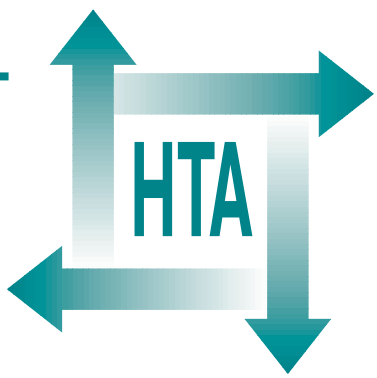
Health Technology Assessment 1997; Vol. 1: No. 12

Review

Routine preoperative testing: a systematic review of the evidence

J Munro
A Booth
J Nicholl

Health Technology Assessment
NHS R&D HTA Programme



Standing Group on Health Technology

Chair: Professor Sir Miles Irving,
Professor of Surgery, University of Manchester, Hope Hospital, Salford †

Dr Sheila Adam, Department of Health

Professor Martin Buxton, Professor of Economics, Brunel University †

Professor Angela Coulter, Director, Kings Fund Centre for Health Services Development †

Professor Anthony Culyer, Deputy Vice-Chancellor, University of York †

Dr Peter Doyle, Executive Director, Zeneca Ltd, ACOST Committee on Medical Research & Health

Professor John Farndon, Professor of Surgery, University of Bristol †

Professor Charles Florey, Department of Epidemiology & Public Health, Ninewells Hospital & Medical School, University of Dundee †

Professor John Gabbay, Director, Wessex Institute for Health Research & Development †

Dr Tony Hope, The Medical School, University of Oxford †

Professor Howard Glennester, Professor of Social Science & Administration, London School of Economics and Political Science

Professor Sir John Grimley Evans, Department of Geriatric Medicine, Radcliffe Infirmary, Oxford †

Mr John H James, Chief Executive, Kensington, Chelsea & Westminster Health Authority

Professor Richard Lilford, Regional Director, R&D, West Midlands †

Professor Michael Maisey, Professor of Radiological Sciences, UMDS, London

Dr Jeremy Metters, Deputy Chief Medical Officer, Department of Health †

Mrs Gloria Oates, Chief Executive, Oldham NHS Trust

Professor Michael Rawlins, Wolfson Unit of Clinical Pharmacology, University of Newcastle-upon-Tyne

Professor Martin Roland, Professor of General Practice, University of Manchester

Mr Hugh Ross, Chief Executive, The United Bristol Healthcare NHS Trust †

Professor Ian Russell, Department of Health, Sciences & Clinical Evaluation, University of York

Professor Trevor Sheldon, Director, NHS Centre for Reviews & Dissemination, University of York †

Professor Mike Smith, Director, The Research School of Medicine, University of Leeds †

Dr Charles Swan, Consultant Gastroenterologist, North Staffordshire Royal Infirmary

Professor Tom Walley, Department of Pharmacological Therapeutics, University of Liverpool †

Dr Julie Woodin, Chief Excutive, Nottingham Health Authority †

† Current members

HTA Commissioning Board

Chair: Professor Charles Florey, Department of Epidemiology & Public Health,
Ninewells Hospital & Medical School, University of Dundee †

Professor Ian Russell, Department of Health, Sciences & Clinical Evaluation, University of York *

Mr Peter Bower, Independent Management Consultant, Newcastle-upon-Tyne †

Ms Christine Clarke, Director of Pharmacy, Hope Hospital, Salford †

Professor David Cohen, Professor of Health Economics, University of Glamorgan

Mr Barrie Dowdeswell, Chief Executive, Royal Victoria Infirmary, Newcastle-upon-Tyne

Dr Mike Gill, Brent and Harrow Health Authority †

Dr Jenny Hewison, Senior Lecturer, Department of Psychology, University of Leeds †

Dr Michael Horlington, Head of Corporate Licensing, Smith & Nephew Group Research Centre

Professor Sir Miles Irving (Programme Director), Professor of Surgery, University of Manchester, Hope Hospital, Salford †

Professor Martin Knapp, Director, Personal Social Services Research Unit, London School of Economics and Political Science †

Professor Theresa Marteau, Director, Psychology & Genetics Research Group, UMDS, London

Professor Sally McIntyre, MRC Medical Sociology Unit, Glasgow

Professor Jon Nicholl, Director, Medical Care Research Unit, University of Sheffield †

Dr Tim Peters, Department of Social Medicine, University of Bristol †

Professor David Sackett, Centre for Evidence Based Medicine, Oxford

Dr David Spiegelhalter, MRC Biostatistics Unit, Institute of Public Health, Cambridge

Dr Ala Szczepura, Director, Centre for Health Services Studies, University of Warwick †

Professor Graham Watt, Department of General Practice, Woodside Health Centre, Glasgow †

Professor David Williams, Department of Clinical Engineering, University of Liverpool

Dr Mark Williams, Public Health Physician, Bristol

* Previous Chair
† Current members

National Coordinating Centre for Health Technology Assessment, Advisory Group

Chair: Professor John Gabbay, Wessex Institute for Health Research & Development

Professor Mike Drummond, Centre for Health Economics, University of York

Professor Charles Florey, Department of Epidemiology & Public Health, University of Dundee

Professor Sir Miles Irving, Department of Surgery, Hope Hospital, Salford

Ms Lynn Kerridge, Wessex Institute for Health Research & Development

Dr Ruairidh Milne, Wessex Institute for Health Research & Development

Ms Kay Pattison, Research & Development Directorate, NHS Executive

Professor James Raftery, Health Economics Unit, University of Birmingham

Dr Paul Roderick, Wessex Institute for Health Research & Development

Professor Ian Russell, Department of Health, Sciences & Clinical Evaluation, University of York

Dr Ken Stein, Wessex Institute for Health Research & Development

Professor Andrew Stevens, Department of Public Health & Epidemiology, University of Birmingham

Routine preoperative testing: a systematic review of the evidence

J Munro
A Booth
J Nicholl

School of Health and Related Research
University of Sheffield

Final manuscript received September 1997
Published December 1997

This report should be referenced as follows:

Munro J, Booth A, Nicholl J. Routine preoperative testing: a systematic review of the evidence. *Health Technol Assessment* 1997; **1**(12).

NHS R&D HTA Programme

The overall aim of the NHS R&D Health Technology Assessment (HTA) programme is to ensure that high-quality research information on the costs, effectiveness and broader impact of health technologies is produced in the most efficient way for those who use, manage and work in the NHS. Research is undertaken in those areas where the evidence will lead to the greatest benefits to patients, either through improved patient outcomes or the most efficient use of NHS resources.

The Standing Group on Health Technology advises on national priorities for health technology assessment. Six advisory panels assist the Standing Group in identifying and prioritising projects. These priorities are then considered by the HTA Commissioning Board supported by the National Coordinating Centre for HTA (NCCHTA).

This report is one of a series covering acute care, diagnostics and imaging, methodology, pharmaceuticals, population screening, and primary and community care. It was identified as a priority by the Diagnostics and Imaging Panel (see inside back cover).

The views expressed in this publication are those of the authors and not necessarily those of the Standing Group, the Commissioning Board, the Panel members or the Department of Health.

Series Editors: Andrew Stevens, Ruairidh Milne and Ken Stein
Assistant Editor: Jane Robertson

The editors have tried to ensure the accuracy of this report but cannot accept responsibility for any errors or omissions. They would like to thank the referees for their constructive comments on the draft document.

ISSN 1366-5278

Published by Core Research, Alton, on behalf of the NCCHTA.
Printed on acid-free paper in the UK by The Basingstoke Press, Basingstoke.

Copies of this report can be obtained from:

The National Coordinating Centre for Health Technology Assessment,
Mailpoint 728, Boldrewood,
University of Southampton,
Southampton, SO16 7PX, UK.
Fax: +44 (0) 1703 595 639 Email: hta@soton.ac.uk
http://www.soton.ac.uk/~hta

Contents

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 1
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 Sweden[1] 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 review[1] was published in 1989, and a smaller number of important studies have appeared since the review from the Basque country[2] 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 Sweden[1] 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 country[2] 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 preoperative 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 strategies[5] 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 Radiologists[8] (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 *et al,* 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 *et al,* 1977[28]	USA	Not specified	1500 children (0–19 years)		✓	✓	
Loder, 1978[29]	UK	Dental, ENT, general, gynaecology, opthalmics, orthopaedics	1000 (age not given)		✓		
Farnsworth *et al,* 1980[30]	USA	Not specified	350 children (0–14 years)		✓	✓	
Rossello *et al,* 1980[31]	Puerto Rico	Not specified	690 children (< 14 years)		✓	✓	
Wood & Hoekelman, 1981[32]	USA	ENT, general, opthalmics, orthopaedics, urology	1924 children (0–19 years)		✓	✓	✓
Seymour *et al,* 1982[23]	UK	Not specified (non-cardiopulmonary)	233 adults (> 60 years)		✓		✓
Tornebrandt & Fletcher, 1982[33]	Sweden	General, orthopaedics, urology	100 adults (> 70 years)	✓	✓		
Rucker *et al,* 1983[34]	USA	ENT, general, gynaecology, not specified, opthalmics, orthopaedics, plastic surgery	905 (age not given)	✓	✓	✓	✓
Muskett & McGreevy, 1986[35]	USA	Cardiothoracic, ENT, general, neurosurgery, opthalmics, 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, opthalmics, 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		✓	✓	
Wiencek *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, opthalmics, 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 study[46]) to 60.1% (in a Nigerian study[41]). 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 *et al,* 1976[26]	667	299	(44.8)	126	(18.9)	–		–	
Petterson & Janower, 1977[27]	1527	134	(8.8)	–		2	(0.1)	–	
Sane *et al,* 1977[27]	1500	111	(7.4)	71	(4.7)	45	(3.0)	–	
Loder, 1978[29]	1000	–		69	(6.9)	–		–	
Farnsworth *et al,* 1980[30]	350	31	(8.9)	–		0	(0)	–	
Rossello *et al,* 1980[31]	682	20	(2.9)	–		2	(0.3)	–	
Wood & Hoekelman, 1981[32]	749	35	(4.7)	9	(1.2)	3	(0.4)	–	
Seymour *et al,* 1982[23]	233	134	(57.5)	101	(43.3)	–		–	
Tornebrandt & Fletcher, 1982[33]	191	43	(22.5)	–		–		–	
Rucker *et al,* 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 *et al,* 1987[24]	332	62	(18.7)	–		–		–	
Turnbull & Buck, 1987[37]	691	38	(5.5)	–		8	(1.2)	8	(1.2)
Weibman *et al,* 1987[38]	734	213	(29.0)	–		39	(5.3)	–	
Wiencek *et al,* 1987[39]	237	101	(42.6)	–		10	(4.2)	–	
Charpak *et al,* 1988[40]	1101	568	(51.6)	–		51	(4.6)	–	
Charpak *et al,* 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 *et al,* 1988[42]	1175	–		118	(10.0)	69	(5.9)	–	
McCleane, 1989[43]	296	103	(34.8)	–		–		–	
Bhuripanyo *et al,* 1990[18]	933	181	(19.4)	84	(9.0)	34	(3.6)	–	
Gagner & Chiasson, 1990[44]	1000	74	(7.4)	–		–		–	
Adams *et al,* 1992[45]	133	6	(4.5)	–		2	(1.5)	–	
MacDonald *et al,* 1992[46]	145	2	(1.4)	–		–		–	
Sommerville & Murray, 1992[47]	319	48	(15.0)	–		6	(1.9)	–	
Perez *et al,* 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 *et al*, 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 *et al*, 1992[45]	81	2 (2.5)	–	0 (0)	–
Sommerville & Murray, 1992[47]	215	13 (6.0)	–	2 (0.9)	–
Perez *et al*, 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 Radiologists[8] 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 review[1] 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 report[8] 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 *et al,* 1983[59]	UK	Not specified	267 (age not given)	✓	✓	✓	✓
Seymour *et al,* 1983[57]	UK	General	222 adults (> 65 years)		✓		✓
Carliner *et al,* 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 *et al,* 1988[40]	France	General, gynaecology, obstetrics, orthopaedics, plastic surgery	3866 adults		✓	✓	
Johnson *et al,* 1988[60]	USA	ENT, general, gynaecology, ophthalmics, orthopaedics, plastic surgery, urology	212 adults		✓		
Yipintsoi *et al,* 1989[61]	Thailand	ENT, general, gynaecology, ophthalmic, orthopaedics	424 (age not given)	✓	✓	✓	
McCleane & McCoy, 1990[62]	UK	Not specified	877 (age not given)		✓		
Adams *et al,* 1992[45]	USA	General (hernia repair)	169 adults	✓	✓	✓	
Bhuripanyo *et al,* 1992[63]	Thailand	ENT, general, gynaecology, obstetrics, ophthalmics, orthopaedics	395 adults (40–77 years)	✓	✓	✓	
Gold *et al,* 1992[64]	USA	Not specified	751 adults/ children (14–88 years)		✓	✓	✓
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)	✓	✓	✓	
Callaghan *et al,* 1995[65]	UK	Dental, ENT, general, neurosurgery, ophthalmics, urology, vascular	354 adults (> 16 years)	✓	✓		
Perez *et al,* 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 *et al,* 1983[59]	267	82 (30.7)	34 (12.7)	4 (1.5)	0 (0)
Seymour *et al,* 1983[57]	222	175 (78.8)	–	–	–
Carliner *et al,* 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 *et al,* 1988[40]	1610	609 (37.8)	–	117 (7.3)	–
Johnson *et al,* 1988[60]	212	140 (66.0)	–	–	–
Yipintsoi *et al,* 1989[61]	424	61 (14.4)	–	6 (1.4)	–
McCleane & McCoy, 1990[62]	877	395 (45.0)	–	–	–
Adams *et al,* 1992[45]	90	12 (13.3)	–	0 (0)	–
Bhuripanyo *et al,* 1992[63]	395	130 (32.9)	31 (7.8)	10 (2.5)	–
Gold *et al,* 1992[64]	751	321 (42.7)	–	–	–
MacDonald *et al,* 1992[46]	145	–	–	3 (2.1)	–
Sommerville & Murray, 1992[47]	290	52 (17.9)	–	4 (1.4)	–
Callaghan *et al,* 1995[65]	230	57 (24.8)	–	–	–
Perez *et al,* 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 study[48]) to 78.8% (in a UK study of persons aged over 65 years[57]). 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 review[1] there is reference to a number of reviews, a paper we sought but were unable to obtain[68] 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 country[2] there is reference to one paper from *Table 7*,[64] as well as a review[54] 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 *et al,* 1980[31]	Puerto Rico	Not specified	690 children (< 14 years)		✓	✓	
Wood & Hoekelman, 1981[32]	USA	ENT, general, opthalmics, orthopaedics, urology	1924 children (0–19 years)		✓	✓	✓
Ramsey *et al,* 1983[72]	USA	Cardiothoracic (cardiac)	92 adults/ children (0–75 years)		✓	✓	
Kaplan *et al,* 1985[73]	USA	Not specified	2785 (age not given)	✓	✓	✓	
Muskett & McGreevy, 1986[35]	USA	Cardiothoracic, ENT, general, neurosurgery, opthalmics, orthopaedics, plastic surgery, urology	200 (age not given)		✓	✓	
Turnbull & Buck, 1987[37]	Canada	General (cholecystectomy)	1010 adults	✓	✓	✓	✓
Charpak *et al,* 1988[40]	France	General, gynaecology, obstetrics, orthopaedics, plastic surgery	3866 adults		✓	✓	
Johnson *et al,* 1988[60]	USA	ENT, general, gynaecology, opthalmics, orthopaedics, plastic surgery, urology	212 adults		✓		
Rohrer *et al,* 1988[74]	USA	General, vascular	282 (age not given)	✓	✓	✓	
Jones *et al,* 1989[75]	UK	Orthopaedics	346 children		✓		
Bolger *et al,* 1990[76]	USA	ENT (tonsillectomy)	52 (age not given)		✓		
Nigam *et al,* 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 *et al,* 1991[79]	USA	Not specified	3782 (age not given)	✓	✓	✓	
Roy *et al,* 1991[80]	Canada	Not specified	2000 children (0–18 years)		✓	✓	✓
Adams *et al,* 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 *et al,* 1992[81]	USA	Not specified	1863 children (< 18 years)		✓	✓	
MacDonald *et al,* 1992[46]	UK	Orthopaedics	147 adults (> 60 years)		✓		
Hoare, 1993[82]	UK	ENT	372 children (2–15 years)	✓	✓	✓	✓
Macpherson *et al,* 1993[83]	South Africa	Cardiothoracic, general	159 (age not given)	✓	✓	✓	
Close *et al,* 1994[84]	USA	ENT (tonsillectomy)	96 adults/ children (1–40 years)	✓	✓	✓	✓
Kozak & Brath, 1994[85]	USA	Unknown (fibreoptic bronchoscopy)	305 (age not given)	✓	✓		✓
Perez *et al,* 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 colleagues[40] 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 *et al,* 1985[73]	610	22 (3.6)	0 (0)	–	–
Muskett & McGreevy, 1986[35]	199	12 (6.0)	–	18 (9.0)	–
Adams *et al,* 1992[45]	167	6 (3.6)	–	0 (0)	–
Kozak & Brath, 1994[85]	952	–	–	38 (4.0)	–
Perez *et al,* 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 *et al,* 1980[31]	689	5 (0.7)	–	0 (0)	–
Wood & Hoekelman, 1981[32]	1918	–	–	1 (0.1)	–
Baron *et al,* 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 *et al,* 1988[40]	2138	688 (32.2)	–	140 (6.5)	–
Johnson *et al,* 1988[60]	212	19 (9.0)	–	–	–
Jones *et al,* 1989[75]	307	2 (0.7)	–	1 (0.3)	0 (0)
Nigam *et al,* 1990[77]	250	2 (0.8)	–	0 (0)	–
O'Connor & Drasner, 1990[78]	484	85 (17.6)	–	2 (0.4)	–
Narr *et al,* 1991[79]	3782	30 (0.8)	–	3 (0.1)	–
Roy *et al,* 1991[80]	2000	11 (0.6)	–	3 (0.2)	0 (0)
MacDonald *et al,* 1992[46]	145	–	–	5 (3.4)	–
Hoare, 1993[82]	372	18 (4.8)	–	10 (2.7)	0 (0)
Perez *et al,* 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 *et al,* 1983[72]	92	0 (0)	–	–	–
Kaplan *et al,* 1985[73]	407	3 (0.7)	1 (0.2)	–	–
Turnbull & Buck, 1987[37]	1005	0 (0)	–	–	–
Charpak *et al,* 1988[40]	290	65 (22.4)	–	5 (1.7)	–
Johnson *et al,* 1988[60]	212	0 (0)	–	–	–
Rohrer *et al,* 1988[74]	280	33 (11.8)	–	0 (0)	–
Bolger *et al,* 1990[76]	52	0 (0)	–	–	–
Narr *et al,* 1991[79]	3782	46 (1.2)	–	0 (0)	–
Macpherson *et al,* 1993[83]	111	1 (0.9)	–	–	0 (0)
Close *et al,* 1994[84]	90	1 (1.1)	–	–	0 (0)
Perez *et al,* 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 *et al,* 1980[31]	686	120 (17.5)	–	9 (1.3)	–
Kaplan *et al,* 1985[73]	390	2 (0.5)	0 (0)	–	–
Turnbull & Buck, 1987[37]	1005	1 (0.1)	–	0 (0)	0 (0)
Johnson *et al,* 1988[60]	212	0 (0)	–	–	–
Perez *et al,* 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 colleagues[74] 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 *et al,* 1985[73]	293	2 (0.7)	0 (0)	–	–
Adams *et al,* 1992[45]	103	3 (2.9)	–	0 (0)	–
Kozak & Brath, 1994[85]	597	–	–	8 (1.3)	–
Perez *et al,* 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 *et al,* 1991[79]	3782	30 (0.8)	–	3 (0.1)	–
Hoare, 1993[82]	372	18 (4.8)	–	10 (2.7)	0 (0)
Perez *et al,* 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 *et al,* 1985[73]	366	2 (0.5)	1 (0.3)	–	–
Turnbull & Buck, 1987[37]	1005	0 (0)	–	–	–
Rohrer *et al,* 1988[74]	163	13 (8.0)	–	0 (0)	–
Narr *et al,* 1991[79]	3782	46 (1.2)	–	0 (0)	–
Macpherson *et al,* 1993[83]	111	1 (0.9)	–	–	0 (0)
Close *et al,* 1994[84]	90	1 (1.1)	–	–	0 (0)
Perez *et al,* 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 *et al,* 1985[73]	324	1 (0.3)	0 (0)	–	–
Turnbull & Buck, 1987[37]	1005	1 (0.1)	–	0 (0)	0 (0)
Perez *et al,* 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 paper[37] 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 study[73] 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 intraoperative 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 *et al,* 1980[31]	Puerto Rico	Not specified	690 children (< 14 years)		✓	✓	
Eisenberg *et al,* 1982[89]	USA	General, gynaecology, obstetrics	750 (age not given)	✓	✓		✓
Ramsey *et al,* 1983[72]	USA	Cardiothoracic (cardiac)	92 adults/ children (0–75 years)		✓	✓	
Barber *et al,* 1985[90]	USA	Not specified	1941 (age not given)		✓	✓	✓
Kaplan *et al,* 1985[73]	USA	Not specified	2785 (age not given)	✓	✓	✓	
Muskett & McGreevy, 1986[35]	USA	Cardiothoracic, ENT, general, neurosurgery, opthalmics, orthopaedics, plastic surgery, urology	200 (age not given)		✓	✓	
Suchman & Mushlin, 1986[91]	USA	Not specified	2134 (age not given)	✓	✓		
Manning *et al,* 1987[92]	USA	ENT (tonsillectomies)	994 children	✓	✓	✓	
Turnbull & Buck, 1987[37]	Canada	General (cholecystectomy)	1010 adults	✓	✓	✓	✓
Charpak *et al,* 1988[40]	France	General, gynaecology, obstetrics, orthopaedics, plastic surgery	3866 adults		✓	✓	
Rohrer *et al,* 1988[74]	USA	General, vascular	282 (age not given)	✓	✓	✓	
Bolger *et al,* 1990[76]	USA	ENT (tonsillectomy)	52 (age not given)		✓		
Schmidt *et al,* 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 *et al,* 1992[95]	USA	ENT (tonsillectomy)	1603 children (3–16 years)		✓	✓	✓
Macpherson *et al,* 1993[83]	South Africa	Cardiothoracic, general	159 (age not given)	✓	✓	✓	
Close *et al,* 1994[84]	USA	ENT (tonsillectomy)	96 adults/ children (1–40 years)	✓	✓	✓	✓
Myers *et al,* 1994[96]	USA	Gynaecology (oncology)	351 adults		✓	✓	✓
Houry *et al,* 1995[97]	France	Cardiothoracic, general, gynaecology, urology, vascular	3242 adults (16–99 years)	✓	✓	✓	✓
Perez *et al,* 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 *et al,* 1982[89]	619	38 (6.1)	–	– 1 (0.2)	
Schmidt *et al,* 1990[93]	91	4 (4.4)	–	1 (1.1)	–
Myers *et al,* 1994[96]	351	12 (3.4)	–	3 (0.9)	1 (0.3)
Houry *et al,* 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 *et al,* 1983[72]	90	14 (15.6)	–	–	–
Barber *et al,* 1985[90]	1800	110 (6.1)	–	42 (2.3)	10 (0.6)
Charpak *et al,* 1988[40]	21	1 (4.8)	–	1 (4.8)	–
Rohrer *et al,* 1988[74]	275	18 (6.5)	–	0 (0)	–
Bolger *et al,* 1990[76]	52	5 (9.6)	–	–	–
Burk *et al,* 1992[95]	1603	5 (0.3)	–	–	1 (0.1)
Macpherson *et al,* 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 *et al,* 1980[31]	626	9 (1.4)	–	0 (0)	–
Ramsey *et al,* 1983[72]	92	3 (3.3)	–	–	–
Kaplan *et al,* 1985[73]	201	2 (1.0)	0 (0)	–	–
Muskett & McGreevy, 1986[35]	128	5 (3.9)	–	0 (0)	–
Manning *et al,* 1987[92]	994	48 (4.8)	–	8 (0.8)	–
Turnbull & Buck, 1987[37]	213	0 (0)	–	0 (0)	0 (0)
Charpak *et al,* 1988[40]	935	121 (12.9)	–	27 (2.9)	–
Rohrer *et al,* 1988[74]	282	2 (0.7)	–	0 (0)	–
Bolger *et al,* 1990[76]	52	3 (5.8)	–	–	–
Aghajanian & Grimes, 1991[94]	1546	30 (1.9)	–	–	–
Burk *et al,* 1992[95]	1603	3 (0.2)	–	–	0 (0)
Macpherson *et al,* 1993[83]	111	0 (0)	0 (0)	0 (0)	0 (0)
Close *et al,* 1994[84]	90	1 (1.1)	–	–	0 (0)
Perez *et al,* 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 (%)
PTT					
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 intraoperative 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 review[1] 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 (%)
Clotting tests (unspecified)					
Eisenberg *et al,* 1982[89]	480	13 (2.7)	–	–	1 (0.2)
Houry *et al,* 1995[97]	2291	340 (14.8)	–	–	–
Median		**8.8%**	–	–	**0.2%**
Range		**2.7–14.8%**	–	–	**0.2%**
BT					
Rohrer *et al,* 1988[74]	105	4 (3.8)	–	0 (0)	–
Macpherson *et al,* 1993[83]	111	0 (0)	0 (0)	0 (0)	0 (0)
Median		**1.9%**	**0%**	**0%**	**0%**
Range		**0–3.8%**	**0%**	**0%**	**0%**
PT					
Kaplan *et al,* 1985[73]	154	0 (0)	0 (0)	–	–
Manning *et al,* 1987[92]	994	48 (4.8)	–	8 (0.8)	–
Turnbull & Buck, 1987[37]	213	0 (0)	–	0 (0)	0 (0)
Rohrer *et al,* 1988[74]	123	1 (0.8)	–	0 (0)	–
Macpherson *et al,* 1993[83]	111	0 (0)	0 (0)	0 (0)	0 (0)
Close *et al,* 1994[84]	90	1 (1.1)	–	–	0 (0)
Perez *et al,* 199548	3044	7 (0.2)	–	–	–
Median		**0.2%**	**0%**	**0.0%**	**0%**
Range		**0–4.8%**	**0%**	**0–0.8%**	**0%**
PTT					
Kaplan *et al,* 1985[73]	154	0 (0)	0 (0)	0 (0)	–
Suchman & Mushlin, 1986[91]	1827	243 (13.3)	–	–	–
Manning *et al,* 1987[92]	994	11 (1.1)	–	7 (0.7)	–
Turnbull & Buck, 1987[37]	210	3 (1.4)	–	0 (0)	0 (0)
Rohrer *et al,* 1988[74]	123	3 (2.4)	–	0 (0)	–
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		**1.9%**	**0%**	**0.0%**	**0%**
Range		**0–15.6%**	**0%**	**0–0.7%**	**0%**

In the review from the Basque country[2] 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 paper[91] 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 intraoperative 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 *et al,* 1985[73]	USA	Not specified	2785 (age not given)	✓	✓	✓	
Muskett & McGreevy, 1986[35]	USA	Cardiothoracic, ENT, general, neurosurgery, opthalmics, orthopaedics, plastic surgery, urology	200 (age not given)		✓	✓	
Turnbull & Buck, 1987[37]	Canada	General (cholecystectomy)	1010 adults	✓	✓	✓	✓
Charpak *et al,* 1988[40]	France	General, gynaecology, obstetrics, orthopaedics, plastic surgery	3866 adults		✓	✓	
Jones *et al,* 1989[75]	UK	Orthopaedics	346 children		✓		
Narr *et al,* 1991[79]	USA	Not specified	3782 (age not given)	✓	✓	✓	
Adams *et al,* 1992[45]	USA	General (hernia repair)	169 adults	✓	✓	✓	
Perez *et al,* 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 McGreevey 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 ≤ 1.4% in tests for sodium or potassium, ≤ 2.5% in tests for urea or creatinine, and ≤ 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 (%)
'Electrolytes' or 'SMA6/7'					
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%**	–
Sodium					
Turnbull & Buck, 1987[37]	995	5 (0.5)	–	0 (0)	0 (0)
Median		**0.5%**	–	**0%**	**0%**
Range		**0.5%**	–	**0%**	**0%**
Potassium					
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%**
Sodium/potassium					
Perez *et al,* 1995[48]	814	6 (0.7)	–	–	–
Median		**0.7%**	–	–	–
Range		**0.7%**	–	–	–
Urea					
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%**

continued

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 *et al,* 1988[40]	995	261 (26.2)	–	55 (5.5)	–
Perez *et al,* 1995[48]	2276	28 (1.2)	–	–	–
Median		**1.2%**	–	**2.7%**	**0%**
Range		**0.2–26.2%**	–	**0–5.5%**	**0%**
Glucose					
Kaplan *et al,* 1985[73]	464	25 (5.4)	2 (0.4)	–	–
Turnbull & Buck, 1987[37]	396	7 (1.8)	–	0 (0)	1 (0.3)
Charpak *et al,* 1988[40]	705	504 (71.5)	–	15 (2.1)	–
Narr *et al,* 1991[79]	3782	70 (1.9)	–	6 (0.2)	–
Perez *et al,* 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 review[1] 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 country[2] 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 (%)
'Electrolytes' or 'SMA6/7'					
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%**	–
Sodium					
Turnbull & Buck, 1987[37]	995	5 (0.5)	–	0 (0)	0 (0)
Median		**0.5%**	–	**0%**	**0%**
Range		**0.5%**	–	**0%**	**0%**
Potassium					
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%**
Sodium/potassium					
Perez *et al,* 1995[48]	814	6 (0.7)	–	–	–
Median		**0.7%**	–	–	–
Range		**0.7%**	–	–	–
Urea					
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%**
Creatinine					
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 (%)
Glucose					
Kaplan *et al*, 1985[73]	361	4 (1.1)	2 (0.6)	–	–
Turnbull & Buck, 1987[37]	396	7 (1.8)	–	0 (0)	1 (0.3)
Narr *et al*, 1991[79]	3782	70 (1.9)	–	6 (0.2)	–
Perez *et al*, 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 *et al,* 1980[31]	Puerto Rico	Not specified	690 children (< 14 years)		✓	✓	
Wood & Hoekelman, 1981[32]	USA	ENT, general, opthalmics, orthopaedics, urology	1924 children (0–19 years)		✓	✓	✓
Kroenke *et al,* 1986[106]	USA	Unknown	3987 adults (17–95 years)	✓	✓	✓	
Muskett & McGreevy, 1986[35]	USA	Cardiothoracic, ENT, general, neurosurgery, opthalmics, orthopaedics, plastic surgery, urology	200 (age not given)		✓	✓	
Akin *et al,* 1987[107]	USA	Unknown	301 adults	✓	✓	✓	
Turnbull & Buck, 1987[37]	Canada	General (cholecystectomy)	1010 adults	✓	✓	✓	✓
Johnson *et al,* 1988[60]	USA	ENT, general, gynaecology, opthalmics, 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 *et al,* 1992[45]	USA	General (hernia repair)	169 adults	✓	✓	✓	
MacDonald *et al,* 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 (%)
Urine (not further defined)					
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%**	–
White blood cells					
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%**
Red blood cells					
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%**	–
Glucose					
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%**	–
Protein					
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 (%)
Urine (not further defined)					
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%**	–
White blood cells					
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%**
Red blood cells					
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%**	–
Glucose					
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%**	–
Protein					
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 review[1] 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 country[2] 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 'postoperative 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 preoperative 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 cardiorespiratory 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 leucocytouria 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.

Acknowledgements

This work was commissioned by the Health Technology Assessment programme of the NHS research and development strategy.

We are grateful to the programme's anonymous referees for their constructive criticism.

References

1. The Swedish Council on Technology Assessment in Health Care. Preoperative routines. *Int J Technol Assess Health Care* 1991;**7**:95–100.
2. Anonymous. Preoperative evaluation in healthy/asymptomatic patients. Osteba: Health Department, 1995.
3. Lefebvre C. The Cochrane Collaboration: the role of the UK Cochrane Centre in identifying the evidence. *Health Libr Rev* 1994;**11**:235–42.
4. Dickersin K, Scherer R, Lefebvre C. Identification of relevant studies for systematic reviews. *BMJ* 1994;**309**:1286–91.
5. McKibbon KA, Walker CJ. Beyond ACP Journal Club: how to harness MEDLINE for diagnosis problems (editorial). *Ann Intern Med* 1994;**121**:A10.
6. Kerr IH. Preoperative chest x-ray. *Br J Anaesth* 1974;**46**:558–63.
7. Sagel SS, Evens RG, Forrest JV. Efficacy of routine screening and lateral chest radiographs in a hospital based population. *N Engl J Med* 1974;**291**:1001–4.
8. Anonymous. Preoperative chest radiology. National study by the Royal College of Radiologists. *Lancet* 1979;**2**:83–6.
9. Roberts CJ. Towards the effective use of diagnostic radiology in surgical practice: discussion paper. *J R Soc Med* 1983;**76**:755–9.
10. Roberts CJ, Fowkes FG, Ennis WP, Mitchell M. Possible impact of audit on chest X-ray requests from surgical wards. *Lancet* 1983;**2**:446–8.
11. Fowkes FG, Davies ER, Evans KT, *et al.* Multicentre trial of four strategies to reduce use of a radiological test. *Lancet* 1986;**1**:367–70.
12. Hall R, Jones DT, Ramaiah RS. Experience in implementation of clinical guidelines: pre-operative chest radiography in non-cardiopulmonary surgery. *Hosp Health Serv Rev* 1985;**81**:270–2.
13. Working Party on the Effective Use of Diagnostic Cardiology. Guidelines on pre-operative chest X-ray. London: Royal College of Radiologists, 1982.
14. Romfh RF. The appropriateness of routine diagnostic studies. *Mil Med* 1989;**154**:140–4.
15. Fowkes FG, Davies ER, Evans KT, *et al.* Compliance with the Royal College of Radiologists' guidelines on the use of pre-operative chest radiographs. *Clin Radiol* 1987;**38**:45–8.
16. Klazinga NS, Helsloot R. Quality assurance of pre-operative assessment – a review of quality assurance activities related to pre-operative assessment in nine hospitals in The Netherlands. *Qual Assur Health Care* 1989;**1**:45–53.
17. Bellan L. Preoperative testing for cataract surgery. *Can J Ophthalmol* 1994;**29**:111–14.
18. Bhuripanyo K, Prasertchuang C, Chamadol N, Laopaiboon M, Bhuripanyo P. The impact of routine preoperative chest X-ray in Srinagarind Hospital, Khon Kaen. *J Med Assoc Thai* 1990;**73**:21–8.
19. Williams Russo P, Charlson ME, MacKenzie CR, Gold JP, Shires GT. Predicting postoperative pulmonary complications. Is it a real problem? *Arch Intern Med* 1992;**152**:1209–13.
20. Tape TG, Mushlin AI. How useful are routine chest x-rays of preoperative patients at risk for postoperative chest disease? *J Gen Intern Med* 1988;**3**:15–20.
21. Charpak Y, Blery C, Chastang C, Szatan M, Fourgeaux B. Prospective assessment of a protocol for selective ordering of preoperative chest x-rays. *Can J Anaesth* 1988;**35**:259–64.
22. Evison G. Routine preoperative chest radiography [letter]. *BMJ* 1976;**2**:44.
23. Seymour DG, Pringle R, Shaw JW. The role of the routine pre-operative chest X-ray in the elderly general surgical patient. *Postgrad Med J* 1982;**58**:741–5.
24. Mendelson DS, Khilnani N, Wagner LD, Rabinowitz JG. Preoperative chest radiography: value as a baseline examination for comparison. *Radiology* 1987;**165**:341–3.
25. Thomsen HS, Gottlieb J, Madsen JK. [Routine radiographic examination of the thorax prior to surgical intervention under general anaesthesia.]. *Ugeskr Laeger* 1978;**140**:765–8.
26. Rees AM, Roberts CJ, Bligh AS, Evans KT. Routine preoperative chest radiography in non-cardiopulmonary surgery. *BMJ* 1976;**1**:1333–5.
27. Petterson SRF, Janower ML. Is the routine pre-operative chest film of value? *Appl Radiol* 1977;**6**:70.
28. Sane SM, Worsing RA, Jr., Wiens CW, Sharma RK. Value of preoperative chest X-ray examinations in children. *Pediatrics* 1977;**60**:669–72.
29. Loder RE. Routine pre-operative chest radiography. 1977 compared with 1955 at Peterborough District General Hospital. *Anaesthesia* 1978;**33**:972–4.

30. Farnsworth PB, Steiner E, Klein RM, SanFilippo JA. The value of routine preoperative chest roentgenograms in infants and children. *JAMA* 1980;**244**:582–3.

31. Rossello PJ, Ramos Cruz A, Mayol PM. Routine laboratory tests for elective surgery in pediatric patients: are they necessary? *Bol Asoc Med P R* 1980;**72**:614–23.

32. Wood RA, Hoekelman RA. Value of the chest X-ray as a screening test for elective surgery in children. *Pediatrics* 1981;**67**:447–52.

33. Tornebrandt K, Fletcher R. Pre-operative chest x-rays in elderly patients. *Anaesthesia* 1982;**37**:901–2.

34. Rucker L, Frye EB, Staten MA. Usefulness of screening chest roentgenograms in preoperative patients. *JAMA* 1983;**250**:3209–11.

35. Muskett AD, McGreevy J. Rational preoperative evaluation. *Postgrad Med J* 1986;**62**:925–8.

36. Boghosian SG, Mooradian AD. Usefulness of routine preoperative chest roentgenograms in elderly patients. *J Am Geriatr Soc* 1987;**35**:142–6.

37. Turnbull JM, Buck C. The value of preoperative screening investigations in otherwise healthy individuals. *Arch Intern Med* 1987;**147**:1101–5.

38. Weibman MD, Shah NK, Bedford RF. Influence of preoperative chest x-rays on the preoperative management of cancer patients. *Anesthesiology* 1987;**67**:A332.

39. Wiencek RG, Weaver DW, Bouwman DL, Sachs RJ. Usefulness of selective preoperative chest x-ray films. A prospective study. *Am Surg* 1987;**53**:396–8.

40. Charpak Y, Blery C, Chastang C, *et al.* Usefulness of selectively ordered preoperative tests. *Med Care* 1988;**26**:95–104.

41. Ogunseyinde AO. Routine pre-operative chest radiographs in non-cardiopulmonary surgery. *Afr J Med Med Sci* 1988;**17**:157–61.

42. Umbach GE, Zubek S, Deck HJ, Buhl R, Bender HG, Jungblut RM. The value of preoperative chest X-rays in gynecological patients. *Arch Gynecol Obstet* 1988;**243**:179–85.

43. McCleane GJ. Routine preoperative chest X-rays. *Ir J Med Sci* 1989;**158**:67–8.

44. Gagner M, Chiasson A. Preoperative chest X-ray films in elective surgery: a valid screening tool. *Can J Surg* 1990;**33**:271–4.

45. Adams JG, Jr., Weigelt JA, Poulos E. Usefulness of preoperative laboratory assessment of patients undergoing elective herniorrhaphy. *Arch Surg* 1992;**127**:801–4.

46. MacDonald JB, Dutton MJ, Stott DJ, Hamblen DL. Evaluation of pre-admission screening of elderly patients accepted for major joint replacement. *Health Bull Edinb* 1992;**50**:54–60.

47. Sommerville TE, Murray WB. Information yield from routine pre-operative chest radiography and electrocardiography. *S Afr Med J* 1992;**81**:190–6.

48. Perez A, Planell J, Bacardaz C, *et al.* Value of routine preoperative tests: a multicentre study in four general hospitals. *Br J Anaesth* 1995;**74**:250–6.

49. Makanjuola D. Reappraisal of the routine pre-operative chest X-ray. *Nig Med Pract* 1985;**9**:45–8.

50. Delahunt B, Turnbull PR. How cost effective are routine preoperative investigations? *N Z Med J* 1980;**92**:431–2.

51. Haubek A, Cold G. [The indications for and consequences of preoperative radiography of the thorax.]. *Ugeskr Laeger* 1978;**140**:772–3.

52. Maigaard S, Ekljaer P, Stefansson T. [Value of routine preoperative radiographic examination of the thorax]. *Ugeskr Laeger* 1978;**140**:769–71.

53. Escolano F, *et al.* Utilidad de la radiografia pre-operatoria de torax en cirugia electiva. *Rev Esp Anestesiol Reanim* 1994;**41**:7–12.

54. Goldberger AL, O'Konski M. Utility of the routine electrocardiogram before surgery and on general hospital admission. Critical review and new guidelines. *Ann Intern Med* 1986;**105**:552–7.

55. Velanovich V. Preoperative screening electrocardiography: predictive value for postoperative cardiac complications. *South Med J* 1994;**87**:431–4.

56. Carliner NH, Fisher ML, Plotnick GD, *et al.* The preoperative electrocardiogram as an indicator of risk in major noncardiac surgery. *Can J Cardiol* 1986;**2**:134–7.

57. Seymour DG, Pringle R, MacLennan WJ. The role of the routine pre-operative electrocardiogram in the elderly surgical patient. *Age Ageing* 1983;**12**:97–104.

58. Ashton CM, Thomas J, Wray NP, Wu L, Kiefe CI, Lahart CJ. The frequency and significance of ECG changes after transurethral prostate resection. *J Am Geriatr Soc* 1991;**39**:575–80.

59. Paterson KR, Caskie JP, Galloway DJ, McArthur K, McWhinnie DL. The pre-operative electrocardiogram: an assessment. *Scott Med J* 1983;**28**:116–18.

60. Johnson H, Jr., Knee-Ioli S, Butler TA, Munoz E, Wise L. Are routine preoperative laboratory screening tests necessary to evaluate ambulatory surgical patients? *Surgery* 1988;**104**:639–45.

61. Yipintsoi T, Vasinanukorn P, Sanguanchua P. Is routine pre-operative electrocardiogram necessary? *J Med Assoc Thai* 1989;**72**:16–20.

62. McCleane GJ, McCoy E. Routine pre-operative electrocardiography. *Br J Clin Pract* 1990;**44**:92–5.

63. Bhuripanyo K, Prasertchuang C, Viwathanatepa M, Khumsuk K, Sornpanya N. The impact of routine preoperative electrocardiogram in patients age > or = 40 years in Srinagarind Hospital. *J Med Assoc Thai* 1992;**75**:399–406.

64. Gold BS, Young ML, Kinman JL, Kitz DS, Berlin J, Schwartz JS. The utility of preoperative electrocardiograms in the ambulatory surgical patient [see comments]. *Arch Intern Med* 1992;**152**:301–5.

65. Callaghan LC, Edwards ND, Reilly CS. Utilisation of the pre-operative ECG. *Anaesthesia* 1995;**50**:488–90.

66. Rabkin SW, Horne JM. Preoperative electrocardiography: its cost-effectiveness in detecting abnormalities when a previous tracing exists. *Can Med Assoc J* 1979;**121**:301–6.

67. Rabkin SW, Horne JM. Preoperative electrocardiography effect of new abnormalities on clinical decisions. *Can Med Assoc J* 1983;**128**:146–7.

68. Ferrer MI. The value of obligatory preoperative electrocardiograms. A survey of 1260 patients. *J Am Med Wom Assoc* 1978;**33**:459–64.

69. Elston RA, Taylor DJ. The preoperative electrocardiogram [letter]. *Lancet* 1984;**1**:349.

70. Jakobsson A, White T. Routine preoperative electrocardiograms [letter]. *Lancet* 1984;**1**:972.

71. Carson JL, Spence RK, Poses RM, Bonata G. Severity of anaemia and operative morbidity and mortality. *Lancet* 1988;**1**:727–9.

72. Ramsey G, Arvan DA, Stewart S, Blumberg N. Do preoperative laboratory tests predict blood transfusion needs in cardiac operations? *J Thorac Cardiovasc Surg* 1983;**85**:564–9.

73. Kaplan EB, Sheiner LB, Boeckmann AJ, *et al.* The usefulness of preoperative laboratory screening. *JAMA* 1985;**253**:3576–81.

74. Rohrer MJ, Michelotti MC, Nahrwold DL. A prospective evaluation of the efficacy of preoperative coagulation-testing. *Ann Surg* 1988;**208**:554–7.

75. Jones MW, Harvey IA, Owen R. Do children need routine preoperative blood-tests and blood cross matching in orthopedic practice. *Ann R C Surg Engl* 1989;**71**:1–3.

76. Bolger WE, Parsons DS, Potempa L. Preoperative hemostatic assessment of the adenotonsillectomy patient. *Otolaryngol Head Neck Surg* 1990;**103**:396–405.

77. Nigam A, Ahmed K, Drake Lee AB. The value of preoperative estimation of haemoglobin in children undergoing tonsillectomy. *Clin Otolaryngol* 1990;**15**:549–51.

78. O'Connor ME, Drasner K. Preoperative laboratory testing of children undergoing elective surgery. *Anesth Analg* 1990;**70**:176–80.

79. Narr BJ, Hansen TR, Warner MA. Preoperative laboratory screening in healthy Mayo patients: cost-effective elimination of tests and unchanged outcomes. *Mayo Clin Proc* 1991;**66**:155–9.

80. Roy WL, Lerman J, McIntyre BG. Is preoperative haemoglobin testing justified in children undergoing minor elective surgery? [see comments]. *Can J Anaesth* 1991;**38**:700–3.

81. Baron MJ, Gunter J, White P. Is the pediatric preoperative hematocrit determination necessary? *South Med J* 1992;**85**:1187–9.

82. Hoare TJ. Preoperative hemoglobin estimation in pediatric ent surgery. *J Laryngol Otol* 1993;**107**:1146–8.

83. Macpherson CR, Jacobs P, Dent DM. Abnormal peri-operative haemorrhage in asymptomatic patients is not predicted by laboratory testing. *S Afr Med J* 1993;**83**:106–8.

84. Close HL, Kryzer TC, Nowlin JH, Alving BM. Hemostatic assessment of patients before tonsillectomy: a prospective study. *Otolaryngol Head Neck Surg* 1994;**111**:733–8.

85. Kozak EA, Brath LK. Do "screening" coagulation tests predict bleeding in patients undergoing fiberoptic bronchoscopy with biopsy? [see comments]. *Chest* 1994;**106**:703–5.

86. Rader ES. Hematologic screening tests in patients with operative prostatic disease. *Urology* 1978;**11**:243–6.

87. Robbins JA, Rose SD. Partial thromboplastin time as a screening test. *Ann Intern Med* 1979;**90**:796.

88. Harris S, Nilsson IM. Preoperative test of bleeding time in ear surgery. *Acta Otolaryngol (Stockh)* 1980;**89**:474–8.

89. Eisenberg JM, Clarke JR, Sussman SA. Prothrombin and partial thromboplastin times as preoperative screening tests. *Arch Surg* 1982;**117**:48–51.

90. Barber A, Green D, Galluzzo T, Tsao CH. The bleeding-time as a preoperative screening-test. *Am J Med* 1985;**78**:761–4.

91. Suchman AL, Mushlin AI. How well does the activated partial thromboplastin time predict postoperative hemorrhage? *JAMA* 1986;**256**:750–3.

92. Manning SC, Beste D, McBride T, Goldberg A. An assessment of preoperative coagulation screening for tonsillectomy and adenoidectomy. *Int J Pediatr Otorhinolaryngol* 1987;**13**:237–44.

93. Schmidt JL, Yaremchuk KL, Mickelson SA. Abnormal coagulation profiles in tonsillectomy and adenoidectomy patients. *Henry Ford Hosp Med J* 1990;**38**:33–5.

94. Aghajanian A, Grimes DA. Routine prothrombin time determination before elective gynecologic operations. *Obstet Gynecol* 1991;**78**:837–9.

95. Burk CD, Miller L, Handler SD, Cohen AR. Preoperative history and coagulation screening in children undergoing tonsillectomy [see comments]. *Pediatrics* 1992;**89**:691–5.

96. Myers ER, Clarke Pearson DL, Olt GJ, Soper JT, Berchuck A. Preoperative coagulation testing on a gynecologic oncology service. *Obstet Gynecol* 1994;**83**:438–44.

97. Houry S, Georgeac C, Hay JM, Fingerhut A, Boudet MJ. A prospective multicenter evaluation of preoperative hemostatic screening tests. The French Associations for Surgical Research. *Am J Surg* 1995;**170**:19–23.

98. Eika C, Havig O, Godal HC. The value of preoperative hemostatic screening. *Scand J Haematol* 1979;**21**:349–54.

99. Suchman AL, Mushlin AI. Preoperative screening with the activated partial thromboplastin time. *Clin Res* 1984;**32**:A229.

100. Macpherson DS, Snow R, Lofgren RP. Preoperative screening: value of previous tests [see comments]. *Ann Intern Med* 1990;**113**:969–73.

101. Laposata M, Teruya J. Reappraisal of preoperative coagulation-testing. *Am J Clin Pathol* 1990;**94**:795–6.

102. Robbins JA, Mushlin AI. Preoperative evaluation of the healthy patient. *Med Clin North Am* 1979;**63**:1145–56.

103. Hirsch IA, Tomlinson DL, Slogoff S, Keats AS. The overstated risk of preoperative hypokalaemia. *Anesth Analg* 1988;**67**:131–6.

104. Vitez TS, Soper JT, Wong KC, Soper P. Chronic hypokalaemia and intraoperative dysrhythmias. *Anesthesiology* 1985;**63**:130–3.

105. Lawrence VA, Kroenke K. The unproven utility of preoperative urinalysis. Clinical use. *Arch Intern Med* 1988;**148**:1370–3.

106. Kroenke K, Hanley J, Copley JB. The admission urinalysis: impact on patient care. *J Gen Intern Med* 1986;**1**:238–42.

107. Akin BV, Hubbell FA, Frye EB. Efficacy of the routine admission urinalysis. *Am J Med* 1987;**82**:719–22.

Acute Sector Panel

Chair: Professor John Farndon, University of Bristol †

Professor Senga Bond, University of Newcastle-upon-Tyne †

Professor Ian Cameron, SE Thames RHA

Ms Lynne Clemence, Mid-Kent Health Care Trust †

Professor Cam Donaldson, University of Aberdeen †

Professor Richard Ellis, St James's University Hospital, Leeds †

Dr David Field, Leicester Royal Infirmary NHS Trust †

Mr Ian Hammond, Hillingdon HA †

Professor Adrian Harris, Churchill Hospital, Oxford

Dr Chris McCall, General Practitioner, Dorset †

Professor Alan McGregor, St Thomas's Hospital, London

Mrs Wilma MacPherson, St Thomas's & Guy's Hospitals, London

Professor Jon Nicoll, University of Sheffield †

Professor John Norman, Southampton University

Professor Gordon Stirrat, St Michael's Hospital, Bristol

Professor Michael Sheppard, Queen Elizabeth Hospital, Birmingham †

Dr William Tarnow-Mordi, University of Dundee

Professor Kenneth Taylor, Hammersmith Hospital, London †

Diagnostics and Imaging Panel

Chair: Professor Mike Smith, University of Leeds †

Professor Michael Maisey, Guy's & St Thomas's Hospitals, London*

Professor Andrew Adam, UMDS, London †

Dr Pat Cooke, RDRD, Trent RHA

Ms Julia Davison, St Bartholomew's Hospital, London †

Professor MA Ferguson-Smith, University of Cambridge †

Dr Mansel Hacney, University of Manchester

Professor Sean Hilton, St George's Hospital Medical School, London

Mr John Hutton, MEDTAP Europe Inc., London †

Professor Donald Jeffries, St Bartholomew's Hospital, London †

Dr Andrew Moore, Editor, Bandolier †

Professor Chris Price, London Hospital Medical School †

Dr Ian Reynolds, Nottingham HA

Professor Colin Roberts, University of Wales College of Medicine †

Miss Annette Sergeant, Chase Farm Hospital, Enfield

Professor John Stuart, University of Birmingham

Dr Ala Szczepura, University of Warwick †

Mr Stephen Thornton, Cambridge & Huntingdon Health Commission

Dr Gillian Vivian, Royal Cornwall Hospitals Trust †

Dr Jo Walsworth-Bell, South Staffordshire Health Authority †

Dr Greg Warner, General Practitioner, Hampshire †

Methodology Panel

Chair: Professor Anthony Culyer, University of York †

Mr Doug Altman, Institute of Health Sciences, Oxford †

Professor Michael Baum, Royal Marsden Hospital

Professor Nick Black, London School of Hygiene & Tropical Medicine †

Professor Martin Buxton, Brunel University †

Dr Rory Collins, University of Oxford

Professor George Davey-Smith, University of Bristol

Professor Ray Fitzpatrick, University of Oxford †

Professor Stephen Frankel, University of Bristol

Dr Stephen Harrison, University of Leeds

Mr Philip Hewitson, Leeds FHSA

Professor Richard Lilford, Regional Director, R&D, West Midlands †

Mr Nick Mays, Kings Fund Institute, London †

Professor Ian Russell, University of York †

Professor David Sackett, Centre for Evidence Based Medicine, Oxford †

Dr Maurice Slevin, St Bartholomew's Hospital, London

Dr David Spiegelhalter, Institute of Public Health, Cambridge †

Professor Charles Warlow, Western General Hospital, Edinburgh †

Pharmaceutical Panel

Chair: Professor Tom Walley, University of Liverpool †

Professor Michael Rawlins, University of Newcastle-upon-Tyne*

Dr Colin Bradley, University of Birmingham

Professor Alasdair Breckenridge, RDRD, Northwest RHA

Ms Christine Clarke, Hope Hospital, Salford †

Mrs Julie Dent, Ealing, Hammersmith and Hounslow HA, London †

Mr Barrie Dowdeswell, Royal Victoria Infirmary, Newcastle-upon-Tyne

Dr Desmond Fitzgerald, Mere, Bucklow Hill, Cheshire †

Dr Alistair Gray, Wolfson College, Oxford †

Professor Keith Gull, University of Manchester

Dr Keith Jones, Medicines Control Agency

Professor Trevor Jones, ABPI, London †

Dr Andrew Mortimore, Southampton & SW Hants Health Authority †

Dr John Posnett, University of York

Dr Frances Rotblat, Medicines Control Agency †

Dr Ross Taylor, University of Aberdeen †

Dr Tim van Zwanenberg, Northern RHA

Dr Kent Woods, RDRD, Trent RO, Sheffield †

Population Screening Panel

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

Dr Sheila Adam, Department of Health*

Dr Anne Dixon Brown, NHS Executive, Anglia & Oxford†

Professor Dian Donnai, St Mary's Hospital, Manchester †

Professor George Freeman, Charing Cross & Westminster Medical School, London

Dr Mike Gill, Brent & Harrow Health Authority †

Dr JA Muir Gray, RDRD, Anglia & Oxford RO †

Dr Ann Ludbrook, University of Aberdeen †

Professor Alexander Markham, St James's University Hospital, Leeds †

Professor Theresa Marteau, UMDS, London †

Professor Catherine Peckham, Institute of Child Health, London †

Dr Connie Smith, Parkside NHS Trust, London †

Dr Sarah Stewart-Brown, University of Oxford †

Professor Nick Wald, University of London †

Professor Ciaran Woodman, Centre for Cancer Epidemiology, Manchester †

Primary and Community Care Panel

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

Professor Martin Roland, University of Manchester*

Dr Simon Allison, University of Nottingham

Mr Kevin Barton, Bromley Health Authority †

Professor John Bond, University of Newcastle-upon-Tyne †

Professor Shah Ebrahim, Royal Free Hospital, London

Professor Andrew Haines, RDRD, North Thames RHA

Dr Nicholas Hicks, Oxfordshire Health Authority †

Professor Richard Hobbs, University of Birmingham †

Professor Allen Hutchinson, University of Hull †

Mr Edward Jones, Rochdale FHSA

Professor Roger Jones, UMDS, London †

Mr Lionel Joyce, Chief Executive, Newcastle City Health NHS Trust †

Professor Martin Knapp, London School of Economics & Political Science †

Professor Karen Luker, University of Liverpool

Dr Fiona Moss, North Thames British Postgraduate Medical Federation†

Professor Dianne Newham, Kings College, London

Professor Gillian Parker, University of Leicester †

Dr Robert Peveler, University of Southampton †

Dr Mary Renfrew, University of Oxford

Dr John Tripp, Royal Devon & Exeter Healthcare NHS Trust †

* Previous Chair
† Current members

Health Technology Assessment 1997; Vol. 1: No. 12

Copies of this report can be obtained from:

The National Coordinating Centre for Health Technology Assessment,
Mailpoint 728, Boldrewood,
University of Southampton,
Southampton, SO16 7PX, UK.
Fax: +44 (0) 1703 595 639 Email: hta@soton.ac.uk
http://www.soton.ac.uk/~hta

ISSN 1366-5278