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Routine Preoperative Tests – Are They Necessary?

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ROUTINE PREOPERATIVE TESTS - ARE THEY NECESSARY?

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Summary

The Issue

Preoperative routine testing before elective surgery began 40 years ago and has expanded to include the plethora of routine diagnostic tests performed today. As technological advances enabled the collection of large amounts of data, the medical community adopted "the more information the better" philosophy as a way to improve quality and reduce costs of care for patients. Routine testing was incorporated into care maps to standardize diagnostic and treatment regimes. Today, these tests are done to detect prognostically important abnormalities prior to surgery. However, opponents argue that the results of these tests are rarely used in clinical practice, and that the testing contributes to a substantial increase in costs without any corresponding benefit to the patient, their anesthesiologist, or their surgeon.

Findings

In the absence of good outcome studies, most reviews and assessments have concluded there is little evidence to support routine testing in otherwise healthy patients prior to elective surgery. Physicians often follow institutional care maps when ordering tests. In general, the chances that preoperative testing will uncover a true abnormality that will affect clinical management are low. That is due, in part, to the large proportion of test results that are not investigated prior to surgery. Evidence suggests that false positive test results can disrupt operating room schedules and unnecessarily stress patients. Furthermore, tests are frequently repeated, even when recent prior results are available.

Studies over the past twenty years have demonstrated cost savings from reduced preoperative testing. The use of ambulatory care preadmission clinics prior to inpatient surgery moves testing to a less costly setting. Indicative test ordering based on the patient's medical condition can lead to a less costly mix and lower frequency of tests ordered. A lower volume of testing also reduces disruption of operating room schedules, fewer false positive results and fewer unnecessary follow-up investigations.

Policy Considerations

Guidelines alone have not always affected clinical behaviour. Guideline adoption requires an implementation process that reaches the widest possible range of health providers and uses educational and administrative strategies that encourage long-term changes in practice patterns.

This report may be used to discuss appropriate changes in health policy and practice related to routine preoperative testing in otherwise healthy patients. It recommends some further research in the field, the convening of a Consensus Development Conference on critical topic issues, and the measurement of the impact of a consensus statement, as well as of other initiatives that may be taken over the coming years to optimize preoperative testing in the health services of Alberta.

Introduction

This report is about routine preoperative testing on otherwise healthy patients who are scheduled for elective surgery. It does not refer to the testing of patients who require surgery related to trauma, cancer, or cardiac conditions, or patients with a previously diagnosed health condition that justifies preoperative testing.

Routine preoperative testing on patients scheduled for elective surgery usually includes an X-ray of the heart and lungs, an electrocardiogram (ECG), and laboratory analysis of blood samples. Selective pre-surgical testing began 40 years ago and has since expanded to include the plethora of routine diagnostic tests performed today. As technological advances enabled the collection of large amounts of data, the medical community adopted "the more information the better"[93] philosophy as a way to improve quality and reduce the costs of patient care. Routine testing was then incorporated into care maps to standardize diagnostic and treatment regimes. Today these tests are done to detect abnormalities prior to surgery. However, opponents argue that the results of these tests are rarely used in clinical practice, and that testing contributes to a substantial increase in costs without any corresponding benefit to the patients, anaesthesiologists, or surgeons.[93]

Several health technology assessments (HTAs) on routine testing in elective surgery have been published during the last 20 years.[9;10;31;42;63;72;77;96;109;113] They unanimously question the need for routine testing without clear indication. The evidence shows that there is little chance of detecting an abnormality that will change clinical management, particularly in relation to chest X-rays. In addition, false-positive test results may harm patients by causing postponement or cancellation of surgery and potentially leading to additional, sometimes invasive, testing and unnecessary treatment.[93] With approximately 1.6 million elective surgical procedures performed in Canada every year[1], the number of false-positive findings from routine testing is likely to be substantial.

Consensus statements and guidelines have been developed to reduce mandatory testing in response to the negative evidence surrounding routine testing in elective surgery.[10] Unfortunately, the adoption of these

evidence-based measures is hindered by a number of barriers including: lack of good outcome studies;[10;77] physician and institutional non-compliance;[101;120] patient demand for testing;[93] and economic pressures exerted by equipment suppliers and pharmaceutical companies to establish minimum testing levels.[93] Although the annual cost of preoperative testing in Alberta is approximately CN$8 million (CN$80 million in ten years), little study has been devoted to this issue. Determining the appropriate level of testing is important not only for economic reasons but also for patient safety, quality of care, and efficient healthcare delivery.

Objectives And Scope Of The Paper

The objective of this report is to review the important issues relating to preoperative testing, provide an overview of the most significant studies published on the subject, examine the cost implications of unnecessary testing, and examine strategies to optimize preoperative testing. This paper is not intended to be a comprehensive systematic literature review because good reviews have already been done. However, these reviews are lengthy, complex, and time-consuming to read. This report is a synopsis of the findings from some of the major health technology assessments and systematic reviews on preoperative testing published during the last two decades. The implications of these results for Alberta are discussed in order to assist decision-makers in efforts to revise institutional preoperative testing routines.

Methodology

An initial literature search of the Centre for Reviews and Dissemination (CRD) databases, PubMed, and the Internet (Google) identified HTAs, systematic reviews, and North American literature that focused on issues related to preoperative routine testing in seemingly healthy patients (all ages) who were scheduled for elective surgery (all types). The search terms "preoperative care" and "preoperative routine" were used to obtain a list of 35 HTAs, from which a smaller group of 10 assessments[9;10;31;42;63;72;77;96;109;113] were selected. This search also uncovered one relevant systematic review,[8] a Canadian costing study,[35] and a textbook.[93] Other relevant studies were identified from the bibliographies of these articles.

Combining the earliest[10] and most recent[77] of the 10 HTAs provided a literature review spanning several decades up to 2002. To update the literature base to 2007, another search was conducted to identify literature published from 2001 onwards (Appendix 2). This uncovered one additional systematic review.[51]

This report summarizes the findings of the earliest[10] and most recent[77] HTA on preoperative testing for elective surgery, as well as relevant North American research for local context. In the literature, costs were expressed in a number of different currencies at varying points in time. Therefore, all costs were converted to 2005 Canadian dollars. This was done in two steps: first, each cost value was adjusted to 2005 dollars by applying a country-specific price index; and second, this value was converted to Canadian dollars using the average exchange rate for 2005.

Literature Synopsis

Health Technology Assessments

The need to reduce unnecessary testing prompted the undertaking of several HTA reviews to synthesize the literature and evaluate the impact of limiting preoperative testing, particularly in healthy patients undergoing elective surgery.[9;10;31;42;63;72;77;96;109;113] The first of these assessments, published in 1989 by the Swedish Council of Technology Assessment in Health Care (SBU),[10] demonstrated the magnitude of savings and improvements in quality of care that were possible by constraining the selection criteria for testing. Since its publication, the SBU report findings have been confirmed by nine other reviews from five countries.[9] The most recent of these HTAs was published in 2003 by the National Institute for Health and Clinical Excellence (NICE)[77] in the United Kingdom (UK).

The SBU report[10] and a precursor to the NICE assessment[72] were incorporated in a report published by the International Network of Agencies for Health Technology Assessment (INAHTA) in 2000, which summarized the findings of six member agencies (Basque Country, Catalonia, France, Sweden, the Netherlands, and the UK) that had conducted reviews of preoperative testing between 1989 and 1999.[11] Among these reports there was general agreement on: 1) the importance of age, sex, and health status in determining diagnostic testing; and 2) the lack of clinician compliance in adopting new testing practices.

Swedish Council of Technology Assessment in Health Care Report

The Swedish report focused on healthy patients scheduled for elective procedures in the areas of general surgery, urology, orthopaedics, and gynaecology. The objectives were to: 1) produce an evidence-based evaluation of the effectiveness of preoperative chest X-rays, ECGs, and laboratory tests; and 2) describe the current state of preoperative testing in Sweden.

Literature review results

The literature review highlighted the lack of good evidence in the form of randomized controlled trials and the wide variation in preoperative testing regimes across the medical community. Two studies of chest X-rays were reviewed. One British study reported significant variation in the use of chest X-rays regardless of patient characteristics, procedure type, or physician qualifications. Additional findings suggested that routine chest X-rays were not always done on high risk patients and that 25% of surgeries were completed before the physician knew the results of the chest X-ray. A Swedish study of 300 patients with positive chest X-ray results found that this had no influence on surgical approach, surgical timing, or choice of anaesthetic.

The evidence regarding ECGs was similarly contradictory. However, there was general agreement that cardiac patients should undergo a routine ECG to detect important prognostic conditions such as undiagnosed myocardial infarction (particularly one occurring within the previous 6 months) or arrhythmia, both of which are known precursors of surgical complications.

At the time of the assessment, no large prospective randomized controlled trials had studied the usefulness of laboratory tests. However, the limited research showed that while abnormalities were found in up to 2% of healthy individuals, approximately 70% of these abnormalities were false-positives that usually led to further testing and unnecessary patient stress. Most research supported preoperative laboratory testing when indicated by an individual's medical history or physical examination.

Findings of SBU literature review.

- Most research supported preoperative testing when indicated by patient history/exam.
- Prevalence of abnormalities was 2%.
- 70% of abnormalities were false-positives.

The report concluded that determining the usefulness of chest X-rays may not be feasible because a very large sample size is required to reach adequate statistical power. Routine ECGs may be appropriate for older patients (beginning somewhere between 50 to 60 years of age), but routine chest X-rays, laboratory tests, and ECGs in younger people should be done only when indicated by the patient's medical history or physical examination

Survey results

A postal survey of all general, surgical, and orthopaedic clinics in Sweden, which achieved a 93% (209/224) response rate, reflected a wide variation in preoperative testing routines. The most common selection criterion for an ECG was patient age (usually done on anyone over the age of 50 years), while chest X-rays were typically done when indicated. The frequency of laboratory tests varied by test and department; ranging from 95% for haemoglobin to around 50% for serum albumin and leukocyte count. Preoperative testing routines for chest X-rays and ECGs tended to be similar in surgery and anaesthesia departments at the same hospital. Although the surgeon often handled the preoperative testing routines, the anaesthesiologist had the final say regarding patient readiness for surgery.

Economic analysis

The economic analysis compared the cost of the current preoperative routine, including anaesthesiologist visit, blood test, ECG, chest X-ray, clinical chemical analysis, and spirometry, to that of more limited testing. The 1989 cost of complete preoperative investigation, including one preoperative hospital day in 75% of cases, was 726 million Swedish crowns (SEK). The tests alone (excluding physician time and additional testing) accounted for 40% of the total costs. It was estimated that more constrained selection criteria for testing would save 100 (14%) to 200 (28%) million SEK annually. Reducing inpatient days by establishing outpatient clinics would free resources amounting to between 87 (12%) and 350 (48%) million SEK. A summary of these estimates is presented in Table 1.

Table 1: Estimate of the Cost of Preoperative Investigation and Potential Savings - Swedish Council of Technology Assessment in Health Care (SBU)

	Annual Cost (1989 millions SEK)	Estimated Annual Per capita Cost (2005 $Canadian)
Preoperative Investigation	726	44
Potential Savings		
Reduced volume of tests	100 - 200	6 - 12
Reduction of inpatient days	87 - 350	5 - 21
Total	187 - 550	11 - 33

Following the publication of the SBU assessment in 1989, a consensus conference was organized on the subject. The resulting consensus statement agreed with the findings of the report and an impact evaluation of the report and consensus statement was done in 1994.[19] The evaluation studied preoperative routines of 3000 elective surgery patients admitted to seven Swedish hospitals 1 year prior (weeks 15-21 of 1989), 1 year following (weeks 15-19 or 1990) and 2 years following (weeks 15-17 of 1991) the publication of the consensus statement. Roughly 50% of the study patients were under age 45 years and quite healthy, limiting the potential impact on preoperative testing. Despite this, preoperative chest x-rays and ECGs dropped about 5% between 1989 and 1991, much of this decline occurring in middle-aged adults (ages 45 through 64) where chest x-ray and ECG rates both decreased to 9% from 17% and 40% respectively. Results varied widely across hospitals and could not be explained by differences in patient health.

The UK National Institute for Health and Clinical Excellence Report

In 2003, NICE used consensus methodology to establish guidelines for preoperative testing in elective surgery patients and various other patient groups with comorbidities.[77] This guideline was formulated as part of an HTA that also included a synthesis of the literature and an economic impact analysis of current preoperative testing practices. The guidelines covered eleven tests: plain chest X-ray; twelve lead resting ECG; full blood count; haemostasis; serum urea, creatinine, and electrolytes; random serum glucose; urine analysis; blood gases; lung function; sickle cell haemoglobin test; and pregnancy test.

Literature review results

In agreement with the SBU report, the literature review noted the absence of good outcome studies and a wide variation in testing across the medical community. For example, abnormal chest X-rays occurred in 0.3% to 65.7% of cases, leading to a change in clinical management in 0% to 13.3% of patients and postoperative complications in 0% to 8.8% of patients (Appendix 3, Table 1). ECG abnormalities showed even greater variation, from 0% to 91.4%, which generated management changes in 0% to 37.4% of cases and postoperative complications in 0% to 22.5% of patients (Appendix 3, Table 2). Most of the other laboratory tests showed similar variations.[77] Abnormal pregnancy tests almost always resulted in surgery cancellation. No outcome papers were found for the sickle cell haemoglobin test. Most of the research identified patient age and comorbidity as the main selection criteria for determining who received preoperative testing.

Findings of literature review.

- Abnormal chest X-rays occurred in 0.3% to 65.7% of cases.
- ECG abnormalities occurred in 0% to 91.4% of cases.
- Wide variation in abnormality rates for most laboratory tests.
- Abnormal pregnancy tests usually resulted in surgery cancellation.

Survey results

A group of 20 anaesthesiologists and trainee surgeons were interviewed regarding the purpose of preoperative testing. Most respondents agreed that preoperative testing should be used to predict postoperative complications and alert the patient or caregiver of increased risk. However, they felt that preoperative testing should not be used as a defensive measure. When asked what actions would construe a change in clinical management, physicians generally agreed upon the following: additional testing following an abnormal result, change of anaesthetic, or revision of postoperative care. All respondents agreed that the need for preoperative testing varies according to patient health and the severity of the surgery, and most felt that preoperative pregnancy and haemoglobin testing (with the exception of the sickle cell haemoglobin test) were unnecessary.

Economic analysis

The economic evaluation included 20 costing studies: 13 cost analyses and 7 studies that compared the cost of anaesthetist-directed outpatient testing versus traditional surgeon-directed preoperative assessment. The largest comparative saving incurred by reducing preoperative testing was US$190 per patient (CN$311 [2005 value]).[115] All of the studies calculated incremental savings based on the cost of the test, but only one also factored in lost operating room and follow-up time.[47]

Cost-effectiveness was estimated by 6 of the 13 studies, but they were heterogeneous in the methods used to measure effectiveness, which was variously assessed by clinically significant abnormal tests, abnormal test results that changed treatment, complications avoided, or lives saved (Appendix 4, Table 1). These studies showed that preoperative testing uncovered prognostically important surgical risk factors, but at an increased cost. One study estimated a cost per life saved of US$4.2 million[52] (CN$9.3 million [2005 value]), making preoperative testing substantially less cost-effective than some other healthcare procedures.

In studies which considered only the costs of testing, the largest comparative saving achieved was CN$311 per patient.

Seven studies contrasted the costs of an anaesthetist-directed outpatient preoperative clinic with the traditional preoperative routine conducted by the surgeon after admission. Six of the seven studies reported reduced testing and corresponding cost savings with the preoperative clinic. The largest cost saving from reduced preoperative testing was US$112 per patient[36] (CN$174 [2005 value]), while the largest total cost saving (including outpatient clinic costs and operating room and inpatient time) was US$366 per patient[17] (CN$458 [2005 value])(Appendix 4, Table 2). Inter-study comparisons were hampered by the significant heterogeneity across several characteristics, including cost measures. Only one study attempted to factor in costs associated with reduced surgical cancellations,[17] although previously reported research suggested that between 20% and 80% of surgical cancellations could be avoided by using outpatient preoperative clinics.[36]

Using anesthetist-directed outpatient preoperative clinics instead of traditional inpatient preoperative routines conducted by the surgeon could:

- reduce preoperative testing and save CN$174 per patient;
- reduce total costs (including outpatient clinic costs and operating room/inpatient time) by CN$458.

Overall, the NICE assessment concluded that there was insufficient evidence to support the effectiveness of preoperative testing and that reduced testing would result in significant cost savings. For patients that do require assessment, the use of pre-admission clinics within an ambulatory care setting is a less costly alternative to early inpatient admission. Other cost saving measures proposed include: 1) test ordering by the staff most knowledgeable about the purpose of testing; 2) testing before the day of surgery to allow patients and physicians time to react to the results; and 3) avoiding replication of recently completed tests.

Health resource savings can be achieved by:

- having the most knowledgeable staff order tests;
- testing before the day of surgery;
- avoiding unnecessary repeat testing.

The report also highlighted the need for further consideration of informed consent in terms of whether it is required and, if so, for which tests. Patients deserve to be informed of the reasons and possible consequences of a positive test result, particularly when they are scheduled for sensitive testing such as for pregnancy or the sickle cell gene.

Systematic Reviews and Meta-Analyses

Chest X-rays can be harmful to patients in terms of the radiation exposure, which poses a lifetime cancer risk of 1.2/100,000,[7] and mental stress related to a false-positive result. A meta-analysis[8] of 21 studies of routine chest X-rays in European and North American populations found that 10% of routine chest X-rays were abnormal, but only 1.3% of these were unexpected. An even smaller proportion (0.1%) prompted a change in management, but the effect on health outcomes could not be imputed from the available evidence. The cost of detecting each abnormality that influenced patient management was CN$23,000. Thus, a thorough medical history and physical examination are more than adequate in most cases. Chest X-rays should be considered only when there is pulmonary disease or a reason to doubt the accuracy of the physical examination or patient history.

A systematic review of 14 studies examining the value of screening chest X-rays found that abnormalities increased with age, primarily because of the increased prevalence of chronic conditions in older patients.[51] Abnormalities appeared in 65% of films, but changed patient management less than 6% of the time. When further testing was done (in 4% to 47% of cases), a change in management occurred in 10% of investigated patients. Postoperative pulmonary complication rates were similar regardless of whether or not the patient had a preoperative chest X-ray. The results suggested that chest X-rays should not be performed in patients with no risk factors who are under 70 years of age. There was insufficient evidence to make recommendations for screening chest X-rays in patients over 70 years of age.

— Abnormalities appeared in 65% of chest X-rays, but management changed in less than 6% of these cases.
— Postoperative pulmonary complication rates were similar regardless of whether or not the patient had a preoperative chest X-ray.
— Chest X-rays should not be performed in patients with no risk factors who are under 70 years of age.

The North American Perspective

United States

Most American physicians now follow institutional preoperative testing pathways and prefer to err on the side of too much, rather than too little, testing for fear of missing something important and incurring possible legal action. Nonetheless, up to 60% of detected preoperative abnormalities are not investigated prior to surgery, which poses a greater legal liability than omitting the test in the first place.[93] Inefficiencies are rife, with estimates suggesting that up to 70% of ordered tests are not indicated by the patient's medical history.[93] In addition, repeat testing often occurs in patients whose health has not changed in the interim. Narr et al.[76] found that 47% of preoperative analyses replicated tests that were done during the past year, and that a change in the result occurred in only 0.4% of cases. In addition, many of these abnormalities could have been predicted from the medical history and examination. Although test "expiry dates" may be test-dependent, research shows that it is generally safe to use laboratory results obtained within the past 4 months[70;76] to 1 year.[93]

— 60% of detected abnormalities are not investigated before surgery.
— 70% of ordered tests are not indicated.
— 47% of preoperative tests unnecessarily replicate analyses done during the past year.

While efforts in earlier years focused on reducing preoperative testing, some in the United States now claim that there is too little testing. By omitting preoperative testing in the healthiest patients, clinicians are missing an opportunity to promote healthier lifestyle choices.[94] Furthermore, when physicians order only indicated tests there is substantial room for error,

and this system unfairly places all the onus on the "history-taker" to complete the difficult task of combining the history, physical examination, and laboratory test indicators.[93] A better alternative is the pre-admission clinic, the goal of which is to "provide a comprehensive anesthesia service for physicians and their presurgical patients". One of the foundations of the preoperative clinic is an interactive electronic information system, which has been shown to reduce total testing costs by 50%.[94] Greater effort must be focused on optimizing the patient's health prior to surgery, which may include pre-surgery treatment with beta-blockers,[116] aspirin,[66] statins,[30;87] or immunizations[20] to reduce operative risk.

It has also been suggested that a preoperative evaluation should encompass the "rule of threes" system for both surgical and non-surgical procedures. This system addresses three factors in each of three areas:[94]

1) The physical exam encompassing the three factors of airway, cardiovascular health, and patient satisfaction.
2) Acute history, which should investigate the three factors of patient activity level (in terms of metabolic equivalents), medications, and acute problems.
3) Chronic history comprising data on hospitalizations/surgeries, family history, and social history.

Canada

The Canadian Anesthesiologists' Society guidelines for the practice of anesthesia state that the preoperative procedure should "include documentation of a current history and physical examination, and a review of appropriate laboratory determinations. Laboratory investigations indicated by the history and physical examination should be carried out. These should take into consideration the physical condition of the patient and the proposed operation."[108]

A survey of all members of the Canadian Anesthesiologists' Society was recently conducted to determine current practice in preoperative testing for healthy patients, or those with stable medical conditions, who are scheduled for ambulatory surgery.[123] The response rate was 46% (617/1335). The majority (80%) of respondents thought that testing in low risk healthy patients should be done as indicated by their medical history, whereas 15% said they follow institutional guidelines. Nearly half (44%) felt that age alone was not sufficient to warrant an ECG, while others preferred various age cut-offs of between 40 and 65 years. Half the respondents were aware of new updates to the American College of Cardiology/American Heart Association guidelines, which state that routine ECG in healthy patients undergoing low risk surgery is not useful and may be harmful. Up to 40% felt that preoperative testing was unnecessary for ambulatory surgery. Consistent with all previous research, a wide variation in preoperative testing routines was reported.

Guidelines on preoperative testing

UK Example

In 2003, NICE used consensus methodology to establish guidelines for preoperative testing in elective surgery patients and various other patient groups with comorbidities.[77] The result was a series of tables summarizing consensus for each preoperative test with a colour-coded recommendation of yes (green – general agreement of test appropriateness), no (red – general agreement of test inappropriateness), or consider (yellow – lack of consensus on test appropriateness) that was determined by the reason for the test and the risk to the patient.

To use the tables, the physician needs to know age grouping, surgical severity, American Society of Anesthesiologists (ASA) grade, and comorbidity grouping if the patient is ASA grade 3. It was estimated that utilizing the new guidelines would result in potential savings of over 70% in the annual cost of preoperative testing, compared with current practice (CN$83.4 million versus CN$306.8 million [2005 value], respectively).

Figure 1 Examples of the NICE Clinical Guidance*

Grade 2 surgery intermediate

Grade 2 Surgery — **ASA Grade 1: adults ≥ 16 years**

Test not recommended

Consider this test (see page 2)

Test recommended

Test	Age				
	< 6 months	≥ 6 to < 12 months	≥ 1 to < 5 years	≥ 5 to < 12 years	≥ 12 < 16 years
Chest X-Ray	NO	NO	NO	NO	NO
ECG	NO	NO	NO	NO	NO
Full Blood Count	NO	NO	NO	NO	NO
Haemostasis	NO	NO	NO	NO	NO
Renal function	NO	NO	NO	NO	NO
Random glucose	NO	NO	NO	NO	NO
Urine analysis*	NO	NO	NO	NO	NO

*Dipstick urine testing in asymptomatic individuals is not recommended (UK National Screening Committee)

ASA Grades

Grade 1 Normal healthy patient (i.e. without any clinically important comorbidity and without a clinically significant past/ present medical history.)

Grade 2 Patient with mild systemic disease.

Grade 3 A patient with severe systemic disease but the disease is not a constant threat to life.

See pages 3-4 for more information

ASA Grade 1: adults ≥ 16 years

Test	Age (years)			
	≥ 16 to < 40	≥ 40 to < 60	≥ 60 to < 80	≥ 80
Chest X-Ray	NO	NO	NO	NO
ECG	NO			YES
Full Blood Count	NO		YES	YES
Haemostasis	NO	NO	NO	NO
Renal function	NO	NO		
Random glucose	NO			
Urine analysis*				

*Dipstick urine testing in asymptomatic individuals is not recommended (UK National Screening Committee)

* Source: National Institute for Clinical Excellence (NICE) (2003) CG 3 Preoperative Tests. The use of routine preoperative tests for elective surgery. Evidence, methods and Guidance. London: NICE. Available from: www.nice.org.uk. Reproduced with permission.

North American Examples

United States

In 2002, the ASA[6] produced a practice advisory for pre-anaesthesia evaluation based on the synthesis of current medical literature and expert opinion regarding ECGs and other cardiac tests, chest X-rays, pulmonary evaluation, haemoglobin and haematocrit measurement, coagulation studies, serum chemistries, urine tests, and pregnancy tests. Pre-anaesthesia evaluation was defined as the "process of clinical assessment that precedes the delivery of anesthesia care for surgery and nonsurgical procedures." The ASA concluded that the pre-anaesthesia evaluation should assess the patient's airway, heart, and lungs through a compilation of information from the patient's history, physical examination, indicated preoperative tests, and other justifiable consultations. The timing of the pre-anaesthesia evaluation should be determined by the patient's health and severity of the planned surgery. The advisory also asserted that routine preoperative tests in healthy patients are unnecessary, although indicated preoperative tests may be useful in the clinical management of patients. The ASA declared that better research is needed to determine guidelines for specific preoperative tests.

Recently updated evidence-based guidelines jointly published by the American College of Cardiology (ACC) and American Heart Association (AHA) make similar recommendations regarding preoperative cardiovascular evaluations in patients undergoing non-cardiac surgery.[32] They state that preoperative testing should only be undertaken when the results are likely to affect patient treatment and outcomes, and recommend a circumspect approach to the use of expensive preoperative tests.

Canada

The Guidelines Advisory Committee (GAC) is a provincial committee mandated to review and endorse evidence-based guidelines relevant to Ontario physicians. The GAC supported literature-based findings that chest X-rays and ECGs were too frequently done in patients undergoing low to intermediate risk surgery and that chest X-rays, in particular, should only be done as indicated.[80] The GAC used three strategies to convey this message to Ontario's medical community. The first, called hospital utilization feedback, consisted of a hospital-specific profile that compared each hospital's chest X-ray and ECG rates to selected peer group and benchmark rates. The second strategy of regional opinion leader training involved recruiting physicians province-wide and training them to provide support and advice to their peers. The final strategy encompassed the assimilation of GAC-endorsed guidelines into continuing medical education activities.[37]

The main barriers to implementation proved to be hospital variation and unclear hospital policies regarding preoperative testing. To counter this, the GAC designed the Ontario Preoperative Testing Grid (Appendix 5), a practical table that depicts preoperative tests by risk factor.[81] For each test-risk factor combination there is a color-coded recommendation (white – recommended; grey – not recommended; striped – variation between hospitals). After dissemination of the grid, the chiefs of staff from 104 Ontario hospitals were surveyed. All of the 80 respondents (77%) felt that the grid had influenced their routine preoperative testing policy.

Implementation issues – the problem of compliance

Even though research suggests that preoperative chest X-rays are of limited benefit for screening purposes, changing clinical practice remains problematic.[21] It seems that even when good evidence is readily available clinicians do not necessarily follow the guidelines. Perhaps the primary reason guidelines fail lies in the inability to change physician and hospital behaviour.[29] It has been suggested that successful guideline adoption requires an accompanying implementation process comprising the following strategies: 1) initial dissemination to the widest possible range of health providers; and 2) encouragement and evaluation of long-term change in practice patterns.[29]

> Despite the research suggesting that preoperative chest X-rays are of limited benefit for screening purposes, the challenge of changing clinical practice remains.

Surgery-specific studies are beginning to emerge that may persuade physicians to forego routine preoperative testing in some patients. For example, a recent study[48] in cataract surgery patients found that omitting routine preoperative testing reduced the average number of tests per patient from 5.8 (at an average cost of CN$40 per patient) to 0.4 (at an average cost of CN$4 per patient). In another study of cataract surgery patients, Schein et al.[100] found that the rates of adverse events and complications were similar regardless of whether or not the patients underwent preoperative testing. However, this is only one patient group. The larger challenge is identifying the optimal preoperative testing system for all patients undergoing surgery.

One cost-effective solution may be to use staff anaesthesiologists for ordering tests rather than relying on guidelines or care maps.[35] Finegan et al.[35] explored this option in a prospective non-randomized comparative study of patients in a pre-admission clinic who had moderate to severe systemic disease. One group of 507 patients received the usual testing procedure (group 1), while an anaesthesiologist or anaesthesia resident ordered tests on the second group of

431 patients (group 2). For the same selection of 22 preoperative tests, the average testing costs for patients assessed by senior staff anaesthesiologists were CN$74 per patient, compared to CN$124 per patient for usual testing.

Further analysis revealed that it was only the staff anaesthesiologists, not the anaesthesia residents, who ordered fewer tests. Although there was a statistically significant higher rate of adverse outcomes in group 2 (including four deaths) relative to group one (no deaths), this was not attributable to the level of preoperative testing. The study authors also commented on the possible overuse of chest X-rays, even by staff anaesthesiologists, indicating the potential for further savings.

Although test ordering by staff anaesthesiologists is an attractive solution, a shortage of anaesthesiologists makes it somewhat impractical.[21] Instead of anaesthesiologists, specially trained nurses could be used to assess low risk patients[114] and decrease testing.[55] However, this will also be expensive.

Preoperative testing in the Canadian healthcare system

Preoperative testing currently poses significant problems for the Canadian medical establishment, and there is, as yet, no unified approach for dealing with them. In some provinces, such as Ontario and British Columbia (BC), provincial agencies have shouldered some of the responsibility by establishing advisory committees to endorse existing guidelines and make provincial recommendations. However, these provincial guidelines tend to be fairly general, leaving the adoption and enforcement of more rigorous routines in the hands of individual health authorities and hospitals. For example, the Guidelines and Protocols Advisory Committee of BC Health Services has presented two general recommendations:[44] firstly, that pre-surgical testing should be done only as indicated; and, secondly, that laboratory and ECG testing should not be repeated within 3 months (6 months for chest X-rays), barring any changes in the patient's health status. In an attempt to further standardize their preoperative testing practices, hospitals under the Interior Health Authority of BC have agreed to implement the NICE guidelines.[45] However, it will be difficult to evaluate the impact of this decision because pre-implementation data are unavailable.

Estimated cost savings of reduced preoperative testing in Alberta

The development of preoperative testing schemes in Alberta has been similarly fragmented, although there appears to be some potential for substantial cost savings. Finegan et al.[35] estimated that CN$50 per elective surgical case could potentially be saved when anaesthetists order preoperative tests based on the patients' health and preoperative evaluation, rather than relying on pre-established care map protocols. However, this estimate was based on data collected at a tertiary care facility and may not be applicable to all inpatient and outpatient elective surgery cases in Alberta.

The potential benefits of reduced testing are:

- less follow-up testing;
- fewer false-positive test results;
- fewer cancelled surgeries.

Nonetheless, if this average cost differential is representative, the potential savings on all surgical cases in Alberta could total CN$7.3 million per year (2005 value), based on the estimated provincial volume of elective surgery (inpatient and outpatient, excluding cardiac surgery)* in 2005. While this estimate of annual savings is based on a sweeping assumption, it still represents a rough order of magnitude of the potential savings that may be achieved by changing the way in which preoperative tests are ordered in Alberta. However, these potential savings may be accompanied by an elevated risk of adverse events.

The saving per patient reported by Finegan et al.[35] was largely achieved by a decrease in the number of chest X-rays performed. This constituted 74% of the savings, while another 24% resulted from the combined reduction in all laboratory tests. The decrease in ECGs accounted for only 2% of the savings. When the saving from the chest X-rays alone is extrapolated to the provincial volume of elective cases, the estimated saving is CN$5.4 million annually, compared to CN$7.3 million for all tests (2005 value). A sensitivity analysis that takes into account the large uncertainty in the foregoing estimates is shown in Table 2. The estimated annual savings range from CN$4.0 million, when only chest X-rays are considered, to CN$9.1 million when all diagnostic tests are included (2005 value).

* Estimated by multiplying the actual elective surgical cases per capita performed on Capital Health residents (Source: unpublished data supplied by the Capital Health Authority, October 2006) by the provincial population.[3] No data were available for the Calgary Regional Health Authority.

Table 2: Sensitivity analysis of the estimated annual saving from a reduction in preoperative testing in Alberta

Estimated Annual Savings (Millions of CN$ [2005 value])			
	Base Estimate	Lower Bound (-25%)	Upper Bound(+25%)
Chest X-rays only	5.4	4.0	6.7
All tests*	7.3	5.4	9.1

*The 22 preoperative tests considered by Finegan et al.[35]

These potential savings relate to a reduction in the volume of testing and do not include further cost savings related to a decrease in the number of false-positive cases, which usually result in additional diagnostic testing, disruption of operating room workflow, and out-of-pocket expense for patients. In addition, no attempt has been made to determine whether duplicate testing is an issue in Alberta and, if so, the extent to which the overall volume of preoperative testing would be reduced by its elimination.

Historically, patients in Alberta were admitted at least one day prior to surgery for preoperative evaluation, including the requisition of preoperative tests. However, the significant increase in the number of elective surgeries performed on an outpatient basis, and the development of outpatient pre-admission clinics for inpatients, has eliminated the necessity of a pre-surgical stay for patient evaluation.

Discussion

Almost 20 years ago the first systematic review of the evidence around preoperative routine testing on otherwise healthy patients was published by a governmental agency in Sweden (SBU The Swedish Council on Technology Assessment in Health Care).[10] That report had a substantial impact on clinical practice in that country[19] and initiated similar assessments in many other countries.[11] A subsequent analysis of the impact of that report demonstrated substantial cost savings along with improvement in quality of care. Overall, since the publication of the SBU report, there is little evidence to support routine testing in otherwise healthy patients prior to elective surgery. Routine testing, which is now embedded within many institutional care maps, generally uncovers relatively few abnormalities that would not have been otherwise discovered and which usually have little effect on patient management. In fact, some evidence suggests that excessive testing is counterproductive because it generates false-negative results that disrupt operating room schedules and leads to even further unnecessary tests.

The nature of the economic problem associated with routine testing has changed somewhat over the last two decades. In the early 1990's, elective surgery was performed in the inpatient setting in most countries. Patients were routinely admitted the day before elective surgery for preoperative assessment, but the shift of elective surgery to the ambulatory care setting has eliminated the need for this. For patients undergoing inpatient surgery, the use of pre-admission clinics has further reduced the early admission of inpatients for preoperative testing.

However, these institutional changes have not influenced the overall volume of preoperative testing. A recent study in Alberta[35] has shown that a significant reduction in the mix and frequency of preoperative tests, as well as the average cost per patient, could be achieved by allowing anaesthesiologists to prescribe tests based on their assessment of the patient's condition. Nonetheless, that study did not lead to institutional change illustrating that permanent institutional change remains difficult. The development of clinical practice guidelines must be based on credible evidence in order to have any chance of garnering physician compliance. In addition, many physicians are concerned about their legal liability if testing is curtailed. These barriers are compounded by the relatively low unit cost of preoperative diagnostic tests, which has led to institutional inertia on the issue.

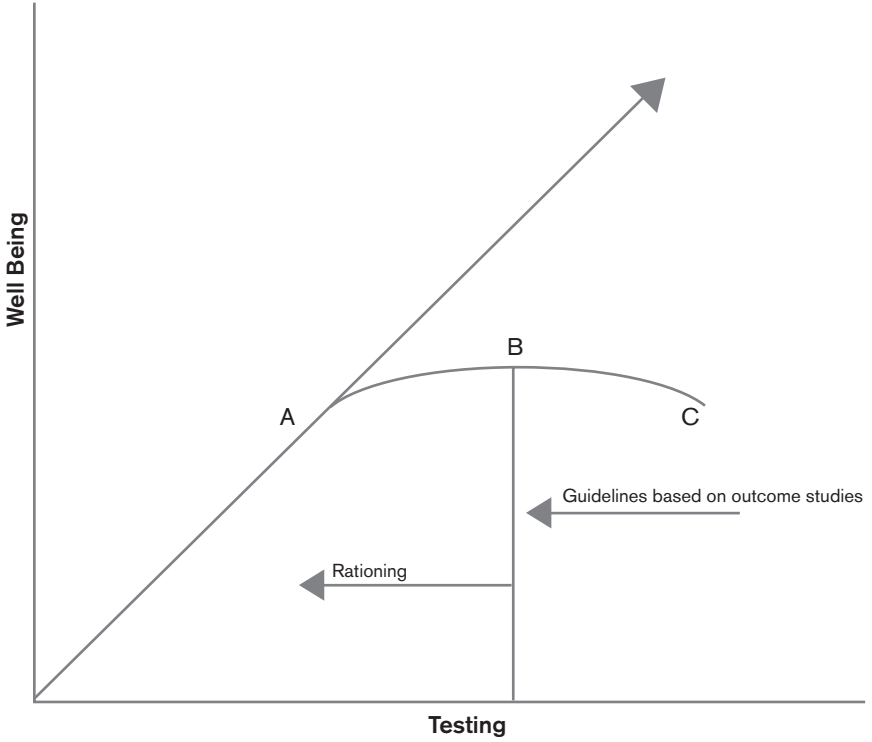
Policy Implications

An important policy issue relates to whether patients and the healthcare system are better served by a policy of preoperative testing constraint, or whether constraint leads to higher long-term costs because important silent health conditions are missed. The absence of rigorous study data upon which to base such decisions is somewhat surprising in view of the enormous interest in and importance of preoperative testing. However, there are several reasons for this:[59]

1) The low incidence of adverse surgical outcomes requires large studies to attain appropriate statistical power.
2) There is a surgical selection bias such that only surgical patients are studied to the exclusion of non-surgical patients who could benefit.
3) The definitions of what constitutes an adverse outcome are inconsistent.
4) Determining a surgical case mix that can provide both clinically useful and generalizable results is difficult.
5) There is a lack of consensus and communication among internists, surgeons, and anaesthesiologists.

The dilemma facing policy-makers as they attempt to formulate meaningful guidelines in the absence of good outcome studies is depicted in Figure 2. The straight line represents the theory that patient well-being increases with more testing. Point B represents the theoretical optimal level of testing, after which the harm of testing eventually outweighs the benefit. Evidence-based guidelines strive to reduce testing, while optimizing patient well-being (i.e. moving from point C to point B), although policy-makers have often failed to assess the subsequent impact of these guidelines on patient health or physician compliance.

Figure 2: Impact of increased testing on patient well-being (adapted from Roizen[90] with permission from Elsevier)



There is concern that government-imposed constraints on preoperative testing may lead to rationing that compromises patient well-being (i.e. moving from point B to point A). Complicating the issue is the fact that different agencies may develop conflicting guidelines. For example, physicians at the Ottawa Hospital in Ontario can follow guidelines developed at the federal (Canadian

Anesthesiologists' Society), provincial (Ontario Preoperative Task Force), or local (pre-admission clinic and the Ottawa Hospital) level,[22] which have discordant recommendations depending on the type of test. Despite the availability of these guidelines, much unnecessary testing still occurs.[22] This non-compliance appears to be related to both the guideline and the physician specialty (surgeons were responsible for 80% of non-compliant orders). These findings support others[29] in suggesting that while policy development is a first step, physician compliance is an equally important and often overlooked component. To be effective, policies need to be consistent and evidence-based. To be adopted and implemented, the policies need to influence physician behaviour through educational and administrative strategies tailored to each individual institution and physician specialty.

Challenges facing Alberta's policy-makers:

- Determining whether testing constraint benefits patients or increases long-term costs.
- Formulating consistent evidence-based policies.
- Changing clinical behaviour.

Conclusion

This report reviewed the issues surrounding preoperative testing routines, examples of strategies to streamline preoperative patient evaluation, and the estimated cost savings from reduced testing as a starting point for further research, policy development, and strategy implementation to optimize preoperative testing. To further this goal, the following multi-pronged approach is recommended.

Recommendation One: A research project be undertaken to examine the use and cost of preoperative chest X-rays in Alberta.

Chest X-rays have a relatively high unit cost, compared with other routine preoperative tests, and thus the greatest potential for cost reduction. The study could consist of:

1) an updated literature review of studies published since 2002;
2) a primary study of chest X-ray utilization in a medically uncomplicated cohort of patients, such as those undergoing joint replacement or cataract surgery, where there is general agreement that a chest X-ray is unnecessary;
3) an estimate of cost savings if testing is constrained according to the medical evidence.

These constitute the first three steps towards the ultimate goal of producing a simple, clinically applicable rule regarding the appropriate use of preoperative chest X-ray. The results of this study would provide locally relevant evidence for the implementation of the next recommendation.

Recommendation Two: Convene a consensus development conference on routine preoperative testing in Alberta.

The conference would involve a group of 12 to 18 experts in the field who deliver the scientific evidence regarding 5 to 8 predetermined questions on preoperative testing to a jury of the same number of people. The experts are carefully selected to represent the most highly regarded and respected researchers, clinicians, and health policy-makers. Potential questions for an Alberta consensus conference may include the following:

- What are preoperative routine investigations?
- How frequently are such routines done in the Alberta health services?
- What are the costs of preoperative routines in Alberta?
- What are the benefits and potential harms of preoperative routines?
- Should preoperative testing be routinely performed on otherwise healthy patients in Alberta?
- What future research is needed in the field?

The final statement would be mailed to all Alberta stakeholders and distributed through publication in a scientific journal.

Recommendation Three: Conduct a follow-up evaluation of the impact of the consensus conference recommendations.

It is expected that recommendations from the consensus conference will result in substantial reductions in chest X-rays, as well as ECGs, in Alberta. This could be assessed by tracking hospital-based utilization rates for chest X-rays and ECGs for 2 years after the consensus conference and comparing them to baseline pre-conference benchmark rates. The evaluation should examine overall rates (all surgeries combined), as well as the rates of individual high volume procedures such as joint replacements. This evaluation will be essential for uncovering unforeseen barriers to compliance.

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Appendix 1: Glossary*

Ambulatory surgery† An operative procedure that does not require the patient to be hospitalized.

ASA grades ASA stands for American Society of Anesthesiologists. ASA grades are a simple scale that describes a patient's fitness to undergo an anaesthetic.

ASA grade 1 – 'normal healthy patient', i.e. without any clinically important comorbidity and without a clinically significant past/present medical history.

ASA grade 2 – 'A patient with mild systemic disease'.

ASA grade 3 – 'A patient with severe systemic disease'.

ASA grade 4 – 'A patient with severe systemic disease that is a constant threat to life'.

ASA grade 5 – 'A moribund patient who is not expected to survive without the operation'.

ASA grade 6 – 'A declared brain-dead patient whose organs are being removed for donor purposes'.

Ref: http://www.asahq.org/clinical/physicalstatus.htm[5]

Care maps‡	A methodology for the mutual decision making and organization of care for a well-defined group of patients during a well-defined period.
Comorbidity	Having two or more diagnosable conditions at the same time.
Generic (routine) testing	Testing carried out on all patients that is not directly related to the operation planned. For example, carrying out electrocardiograms (ECGs) in all patients with minor comorbidity over the age of 75 years would constitute generic testing. However, carrying out a preoperative ECG in patients with minor comorbidity who are undergoing cardiac surgery would not constitute generic testing because the test is related to the planned surgery.
Elective surgery	Scheduled procedure, i.e. not an urgent or emergency procedure.
Preoperative	Before surgery.
Procedure	A surgical procedure, operation, or investigation.
Severity of surgery grades	Grade 1 (minor); Grade 2 (intermediate); Grade 3 (major); Grade 4 (major+)

* Source: all definitions except as indicated from National Collaborating Centre for Acute Care. Preoperative testing: the use of routine preoperative tests for elective surgery.[77]

† Souce: http://www.century-health.com/glossary.asp.[25] Accessed October 14, 2006.

‡ Source: European Pathway Association. Accessed at http://www.e-p-a.org/000000979b08f9803/index.html.[33] Accessed October 14, 2006.

Appendix 2: Search Strategy

A search of the medical literature was conducted between November 27, 2006 and February 1, 2007 to identify studies or background information on routine preoperative testing for elective surgery (Table A.1). Major electronic databases used included The Cochrane Library, the NHS Centre for Reviews and Dissemination (CRD Databases: NHS EED, HTA, DARE), PubMed, EMBASE, CINAHL, and Web of Science. In addition, relevant library collections and the web sites of practice guideline clearing houses, regulatory agencies, evidence-based resources, and other HTA-related agencies (AETMIS, CADTH, ECRI) were searched. Internet search engines were also used to locate grey literature.

Medical Subject Headings (MeSH) terms relevant to this topic are: preoperative care; surgery, elective, diagnostic tests, routine.

Table 1: Databases and search terms used in the search strategy

Database	Platform/Date	Search Terms
Core Databases		
CRD Databases (DARE, HTA & NHS EED)	http://nhscrd.york.ac. Uk November 27, 2006	#1 "preoperative test" OR "preoperative testing" OR "preoperative tests" OR "preoperative evaluation*" OR "preoperative procedure*" OR "preoperative care" #2 "elective surgery" OR "elective surgeries" #3 #1 AND #2
PubMed National Library of Medicine (MEDLINE, Pre-MEDLINE, HealthSTAR)	http://www.pubmed. Gov November 27, 2006	#1 elective surgery OR elective surgeries #2 "Diagnostic Tests, Routine"[MeSH] OR preoperative evaluation* OR preop evaluation* OR preop test OR preop tests OR preop testing OR preop procedure* OR preoperative test* OR preoperative procedure* #3 #1 AND #2
CINAHL Cumulative Index to Nursing & Allied Health Literature	Ovid November 27, 2006 <1982 to November Week 3 2006>	#1 exp Diagnostic Tests, Routine/ or exp Preoperative Care/ #2 (preoperative test or preoperative procedure$ or preoperative evaluation$ or preoperative assessment$).mp #3 (preop test$ or preop assessment$ or preop procedure$ or preop evaluation$).mp. #4 or/1-3 #5 exp Surgery, Elective/ #6 4 and 5 #7 review.ab,pt #8 meta-analysis.ab,pt,ti #9 or/7-8 #10 (letter or comment or editorial).pt #11 9 not 10or/9-10 #12 6 and 11

Table 1: Databases and search terms used in the search strategy (continued)

Database	Platform/Date	Search Terms
Core Databases (continued)		
EMBASE	Ovid November 27, 2006 <1996 to 2006 Week 46>	#1 exp Preoperative Evaluation/ or exp Preoperative Care/ #2 (preoperative procedure$ or preoperative test$ or preoperative assessment$).mp. #3 preoperative.mp and exp Diagnostic Test/ #4 or/1-3 #5 exp Elective Surgery/ #6 4 and 5 #7 review.ab,pt. #8 meta-analysis.ab,ti,pt #9 or/7-8 (36470) #10 8 or 9 (37921) #11 (letter or comment or editorial).pt #12 10 not 11 #13 6 and 12
HealthStar	Ovid November 27, 2006 <1966 to October 2006>	#1 (preoperative procedure$.mp. or preoperative evaluation or preoperative assessment or "preoperative test$").mp #2 (exp Preoperative Care/ or exp Diagnostic Tests, Routine/) #3 or/1-2.mp. #4 exp Surgical Procedures, Elective/ #5 limit 4 to (humans and yr="2001 - 2007") #6 review.ab,pt. #7 meta-analysis.ab,pt,ti #8 or/6-7 #9 (letter or comment or editorial).pt #10 8 not 9 (223) #11 5 and 10
Academic Search Premier	EBSCOhost November 27, 2006	S1 (preoperative care or preoperative procedure* or preoperative test* or preoperative assessment* or preoperative evaluation* or preop care or routine diagnostic test*) S2 elective surgery S3 (S1 and S2) S4 (S3 or S2 or S1)
Library Catalogues		
NEOS (Central Alberta Library Consortium)	www.library.ualberta.ca/catalogue January 29, 2007	Preoperative testing

Table 1: Databases and search terms used in the search strategy (continued)

Database	Platform/Date	Search Terms
Library Catalogues (continued)		
AMA Clinical Practice Guidelines	January 29, 2007	Browsed headings of guidelines
CMA Infobase	January 29, 2007	Preoperative testing
National Guideline Clearinghouse	www.ngc.gov January 29, 2007	"preoperative testing" AND "elective surgery"
Clinical Trials		
Clinical Trials.gov	http://clinicaltrials.gov January 29, 2007	Preoperative testing
Evidence-Based Medicine Resources		
Bandolier	www.jr2.ox.ac.uk/bandloier January 30, 2007	Preoperative testing
BestBETS	www.bestbets.org January 30, 2007	Preoperative testing
Grey Literature		
Google	www.google.ca January 29, February 1, 2007	"preoperative testing" AND "elective surgery"
HTA Resources		
AETMIS	www.aetmis.gouv.qc. ca January 29, 2007	Preoperative testing AND elective surgery
ICES (Institute for Clinical and Evaluative Sciences	www.ices.on.ca January 29, 2007	Preoperative testing
HTAi vortal	www.htai.org/vortal January 29, 2007	Preoperative testing filetype:pdf
ECRI	www.ecri.org January 29, 2007	(preoperative OR preop) AND (test* OR procedure* OR evaluation*) AND (elective surgery OR elective surgeries)

* is A truncation character that retrieves all possible suffix variations of the root word e.g. surg* retrieves surgery, surgical, surgeon, etc. In databases accessed via the Ovid platform the truncation character is $.

† Searches were limited to: publication dates 2001-2006; publication type - systematic reviews; human studies; and English language only. These limits were applied in databases where such functions are available.

Appendix 3: Summary of preoperative chest radiograph and electrocardiogram results

Table 1: Summary of preoperative chest radiograph results (includes routine and indicated tests)*

First author	Number of tests	Abnormal results	Changes in clinical management
	(N)	N (%)	N(%)
Krupski [57]	161	42 (28.1)	8 (5.0)
Silvestri [103]	6111	1116 (18.3)	313 (5.1)
Pal [82]	320	192 (60.0)	1 (0.3)
Ishaq [49]	452	203 (44.9)	1 (0.2)
Wattsman [117]	22	3 (13.6)	0
Bouillot [18]	2092	125 (6.0)	
Clelland [28]	238	Not stated	1 (0.4)
Khong [54]	203	93 (45.8)	3 (1.5)
Ranparia [90]	236	28 (11.9)	
Boland [16]	61	4 (6.6)	1 (1.6)
Perez [84]	2151	485 (22.6)	45 (2.1)
Adams [2]	133	6 (4.5)	0
MacDonald [65]	145	7 (4.8)	
Sommerville [104]	319	48 (15.0)	4 (1.3)
Bhuripanyo [12]	933	181 (19.4)	34 (3.6)
Gagner [40]	1000	74 (7.4)	0
McCleane [67]	297	127 (43.3)	
Charpak [27]	1101	568 (52.0)	51 (4.6)
Ogunseyin[78]	203	122 (60.1)	(13.3)
Tape [107]	336	116 (34.5)	
Umbach [112]	1175	118 (10.0)	15 (1.3)
Boghosian [15]	136	88 (64.7)	
McKee [69]	327	121 (37.0)	1 (0.3)
Mendelson [71]	332	62 (18.7)	
Wiencek [119]	237	101 (42.6)	10 (4.0)
Muskett [74]	119	35 (29.4)	6 (5.0)

	Postoperative complications	Routine	Prospective data	Consecutive recruitment	Asa grades stated
	N(%)				
	8 (5.0)	Not stated	X	√	X
		Routine Only	√	X	ASA I to V
		Routine Only	X	X	X
		Routine Only	X	√	X
	0	Routine & indicated	√	√	ASA I to III
	2 (0.1)	Routine Only	√	X	X
	1.4 (5.0)	Not stated	√	√	X
	3 (1.5)	Routine Only	X	X	ASA I to II
		Not stated	X	X	X
		Routine Only	X	X	X
		Routine Only	X	X	ASA I to II
		Routine Only	X	X	X
		Routine Only	√	X	X
		Routine & indicated	X	X	ASA I to IV
	0	Routine Only	√	√	X
		Not stated	X	X	X
		Routine & indicated	√	X	ASA I to V
	193 (34.0)	Routine & indicated	√	X	X
		Routine Only	X	√	X
	12 (3.6)	Routine Only	X	X	X
	14 (1.2)	Routine & indicated	X	√	X
	12 (8.8)	Routine Only	X	X	X
	27 (8.3)	Routine & indicated	√	X	X
		Routine Only	X	X	X
		Routine & indicated	√	√	X
		Routine & indicated	X	√	X

Table 1: Summary of preoperative chest radiograph results (includes routine and indicated tests)* (continued)

First author	Number of tests	Abnormal results	Changes in clinical management
Rucker [98]	368	1 (0.3)	0
Seymour [102]	233	134 (57.5)	
Tornebran[110]	91	43 (47.3)	
Wood [121]	749	35 (4.7)	3 (0.4)
Farnsworth [34]	350	31 (8.9)	
Rossello [97]	682	20 (2.9)	2 (2.4)
Loder [62]	1000	97 (9.7)	
Petterson [85]	1527	134 (8.8)	2 (0.01)
Sane [99]	1500	111 (7.4)	57 (3.8)
Rees [91]	667	299 (44.8)	

*Papers included in the HTA review

The number of tests carried out may differ from the sample size in some studies. This occurs in papers reporting the results of multiple preoperative tests because not all of the patients in the study sample received all of the preoperative tests detailed in the paper.

	Postoperative complications	Routine	Prospective data	Consecutive recruitment	Asa grades stated
	0	Routine Only	X	X	X
	10 (5.8)	Routine Only	√	X	X
		Routine Only	X	√	X
		Routine Only	X	X	X
		Routine & indicated	X	X	X
	0	Routine & indicated	X	X	X
		Routine Only	X	√	X
		Routine Only	X	√	X
		Routine Only	√	√	X
		Routine Only	X	√	X

Table 2: Summary of preoperative electrocardiogram study results from the eligible studies (includes routine and indicated tests)*

Study	Number of tests	Abnormal results	Changes in clinical management
	(N)	N (%)	N (%)
Gauss [41]	185	40 (21.6)	
French [39]	127	42 (33.1)	
Haug [46]	24	0	
Murdoch [73]	154	40 (26.0)	8 (5.3)
Rosenfeld [95]	1006	523 (54.5)	376 (37.4)
Polanczyk [86]	4181		
Biavati [14]	65	4 (6.2)	
Landesberg [58]	405	134 (33.1)	
Tait [106]	573	211 (36.8)	
Callaghan [23]	230	57 (24.8)	
Liu [60]	537	17 (3.2)	
Perez [84]	2401	250 (10.4)	25 (1.0)
Allman [4]	325	64 (19.7)	
Kirwin [56]	96	9 (9.4)	
Older [79]	187	55 (29.4)	
Adams [2]	90	12 (13.3)	0
Bhuripanyo [13]	385	130 (32.9)	10 (2.5)
Gold [43]	751	3.21 (42.7)	
MacDonald [65]	145	3 (2.1)	3 (2.1)
Sommerville [104]	290	25 (17.9)	4 (1.4)
McCleane [68]	877	395 (45.0)	
Yipintsoi [122]	424	61 (14.4)	
Charpak [26]	1610	609 (37.8)	116 (7.2)
Johnson [50]	212	140 (66.0)	0
Turnbull [111]	632	101 (6.0)	0
Carliner [24]	198	125 (63.1)	
Muskett [74]	145	53 (36.5)	2 (1.4)
Paterson [83]	267	82 (22.3)	2 (1.4)
Seymour [102]	222	175 (78.8)	

* Papers included in the HTA review

The number of tests carried out may differ from the sample size in some studies. This occurs in papers reporting the results of multiple preoperative tests because not all of patients in the study sample received all the preoperative tests detailed in the paper.

Source: National Institute for Clinical Excellence (NICE) (2003) CG 3 Preoperative Tests. The use of routine preoperative tests for elective surgery. Evidence, methods and Guidance. London: NICE. Available from www.nice.org.uk Reproduced with permission.

	Postoperative complications	Routine	Prospective data	Consecutive recruitment	Asa grades stated
	N (%)				
	16 (8.6)	Routine only	√	√	ASA I to IV
		Routine only	X	X	ASA I to III
	0	Routine & indicated	X	X	ASA I to II
	0	Routine & indicated	X	X	X
		Routine only	√	√	X
	256 (6.1)	Routine only	√	√	ASA I to IV
	4 (6.2)	Not stated	X	X	X
	19 (4.7)	Routine only	X	X	X
	129 (22.5)	Routine only	√	√	ASA I to II
		Routine & indicated	X	X	
		Not stated	X	X	ASA I to IV
		Routine only	X	X	ASA I to III
		Routine only	X	X	ASA I to II
	21 (21.9)	Routine only	X	X	X
	14 (7.5)	Not stated	X	X	X
		Routine only	X	X	X
	5 (1.3)	Routine only	√	√	X
	12 (1.6)	Routine & indicated	X	X	ASA I to III
	3 (2.1)	Routine only	X	X	X
		Routine only	X	X	ASA I to IV
		Routine only	X	X	ASA I to V
	1 (1.7)	Routine only	X	X	X
		Routine & indicated	√	√	X
	0	Not stated	√	√	X
	12 (1.9)	Not stated	X	X	X
	6 (3.0)	Routine only	√	√	X
	0	Routine only	√	√	S
	0	Routine & indicated	√	√	X
	18 (8.1)	Routine only	X	X	X

Appendix 4: Costs of Preoperative Testing

Table 1: Economic analyses of preoperative testing – cost of routine testing*

First author	Year	Currency	Cost comparison
Adams[2]	1992	US$ 1991	Observed practice vs. not testing (charges not costs)
Archer[8]	1993	Canada$ 1992	Routine testing vs. not testing
Kaplan[52]	1985	US$ 1985	Observed practice vs. indicated testing
Kettler[53]	1996	US$ 1995	Routine testing vs. not testing (charges not costs)
Robbins[92]	1979	US$ 1978	Routine testing vs. not testing
Sommerville[104]	1992	South African Rand 1991	Observed practice vs. indicated testing
Turnbull[111]	1987	US$	Observed practice vs. not testing
Callaghan[23]	1995	UKE 1994	Observed practice vs. not testing
Hoare[47]	1993	OKE 1993	Routine testing vs. not testing

	Type of test	Incremental cost per patient	Incremental total cost	Incremental cost-effectiveness
	Various	Group1: $175 Group2: $66	Group1: $18,397 for sample Group2: $12,707 for sample	Group1: $18397 per abnormal test that changed treatment Group2: $4236 per abnormal test that changed treatment
	Chest x-ray	$23		Can$2,300 Cost per abnormality Can$23,000 per clinically significant abnormality Can$115,000-Can$460,000 per health benefit
	Various laboratory tests		$95,800 annually for institution	$4,170 per extra significant abnormality $4.2m per life saved
	Pregnancy	$25		$1,050 per pregnancy detected in adolescents $7,750 per pregnancy detected in adults
	Various			Various from $1,400 per case found with pregnancy testing to $1.1m with PTT
	Chest x-ray	R5.73	R4,565 for sample	Indicated: R134 per case detected; Non-indicated age>60: R262 per case detected; Non indicated age <60: R2,396 per case detected
	Various	$102.97	$104,000	$26,000 per complication averted
	ECG	€2.50	€885 for sample (2 week intake for unit)	
	FBC	Lab costs €21.51 Wasted theatre time €1.04 Extra clinic visits €1.04	Costs for unit per year: Lab costs: €8000 Wasted theatre time: €500 Extra clinic visits: €500	

Table 1: Economic analyses of preoperative testing - cost of routine testing* (continued)

First author	Year	Currency	Cost comparison
Livesey[61]	1993	UKE 1992	Routine testing vs. not testing
Macario[64]	1992	US$ 1991	a. 1979 vs. 1987 b. observed practice vs. indicated testing (Charges not costs)
Narr[75]	1991	US$ 1988	Observed practice vs. not testing
Velanovich[115]	1993	US$	Routine testing vs. indicated testing
Wattsman[117]	1997	US$ 1994	Observed practice vs. indicated testing

*Source: National Institute for Clinical Excellence (NICE) (2003) CG 3 Preoperative Tests. The use of routine preoperative tests for elective surgery. Evidence, methods and Guidance. London: NICE. Available from www.nice.org.uk Reproduced with permission.

Table 2: Cost Analysis or preoperative evaluation clinics – cost savings*

First author	Year	Currency
Boothe[17]	1995	Canadian $1992/3
Fischer[36]	1996	US $1995
France[38]	1997	Belgian Franc 1996
MacDonald[65]	1992	UK €1991
Pollard[88]	1996	US $1995
Power[89]	1999	Australian $1997
Starsnic[105]	1997	US $1996

*MacDonald et al calculated additional costs instead of savings. This is because this cost component was not measured incrementally; testing costs were not estimated for this control group.

	Type of test	Incremental cost per patient	Incremental total cost	Incremental cost-effectiveness
	FBC	€2.50	€2,000 for a 3 year consultant unit per year	
	Various	a. $7.08 b. $48.47	a. $320m in USA per year b. $1.3bn in USA per year	
	Various	$35.95	$2.9bn-$4.3bn in USA per year	
	Various	$190.48	>$80,000 for sample	
	Various	$60.37	$5,573 for sample $413,467 for medical facility	

	Incremental cost savings – preoperative testing		Incremental cost savings – all components	
	Per patient	Total	Per patient	Total
	Lab: Can $1.17 Rad: Can $25.49		Can $366.38	Can $758,767 annually for hospital
	$112.09	$1.01m annually for hospital		
	BEF 2,212	BEF 1,247m annually for Belgium		
	€25.37	€3,730 for sample	€33.74	€4,960 for sample
				%530,00 annually for hospital
	AUS $25.44	AUS $57,600 annually for hospital		
	$20.89 $20.89	$173,799		

Appendix 5: Ontario Preoperative Grid

White areas indicate **recommended** test

Light grey areas indicate tests **not recommended**

Dark grey areas indicate the presence of **variation** between hospitals represented in the development of the grid. Details available upon request.

Please indicate tests required with a check mark

			CBC			
	Chest X-Ray	ECG	M	F	Type/Screen	INR/PT
Surgical Procedure on Type & Screen List No of Units						
Age: < 45						
45 - 70						
> 70						
Cardiovascular disease/HBP						
Pulmonary disease						
Malignancy						
Hepatic disease/ETOH						
Renal Disease						
Blood disorders						
Diabetes						
Smoking > 20 pack years (1 pack year equals 1 pack daily for one year)						
Use of Digoxin, Diuretics, ACE inhib.						
Use of Steroids						
Use of Anticoagulants						
CNS disease						
Sickle Risk*						

* Sickle risk areas: West Central Africa, Saudi Arabia, East Central India, southern Italy, northern Greece, southern Turkey, USA, Caribbean.

This table is based on the format currently in effect at the Sunnybrook and Women's College Health Sciences Centre

Other Tests

Signature Date

Executed by Date

	Lytes	Urea Creat.	Blood glucose	AST/ALP/BILI	Sickle Cell Screen

Grid Created by the Ontario Preoperative Task Force:

Dr. Neal Badner - Associate Professor, Department of Anesthesia; Medical Director, Preadmission Clinic, London Health Sciences Centre; **Dr. Greg Bryson** - Assisant Professor of Anaesthesia, University of Ottawa; Head of Pre-admission Unit - Ottawa Hospital; **Dr. Brian Kashin** - Corporate Director of Critical Care, Corporate Chief of Anaesthesiology; William Olsar Health Centre, Brampton Memorial Hospital Campus; **Dr. Mark Mensour** - Staff Emergency Medicine and Anesthesia, Algonquin health Services; **Dr. Danny Riegert** - Medical Director, Pre - Operative Assesment Centre and Outpatients, Sunnybrook and Women's College HSC, Associate professor, U of T; **Dr. Janet van Vlymen** - Medical Director, Preadmission Services, Kingston General Hospital; **Dr. David Wong** - Medical Director, Preadmission Program, Toronto Western Hospital.

This grid is a consensus document and has been created using the Preoperative testing guideline grids from the following hospitals: Brantford General Hospital, London Health Sciences Centre, Ottawa Hospital, Kingston General Hospital, Sunnybrook and Women's College Health Sciences Centre, Toronto Western Hospital.

Disclaimer: The content of this grid is provided as a practice aid and may be adapted by individual hospitals who are in the process of reviewing their preoperative testing practices. This grid is not a standard of medical care and it is not intended to be a comprehensive statement concerning the ordering of preoperative tests, nor meant to replace clinical judgement of individual cases. Neither the Task Force Members nor the Guidelines Advisory Committee assume any responsibility for liability arising from any error or omission from this tool grid or from the use of any information contained here within.

Endorsed by the Ontario Guidelines Advisory Committee
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Notes

Notes

Notes

IHE Publications

- Cost-effectiveness in the detection of syphilis
- The use and benefit of teleoncology services
- Screening newborns for hearing
- Screening newborns for cystic fibrosis
- The use of nitric oxide in acute respiratory distress syndrome
- Rountine pre-operative testing – is it necessary?
- Consensus Statement on Self-monitoring in Diabetes
- Consensus Statement on How to Prevent Low Birth Weight

Routine Preoperative Tests - are they necessary? is about routine preoperative testing on otherwise healthy patients who are scheduled for elective surgery. This report is a synopsis of the findings from some of the major health technology assessments and systematic reviews on preoperative testing published during the last two decades. The implications of these results for Alberta are discussed in order to assist decision-makers in efforts to revise institutional preoperative testing routines.

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