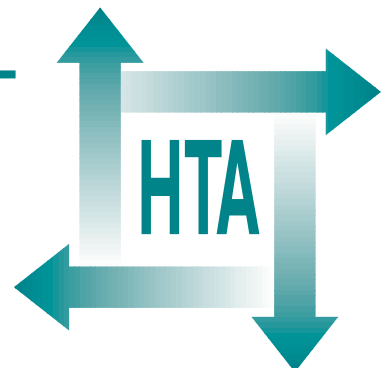


Routine preoperative testing: a systematic review of the evidence

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List of abbreviations

ASA	American Society of Anesthesiologists
BT	bleeding time
ECG	electrocardiogram
ENT	ear, nose and throat
FBC	full blood count
Hb	haemoglobin
PT	prothrombin time
PTT	partial thromboplastin time
UTI	urinary tract infection

Executive summary

Objectives

- To review the available evidence on the value of routine preoperative testing in healthy or asymptomatic adults.
- To assess the completeness of existing reviews of preoperative testing and how applicable their conclusions are to the UK.
- To identify areas for further research.

How the research was conducted

The databases Medline, Embase, *Biological Abstracts*, *Science Citation Index* and HealthSTAR were thoroughly searched for relevant articles which were then classified and appraised. The databases of the Centre for Reviews and Dissemination (DARE and NHS Economic Evaluations Database) and the Cochrane Collaboration (the Cochrane Library) were also used to verify the completeness of the search.

In this review, 'routine' tests are defined as those ordered for an asymptomatic, apparently healthy individual in the absence of any specific clinical indication, to identify conditions undetected by clinical history and examination.

Research findings

No controlled trials of the value of the following routine preoperative tests have been published. All available evidence reports the results of case-series.

Chest X-ray

Few studies allow the outcome of routine chest X-rays to be distinguished from those of indicated chest X-rays, and fewer have gone beyond abnormality yields to examine the impact on clinical management.

Findings from routine preoperative chest X-ray are reported as abnormal in 2.5–37.0% of cases, and lead to a change in clinical management in 0–2.1% of patients. The effect on patient outcomes is unknown.

Both abnormality yield and impact on patient management rise with age and poorer American Society of Anesthesiologists (ASA) status.

The limited evidence on the value of a chest X-ray as a baseline measure suggests that it will be of value in less than 9% of patients.

Electrocardiography

The findings from routine preoperative electrocardiograms (ECGs) are abnormal in 4.6–31.7% of cases, and lead to a change of management in 0–2.2% of patients. The effect on patient outcomes is unknown.

The proportion of abnormal tests rises with age and worsening ASA status.

The predictive power of preoperative ECGs for postoperative cardiac complications in non-cardiopulmonary surgery is weak.

There is no evidence to support the value of recording a preoperative ECG as a 'baseline'.

Haemoglobin measurement and blood counts

Routine preoperative measurement shows that the haemoglobin level may be lower than 10–10.5 g/dl in up to 5% of patients, but that it is rarely lower than 9 g/dl. The routine test leads to a change of management in 0.1% to 2.7% of patients.

Routine preoperative measurement shows that the platelet count is abnormally low in less than 1.1% of patients, and that platelet count results rarely if ever lead to change in management of patients.

Routine preoperative white blood cell count is abnormal in less than 1% of patients, and rarely if ever leads to change in management of patients.

Tests of haemostasis

Abnormalities of bleeding time, prothrombin time and partial thromboplastin time are found in up to 3.8%, 4.8% and 15.6% of routine preoperative tests, respectively. The results of these tests very rarely lead to change in the clinical management of patients.

Biochemistry

In routine preoperative tests of serum biochemistry, abnormal levels of sodium or potassium are found in up to 1.4% of patients, and abnormal levels of urea or creatinine are found in up to 2.5% of patients. Abnormal levels of glucose are found in up to 5.2% of patients. These abnormalities rarely lead to change in clinical management of patients.

Urine testing

Routine preoperative urinalysis finds abnormal results in 1–34.1% of patients, and leads to a change of management in 0.1–2.8% of patients. The only abnormality that leads to a change in management of patients is the finding of white blood cells in the urine.

There is no good evidence that preoperative abnormal urinalysis is associated with any postoperative complication in non-urinary tract surgery.

There is little or no apparent value in routine preoperative urinalysis as an opportunistic screening test for unrelated disease, since even when abnormalities are found, they evoke no change in clinical management.

Conclusions

The tests reviewed produce a wide range of abnormal results, even in apparently healthy individuals.

The clinical importance of many of these abnormal results is uncertain.

The tests lead to changes in clinical management in only a very small proportion of patients, and for some tests virtually never.

The clinical value of changes in management which do occur in response to an abnormal test result may also be uncertain in some instances.

The power of preoperative tests to predict adverse postoperative outcomes in asymptomatic patients is either weak or non-existent. However, the same tests may have greater predictive power in defined high-risk populations.

For all the tests reviewed, a policy of routine testing in apparently healthy individuals is likely to lead to little, if any, benefit. It remains possible that routine testing could still be of some benefit in

asymptomatic patients in defined groups, such as those over a given age. No good evidence exists to suggest that this will be the case but conversely, no good evidence exists to suggest that it will not.

Recommendations

Primary research studies

Further studies should investigate whether routine testing would be of benefit in a clearly defined asymptomatic population who are potentially at risk of perioperative complications, for example, older patients. Such studies could include the following:

- prospective case-series examining the impact on clinical management of routine testing in patients over, for example, 60 years of age
- randomised trials of alternative testing policies in older patients who may be at higher risk of complications (if such a trial were to be undertaken it should include an economic evaluation, address the marginal benefits of testing over clinical examination, and allow results for each individual type of test to be isolated if more than one test is the subject of the trial)
- studies to assess the value of the preoperative chest X-ray or ECG as a 'baseline' in defined groups of patients at high risk of postoperative cardiorespiratory complications.

Analysis of existing research

Taking the present review as a starting point, further analysis of the existing evidence could examine a number of issues in greater depth. These issues would include the following.

- Estimates of predictive values or likelihood ratios for each test in predicting postoperative events should be derived from those studies that contain adequate data.
- The potential for pooling results from existing studies should be examined. Data from those with similar study samples, methods and outcomes could be pooled to provide more precise estimates of abnormality and impact rates for each test.
- Economic modelling of the likely resource costs and patient benefits of current practice should be undertaken using best estimates of test performance.
- A review of available evidence on the performance of test selection algorithms, such as the US HealthQuiz instrument, should be undertaken.

Chapter I

Introduction

Background

The routine ordering of a range of tests preoperatively, whether or not indicated by an individual patient's clinical features, has been a part of clinical practice for many years. The purposes of such testing may include:

- the identification of unsuspected conditions which may require treatment preoperatively or a change in anaesthetic or surgical management perioperatively
- the prediction of postoperative complications
- the establishment of a 'baseline' measurement for later reference
- opportunistic screening, unrelated to the surgical procedure.

We have found no estimates in the published literature of the current scale of routine preoperative testing in the UK, nor of the overall costs of such testing to the NHS. Nonetheless, there is a widely held view that many of the tests currently performed are unnecessary, an opinion supported by the conclusions of two earlier reviews, one from Sweden¹ and one from the Basque country.² In both of these reviews it was concluded that routine preoperative tests were unnecessary, and that tests should only be ordered in the presence of a specific clinical indication.

While both of these reports have made a valuable contribution to the literature in this area, it is not clear from the reviews themselves whether they are comprehensive in their coverage of the published evidence. Nor is it clear that the evidence identified was assessed against explicit standards for critical appraisal to ensure that the conclusions reached took account of the quality of studies.

In addition, many further studies on various preoperative tests have been reported since the Swedish review¹ was published in 1989, and a smaller number of important studies have appeared since the review from the Basque country² was published in 1995. The conclusions from the earlier reviews may need to be modified in the light of the data now available, and, in any case, they should be judged in the context of current surgical and anaesthetic practice in the UK.

Objectives of this review

The overall aim of the present review is to assess the currently available evidence on the value of routine preoperative testing in healthy or asymptomatic adults. This involves identifying both those areas where clear evidence is available to guide policy, and those where the lack of evidence highlights a need for further research.

The specific objectives of the review include:

- an 'audit' of the completeness of the two existing reviews of routine preoperative testing and the applicability of their conclusions to the UK context
- systematic identification and review of additional evidence that was not included in the existing reviews
- identification of areas where further research is required as a matter of priority.

It should be noted that it is **not** an objective of the review to generate evidence-based 'clinical guidelines' which indicate the various circumstances in which tests should and should not be ordered. Nor is it our objective to estimate the current costs to the NHS of routine preoperative testing, or the costs that might be avoided by the implementation of defined guidelines for testing. The purpose is simply to identify where good quality evidence exists which might inform such guidelines.

Scope of the review

The scope of a review of the value of all possible preoperative tests would be very wide. There are some important limits to the scope of the current review.

The definition of routine preoperative testing

There are many reasons why preoperative tests may be ordered. The attention of this review will focus primarily on routinely ordered tests.

The term 'routine' is ambiguous and needs clarification. One meaning of routine tests might be all those ordered according to some pre-existing

rule which is never altered by the individual clinician. Thus, a chest X-ray might be ordered 'routinely' in all patients more than 50 years old who smoke.

In this report, a slightly different definition is taken. We take routine here to mean tests ordered for asymptomatic, apparently healthy individuals, in the absence of any specific clinical indication, to identify conditions undetected by clinical history and examination. According to this definition, if a patient is found to have specific clinical features suggesting that a test might be useful (an 'indication'), then we define the test as 'indicated' rather than 'routine'.

The range of routinely conducted tests

In principle, a very large number of tests could be evaluated for their ability to detect important conditions preoperatively. In practice, only a limited selection of tests are in common use in the UK, and these coincide with those reviewed in the earlier reports.^{1,2} The present review therefore covers the following:

- chest X-ray
- electrocardiogram (ECG)
- haemoglobin (Hb) and blood cell counts
- tests of haemostasis
- tests for urea, electrolytes and blood glucose
- urinalysis.

The patient population

The scope of the review from Sweden¹ was explicitly restricted to studies of adult patients undergoing elective surgery in the specialties of general surgery, orthopaedics, urology and gynaecology. The review from the Basque country² included children, and did not explicitly limit attention to particular specialties.

In this review we have considered evidence relating to any age group and all surgical specialties. However, because the focus of both earlier reviews was on the general anaesthetic management of patients, papers which report findings that relate only to specialist anaesthetic practice (such as obstetric or cardiothoracic anaesthesia) have been excluded.

Chapter 2

Methods

Search strategy

A very sensitive strategy was used to ensure retrieval of all relevant references. For example, the Medical Subject Heading index term on Medline 'Diagnostic-Tests-Routine' was found to cover only about two-thirds of relevant references. In contrast, the term 'Preoperative-Care', although covering a range of interventions and not restricted to diagnostic pre-assessment, frequently covered relevant materials. The search strategy therefore had to use numerous permutations of both free-text and index terms in order to capture data relating to three concepts:

- the population (i.e. healthy, asymptomatic preoperative patients)
- the intervention, which could either be routine preoperative testing in general or specific tests (e.g. chest X-ray, clotting tests)
- the study design, which had to be rigorous enough to inform the review.

These general concepts were operationalised and tested on the Medline database, and subsequently

translated to other databases as appropriate. For example on the Embase database there is the facility to identify papers classified as being a 'major-clinical-study' as well as looking for other terms that reflect the general soundness of the methodology. A summary of the search terms used is shown in *Table 1*.

This two-tier search strategy – searching for either routine diagnostic tests in general or for specific tests or types of test – ensures a reasonable amount of confidence in the sensitivity of the search strategy. It is National Library of Medicine indexing policy to index to the highest level of specificity, which means that if we had not used such a search strategy there would have been a distinct risk of missing many relevant documents.

Data sources

Four core biomedical databases were searched: Medline, Embase, *Biological Abstracts*, and Science Citation Index (through BIDS). In addition the

TABLE 1 Search terms used in the review

Population	Intervention	Study design
Surgery-Elective	Diagnostic-Tests-Routine	Predictive-value-of-tests
asymptomatic	Preoperative-Care	Sensitivity-and-specificity
preoperative	Hematologic-Tests	sensitivity
pre-operative	Respiratory-Function-Tests	specificity
Ambulatory-Care	Liver-Function-Tests	randomized-controlled-trial
	Heart-Function-Tests	review-academic
	Spirometry	meta-analysis
	Echocardiography	clinical-trial
	routine AND test*	
	urine test*	
	blood test*	
	chest xray*	
	etc.	

HealthSTAR database (formerly HealthPlan), which has an emphasis on health technology assessment and evaluation of health services, was searched painstakingly for any potentially relevant items. The pre-existence of the reviews from Sweden and the Basque country,^{1,2} together with the specific commissioning brief, resulted in a focus on materials published since the first of these reviews (i.e. 1989). However, the searches conducted over the full Medline system (1966 to mid-1996) were used to check on the comprehensiveness of the two earlier reviews. In addition, the lists of references cited in the reviews, and in the papers retrieved through the search, were used to validate the strategy and extend it to any studies that had been missed.

The new 'evidence-based' databases of the Centre for Reviews and Dissemination (DARE and NHS Economic Evaluations Database) and the Cochrane Collaboration (the Cochrane Library), though more limited in their coverage, were also used to verify the comprehensiveness of the search coverage.

Time periods searched

Reviews and randomised controlled trials of pre-operative testing were searched for over the period 1966 to mid-1996 on Medline using the Cochrane Collaboration's specialist search strategies.^{3,4} An

equivalent approach was used for the Embase database. The yield of randomised controlled trials was very low, and so the specialist diagnosis search strategies⁵ developed by McMaster University's Health Information Research Unit were adapted for use over the same time period. A far more sensitive search was used over the period 1989 to mid-1996 across all the databases with the aim of minimising the risk of overlooking potentially relevant articles published since the review from Sweden.¹

Reference management

Retrieved references were loaded into a dedicated reference database (Reference Manager®). The list of bibliographic references and abstracts (if available) thus generated was screened by the reviewer to determine which papers were relevant to the review. Articles were categorised for definite inclusion or exclusion or, in cases of doubt, the full article was obtained. Photocopies of articles for definite or potential inclusion were subsequently evaluated by the reviewer and a final assessment of the value for inclusion or exclusion was made at this point.

Classification of relevant papers

Papers judged relevant to the scope of the review were individually classified and appraised. The

TABLE 2 Classification of reviewed papers

Field	Terms	Field	Terms
Type of paper	Primary empirical research Systematic review Non-systematic review or editorial Consensus statement, guidelines Methodological issues Opinion, letters with no new data Other	Study design	Randomised controlled trial Controlled non-random or cohort Case-control Uncontrolled before and after intervention Case-series with no change in intervention Single case report Expert opinion
Tests considered	Chest X-ray ECG Urinalysis Hb/blood counts Haemostatic tests Biochemistry	Clinical setting	Elective Emergency Day case
Sample population	Number Age group/age range Diagnostic group	Surgical specialties	All listed in paper
		Outcome	Adverse patient events (e.g. postoperative complications) measures used Clinical management Prevalence of abnormal test result Test ordering behaviour Other

initial classification grouped papers according to whether they contributed primary empirical evidence to the review or did not (i.e. papers that were editorials, commentaries, letters, etc.). Only those papers which included primary research data were included in the detailed review of each test, although other types of paper were important in contributing to a fuller understanding of the methodological and clinical issues involved. Where references reported study data as an abstract only, and a subsequent publication reported definitive results from the same study, only the full publication was included. All papers, whether reporting primary research or not, were screened for additional references missed by the search.

All papers were also further classified according to the additional fields shown in *Table 2*.

Critical appraisal and data extraction

Each empirical paper was critically appraised by an experienced reviewer with a clinical background. The customary grading of studies according to the strength of the design modified by any methodological flaws in the conduct of the study was not used in this review since, in practice, all studies within the scope of the review were simple case-series. Instead, the appraisal process concentrated on defining whether tests had been conducted in the presence or absence of clinical indications, on identifying possible

biases in the collection of cases and outcomes, and on any weaknesses in the reporting of the outcome data.

Where possible, outcome data were extracted in a standard form to feed into the detailed assessment of each test, according to the scheme shown in *Table 3*. Where the presentation of data was sufficient to distinguish routine from indicated tests, these results were extracted separately. Where this was not possible, overall results were coded as 'mixed' (i.e. indicated and routine tests).

Presentation of results

The detailed results of studies are presented as a series of tables in the following chapters. In each chapter that relates to a single test or group of related tests the tables are structured as follows.

- The first table presents an overview of all identified empirical studies which contain data in a form that is usable within this review. This table includes details of the country, surgical setting and study sample, and indicates whether the study distinguishes routine tests from indicated tests, and which outcomes are reported.
- The second table presents outcome data from all papers from which the data can be extracted, including routine and indicated test results together.
- The third table presents outcome data in the same form as the second table but is

TABLE 3 Outcome data extracted

Name	Description
RefID	The ID of the study
TestID	The ID of the specific test
TestStatus	Whether the tests conducted were routine, indicated or a mixture of both
NTests	The number of tests performed
NAbnormal	The number of abnormal results
NAbnSignificant	The number of 'significant' abnormal results
ChangeMx	The type of management change recorded, if specified
NChangeMx	The number of abnormal results leading to management change
AdvOutcome	The type of adverse patient event recorded, if specified
NChangeOutcome	The number of abnormal results in which an adverse patient event was recorded

limited to results relating to tests that have been conducted routinely (i.e. in the absence of any specific clinical feature indicating the test).

Where a study has not reported data in a way that allows the results to be extracted and presented in this standard form, the study is omitted from the relevant table.

Chapter 3

Preoperative chest X-ray

Background

For many years, the routine preoperative chest X-ray was a mainstay of preoperative evaluation. In the 1970s studies of the yield of abnormalities from routine chest X-ray began to raise doubts about its value as a routine screening test.^{6,7}

In 1979 the Royal College of Radiologists published a study suggesting that routine chest X-ray seemed to have little, if any, impact on surgical or anaesthetic management.⁸ This study proved highly influential, leading both to a fall in the use of routine preoperative chest X-ray,⁹⁻¹² and to a statement by the Royal College of Radiologists in 1982 that routine preoperative chest X-ray was no longer justified.¹³

Nonetheless, wide variation in the use of preoperative chest X-ray has remained, both between hospitals and between specialties within the same hospital.¹⁴⁻¹⁷

Purposes of routine preoperative chest X-ray

Immediate medical or anaesthetic management

The major purpose of performing a preoperative chest X-ray, in non-cardiopulmonary surgery, is to contribute to the assessment of fitness for general anaesthetic. It is hoped that the chest X-ray will detect conditions such as heart failure or chronic lung disease which are not detectable clinically but which might lead to postponement or cancellation of the operation, or require modification of anaesthetic technique. Most studies have considered the chest X-ray in these terms.

Prediction of postoperative complications

Another purpose of preoperative chest X-ray can be to identify patients who are likely to suffer respiratory or cardiac complications postoperatively, so that postoperative surveillance and management can be modified accordingly, for instance by moving the patient to a high dependency area. Although the predictive power of

the chest X-ray is not a major focus of this review, a number of studies that examined this issue were identified.¹⁸⁻²¹

It is worth pointing out that it is not a function of a routine preoperative test to predict the prognosis of the condition that has led to surgery, nor the likely outcome of the surgery itself.

A 'baseline' for postoperative interpretation

A number of authors have asserted the importance of a preoperative chest X-ray in establishing a 'baseline' to assist in accurate interpretation of postoperative films if the patient develops postoperative cardiac or respiratory complications.^{22,23} The example frequently given is that of postoperative pulmonary embolus, in which subtle chest X-ray features may not be apparent unless a preoperative film is available for comparison.

Though frequently raised, this question has not been addressed in the majority of studies. A few studies have examined the issue explicitly.^{8,24,25}

Opportunistic screening

At one time the routine preoperative chest X-ray might have been justified as an opportunistic screening test for tuberculosis. With the continued decline in the prevalence of TB over the past century (albeit with a small rise in prevalence in recent years) this rationale for routine chest X-ray is now very rarely offered.

Review of studies

Despite the 1979 study by the Royal College of Radiologists⁸ (which is not listed in the tables below because of the way outcomes were reported) and 1982 guidelines,¹³ many further papers on the value of preoperative chest X-ray have been published, most of which have measured only abnormality rates, rather than impact on clinical management or patient outcomes. Few of these papers have distinguished between indicated and routine tests. The following sections summarise the methodological features and outcomes of the empirical studies identified by our search strategy.

Characteristics of identified studies

We identified 46 empirical studies which included preoperative chest X-ray, of which 28 reported data in a way that could be used in this review.^{18,20,21,23,24,26-48} All of these were reports of simple case-series, with no comparison of testing policies between groups. Eleven studies were in adults,^{18,20,21,23,33,36-38,40,45,46} four of the studies were in children,^{28,30-32} four were in both adults and children,^{27,41,44,47} and in the remainder of the studies the age of the study population was not specified.^{24,26,29,34,35,39,42,43,48}

Of the 28 studies, all measured abnormality rates, 18 measured impact on clinical management,^{18,20,21,27,28,30-32,34,35,37-40,42,45,47,48} and six measured the number of relevant adverse events (for example, respiratory complications) in patients with an abnormal test finding.^{20,23,32,34,36,37} For only eight of the studies could routine tests be distinguished from indicated tests.^{27,33,34,36,37,45,47,48} Details of the studies are summarised in *Table 4*.

TABLE 4 Identified empirical studies of preoperative chest X-ray

Reference	Country	Surgical setting	Study sample	Routine	Abnormal test	Change in management	Adverse events
Rees <i>et al</i> , 1976 ²⁶	UK	Not specified	667 (age not given)		✓		
Petterson & Janower, 1977 ²⁷	USA	Dental, ear, nose and throat (ENT), gastrointestinal, general, ophthalmics, orthopaedics, urology	1530 adults/ children	✓	✓	✓	
Sane <i>et al</i> , 1977 ²⁸	USA	Not specified	1500 children (0-19 years)		✓	✓	
Loder, 1978 ²⁹	UK	Dental, ENT, general, gynaecology, ophthalmics, orthopaedics	1000 (age not given)		✓		
Farnsworth <i>et al</i> , 1980 ³⁰	USA	Not specified	350 children (0-14 years)		✓	✓	
Rossello <i>et al</i> , 1980 ³¹	Puerto Rico	Not specified	690 children (< 14 years)		✓	✓	
Wood & Hoekelman, 1981 ³²	USA	ENT, general, ophthalmics, orthopaedics, urology	1924 children (0-19 years)		✓	✓	✓
Seymour <i>et al</i> , 1982 ²³	UK	Not specified (non-cardiopulmonary)	233 adults (> 60 years)		✓		✓
Tornebrandt & Fletcher, 1982 ³³	Sweden	General, orthopaedics, urology	100 adults (> 70 years)	✓	✓		
Rucker <i>et al</i> , 1983 ³⁴	USA	ENT, general, gynaecology, not specified, ophthalmics, orthopaedics, plastic surgery	905 (age not given)	✓	✓	✓	✓
Muskett & McGreevy, 1986 ³⁵	USA	Cardiothoracic, ENT, general, neurosurgery, ophthalmics, orthopaedics, plastic surgery, urology	200 (age not given)		✓	✓	

continued

TABLE 4 contd Identified empirical studies of preoperative chest X-ray

Reference	Country	Surgical setting	Study sample	Routine	Abnormal test	Change in management	Adverse events
Boghosian & Mooradian, 1987 ³⁶	USA	General, ophthalmics, orthopaedics, urology	136 adults (60–93 years)	✓	✓		✓
Mendelson et al, 1987 ²⁴	USA	General	369 (age not given)		✓		
Turnbull & Buck, 1987 ³⁷	Canada	General (cholecystectomy)	1010 adults	✓	✓	✓	✓
Weibman et al, 1987 ³⁸	USA	Not specified (cancer patients)	734 adults		✓	✓	
Wienczek et al, 1987 ³⁹	USA	Not specified	403 (age not given)		✓	✓	
Charpak et al, 1988 ⁴⁰	France	General, gynaecology, obstetrics, orthopaedics, plastic surgery	3866 adults		✓	✓	
Charpak et al, 1988 ²¹	France	General, gynaecology, obstetrics, orthopaedics, plastic surgery	3866 adults		✓	✓	
Ogunseyinde, 1988 ⁴¹	Nigeria	Not specified (non-cardiopulmonary)	203 adults/ children (1–79 years)		✓		
Tape & Mushlin, 1988 ²⁰	USA	Vascular	318 adults (24–90 years)		✓	✓	✓
Umbach et al, 1988 ⁴²	Germany	Gynaecology	1175 (age not given)		✓	✓	
McCleane, 1989 ⁴³	UK	Not specified	687 (age not given)		✓		
Bhuripanyo et al, 1990 ¹⁸	Thailand	ENT, general, gynaecology, obstetrics, ophthalmics, orthopaedics	1013 adults (> 15 years)		✓	✓	
Gagner & Chiasson, 1990 ⁴⁴	Canada	Not specified	1000 adults/ children		✓		
Adams et al, 1992 ⁴⁵	USA	General (hernia repair)	169 adults	✓	✓	✓	
MacDonald et al, 1992 ⁴⁶	UK	Orthopaedics	147 adults (> 60 years)		✓		
Sommerville & Murray, 1992 ⁴⁷	South Africa	Not specified	797 adults/ children (0–80 years)	✓	✓	✓	
Perez et al, 1995 ⁴⁸	Spain	Not specified	3131 (age not given)	✓	✓	✓	

Results of studies of routine and indicated preoperative chest X-ray

The number of tests performed, and the number and percentage of these with abnormal findings, with 'significantly' abnormal findings (as defined by the study authors), which resulted in a change in patient management, or which were related to a postoperative adverse event are shown in *Table 5*. It should be emphasised that this table includes studies in which no distinction was made between indicated and routine tests, and so many of the chest X-rays will have been performed in response to clinical features that suggested cardiac or respiratory abnormality.

A total of 18,913 chest X-rays are reported over all of the papers identified as usable for this report. The proportion of tests with abnormal findings varies from 1.4% (in a UK study⁴⁶) to 60.1% (in a Nigerian study⁴¹). The proportion of tests producing a change in clinical management ranges from 0% to 5.9%.

Results of studies only of routine preoperative chest X-ray

The results of routine chest X-rays could be extracted separately from those of indicated chest X-rays for only eight of the studies.^{27,33,34,36,37,45,47,48} The results of these studies are summarised in *Table 6* and show a similarly wide range of reported results.

Discussion

Abnormality rates

The results reported from the identified studies revealed wide variation in the proportion of preoperative chest X-rays that showed abnormality. Considerable variation persists even when attention is restricted to those studies in which the results from routine (non-indicated) tests can be isolated. Much of the variation will undoubtedly be due to the considerable heterogeneity in the populations under study. For example, in *Table 4* the papers which report the greatest abnormality rates are those on studies that were conducted in older populations.^{33,36}

The studies of chest X-ray clearly illustrate major difficulties in taking the yield of abnormal results as a meaningful outcome measure. Firstly, a single chest X-ray may contain many reported 'abnormalities', and it is arguable that the most assiduous radiologist could probably find something abnormal to comment on in even the most innocent of radiographs. Secondly, many

reported abnormalities, such as old rib fractures or pleural thickening, are trivial and others, such as mild degrees of cardiomegaly, are of dubious significance. Surprisingly, many papers ignore this issue and report only overall abnormality rates, while others attempt to separate 'significant' abnormalities, usually by means of a defined list of radiological features. Typically, such reports show that about half of abnormalities are 'significant' (17% to 75% in the identified studies).

Predictors of abnormality

It is clear that the proportion of chest X-rays with at least one abnormality rises with age, as does the number of abnormalities per X-ray. A number of studies have shown age-specific abnormality rates, which have often been used to frame recommendations of the form 'preoperative chest X-rays should be routine over the age of n years'.^{26,27,44,49}

In contrast to these studies, Delahunt and Turnbull have reported that 'significant unexpected' chest X-ray results are no more frequent in older than younger patients.⁵⁰ McCleane argues that increasing prevalence of chest X-ray abnormality correlates more closely with American College of Anesthesiologists (ASA) status than with age, and that the former rather than the latter should therefore be used as an indication for chest X-ray.⁴³

However, if abnormality rate *per se* is not a useful outcome measure, then it is hard to see how age-specific or ASA-specific abnormality rates can be more helpful in determining policy.

Impact on patient management

The effects of routine testing on clinical management are of much greater importance than abnormality rates, though harder to measure. Only six papers have reported this outcome for routine chest X-rays,^{27,34,37,45,47,48} with the results of between 0% and 2.1% of chest X-rays leading to a change in management. As might be expected, studies in which patients with an indication for chest X-ray are included have shown a greater overall impact on patient management, since the prevalence of morbidity is higher.

Weibman and colleagues examined age-specific rates of impact on clinical management, in a population of patients with known or suspected cancer.³⁸ In that study, age-specific rates of anticipated impact on anaesthetic management were higher than the corresponding actual rates. Care was altered because of an abnormal chest X-ray result in less than 2% of patients younger than 40 years but in almost 50% of patients aged over 80 years.

TABLE 5 Results of studies of preoperative chest X-ray (routine and indicated)

Reference	Tests performed	Abnormal n (%)	'Significantly' abnormal n (%)	Change in management n (%)	Adverse events n (%)
Rees <i>et al</i> , 1976 ²⁶	667	299 (44.8)	126 (18.9)	–	–
Petterson & Janower, 1977 ²⁷	1527	134 (8.8)	–	2 (0.1)	–
Sane <i>et al</i> , 1977 ²⁷	1500	111 (7.4)	71 (4.7)	45 (3.0)	–
Loder, 1978 ²⁹	1000	–	69 (6.9)	–	–
Farnsworth <i>et al</i> , 1980 ³⁰	350	31 (8.9)	–	0 (0)	–
Rossello <i>et al</i> , 1980 ³¹	682	20 (2.9)	–	2 (0.3)	–
Wood & Hoekelman, 1981 ³²	749	35 (4.7)	9 (1.2)	3 (0.4)	–
Seymour <i>et al</i> , 1982 ²³	233	134 (57.5)	101 (43.3)	–	–
Tornebrandt & Fletcher, 1982 ³³	191	43 (22.5)	–	–	–
Rucker <i>et al</i> , 1983 ³⁴	872	–	115 (13.2)	0 (0)	0 (0)
Muskett & McGreevy, 1986 ³⁵	119	35 (29.4)	–	6 (5.0)	–
Boghosian & Mooradian, 1987 ³⁶	136	–	72 (52.9)	–	12 (8.8)
Mendelson <i>et al</i> , 1987 ²⁴	332	62 (18.7)	–	–	–
Turnbull & Buck, 1987 ³⁷	691	38 (5.5)	–	8 (1.2)	8 (1.2)
Weibman <i>et al</i> , 1987 ³⁸	734	213 (29.0)	–	39 (5.3)	–
Wiencek <i>et al</i> , 1987 ³⁹	237	101 (42.6)	–	10 (4.2)	–
Charpak <i>et al</i> , 1988 ⁴⁰	1101	568 (51.6)	–	51 (4.6)	–
Charpak <i>et al</i> , 1988 ²¹	1101	568 (51.6)	–	51 (4.6)	–
Ogunseyinde, 1988 ⁴¹	203	122 (60.1)	27 (13.3)	–	–
Tape & Mushlin, 1988 ²⁰	336	116 (34.5)	20 (6.0)	9 (2.7)	–
Umbach <i>et al</i> , 1988 ⁴²	1175	–	118 (10.0)	69 (5.9)	–
McCleane, 1989 ⁴³	296	103 (34.8)	–	–	–
Bhuripanyo <i>et al</i> , 1990 ¹⁸	933	181 (19.4)	84 (9.0)	34 (3.6)	–
Gagner & Chiasson, 1990 ⁴⁴	1000	74 (7.4)	–	–	–
Adams <i>et al</i> , 1992 ⁴⁵	133	6 (4.5)	–	2 (1.5)	–
MacDonald <i>et al</i> , 1992 ⁴⁶	145	2 (1.4)	–	–	–
Sommerville & Murray, 1992 ⁴⁷	319	48 (15.0)	–	6 (1.9)	–
Perez <i>et al</i> , 1995 ⁴⁸	2151	485 (22.5)	–	45 (2.1)	–
Median		20.0%	10.0%	2.4%	1.2%
Reported range		1.4–60.1%	1.2–52.9%	0–5.9%	0–8.8%

TABLE 6 Results of studies of preoperative chest X-ray (routine only)

Reference	Tests performed	Abnormal n (%)	'Significantly' abnormal n (%)	Change in management n (%)	Adverse events n (%)
Petterson & Janower, 1977 ²⁷	1527	134 (8.8)	–	2 (0.1)	–
Tornebrandt & Fletcher, 1982 ³³	27	10 (37.0)	–	–	–
Rucker <i>et al</i> , 1983 ³⁴	368	–	1 (0.3)	0 (0)	0 (0)
Boghosian & Mooradian, 1987 ³⁶	44	–	15 (34.1)	–	3 (6.8)
Turnbull & Buck, 1987 ³⁷	691	38 (5.5)	–	8 (1.2)	8 (1.2)
Adams <i>et al</i> , 1992 ⁴⁵	81	2 (2.5)	–	0 (0)	–
Sommerville & Murray, 1992 ⁴⁷	215	13 (6.0)	–	2 (0.9)	–
Perez <i>et al</i> , 1995 ⁴⁸	2151	485 (22.5)	–	45 (2.1)	–
Median		7.4%	17.2%	0.5%	1.2%
Reported range		2.5–37.0%	0.3–34.1%	0–2.1%	0–6.8%

Value in prediction of complications

The predictive value of chest X-ray for postoperative complications was not the major focus of this review. However, our search yielded three papers which addressed this issue. Two of these found that abnormal chest X-ray results were not predictive of postoperative respiratory complications.^{18,19} The third found that a 'major abnormality' on the preoperative radiograph was associated with postoperative complications (likelihood ratio 6.6).²⁰ In this study, in which some chest X-rays were indicated by clinical features, a major abnormality occurred in ten out of 336 (3%) of cases.

Value as a 'baseline' measure

We identified only two studies which attempted to assess the value of the preoperative chest X-ray as a 'baseline' for postoperative interpretation.

Thomsen and colleagues studied 1262 patients who had a preoperative chest X-ray,²⁵ of whom 198 (16%) went on to have a postoperative radiograph. For 88 patients (7%) the postoperative X-ray showed a new abnormality. However, Thomsen and co-workers concluded that "the possibility of comparing a postoperative X-ray with a preoperative X-ray did not have therapeutic consequence in any case".

Mendelson and colleagues studied 369 patients undergoing surgery,²⁴ of whom 65 underwent

postoperative chest X-ray. A radiologist judged that the interpretation of the radiographs for 33 of these patients would have been improved by having a preoperative baseline radiograph. Thus, a radiograph may be of value as a baseline in 9% of patients. However, as in the study by Thomsen and colleagues,²⁵ it should be noted that the outcome measured relates to abnormality, not to clinical management or patient outcome.

The study by the Royal College of Radiologists⁸ found that 70% of postoperative pulmonary complications develop in patients without serious cardiorespiratory disease. On this basis, the authors argued that it would be necessary to X-ray "upwards of 90% of all patients going to operation to be reasonably sure of having a baseline available for all those in whom a postoperative pulmonary complication develops".

Conclusions from the earlier reviews

Both existing reviews of preoperative testing^{1,2} include a section on the value of routine chest X-ray. Ten of the studies examined in the Swedish review¹ are included in *Table 4*. In addition the review covered three papers published in Swedish (not listed in *Table 4*)^{25,51,52} and a further study from which results cannot be extracted in the form used in our study.⁵⁰ Overall, it is concluded that:

We have no scientifically documented evidence that preoperative chest radiography has a

favourable effect by decreasing perioperative risk. Likewise, we have no documented evidence that it does not ... In summary, this means that preoperative chest radiography should not be performed as a routine.

Four of the papers listed in *Table 4* are cited in the review from the Basque country,² along with the Royal College report⁸ and a further study published in Spanish.⁵³ A similar conclusion is reached:

There is no published scientific evidence that routine preoperative chest X-rays decrease perioperative risks.

These conclusions are consistent with the findings of the current systematic review.

Conclusions

In summary, the evidence reviewed shows the following.

- No controlled trials of the effectiveness of routine preoperative chest X-ray have been

published. All available evidence reports the results of case-series.

- Few studies allow the outcome of routine chest X-rays to be distinguished from those of indicated chest X-rays, and fewer have gone beyond abnormality yields to examine the impact on clinical management.
- Findings from routine preoperative chest X-ray are reported as abnormal in 2.5–37.0% of cases, and lead to a change in clinical management in 0–2.1% of cases. The effect on patient outcomes is unknown.
- Both abnormality yield and impact on patient management rise with age and poorer ASA status.
- The limited evidence on the value of a chest X-ray as a baseline measure suggests that it will be of value in less than 9% of patients.

The available evidence does not support a policy of performing routine preoperative chest X-ray for all patients. Although there is no evidence available showing that such a policy would lead to worse outcomes for patients, the finding that only 2% of chest X-rays lead to change in management of patients suggests a high level of cost and inconvenience for potentially very limited benefits.

Chapter 4

Preoperative electrocardiography

Background

Like the chest X-ray, the ECG has been a key element of the preoperative assessment for many years, mainly in response to the perceived risk of myocardial infarction during or after general anaesthesia. Literature critically assessing the value of taking an ECG in all patients did not begin to appear until the late 1970s, leading to a major review in 1986 which suggested that there were limited indications for preoperative electrocardiography.⁵⁴ A number of major studies assessing the value of routine preoperative recording of an ECG have been reported since that time.

Despite attempts to define more limited indications for preoperative electrocardiography considerable variation between specialties and hospitals persists,^{14,16,17} as was found for chest X-ray (see chapter 3).

Purposes of routine preoperative electrocardiography

Immediate medical or anaesthetic management

A major purpose of preoperative recording of an ECG is to detect cardiac conditions, such as recent myocardial infarction, cardiac ischaemia, conduction defect or arrhythmia, which would lead to modification of anaesthesia or postponement of surgery. Most of the papers we identified examined the utility of electrocardiography in terms of preoperative management.

Prediction of postoperative complications

While not completely distinct from the above, a second purpose of taking a preoperative ECG is to identify those patients who may go on to suffer a cardiac complication – particularly acute myocardial infarction – postoperatively. The predictive value of the preoperative ECG for this purpose has been examined in a few studies.^{37,55–57}

A 'baseline' for postoperative interpretation

The value of the preoperative ECG as a 'baseline' to aid postoperative interpretation should

complications occur has not been advanced, or investigated, to the extent that it has for chest X-rays, perhaps because the features of acute infarction are usually obvious and in any case can be confirmed by measurement of cardiac enzymes. We identified only a single study which addressed this issue, albeit indirectly.⁵⁸

Review of studies

Characteristics of identified studies

Our search identified 30 studies of preoperative electrocardiography, of which 16 reported outcome data in a usable form.^{35,37,40,45–48,56,57,59–65}

All were simple case-series. Nine studies were in adults,^{37,40,45,46,56,57,60,63,65} two studies in both adults and children,^{47,64} and in the remainder of the studies the age of the study population was not specified.^{35,48,59,61,62}

Of the 16 studies, all measured abnormality rates, ten measured impact on clinical management,^{35,37,40,45,47,48,59,61,63,64} and five measured the number of adverse events in patients with an abnormal test finding.^{37,56,59,57,64} Routine tests could be distinguished from indicated tests for eight studies.^{37,45,47,48,59,61,63,65} Details of the studies are summarised in *Table 7*.

Results of identified studies of routine and indicated preoperative electrocardiography

The number of tests performed, and the number and percentage of these with abnormal findings, with 'significantly' abnormal findings (as defined by the study authors), which resulted in a change in patient management, or which were related to a postoperative adverse event are shown in *Table 8*. It should be emphasised that this table includes studies in which no distinction was made between indicated and routine tests, and so many of the ECGs will have been recorded in response to clinical features suggesting cardiac disease.

The results from a total of 8889 ECGs are reported over all the studies listed in *Table 8*. The proportion of tests showing abnormal

TABLE 7 Identified empirical studies of preoperative ECG

Reference	Country	Surgical setting	Study sample	Routine	Abnormal test	Change in management	Adverse events
Paterson <i>et al</i> , 1983 ⁵⁹	UK	Not specified	267 (age not given)	✓	✓	✓	✓
Seymour <i>et al</i> , 1983 ⁵⁷	UK	General	222 adults (> 65 years)		✓		✓
Carliner <i>et al</i> , 1986 ⁵⁶	USA	Cardiothoracic, general, vascular	198 adults (> 40 years)		✓		✓
Muskett & McGreevy, 1986 ³⁵	USA	Cardiothoracic, ENT, general, neurosurgery, ophthalmics, orthopaedics, plastic surgery, urology	200 (age not given)		✓	✓	
Turnbull & Buck, 1987 ³⁷	Canada	General (cholecystectomy)	1010 adults	✓	✓	✓	✓
Charpak <i>et al</i> , 1988 ⁴⁰	France	General, gynaecology, obstetrics, orthopaedics, plastic surgery	3866 adults		✓	✓	
Johnson <i>et al</i> , 1988 ⁶⁰	USA	ENT, general, gynaecology, ophthalmics, orthopaedics, plastic surgery, urology	212 adults		✓		
Yipintsoi <i>et al</i> , 1989 ⁶¹	Thailand	ENT, general, gynaecology, ophthalmic, orthopaedics	424 (age not given)	✓	✓	✓	
McCleane & McCoy, 1990 ⁶²	UK	Not specified	877 (age not given)		✓		
Adams <i>et al</i> , 1992 ⁴⁵	USA	General (hernia repair)	169 adults	✓	✓	✓	
Bhuripanyo <i>et al</i> , 1992 ⁶³	Thailand	ENT, general, gynaecology, obstetrics, ophthalmics, orthopaedics	395 adults (40–77 years)	✓	✓	✓	
Gold <i>et al</i> , 1992 ⁶⁴	USA	Not specified	751 adults/ children (14–88 years)		✓	✓	✓
MacDonald <i>et al</i> , 1992 ⁴⁶	UK	Orthopaedics	147 adults (> 60 years)		✓		
Sommerville & Murray, 1992 ⁴⁷	South Africa	Not specified	797 adults/ children (0–80 years)	✓	✓	✓	
Callaghan <i>et al</i> , 1995 ⁶⁵	UK	Dental, ENT, general, neurosurgery, ophthalmics, urology, vascular	354 adults (> 16 years)	✓	✓		
Perez <i>et al</i> , 1995 ⁴⁸	Spain	Not specified	3131 (age not given)	✓	✓	✓	

TABLE 8 Results of studies of preoperative ECG (routine and indicated)

Reference	Tests performed	Abnormal n (%)	'Significantly' abnormal n (%)	Change in management n (%)	Adverse events n (%)
Paterson <i>et al</i> , 1983 ⁵⁹	267	82 (30.7)	34 (12.7)	4 (1.5)	0 (0)
Seymour <i>et al</i> , 1983 ⁵⁷	222	175 (78.8)	–	–	–
Carliner <i>et al</i> , 1986 ⁵⁶	198	125 (63.1)	–	–	28 (14.1)
Muskett & McGreevy, 1986 ³⁵	145	53 (36.6)	–	2 (1.4)	–
Turnbull & Buck, 1987 ³⁷	632	101 (16.0)	–	0 (0)	4 (0.6)
Charpak <i>et al</i> , 1988 ⁴⁰	1610	609 (37.8)	–	117 (7.3)	–
Johnson <i>et al</i> , 1988 ⁶⁰	212	140 (66.0)	–	–	–
Yipintsoi <i>et al</i> , 1989 ⁶¹	424	61 (14.4)	–	6 (1.4)	–
McCleane & McCoy, 1990 ⁶²	877	395 (45.0)	–	–	–
Adams <i>et al</i> , 1992 ⁴⁵	90	12 (13.3)	–	0 (0)	–
Bhuripanyo <i>et al</i> , 1992 ⁶³	395	130 (32.9)	31 (7.8)	10 (2.5)	–
Gold <i>et al</i> , 1992 ⁶⁴	751	321 (42.7)	–	–	–
MacDonald <i>et al</i> , 1992 ⁴⁶	145	–	–	3 (2.1)	–
Sommerville & Murray, 1992 ⁴⁷	290	52 (17.9)	–	4 (1.4)	–
Callaghan <i>et al</i> , 1995 ⁶⁵	230	57 (24.8)	–	–	–
Perez <i>et al</i> , 1995 ⁴⁸	2401	250 (10.4)	–	22 (0.9)	–
Median		32.9%	10.2%	1.4%	0.6%
Reported range		10.4–78.8%	7.8–12.7%	0–7.3%	0–14.1%

results varies from 10.4% (in a Spanish study⁴⁸) to 78.8% (in a UK study of persons aged over 65 years⁵⁷). The proportion of tests producing a change in clinical management ranges from 0% to 7.3%.

Results of studies only of routine preoperative electrocardiography

The results of routinely recorded ECGs could be extracted separately from those of indicated ECGs for only eight of the studies.^{37,45,47,48,59,61,63,65} The results of these studies are summarised in *Table 9*. In comparison with routine and indicated tests combined (*Table 8*), a smaller proportion of routine tests showed an abnormality (4.6–31.7%) or resulted in change in management of patients (0–2.2%).

Discussion

Abnormality rates

As with chest X-rays, the results of the identified studies show a wide variation in the proportion of ECGs which are abnormal. However, the range does narrow considerably for papers that report the results of studies of routine tests. Again, there will be considerable heterogeneity between studies in the tested populations. In *Table 9* (routine ECGs only), the highest abnormality yield is in a Thai population,⁶³ which may not usefully apply to the UK. Restricting the studies to those conducted in European and North American populations^{37,45,48,59,65} narrows the reported range for abnormalities to 4.6–16.0%.

TABLE 9 Results of studies of preoperative ECG (routine only)

Reference	Tests performed	Abnormal n (%)	'Significantly' abnormal n (%)	Change in management n (%)	Adverse events n (%)
Paterson et al, 1983 ⁵⁹	171	27 (15.8)	5 (2.9)	1 (0.6)	0 (0)
Turnbull & Buck, 1987 ³⁷	632	101 (16.0)	–	0 (0)	4 (0.6)
Yipintsoi et al, 1989 ⁶¹	424	61 (14.4)	–	6 (1.4)	–
Adams et al, 1992 ⁴⁵	48	4 (8.3)	–	0 (0)	–
Bhuripanyo et al, 1992 ⁶³	357	113 (31.7)	23 (6.4)	8 (2.2)	–
Sommerville & Murray, 1992 ⁴⁷	157	11 (7.0)	–	1 (0.6)	–
Callaghan et al, 1995 ⁶⁵	131	6 (4.6)	–	–	–
Perez et al, 1995 ⁴⁸	2401	250 (10.4)	–	22 (0.9)	–
Median		12.4%	4.6%	0.6%	0.3%
Reported range		4.6–31.7%	2.9–6.4%	0–2.2%	0–0.6%

These results also provide evidence, similar to that for chest X-rays, that abnormality *per se* is not a useful measure of value. 'Significantly' abnormal ECGs account for only about one-fifth of all abnormal ECGs.^{59,63}

Predictors of abnormality

The prevalence of abnormal ECGs rises exponentially with age, as Goldberger and O'Kinski's synthesis of results from four studies demonstrated very clearly.⁵⁴ This observation has frequently been used to suggest a lower age limit, usually between 45 and 65 years, above which a policy of routine preoperative ECG might be justifiable. The choice of age limit, while based on expected abnormality yield, remains arbitrary because the chosen yield itself is arbitrary, and because the benefit of detecting the abnormalities has not been shown.

McCleane has shown that the prevalence of abnormality also rises with worsening ASA status, suggesting that this might also be an approach to setting guidelines.⁶²

Rabkin and Horne addressed the specific question of how often new ECG changes are found in patients who have a previous ECG in their notes. A new, relevant abnormality was noted in only about 2% of patients overall, though the probability of such an abnormality rose with age.⁶⁶

Impact on patient management

As argued previously in this report, the impact of a test on patient management gives a better indication of any possible benefit than simple consideration of abnormality yield. Seven papers have reported this outcome for routine preoperative ECGs,^{37,45,47,48,59,61,63} suggesting that the findings from between 0% and 2.2% of ECGs lead to a change in management. If the Thai studies^{61,63} are omitted, the range falls to 0–0.9%.

Rabkin and Horne studied a population of 157 patients with a previous ECG, to determine the effect of new ECG changes on clinical management. They found that anaesthetic management may have been influenced in two cases, a result consistent with those from the studies reported above.⁶⁷

Value in prediction of complications

We identified four studies which investigated the predictive value of the preoperative ECG for postoperative cardiac events.

Seymour and colleagues studied 222 patients aged 65 years or older, and found that an abnormal ECG was not associated with postoperative cardiac complications in men, but might be in women.⁵⁷ Carliner and co-workers examined the issue in a series of 198 patients and concluded that ST-T wave abnormalities and intraventricular conduction delays were associated with increased postoperative

cardiac morbidity and mortality. The predictive value of any ECG abnormality was weak, however, with only 22% of patients who showed 'any abnormality' having a postoperative complication.⁵⁶

Turnbull and Buck examined the charts of 1010 healthy patients admitted for cholecystectomy. They estimated the positive predictive value of an ECG for a relevant postoperative complication as 4%, compared with a predictive value from the history and examination alone as 2% (given that patients are apparently healthy), a difference they regard as of no clinical importance.³⁷

Finally, Velanovich undertook a multivariate analysis of factors predicting postoperative cardiac events in a population of 481 patients (not all asymptomatic).⁵⁵ He found that ECG evidence of previous infarction and ST segment abnormalities were independent predictors of postoperative ischaemia, and P wave abnormalities were predictive of postoperative arrhythmia. However, insufficient data are provided in the study to allow an assessment of the clinical importance of these findings.

Value as a 'baseline' measure

We identified no study which provides any direct evidence of the utility of taking a routine preoperative ECG as a 'baseline' for postoperative interpretation.

However, an investigation by Ashton and colleagues on the significance of ECG changes after prostate surgery provides some indirect evidence.⁵⁸ In this study, ECGs performed in 206 men immediately after their operation were of no value in predicting myocardial infarction, despite ECG changes occurring in one-fifth of patients. Given this, the authors argue that there can be no value in recording a preoperative baseline ECG to help to determine which postoperative changes are new.

Conclusions from the earlier reviews

Both existing reviews of preoperative testing include a section on the value of routine electrocardiography.^{1,2}

In the Swedish review¹ there is reference to a number of reviews, a paper we sought but were unable to obtain⁶⁸ and papers from which data could not be extracted in the form required for our review.^{54,69,70} Oddly, none of the studies listed in *Table 7* is referred to in the Swedish review. The report does not include a clear statement on the evidence for routine preoperative recording of an ECG, but it is argued that:

Since the occurrence of significant ECG changes predictably increases with age, it appears reasonable to use age limits to select those patients who, despite lack of problems, should undergo preoperative ECG examination ... Exactly where to establish the limits is a difficult assessment issue. Many clinicians apply age limits in the range of 50–60 years.

In the review from the Basque country² there is reference to one paper from *Table 7*,⁶⁴ as well as a review⁵⁴ and a paper we were unable to obtain.⁶⁸ The conclusion in this report is similar to that in the Swedish report:

In the healthy patient, it is advisable only to request a preoperative ECG in those patients who are more than 60 years old and in those who are more than 40 years old if they have not had a normal ECG for reference.

These conclusions are consistent with the findings of the current systematic review, but they suggest a degree of certainty over the benefit of routine ECG which does not exist in the published evidence.

Conclusions

In summary, the evidence reviewed shows the following.

- No controlled trials of the value of routine preoperative electrocardiography have been published. All available evidence reports the results of case-series.
- The findings from routine preoperative ECGs are abnormal in 4.6–31.7% of cases, and lead to a change of management in 0–2.2% of cases. The effect on patient outcomes is unknown.
- The proportion of abnormalities rises with age and worsening ASA status.
- The predictive power of preoperative ECGs for postoperative cardiac complications in non-cardiopulmonary surgery is weak, at best.
- There is no evidence to support the value of taking a preoperative ECG as a 'baseline'.

The evidence reviewed does not support a policy of routine preoperative electrocardiography in all patients, and conversely provides no evidence that such a policy would be harmful. Given that benefits would probably only occur in those 2% of patients in whom management is altered, a policy of routine ECG recording is unlikely to yield important benefits for patients.

Chapter 5

Preoperative haemoglobin measurement and blood counts

Background

Preoperative determination of Hb and blood cell counts ('full blood count', FBC) is often regarded as self-evidently important, since virtually every surgical procedure involves some loss of blood, and it should therefore be worth knowing 'how much' blood the patient has to begin with. Because the FBC is determined on a machine which simultaneously measures Hb along with a variety of blood cell counts, in effect a number of different tests with different purposes are undertaken at the same time. In principle, it is important to try to separate the purposes and results of these different tests in the available evidence, so that the relative value of each can be assessed.

Purposes of performing routine preoperative Hb measurement and blood counts

Immediate medical or anaesthetic management

One purpose of the routine preoperative measurement of Hb is to detect anaemia which is not clinically apparent, since it is believed that mild to moderate anaemia increases the risks of general anaesthesia. The conventional threshold for anaemia below which postponement of surgery or preoperative transfusion might be considered is an Hb level of 10 g/dl. However, there is some evidence to suggest that the risks of surgery do not rise significantly until the Hb level falls below 8 g/dl.⁷¹

Other abnormalities which might affect immediate anaesthetic decisions include a high white cell count, possibly indicating infection not obvious clinically, or a low platelet count, which could lead to excessive perioperative bleeding.

Other purposes

Given a markedly abnormal FBC, it would be likely that an operation would be postponed or, if surgery was needed urgently, that the relevant abnormality would be corrected, for example, by transfusion of

red cells or platelets. In these circumstances, the use of the FBC to predict postoperative complications, or as a baseline measure for postoperative comparison, becomes unimportant. Nor is the use of the preoperative FBC as an opportunistic screening test widely advanced as a reason for testing.

Review of studies

Characteristics of identified studies

Our search identified 23 studies of preoperative Hb determination or blood counts which reported outcome data in a usable form.^{31,32,34,37,40,45,46,48,60,72-85}

All were simple case-series. Five studies were in adults,^{37,40,45,46,60} eight in children,^{31,32,75,77,78,80-82} two in both adults and children,^{72,84} and in the remainder the age of the study population was not specified.^{34,48,73,74,79,85}

Of the 23 studies, all measured abnormality rates, 18 measured impact on clinical management,^{31,32,34,37,40,45,48,72-74,77-84} and six measured the number of adverse events in those with an abnormal test finding.^{32,37,80,82,84,85} Results for routine tests could be distinguished from those for indicated tests for ten studies.^{37,45,48,73,74,79,82-85} Details of all of the identified studies are summarised in *Table 10*.

Results of studies of routine and indicated preoperative Hb measurement and FBCs

The number of tests performed, and the number and percentage of these with abnormal findings, with 'significantly' abnormal findings (as defined by the study authors), which resulted in a change in patient management, or which were related to a postoperative adverse event are shown in *Table 11*. As before, this table includes studies in which no distinction was made between indicated and routine tests, and so many of the tests will have been performed in response to clinical features indicating a blood test.

Five of the papers^{35,45,48,73,85} either did not report separately the specific abnormalities found on

TABLE 10 Identified empirical studies of preoperative Hb/FBC

Reference	Country	Surgical setting	Study sample	Routine	Abnormal test	Change in management	Adverse events
Rossello <i>et al</i> , 1980 ³¹	Puerto Rico	Not specified	690 children (< 14 years)		✓	✓	
Wood & Hoekelman, 1981 ³²	USA	ENT, general, ophthalmics, orthopaedics, urology	1924 children (0–19 years)		✓	✓	✓
Ramsey <i>et al</i> , 1983 ⁷²	USA	Cardiothoracic (cardiac)	92 adults/ children (0–75 years)		✓	✓	
Kaplan <i>et al</i> , 1985 ⁷³	USA	Not specified	2785 (age not given)	✓	✓	✓	
Muskett & McGreevy, 1986 ³⁵	USA	Cardiothoracic, ENT, general, neurosurgery, ophthalmics, orthopaedics, plastic surgery, urology	200 (age not given)		✓	✓	
Turnbull & Buck, 1987 ³⁷	Canada	General (cholecystectomy)	1010 adults	✓	✓	✓	✓
Charpak <i>et al</i> , 1988 ⁴⁰	France	General, gynaecology, obstetrics, orthopaedics, plastic surgery	3866 adults		✓	✓	
Johnson <i>et al</i> , 1988 ⁶⁰	USA	ENT, general, gynaecology, ophthalmics, orthopaedics, plastic surgery, urology	212 adults		✓		
Rohrer <i>et al</i> , 1988 ⁷⁴	USA	General, vascular	282 (age not given)	✓	✓	✓	
Jones <i>et al</i> , 1989 ⁷⁵	UK	Orthopaedics	346 children		✓		
Bolger <i>et al</i> , 1990 ⁷⁶	USA	ENT (tonsillectomy)	52 (age not given)		✓		
Nigam <i>et al</i> , 1990 ⁷⁷	UK	ENT (tonsillectomy)	250 children (3–12 years)		✓	✓	
O'Connor & Drasner, 1990 ⁷⁸	USA	ENT, general, orthopaedics, urology	486 children (< 18 years)		✓	✓	
Narr <i>et al</i> , 1991 ⁷⁹	USA	Not specified	3782 (age not given)	✓	✓	✓	
Roy <i>et al</i> , 1991 ⁸⁰	Canada	Not specified	2000 children (0–18 years)		✓	✓	✓
Adams <i>et al</i> , 1992 ⁴⁵	USA	General (hernia repair)	169 adults	✓	✓	✓	

continued

TABLE 10 contd Identified empirical studies of preoperative Hb/FBC

Reference	Country	Surgical setting	Study sample	Routine	Abnormal test	Change in management	Adverse events
Baron <i>et al</i> , 1992 ⁸¹	USA	Not specified	1863 children (< 18 years)		✓	✓	
MacDonald <i>et al</i> , 1992 ⁴⁶	UK	Orthopaedics	147 adults (> 60 years)		✓		
Hoare, 1993 ⁸²	UK	ENT	372 children (2–15 years)	✓	✓	✓	✓
Macpherson <i>et al</i> , 1993 ⁸³	South Africa	Cardiothoracic, general	159 (age not given)	✓	✓	✓	
Close <i>et al</i> , 1994 ⁸⁴	USA	ENT (tonsillectomy)	96 adults/children (1–40 years)	✓	✓	✓	✓
Kozak & Brath, 1994 ⁸⁵	USA	Unknown (fiberoptic bronchoscopy)	305 (age not given)	✓	✓		✓
Perez <i>et al</i> , 1995 ⁴⁸	Spain	Not specified	3131 (age not given)	✓	✓	✓	

the FBC (for example, Hb, white cell count, platelets), or did not do so in a way that allowed these results to be extracted meaningfully. Results for one or more specific counts could be extracted separately from the remainder of the papers, and are listed under subheadings in *Table 11*.

Overall the papers cover the results from a total of 20,807 blood tests (some of which generated multiple outcomes). The proportion of tests with abnormal findings clearly varies according to the test outcome recorded.

Results of studies only of routine preoperative Hb measurement and FBCs

For ten of the identified studies the results of routine Hb/blood count estimation could be extracted separately from those of indicated tests.^{37,45,48,73,74,79,82–85} The results of these studies are shown in *Table 12*. The proportion of tests that lead to a change in management is generally low, being 2.7% or less in all studies.

Discussion

Abnormality rates Hb and haematocrit

Much of the variation in abnormality rates reported for Hb is due to the different limits of abnormality

defined in different studies. In five of the studies reporting Hb results separately the lower limit of normality for Hb was taken to be 10–10.5 g/dl.^{46,77,79,80,82} In two studies the defined threshold was much higher, 14 g/dl for men and 12–12.5 g/dl for women.^{40,60} In one study a test result was defined as abnormal if the mean cell volume was low, even when the Hb level was normal.⁷⁸ Unsurprisingly, the reports for these studies show relatively high yields of Hb abnormality in their samples.

In relation to the evidence that perioperative risk does not seem to rise until the Hb level falls below 8 g/dl, it is worth noting that no study of routine testing in which Hb results are extractable reported finding a patient with an Hb level of less than 8.5 g/dl.

Many would regard the haematocrit as more or less interchangeable with the Hb. In papers which reported this test, abnormality rates were between 0.7% and 1.1%.

Platelet count

All but two papers which include platelet counts report the proportion of abnormal results in both indicated and routine testing as less than 1.2%.^{37,48,60,72,73,76,79,83,84} Of the two papers in which much higher rates were reported, Charpak and colleagues⁴⁰ had studied specifically indicated

TABLE 11 Results of studies of preoperative Hb/FBC (routine and indicated)

Reference	Tests performed	Abnormal n (%)	'Significantly' abnormal n (%)	Change in management n (%)	Adverse events n (%)
FBC (not further defined)					
Kaplan <i>et al</i> , 1985 ⁷³	610	22 (3.6)	0 (0)	–	–
Muskett & McGreevy, 1986 ³⁵	199	12 (6.0)	–	18 (9.0)	–
Adams <i>et al</i> , 1992 ⁴⁵	167	6 (3.6)	–	0 (0)	–
Kozak & Brath, 1994 ⁸⁵	952	–	–	38 (4.0)	–
Perez <i>et al</i> , 1995 ⁴⁸	3089	–	–	12 (0.4)	–
Median		3.6%	0%	2.2%	–
Reported range		3.6–6.0%	0%	0–9.0%	–
FBC (haematocrit)					
Rossello <i>et al</i> , 1980 ³¹	689	5 (0.7)	–	0 (0)	–
Wood & Hoekelman, 1981 ³²	1918	–	–	1 (0.1)	–
Baron <i>et al</i> , 1992 ⁸¹	1863	21 (1.1)	–	0 (0)	–
Median		0.9%	–	0%	–
Reported range		0.7–1.1%	–	0–0.1%	–
FBC (Hb)					
Turnbull & Buck, 1987 ³⁷	1005	7 (0.7)	–	2 (0.2)	2 (0.2)
Charpak <i>et al</i> , 1988 ⁴⁰	2138	688 (32.2)	–	140 (6.5)	–
Johnson <i>et al</i> , 1988 ⁶⁰	212	19 (9.0)	–	–	–
Jones <i>et al</i> , 1989 ⁷⁵	307	2 (0.7)	–	1 (0.3)	0 (0)
Nigam <i>et al</i> , 1990 ⁷⁷	250	2 (0.8)	–	0 (0)	–
O'Connor & Drasner, 1990 ⁷⁸	484	85 (17.6)	–	2 (0.4)	–
Narr <i>et al</i> , 1991 ⁷⁹	3782	30 (0.8)	–	3 (0.1)	–
Roy <i>et al</i> , 1991 ⁸⁰	2000	11 (0.6)	–	3 (0.2)	0 (0)
MacDonald <i>et al</i> , 1992 ⁴⁶	145	–	–	5 (3.4)	–
Hoare, 1993 ⁸²	372	18 (4.8)	–	10 (2.7)	0 (0)
Perez <i>et al</i> , 1995 ⁴⁸	3081	44 (1.4)	–	–	–
Median		1.1%	–	0.3%	0%
Reported range		0.6–32.2%	–	0–6.5%	0–0.2%

continued

TABLE 11 contd Results of studies of preoperative Hb/FBC (routine and indicated)

Reference	Tests performed	Abnormal n (%)	'Significantly' abnormal n (%)	Change in management n (%)	Adverse events n (%)
FBC (platelet count)					
Ramsey <i>et al</i> , 1983 ⁷²	92	0 (0)	–	–	–
Kaplan <i>et al</i> , 1985 ⁷³	407	3 (0.7)	1 (0.2)	–	–
Turnbull & Buck, 1987 ³⁷	1005	0 (0)	–	–	–
Charpak <i>et al</i> , 1988 ⁴⁰	290	65 (22.4)	–	5 (1.7)	–
Johnson <i>et al</i> , 1988 ⁶⁰	212	0 (0)	–	–	–
Rohrer <i>et al</i> , 1988 ⁷⁴	280	33 (11.8)	–	0 (0)	–
Bolger <i>et al</i> , 1990 ⁷⁶	52	0 (0)	–	–	–
Narr <i>et al</i> , 1991 ⁷⁹	3782	46 (1.2)	–	0 (0)	–
Macpherson <i>et al</i> , 1993 ⁸³	111	1 (0.9)	–	–	0 (0)
Close <i>et al</i> , 1994 ⁸⁴	90	1 (1.1)	–	–	0 (0)
Perez <i>et al</i> , 1995 ⁴⁸	3072	13 (0.4)	–	–	–
Median		0.7%	0.2%	0.0%	0%
Reported range		0–22.4%	0.2%	0–1.7%	0%
FBC (white blood cell count)					
Rossello <i>et al</i> , 1980 ³¹	686	120 (17.5)	–	9 (1.3)	–
Kaplan <i>et al</i> , 1985 ⁷³	390	2 (0.5)	0 (0)	–	–
Turnbull & Buck, 1987 ³⁷	1005	1 (0.1)	–	0 (0)	0 (0)
Johnson <i>et al</i> , 1988 ⁶⁰	212	0 (0)	–	–	–
Perez <i>et al</i> , 1995 ⁴⁸	3053	27 (0.9)	–	–	–
Median		0.5%	0%	0.6%	0%
Reported range		0–17.5%	0%	0–1.3%	0%

tests, and the abnormal platelet counts identified by Rohrer and colleagues⁷⁴ were all 'minimally elevated', but none were low. These results are unlikely to be clinically relevant.

White blood cell count

In all but one study abnormality rates for white blood cell counts were below 1%. The exception was a study by Rossello and colleagues who

found an abnormal white cell count in 120 of 686 children scheduled for surgery in Puerto Rico.³¹ Of these, 116 were elevated counts and four were low counts.

Impact on patient management Hb and haematocrit

In studies of routine testing, the highest proportion of cases in which management was changed by an

TABLE 12 Results of studies of preoperative Hb/FBC (routine only)

Reference	Tests performed	Abnormal n (%)	'Significantly' abnormal n (%)	Change in management n (%)	Adverse events n (%)
FBC (not further defined)					
Kaplan <i>et al</i> , 1985 ⁷³	293	2 (0.7)	0 (0)	–	–
Adams <i>et al</i> , 1992 ⁴⁵	103	3 (2.9)	–	0 (0)	–
Kozak & Brath, 1994 ⁸⁵	597	–	–	8 (1.3)	–
Perez <i>et al</i> , 1995 ⁴⁸	3089	–	–	12 (0.4)	–
Median		1.8%	0%	0.4%	–
Reported range		0.7–2.9%	0%	0–1.3%	–
FBC (Hb)					
Turnbull & Buck, 1987 ³⁷	1005	7 (0.7)	–	2 (0.2)	2 (0.2)
Narr <i>et al</i> , 1991 ⁷⁹	3782	30 (0.8)	–	3 (0.1)	–
Hoare, 1993 ⁸²	372	18 (4.8)	–	10 (2.7)	0 (0)
Perez <i>et al</i> , 1995 ⁴⁸	3081	44 (1.4)	–	–	–
Median		1.1%	–	0.2%	0.1%
Reported range		0.7–4.8%	–	0.1–2.7%	0–0.2%
FBC (platelet count)					
Kaplan <i>et al</i> , 1985 ⁷³	366	2 (0.5)	1 (0.3)	–	–
Turnbull & Buck, 1987 ³⁷	1005	0 (0)	–	–	–
Rohrer <i>et al</i> , 1988 ⁷⁴	163	13 (8.0)	–	0 (0)	–
Narr <i>et al</i> , 1991 ⁷⁹	3782	46 (1.2)	–	0 (0)	–
Macpherson <i>et al</i> , 1993 ⁸³	111	1 (0.9)	–	–	0 (0)
Close <i>et al</i> , 1994 ⁸⁴	90	1 (1.1)	–	–	0 (0)
Perez <i>et al</i> , 1995 ⁴⁸	3072	13 (0.4)	–	–	–
Median		0.9%	0.3%	0%	0%
Reported range		0–8.0%	0.3%	0%	0%
FBC (white blood cell count)					
Kaplan <i>et al</i> , 1985 ⁷³	324	1 (0.3)	0 (0)	–	–
Turnbull & Buck, 1987 ³⁷	1005	1 (0.1)	–	0 (0)	0 (0)
Perez <i>et al</i> , 1995 ⁴⁸	3053	27 (0.9)	–	–	–
Median		0.3%	0%	0%	0%
Reported range		0.1–0.9%	0%	0%	0%

abnormal Hb measurement is reported as 2.7%.⁸² In that study, of children listed for ENT surgery, ten patients had their surgery postponed and were treated with oral iron therapy. In fact, only five of these children had an Hb level below 10 g/dl, and none had a level below 9 g/dl. Two other papers reported that changes in patient management resulted from findings from 0.1% and 0.2% of tests for Hb/haematocrit.^{37,79}

Platelet count

Neither study which examined the impact of routine platelet counts on clinical management found any patient in which management had been altered by the test result.^{74,79} In their study of selectively ordered tests, Charpak and colleagues found that platelet counts altered management in 1.7% of cases.⁴⁰

White blood cell count

Evidence is available on the impact of the routine white cell count on patient management from only two of the studies identified. In a study of healthy adults, Turnbull and Buck found no patients in which management was altered.³⁷ In the study by Rossello and colleagues, referred to above, nine children with an elevated white cell count had surgery postponed.³¹ In each of these children, infection was evident clinically.

Conclusions from the earlier reviews

Only one relevant empirical paper³⁷ is referred to in the section on Hb/FBC tests in the Swedish review.¹ It is concluded that:

Of the usual tests, Hb or haematocrit seem to be the most cost-effective. However, not even for these simple analyses can we find clear support for totally unselective preoperative investigation.

No empirical studies in relation to Hb are cited in the review from the Basque country,² but nonetheless it is recommended that:

An Hb or haematocrit test should be requested in all fertile female patients and in all patients aged 60 or more having a surgical intervention.

In relation to the platelet count, a single study⁷³ is cited and it is concluded that:

The platelet count is considered to be adequate [necessary?] in patients who are going to have a major surgical intervention and in patients in whom the haemostasis can be difficult.

Conclusions

In summary, the evidence reviewed shows the following.

- No controlled trials of the value of routine preoperative Hb measurement or FBCs have been published. All available evidence reports the results of case-series.
- Routine preoperative measurement shows that the Hb level may be lower than 10–10.5 g/dl in up to 5% of patients, but that it is rarely lower than 9 g/dl. The routine test leads to a change of management in 0.1% to 2.7% of patients.
- Routine preoperative measurement shows that the platelet count is abnormally low in less than 1.1% of patients, and that platelet count results rarely if ever lead to change in management of patients.
- Routine preoperative white blood cell count is abnormal in less than 1% of patients, and rarely if ever leads to change in management of patients.

The evidence reviewed does not support a policy of routine preoperative Hb/FBC testing in all patients, and conversely provides no evidence that such a policy would be harmful. There would probably only be benefit for the small proportion of patients (< 3%) who have an abnormal Hb level and for whom management is altered.

However, it is not clear that postponement or cancellation of surgery in an otherwise fit patient is necessary if the Hb level is > 8.0 g/dl.⁷¹ In the studies of routine tests none of the patients in whom management was changed had this severity of anaemia. Overall, the evidence suggests that any patient in whom anaemia is severe enough to warrant postponement of surgery is likely to have either clinically evident features of anaemia itself, or of an associated disease.

Chapter 6

Preoperative tests of haemostasis

Background

It can be argued that tests of haemostasis have a qualitatively different purpose from the other tests discussed in this report. Rather than being used to assess the fitness of a patient for the challenge of anaesthesia, their fundamental purpose is to assess the fitness of a patient to withstand the challenge of surgery: that is, the ability of the patient to stop bleeding rapidly after being cut. It follows from this that whereas the utility of the various other preoperative tests may vary according to the level of the anaesthetic challenge (for example, local, regional or general anaesthesia), the utility of the haemostatic tests may vary according to the level of the surgical challenge, and indeed the importance of controlling bleeding.

Thus, even minor degrees of bleeding in neurosurgery or ENT surgery may be unacceptable, while in abdominal or orthopaedic surgery bleeding may be entirely tolerable. In addition, in the case of day surgery when minor postoperative bleeding will be distressing to the patients who have been discharged, the prediction of such bleeding becomes important. In view of this, it is not surprising that at least six of the studies identified have been carried out among patients undergoing ENT surgery, with three or more of the studies dealing with children undergoing tonsillectomy.

A further point of difference between tests of haemostasis and the other tests in this report is that the major conditions which these tests aim to detect are congenital, and therefore exist even in young children. The problem is that young children with bleeding disorders may not have experienced sufficient physical trauma to develop any history of abnormal bleeding episodes. Thus the clinical history may be useful in adults, but not in children, in whom an accurate test would be correspondingly more useful.

Purposes of routine preoperative haemostasis testing

Immediate medical or anaesthetic management

One purpose of tests of haemostasis is to identify patients with a bleeding tendency which is treatable

or reversible prior to surgery. A simple example would be the postponement of surgery in patients taking aspirin or some other drug inhibiting platelet function.

Prediction of postoperative complications

As indicated above, a major purpose of testing is to identify patients at high risk of excessive intra-operative or postoperative bleeding, so that surgical technique might be modified, extra blood ordered for possible transfusion, or, in the case of day surgery, discharge arrangements altered.

Other purposes

Opportunistic screening and the establishment of a haemostatic baseline are not usually advanced as reasons for routine testing.

Review of studies

Characteristics of identified studies

Our search identified 23 studies of preoperative clotting tests which reported outcome data in a usable form.^{31,35,37,40,48,72-74,76,83,84,86-97} All were simple case-series. Six studies were in adults,^{86,37,40,94,96,97} three were in children,^{31,92,95} three were in both adults and children,^{88,72,84} and in the remainder of the studies the age of the study population was not specified.^{35,48,73,74,76,83,87,89,90,91,93}

Of the 23 studies, all measured abnormality rates, 19 measured impact on clinical management,^{31,35,37,40,48,72-74,83,84,86,88,90,92-97} and eight measured the number of adverse events in those with an abnormal test finding.^{37,84,89,90,94,95,96,97} The results from routine tests could be distinguished from those for indicated tests for ten of the studies.^{37,48,73,74,83,84,89,91,92,97} Details of the studies are summarised in *Table 13*.

Results of studies of routine and indicated preoperative haemostasis tests

The number of tests performed, and the number and percentage of these with abnormal findings, with 'significantly' abnormal findings (as defined by the study authors), which resulted in a change in patient management, or which were related to

TABLE 13 Identified empirical studies of preoperative haemostasis tests

Reference	Country	Surgical setting	Study sample	Routine	Abnormal test	Change in management	Adverse events
Rader, 1978 ⁸⁶	USA	Urology (prostatic disease)	165 adults		✓	✓	
Robbins & Rose, 1979 ⁸⁷	USA	Not specified	1025 (age not given)		✓		
Harris & Nilsson, 1980 ⁸⁸	Sweden	ENT (ear surgery)	300 adults/ children (3–79 years)		✓	✓	
Rossello <i>et al</i> , 1980 ³¹	Puerto Rico	Not specified	690 children (< 14 years)		✓	✓	
Eisenberg <i>et al</i> , 1982 ⁸⁹	USA	General, gynaecology, obstetrics	750 (age not given)	✓	✓		✓
Ramsey <i>et al</i> , 1983 ⁷²	USA	Cardiothoracic (cardiac)	92 adults/ children (0–75 years)		✓	✓	
Barber <i>et al</i> , 1985 ⁹⁰	USA	Not specified	1941 (age not given)		✓	✓	✓
Kaplan <i>et al</i> , 1985 ⁷³	USA	Not specified	2785 (age not given)	✓	✓	✓	
Muskett & McGreevy, 1986 ³⁵	USA	Cardiothoracic, ENT, general, neurosurgery, ophthalmics, orthopaedics, plastic surgery, urology	200 (age not given)		✓	✓	
Suchman & Mushlin, 1986 ⁹¹	USA	Not specified	2134 (age not given)	✓	✓		
Manning <i>et al</i> , 1987 ⁹²	USA	ENT (tonsillectomies)	994 children	✓	✓	✓	
Turnbull & Buck, 1987 ³⁷	Canada	General (cholecystectomy)	1010 adults	✓	✓	✓	✓
Charpak <i>et al</i> , 1988 ⁴⁰	France	General, gynaecology, obstetrics, orthopaedics, plastic surgery	3866 adults		✓	✓	
Rohrer <i>et al</i> , 1988 ⁷⁴	USA	General, vascular	282 (age not given)	✓	✓	✓	
Bolger <i>et al</i> , 1990 ⁷⁶	USA	ENT (tonsillectomy)	52 (age not given)		✓		
Schmidt <i>et al</i> , 1990 ⁹³	USA	ENT	91 (age not given)		✓	✓	
Aghajanian & Grimes, 1991 ⁹⁴	USA	Gynaecology	1546 adults		✓	✓	✓

continued

TABLE 13 contd Identified empirical studies of preoperative haemostasis tests

Reference	Country	Surgical setting	Study sample	Routine	Abnormal test	Change in management	Adverse events
Burk <i>et al</i> , 1992 ⁹⁵	USA	ENT (tonsillectomy)	1603 children (3–16 years)		✓	✓	✓
Macpherson <i>et al</i> , 1993 ⁸³	South Africa	Cardiothoracic, general	159 (age not given)	✓	✓	✓	
Close <i>et al</i> , 1994 ⁸⁴	USA	ENT (tonsillectomy)	96 adults/children (1–40 years)	✓	✓	✓	✓
Myers <i>et al</i> , 1994 ⁹⁶	USA	Gynaecology (oncology)	351 adults		✓	✓	✓
Houry <i>et al</i> , 1995 ⁹⁷	France	Cardiothoracic, general, gynaecology, urology, vascular	3242 adults (16–99 years)	✓	✓	✓	✓
Perez <i>et al</i> , 1995 ⁴⁸	Spain	Not specified	3131 (age not given)	✓	✓	✓	

a postoperative adverse event are shown in *Table 14*. In line with the format of our review, this table includes studies which did not distinguish between indicated and routine tests, and so many of the tests will have been performed in response to clinical features suggesting a possible bleeding tendency.

Four of the papers reported outcomes for 'clotting tests' in aggregate, without specifying the exact tests which were abnormal, and these are shown first in *Table 14*.^{89,93,96,97} Subsequent subheadings show results for specific haemostatic parameters, where these data are available.

Results of studies only of routine preoperative haemostasis tests

The results of routine clotting tests could be extracted separately from those of indicated tests for ten of the studies.^{37,48,73,74,83,84,89,91,92,97} The results of these studies are shown in *Table 15*. The percentage of tests which lead to a change in management is low, being 0.8% or less in all studies.

Discussion

Abnormality rates

Bleeding time

Bleeding time (BT) was reported as abnormal in 0% to 15.6% of routine and indicated tests

(*Table 14*). The range reported in the reviewed studies suggests considerable heterogeneity of study samples. However, for routine tests in apparently asymptomatic patients, the reported results suggest that abnormalities are detected in only 3.8% of patients at most.

Prothrombin time

Similarly, prothrombin time (PT) is reported as abnormal in 0% to 12.9% of patients, this latter value being reported in the study by Charpak and colleagues of selectively ordered tests.⁴⁰ For routine tests alone, abnormality yields vary from 0% to 4.8%.

Partial thromboplastin time

It seems that abnormal results are more likely for tests for partial thromboplastin time (PTT) than in the other tests. In the identified studies, findings in up to 16.3% of PTT tests are abnormal. For routine tests alone, abnormalities are still reported in up to 15.6% of tests.

Impact on patient management

In contrast to the proportions of tests showing abnormalities, the impact of tests for haemostasis on the management of patients is uniformly small. In studies of routine and indicated tests, up to 5.3% of tests produce a change in management. However, in routine testing a change in patient management was reported for only up to 0.8% of patients.

TABLE 14 Results of studies of preoperative haemostasis tests (routine and indicated)

Reference	Tests performed	Abnormal n (%)	'Significantly' abnormal n (%)	Change in management n (%)	Adverse events n (%)
Clotting tests (unspecified)					
Eisenberg <i>et al</i> , 1982 ⁸⁹	619	38 (6.1)	–	– 1 (1.1)	(0.2)
Schmidt <i>et al</i> , 1990 ⁹³	91	4 (4.4)	–	1 (1.1)	–
Myers <i>et al</i> , 1994 ⁹⁶	351	12 (3.4)	–	3 (0.9)	1 (0.3)
Houry <i>et al</i> , 1995 ⁹⁷	3242	512 (15.8)	–	–	–
Median		3.9%	–	1.0%	0.3%
Range		3.4–15.8%	–	0.9–1.1%	0.2–0.3%
BT					
Harris & Nilsson, 1980 ⁸⁸	300	25 (8.3)	–	16 (5.3)	–
Ramsey <i>et al</i> , 1983 ⁷²	90	14 (15.6)	–	–	–
Barber <i>et al</i> , 1985 ⁹⁰	1800	110 (6.1)	–	42 (2.3)	10 (0.6)
Charpak <i>et al</i> , 1988 ⁴⁰	21	1 (4.8)	–	1 (4.8)	–
Rohrer <i>et al</i> , 1988 ⁷⁴	275	18 (6.5)	–	0 (0)	–
Bolger <i>et al</i> , 1990 ⁷⁶	52	5 (9.6)	–	–	–
Burk <i>et al</i> , 1992 ⁹⁵	1603	5 (0.3)	–	–	1 (0.1)
Macpherson <i>et al</i> , 1993 ⁸³	111	0 (0)	0 (0)	0 (0)	0 (0)
Median		6.3%	0%	2.3%	0.1%
Range		0–15.6%	0%	0–5.3%	0–0.6%
PT					
Rader, 1978 ⁸⁶	165	0 (0)	–	0 (0)	–
Rossello <i>et al</i> , 1980 ³¹	626	9 (1.4)	–	0 (0)	–
Ramsey <i>et al</i> , 1983 ⁷²	92	3 (3.3)	–	–	–
Kaplan <i>et al</i> , 1985 ⁷³	201	2 (1.0)	0 (0)	–	–
Muskett & McGreevy, 1986 ³⁵	128	5 (3.9)	–	0 (0)	–
Manning <i>et al</i> , 1987 ⁹²	994	48 (4.8)	–	8 (0.8)	–
Turnbull & Buck, 1987 ³⁷	213	0 (0)	–	0 (0)	0 (0)
Charpak <i>et al</i> , 1988 ⁴⁰	935	121 (12.9)	–	27 (2.9)	–
Rohrer <i>et al</i> , 1988 ⁷⁴	282	2 (0.7)	–	0 (0)	–
Bolger <i>et al</i> , 1990 ⁷⁶	52	3 (5.8)	–	–	–
Aghajanian & Grimes, 1991 ⁹⁴	1546	30 (1.9)	–	–	–
Burk <i>et al</i> , 1992 ⁹⁵	1603	3 (0.2)	–	–	0 (0)
Macpherson <i>et al</i> , 1993 ⁸³	111	0 (0)	0 (0)	0 (0)	0 (0)
Close <i>et al</i> , 1994 ⁸⁴	90	1 (1.1)	–	–	0 (0)
Perez <i>et al</i> , 1995 ⁴⁸	3044	7 (0.2)	–	–	–
Median		1.1%	0%	0.0%	0%
Range		0–12.9%	0%	0–2.9%	0%

continued

TABLE 14 contd Results of studies of preoperative haemostasis tests (routine and indicated)

Reference	Tests performed	Abnormal n (%)	'Significantly' abnormal n (%)	Change in management n (%)	Adverse events n (%)
<i>PTT</i>					
Rader, 1978 ⁸⁶	165	0 (0)	–	0 (0)	–
Robbins & Rose, 1979 ⁸⁷	1025	143 (14.0)	–	–	–
Rossello et al, 1980 ³¹	678	7 (1.0)	–	3 (0.4)	–
Ramsey et al, 1983 ⁷²	92	11 (12.0)	–	–	–
Kaplan et al, 1985 ⁷³	199	1 (0.5)	0 (0)	0 (0)	–
Muskett & McGreevy, 1986 ³⁵	126	5 (4.0)	–	0 (0)	–
Suchman & Mushlin, 1986 ⁹¹	2134	347 (16.3)	–	–	–
Manning et al, 1987 ⁹²	994	11 (1.1)	–	7 (0.7)	–
Turnbull & Buck, 1987 ³⁷	210	3 (1.4)	–	0 (0)	0 (0)
Charpak et al, 1988 ⁴⁰	952	76 (8.0)	–	27 (2.8)	–
Rohrer et al, 1988 ⁷⁴	282	13 (4.6)	–	0 (0)	–
Bolger et al, 1990 ⁷⁶	52	6 (11.5)	–	–	–
Burk et al, 1992 ⁹⁵	1603	26 (1.6)	–	–	1 (0.1)
Macpherson et al, 1993 ⁸³	111	8 (7.2)	–	0 (0)	0 (0)
Close et al, 1994 ⁸⁴	90	14 (15.6)	–	–	0 (0)
Perez et al, 1995 ⁴⁸	2957	8 (0.3)	–	–	–
Median		4.3%	0%	0%	0.1%
Range		0–16.3%	0%	0–2.8%	0–0.1%

Value in prediction of complications

Nine of the papers we identified explicitly address the question of whether preoperative tests of haemostasis have any predictive value at all for intra-operative or postoperative bleeding.^{37,72,84,85,91,92,98–100}

In each of these studies it was found either that there is no association between an abnormal preoperative haemostatic test and postoperative bleeding, or that the positive predictive value of the test is so low that it is clinically useless. These results are not invalidated by the possibility that the test leads to clinical action to avert the outcome, since clinical management was unaltered in almost every case. In one well-conducted study, Suchman and Mushlin found that the PTT was able to show some predictive power when used in a population of patients at high risk of bleeding,⁹¹ but that it had no value when used as a routine test in patients without indications for testing.

The results of many of these studies suggest that intraoperative or postoperative bleeding may be related much more to surgical technique than to any minor disorder of coagulation. This conclusion is compatible with that of a large and thorough review of the BT test, which concluded that the BT had no clinical value in predicting bleeding, in either preoperative or other settings.¹⁰¹

Conclusions from the earlier reviews

The Swedish review¹ cites a single study on tests of haemostasis, which is a review rather than primary research.¹⁰² No specific conclusion on these tests is reached, although there is a general statement that:

there are no studies which adequately demonstrate the clinical value of preoperative laboratory tests on asymptomatic individuals.

TABLE 15 Results of studies of preoperative haemostasis tests (routine only)

Reference	Tests performed	Abnormal n (%)	'Significantly' abnormal n (%)	Change in management n (%)	Adverse events n (%)
<i>Clotting tests (unspecified)</i>					
Eisenberg <i>et al</i> , 1982 ⁸⁹	480	13 (2.7)	–	–	1 (0.2)
Houry <i>et al</i> , 1995 ⁹⁷	2291	340 (14.8)	–	–	–
Median		8.8%	–	–	0.2%
Range		2.7–14.8%	–	–	0.2%
<i>BT</i>					
Rohrer <i>et al</i> , 1988 ⁷⁴	105	4 (3.8)	–	0 (0)	–
Macpherson <i>et al</i> , 1993 ⁸³	111	0 (0)	0 (0)	0 (0)	0 (0)
Median		1.9%	0%	0%	0%
Range		0–3.8%	0%	0%	0%
<i>PT</i>					
Kaplan <i>et al</i> , 1985 ⁷³	154	0 (0)	0 (0)	–	–
Manning <i>et al</i> , 1987 ⁹²	994	48 (4.8)	–	8 (0.8)	–
Turnbull & Buck, 1987 ³⁷	213	0 (0)	–	0 (0)	0 (0)
Rohrer <i>et al</i> , 1988 ⁷⁴	123	1 (0.8)	–	0 (0)	–
Macpherson <i>et al</i> , 1993 ⁸³	111	0 (0)	0 (0)	0 (0)	0 (0)
Close <i>et al</i> , 1994 ⁸⁴	90	1 (1.1)	–	–	0 (0)
Perez <i>et al</i> , 1995 ⁴⁸	3044	7 (0.2)	–	–	–
Median		0.2%	0%	0.0%	0%
Range		0–4.8%	0%	0–0.8%	0%
<i>PTT</i>					
Kaplan <i>et al</i> , 1985 ⁷³	154	0 (0)	0 (0)	0 (0)	–
Suchman & Mushlin, 1986 ⁹¹	1827	243 (13.3)	–	–	–
Manning <i>et al</i> , 1987 ⁹²	994	11 (1.1)	–	7 (0.7)	–
Turnbull & Buck, 1987 ³⁷	210	3 (1.4)	–	0 (0)	0 (0)
Rohrer <i>et al</i> , 1988 ⁷⁴	123	3 (2.4)	–	0 (0)	–
Macpherson <i>et al</i> , 1993 ⁸³	111	8 (7.2)	–	0 (0)	0 (0)
Close <i>et al</i> , 1994 ⁸⁴	90	14 (15.6)	–	–	0 (0)
Perez <i>et al</i> , 1995 ⁴⁸	2957	8 (0.3)	–	–	–
Median		1.9%	0%	0.0%	0%
Range		0–15.6%	0%	0–0.7%	0%

In the review from the Basque country² one study is examined in relation to the BT,⁹⁰ and it is concluded:

Without suspicion of haemorrhagic pathology, this test should not be performed for selective detection.

In relation to the PT and PTT, a single empirical paper⁹¹ is cited and it is stated that:

It is not recommended to perform the pre-operative PTT or PT detection in patients without clinical evidence of coagulation disorder.

Conclusions

In summary, the evidence reviewed shows the following.

- No controlled trials of the value of routine preoperative testing of haemostasis have been published. All available evidence reports the results of case-series.

- BT is abnormal in up to 3.8% of routine preoperative tests, and rarely, if ever, leads to change in management of patients.
- PT is abnormal in up to 4.8% of routine preoperative tests, and rarely leads to change in management of patients.
- PTT is abnormal in up to 15.6% of routine preoperative tests, and rarely leads to change in management of patients.

The evidence reviewed does not support a policy of routine preoperative testing for bleeding disorders in all patients, and conversely provides no evidence that such a policy would be harmful. Benefits would probably only occur in the small proportion (< 1%) of patients who have an abnormal test result and for whom management is altered.

It is not clear that postponement or cancellation of surgery in an otherwise fit patient is necessary simply on the basis of a mildly abnormal result since transfusion requirements and intraoperative or postoperative bleeding seem to bear little or no relationship to the result of the preoperative test.

Chapter 7

Preoperative biochemical testing

Background

Routine biochemical testing, in the form of 'U and Es' (urea and electrolytes), is performed for the vast majority of patients admitted to hospital, whether as medical or surgical patients. Sometimes there may be a clear indication, but much more frequently the tests are carried out 'just in case'.

As with Hb measurement and FBCs, biochemical tests are frequently run on auto analyser machines which allow multiple serum electrolyte and other biochemical parameters to be measured simultaneously. In principle, since each test may have a different abnormality yield and a different probability of affecting clinical management, it is worth trying to separate the results for each. A few of the research studies in this area have reported results in sufficient detail to allow this to be done, but the majority have not.

Purposes of routine preoperative biochemical testing

Immediate medical or anaesthetic management

In principle, the entire range of possible biochemical abnormalities could demand immediate preoperative medical investigation and treatment. However, since significant disturbance of sodium or acid-base balance in apparently healthy patients is extremely rare, in practice the justification for routine testing would be to detect mild to moderate preoperative hypokalaemia, renal impairment, or diabetes which were not clinically evident. Each of these could potentially require surgery to be postponed while the abnormality was corrected.

The significance of mild degrees of preoperative hypokalaemia has been much debated. Concern centres on whether a low preoperative potassium level predisposes towards life-threatening intra-operative arrhythmias, particularly in patients with pre-existing heart disease. Evidence from at least two studies suggests that it does not,^{103,104} and if this is so, then the argument for routinely determining (and correcting) serum potassium preoperatively is much diminished.

Other purposes

As with haematology tests, markedly abnormal serum biochemistry would lead to postponement of surgery while the problem was corrected. Routine use of biochemical abnormalities to predict complications or as a baseline for postoperative measures is therefore unimportant.

Review of studies

Characteristics of identified studies

Our search identified eight studies of preoperative biochemistry which reported outcome data in a usable form.^{35,37,40,45,48,73,75,79} All were simple case-series. Three studies were in adults,^{37,40,45} one study was in children,⁷⁵ and in the remainder of the studies the age of the study population was not specified.^{35,48,73,79}

Of the eight studies, all measured abnormality rates, seven measured impact on clinical management,^{35,37,40,45,48,73,79} and one measured the number of adverse events in those with an abnormal test result.³⁷ The results for routine tests could be distinguished from those for indicated tests for five of the studies.^{37,45,48,73,79} Details of the studies are summarised in *Table 16*.

Results of routine and indicated identified studies of preoperative biochemical tests

The number of tests performed, and the number and percentage of these with abnormal findings, with 'significantly' abnormal findings (as defined by the study authors), which resulted in a change in patient management, or which were related to a postoperative adverse event are shown in *Table 17*. In line with the presentation in other chapters, this table includes studies which did not distinguish between indicated and routine tests, and so many of the tests will have been performed in response to clinical features indicating biochemical testing.

Five of the papers reported at least some outcomes for 'electrolytes' or 'SMA6/7' (multichannel analyser results) in aggregate,^{35,40,45,48,73} and these are shown first in *Table 17*. Subsequent subheadings show results for specific biochemical parameters, where these data are available.

TABLE 16 Identified empirical studies of preoperative biochemistry

Reference	Country	Surgical setting	Study sample	Routine	Abnormal test	Change in management	Adverse events
Kaplan <i>et al</i> , 1985 ⁷³	USA	Not specified	2785 (age not given)	✓	✓	✓	
Muskett & McGreevy, 1986 ³⁵	USA	Cardiothoracic, ENT, general, neurosurgery, ophthalmics, orthopaedics, plastic surgery, urology	200 (age not given)		✓	✓	
Turnbull & Buck, 1987 ³⁷	Canada	General (cholecystectomy)	1010 adults	✓	✓	✓	✓
Charpak <i>et al</i> , 1988 ⁴⁰	France	General, gynaecology, obstetrics, orthopaedics, plastic surgery	3866 adults		✓	✓	
Jones <i>et al</i> , 1989 ⁷⁵	UK	Orthopaedics	346 children		✓		
Narr <i>et al</i> , 1991 ⁷⁹	USA	Not specified	3782 (age not given)	✓	✓	✓	
Adams <i>et al</i> , 1992 ⁴⁵	USA	General (hernia repair)	169 adults	✓	✓	✓	
Perez <i>et al</i> , 1995 ⁴⁸	Spain	Not specified	3131 (age not given)	✓	✓	✓	

Results of studies only of routine preoperative biochemical tests

The results of routine biochemical tests could be extracted separately from those of indicated tests for five of the studies.^{37,45,48,73,79} The results of these studies are shown in *Table 18*. The proportion of tests which lead to a change in management is generally low, being 1.1% or less in all studies.

Discussion

Abnormality rates

As expected, the abnormality yields from routine tests alone are far lower than those reported from studies which include both routine and indicated test results. Two papers cited in *Table 17* report particularly high abnormality yields, which merit some comment. The study by Charpak and colleagues was of an algorithm to generate specifically indicated tests, and the high prevalence of abnormalities is an indication of the success of the algorithm in selecting a highly

co-morbid population.⁴⁰ Likewise, Muskett and McGreevy studied a 'highly diseased patient population', with a high prevalence of medical conditions, in a Veteran's Administration hospital.³⁵

When routine tests are considered alone, the frequency of abnormal results is low, being $\leq 1.4\%$ in tests for sodium or potassium, $\leq 2.5\%$ in tests for urea or creatinine, and $\leq 5.2\%$ in tests for glucose.

In interpreting these findings, it is worth bearing in mind that it is standard laboratory practice, at least for serum electrolyte results, to define the 'normal range' statistically as results within two standard deviations of the mean for the local (hospital) population. On this definition, one would expect 5% of results to be reported as abnormal for all tests taken together (i.e. routine and indicated tests).

One study has examined the impact of previous biochemical testing on the likelihood of a new abnormality.¹⁰⁰

TABLE 17 Results of studies of preoperative biochemistry (routine and indicated)

Reference	Tests performed	Abnormal n (%)	'Significantly' abnormal n (%)	Change in management n (%)	Adverse events n (%)
<i>'Electrolytes' or 'SMA6/7'</i>					
Charpak et al, 1988 ⁴⁰	1001	813 (81.2)	–	105 (10.5)	–
Adams et al, 1992 ⁴⁵	1050	2 (0.2)	–	0 (0)	–
Kaplan et al, 1985 ⁷³	514	41 (8.0)	1 (0.2)	–	–
Muskett & McGreevy, 1986 ³⁵	117	77 (65.8)	–	24 (20.5)	–
Perez et al, 1995 ⁴⁸	2784	–	–	31 (1.1)	–
Median		36.9%	0.2%	5.8%	–
Range		0.2–81.2%	0.2%	0–20.5%	–
<i>Sodium</i>					
Turnbull & Buck, 1987 ³⁷	995	5 (0.5)	–	0 (0)	0 (0)
Median		0.5%	–	0%	0%
Range		0.5%	–	0%	0%
<i>Potassium</i>					
Turnbull & Buck, 1987 ³⁷	995	14 (1.4)	–	4 (0.4)	1 (0.1)
Narr et al, 1991 ⁷⁹	3782	7 (0.2)	–	1 (0)	–
Median		0.8%	–	0.2%	0.1%
Range		0.2–1.4%	–	0–0.4%	0.1%
<i>Sodium/potassium</i>					
Perez et al, 1995 ⁴⁸	814	6 (0.7)	–	–	–
Median		0.7%	–	–	–
Range		0.7%	–	–	–
<i>Urea</i>					
Turnbull & Buck, 1987 ³⁷	995	1 (0.1)	–	0 (0)	0 (0)
Jones et al, 1989 ⁷⁵	28	2 (7.1)	–	0 (0)	–
Perez et al, 1995 ⁴⁸	2754	68 (2.5)	–	–	–
Median		2.5%	–	0%	0%
Range		0.1–7.1%	–	0%	0%
					<i>continued</i>

TABLE 17 contd Results of studies of preoperative biochemistry (routine and indicated)

Reference	Tests performed	Abnormal n (%)	'Significantly' abnormal n (%)	Change in management n (%)	Adverse events n (%)
Creatinine					
Turnbull & Buck, 1987 ³⁷	995	2 (0.2)	–	0 (0)	0 (0)
Charpak <i>et al</i> , 1988 ⁴⁰	995	261 (26.2)	–	55 (5.5)	–
Perez <i>et al</i> , 1995 ⁴⁸	2276	28 (1.2)	–	–	–
Median		1.2%	–	2.7%	0%
Range		0.2–26.2%	–	0–5.5%	0%
Glucose					
Kaplan <i>et al</i> , 1985 ⁷³	464	25 (5.4)	2 (0.4)	–	–
Turnbull & Buck, 1987 ³⁷	396	7 (1.8)	–	0 (0)	1 (0.3)
Charpak <i>et al</i> , 1988 ⁴⁰	705	504 (71.5)	–	15 (2.1)	–
Narr <i>et al</i> , 1991 ⁷⁹	3782	70 (1.9)	–	6 (0.2)	–
Perez <i>et al</i> , 1995 ⁴⁸	2772	143 (5.2)	–	–	–
Median		5.2%	0.4%	0.2%	0.3%
Range		1.8–71.5%	0.4%	0–2.1%	0.3%

Impact on patient management

Taking all routinely performed biochemical tests together, Perez and colleagues found that management was altered in 1.1% of cases.⁴⁸ Only two studies allow more specific conclusions to be drawn about the impact of individual routine tests on clinical management.^{37,79} In both of these studies, the results of very few tests (0.4% of potassium tests, 0.2% of blood glucose tests) caused changes in patient management.

Conclusions from the earlier reviews

In the Swedish review¹ four papers are cited in the discussion of biochemical tests.^{35,37,40,73}

It is concluded that:

there are no studies which adequately demonstrate the clinical value of preoperative laboratory tests on asymptomatic individuals.

In the review from the Basque country² there is reference to a single non-systematic review of testing in the section on biochemical tests, and it is argued that:

most of the results that did help to change anaesthetic management could have been obtained by clinical history and physical examination.

Conclusions

In summary, the evidence reviewed shows the following.

- No controlled trials of the value of routine preoperative biochemical testing have been published. All available evidence reports the results of case-series.
- Results for sodium or potassium are abnormal in up to 1.4% of routine preoperative tests, and rarely lead to change in management of patients.
- Results for urea or creatinine are abnormal in up to 2.5% of routine preoperative tests, and infrequently lead to change in management of patients.
- Results for glucose are abnormal in up to 5.2% of routine preoperative tests, and rarely lead to change in management of patients.

TABLE 18 Results of studies of preoperative biochemistry (routine only)

Reference	Tests performed	Abnormal n (%)	'Significantly' abnormal n (%)	Change in management n (%)	Adverse events n (%)
<i>'Electrolytes' or 'SMA6/7'</i>					
Adams et al, 1992 ⁴⁵	651	0 (0)	–	0 (0)	–
Kaplan et al, 1985 ⁷³	176	1 (0.6)	1 (0.6)	–	–
Perez et al, 1995 ⁴⁸	2784	–	–	31 (1.1)	–
Median		0.3%	0.6%	0.6%	–
Range		0–0.6%	0.6%	0–1.1%	–
<i>Sodium</i>					
Turnbull & Buck, 1987 ³⁷	995	5 (0.5)	–	0 (0)	0 (0)
Median		0.5%	–	0%	0%
Range		0.5%	–	0%	0%
<i>Potassium</i>					
Turnbull & Buck, 1987 ³⁷	995	14 (1.4)	–	4 (0.4)	1 (0.1)
Narr et al, 1991 ⁷⁹	3782	7 (0.2)	–	1 (0)	–
Median		0.8%	–	0.2%	0.1%
Range		0.2–1.4%	–	0–0.4%	0.1%
<i>Sodium/potassium</i>					
Perez et al, 1995 ⁴⁸	814	6 (0.7)	–	–	–
Median		0.7%	–	–	–
Range		0.7%	–	–	–
<i>Urea</i>					
Turnbull & Buck, 1987 ³⁷	995	1 (0.1)	–	0 (0)	0 (0)
Perez et al, 1995 ⁴⁸	2754	68 (2.5)	–	–	–
Median		1.3%	–	0%	0%
Range		0.1–2.5%	–	0%	0%
<i>Creatinine</i>					
Turnbull & Buck, 1987 ³⁷	995	2 (0.2)	–	0 (0)	0 (0)
Perez et al, 1995 ⁴⁸	2276	28 (1.2)	–	–	–
Median		0.7%	–	0%	0%
Range		0.2–1.2%	–	0%	0%

continued

TABLE 18 contd Results of studies of preoperative biochemistry (routine only)

Reference	Tests performed	Abnormal n (%)	'Significantly' abnormal n (%)	Change in management n (%)	Adverse events n (%)
<i>Glucose</i>					
Kaplan <i>et al</i> , 1985 ⁷³	361	4 (1.1)	2 (0.6)	–	–
Turnbull & Buck, 1987 ³⁷	396	7 (1.8)	–	0 (0)	1 (0.3)
Narr <i>et al</i> , 1991 ⁷⁹	3782	70 (1.9)	–	6 (0.2)	–
Perez <i>et al</i> , 1995 ⁴⁸	2772	143 (5.2)	–	–	–
Median		1.9%	0.6%	0.1%	0.3%
Range		1.1–5.2%	0.6%	0–0.2%	0.3%

The evidence reviewed does not support a policy of routine preoperative biochemistry testing in all patients, and conversely provides no evidence that such a policy would be harmful. Benefits would probably only occur in the approximately 1% of patients who have an abnormal test result and in

whom management is altered. It is not clear that postponement or cancellation of surgery in an otherwise fit patient is necessary simply on the basis of mild to moderate hypokalaemia, and the impact of routine biochemical testing on patient outcomes remains unknown.

Chapter 8

Preoperative urine testing

Background

Testing the urine is a part of the admission ritual for almost every patient who comes into hospital, regardless of age, sex, medical specialty or diagnosis. Being a low cost test, particularly since the introduction of bedside testing with 'dipsticks' (which is usually performed by nurses on the ward), the urine test tends to be seen as something which can and should be done, and is simply not worth thinking about further. This may explain why there are relatively few studies that have attempted to examine the value of the routine urine test.

Purposes of routine preoperative urine testing

Immediate medical or anaesthetic management

Although urine testing may be undertaken to identify conditions which might, conceivably, alter anaesthetic management, this is not usually its primary purpose. For some procedures, such as joint replacement, which require strict asepsis, the presence of a urinary tract infection (UTI) might be regarded as sufficient reason to postpone an operation, although there is evidence to suggest that the risk of a wound infection is unaffected by the presence of UTI.¹⁰⁵

Opportunistic screening

The major justification for routine admission or preoperative urine testing in the absence of clinical features of disease is that of opportunistic screening. The test is done simply because the opportunity has arisen to detect conditions, such as UTI, diabetes or renal disease, which might be present.

Review of studies

Characteristics of identified studies

Our search identified 11 studies which investigated preoperative urine testing.^{31,32,35,37,45,46,60,78,105-107}

All were simple case-series. Seven studies were in adults^{37,45,46,60,105-107} three were in children,^{31,32,78} and in one study the age of the study population

was not specified.³⁵ Two of the studies included here fall, strictly, outside the terms of our search strategy, since they were conducted on medical admissions rather than for preoperative assessment.^{105,106} Each of the studies involved laboratory-based urine testing, rather than simply bedside dipstick testing.

Of the 11 studies, all measured abnormality rates, nine measured impact on clinical management,^{31,32,35,37,45,78,105-107} and three measured the number of adverse events in those with an abnormal test result.^{32,37,105} Five studies allow routine tests to be distinguished from indicated tests.^{37,45,105-107} Details of the studies are summarised in *Table 19*.

Results of identified studies of routine and indicated preoperative urine testing

The number of tests performed, and the number and percentage of these with abnormal findings, with 'significantly' abnormal findings (as defined by the study authors), which resulted in a change in patient management, or which were related to a postoperative adverse event are shown in *Table 20*. In line with the presentation in other chapters, this table includes studies which did not distinguish between indicated and routine tests, and so many of the urine tests will have been performed in response to clinical features indicating testing.

Eight of the papers either did not report separately the specific abnormalities found on urine testing (for example, white cells, red cells, glucose, protein), or did not do so in a way which allowed the results to be extracted meaningfully.^{31,32,35,45,46,60,78,106} Three studies did allow results to be extracted in this way,^{37,105,107} and the results for each test abnormality are listed under subheadings in *Table 20*.

Overall the results from the studies cover a total of 6740 urine tests. The proportion of tests with abnormal results clearly varies according to the test outcome recorded. However, if different test outcomes are aggregated, then the proportion of tests which report any abnormality varies from 2.4% to 39.2%. The proportion of tests producing

TABLE 19 Identified empirical studies of preoperative urine testing

Reference	Country	Surgical setting	Study sample	Routine	Abnormal test	Change in management	Adverse events
Rossello <i>et al</i> , 1980 ³¹	Puerto Rico	Not specified	690 children (< 14 years)		✓	✓	
Wood & Hoekelman, 1981 ³²	USA	ENT, general, ophthalmics, orthopaedics, urology	1924 children (0–19 years)		✓	✓	✓
Kroenke <i>et al</i> , 1986 ¹⁰⁶	USA	Unknown	3987 adults (17–95 years)	✓	✓	✓	
Muskett & McGreevy, 1986 ³⁵	USA	Cardiothoracic, ENT, general, neurosurgery, ophthalmics, orthopaedics, plastic surgery, urology	200 (age not given)		✓	✓	
Akin <i>et al</i> , 1987 ¹⁰⁷	USA	Unknown	301 adults	✓	✓	✓	
Turnbull & Buck, 1987 ³⁷	Canada	General (cholecystectomy)	1010 adults	✓	✓	✓	✓
Johnson <i>et al</i> , 1988 ⁶⁰	USA	ENT, general, gynaecology, ophthalmics, orthopaedics, plastic surgery, urology	212 adults		✓		
Lawrence & Kroenke, 1988 ¹⁰⁵	USA	Orthopaedics	200 adults (> 15 years)	✓	✓	✓	✓
O'Connor & Drasner, 1990 ⁷⁸	USA	ENT, general, orthopaedics, urology	486 children (< 18 years)		✓	✓	
Adams <i>et al</i> , 1992 ⁴⁵	USA	General (hernia repair)	169 adults	✓	✓	✓	
MacDonald <i>et al</i> , 1992 ⁴⁶	UK	Orthopaedics	147 adults (> 60 years)		✓		

a change in clinical management ranges from 0.1 to 16.6%.

Results of studies only of routine preoperative urine testing

The results of routine urine tests could be extracted separately from those of indicated tests for only five of the studies.^{37,45,105–107} The results of these studies are shown in *Table 21*. Although there is still marked variation in the proportion of tests with abnormal results, the proportion of tests which lead to a change in management varies little, being no more than 2.8% in all studies.

Discussion

Abnormality rates

The proportions of routine urine tests which show any abnormality vary widely, from one in one hundred to one in three of all tests. Clearly, some of this variation will arise from heterogeneity in the tested population, and some may also arise from the degrees of abnormality thought worthy of report.

Again, the low frequency of changes in clinical management indicates the doubtful importance of many of the abnormalities reported.

TABLE 20 Results of studies of preoperative urine testing (routine and indicated)

Reference	Tests performed	Abnormal n (%)	'Significantly' abnormal n (%)	Change in management n (%)	Adverse events n (%)
<i>Urine (not further defined)</i>					
Rossello et al, 1980 ³¹	688	52 (7.6)	–	1 (0.1)	–
Wood & Hoekelman, 1981 ³²	1859	226 (12.2)	131 (7.0)	1 (0.1)	–
Kroenke et al, 1986 ¹⁰⁶	1607	476 (29.6)	–	267 (16.6)	–
Muskett & McGreevy, 1986 ³⁵	174	39 (22.4)	–	9 (5.2)	–
Johnson et al, 1988 ⁶⁰	212	83 (39.2)	–	–	–
O'Connor & Drasner, 1990 ⁷⁸	453	73 (16.1)	36 (7.9)	2 (0.4)	–
Adams et al, 1992 ⁴⁵	164	4 (2.4)	–	3 (1.8)	–
MacDonald et al, 1992 ⁴⁶	145	–	–	9 (6.2)	–
Median		16.1%	7.5%	1.8%	–
Range		2.4–39.2%	7.0–7.9%	0.1–16.6%	–
<i>White blood cells</i>					
Akin et al, 1987 ¹⁰⁷	243	31 (12.8)	–	3 (1.2)	–
Turnbull & Buck, 1987 ³⁷	995	43 (4.3)	–	1 (0.1)	6 (0.6)
Lawrence & Kroenke, 1988 ¹⁰⁵	200	23 (11.5)	–	9 (4.5)	0 (0)
Median		11.5%	–	1.2%	0.3%
Range		4.3–12.8%	–	0.1–4.5%	0–0.6%
<i>Red blood cells</i>					
Akin et al, 1987 ¹⁰⁷	243	21 (8.6)	–	0 (0)	–
Lawrence & Kroenke, 1988 ¹⁰⁵	200	4 (2.0)	–	0 (0)	–
Median		5.3%	–	0%	–
Range		2.0–8.6%	–	0%	–
<i>Glucose</i>					
Akin et al, 1987 ¹⁰⁷	243	31 (12.8)	–	0 (0)	–
Lawrence & Kroenke, 1988 ¹⁰⁵	200	6 (3.0)	–	0 (0)	–
Median		7.9%	–	0%	–
Range		3.0–12.8%	–	0%	–
<i>Protein</i>					
Akin et al, 1987 ¹⁰⁷	243	45 (18.5)	–	0 (0)	–
Median		18.5%	–	0%	–
Range		18.5%	–	0%	–

TABLE 21 Results of studies of preoperative urine testing (routine only)

Reference	Tests performed	Abnormal n (%)	'Significantly' abnormal n (%)	Change in management n (%)	Adverse events n (%)
<i>Urine (not further defined)</i>					
Kroenke et al, 1986 ¹⁰⁶	746	135 (18.1)	–	10 (1.3)	–
Adams et al, 1992 ⁴⁵	100	1 (1.0)	–	1 (1.0)	–
Median		9.0%	–	1.2%	–
Range		1.0–18.1%	–	1.0–1.3%	–
<i>White blood cells</i>					
Akin et al, 1987 ¹⁰⁷	123	9 (7.3)	–	3 (2.4)	–
Turnbull & Buck, 1987 ³⁷	995	43 (4.3)	–	1 (0.1)	6 (0.6)
Lawrence & Kroenke, 1988 ¹⁰⁵	180	19 (10.6)	–	5 (2.8)	0 (0)
Median		7.3%	–	2.4%	0.3%
Range		4.3–10.6%	–	0.1–2.8%	0–0.6%
<i>Red blood cells</i>					
Akin et al, 1987 ¹⁰⁷	123	7 (5.7)	–	0 (0)	–
Lawrence & Kroenke, 1988 ¹⁰⁵	180	4 (2.2)	–	0 (0)	–
Median		4.0%	–	0%	–
Range		2.2–5.7%	–	0%	–
<i>Glucose</i>					
Akin et al, 1987 ¹⁰⁷	123	6 (4.9)	–	0 (0)	–
Lawrence & Kroenke, 1988 ¹⁰⁵	180	3 (1.7)	–	0 (0)	–
Median		3.3%	–	0%	–
Range		1.7–4.9%	–	0%	–
<i>Protein</i>					
Akin et al, 1987 ¹⁰⁷	123	16 (13.0)	–	0 (0)	–
Median		13.0%	–	0%	–
Range		13.0%	–	0%	–

Impact on patient management

From the data shown in *Table 21* it seems that an abnormal urine result changes clinical management only when it reveals white blood cells, which may indicate urinary infection. However, even when white cells are present, not all patients receive treatment. Taking *Tables 20* and *21* together, the results of studies which examined both indicated and routine tests suggest that a clinical response to abnormality is more likely to occur for indicated than for routine tests. This observation was also made in the study by Kroenke and colleagues of routine admission urinalysis.¹⁰⁶

Value as an opportunistic screening test

It is worthy of note that, whether tests were indicated or routine, isolated abnormalities of urinary protein, glucose or red cells did not lead to any identifiable changes in clinical management. This suggests that clinicians do not regard simple urine testing as an important or meaningful screening test for diabetes or urinary tract disease.

Value in prediction of complications

No study has provided any evidence that an abnormal preoperative urinalysis is associated with any adverse perioperative or postoperative event. Lawrence and Kroenke studied 200 orthopaedic patients and found no association between preoperative abnormality and postoperative wound infections.¹⁰⁵ Similarly, Wood and Hoekelman found no relationship between preoperative urine abnormality and postoperative complications in a study of 1859 urine tests in children undergoing elective surgery.³²

In a study of 1010 healthy adults undergoing cholecystectomy, Turnbull and Buck calculated the positive predictive value of preoperative urine abnormality for a 'relevant postoperative complication' (undefined) to be 14%, not importantly different from the predictive value of history and examination alone (12%).³⁷

Conclusions from the earlier reviews

In the Swedish review¹ only a single study was examined in relation to urinalysis.¹⁰⁷ Although it is not explicitly stated, the review suggests that benefits from urine testing are low, but it is argued that:

it is obvious that indication of asymptomatic bacteriuria is of importance prior to all surgery which includes manipulation of the urinary tract.

Consideration of this question lies beyond the scope of our review.

The review from the Basque country² also examines only one study,³⁷ and also suggests, though not explicitly, that routine urine testing need not be performed. It is recommended:

that urine analysis and treatment of asymptomatic pyuria [white cells in the urine] should be performed in the following: hip prosthesis intervention and surgery which involves manipulation of the urinary tract.

Conclusions

In summary, the evidence reviewed shows that:

- No controlled trials of the value of routine preoperative urine testing have been published. All available evidence reports the results of case-series.
- Routine preoperative urinalysis finds abnormal results in 1–34.1% of patients, and leads to a change of management in 0.1–2.8% of patients. The only abnormality that leads to a change in management of patients is the finding of white cells in the urine.
- There is no good evidence that preoperative abnormal urinalysis is associated with any postoperative complication.
- There is little or no apparent value in routine preoperative urinalysis as an opportunistic screening test for unrelated disease, since even when abnormalities are found, they evoke no change in clinical management.

The evidence reviewed does not support a policy of routine preoperative urine testing in all patients, and conversely provides no evidence that such a policy would be harmful. Benefits would probably only occur in the small proportion (< 3%) of patients for whom management is altered.

However, it may be that a policy of routine dipstick testing for features suggestive of infection, followed by laboratory microscopy and culture for those which are positive, would still be worthwhile in a selected population (such as older women).

Chapter 9

Some limitations of the available evidence

The evidence reviewed suggests that the likely extent of any benefits which could follow from routine preoperative testing will be very small. However, it is also clear that the evidence available in this area suffers a number of important limitations. The purpose of this chapter is to draw attention to some important methodological issues raised by the existing evidence.

Potential bias in case-series

There are a number of potential selection biases in the design of case-series reports which may affect the observed results.

Firstly, the study sample may show selection bias according to the result of the preoperative test under consideration. If the test result is abnormal and the patient's operation is cancelled, then studies which select samples on the basis of operative procedures (for example, from theatre logs) will tend to omit patients with abnormal test results, and underestimate the abnormality rate and the impact on clinical management. In many papers, there is insufficient information reported to determine whether this bias could have occurred.

Secondly, if tests are ordered selectively by clinicians, then clearly the proportion of tests which either show an abnormality or change management will be higher than if a test is ordered for every member of the study sample. The reports of many studies do not allow us to distinguish between tests which are ordered selectively, on the basis of clinical features, and those which are ordered in asymptomatic patients.

This point is illustrated in Charpak's study of selectively ordered tests,⁴⁰ in which the ordering of a test was more strongly predictive of postoperative complications than was the result of that test.

Which outcomes should studies examine?

Abnormal test results as an outcome

The yield of abnormalities which a test generates is a very poor measure of the value of testing, for the following reasons.

- For some tests, such as serum biochemical parameters, the 'normal range' is defined statistically as results falling within two standard deviations of the mean for the local population, so that the abnormality rate in healthy patients will always be about 5%.
- For other tests, principally the chest X-ray and ECG, multiple abnormalities are possible with a single test. Some of these are trivial and some may be important, but there will be considerable variation between clinicians in which findings are regarded as important.
- Many of the abnormalities identified by the tests are trivial or are of debatable importance to patient management.
- Significant abnormalities may be ignored by clinicians, or have no possible management implication which could improve patient outcome.
- Normal results may be as important as abnormal results in the optimal management of some patients, either through avoiding unnecessary interventions or by providing information for later management.

Clinical management as an outcome

Many studies have tried to examine the impact on clinical management of abnormal test results, and this is likely to be a better measure of outcome since at least those abnormalities which are ignored or have no implication for management are not included. It seems reasonable to argue that test results which produce no change in management are unlikely to produce benefit for the patient.

Forty-two of the studies reviewed here have attempted to measure whether or not a test result changes clinical measurement. Two basic approaches have been taken.

- (1) The majority of studies have relied on reviewing the patient's notes and other written or electronic records (theatre logs, anaesthetic notes, transfusion records, laboratory requests, etc.) for evidence that management has been altered.
- (2) In fewer, but still a substantial number, of studies a prospective approach has been taken by recording, or asking clinicians to record, on a dedicated data collection form

the anaesthetic or surgical management plan prior to testing. Test results and any changes to management which result are also recorded, at the time they occur.

The studies taking each of these approaches are identified in *Table 22*, for reference.

With either approach, it is important to consider how likely it is that any impact a test result may have on management will be reliably detected. There are a number of observations which can be made.

- It seems likely that prospective data collection will be more sensitive than case-note review, since not all relevant test results nor subsequent actions might have been recorded in writing.
- On the other hand, prospective data collection by those whose decisions are the subject of research may in itself alter usual behaviour. For example, many studies have recorded low levels of response by clinicians to abnormal results which warrant retesting or treatment (for example, urinary white cells suggesting infection). Clinicians may be less likely to ignore abnormal test results if they have to record their responses explicitly in writing.
- There are some features specific to the routine preoperative testing situation which simplify possible courses of action and would be expected to make detection of any change in management of patients reasonably sensitive and specific, even if case-note review is the chosen method.

Some issues regarding change in clinical management as an outcome should be considered.

Firstly, the focus of this review is on routine testing, for which patients are, by definition, asymptomatic in relation to the conditions for which tests are ordered. In the absence of an abnormal preoperative test, one would therefore expect perioperative management to follow a

standard pattern which is recognisable as such by those (usually anaesthetists or surgeons) assessing the study data. In the presence of an abnormal preoperative test, relevant alterations in management are therefore likely to be due to the test result itself rather than to some other factor.

Secondly, the relevant alterations in management which a test can provoke are frequently clear, unambiguous, routinely recorded and specific to the test in question. Examples of such changes, many of which have been sought in the studies we have reviewed here, include: cancellation or postponement of surgery; referral for a medical opinion; perioperative cross-matching or transfusion of blood beyond local hospital policy; repeat testing; preoperative treatment with antibiotic for other than prophylactic reasons.

For some tests, only a limited range of clinical responses are relevant. For example, many of the studies of clotting times record preoperative ordering of blood as the appropriate (and routinely recorded) change in management of patients.

However, some possible responses, such as alteration in the anaesthetic agent or induction technique, or indeed simply increased vigilance during anaesthesia, may be subtle and not easily detectable from routinely held records. They may, nonetheless, have been recorded prospectively by anaesthetists in some of the studies using that approach.

A third consideration is that in wider clinical practice a normal test result may alter management. For example, a normal chest X-ray may disprove a clinical suspicion of heart failure. Of course, this benefit of a normal test result can only be gained if there is a suspicion of some problem to begin with, on the basis of the clinical history and examination. Since here we are, by definition, dealing with apparently healthy patients then there will be no pre-existing suspicion to be disproved. Put another way, all normal findings

TABLE 22 *Methods for examining impact on management*

Approach to measuring impact on management	Number of studies	Reference numbers of relevant studies
Review of patient notes or other records	27	20, 28, 30, 31, 32, 34, 36, 42, 45, 47, 48, 61, 73, 75, 77, 78, 79, 81, 82, 85, 90, 92, 93, 96, 105, 106, 107
Prospective data collection on management decisions	11	18, 21, 38, 39, 40, 46, 59, 63, 74, 80, 83
Not specified or ambiguous	4	27, 35, 86, 88

of routine tests will be expected, and will not change management.

Taken as a whole, these considerations suggest that the results of those studies reporting change in management of patients may be a reasonably accurate reflection of reality, at least for the routine tests.

A number of studies show that an abnormal test result is more likely to evoke a clinical response if it was selectively ordered than if the test was routine, and this may reflect an accurate judgement by doctors that routinely ordered tests have a lower predictive value (i.e. are more likely to be 'false-positives') than selectively ordered tests.

Patient health status or perioperative complications

The important outcomes which preoperative tests are trying to improve are those related directly to the patient. Such an outcome might be some measure of health status, or the incidence of relevant postoperative complications, or a measure of resource use such as length of stay.

It will be clear from the tables in previous chapters that many studies have provided some data on 'post-operative complications', though often these are undefined. The tables also make it clear that the adverse events which testing aims to prevent are themselves rare, so that a trial of adequate size to show benefits of testing in this context would need to be very large. However, it may be possible to define populations at relatively high risk of adverse events, such as older patients, in whom a moderately sized trial of routine testing could be conducted.

A number of studies have examined whether pre-operative testing can predict (rather than necessarily reduce) postoperative outcomes. This is likely

to be problematic because, usually, the clinicians treating the patient will be aware of the result of the test and may alter the care given to the patient to try to avoid the adverse outcomes in question.

What is an 'indicated' test?

For the purposes of this review we have defined a routine test as one undertaken in an apparently health patient, that is a patient with no 'indication' for the test. This raises the question of what might count as an indication, and how indications for tests are to be derived.

In the literature, the purpose of defining indications for tests often seems to be taken to mean defining a population of patients in whom a large proportion of abnormalities might be expected. Thus, a number of studies and reviews recommend testing patients over a certain age, or with a certain ASA status.

However, it is clear that taking abnormality yield as a measure of test benefit is inadequate, for the reasons discussed above, and so this approach to defining indications is unlikely to be helpful.

Furthermore, while abnormalities and changes in management may rise with age, so may clinical features which prompt a test to be ordered. The key point here is that what needs to be identified is not simply a population with a high proportion of relevant outcomes, but a population in which there is maximal marginal benefit added by ordering a test in addition to undertaking a clinical history and examination.

A number of studies attempt to address this issue by assessing the 'unexpectedness' of the abnormal result, which solves a part of the problem but still focuses on the wrong outcome measure.

Chapter 10

Summary of reviewed evidence

In chapters 3–8 we have reviewed in detail the outcome data which could be extracted from the 82 relevant empirical studies we identified. All of the studies identified were simple case-series, rather than controlled trials of alternative screening policies.

Almost all studies have reported the proportion of test results which are abnormal, but this may be a poor outcome measure because many abnormalities are trivial or have no implication for perioperative management. The proportion of tests which lead to a change in management is likely to be better reflection of the clinical utility of testing. This outcome is reported in about half of the papers reviewed.

For each test, we summarise below the key findings from the available evidence on the value of routine preoperative testing. The focus of this report is on the value of routine, rather than indicated, tests, but many of the studies reviewed do not distinguish between the two types of test. In summarising, we have therefore excluded those results which do not relate specifically to routine tests.

Chest X-ray

Routine preoperative chest X-rays are abnormal in a median of 7.4% of patients (range 2.5–37.0%) and lead to change clinical management in a median of 0.5% of patients (range 0–2.1%). Abnormality rates rise with age. The rates of impact of testing on clinical management may also rise with patient age, but this finding needs confirmation.

It is uncertain whether preoperative chest X-rays are helpful in predicting postoperative cardio-respiratory complications. Similarly, the value of a preoperative X-ray as a baseline measure is uncertain, but probably small.

ECG

Routinely recorded preoperative ECGs are abnormal in a median of 12.4% of patients

(range 4.6–31.7%) and result in change in clinical management in a median of 0.6% of patients (range 0–2.2%). Abnormality rates rise exponentially with age. There is no evidence on whether the rates of change of clinical management in response to ECG results also increase with patient age.

The value of preoperative ECGs in predicting postoperative cardiac complications seems to be very small. Similarly, indirect evidence suggests that routinely recorded preoperative ECGs as a baseline measure are likely to be of little or no value.

Haemoglobin and blood counts

Routine preoperative Hb estimation shows abnormal results in a median of 1.1% of patients (range 0.7–4.8%) and changes clinical management in a median of 0.2% of patients (range 0.1–2.7%). No study has reported the finding of unsuspected anaemia so severe that perioperative risk would be increased.

Routine preoperative platelet count is abnormal in a median of 0.9% of patients (range 0–8.0%) but rarely, if ever, changes clinical management. Routine preoperative white cell count is abnormal in a median of 0.3% of patients (range 0.1–0.9%) but rarely, if ever, changes management.

Tests of haemostasis

Routinely determined preoperative BT shows abnormal results in a median of 1.9% of patients (range 0–3.8%) but rarely, if ever, changes clinical management. PT determined by routine testing is abnormal in a median of 0.2% of patients (range 0–4.8%) but very rarely changes clinical management. Routinely determined preoperative PPT is abnormal in a median of 1.9% of patients (range 0–15.6%) but very rarely changes clinical management.

In patients without clinical features suggestive of a bleeding disorder, tests of haemostasis have no value in the prediction of perioperative bleeding.

Biochemistry

Routinely measured preoperative serum sodium levels are abnormal in a median of 0.5% of patients but rarely, if ever, change clinical management.

Routine determination of preoperative potassium is abnormal in a median of 0.8% of patients (range 0.2–1.4%) and changes clinical management in a median of 0.2% of patients (range 0–0.4%).

Routinely measured preoperative levels of serum urea and creatinine are abnormal in a median of 1.3% and 0.7% of patients, respectively. These tests rarely change management.

Preoperative blood glucose levels measured by routine testing are abnormal in a median of 1.9% of patients (range 1.1–5.2%) and change clinical management in a median of 0.1% of patients (range 0–0.2%).

Urine testing

White blood cells are present in routine preoperative urine specimens in a median of 7.3% of patients (range 4.3–10.6%) and routinely determined leucocyturia changes clinical management in a median of 2.4% of patients (range 0.1–2.8%).

Red blood cells are present in routine preoperative urine specimens in a median of 4.0% of patients (range 2.2–5.7%) but their presence rarely, if ever, changes clinical management.

Glucose is present in routine preoperative urine specimens in a median of 3.3% of patients (range 1.7–4.9%). However, routinely determined glucosuria rarely, if ever, changes clinical management.

Protein is present in routine preoperative urine specimens in a median of 13% of patients but the finding rarely, if ever, changes management.

Preoperative abnormalities of urine are not predictive of perioperative complications in non-urinary tract surgery.

Routine urine testing results in treatment for urinary infection sufficiently often (in about one in 40 patients) that it may be worthwhile considering it as a routine test. It is likely that such testing would be more worthwhile for women than for men.

Conclusions

Overall, the evidence reviewed in this report suggests the following broad conclusions.

- (1) The tests reviewed produce a wide range of abnormal results, even in apparently healthy individuals.
- (2) The clinical importance of many of these abnormal results is uncertain.
- (3) The tests lead to changes in clinical management in only a very small proportion of patients, and for some tests virtually never.
- (4) The clinical value of changes in management which do occur in response to an abnormal test result may also be uncertain in some instances.
- (5) The power of preoperative tests to predict adverse postoperative outcomes in asymptomatic patients is either weak or non-existent. However, the same tests may have greater predictive power in defined high-risk populations.
- (6) For all the tests reviewed, a policy of routine testing in apparently healthy individuals is likely to lead to little, if any, benefit. It remains possible that routine testing could still be of some benefit in asymptomatic patients in defined groups, such as those over a given age. No good evidence exists to suggest that this will be the case but conversely, no good evidence exists to suggest that it will not.

Chapter 11

Recommendations for further research

The evidence reviewed suggests that the benefits from routine non-selective preoperative testing for all patients will be extremely small or non-existent. Routine testing contributes very little to clinical management. It is likely that many clinicians already recognise this, since in some hospitals and in some specialties the prevalence of routine testing is low, and routine testing is infrequently advocated in healthy young patients (for example, patients aged less than 40 years).

However, it remains uncertain whether or not there would be greater benefit from routine testing in a clearly defined asymptomatic population at potentially higher risk of perioperative complications, for example, patients aged 65 years. Although there is good evidence that test abnormality rates increase with age, this is not the important issue. The question is whether the rate of unexpected abnormalities requiring a change in clinical management increases with age, and it is not self-evident that it will. The evidence available is not sufficient to provide an answer to this question.

It is worth noting that the answer to this question will not necessarily be uniform across all tests. The prevalence of clinically relevant unsuspected abnormalities may increase with age for some tests, but not for others. If an increase with age is shown, there is then the issue of determining the age above which routine testing is 'worthwhile', and this age may vary from test to test.

It should also be noted that for haemostatic tests, the same reasoning may apply to young children (i.e. those below a certain age) since some of the conditions for which testing is carried out are congenital.

Below, we make suggestions for primary research to address this issue, as well as for further review and analysis of existing studies in the light of the findings of this review.

Recommendations for primary research studies

- (1) The question posed above could be examined in a number of ways. Perhaps the simplest would be a prospective case-series examining

the impact on clinical management of routine testing in patients aged more than, say, 60 years. Such a study should record clinical features, any possible test indications, the anaesthetic and surgical plan prior to testing, the tests performed and their results, and any changes to management which result. The study should be of sufficient size to allow reasonably precise estimates of age-specific impact rates to be determined in 5-year age bands for age groups up to at least 85 years.

- (2) An alternative approach is to undertake pragmatic randomised trials of alternative testing policies. Because the relevant outcomes are rare, such trials would potentially have to be very large. In itself, this is not a barrier since every day a large number of patients undergo elective surgery in acute hospitals. However, the size of trial required could be reduced by restricting attention, as above, to older patients who may be at higher risk of complications. If such a trial were to be undertaken it should include an economic evaluation, address the marginal benefits of testing over clinical examination, and allow results for each individual type of test to be isolated if more than one test is the subject of the trial.
- (3) It is frequently asserted that routine chest X-ray or electrocardiography has value as a baseline, but available evidence is weak. Studies are therefore required which explicitly assess the value of the preoperative chest X-ray or ECG as a 'baseline' in defined groups of patients at high risk of postoperative cardiorespiratory complications.

Recommendations for analysis of existing research

Taking the present review as a starting point, further analysis of the existing evidence could examine a number of issues in greater depth than has been possible here, at relatively low cost. These issues would include the following.

- (1) Estimates of predictive values or likelihood ratios for each test in predicting postoperative events should be derived from those studies that contain adequate data.

- (2) The potential for pooling results from existing studies should be examined. Data from those with similar study samples, methods and outcomes could be pooled provide more precise estimates of abnormality and impact rates for each test.
- (3) Economic modelling of the likely resource costs and patient benefits of current practice should be undertaken using best estimates of test performance.
- (4) A review of available evidence on the performance of test selection algorithms, such as the US HealthQuiz instrument, should be undertaken.



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		Dr Keith Jones, Medicines Control Agency	Dr Frances Rotblat, Medicines Control Agency †	

Population Screening Panel

Chair: Professor Sir John Grimley Evans, Radcliffe Infirmary, Oxford †

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Professor Dian Donnai, St Mary's Hospital, Manchester †	Dr JA Muir Gray, RDRD, Anglia & Oxford RO †	Professor Theresa Marteau, UMDS, London †	Dr Sarah Stewart-Brown, University of Oxford †	

Primary and Community Care Panel

Chair: Professor Angela Coulter, Kings Fund Centre for Health Services Development, London †

Professor Martin Roland, University of Manchester*	Professor Andrew Haines, RDRD, North Thames RHA	Professor Roger Jones, UMDS, London †	Dr Fiona Moss, North Thames British Postgraduate Medical Federation†	Dr Mary Renfrew, University of Oxford
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