# Radiology for Anaesthesia and Intensive Care

## Second edition

# Radiology for Anaesthesia and Intensive Care

## Second Edition

**Richard Hopkins,**
**Carol Peden and**
**Sanjay Gandhi**

CAMBRIDGE
UNIVERSITY PRESS

CAMBRIDGE UNIVERSITY PRESS
Cambridge, New York, Melbourne, Madrid, Cape Town, Singapore, São Paulo, Delhi

Cambridge University Press
The Edinburgh Building, Cambridge CB2 8RU, UK

Published in the United States of America by
Cambridge University Press, New York

www.cambridge.org
Information on this title: www.cambridge.org/9780521735636



First edition © Greenwich Medical Media 2003
This edition published 2010

Printed in the United Kingdom at the University Press, Cambridge

*A catalogue record for this publication is available from the British Library*

*Library of Congress Cataloguing in Publication data*
Hopkins, Richard, 1967–
Radiology for anaesthesia and intensive care / Richard Hopkins, Carol Peden, and Sanjay Gandhi.
p. ; cm.
Includes bibliographical references and index.
ISBN 978-0-521-73563-6 (pbk.)
1. Radiology, Medical. 2. Anesthesia. 3. Critical care medicine. I. Peden, Carol. II. Gandhi, Sanjay. III. Title.
[DNLM: 1. Anesthesia. 2. Radiology – methods. 3. Intensive Care. WO 200 H795r 2010]
RC78.H657 2010
616.07′54 – dc22 2009020681

ISBN 978-0-521-73563-6 Paperback

To my parents, loving wife Ila and
inspirational children Sanchit and Sahaj.
*Sanjay Gandhi*

To Martin for his continuing support.
*Carol Peden*

To my loving family – Carol, Rhys and
Rheanna and my parents.
*Richard Hopkins*

# Contents

## Contents

# Contributors

**Marcus Bradley**
Consultant Neuroradiologist
Frenchay Hospital
Bristol
UK

**Lai Peng Chan**
Vancouver General Hospital
British Columbia
Canada

**Chris Cook**
Consultant Radiologist
Department of Radiology
Weston General Hospital
Weston-super-Mare
UK

**Danial Fox**
Consultant Radiologist
Radiology Department
Musgrove Park Hospital
Taunton
UK

**Sanjay Gandhi**
Consultant Radiologist
Department of Clinical Radiology
Frenchay Hospital
Bristol
UK

**Richard Gee**
Vancouver General Hospital
British Columbia
Canada

**Richard Hopkins**
Consultant Radiologist
Department of Radiology
Cheltenham General Hospital
Cheltenham
UK

**Lyn Jones**
Consultant Radiologist
Department of Clinical Radiology
Frenchay Hospital
Bristol
UK

**Cieran Keogh**
Vancouver General Hospital
British Columbia
Canada

**Julie Lewis**
Specialist Registrar in Anaesthesia
Plymouth Hospitals NHS Trust
Derriford Hospital
Plymouth
UK

**Caleb McKinstry**
Consultant Anaesthetist
Department of Anaesthesia
Cheltenham General Hospital
Cheltenham
UK

**Peter Munk**
Vancouver General Hospital
British Columbia
Canada

**Barry Nicholls**
Consultant in Anaesthesia and Pain Management
Taunton & Somerset NHS Foundation Trust
Musgrove Park Hospital
Taunton
Somerset
UK

**Savvas Nicolaou**
Vancouver General Hospital
British Columbia
Canada

**Robert Orme**
Consultant Anaesthetist
Department of Anaesthesia
Cheltenham General Hospital
Cheltenham
UK

**Carol Peden**
Consultant in Anaesthesia and Intensive Care Medicine
Royal United Hospital
Bath
UK

**James K. Ralph**
Consultant Anaesthetist
University Department of Anaesthesia
The Queen Elizabeth Hospital
Birmingham
UK

**J. Mark Regi**
Specialist Registrar in Radiology
Bristol Training Scheme
Bristol
UK

**Julie Searle**
Consultant Radiologist
Department of Radiology
Cheltenham General Hospital
Cheltenham
UK

**Ian Taylor**
Consultant Anaesthetist
Department of Anaesthesia
Queen Alexandra Hospital
Portsmouth
UK

# Acknowledgements

The authors would like to express their appreciation and thanks to the following contributors for their involvement in the project.

Dr Caleb McKinstry. In addition to Dr McKinstry's ultrasound chapter, he was heavily involved in updating the book and advising about changes to the second edition. He has advised on the planning of several of the chapters and has written sections within the chest, abdominal and c spine chapters. He has written and advised on matters relating to the anaesthetic exam. He proof read and helped edit many of the sections. We are deeply indebted for his contribution and expert advice. The second edition of the book would not have been possible without his energy, enthusiasm and commitment.

Dr Ian Taylor. Advised on content and updates to second edition.

Dr Lyn Jones. Advised and contributed sections of the interventional radiology section. Her advice and input is particularly recognised for the vascular interventional radiology components.

Mr Chris Cassop. His input into the MRI section was integral in updating the second edition.

Dr Mat Shaw. For his contribution to the abdominal section.

Dr Tariq Ahmed. For his contribution to the abdominal section.

Images contributed by Dr L Marchenko, Dr M Gibson, Dr G McGann.

*Richard Hopkins*
*Carol Peden*
*Sanjay Gandhi*

*February 2009*

# Introduction

This book has been written for anaesthetists and intensive care doctors working in hospital practice. The material in the book covers all the common pathologies encountered in hospital anaesthetic practice and intensive care. Included are the core radiological requirements for the FRCA examination, but it is also ideally suited for doctors preparing for the Diploma in Intensive Care Medicine. It is not only intended as an examination revision aid, but also as a general radiological or revision text in anaesthetic radiology. In addition to the more commonly encountered areas such as chest and abdominal imaging, particular attention has been given to the topics of cervical spine imaging and blunt trauma. Sections covering trauma imaging of the chest, abdomen, pelvis, cervical spine and head are included.

An excellent knowledge of anatomy is crucial when interpreting any radiological investigation. Particular attention has been paid to illustrating relevant radiological anatomy. For each body system (chest and cardiovascular, abdomen and pelvis, and head), the radiological anatomy of both conventional radiographs and CT is discussed in some detail. This appears at the beginning of the relevant chapters. For instance, Chapter 1, *Imaging the chest*, includes detailed diagrams of the cardiac silhouette, the mediastinal outline and the anatomy that appears on a conventional chest radiograph. In addition, the anatomy visible on chest CT is explained and illustrated.

Technology in radiology is advancing rapidly, especially in the fields of cross-sectional imaging such as CT and MRI. Clinicians require a basic understanding of how various imaging modalities work in order to be able to interpret the images correctly. The basic principles of image formation in CT, MRI and ultrasound are explained. Special attention is paid to the unique problems encountered in MRI scanners with particular regard to patient monitoring and support systems.

In radiology, a diagnosis is often made by recognizing patterns of disease. Various imaging patterns (air space shadowing, interstitial lung patterns, pulmonary nodules, etc.) often have a broad differential diagnosis. Final diagnosis is dependent upon clinical history, imaging features and further laboratory investigations. The clinical case scenarios in the book have been written to include clinical history, results of investigations and the radiology. For each case, a differential diagnosis is given where appropriate and anaesthetic management is discussed.

## Second edition

Hospital practice has progressed since the first edition of this book was published in 2003. Probably the biggest change over this period has been the widespread introduction of picture archiving and communication systems (PACS). This has revolutionized imaging departments and the way in which hospitals acquire, store and distribute medical diagnostic imaging. Most UK hospitals are now 'filmless' with clinicians viewing scans and X-rays on computer screens. This has improved the availability of medical imaging for the anaesthetist. All imaging modalities (plain X-rays, CT, MRI, ultrasound, etc.) are now accessible to hospital clinicians in locations scattered around the hospital and not just in the radiology department. There are improved learning and teaching opportunities as a result.

CT scanning has continued to develop with technological advances, the widespread use of multi-slice spiral CT and new versatile CT work stations. CT is the workhorse of modern

medical imaging. The second edition has been updated to include sections on multi-slice CT, image manipulation and new scanning techniques such as CT angiography.

Ultrasound is a rapidly expanding imaging modality and is now undertaken by many different hospital specialists including anaesthetists. This is partly due to the improved size, portability and cost of ultrasound systems. The ultrasound chapter has been expanded for the second edition with new sections on ultrasound guided regional anaesthesia, echocardiography in the setting of ITU and further additions to reflect its extensive use in central line placement.

New interventional techniques have been validated in the last few years, for instance, new minimally invasive techniques such as endovascular aneurysm repair (EVAR). New material has been written to revise and update the relevant chapters.

The format of the book remains unchanged, with a general introduction to most chapters followed by a number of clinical cases presented in question and answer format. To derive the maximum benefit from each chapter, it is recommended that the introduction to the main chapters is read prior to attempting the accompanying clinical cases.

# About the FRCA examination

## Updated for the current edition by Ian Taylor

James K. Ralph and Carol J. Peden

The examination for Fellow of the Royal College of Anaesthetists is in two parts. These two parts are known as the Primary and Final examinations. Each part comprises both written and Short Oral Examination (SOE), with the Primary also including an 'OSCE' (Objective Structured Clinical Examination).

There are currently ongoing revisions to the Primary and Final FRCA Examinations to be introduced during 2009–11, so it is recommended to visit the RCA website to get up-to-date information relating to eligibility for, and format of, the examinations.

A good knowledge of radiological topics as applied to clinical practice is essential to attain the FRCA.

### The Primary examination

The Primary examination is designed to assess trainees who are on a Postgraduate Medical Examination and Training Board (PMETB) approved training programme in anaesthesia or an acute care common stem (ACCS) trainee with anaesthesia as their chosen specialty. The details of eligibility can be found in the regulations for the Primary and Final FRCA examinations published by the RCA; however, it is recommended that candidates should not sit the Primary FRCA OSCE and SOE until at least half way through their basic level training programme in anaesthesia, i.e. most will have completed 12 months. The Primary examination examines both the relevant basic sciences and clinical practice of anaesthesia undertaken in the Basic Level Training (ST1-2) and consists of three parts: MCQ, OSCE and SOE. Candidates are expected to demonstrate a good understanding of the fundamentals of clinical anaesthesia practice. With particular reference to radiology, this includes the selection and interpretation of relevant pre-operative investigations and the basic principles of ultrasound and the Doppler effect. Radiological images that may be encountered will appear in the OSCE section of the examination. Interpretation will take the form of short questions based on chest radiographs, neck and thoracic inlet films, abdominal fluid levels/air/masses, skull films and other imaging investigations (simple data only). The SOE in the Primary examination does not currently include X-ray interpretation.

### The Final examination

The Final examination is designed to assess trainees who have passed the Primary examination, been awarded the UK Basic Level Training Certificate, the UK SHO Training Certificate or the Irish Certificate of Completion of Basic Specialist Training and are at least one-third of the way through their intermediate level training programme in anaesthesia. Final examination candidates are expected to have a thorough knowledge of medicine and surgery, appropriate to the practice of anaesthesia, intensive care and pain management. This

includes pre-operative assessment and selection and interpretation of appropriate investigations. It also includes knowledge of diagnostic imaging and the appropriate anaesthesia and sedation, pre-anaesthetic preparation and techniques appropriate for adults and children for CT scan, MRI and angiography and post-investigation care. An understanding of the principles of imaging techniques including CT, MRI and ultrasound is also required.

The Final examination is also divided into four parts: MCQ, SAQ and two SOEs. Radiology-related questions may arise in any of these sections.

There are two structured SOEs: SOE 1 (50 minutes) – Clinical Anaesthesia – is where radiological images will occur. This viva consists of a long case and three short cases. During the first 10 minutes, you will have the opportunity to view, on your own, clinical information related to the long case, including radiological images (usually a chest X-ray), followed by 20 minutes of questioning on this material. There are easy marks to be had if you have practised X-ray interpretation. An ordered, sensible approach to the chest X-ray will also give the examiners the impression that you are safe and experienced – practise and impress them! During the final 20 minutes you will be asked questions on three further clinical topics. In this section further images may be used to form the basis for questions, e.g. a CT scan to discuss head injury management.

In SOE 2, where questions are based on basic science topics, subjects could include the physical principles of MRI or ultrasound, and their clinical applications.

## Preparation

Preparation for the examination should start by obtaining and reading the current syllabus for the examinations which form the 'knowledge' sections of the relevant Competency Based Training documents and the examination regulations, which can be obtained from the RCA. A period of intensive study is a prerequisite to success but also realistic viva practice from consultant colleagues and recent successful examination candidates. It is important to develop a system for reviewing and presenting X-rays and, again, practice with colleagues, and preferably a radiologist, will refine your technique.

## Competency-based training and assessment

Becoming a safe and competent anaesthetist is not only about passing the appropriate examinations; workplace assessments must be successfully completed by a trainee to achieve the Basic, Intermediate and Higher/Advanced Level Training Certificates in order to receive accreditation. At Basic Level Training the trainee must be able to interpret simple radiological images showing clear abnormalities including chest radiographs, CT and MRI scans of head (showing fracture and haemorrhage), neck and thoracic inlet films, plus films showing abdominal fluid levels/air. At Intermediate Training level and above, the anaesthetist should understand the implications of different radiological procedures in their anaesthetic care of the patient and be able to establish safe anaesthesia or sedation within the confines and limitations of the X-ray department where a wider range of interventional procedures is occurring. Intermediate and Advanced Training in Intensive Care Medicine requires the clinician to be competent in the interpretation of radiological investigations performed on critically ill patients and to understand how radiological investigations can be used to aid management of those patients.

## Recommended reading

*The CCT in Anaesthetics. Manuals for Trainees and Trainers*, Parts I–IV. Royal College of Anaesthetists, 2007–2008.

RCA website: http://www.rcoa.ac.uk.

*Guide to the FRCA Examination. The Primary*. Royal College of Anaesthetists, September 2007.

*Guide to the FRCA Examination. The Final*. Royal College of Anaesthetists, June 2008.

*The Clinical Anaesthesia Viva Book*. Mills SJ, Maguire SL, Barker JM (eds) London: *Greenwich Medical Media*, 2002.

# The pre-operative assessment

James K. Ralph

## Looking at X-ray films as part of the pre-operative assessment

Pre-operative assessment consists of the consideration of information from multiple sources that may include the patient's medical record, interview, physical examination and findings from medical tests and evaluations. Pre-operative tests may be indicated for various purposes including:

- discovery or identification of a disease or disorder that may affect peri-operative anaesthetic care,
- verification or assessment of an already known disease, disorder or therapy,
- formulation of specific plans and alternatives for peri-operative care.

Any test required for a patient should be ordered with the reasonable expectation that it will result in benefit, such as a change in the timing or selection of a technique or appropriate pre-operative optimization, that exceeds any potential adverse effects.

A number of guidelines and publications by various working parties and taskforces exist with advice on which investigations are appropriate, when they are appropriate and in which individuals.

## Association of Anaesthetists of Great Britain and Ireland [1]

Blanket routine pre-operative investigations are inefficient, expensive and unnecessary. Medical and anaesthetic problems are identified more efficiently by the taking of a history and by the physical examination of patients. It should be remembered that pre-operative investigations can themselves be the cause of morbidity.

Departments should have policies on which investigations should be performed. These should reflect the patient's age, co-morbidity and the complexity of surgery. Chest X-rays should be arranged in accordance with the recommendations from the Royal College of Radiologists in conjunction with local hospital policy.

## Royal College of Radiologists [2]

The pre-operative chest X-ray is not routinely indicated. Exceptions are before cardiopulmonary surgery, likely admission to ITU or suspected malignancy or TB. Anaesthetists may also request chest X-rays for dyspnoeic patients, those with known cardiac disease and the very elderly. Many patients with cardio-respiratory disease have a recent chest X-ray available; a repeat chest X-ray is not then usually required.

## Task Force on Preanesthetic Evaluation of the American Society of Anesthesiologists [3]

The Task Force 'agreed that pre-operative tests including chest X-ray should not be ordered routinely. The Task Force agreed that pre-operative tests might be performed on a selective basis for the purpose of guiding or optimising management …'.

'The Task Force agreed that the clinical characteristics to consider when deciding whether to order a pre-operative chest X-ray include smoking, recent upper respiratory tract infection (URTI), chronic obstructive pulmonary disease (COPD) and cardiac disease. The Task Force agreed chest X-ray abnormalities may be higher in such patients but does not believe that extremes of age, smoking, stable COPD, stable cardiac disease or recent resolved URTI should be considered unequivocal indications for chest X-ray.'

In their review of the literature, they noted that routine chest X-rays were reported as abnormal in 2.5%–60.1% of cases (20 studies) and led to changes in management in 0%–51% of cases found to be abnormal (9 studies). Indicated chest X-rays were reported as abnormal in 7.7%–65.4% of cases (18 studies) and led to a change in management in 0.5%–74% of cases (9 studies). In other words, there is a wide range of reported abnormality in both routine and indicated chest X-ray, many of which do not result in a change in patient management.

In summary, the pre-operative chest X-ray is not routinely indicated. It should be preceded by a thorough history and physical examination and ordered if these elicit an indication consistent with departmental policies in conjunction with recommendations from the Royal College of Radiologists. This should result in requests for chest X-rays that have a higher probability of showing an abnormality, which will then be acted on with a change in patient management whilst minimizing risk to the patient.

## References

1. *Preoperative Assessment. The Role of the Anaesthetist*. Association of Anaesthetists of Great Britain and Ireland, 2001.
2. *Making the Best Use of a Department of Clinical Radiology: Guidelines for Doctors*, 6th edition. Royal College of Radiologists, 1998 (ISBN 1872599370).
3. Practice Advisory for Preanesthetic Evaluation. A Report by the American Society of Anesthesiologists Task Force on Preanesthetic Evaluation, 2001.