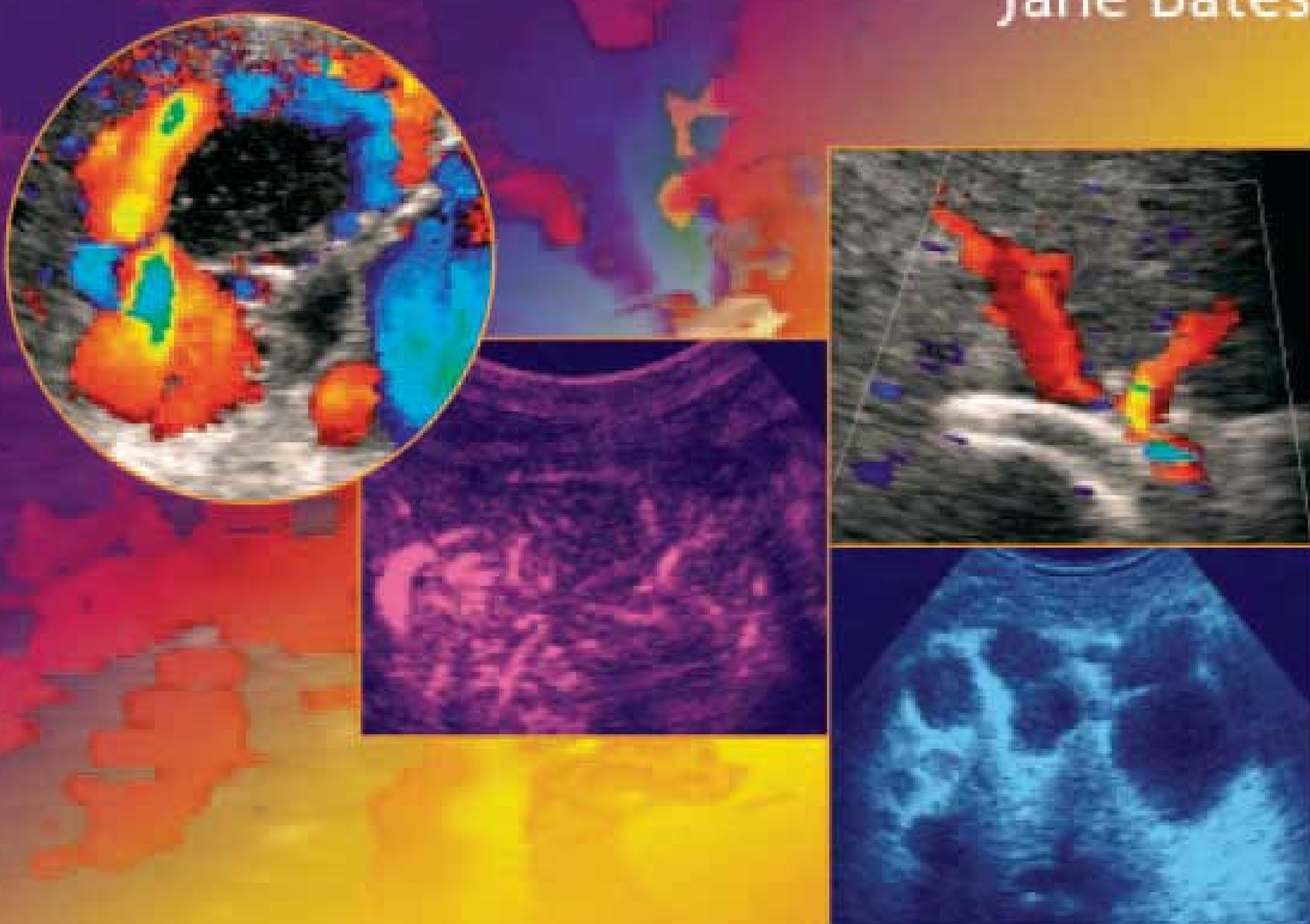
SECOND EDITION

Abdominal ULTRASOUND

HOW, WHY AND WHEN

Jane Bates



CHURCHILL LIVINGSTONE


Medical book
MedWedi.ru

Abdominal Ultrasound

For Churchill Livingstone

Commissioning Editor: Dinah Thom
Development Editors: Kerry McGechie
Project Manager: Morven Dean
Designer: Judith Wright

Abdominal Ultrasound

How, Why and When

SECOND EDITION

Jane A. Bates MPhil DMU DCR

Lead Practitioner, Ultrasound Department, St James's University Hospital, Leeds, UK

CHURCHILL LIVINGSTONE

ЗНАХАР

EDINBURGH LONDON NEW YORK OXFORD PHILADELPHIA ST LOUIS SYDNEY TORONTO 2004

CHURCHILL LIVINGSTONE
An imprint of Elsevier Limited

First edition 1999
Second edition 2004

ISBN 0 443 07243 4

British Library Cataloguing in Publication Data
A catalogue record for this book is available from the British Library

Library of Congress Cataloging in Publication Data
A catalog record for this book is available from the Library of Congress

Note
Knowledge and best practice in this field are constantly changing. As new research and experience broaden our knowledge, changes in practice, treatment and drug therapy may become necessary or appropriate. Readers are advised to check the most current imformation provided (i) on procedures featured or (ii) by the manufacturer of each product to be administered, to verify the recommended dose or formula, the method and duration of administration, and contraindications. It is the responsibility of the practitioner, relying on their own experience and knowledge of the patient, to make diagnoses, to determine dosages and the best treatment for each individual patient, and to take all appropriate safety precautions. To the fullest extent of the law, neither the publisher nor the authors assumes any liability for any injury and/or damage.

The Publisher

The Publisher's policy is to use **paper manufactured from sustainable forests**

Printed in China

Contents

Contributors vii

Preface ix

Abbreviations xi

1. Optimizing the diagnostic information 1
2. The normal hepatobiliary system 17
3. Pathology of the gallbladder and biliary tree 41
4. Pathology of the liver and portal venous system 79
5. The pancreas 121
6. The spleen and lymphatic system 137
7. The renal tract 153
8. The retroperitoneum and gastrointestinal tract 195
9. The paediatric abdomen 215
10. The acute abdomen 243
11. Interventional and other techniques 253

Bibliography and further reading 275

Index 277

This page intentionally left blank

Contributors

Rosemary Arthur FRCR Consultant Radiologist Department of X-ray & Ultrasound, The General Infirmary at Leeds, Leeds, UK

Simon T. Elliott MB ChB FRCR Consultant Radiologist Department of Radiology, Freeman Hospital, Newcastle-upon-Tyne, UK

Grant M. Baxter FRCR Consultant Radiologist Western Infirmary University NHS Trust, Glasgow, UK

This page intentionally left blank

Preface

Ultrasound continues to be one of the most important diagnostic tools at our disposal. It is used by a wide range of healthcare professionals across many applications. This book is intended as a practical, easily accessible guide to sonographers and those learning and developing in the field of abdominal ultrasound. The most obvious drawbacks of ultrasound diagnosis are the physical limitations of sound in tissue and its tremendous dependence upon the skill of the operator. This book seeks to enable the operator to maximize the diagnostic information and to recognize the limitations of the scan.

Where possible it presents a wider, more holistic approach to the patient, including presenting symptoms, complementary imaging procedures and further management options. It is not a comprehensive account of all the pathological processes likely to be encountered, but is intended as a springboard from which practical skills and clinical knowledge can develop further.

This book aims to increase the sonographer's awareness of the contribution of ultrasound within the general clinical picture, and introduce the sonographer to its enormous potential.

The author gratefully acknowledges the help and support of the staff of the Ultrasound Department at St James's University Hospital, Leeds.

Leeds 2004 Jane Bates

Abbreviations

ADPCDK	autosomal dominant polycystic disease of the kidney
AFP	alpha-fetoprotein
AI	acceleration index
AIDS	acquired immune deficiency syndrome
AIUM	American Institute for Ultrasound in Medicine
ALARA	as low as reasonably achievable
ALT	alanine aminotransferase
AP	anteroposterior
APKD	autosomal dominant (adult) polycystic kidney
ARPCDK	autosomal recessive polycystic disease of the kidney
AST	aspartate aminotransferase
AT	acceleration time
AV	arteriovenous
BCS	Budd–Chiari syndrome
CAPD	continuous ambulatory peritoneal dialysis
CBD	common bile duct
CD	common duct
CF	cystic fibrosis
CT	computed tomography
DIC	disseminated intravascular coagulation
DICOM	Digital Imaging and Communications in Medicine
DMSA	dimercaptosuccinic acid
DTPA	diethylene triaminepenta-acetic acid
EDF	end-diastolic flow
ERCP	endoscopic retrograde cholangiopancreatography
ESWL	extracorporeal shock wave lithotripsy
EUS	endoscopic ultrasound
FAST	focused assessment with sonography for trauma
FDA	Food and Drug Administration
FPS	frames per second
HA	hepatic artery
HCC	hepatocellular carcinoma
HELLP	haemolytic anaemia, elevated liver enzymes and low platelet count
HIDA	hepatic iminodiacetic acid
HPS	hypertrophic pyloric stenosis
HV	hepatic vein
INR	international normalized ratio
IOUS	intraoperative ultrasound
IVC	inferior vena cava
IVU	intravenous urogram
KUB	kidneys, ureters, bladder
LFT	liver function test
LPV	left portal vein
LRV	left renal vein
LS	longitudinal section
LUQ	left upper quadrant
MCKD	multicystic dysplastic kidney

MHA	middle hepatic artery
MHV	middle hepatic vein
MI	mechanical index
MPV	main portal vein
MRA	magnetic resonance angiography
MRA	main renal artery
MRCP	magnetic resonance cholangiopancreatography
MRI	magnetic resonance imaging
MRV	main renal vein
ODS	output display standard
PAC	photographic archiving and communications
PACS	photographic archiving and communications systems
PBC	primary biliary cirrhosis
PCKD	polycystic kidney disease
PCS	pelvicalyceal system
PD	pancreatic duct
PI	pulsatility index
PID	pelvic inflammatory disease
PRF	pulse repetition frequency
PSC	primary sclerosing cholangitis
PTLD	post-transplant lymphoproliferative disorder
PV	portal vein
RAS	renal artery stenosis
RCC	renal cell carcinoma
RF	radiofrequency
RHV	right hepatic vein
RI	resistance index
RIF	right iliac fossa
RK	right kidney
RPV	right portal vein
RRA	right renal artery
RRV	right renal vein
RUQ	right upper quadrant
RVT	renal vein thrombosis
SA	splenic artery
SLE	systemic lupus erythematosus
SMA	superior mesenteric artery
SV	splenic vein
TB	tuberculosis
TGC	time gain compensation
THI	tissue harmonic imaging
TI	thermal index
TIB	bone-at-focus index
TIC	cranial index
TIPS	transjugular intrahepatic portosystemic shunt
TIS	soft-tissue thermal index
TORCH	toxoplasmosis, rubella, cytomegalovirus and HIV
TS	transverse section
UTI	urinary tract infection
VUJ	vesicoureteric junction
WRMSD	work-related musculoskeletal disorders
XGP	xanthogranulomatous pyelonephritis

This page intentionally left blank

Chapter 1

Optimizing the diagnostic information

CHAPTER CONTENTS

Image optimization 1
The use of Doppler 2
Getting the best out of Doppler 5
Choosing a machine 6
Recording of images 9
Safety of diagnostic ultrasound 10
Medicolegal issues 12
Departmental guidelines/schemes of work 13
Quality assurance 13

IMAGE OPTIMIZATION

Misinterpretation of ultrasound images is a significant risk in ultrasound diagnosis. Because ultrasound scanning is operator-dependent, it is imperative that the sonographer has proper training in order to achieve the expected diagnostic capabilities of the technique. The skill of effective scanning lies in the operator's ability to maximize the diagnostic information available and in being able to interpret the appearances properly. This is dependent upon:

- Clinical knowledge—knowing what to look for and why, knowing how to interpret the appearances on the image and an understanding of physiological and pathological processes.
- Technical skill—knowing how to obtain the most useful and relevant images, knowledge of artifacts and avoiding the pitfalls of scanning.
- Knowledge of the equipment being used—i.e. making the most of your machine.

The operator must use the controls to their best effect (see Box 1.1). There are numerous ways in which different manufacturers allow us to make compromises during the scanning process in order to improve image quality and enhance diagnostic information.

The quality of the image can be improved by:

- Increasing the frequency—at the expense of poorer penetration (Fig. 1.1).
- Increasing the line density—this may be achieved by reducing the frame rate and/or reducing the sector angle and/or depth of field (Fig. 1.2).

Box 1.1 Making the most of your equipment

- Use the highest frequency possible—try increasing the frequency when examining the pancreas or anterior gallbladder.
- Use the lowest frame rate and highest line density possible. Restless or breathless patients will require a higher frame rate.
- Use the smallest field practicable—sections through the liver require a relatively wide sector angle and a large depth of view, but when examining an anterior gallbladder, for example, the field can be greatly reduced, thereby improving the resolution with no loss of frame rate.
- Use the focal zone at relevant correct depth.
- Use tissue harmonic imaging to increase the signal to noise ratio and reduce artefact.
- Try different processing curves to highlight subtle abnormalities and increase contrast resolution.

- Using the focal zones correctly—focus at the level under investigation, or use multiple focal zones at the expense of a decreased frame rate (Fig. 1.3).
- Utilizing different pre- and post-processing options, which may highlight particular areas (Fig. 1.4).
- Using tissue harmonics to reduce artefact (Fig. 1.5). This technique utilizes the second harmonic rather than the fundamental frequency using either filtration or pulse inversion.[1] This results in a higher signal-to-noise ratio which demonstrates particular benefits in many difficult scanning situations, including obese or gassy abdomens.

It is far better to have a scan performed properly on a low-tech piece of equipment by a knowledgeable and well-trained operator than to have a poorly performed scan on the latest high-tech machine (Fig. 1.6). A good operator will get the best out of even the lowliest scanning device and produce a result that will promote the correct patient management. A misleading result from a top-of-the-range scanner can be highly damaging and at best delay the correct treatment or at worst promote incorrect management. The operator should know the limitations of the scan in terms of equipment capabilities, operator skills, clinical problems and patient limitations, take those limitations into account and communicate them where necessary.

THE USE OF DOPPLER

The use of Doppler ultrasound is an integral part of the examination and should not be considered as a separate entity. Many pathological processes in the abdomen affect the haemodynamics of relevant organs and the judicial use of Doppler is an essential part of the diagnostic procedure. This is discussed in more detail in subsequent chapters.

Colour Doppler is used to assess the patency and direction of flow of vessels in the abdomen,

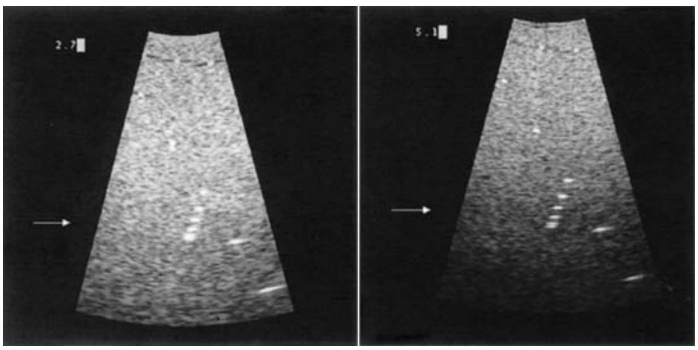
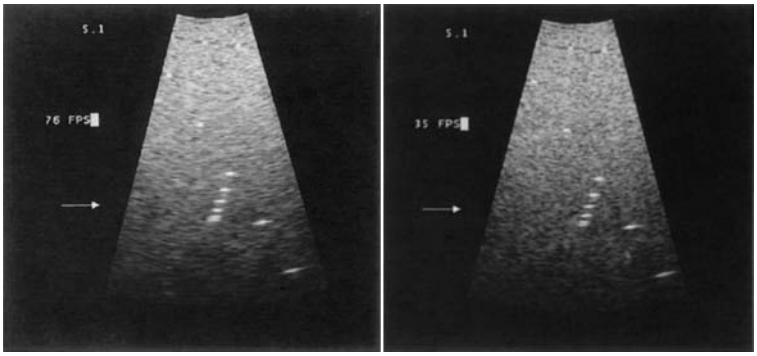
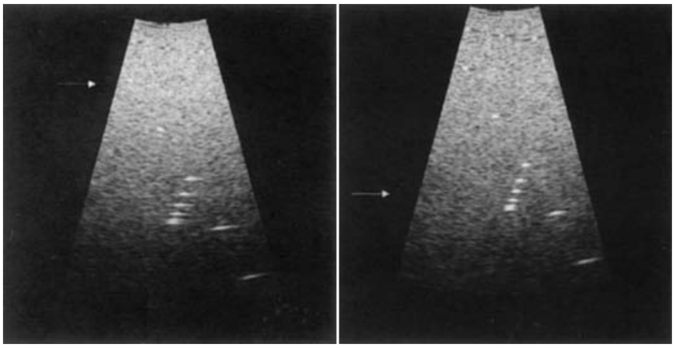


Figure 1.1 The effect of changing frequency. (A) At 2.7 MHz the wires are poorly resolved and the background 'texture' of the test object looks coarse. (B) The same transducer is switched to a resonant frequency of 5.1 MHz. Without changing any other settings, the six wires are now resolved and the background texture appears finer.



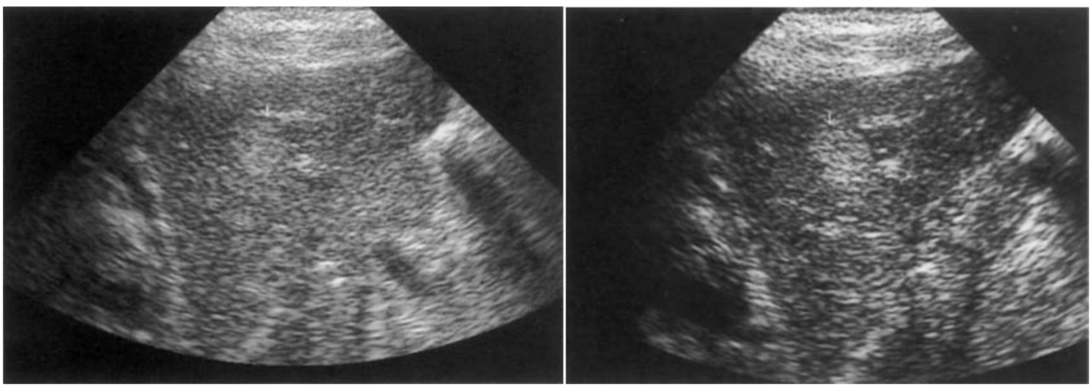
A B

Figure 1.2 The effect of frame rate. (A) 76 frames per second (FPS). (B) 35 FPS—the resulting higher line density improves the image, making it sharper.



A B

Figure 1.3 The effect of focal zone placement. (A) With the focal zone in the near field, structures in the far field are poorly resolved. (B) Correct focal zone placement improves both axial and lateral resolution of the wires.



A B

Figure 1.4 The effect of using post-processing options. (A) A small haemangioma in the liver merges into the background and is difficult to detect. (B) A post-processing option, which allocates the range of grey shades in a non-linear manner, enhances contrast resolution and improves detection of focal lesions.

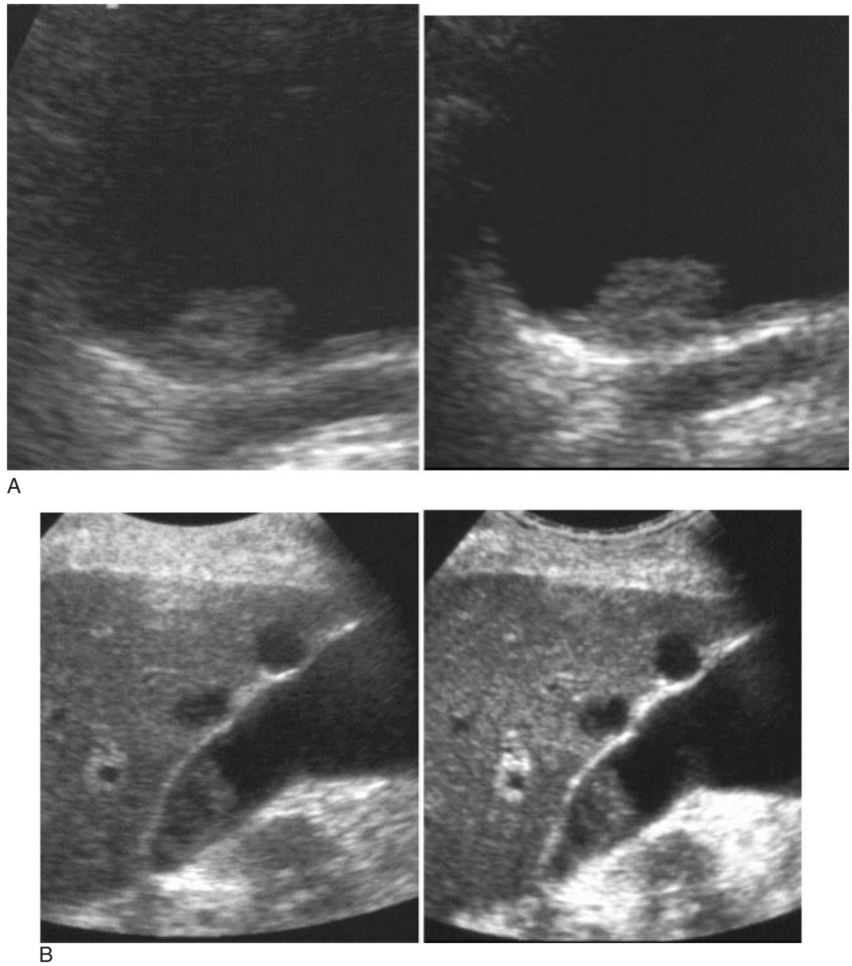
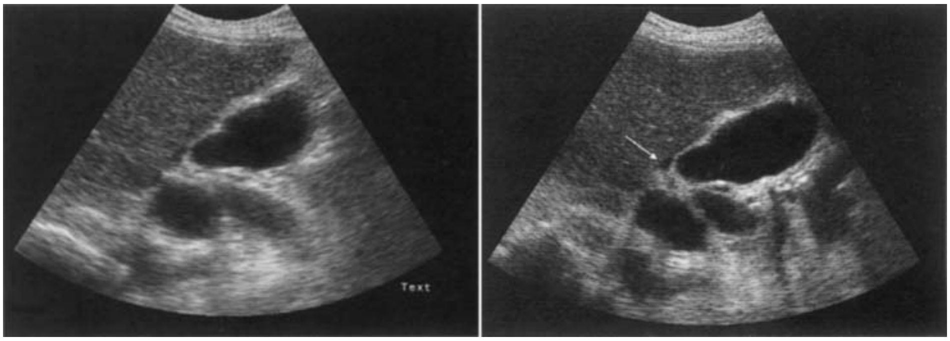


Figure 1.5 The effect of tissue harmonic imaging (THI): (A) a bladder tumour in fundamental imaging mode (left) is shown with greater definition and loss of artifact in THI (right). (B) In an obese patient, cysts near the gallbladder (left) are shown in greater detail using pulse inversion tissue harmonics (right). A small nodule is demonstrated in the lower cyst.

to establish the vascularity of masses or lesions and to identify vascular disturbances, such as stenoses. Flow information is colour-coded (usually red towards and blue away from the transducer) and superimposed on the image. This gives the operator an immediate impression of a vascular map of the area (Fig. 1.7). This Doppler information is obtained simultaneously, often from a relatively large area of the image, at the expense of the grey-scale image quality. The extra time taken to obtain the Doppler information for each line results in a reduction in frame rate and line density which worsens as the colour Doppler area is enlarged. It is advisable, therefore, to use a compact colour 'box' in order to maintain image quality.

Power Doppler also superimposes Doppler information on the grey-scale image, but without any directional information. It displays only the amount of energy (Fig. 1.8). The advantage of this is that the signal is stronger, allowing identification of smaller vessels with lower velocity flow than colour Doppler. As it is less angle-dependent than colour Doppler it is particularly useful for vessels which run perpendicular to the beam, for example the inferior vena cava (IVC).



A B

Figure 1.6 The importance of using the equipment properly. (A) Incorrect use of equipment settings makes it difficult to appreciate the structures in the image. (B) By increasing the resonant frequency, decreasing the frame rate and adjusting the focal zone correctly, a small rim of fluid around the gallbladder is seen and the gallbladder wall and vessels posterior to the gallbladder are made clear.

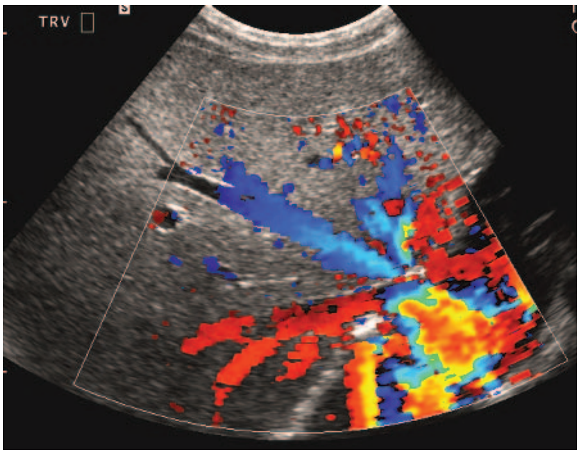


Figure 1.7 Colour Doppler of the hepatic vein confluence. The right hepatic vein appears red, as it is flowing towards the transducer. The left and middle hepatic veins are in blue, flowing away from the transducer. Note the peripheral middle hepatic vein, which appears to have no flow; this is an artifact due to the angle of that part of the vessel to the beam.

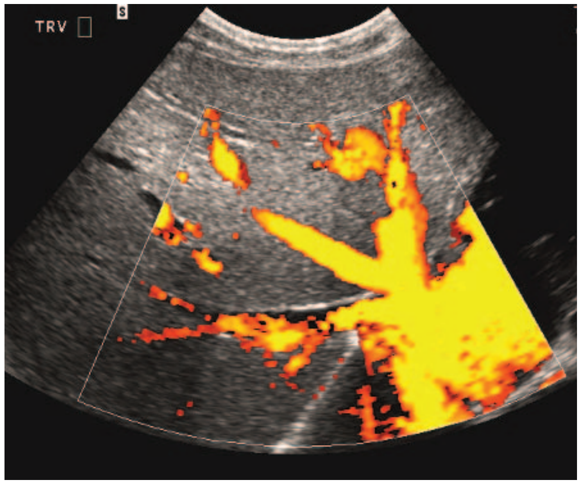


Figure 1.8 Power Doppler of the hepatic vein confluence. We have lost the directional information, but flow is demonstrated in all parts of the vessel—even those perpendicular to the beam.

Pulsed Doppler uses pulses of Doppler from individual elements or small groups of elements within the array. This allows the operator to select a specific vessel, which has been identified on the grey-scale or colour Doppler image, from which to obtain a spectrum. This gives further information regarding the flow envelope, variance, velocity and downstream resistance of the blood flow (Fig. 1.9).

Getting the best out of Doppler

Familiarity with the Doppler controls is essential in order to avoid the pitfalls and increase confidence in the results.

It is relatively straighforward to demonstrate flow in major vessels and to assess the relevant spectral waveform; most problems arise when trying to diagnose the *lack* of flow in a suspected thrombosed vessel, and in displaying low-velocity