

Michael Riccabona

Pediatric Ultrasound

Requisites and
Applications

With contributions by
Brian Coley
Andreas Gamillscheg
Bernd Heinzl
Gerolf Schweintzger



Springer

Michael Riccabona

Pediatric Ultrasound

Requisites and
Applications

With contributions by
Brian Coley
Andreas Gamillscheg
Bernd Heinzl
Gerolf Schweintzger



Springer

Pediatric Ultrasound

Michael Riccabona

Pediatric Ultrasound

Requisites and Applications

With Contributions by
Brian Coley,
Andreas Gamillscheg,
Bernd Heinzl,
and Gerolf Schweintzger

 Springer

Michael Riccabona
Division of Pediatric Radiology
Department of Radiology
University Hospital Graz
Graz
Austria

First edition originally published by © Georg Thieme Verlag, 2000

ISBN 978-3-642-39155-2 ISBN 978-3-642-39156-9 (eBook)
DOI 10.1007/978-3-642-39156-9
Springer Heidelberg New York Dordrecht London

Library of Congress Control Number: 2014931858

© Springer Berlin Heidelberg 2014

This work is subject to copyright. All rights are reserved by the Publisher, whether the whole or part of the material is concerned, specifically the rights of translation, reprinting, reuse of illustrations, recitation, broadcasting, reproduction on microfilms or in any other physical way, and transmission or information storage and retrieval, electronic adaptation, computer software, or by similar or dissimilar methodology now known or hereafter developed. Exempted from this legal reservation are brief excerpts in connection with reviews or scholarly analysis or material supplied specifically for the purpose of being entered and executed on a computer system, for exclusive use by the purchaser of the work. Duplication of this publication or parts thereof is permitted only under the provisions of the Copyright Law of the Publisher's location, in its current version, and permission for use must always be obtained from Springer. Permissions for use may be obtained through RightsLink at the Copyright Clearance Center. Violations are liable to prosecution under the respective Copyright Law.

The use of general descriptive names, registered names, trademarks, service marks, etc. in this publication does not imply, even in the absence of a specific statement, that such names are exempt from the relevant protective laws and regulations and therefore free for general use.

While the advice and information in this book are believed to be true and accurate at the date of publication, neither the authors nor the editors nor the publisher can accept any legal responsibility for any errors or omissions that may be made. The publisher makes no warranty, express or implied, with respect to the material contained herein.

Printed on acid-free paper

Springer is part of Springer Science+Business Media (www.springer.com)

Preface

Ultrasound (US) has become the mainstay of paediatric radiology, particularly as neonates, infants and children offer ideal scanning conditions. Furthermore, with growing concern about radiation risks imposed to children for medical imaging, it has become even more important to exploit all options US may offer. Numerous papers have been written on this topic focusing on the child's increased radiation sensitivity. Many campaigns have been initiated to promote radiation protection awareness throughout the world, such as the Image Gently campaign in the United States. However, children will continue to need medical imaging, and when trying to avoid irradiating methods such as CT and fluoroscopy, alternative non-invasive imaging must be available. Ultrasound is a relatively inexpensive, non-invasive and non-radiating imaging modality that promises to comply with all these requirements and must be promoted as the major initial modality. As a consequence of this paradigm, high standard paediatric US must become available to all children in need throughout the world, 24 h a day, 7 days a week, throughout the year.

When trying to support and educate people to properly perform high level paediatric US I was often asked by participants of various courses and lectures, if I know a reasonably priced comprehensive booklet that covers all main aspects of paediatric US. It shouldn't be too big, and should address not only all relevant aspects and diseases but also modern methods and must offer image examples. This request came particularly from colleagues from less wealthy countries such as the Third World and Asia, but also from sonographers and technicians, students, young colleagues and residents in training, as well as paediatricians, paediatric surgeons, and radiologists who are not full time paediatric radiologists.

So I set out to try and create such booklet. In order to achieve these goals the text had to be short - thus this book is written in a checklist like style. The text is less extensive, and the legends are compact. Some less important conditions and aspects are only briefly mentioned or omitted, and image examples are focused on either very common important entities or on rare but still essential conditions that should not be overlooked or mistaken (i.e., relevant for differential diagnosis). Particular emphasis has been given to new approaches that widen US potential such as perineal US, contrast-enhanced US or filling techniques, using modern equipment and routinely encompassing Doppler sonography. However, basic features and rules also remain valid and important, particularly as they need to be respected and be addressed with any standard equipment; the description of those should enable the

reader to make an US diagnosis provided careful and proper selection of adequate transducers and correct device settings is available. Further and more detailed information must, however, be retrieved from respective established textbooks.

This project could only be realized by the help and support of Springer company, my colleagues at work, the input (and images) from my co-authors, and the patience of my partner Barbara. And the enterprise was further spurred by the motivation and inspiration I got from all the children and parents I encountered during daily work, their needs and suffering, but also their gratitude or their rewarding smile. I can only hope that you will find this booklet helpful for your daily needs and that it will achieve its goal, to contribute and improve access to dedicated paediatric US for all children in need, inspiring sonographers and physicians to outmost exploit US potential, to use creative approaches and apply US whenever there is an option that this might offer a diagnostic or therapeutic solution to the child's condition. Even if US is financially not as rewarding as other imaging methods, it will hopefully be rewarding in terms of diagnostic success at reduced invasiveness and without radiation burden - an aspect I particularly learned to pursue and value from my four children to whom I want to dedicate this work.

Graz, Austria
January 2013

Prof. Michael Riccabona

Acknowledgements

I thank my co-authors for also providing many images for the various chapters of the book, and I am furthermore particular thankful to Prof. Coley for all the hard work he must have had with English editing, as well as Mrs. Einspieler for typing the scripts.

Contents

1	Theory and Basics	1
1.1	Ultrasound (US) Physics	2
1.1.1	US Waves	2
1.1.2	Propagation and Modulation of US	2
1.2	Practical Application in US Device	4
1.2.1	Emission, Transmission, Reception and Amplification	4
1.2.2	Signal Processing	5
1.2.3	Components of US Device	6
1.3	US Methods	9
1.3.1	A (Amplitude)-Mode	9
1.3.2	(T)M-Mode (Time-Motion-Mode).	9
1.3.3	B (Brightness)-Mode	10
1.3.4	Doppler Sonography	11
1.4	Artefacts	11
1.4.1	General Remarks	11
1.4.2	Common Artefacts	12
1.5	Biologic Effects	15
1.5.1	General Remarks	15
1.5.2	Thermal Effects	16
1.5.3	Mechanical Effects and Resonance	16
1.5.4	Potential Risks of Diagnostic US.	17
1.5.5	Various Methods and Indices That Allow Estimation of Biological Risks	18
1.6	How to Perform Paediatric US	19
1.6.1	Requisites	19
1.6.2	Positioning	20
1.6.3	Device Handling.	21
1.6.4	Transducer Selection	22
1.6.5	Course of Investigation and Measurements	23
1.7	Documentation and Interpretation	25
1.7.1	Image Documentation	25
1.7.2	Report	26

1.8	Doppler Sonography	27
1.8.1	The Doppler Phenomenon	27
1.8.2	Different Techniques and Applications of Doppler Sonography	28
1.8.3	Artefacts in (Colour) Doppler Sonography	34
1.8.4	How to Perform (Colour) Doppler Investigations	37
1.8.5	Limitations	37
1.8.6	Interpretation	37
1.9	Modern and Future US Methods and Techniques	39
1.9.1	High-Resolution US (HR-US)	39
1.9.2	Image Compounding	39
1.9.3	Harmonic Imaging (HI)	39
1.9.4	Extended Field of View US	39
1.9.5	US Texture Analysis	41
1.9.6	Sonoelastography	41
1.9.7	US with Contrast Enhancement (Echo-Enhanced US – ee-US, Contrast-Enhanced US – ce-US/CEUS) by Ultrasound Contrast Media (US-CM)	42
1.9.8	Three- and Four-Dimensional US (3D-/4DUS)	50
1.9.9	Potential Future for Other Modern Paediatric US Applications	57
2	Ultrasound-Guided Interventions	59
2.1	General Aspects	60
2.1.1	Requisites	60
2.1.2	Precautions and Preparations	60
2.2	US-Guided Filling of Structures for Diagnostic or Therapeutic Purpose	61
2.2.1	General Remarks for Assessing Physiologic Cavities (e.g. Bladder, Vagina, Intestines and Stomach)	61
2.2.2	Diagnostic Sonographic Enema	61
2.2.3	Therapeutic Sonographic Enema	62
2.2.4	US Genitography	64
2.2.5	Contrast-Enhanced Voiding Urosonography (ce-VUS)	64
2.2.6	Other Intracavitary Contrast Applications	67
2.2.7	Intravenous ce-US	68
2.3	Biopsies and Punctures	69
2.4	Drainage	71
2.5	Vascular Access	73
2.6	Lumbar Puncture	74
2.7	Foreign Body Removal	75

3 Neurosonography in Neonates, Infants and Children	77
3.1 Requisites	78
3.1.1 Equipment and Transducer Needs	78
3.1.2 Indications for Brain US	79
3.1.3 How to Investigate	79
3.2 Normal Findings.	81
3.2.1 Transfontanellar Access	81
3.2.2 Alternate Access Findings	83
3.2.3 Colour Doppler Sonography (CDS).	84
3.2.4 Normal Variances in Preterm Babies	87
3.3 Pathologic Findings	92
3.3.1 Neural Tube Defects.	92
3.3.2 Migration and Gyration Alterations and Disturbances	94
3.3.3 Phakomatoses.	98
3.3.4 Cerebral Cysts	98
3.3.5 Ischemic Encephalopathy.	100
3.3.6 Inflammation	105
3.3.7 Dilatation of CSF Spaces: Hydrocephalus.	107
3.3.8 Cerebral Haemorrhage	114
3.3.9 Tumours and Space-Occupying Lesions	119
3.3.10 Cerebral Calcifications.	122
3.4 Ultrasound of the Skull	122
3.4.1 Introduction	122
3.4.2 Haematoma	122
3.4.3 Space-Occupying Lesions and Tumours	123
3.4.4 Skull Fracture.	123
3.5 Additional Imaging	123
3.5.1 Plain Film.	123
3.5.2 CT.	123
3.5.3 MRI	124
3.5.4 Catheter Angiography	124
3.5.5 Additional Supporting Procedures.	124
3.6 Ultrasound of the Eye and the Orbit	124
3.6.1 Introduction	124
3.6.2 Normal Findings.	124
3.6.3 Sonographically Depictable Pathology	125
3.7 Ultrasound of the Spinal Canal	127
3.7.1 Requisites.	127
3.7.2 Transducers and Technique	127
3.7.3 Indications	127

3.7.4	Normal Findings	128
3.7.5	Pathologic Findings of the Spinal Cord	130
3.7.6	Trauma	134
3.7.7	Tumours	134
3.7.8	Other Spinal and Vertebral Pathology	135
3.7.9	Additional Imaging	135
3.7.10	Value of US	136
4	Ultrasound of the Neck	137
4.1	Indications, Requisites and Techniques	138
4.1.1	Transducers	138
4.1.2	Positioning and Handling	138
4.1.3	Typical Examinations	138
4.2	Normal Findings	140
4.2.1	Lymph Nodes	140
4.2.2	Cervical Glands	140
4.2.3	Other Cervical Soft Tissues	143
4.2.4	Cervical Vessels	144
4.3	Pathologic Findings	146
4.3.1	Lymph Nodes	146
4.3.2	Pathology of Cervical Soft Tissue	146
4.3.3	Thyroid Gland	152
4.3.4	Salivary Glands (Parotid, Sublingual, Submandibular Gland)	155
4.3.5	Cervical Vessels	157
5	Basics of Paediatric Echocardiography	163
5.1	Introduction	164
5.2	Equipment Needs and Specific Considerations	165
5.2.1	Transducers	165
5.2.2	Standard US Techniques	165
5.2.3	Patient Position	165
5.2.4	Sedation	165
5.3	Standard Planes and Standardised Course of Examination	165
5.4	Normal 2D Echocardiogram Findings	166
5.4.1	Parasternal Views	166
5.4.2	Apical Views	167
5.4.3	Subcostal Views	169
5.4.4	Suprasternal View	169
5.5	Other Techniques	170
5.5.1	M (Motion)-Mode Echocardiography	170
5.5.2	Doppler Sonography	171
5.5.3	Other Calculations and Functional Parameters	171

5.6	Special Echocardiographic Techniques	172
5.6.1	Transoesophageal Echocardiography (TEE)	172
5.6.2	Three-Dimensional (3D) Echocardiography	172
5.6.3	Tissue Doppler Imaging (TDI)	172
5.6.4	Contrast-Enhanced US	172
5.7	Normal Values	172
5.8	Pathologic Findings	173
5.8.1	Congenital Heart Defects with Left-to-Right Shunt	173
5.8.2	Obstructions of Left Ventricular Outflow	177
5.8.3	Obstructions of the Right Ventricular Outflow	179
5.8.4	Miscellaneous Congenital Heart Defects	181
5.9	Acquired Paediatric Heart Diseases	184
5.9.1	Cardiomyopathies (CMP)	184
5.9.2	Acute Myocarditis	184
5.9.3	Acute (Infective) Endocarditis	184
5.9.4	Pericarditis/Pericardial Effusion	185
5.9.5	Kawasaki Disease	185
5.9.6	Intracardiac Thrombi	186
5.9.7	Cardiac Tumours	186
5.10	Complementing Investigations	186
5.10.1	Cardiac Catheterisation and Angiography	186
5.10.2	Cardiac MRI and CT	187
5.11	When to Do What	187
5.11.1	Imaging in Typical Clinical Scenarios	187
5.11.2	Trauma and Emergency	188
6	Ultrasound of the Chest	189
6.1	Requisites	190
6.1.1	Transducers	190
6.1.2	Positioning	190
6.1.3	Indications	190
6.1.4	How to Perform Chest US	191
6.2	Normal Findings	191
6.2.1	Chest Wall	191
6.2.2	Breast	191
6.2.3	Pleural Space	192
6.2.4	Diaphragm	192
6.2.5	Lung	192
6.2.6	Mediastinum	193
6.2.7	CDS	195
6.3	Pathology of Chest Wall	195
6.3.1	Aplasia, Variations of Ribs	195
6.3.2	Congenital Malformations	195