopedic surgery faculty and resident		
Composition of medical team		Consultative medical specialty teams (faculty and resident)	Hospitalist faculty (no residents); consultative medical specialty teams (faculty and resident)
Nursing personnel	Predominantly registered nurses on 1 of 2 specific orthopedic surgical floors		
Direct patient care			
Preanesthetic medical examination		General internist, medical subspecialist, or anesthesiologist	Hospitalist
Daily patient evaluation during hospitalization		Orthopedic surgical team	Hospitalist–Orthopedic surgical team
Perioperative medical care		Orthopedic surgical team	Hospitalist
Subspecialty medical consultation		Discretion of orthopedic surgical team	Discretion of hospitalist
Responsible team to nurses' postoperative patient care concerns		Orthopedic surgical team	Hospitalist (medical issues); orthopedic surgical team (surgical issues)
Discharge responsibilities		Surgeons contact referring physician	Hospitalist contacts primary medical physician; orthopedic surgical team contacts surgical/referring physician
		Surgeons complete discharge summary	Both surgeons and hospitalists complete respective portions of discharge summary
Laboratory tests and medications			
Surveillance for and prophylaxis against deep venous thrombosis	Orthopedic surgical team		
Initial postoperative laboratory and medical orders	Orthopedic surgeons with standard postoperative order set		

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Partnering for Optimal Patient Care: Medical and Surgical Comanagement (continued)

Practical Implementation of a Comanagement Model

Table 1 outlines the specific roles for members of the comanagement team used in the Hospitalist-Orthopedic Team model at Mayo Clinic, Rochester, MN.

In addition to creating very clear role expectations, there are a few other issues that have been encountered. The following is a short list of those practice management pearls:

- A "practice agreement" needs to be well articulated (and preferably written) prior to implementing the partnership. This is essential to minimize inevitable role confusion, especially early in model implementation. This agreement should include expectations regarding who is going to order postoperative labs, manage postoperative pain, deal with the DVT prophylaxis, contact the referring medical physician, manage fluid status, etc. Once implemented and fine-tuned, all new members of either practice need to be carefully oriented to ensure adherence to the model developed.
- Pick up the phone any time there is role confusion. Call the operating room if the surgeon is scrubbed in and have someone serve as conduit for the communication. Better to have a unified plan around anticoagulation or transfusion decisions, rather than a particular issue being ignored because people think the other is addressing it. Potentially even more hazardous would be a patient having the same issue addressed twice by different people (e.g., potassium being dosed twice, two transfusion orders, etc).
- Insist that the surgeon be the physician of record for any patient having surgery. This accomplishes several things. One, it keeps everyone engaged when the patient is on the "list". Secondly, in academic settings, it is a surgery Residency Review Committee violation to have too many surgical patients on the medical services. Third, an initial consult note is worth more than an H & P. Discuss billing issues with a reimbursement specialist to ensure your services are billable and your documentation is in compliance.
- In order to prevent unnecessary delays in patient care, work closely with surgical nursing staff to clarify who is doing what for which patient and to ensure that they are calling the hospitalist for patient care needs. Adding an additional physician who is actively managing the surgical patient may be a new experience for the nurses (specifically in academic settings).

Conclusion: "Americans should be able to count on receiving care that meets their needs and is based on the best scientific knowledge".(20) Patients are getting sicker, and the number of old and even 'oldest old' undergoing surgery continues to escalate. If patients are to receive the best scientific knowledge, then they will have to be treated by experts in the appropriate areas. They need surgeons to be expert at the surgery and perioperative planning for recovery. Patients also need providers who are experts at delivering and coordinating reliable inpatient medical care, and they need this with the type of availability that only hospitalists can provide. Health care delivery is a team sport now. Comanagement is one version that has promise to improve the care Americans obtain in the hospital.

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Preoperative Care: An Opportunity to Expand and Diversify the Hospitalist's Portfolio

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Each year, over 36 million procedures are performed in the United States (1). Approximately one third are performed in patients over the age of 65 years (1). This subset of the population is also the fastest growing, with estimates that by 2030, this population will double from 35 million to 70 million people and will account for 20% of the American population (2). A recent prospective cohort study from a major academic center showed that elderly patients have a higher rate of major perioperative complications and mortality after noncardiac surgery than their younger counterparts (3). Therefore, it is important for these (and younger patients with major medical illnesses) to undergo a thorough preoperative evaluation geared towards risk assessment and implementation of risk reduction therapies that will decrease the risk of perioperative morbidity and mortality.

In our current health care environment, many patients are sent home the day of their procedure. In addition, for most major elective surgeries, patients are admitted the morning of the procedures. This allows little or no time for the anesthesiologists to perform a thorough risk assessment and implement many risk reduction strategies, so they must rely on one of the following models or providers to perform the preoperative evaluation:

1. **A Traditional Preoperative Assessment Model:** The surgeon, surgical resident, nurse practitioner, or physician assistant working on the surgical team performs this assessment. This approach often may rely upon multiple consultants and employ excessive diagnostic testing; sometimes, patients may be admitted to the hospital 1 or more days before surgery for preoperative evaluation. In this model, the consultants may choose to follow these patients postoperatively. However, in the era of managed care and cost containment, admission to the hospital to conduct preoperative testing has become increasingly difficult to justify (4).

2. **Preanesthesia Testing Clinic Model:** A nurse practitioner, physician assistant, or nurse anesthetist evaluates preoperative patients under the supervision of an anesthesiologist. This service is provided at no additional cost to the patient, as the preoperative anesthesiology fee is bundled into the diagnosis-related group. Clinics utilizing this model may decrease costs by limiting excessive testing and decreasing surgical cancellation rates, but this approach is associated with substantial start-up costs and annual administrative costs (4–6). These clinics are generally not geared to handle the complex medical patient with chronic conditions that require optimization before surgery and close follow-up after surgery.

3. **Primary Care Physician Model:** The patient's family physician, internist, or cardiologist performs the preoperative evaluation with a formal request for consultation from the surgeon or anesthesiologist. Although this is probably the most commonly used model, practice patterns vary significantly in different parts of the country and among patients receiving care under different health care systems (7). Although this model allows for continuity of care, the average primary care physician may not be able to devote the necessary time to perform a comprehensive preoperative assessment of a complicated medical patient. Furthermore, many primary care physicians may find it difficult to follow their patients postoperatively in the hospital and to stay current with the nuances of perioperative medicine. Anesthesiologists and surgeons may have to contend with many different styles of preoperative management. They may be frustrated by wide variations in the preoperative

	Surgical Class				
	I	II	III	IV	V
HQ Status					
1	Express	Express	Express	Express	Express
2	Express	Express	Express	Express	Express
3	Express	IMPACT & PACE	IMPACT & PACE	Impact & PACE	IMPACT & PACE
4	Impact	IMPACT & PACE	IMPACT & PACE	IMPACT & PACE	IMPACT & PACE

The preoperative decision grid is to be used as a guide to help direct the patient through the preoperative process. Patients can be "expressed" through the preoperative process without seeing an internist preoperatively and seeing an anesthesiologist only on the day of surgery. However, any patient may be evaluated by IMPACT and/or PACE, regardless of their position on the decision grid, at the surgeon's discretion.

Figure 1. Preoperative decision grid.

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Perioperative Care (cont.)

advice that their patients receive with regards to cardiovascular medications, anticoagulants and antiplatelet agents, and diabetes medications. Some patients may have received inadequate cardiovascular risk stratification.

4. **Preoperative Evaluation Clinic Model:** Internists and/or anesthesiologists perform focused preoperative evaluation in a hospital-based preoperative clinic that is structured to perform this service. Several institutions across the country have such a clinic. The Cleveland Clinic Foundation's IMPACT (Internal Medicine Preoperative Assessment, Consultation and Treatment) Center has been operational since 1997. Members of the Section of Hospital Medicine staff this clinic and conduct preoperative evaluations. On an average day, staff perform over 50 consultations at the request of surgeons from at least 11 different subspecialties. In 2003, the IMPACT Center evaluated over 12,000 patients, generating over $2 million in revenue.

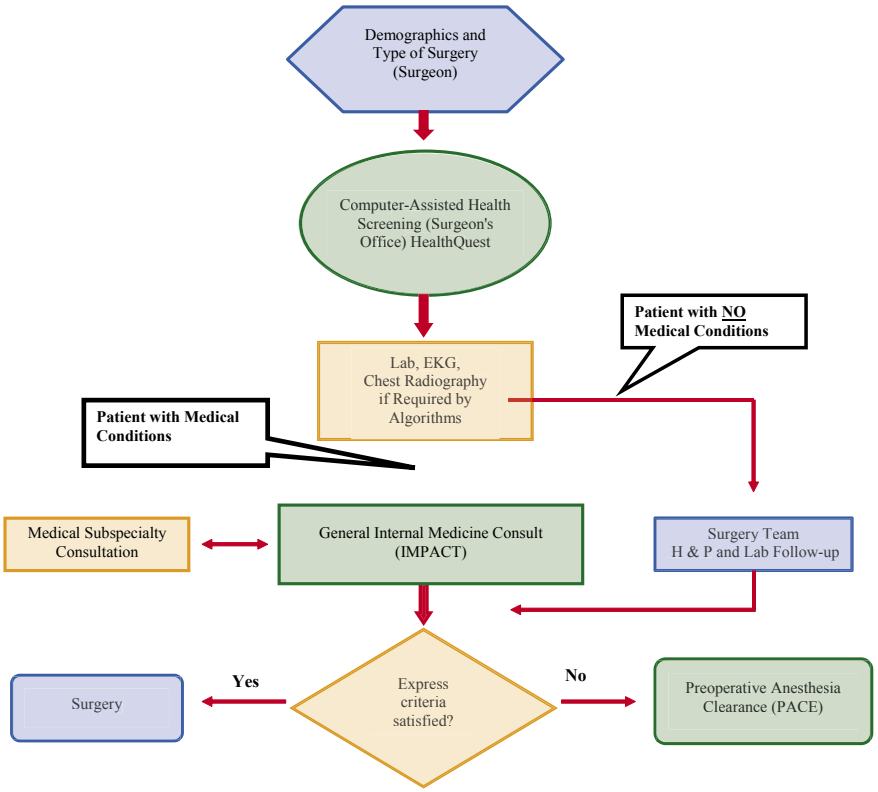

***Figure* 2. Patient flow in the preoperative evaluation model at the Cleveland Clinic.**

The IMPACT Center is part of a unique multidisciplinary preoperative evaluation model. Our model has decreased the surgery delay rate by 49% and allows the anesthesiologists in the PACE (Perioperative Anesthesia Consultation and Evaluation) Clinic to concentrate on anesthesia issues, such as choice of anesthetic, airway assessment, previous anesthetic events, patient directives, and postoperative pain control (8). In addition, this model led to cost savings by reducing routine lab testing. Specific indications and diagnoses are used when lab testing is necessary, and this is not bundled to the surgical diagnosis-related group. It is notable that the impetus for the IMPACT Center's inception arose from the anesthesiologists; they did not feel their own clinic could adequately handle the comprehensive risk assessment, implementation of risk reduction therapies, and optimization therapies necessary for optimal management of the complex medical patient.

The preoperative process begins when the surgeon decides that surgery is indicated. At the surgeon's office, every patient takes a computer-assisted health screening questionnaire online called the HealthQuest (HQ), developed by the anesthesiologists at the Cleveland Clinic Foundation. The HQ program generates a printed summary of the patient's history that serves as a quick reference sheet for the care providers in the IMPACT center and the PACE Clinic. Responses to the questions are also coded to create a HQ score corresponding to the American Society of Anesthesiology's scoring system, ranging from 1 (healthy) to 4 (multiple complex medical issues). The American Society of Anesthesiology's class 5 is not included, since these surgeries are emergency procedures. This score is incorporated into a decision grid (**Figure 2**), along with the surgical procedure classification (based on the Johns Hopkins Classification system [9], which considers potential intraoperative blood loss and invasiveness of the surgical procedure). This grid provides a quick guide for the surgeon and the surgical team as to whether the patient might benefit from referral to the IMPACT Center and/or the PACE clinic. Preoperative anesthesiology input is generally unnecessary for patients with low HQ scores; these patients undergo anesthesia evaluation on the day of surgery. However, any patient may be referred to the IMPACT Center and/or the PACE Clinic at the surgeon's discretion, regardless of the patient's position on the decision grid. Labs, electrocardiography, and chest radiography are ordered by the surgeon's office based on the institution's evidence-based algorithms and guidelines. An overview of our patient flow in this model is summarized in **Figure 3**.

During the preoperative evaluation, the goal is not only to "clear" patients for surgery but, more importantly, to prepare them for surgery. Each patient undergoes a thorough but focused history and physical aimed at medical risk assessment; perioperative medication management; implementation of prophylactic therapies, such as beta-blockers; optimization of existing chronic medical conditions; and further testing, if necessary. The consultation includes a note in the electronic medical record that is available to all practitioners involved in the patient's care. Finally, all recommendations are discussed in person with the patient.

Hospitalists in our section rotate on the Internal Medicine Consult Service providing postoperative follow-

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Perioperative Care (cont.)

up to high-risk patients and continuity of medical care. We are also available to see some of the lower-risk patients who develop unforeseen medical complications postoperatively. Some of the patients may be referred to our skilled nursing facility, also staffed by our hospitalists, for rehabilitation, wound care, and/or intravenous antibiotic therapy.

The effects of hospitalists on the medical care of surgical patients are only now starting to be studied. A recent study from the Mayo Clinic showed that medical comanagement by the hospitalist-orthopedic team (HOT) decreased minor postoperative complications without any statistically significant difference in length of stay or cost. The nurses and surgeons strongly preferred the comanagement model (10). In unpublished data from our institution, we were able to show that amongst 510 patients undergoing a preoperative evaluation for major noncardiac surgery, the rate of postoperative pulmonary complications was 2.7% compared with a rate of 6% reported in the literature.

Hospitalists are potentially able to staff multiple areas of the hospital and have expertise in the management of chronic medical problems in acutely ill patients, preoperative risk assessment, and postoperative medical care. Based on our experience, we believe that hospitalists are ideally positioned to provide perioperative medical care to the surgical patient, freeing the surgeons and anesthesiologists to focus on their areas of expertise.

The IMPACT Center also provides a fertile environment for academic projects in perioperative medicine. On the education front, we have developed a perioperative curriculum for residents in internal medicine, dentistry, podiatry, and obstetrics and gynecology who rotate through the IMPACT Center. We are also actively involved in research and quality improvement projects in various areas of perioperative medicine.

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The Comprehensive Role of the Hospitalist as Medical Consultant: A Case Discussion (continued from page 49)

- Communication with primary care physician, other consultants
- Early identification and treatment of delirium
- Elimination of tethers
- Patient and family communication

Discharge planning

- Referral to disease case management when indicated
- Routine influenza, pneumococcal immunization
- Reconciliation of medications at the time of discharge
- Work with care coordination
- Communication with primary care physician key information
- Seamless communication with receiving ECF physician

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The Preoperative Clinic: A Perspective from a Community Teaching Hospital

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Although hospital medicine programs evolved from focusing on the care provided within hospitals, early on a need arose for coordinated care for patients admitted to hospitals electively. Elective surgical patients in particular benefited from prehospital assessments before admission, with the focus on the major issues for which this population was at risk. Moreover, they often had complex issues that required careful perioperative planning, such as management of anticoagulation in patients with mechanical heart valves.

In addition to the opportunity to improve the quality and efficiency of care for surgical patients, preoperative clinics are an important source of new referrals and ancillary services for hospital medicine programs and health care organizations. This is particularly important if one realizes that about 65% of hospital medicine programs are underwritten by other organizations, especially hospitals (1).

Preoperative clinics, such as the IMPACT and PACE clinics at the Cleveland Clinic, have evolved in academic centers to meet these needs (2). This article summarizes our hospital medicine program's experience with a preoperative evaluation clinic attached to a community teaching hospital.

Structure of the Clinic

Our hospital medicine program is part of Medical Consultants (MCs), a large internal medicine multispecialty organization, and the preoperative clinic is housed in the specialty practice's office. MCs is physically attached to the Ball Memorial Hospital, a 350-bed, tertiary referral center. Ball Memorial is surrounded by counties having only critical access hospitals, and a large number of patients are routinely referred here for most major surgical procedures. Although most of our preoperative clinic patients are referred for orthopedic surgery, patients from virtually all surgical specialties, including general and vascular surgery, urology, neurosurgery, and ophthalmology, are routinely seen. The clinic started informally through hospitalists occasionally seeing preoperative consultations as a "favor" for some of the surgeons. It has since been formalized with a preoperative clinic structure in which we now see approximately 250 patients per year.

Although our hospital medicine service was often constrained by the availability of hospitalist coverage, it was decided to provide 1 hour per day for preoperative consultations. At the onset, our referrals were sparse, averaging two to three assessments per week. However, we currently provide services for an average of five to seven patients per week, with the ability to see up to three patients daily Monday through Friday.

The supporting resources provided by MCs include examination rooms as well as nursing, medical assistants, and phlebotomy staff. Referrals typically come via phone through our communication center. Referring physician's office staff are queried on patient demographics and expected surgical date, an appointment is assigned, and any pertinent medical information is faxed to our office. The referral information is then passed onto the nurse coordinator of the hospital medicine program, and a hospitalist is then assigned to the patient. Continuity of care from the clinic to the hospital is the focus of this part of the process, and we make every attempt to schedule a hospitalist who will also be available for the patient's care during the expected hospital stay.

A welcome packet is then mailed to the patient confirming the appointment date; the name of the physician performing the assessment; and an instruction sheet, including a reminder to bring all prescription bottles. Also included in the packet is a detailed brochure for the hospital medicine program, including photos of the physicians and a map to identify parking and office location.

On the day of the scheduled preoperative evaluation, the patient arrives and is greeted in a standard fashion. If an EKG or pulmonary function testing is required, the medical assistant is empowered to perform that specific test. The hospitalist is notified of the patient's arrival, and the group has agreed to a maximum 15-minute response time to start the consultation.

Hospitalists generally perform a complete evaluation and dictate their consultation in a preoperative clinic–defined template, using our standard approach to common clinical issues. Upon completion of the consultation, the patient is "cleared" if he or she is considered to be stable for surgery and no further testing or assessments are necessary, or recommendations are made for patients at increased risk. These patients may require additional testing or specialty consultation. In most circumstances, follow-up testing is all that is required, and most patients are subsequently cleared. Those who have abnormal testing results usually require specialty consultation. Such consultation is arranged on an urgent basis and is usually completed within a week. Upon reviewing the subspecialty consultation, the hospitalist then makes an assessment of risk and appropriate disposition. Most of these patients are cleared for surgery, with the appropriate perioperative planning determined. Hospitalists will call both the patients and referring physicians to inform them of this information; patients rarely need to return for follow-up visits before surgery.

Copies of the patients' consultation and other relevant information are routinely forwarded to the anesthesiology department's preoperative assessment area, the Surgical Admissions Unit. The patient is informed of his or her status during the initial visit, and a dictated copy of the consultation is faxed and/or mailed to both the referring and primary care physician's offices. All dictations are transcribed within 24 hours. A database and calendar are kept on patients seen in the preoperative clinic for tracking purposes.

Our preoperative clinic is distinct because it is part of a large medical subspecialty practice. Our group offers the following ancillary services:

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- EKG
- Treadmill
- 2-D echocardiogram
- Stress echocardiograms
- Dipyridamole/nuclear stress test
- Complete pulmonary function testing
- Cardiopulmonary exercise testing and oximetry studies
- Routine laboratory testing

Furthermore, if a patient requires an internal medicine specialty consultation, this is regarded as a high priority from the group, and is readily available.

On the day of surgery, the patient's preoperative dictation is forwarded to his or her hospital chart with the order to page the hospitalist upon the patient's arrival to the unit. We also maintain our own calendar of scheduled admissions.

Key Systems of Operation Required for Success

For the clinic to be successful, several operation issues had to be addressed. Each issue required careful deliberation, planning, and problem solving throughout the evolution of the preoperative clinic. The following points summarize our experience and recommendations from our preoperative clinic.

1. Hospitalist commitment to the preoperative clinic. Hospitalists must support the preoperative clinic by 1) being available to see patients on a timely basis, 2) offering complete follow-up assessments when information is available and then speaking with patients and referring physicians, and 3) prioritizing the care of these patients during hospitalization along with their other responsibilities.
2. Organization and tracking. Effective organization and tracking of patients in the preoperative process are crucial to ensure that patients receive their consultations in a timely manner and to keep referring physicians informed. It is also crucial to optimize the quality of the care provided and prevent unnecessary risk from "lost" information or follow-up. The key elements of the preoperative process that require tracking are:
   - Scheduling of patients and then matching them with hospitalists. A seamless and easy system for scheduling invites goodwill from referring physicians and patients alike. Although we attempt to schedule a hospitalist with a patient when the initial appointment is made, there may be occasions when doing it immediately beforehand may allow more flexibility.
   - Documentation. Once consultations are dictated, the dictations require an urgent turnaround time (preferably 24 hours or less). The other two important documentation priorities are hospitalist validation for consultation completeness and accuracy, and verification that they are received (faxed or mailed) by referring and primary care physicians.
   - Tracking patients throughout the process. After initial consultation, patients are either initially cleared or require further testing or consultation. Developing a tracking process is crucial to verify that cleared patients are on the hospitalist schedule, all follow-up testing and consultations are scheduled, appropriate follow-up is assessed by each patients' hospitalists, disposition has been completed with preoperative planning, and patients and referring and primary care physicians have been informed. Substandard tracking can be both inconvenient to patient and physicians and result in increased risk due to surgical delay.
3. Communication. Effective communication must occur between the preoperative clinic, all involved physicians, the hospital, and the patients.
   - Referring physicians need to know when preoperative clinic appointments are scheduled and require copies of all consultations in a timely manner (as discussed above). When clearance in not immediate, they also need to know what is required, a time frame for completion, and follow-up and disposition plans when testing or specialty consultation is complete.
   - Specialty consultants should be told why they are being asked to assess a preoperative clinic patient. Timely consultation and any further testing or follow-up are expected. Information should be returned to the preoperative clinic, again in a timely manner.
   - A mechanism should be in place to ensure that preoperative consultations and perioperative management plans accompany a patient to the hospital on the day of admission. This information should also be provided to the anesthesiologists/anesthesiology department before surgery.
   - Primary care physicians should be informed of all the preoperative clinic's activities. This is both a necessary courtesy and contributes to optimal long-term care by providing important information to these physicians.
   - Patients are often unaware why they are being asked to be seen in a preoperative clinic. Educating them is both a courtesy and a way to facilitate their assistance when further testing or follow-up is needed. This can be accomplished by mailing an information packet ahead of time (as we do) or by providing the information at the time of evaluation.
4. Continuity of care. Under ideal circumstances, the hospitalist performing the preoperative consultation is the same as the one providing the hospital care. If scheduling makes this impossible, a covering hospitalist should have access to the consultation, other relevant information used in the preoperative assessment, and other "sign-out" information.
5. Follow-up after hospital discharge. For inpatients with complex problems, a mechanism should be in place to inform primary care physicians about pertinent events that occurred during the hospital admission.

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The Preoperative Clinic: A Perspective from a Community Teaching Hospital (continued)

Clinical Protocols

Although a complete description of our clinic protocols is beyond the scope of this article, following is a summary of the key clinical issues that we routinely face in our environment:

- Cardiac risk assessment, stratification, and reduction
- Considerations for patients with valvular heart disease
- Antimicrobial prophylaxis for bacterial endocarditis
- Perioperative management of anticoagulation
- Assessment and management of hypertension
- Pulmonary evaluation and risk reduction
- Perioperative diabetes management

Billing Diagnoses and Coding

Consultations provided in the preoperative clinic are coded using outpatient consultation codes. For diagnoses, preoperative consultations use the V codes with appropriate diagnoses, symptoms, or other accurate descriptors. When patients are seen in the hospital setting after surgery, routine daily visit codes are used, again with appropriate diagnoses that are usually the same as those used for the original consultation. Again, it should be noted that preoperative evaluation often requires use of ancillary services for appropriate high-quality and complete evaluations.

Potential Political Pitfalls

Most physicians and patients have positive experiences with the preoperative clinic. This is particularly true of patients from outlying counties whose primary care doctors do not come to Ball Memorial Hospital. Some of our local primary care doctors, however, prefer to do their own preoperative evaluations. In addition, our internal medicine and family practice residencies also prefer to perform preoperative evaluations on their patients. Our hospital medicine nurse coordinator works with our surgical referring groups to try and identify these patients ahead of time and have them referred to their appropriate physicians instead of our clinic.

It is incumbent upon the primary care doctors who perform their own evaluations to provide the same level of preoperative urgency in scheduling, detail, and communication that the hospitalist service provides. There have been occasions where this has not happened, and surgeons' needs have not been met and patient care may have been at risk. Consequently, some surgeons only want to use the preoperative clinic, which can elicit displeasure among some of our primary care physicians and residency program directors. On occasion, this has created political angst directed toward the hospital medicine program, with potential effects on referral patterns for the surgical groups. In response to this problem, preoperative clinic consultation is also offered as a free-standing service, where hospitalists provide only the preoperative consultation and clearance. Primary care physicians, at their discretion, may then provide the inpatient care.

Conclusion

This article has summarized our preoperative clinic experience and what we have learned from it. A preoperative clinic is a valuable asset to the repertoire of services that a community hospital medicine program provides. It is our hope that other hospital medicine programs may benefit from these experiences.

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Perioperative Medicine: The Present and the Future

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It is clear that the at-risk patient undergoing noncardiac surgery faces a complex set of challenges. The pressures on this patient are now well-recognized, and particularly include excitotoxic, inflammatory, thermic and mechanical stresses. These stressors involve not only the heart, but also the lungs, kidney, and gastrointestinal tract, especially in older patients. There also exists a subset of patients who are likely to suffer cognitive dysfunction or focal neurologic irreversible injury. Buttressing the importance of this problem is the finding that more than 42 million patients in the United States alone undergo noncardiac surgery annually, with an estimated one-third having 2 or more risk factors for vascular disease, or manifest vascular disease itself. More than 10,000 baby-boomers per day are now turning 58 years old, which will increase the number of operations performed each year—an incidence that grows nearly geometrically by decade of life. This latter group will fully expect to have their medical needs attended to, specifically with respect to myocardial revascularization, correction of orthopedic injury, and attention to various forms of cancer. Thus, the burden on perioperative medicine is substantial and growing.

Perioperative medicine has only relatively recently begun to receive the attention it warrants, and still suffers from communication gaps between the multiple specialists caring for these patients. A major current challenge is to address these communication gaps. Clearly, variability in health care provision by different specialists has received attention, as highlighted by the Institute of Medicine Report on medical errors (1). The patient undergoing surgery usually has a general practitioner or internist caring for them chronically, and one or more specialists if other organ systems are involved. Prior to surgery, an assessment by the general internist, as well as the surgeon and anesthesiologist, generally occurs. The information communicated to the patient, and specifically the risk of surgery and either direct or collateral damage to other organs, is detailed by both the anesthesiologist and surgeon. The internist's involvement in this risk discussion varies widely. However, it is clear that such risk assessment is not uniform among the various specialties that have educated the patient regarding risk. For example, various indices for assessment of perioperative cardiac risk have been promulgated over the last 30 years, including the American Society of Anesthesiologists (ASA) simple Risk Index. Although these risk indices have been incorporated into perioperative care guidelines, adherence to them is variable. In fact, many practitioners have found the risk indices too cumbersome for effective use. Furthermore, anesthesiologists in general do not use any of these indices in their communication with patients, but rely on the ASA Index, which appears to work as effectively as other indices (2).

Another example of the communication challenges existing between specialties is the perceived need for non-routine, specialized testing prior to surgery. Cardiologists, anesthesiologists and internists have set up guidelines. However, these often yield conflicting recommendations with respect to the need for specialized testing.

The evolution of the hospitalist, and hospital medicine in general, may help to alleviate some of these difficult clinical and communication problems. Clearly, there are examples of collaborative relationships among multispecialties who co-manage patients in virtually seamless fashion. As a result, the academic hospital medicine community has embraced multispecialty management, and is formally addressing this area both from a research and an organizational prospective. In effect, the problem that must be addressed is the fragmentation that occurs when care is divided into preoperative, early postoperative, and late postoperative periods. Thus, hospitalists whose care is more continuous over these periods may best serve as the ultimate organizers of such care, by serving as the principal enablers of communication among these highly trained specialists, and by creating systems that optimize perioperative patient safety.

Challenges to Moving Forward

Several years ago, Dr. Claude Lenfant of the National Institutes of Health and Dr. Dennis Mangano of the Ischemia Research and Education Foundation organized an NIH-NHLBI Working Group to address perioperative medicine. Over an 18-month period, the group brought together 45 nationally recognized experts from a variety of fields including surgery, anesthesiology, general medicine, internal medicine and critical care; as well as government and health economics experts. The results were published after 18 months of deliberations in February 2004 (3). Topics of deliberation included risk profiling, preventable and treatable complications, and multispecialty guidelines. The Working Group's recommendations (Table 1) included the recognition that there are significant numbers of perioperative complications as previously discussed , and that complications are costly, at $450 billion annually (40% of the healthcare budget); mandating that perioperative medicine be included as a unique entity for funding at the national level. The Working Group also highlighted the potential for an impending surgical crisis as the population ages. By 2020 the Medicare population will increase by 25% (4). Therefore the total number of surgeries will increase as surgery becomes more common with age; surgical costs will be difficult to contain; and adverse events will increase as the surgical population will be sicker. Finally, in-hospital and discharge plans will become more challenging as the health care system attempts to absorb this population stressor.

The NHLBI Working Group recommended that risk profiling deserved further attention, especially for patients

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Perioperative Medicine: The Present and the Future (continued)

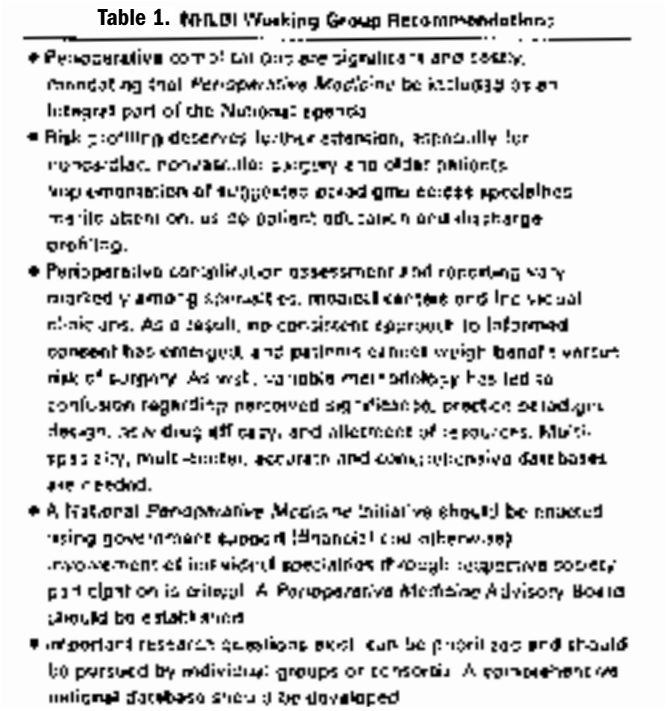

Table 1. NHLBI Working Group Recommendations

- Perioperative control of cardiac risk is significant and costly, mandating that Perioperative Medicine be included as an integral part of the National agenda.
- Risk profiling deserves further extension, especially for noncardiac, nonvascular surgery and older patients. Implementation of suggested paradigms across specialties may be attained via use of patient education and discharge profiling.
- Perioperative complication assessment and reporting vary markedly among specialties, medical centers and individual clinicians. As a result, no consistent approach to informed consent has emerged, and patients cannot weigh benefit versus risk of surgery. As well, variable methodology has led to confusion regarding perceived significance, practice paradigm design, drug efficacy, and allotment of resources. Multispecialty, multi-center, accurate and comprehensive databases are needed.
- A National Perioperative Medicine Initiative should be enacted using government support (financial and otherwise). Involvement of individual specialties through respective society participation is critical. A Perioperative Medicine Advisory Board should be established.
- Important research questions exist that can be prioritized and should be pursued by individual groups or consortia. A comprehensive national database should be developed.

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undergoing nonvascular, noncardiac surgery, as well as for the growing elderly population. In addition, it was felt that multispecialty paradigms such as co-management need more attention, as do patient education before and after surgery, and discharge risk profiling. The Working Group agreed that the assessment and reporting of perioperative complications varies markedly across different specialties, such that no consistent approach to informed consent is standard. A comprehensive multispecialty, multi-center, national database was felt to best address the variability of perioperative complications. The Working Group recommended a national Perioperative Medicine Initiative, and the establishment of a Perioperative Medicine Advisory Board using federal support; and stated that involvement of all affected specialty societies is critical to the success of such a board. Finally, the Working Group acknowledged that the current varied specialty guidelines for preoperative assessment do have much in common, but without widespread agreement upon and implementation of a general paradigm by the multiple specialties involved in perioperative medicine, a unified approach to preoperative assessment will not be realized.

Other Challenges

There are additional challenges facing perioperative medicine. Common postoperative adverse events involving the central nervous, renal, gastrointestinal, and hematologic systems are not currently addressed by the existing preoperative guidelines. More importantly, interventions to decrease perioperative risk are few, and those that exist are used in less than 50 percent of high-risk patients. For example, the one intervention that has amassed enough data to be included in preoperative guidelines, and is a measure of quality as defined by the Agency for Healthcare Research and Quality (5), is the use of perioperative beta-blockers for patients with known coronary artery disease or at least two risk factors for coronary artery disease. The actual use of perioperative beta-blockers (PBB) is approximately 40% (6-8), which is similar to the ambulatory use-level for coronary artery disease (40%-50%), but is suboptimal.

For example, in a study of open cholecystectomy patients (6), 43% had indications for PBB use and 84% of these were seen by a physician for a preoperative evaluation before surgery. Thirty percent of these patients were receiving beta-blockers before surgery. Of those eligible to start PBB de novo, 92% did not receive them. In addition, the lack of PBB usage has been associated with adverse outcomes. Another study showed that of the 81% of patients sustaining a myocardial infarction (MI) after noncardiac surgery who were ideal candidates for PBB, 41% were taking beta-blockers before surgery, and 52% received a beta-blocker at some time before their MI (7). Only 9% of these postoperative MI patients received a beta-blocker both before and after surgery. The use of PBB decreased in-hospital death by 81%. Another study (8) reported an incidence of PBB usage for noncardiac surgery to be 37%, and further extrapolated, using the results of a randomized controlled trial by Mangano *et al* (9), that the appropriate use of PBB would have prevented 62-89 deaths and saved $318,000 to $463,000 annually at that institution.

Surveys assessing attitudes toward the use of PBB have attempted to clarify why PBB are not more widely implemented. In a Canadian survey of anesthesiologists (10) 57% reported using PBB in patients with known coronary artery disease (CAD), but 93% agreed that PBB were beneficial in patients with known CAD. In another survey (11), anesthesiologists, surgeons, and cardiologists from the Department of Veterans Affairs reported a 71% usage of PBB in their practice, but 92% agreed PBB are effective in the short term to decrease adverse events. Stronger agreement for use of PBB was reported for patients with known CAD at 87%, compared to 72% for patients with risk factors for CAD. Surprisingly, only 30% were convinced PBB were efficacious in non-vascular, noncardiac surgery. The multidisciplinary model may provide hope for increasing the usage of PBB, as a collaborative study using anesthesiologists, internists, and family practitioners in Canada reported an incidence of PBB usage for noncardiac surgery of 69% after implementing a systems improvement (12).

Unique Challenges

Perioperative medicine also represents a unique physiologic state comprised of excitotoxic, inflammatory, and thrombogenic stressors that persist for days, and have manifestations that may present weeks to months after hospital discharge. The early observational studies suggested a continuing impact on adverse events and mortality lasting 6 months or more after surgery (13). Aside from the July 1992 focus issue of JAMA, there has been only limited effort to accumulate long-term outcome data on patients undergoing surgery. In this regard, such data might allow patient sub-

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group identification for design of longer-term therapies. Even without this data, the hospitalist can always seize an opportunity to address chronic conditions that may affect the quality and quantity of the patient's life, such as new diagnoses of diabetes, hypertension, or the metabolic syndrome, and counsel and start medications accordingly. Ideally, perioperative medicine physicians should have a wide spectrum of drugs at their disposal known to help patients during and after the unique perioperative physiologic state. Unfortunately, much work is left to do for that to become a reality.

Proposed Actions for Researchers in Perioperative Medicine

For the recommendations of the NHLBI Working Group to come to fruition, it will take a commitment of multispecialty researchers and societies to work collaboratively at a national level to assist the government in understanding how to prioritize this challenge among competing funding interests. At present, due to its youth, hospital medicine has not been engaged in the national perioperative medicine debate. As hospitalists are now at the forefront of the practice paradigm of multispecialty co-management, and as hospitalist investigators are maturing within the national research community, this will hopefully change in the near future. Hospitalists have become familiar and adept at multidisciplinary interaction and systems improvements in the course of their normal daily routine. Perhaps the hospitalist researcher can use this experience to advance the current status of national multidisciplinary perioperative medicine research. Whatever obstacles exist will hopefully be overcome as we all work together to make perioperative medicine the safest and most robust system of care possible for our patients undergoing surgery.

The Future of Perioperative Medicine

Among the systems of care that have evolved into well-run multispecialty co-management practices, there is little inclination to return to former ways. This has been due in large part to a favorable effect on quality of life for the surgeon, anesthesiologist, and primary care physician, much as was seen with the advent of hospital medicine. As hospitalist researchers collaborate with researchers from the fields of anesthesiology and surgery, it is hoped that comprehensive data will allow broad-based evolution of such multi-specialty care paradigms. Practically speaking, the pressure to evolve may emanate from patient-centered, system-centered, or data-centered concerns. Regardless, however, we continue to hope that the system will evolve, and even that multispecialty research collaboration will advance drug and technology development to meet the unique needs of surgical patients—thereby helping to alleviate the impending surgical crisis. Many aspects of the care of hospitalized high acuity older patients fall within the expertise of the hospitalist; therefore, hospital medicine will do well to continue to embrace perioperative medicine by making it a core competency and research priority.

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