Pre-Oping Wisely

A Guide to More Judicious Pre-Operative Testing

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This is to acknowledge that Michael Burton, MD, MSPH, has disclosed that he does not have any financial interests or other relationships with commercial concerns related directly or indirectly to this program. Dr. Burton will not be discussing off-label uses in his presentation.

About Dr. Burton

Dr. Burton is an Assistant Professor in the Division of General Internal Medicine at UT Southwestern. Since joining the faculty, he has been involved in quality improvement and patient safety initiatives as a Quality Officer, and then in improving the effective use of our electronic health record as a Deputy Chief Medical Informatics Officer. In addition to frequently attending on the wards, he currently serves as Director of the Preoperative clinic within General Internal Medicine, where he has a keen interest in performing comprehensive yet efficient evaluations of patients before urgent and elective surgery.

Purpose and Overview

This presentation reviews the use of preoperative testing prior to non-cardiac surgery. The purpose is to encourage the audience to make more informed decisions with respect to the need for testing, and to promote a more judicious approach that focuses on optimizing patient management rather than unselected screening.

Objectives

1. Stop ordering routine preoperative tests for cataract and other low risk surgeries
2. Stop ordering echocardiograms for asymptomatic patients
3. Stop ordering preoperative chest x-rays without a clinical suspicion from the history and physician exam, *especially* for ambulatory surgery

Introduction

Thirty million Americans undergo surgery every year; 234 million surgeries globally. Surgery can be associated with specific physiologic stresses including fluid shifts, blood loss, hemodynamic changes, platelet reactivity and a prothrombotic milieu that put the surgical patient at risk for medical complications and decompensation. Internists are often asked to perform preoperative evaluations of patients in order to accomplish several objectives (1):

1. Identify factors that increase the risk of surgery,
2. Quantify this risk in order to make decisions about the appropriateness and timing of surgery,
3. Provide recommendations for minimizing risk, and
4. Identify and manage coexisting medical conditions and their medication requirements.

Thus, the overall aim of the evaluation is to reduce both the morbidity and mortality associated with medical complications of a surgically treated patient. The cornerstone of such an evaluation rests with a history and physical examination focused most heavily on identifying and assessing factors that will influence this outcome. Preoperative testing has traditionally been used to supplement this evaluation in order to complete the history, in order to establish a baseline, or to screen for abnormal results in order to address them before surgery (2). There is wide agreement that the value of routine preoperative testing before many surgical procedures is probably low. This is especially true for ambulatory and low risk procedures, but even the evidence behind the benefits of routine preoperative testing for the broader category of non-cardiac surgery is fairly sparse (3). Abnormal results are very common, and yet routine tests correlate poorly with complications in most individuals and rarely change management. For that reason, there have been studies and efforts spanning decades to reduce the use of unnecessary preoperative testing.

Several recent endeavors include the Choosing Wisely campaign, spurred by the American Board of Internal Medicine's "Medical Professionalism in the New Millenium: A Physician Charter", along with the American College of Cardiology / American Heart Association (ACC/AHA) update for Perioperative Cardiovascular Evaluation of Noncardiac Surgery, and the American Society of Anesthesiologists' (ASA) practice advisory guidance for preanesthesia evaluation. Despite these efforts, practice patterns vary widely, and unnecessary preoperative testing is still common for a variety of reasons (4). These unnecessary tests can result in chasing unimportant or false positive findings, delays or cancellations of surgery, and patient discomfort and worry, not to mention the tremendous financial waste. As such, consistent with the ethical principles of beneficence and nonmaleficence, we must practice parsimonious medicine, which seeks to only provide the care necessary for the patient's good (5).

Background of routine preoperative testing.

Historically, the history and physical examination was the primary focus of preoperative assessment, with only selective laboratory testing. In the 1960s, advances in laboratory equipment made it easy to order larger panels of tests with little perceived cost added. Managed care organizations tried to enhance efficiency of the system by screening with laboratory tests to detect diseases earlier in their preclinical phase (6). Extensive and frequent laboratory testing became the norm.

Today, fifteen million preoperative evaluations occur in the United States every year, and 10% of the $30 billion dollars spent on laboratory testing are spent on preoperative evaluation (7). Many physicians undoubtedly feel that the testing is going to predict complications or otherwise positively impact the patient's care. This assumption warrants some further consideration, however, depending on the type of surgery being considered.

Despite the habits developing among clinicians in the 1960's and 70's, it has long been established that screening tests without a specific reason is not beneficial. In 1974, Korvin et al studied nearly twenty thousand screening tests of one thousand medical patients being admitted to the hospital (8). More than two thousand abnormal results were found and more than two hundred led to further evaluation and diagnoses, although many were transient or of questionable importance and none was unequivocally beneficial to the patient.

In the preoperative setting, in 1980 Delahunt and Turnbull demonstrated that among 860 patients undergoing minor surgery, 172 patients had abnormal results among the nearly 1800 radiology and laboratory tests (9). None of the unexpected results changed management. Similarly, in 1982, Eisenberg looked at prothrombin and partial thromboplastin times as preoperative screening tests in 750 patients, most of whom had no history of bleeding (10). Only 1 result was relevant, and there were 12 apparent false-positives. Several years later, Kaplan reached similar conclusions when he sampled 2000 patients undergoing elective surgery; only 0.22% of the abnormalities had any management implications and even those weren't acted upon and didn't have any adverse consequences (11). Likewise, Johnson et al found that routine testing of patients in ambulatory surgery with complete blood counts, urinalysis, and electrocardiogram (EKG) did not predict cancellations or complications (12).

Turnbull and Buck did a large study in 1987 of more than five thousand patients undergoing elective cholecystectomy (13). Only four patients had findings of any conceivable benefit beyond

what was identified in the history and physical; two had hypokalemia, one had anemia, and one had emphysema on the chest film.

Even among studies that found a high prevalence of abnormalities, these results rarely changed management. Ajimura performed a cross sectional study of nearly one thousand patients having elective non-cardiac surgery (14). Half of the EKGs had abnormalities, as did 42% of the 646 chest films. Laboratory abnormalities were also common (Table 1). Nonetheless, these abnormal results rarely changed management.

Table 1. Ajimura finds that routine labs are often abnormal.

Test	Mean	% outside reference value
Sodium	139.7 +/- 4 (meq/L)	11.3
Potassium	4.4 +/- 0.5 (meq/L)	13.6
BUN	39.9 +/- 18.5 (meq/dL)	25.3
Creatinine	1.1 +/- 0.5 (mg/dL)	13.2
White blood cells	8.2 +/- 2.9 (units x $10^3/mm^2$)	31.4
Hematocrit	40.0 +/- 5/2 (%)	41.0
Platelet count	260,249 +/- 90k (units/mm^2)	13.1
Prothrombin time	11.5 +/- 1.6 (sec)	5.1

Many studies have reached similar conclusions. Although high quality evidence was not available, organizations within the U.S. and abroad began making recommendations with respect to beginning to limit the use of routine comprehensive testing in many patients.

Routine versus per protocol testing.

In 2002, the American Society of Anesthesiologists Task Force on Preanesthesia Evaluation defined routine testing as a test ordered in the absence of a specific clinical indication or purpose (15). On the other hand, an indicated test was defined as a test that is ordered for a specific clinical indication or purpose. An example is ordering coagulation studies for the assessment of warfarin therapy. On the basis of expert opinion and the available evidence, the Task Force developed a series of guiding principles for selecting preoperative testing. This was updated in the 2012 Practice Advisory for Preanesthesia Evaluation (16)(Table 2).

Table 2. Practice Advisory for Preanesthesia Evaluation, 2012.

Test	Consideration
Serum chemistries	Endocrine disorders, risk of renal or liver dysfunction, use of certain medication, likely perioperative therapies
Hemoglobin	Type and invasiveness of the surgical procedure, liver disease, extremes of age, history of anemia, bleeding, other hematologic disorder
Coagulation studies	Bleeding disorder, renal or liver dysfunction, type and invasiveness of procedure
Urinalysis	Specific procedures, e.g. prosthesis implantation, urologic procedures; urinary tract symptoms present
Pregnancy testing	Literature is inadequate to inform patients or physicians. May be offered.
ECG	Cardiovascular disease, respiratory disease, type or invasiveness of surgery
Cardiac testing	Cardiovascular risk factors and type of surgery
Chest radiograph	Smoking, recent upper respiratory infection, chronic obstructive pulmonary disease, cardiac disease
Pulmonary testing	Type and invasiveness of the surgical procedure, interval from previous examination, symptomatic asthma or COPD, scoliosis with restricted function

Other entities like the National Institute for Health and Clinical Excellence (NICE) in the United Kingdom, have attempted to assemble complex algorithms incorporating the type of surgery and age of the patient (17). These algorithms were criticized for their complexity and lack of sufficient supporting data (18). Around the same time, the Ontario Preoperative Task Force (OPTF) published the Ontario Preoperative Testing Grid in 2003 and the Canadian Anesthesiologists' Society (CAS) issued guidelines in 2004 which each favored selective testing.

To explore the approach of selective or "per-protocol" testing based on the risks of the individual patient, the Agency for Healthcare Research and Quality (AHRQ) conducted a comparative effectiveness review of the benefits and harms of preoperative testing (19). The key questions asked were how routine or per-protocol testing strategies compared to no testing or alternative testing strategies with respect to outcomes, and what the harms were of routine or per protocol preoperative testing strategies compared to no testing or an alternative testing strategy. Other than cataract surgery this review found that there was insufficient evidence for the effect of routine preoperative testing, and insufficient evidence for the effect of testing routinely or per protocol. Within the cohort studies, no two studies showed that the same test(s) for the same population resulted in no change in management. Studies were noted to be highly heterogeneous in populations, surgeries, and tests.

Nonetheless, Charpak et al found that 30% of targeting testing was abnormal compared to 2% of routine tests, suggesting that selective testing could be a more useful approach rather than testing healthy patients (20). There have been multiple studies since that time that have looked at whether we follow these recommendations regarding selective preoperative testing. Bryson et al found that 31% of testing was not compliant with the CAS guidelines. In addition to selective testing based on the condition and inherent risks of the patient, there is now a significant focus on incorporating the risk of the surgery into the decision to test.

A few words about risk.

Risk can be defined and described for a variety of important variables, chief among them mortality, but also includes the possibility of cardiac, pulmonary, renal, and neurologic injury; chance of infectious complications; possibility of thromboembolic phenomena, and others.

In 1940, the American Society for Anesthesiology commissioned a panel of experts to develop a classification scheme for clinicians to assign a measure of operative risk. Ultimately, they determined that they were unable to do so, but could instead assign an estimate of the level of patient-specific risk. This is what we know as the ASA physical status (ASA PS). Although the ASA PS classification has been criticized for it's inter-rater reliability, it does correlate with the operative risk and patient outcome.

Table 3. ASA PS Classification

ASA PS	Definition
I	Healthy patient
II	Mild disease, e.g. well controlled diabetes or hypertension, smoker, obesity
III	Severe disease, e.g. compensated heart failure, COPD, history MI or CVA, poorly controlled diabetes
IV	Severe disease, constant threat to life, e.g. recent/ongoing ischemia, severe valvular disease, sepsis, emergent dialysis
V	Moribund patient, not expected to survive without surgery

Since then there have been many attempts at assigning risk at the level of the surgical procedure, at the level of the patient, or both. A national registry involving 3.7 million surgical procedures in the Netherlands provided a detailed look at postoperative mortality (21). Seventy percent of procedures were associated with a mortality of less than 1% (Table 4). Using the American College of Surgeons National Surgical Quality Improvement (ACS-NSQIP) database, Bilimoria

Table 4. Type of Surgery and Mortality

Type of Surgery	Unadjusted Mortality (%)	Adjusted Mortality (%)
Herniated disc	0.03	0.07
Breast	0.07	0.1
Knee	0.14	0.12
Prostate	0.37	0.2
Gynecology	0.13	0.22
Hernia	0.28	0.24
Spinal cord	0.3	0.31
Thyroid	0.23	0.34
Carotid	1.22	0.38
Bladder	0.9	0.49
Appendectomy	0.3	0.74
Hip	1.6	0.8
ENT	0.85	0.8
CABG	2.06	0.95
Pituitary	0.68	0.99
Renal transplant	1.05	1
Peripheral vascular	3.7	1.07
Cholecystectomy	1.54	1.38
Adrenal	1.04	1.45
Biliary duct	2.66	1.58
Renal	2	1.77
Valvular	4.36	2.17
Neurovascular	4.28	2.3
Pulmonary	3.36	2.67
Aortic	10.23	3.46
Intestinal	4.67	3.52
Esophagus	5.5	4.02
Pancreatic	6.64	5.93
Brain	7.26	5.93
Gastric	10.26	6.53
Liver	6.42	7.27
Heart transplant	9.91	8.46
Spleen	7.48	8.96
Congenital heart	11.68	12.3
Lung transplant	8.45	14.78
Liver transplant	9.66	18.51

et al looked at 21 preoperative factors from more than 1.4 million patients and more than 1500 CPT codes to predict mortality, overall morbidity, and 6 other specific risks and complications (22). It's available online at www.riskcalculator.facs.org.

Because the ACS-NSQIP surgical risk calculator cannot be done easily at the bedside, Glance et al sought to develop a simple risk score, the Surgical Mortality Probability Model (S-MPM) based on readily available information that was simple and accurate (23). Based on nearly 300,000 patients having noncardiac surgery in the same database, they found that ASA PS, emergency status, and surgery risk class could stratify patients into 3 risk categories of mortality with good discrimination and reasonable calibration (Tables 5 and 6).

The American College of Cardiology now defines low risk procedures as those with risk of major adverse cardiac events (MACE) of less than 1%, and those with risk of MACE of 1% or greater as *elevated risk* (24). There have been a variety of methods and tools to determine cardiac risk. Lee Goldman back in 1977 published a cardiac risk index including factors like active heart failure, recent MI, older age, significant aortic stenosis, among others. Detsky updated the index in 1986, and then Eagle addressed the poor performance of this model in vascular patients with a model for high risk surgeries in 1989. Finally, Lee published the Revised Cardiac Risk Index in 1999, a simple 6-item model, which has since been externally validated and used extensively (Table 7)(25). Davis et al used a prospective cohort to re-examine and update RCRI, removing diabetes and replacing creatinine with GFR < 30ml/min with improved discrimination and calibration (26).

Now in the age of "big data," Gupta developed a more complex myocardial infarction/cardiac arrest (MICA) risk model from 200,000 patients in the ACS-NSQIP database in 2007 (27).

Table 5. S-MPM Score

Risk factor	Points
ASA PS	
I	0
II	2
III	4
IV	5
V	6
Procedure risk	
Low risk	0
Intermediate risk	1
High risk	2
Emergency	
Nonemergent	0
Emergency surgery	1

Table 6. S-MPM associated risk

Class	Points	Mortality
I	0-4	<0.5%
II	5-6	1.5-4%
III	7-9	>10%

Table 7. Revised Cardiac Risk Index

Variable	Adjusted OR in Validation Set (95% CI)
High-risk type of surgery	2.6 (1.3, 5.3)
Ischemic heart disease	3.8 (1.7, 8.2)
History of congestive heart failure	4.3 (2.1, 8.8)
History of cerebrovascular disease	3.0 (1.3, 6.8)
Insulin therapy for diabetes	1.0 (0.3, 3.8)
Preoperative serum creatinine > 2 mg/dL	0.9 (0.2, 3.3)

Although cardiac risk has traditionally been the focus of preoperative evaluations, postoperative pulmonary complications are just as prevalent and morbid. In 2000, Arozullah developed a risk index for the prediction of postoperative respiratory failure from 81,719 patients in the National Veterans Affairs Surgical Quality Improvement Program, followed in 2001 by a similar model for postoperative pneumonia (28, 29). Both of these studies included only male veterans, so Gupta et al developed models for postoperative respiratory failure and pneumonia from the ACS-NSQIP in 2011 and 2013, respectively (30, 31). Finally, Canet et al developed the ARISCAT Risk Index, which predicts the overall incidence of postoperative pulmonary complications (Table 8)(32). Both the strength and limitation of the model is its inclusion of essentially every conceivable postoperative pulmonary complication, some with limited significance (e.g. atelectasis).

Table 8. ARISCAT (Canet) risk index for postoperative pulmonary complications

Factor	Adjusted odds ratio (95% CI)	Risk score
Age, years		
<51	1	
51-80	1.4 (0.6-3.3)	3
>80	5.1 (1.9-13.3)	16
Preoperative O2 saturation		
>95%	1	
91-95%	2.2 (1.2-4.2)	8
<91%	10.7 (4.1-28.1)	24
Respiratory infection w/in 1 mo	5.5 (2.6-11.5)	17
Preoperative anemia - Hgb < 10	3 (1.4-6.5)	11
Surgical incision		
Upper abdominal	4.4 (2.3-8.5)	15
Intrathoracic	11.4 (1.9-26.0)	24
Duration of surgery		
< 2 hours	1	
2-3 hours	4.9 (2.4-19.9)	16
>3 hours	9.7 (2.4-19.9)	23
Emergency surgery	2.2 (1.0-4.5)	8

Getting with the Guidelines

The following is a summary and discussion of the most relevant preoperative testing recommendations issued through the Choosing Wisely campaign, along with related recommendations from national guidelines. The source of each recommendation is noted.

Do not order routine preoperative testing for cataract surgery. [American Academy of Ophthalmology]

Ten million cases of cataract surgery are performed around the world each year; more than 1.5 million in the United States. This costs more than $3 billion to Medicare annually. On average, patients who have cataract surgery are in their mid-70s and the majority have an important comorbidity. It is well-documented that cataract surgery is a very low risk surgery. Historically, the vast majority of Ophthalmologists, Internists, and Anesthesiologists obtained extensive preoperative testing including a complete blood count (CBC), basic metabolic panel (BMP), and electrocardiogram (EKG). Many also obtained a chest film. In one study, up to 80% of clinicians

believed that the tests were probably unnecessary, but obtained the tests for medico-legal reasons, institutional policies, or because they thought one of the other physician groups needed it (33).

The first and largest randomized controlled trial to date that examined whether this was necessary was a multi-center trial by Schein et al from Johns Hopkins (34). He randomized more than 18,000 patients to either a CBC, BMP, and EKG, or to no preoperative testing. They had the same rate of complications (31.3 per 1000 operations), even when stratified by age, sex, race, ASA class, or medical history. A group in Brazil later randomized 1,025 patients to either routine testing or "selective testing" for a new or worsening medical problem (35). Cancellations were similar (2%), as were complication rates (9.6% vs 9.7%). The cost was more than 2.5 times higher in the routine testing group despite the lack of predictive value. Finally, a study in Italy randomized 1,276 patients to have routine preoperative testing or not (36). Rates of adverse medical events were low and equal in both groups. The Cochrane Collaboration performed a meta-analysis of the data and concluded that complication rates were low in cataract surgery and were not influenced by preoperative testing (37). Imasogie et al implemented a policy for their hospital in Toronto based on the work of Schein that prohibited routine testing in cataract surgery (38). They studied the effect on 1,231 total patients from June to September before the policy and the same period the following year after the policy. Tests were reduced from an average of 5.8 per patient to 0.4 per patient with a 90% reduction in cost and no change in intraoperative or postoperative events.

Even the preoperative visit itself may not be necessary for cataract surgery. It's been shown in several studies that health questionnaires filled out by patients can fairly accurately gather their history for many conditions. As part of the study by Schein et al, they administered a standardized health questionnaire to each participant in the trial with simple "Yes," "No," or "I don't know" answers to identify 12 comorbidities like diabetes, hypertension, or chronic cardiac, pulmonary, kidney or liver disease (39). Using the physician preoperative evaluation as the gold standard, the sensitivity of the questionnaire varied by comorbidity; higher for conditions like diabetes, but lower for liver disease or heart failure. All conditions were identified with a high degree of specificity. The only increased relative risk of an event missed by the questionnaire was for renal disease. When looking at the collective number of comorbidities, those identified by the questionnaire and the physician's history and physical performed equally well at predicting the rate of medical adverse events (Table 9).

Table 9. Risk of Medical Event by Number of Comorbidities in Cataract Surgery.

Total diagnoses per patient	Questionnaire Medical events / 1,000	History and Physical Medical events / 1,000	P value
0	12.4	12.1	0.87
1	18.5	19.8	0.58
2	26.5	25.3	0.75
3	28.0	27.3	0.89
4	29.9	23.4	0.44
>=5	31.3	41.7	0.43

In conclusion, data from 3 randomized trials has demonstrated that routine preoperative testing does not result in a reduction in complications from cataract surgery and should not be performed. Furthermore, we may even be able to stratify patients with a standardized questionnaire into risk categories to determine which patients even need to see a physician ahead of time. The American Academy of Ophthalmology, American Society for Clinical Pathology, and Society of General Internal Medicine all agree that routine testing in this circumstance is not useful.

Do not order routine preoperative testing (like CBC, BMP or CMP, coagulation studies) in low risk surgeries, *especially* in patients without significant comorbidities. [American Society of Anesthesiologists, Society of General Internal Medicine, American Society for Clinical Pathology]

In a recent systematic review performed to update the findings of the National Institute for Health and Clinical Excellence (NICE) guidelines, Johansson and colleagues found that from 2001 to 2011 there were 101 studies that examined preoperative testing in non-cardiac surgery (3). Only 3 of the studies were randomized controlled trials, and the remaining 98 were observational. In general, most of these studies were performed in an effort to demonstrate that patients would not be harmed by removal of unnecessary testing by demonstrating that those patient who did not have testing had similar rates of adverse events. The systematic review, on the other hand, took the reverse viewpoint. Typically when we are conducting non-inferiority trials, for example, we are comparing the intervention in question against an intervention with known efficacy. But Johansson makes the case that the practice of preoperative evaluation has

never been an evidence-based intervention. So instead the question became whether there was evidence that preoperative testing showed any benefit over no preoperative testing. The conclusions, as will be explored further, were several fold. First, patients having cataract surgery and ambulatory surgery should not have routine preoperative testing. Secondly, there is insufficient evidence that healthy adults should have preoperative testing prior to non-cardiac surgery. Third, that the evidence for selective testing based on the risks of the individual patient was scarce, but nonetheless a reasonable option.

In addition to the trials on cataract surgery mentioned above, Chung conducted a randomized study in which 1,061 patients undergoing ambulatory surgery were assigned to either testing indicated based on specific clinical features and preexisting conditions or to no testing (40). There was no difference in the rates of perioperative adverse events or the rates of adverse events within 30 days between the no testing and indicated testing groups. None of the adverse events were related to the testing or no testing. However, the rates of total complications was low at 1.3% in the per protocol group, and 1.4% in the no testing group, so the systematic review concluded that the study was underpowered to detect a difference.

After the systematic review was published, Benarroch-Gampel from University of Texas Medical Branch in Galveston supplemented this idea in 2012 by reporting on 73,596 patients who underwent elective hernia repair in the NSQIP database (41). A total of 46,977 (63.8%) patients had preoperative testing and 61.6% had an abnormal result. Even among the low risk patients with no comorbidities and no clear reason for testing, 54% of patients still received testing. Major complications (reintubation, pulmonary embolus, stroke, renal failure, coma, cardiac arrest, myocardial infarction, septic shock, bleeding, or death) occurred in 0.3% of patients. After adjusting for patient and procedural factors, neither testing nor abnormal results were associated with postoperative complications. He went on to conclude that on the basis of the high rates of testing, physician and facility preferences dictate use of preoperative testing, not the condition and needs of the individual patient.

Since the majority of surgeries performed are low risk, the majority of patients having surgery should not need routine preoperative testing. There is no evidence that it is benefiting the patient.

Do not order a preoperative EKG for an asymptomatic patient having low-risk surgery. [2014 ACC/AHA Guidelines]

An electrocardiogram (EKG) is often obtained fairly routinely in the preoperative evaluation. However, there is little evidence that it has much utility in patients who are at low risk for having a major adverse cardiac event (MACE). As the population ages, abnormalities on the EKG become increasingly frequent. Gold et al studied relatively healthy ambulatory surgical patients and found that 42% of EKGs were abnormal (42). Seymour et al showed that over the age of 65, 53% of patients had a major EKG abnormality, and Liu et al showed that 75% of the elderly had an abnormal EKG (43, 44). None of these studies predicted postoperative complications, however, and in fact van Klei et al showed that although a left bundle branch was predictive of myocardial infarction or death, it didn't actually add anything to the history (45). As the risk of the surgery increases, the predictive value of the EKG increases (46). When the risk of MACE is low, obtaining an EKG may not be a good use of resources. The 2014 American College of Cardiology / American Heart Association guidelines have designated that obtaining an EKG in this circumstance is contraindicated.

Do not perform a preoperative chest x-ray without a clinical suspicion from the history and physician exam, *especially* for ambulatory surgery. [American College of Physicians, American College of Radiology, American College of Surgeons]

As an indication about the historical prevalent use of preoperative chest x-rays, in 1995, Bass and colleagues at Hopkins showed that chest radiographs were obtained in up to 50% of patients having cataract surgery, a very low risk surgery (33). Most of the studies examining the use of preoperative chest radiographs were conducted before the year 2000. A meta-analysis of 14,390 patients by Archer et al from McGill University reported that although abnormalities were identified in 10% of routine preoperative chest films, only 1.3% of the abnormalities were unexpected, i.e. were not already known or would not otherwise have been detected (47). Furthermore, the findings only changed management in 0.1% of patients. In a bold statement about the inefficient use of resources, the study concluded that even if only the direct cost to the health care system was considered ($23) for each chest film, each abnormality that changed management would cost $23,000, and that it was no longer justifiable. Similarly, the National Study of the Royal College of Radiologists in the U.K. found that for 10,619 preoperative patients, the preoperative chest film did not influence the decision to use inhalational anesthesia a single time.

Munro et al performed a systemic review of 28 empirical studies including 18,913 apparently healthy patients from 11 countries and found that the number of abnormalities on chest x-ray varied widely by study (48). The impact on patient patient management was noted to be exceedingly small in a subset of these studies. Unfortunately, no controlled trials have been performed in this area.

Smetana et al later conducted a large systematic review of 324,648 patients having 10,960 postoperative pulmonary complications (49). He concluded that the evidence did not allow firm conclusions, but that the incremental value of chest x-rays in estimating postoperative complications was small. Two very small studies suggested that older patients having high risk surgery and patients with known cardiopulmonary disease might benefit.

Do not order stress tests or echocardiograms for low-risk surgery, for asymptomatic patients with cardiac disease having intermediate-risk surgery, or echo for any risk surgery if no signs or symptoms of heart disease. [American College of Cardiology, Society for Vascular Medicine, Society for Cardiovascular Magnetic Resonance, American Society of Anesthesiologists, American Society of Nuclear Cardiology, American Society of Echocardiography]

Cardiac testing is performed with the intent of predicting and mitigating risk of cardiovascular complications. It stands to reason that a patient with elevated risk would benefit more than a healthy asymptomatic patient, thus most of the studies surrounding the use of preoperative echocardiogram and stress testing have been for major non-cardiac surgery. Rhode et al evaluated the incremental information provided by echocardiography to the prediction of postoperative cardiac complications (50). Among 4,325 patients who had 570 preoperative echocardiograms, moderate to severe left ventricular hypertrophy (OR 2.3, 95% CI 1.0 to 4.5), systolic dysfunction (OR 2.0, 95% CI 1.0 to 4.5), and peak instantaneous aortic gradients of 40 mm Hg (OR 6.8, 95% CI 1.3 to 31) remained significant correlates of major cardiac complications after multivariate analysis. However, when patients were stratified using the Revised Cardiac Risk Index (RCRI), complication rates were low at 2-3% for those in Class I and II, and an abnormal echo was no longer predictive of complications (OR 1.6, 95% CI 0.3-8.3). In other words, if the patient only had one RCRI factor, an echo was not helpful even for major non-cardiac surgery.

There have been several meta-analyses that have looked at the utility of preoperative stress testing. Recently, Beattie et al looked at both thallium imaging and stress echocardiography and

found that among 68 studies of 10,278 patients, stress echo had a positive LR of 4.09 compared to 1.83 for thallium imaging (c-statistic 0.80 vs 0.75)(51). A moderate to large perfusion defect had an almost nine-fold increase in the rate of MI or death after noncardiac surgery. Likewise, the negative LR of stress echo was 0.23 (95% CI 0.17-0.32) compared to 0.44 (95% CI 0.36-0.54) for thallium imaging. An earlier study by Etchells further stratified that it was patients with more than a 20% perfusion defect that predicted perioperative events; those with fixed defects or small defects did not (52). However, because low risk surgeries by definition have low rates of adverse outcomes, there are 6 different societies that advocate against use of stress testing in low risk scenarios. Fortunately, in a sample of 109,270 Medicare patients, Kerr et al found that at least in very low risk surgeries like cataract and knee arthroscopy we are not using it very much (1.76% and 4.37%, respectively)(53).

Traditionally, when a patient had a positive preoperative stress test, they were referred for revascularization. The Coronary Artery Revascularization Prophylaxis (CARP) trial compared preoperative coronary artery revascularization to no revascularization (54). Among 5,859 patients scheduled for vascular surgery, 1,190 patients categorized as high risk underwent angiography. After excluding left main disease, ejection fraction less than 20%, and severe aortic stenosis, the remaining 510 patients were randomized to PCI or CABG vs no revascularization. There was no difference in mortality (22% vs. 23%) or various 30-day outcomes. This issued a change in practice, and is reflected in the current ACC/AHA guidelines that essentially recommend that a patient receive similar guideline-based care revascularization regardless of whether they have an upcoming surgery. Some critics contend that those identified as higher risk in CARP may have benefited from preoperative revascularization, but the study was underpowered to detect this effect.

This contrasts with previous guidelines that we may have begun practicing under. Under the 1996 guidelines, it was given a Class I indication to get a stress test for someone with an intermediate pretest probability of coronary artery disease, and a IIa indication if subjective assessment of exercise capacity was unreliable. It could even be considered for someone with a low pretest probability of CAD. Current evidence suggests that we should focus our attention on patients at higher risk.

Schwartz et al took a 5% sample of Medicare claims from 2008-2009 based on the Choosing Wisely campaign and found that we spent $315 million dollars on low value preoperative stress testing, echo, pulmonary function testing, and chest x-rays (55).

Final thoughts and conclusions.

Many surgeries today are performed safely with a low rate of complications. Although the data may not be robust, the evidence suggests that for many of them preoperative testing including labs, EKG, and especially imaging is probably not useful. Preoperative testing is low cost but high volume, so it has a significant collective impact, both on our patients and the health care system. The ideals of our profession dictate that we do no harm. This includes not subjecting patients to painful phlebotomy, unnecessary radiation, false positive results requiring additional testing that adds little or no incremental value to their health, and the financial burden of paying for all of the above. There are many preoperative habits we may have learned or adopted, but many of them are probably not evidence-based, and *may* not be the best way to evaluate patients before surgery. We must resist the urge to order more tests just because we can. Together, we have to find evidence-based and common sense approaches to guide our preoperative testing so that it benefits the patient and yet still reflects the ideals of judicious and parsimonious care.

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