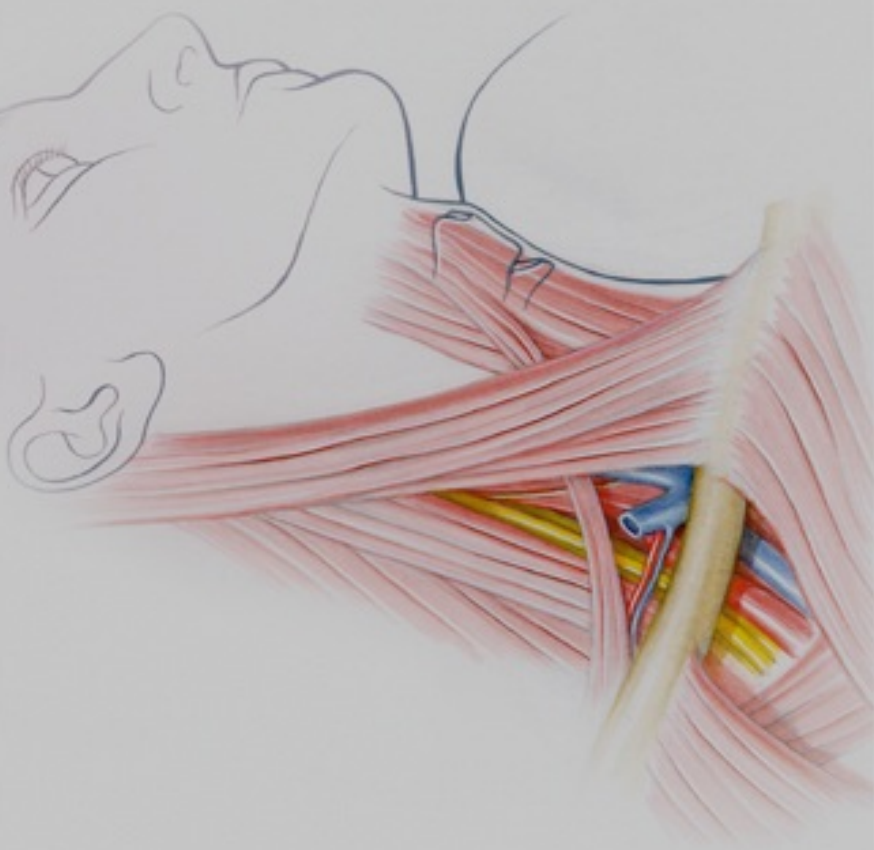
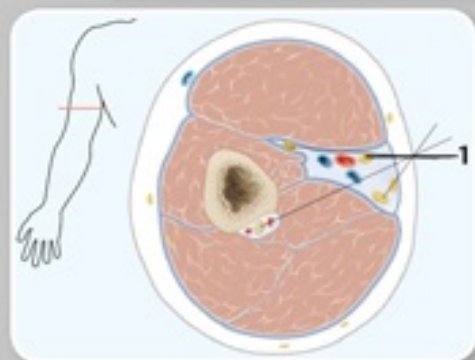
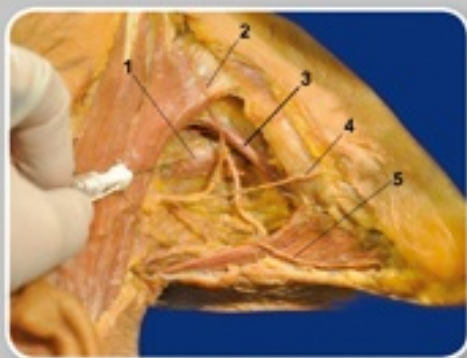



# Atlas of Peripheral Regional Anesthesia

Anatomy and Techniques

Gisela Meier  
Johannes Buettner

3rd Edition



 MediaCenter.thieme.com  
includes videos online

 Thieme

# Find instructive videos and additional figures on [MediaCenter.thieme.com!](https://www.thieme.com/MediaCenter)

Simply visit [MediaCenter.thieme.com](https://www.thieme.com/MediaCenter) and, when prompted during the registration process, enter the code below to get started today.

3QF6-9QJ2-V595-C4Y4

# Atlas of Peripheral Regional Anesthesia

**Anatomy and Techniques**

**3rd Edition**

**Gisela Meier, MD**

Former Head of the Department of Anesthesia and Interventional Pain Therapy  
Oberammergau Center for Rheumatology  
Oberammergau, Germany

**Johannes Buettner, MD**

Former Head of the Department of Anesthesia  
Trauma Center  
Murnau, Germany

780 illustrations

Thieme

Stuttgart • New York • Delhi • Rio de Janeiro

## Library of Congress Cataloging-in-Publication Data

Meier, Gisela, 1954-, author.

[Atlas der peripheren Regionalanästhesie. English]

Atlas of peripheral regional anesthesia: anatomy and techniques/Gisela Meier, Johannes Buettner. – 3rd edition.

p.; cm.

“This book is an authorized translation of the 3rd German edition published and copyrighted 2013 by Georg Thieme Verlag, Stuttgart.”

Includes bibliographical references and index.

ISBN 978-3-13-139793-5 (alk. paper) – ISBN 978-3-13-164973-7 (eISBN)

I. Buettner, Johannes, 1950-, author. II. Title.

[DNLM: 1. Anesthesia, Conduction–Atlases. 2. Nerve Block–methods–Atlases. 3. Pain Management–methods–Atlases. WO 517]

RD84

617.9'640222–dc23

2015016781

This book is an authorized translation of the 3rd German edition published and copyrighted 2013 by Georg Thieme Verlag, Stuttgart. Title of the German edition: Atlas der peripheren Regionalanästhesie. Anatomie-Sonografie-Anästhesie-Schmerztherapie

Translator: Melanie Nassar, Beit Sahour, Palestine

Illustrator: Nikolaus Lechenbauer and Gerhard Schlich (for Astra Zeneca); Peter Haller, Stuttgart, Germany; Gay & Rothenburger, Sternenfels, Germany

© 2016 Georg Thieme Verlag KG

Thieme Publishers Stuttgart

Rüdigerstrasse 14, 70469 Stuttgart, Germany

+49 [0]711 8931 421, [customerservice@thieme.de](mailto:customerservice@thieme.de)

Thieme Publishers New York

333 Seventh Avenue, New York, NY 10001, USA

+1-800-782-3488, [customerservice@thieme.com](mailto:customerservice@thieme.com)

Thieme Publishers Delhi

A-12, Second Floor, Sector-2, Noida-201301

Uttar Pradesh, India

+91 120 45 566 00, [customerservice@thieme.in](mailto:customerservice@thieme.in)

Thieme Publishers Rio, Thieme Publicações Ltda.

Edifício Rodolpho de Paoli, 25º andar

Av. Nilo Peçanha, 50 – Sala 2508,

Rio de Janeiro 20020-906 Brasil

Tel: +55 21 3172-2297/+55 21 3172-1896

Cover design: Thieme Publishing Group

Typesetting by Thomson Digital, India

Printed in China by Everbest Printing Ltd, Hong Kong 5 4 3 2 1

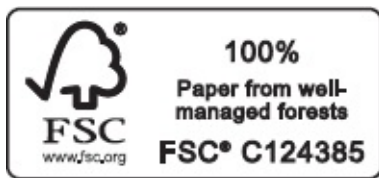
ISBN 9783131397935

Also available as an e-book:  
eISBN 9783131649737

**Important note:** Medicine is an ever-changing science undergoing continual development. Research and clinical experience are continually expanding our knowledge, in particular our knowledge of proper treatment and drug therapy. Insofar as this book mentions any dosage or application, readers may rest assured that the authors, editors, and publishers have made every effort to ensure that such references are in accordance with **the state of knowledge at the time of production of the book.**

Nevertheless, this does not involve, imply, or express any guarantee or responsibility on the part of the publishers in respect to any dosage instructions and forms of applications stated in the book. **Every user is requested to examine carefully** the manufacturers' leaflets accompanying each drug and to check, if necessary in consultation with a physician or specialist, whether the dosage schedules mentioned therein or the contraindications stated by the manufacturers differ from the statements made in the present book. Such examination is particularly important with drugs that are either rarely used or have been newly released on the market. Every dosage schedule or every form of application used is entirely at the user's own risk and responsibility. The authors and publishers request every user to report to the publishers any discrepancies or inaccuracies noticed. If errors in this work are found after publication, errata will be posted at [www.thieme.com](http://www.thieme.com) on the product description page.

Some of the product names, patents, and registered designs referred to in this book are in fact registered trademarks or proprietary names even though specific reference to this fact is not always made in the text. Therefore, the appearance of a name without designation as proprietary is not to be construed as a representation by the publisher that it is in the public domain.



This book, including all parts thereof, is legally protected by copyright. Any use, exploitation, or commercialization outside the narrow limits set by copyright legislation, without the publisher's consent, is illegal and liable to prosecution. This applies in particular to photostat reproduction, copying, mimeographing, preparation of microfilms, and electronic data processing and storage.

# Contents

**Foreword**  
**Acknowledgments**  
**Contributors**  
**List of Videos**  
**Abbreviations**

## **Part I General Aspects of Ultrasound-Guided Peripheral Regional Anesthesia**

### **1 General Principles of Ultrasound-Guided Peripheral Nerve Blocks**

#### **1.1 Technical Requirements**

1.1.1 Equipment  
1.1.2 Optimizing the Ultrasound Image  
1.1.3 Structural Features in Ultrasound

#### **1.2 Ultrasound-Guided Needle Approach**

1.2.1 Ultrasound Techniques for Needle Insertion

#### **1.3 Ultrasound for Continuous Block Techniques**

1.3.1 Learning Ultrasound-Guided Needle Placement Techniques  
1.3.2 How to Approach the Nerve? Intraneurally, Extraneurally?  
1.3.3 Ultrasound in Any Event—What is the Available Evidence?  
References

## **Part II Upper Limb**

### **2 General Overview**

#### **2.1 Anatomy**

#### **2.2 Important Topographical Anatomical Relations in the Region of the Brachial Plexus**

#### **2.3 Motor and Sensory Supply of the Upper Limb**

#### **2.4 Historical Overview—Upper Limb**

References

### **3 Interscalene Techniques of Brachial Plexus Block**

#### **3.1 Anatomy**

#### **3.2 Meier Approach**

3.2.1 Positioning  
3.2.2 Needle Approach  
3.2.3 Interscalene Brachial Plexus Block with Ultrasound

#### **3.3 Pippa Approach**

3.3.1 Posterior Approach  
3.3.2 Interscalene Block of the Brachial Plexus Using Ultrasound (Pippa Approach)

### **3.4 Sensory and Motor Effects**

### **3.5 Indications and Contraindications**

3.5.1 Indications

3.5.2 Contraindications

### **3.6 Supraclavicular Nerve Block (Cervical Plexus)**

### **3.7 Complications, Side Effects, Method-Specific Problems**

3.7.1 Neurological Complications after Shoulder Surgery in Interscalene Plexus Anesthesia

3.7.2 Side Effects Intrinsic to the Method

References

## **4 Supraclavicular and Infraclavicular Techniques of Brachial Plexus Block**

### **4.1 Anatomy**

### **4.2 Supraclavicular Block Techniques**

4.2.1 Ultrasound-Guided Supraclavicular Block of the Brachial Plexus

### **4.3 Vertical Infraclavicular Block According to Kilka, Geiger, and Mehrkens**

4.3.1 Positioning

4.3.2 Needle Approach

4.3.3 Local Anesthetics, Dosages

4.3.4 Comparison of the Vertical Infraclavicular Technique with the Axillary Technique

### **4.4 Raj Technique, Modified by Borgeat**

4.4.1 Positioning

4.4.2 Needle Approach

4.4.3 Material

4.4.4 Local Anesthetics, Dosages

### **4.5 Infraclavicular Brachial Plexus Block Using Ultrasound**

4.5.1 Ultrasound Visualization of the Brachial Plexus

4.5.2 Needle Approach

4.5.3 Catheter Placement

### **4.6 Sensory and Motor Effects**

### **4.7 Indications and Contraindications**

4.7.1 Indications

4.7.2 Contraindications

### **4.8 Complications, Side Effects, Method-Specific Problems**

4.8.1 Horner Syndrome

4.8.2 Phrenic Nerve Paresis

4.8.3 Pneumothorax

References

## **5 Suprascapular Nerve Block**

### **5.1 Anatomy**

### **5.2 Meier Approach**

5.2.1 Procedure

5.2.2 Suprascapular Nerve Block with Ultrasound

### **5.3 Sensory and Motor Effects**

### **5.4 Indications and Contraindications**

5.4.1 Indications

5.4.2 Contraindications

### **5.5 Complications, Side Effects, Method-Specific Problems**

References

## **6 Axillary Block**

### **6.1 Anatomy**

### **6.2 Perivascular Single-Injection Technique**

6.2.1 Method

6.2.2 Perivascular Axillary Block of the Brachial Plexus Using Ultrasound

### **6.3 Sensory and Motor Effects**

6.3.1 Local Anesthetic, Dosages

### **6.4 Indications and Contraindications**

6.4.1 Indications

6.4.2 Contraindications

### **6.5 Complications, Side Effects, Method-Specific Problems**

### **6.6 Multistimulation Technique, “Midhumeral Approach” According to Dupré**

6.6.1 Positioning, Landmarks

6.6.2 Method

6.6.3 Puncture Needle

### **6.7 “Classical” Axillary Block of the Brachial Plexus with Ultrasound**

6.7.1 Visualization of the Brachial Plexus Using Ultrasound (in the Axilla)

6.7.2 Puncture

6.7.3 Catheter Placement

References

## **7 Selective Blocks of Individual Nerves in the Upper Arm, at the Elbow, and Wrist**

### **7.1 Radial Nerve Block (Middle of Upper Arm)**

7.1.1 Anatomy

7.1.2 Method

7.1.3 Radial Nerve Block of the Upper Arm Using Ultrasound

### **7.2 Blocks at the Elbow**

7.2.1 Anatomy

7.2.2 Radial Nerve Block (Elbow)

7.2.3 Musculocutaneous Nerve Block (Elbow)

7.2.4 Median Nerve Block (Elbow)

7.2.5 Ulnar Nerve Block (Elbow)

7.2.6 Individual Nerve Blocks with Ultrasound (Elbow)

### **7.3 Blocks at the Forearm (“Wrist Block”)**

7.3.1 Anatomy

7.3.2 Median Nerve Block (Wrist)



- 7.3.3 Ulnar Nerve (Wrist)
- 7.3.4 Radial Nerve (Wrist)
- 7.3.5 Block of Individual Nerves with Ultrasound
- References

## **Part III Lower Limb**

### **8 General Overview**

#### **8.1 Lumbosacral Plexus**

- 8.1.1 Lumbar Plexus
- 8.1.2 Sacral Plexus

#### **8.2 Historical Overview—Lower Limb**

#### **8.3 Sensory Innervation of the Leg**

- 8.3.1 Innervation of the Bones (Innervation of Periosteum)
- References

### **9 Psoas Block**

#### **9.1 Anatomical Overview**

#### **9.2 Technique of Psoas Block**

- 9.2.1 Classical Technique (according to Chayen)
- 9.2.2 Psoas Blockade with Ultrasound

#### **9.3 Sensory and Motor Effects**

#### **9.4 Indications and Contraindications**

- 9.4.1 Indications
- 9.4.2 Contraindications

#### **9.5 Complications, Side Effects, Method-Specific Problems**

#### **9.6 Remarks on the Technique**

#### **9.7 Summary**

- References

### **10 Inguinal Paravascular Lumbar Plexus Anesthesia (Femoral Nerve Block)**

#### **10.1 Anatomical Overview**

#### **10.2 Femoral Nerve Block**

- 10.2.1 Needle Approach
- 10.2.2 Needle Approach with Ultrasound

#### **10.3 Sensory and Motor Effects**

#### **10.4 Indications and Contraindications**

- 10.4.1 Indications
- 10.4.2 Contraindications

#### **10.5 Complications, Side Effects, Method-Specific Problems**

- 10.5.1 Method-Specific Problems

## **10.6 Remarks on the Technique**

References

# **11 Proximal Sciatic Nerve Block**

## **11.1 Anatomical Overview**

- 11.1.1 Sciatic Plexus
- 11.1.2 Sciatic Nerve (L4–S3)
- 11.1.3 Posterior Cutaneous Nerve of the Thigh (S1–S3)
- 11.1.4 Periosteal Innervation

## **11.2 Anterior Proximal Sciatic Nerve Block (with Patient in Supine Position)**

- 11.2.1 Technique of Anterior Sciatic Nerve Block
- 11.2.2 Indications and Contraindications (in Combination with Femoral Nerve Block)
- 11.2.3 Side Effects and Complications
- 11.2.4 Remarks on the Technique
- 11.2.5 Anterior Proximal Sciatic Nerve Block Using Ultrasound

## **11.3 Posterior Proximal Sciatic Nerve Block (in Supine Position)**

- 11.3.1 Technique
- 11.3.2 Indications and Contraindications
- 11.3.3 Side Effects and Complications
- 11.3.4 Remarks on the Technique
- 11.3.5 Posterior Proximal Sciatic Nerve Block (in Supine Position) with Ultrasound

## **11.4 Proximal Lateral Sciatic Nerve Block (with Patient in Supine Position)**

- 11.4.1 Technique
- 11.4.2 Indications, Contraindications, Complications, Side effects
- 11.4.3 Remarks on the Technique

## **11.5 Proximal Sciatic Nerve Block (with Patient Lying on Side)**

- 11.5.1 Techniques of Posterior Transgluteal Sciatic Nerve Block
- 11.5.2 Indications and Contraindications
- 11.5.3 Complications and Side Effects
- 11.5.4 Remarks on the Technique
- 11.5.5 Proximal Sciatic Nerve Block (in Lateral Position) with Ultrasound
- 11.5.6 Infragluteal Block of the Sciatic Nerve in Lateral Position with Ultrasound

## **11.6 Parasacral Sciatic Nerve Block (Mansour Technique)**

- 11.6.1 Technique
- 11.6.2 Indications and Contraindications
- 11.6.3 Side Effects and Complications
- 11.6.4 Remarks on the Technique
- 11.6.5 Parasacral Sciatic Nerve Block with Ultrasound

References

# **12 Blocks at the Knee**

## **12.1 Anatomical Overview**

## **12.2 Classical Popliteal Block, Posterior Approach**

- 12.2.1 Technique
- 12.2.2 Remarks on the Technique

## **12.3 Distal Block of the Sciatic Nerve**

- 12.3.1 Technique
- 12.3.2 Indications and Contraindications
- 12.3.3 Side Effects and Complications
- 12.3.4 Remarks on the Technique
- 12.3.5 Distal Sciatic Nerve Block Using Ultrasound
- References

## **13 Peripheral Block (Conduction Block) of Individual Nerves of the Lower Limb**

### **13.1 Lateral Cutaneous Nerve of the Thigh**

- 13.1.1 Anatomy
- 13.1.2 Techniques
- 13.1.3 Indications, Contraindications, Side Effects
- 13.1.4 Remarks on the Technique
- 13.1.5 Block of the Lateral Cutaneous Nerve of the Thigh Using Ultrasound

### **13.2 Infiltration of the Iliac Crest**

- 13.2.1 Indication
- 13.2.2 Procedure

### **13.3 Transversus Abdominis Plane Block (TAP Block)**

- 13.3.1 Anatomy
- 13.3.2 Landmarks
- 13.3.3 Indications and Contraindications
- 13.3.4 Procedure

### **13.4 Obturator Nerve Block**

- 13.4.1 Anatomy
- 13.4.2 Techniques
- 13.4.3 Indications and Contraindications
- 13.4.4 Side Effects and Complications
- 13.4.5 Remarks on the Technique

### **13.5 Saphenous Nerve Block**

- 13.5.1 Anatomy
- 13.5.2 Techniques
- 13.5.3 Indications and Contraindications
- 13.5.4 Side Effects and Complications
- 13.5.5 Remarks on the Technique

### **13.6 Fibular Nerve Block**

- 13.6.1 Anatomy
- 13.6.2 Techniques
- 13.6.3 Indications and Contraindication
- 13.6.4 Side Effects and Complications
- 13.6.5 Remarks on the Technique
- References

## **14 Peripheral Nerve Blocks at the Ankle**

### **14.1 Anatomy**

### **14.2 Saphenous Nerve, Sural Nerve, and Superficial Fibular Nerve Block**

- 14.2.1 Saphenous Nerve Block
- 14.2.2 Superficial Fibular Nerve Block and Sural Nerve Block

### **14.3 Deep Fibular Nerve Block**

14.3.1 Landmarks

14.3.2 Procedure

### **14.4 (Posterior) Tibial Nerve Block**

14.4.1 Landmarks and Position

14.4.2 Procedure

### **14.5 Ankle Block**

### **14.6 Indications, Contraindications, Complications, Side Effects**

14.6.1 Indications

14.6.2 Contraindications

14.6.3 Side Effects and Complications

### **14.7 Remarks on the Combination Block (Ankle Block)**

### **14.8 Summary**

### **14.9 Blocks at the Toes**

14.9.1 Anatomy

14.9.2 Block Anesthesia of the Toes (Oberst Anesthesia)

References

## **Part IV Peripheral Regional Anesthesia in Pediatrics**

### **15 General Overview**

#### **15.1 Needle-Transducer Alignment**

#### **15.2 Ultrasound Axes**

References

### **16 Upper Limb**

#### **16.1 Supraclavicular Block of the Brachial Plexus**

16.1.1 Anatomy

16.1.2 Sonoanatomy

16.1.3 Technique of Supraclavicular Brachial Plexus Block

16.1.4 Indications and Contraindications

16.1.5 Complications, Side Effects, Method-Specific Problems

16.1.6 Remarks on the Technique

#### **16.2 Axillary Block of the Brachial Plexus**

16.2.1 Anatomy

16.2.2 Technique of Axillary Brachial Plexus Block

16.2.3 Indications and Contraindications

16.2.4 Complications, Side Effects, Method-Specific Problems

16.2.5 Remarks on the Technique

References

### **17 Lower Limb**

#### **17.1 Femoral Nerve Block**

17.1.1 Anatomy

- 17.1.2 Sonoanatomy
- 17.1.3 Technique of Femoral Nerve Block
- 17.1.4 Indications and Contraindications
- 17.1.5 Complications, Side Effects, Method-Specific Problems
- 17.1.6 Remarks on the Technique

## **17.2 Distal Sciatic Nerve Block**

- 17.2.1 Anatomy
- 17.2.2 Technique of Distal Sciatic Nerve Block
- 17.2.3 Indications and Contraindications
- 17.2.4 Complications, Side Effects, Method-Specific Problems
- 17.2.5 Remarks on the Technique
- References

# **18 Abdominal Wall**

## **18.1 Penile Root Block**

- 18.1.1 Anatomy
- 18.1.2 Technique of Penile Root Block
- 18.1.3 Indications and Contraindications
- 18.1.4 Complications, Side Effects, Method-Specific Problems
- 18.1.5 Remarks on the Technique

## **18.2 Ilioinguinal Nerve Block**

- 18.2.1 Anatomy
- 18.2.2 Sonoanatomy
- 18.2.3 Technique of Ilioinguinal Nerve Block
- 18.2.4 Indications and Contraindications
- 18.2.5 Complications, Side Effects, Method-Specific Problems
- 18.2.6 Remarks on the Technique

## **18.3 Transversus Abdominis Plane Block**

- 18.3.1 Anatomy
- 18.3.2 Sonoanatomy
- 18.3.3 Technique of Transversus Abdominis Plane Block
- 18.3.4 Indications and Contraindications
- 18.3.5 Complications, Side Effects, Method-Specific Problems
- 18.3.6 Remarks on the Technique
- References

# **Part V General Aspects of Peripheral Nerve Blocks of the Extremities**

## **19 Special Features of Peripheral Nerve Blocks**

### **19.1 Advantages of Peripheral Nerve Blocks**

### **19.2 Problems of Peripheral Nerve Blocks**

- 19.2.1 Incomplete Block
- 19.2.2 Dosages of Local Anesthetic
- References

## **20 Complications and General Contraindications of Peripheral Blocks**

### **20.1 Complications of Peripheral Nerve Blocks**

- 20.1.1 Toxic Reactions Caused by the Local Anesthetic

20.1.2 Neurological Injuries (Neuropathy)

## **20.2 General Contraindications to Peripheral Nerve Blocks**

20.2.1 Infections

20.2.2 Coagulation Disorders

20.2.3 Pre-existing Neurological Deficits

References

## **21 General Principles for Performing Peripheral Blocks**

### **21.1 Essential Components Necessary for Proper Aseptic Technique**

### **21.2 General Principles of Informed Consent, Positioning and Monitoring**

21.2.1 Patient Informed Consent before Peripheral Nerve Blocks

21.2.2 Position

21.2.3 Monitoring

### **21.3 Technical Aids for Performing Peripheral Nerve Blocks**

21.3.1 Vascular Doppler Sonography

21.3.2 Ultrasonography

21.3.3 Surface Thermometer

21.3.4 Peripheral Nerve Stimulation

21.3.5 Needles and Catheters

### **21.4 General Principles for Performing Regional Anesthesia**

21.4.1 With Nerve Stimulator

21.4.2 With Ultrasound

### **21.5 Analgo-sedation**

21.5.1 For Peripheral Nerve Blocks

21.5.2 Concomitant Medication during Surgery under Regional Anesthesia

### **21.6 General Principles for Administration of Local Anesthetics in Peripheral Nerve Block**

21.6.1 Local Anesthetics

21.6.2 Dosage

21.6.3 Measures to Shorten the Latency Time

21.6.4 Adjuvants

References

## **22 Continuous Peripheral Nerve Blocks**

### **22.1 Advantages**

### **22.2 Indications**

22.2.1 Differential Indications

### **22.3 Local Anesthetics: Administration, Dosage**

22.3.1 Care of Peripheral Pain Catheters in a General Ward

22.3.2 Peripheral Nerve Catheters for Outpatient Regional Pain Management

22.3.3 Complications of Peripheral Nerve Catheters for Pain Management

References

**Index**

# Foreword

Compared to general anesthesia, regional anesthesia can provide anatomically selective anesthesia with less interference with the patient's vital functions and a reduced need for opiates. Using a continuous catheter technique, the regional block can be transformed into a likewise selective analgesia with similar advantages for postoperative and other pain management.

Regional anesthesia is sometimes considered an art; this art can, however, be learnt by any interested anesthesiologist who has access to professional instructions and a good training program. The most exclusive form of regional anesthesia is peripheral nerve blockade, and for colleagues interested in practicing peripheral nerve and plexus blocks, this Atlas is an excellent source of clear and instructive descriptions of most clinically relevant extremity blocks. The art of peripheral nerve blockade is based on good anatomical understanding, careful handling of needles, catheters and patients, and good knowledge of pharmacology of local anesthetics. All these components are well presented in this Atlas.

Today's technology offers advanced assistance in localizing the target nerve; however, the use of electrostimulation or ultrasonography, for example, does not reduce the importance of anatomical knowledge. In my opinion, a competent anesthetist should also be able to find most peripheral nerves without this special equipment. And those readers who have carefully studied this Atlas will certainly be able to do that!

*Dag E. Selander<sup>†</sup>*  
*Nösund, Orust, Sweden*

<sup>†</sup>This foreword to the 2nd English Edition was written in 2007 by Dag Selander, who sadly passed away 4 July 2013. In memory of this truly marvelous clinician, scientist, teacher, and above all human being, we decided to take over this foreword for the 3rd Edition, especially since it has lost none of its relevance.

# Acknowledgements

The authors of this book consider themselves lucky to have had the continued support for many years of trusted colleagues and numerous friends. In the last decade we have been actively involved, both as speakers and tutors, in courses on anatomy for regional anesthesia and pain management at Innsbruck University and at the Medical University of Graz, Austria. Thanks to Drs. Christoph Huber, Gottfried Mitterschiffthaler, and Asst. Prof. Herbert Maurer and their courses, the field of anatomy has been opened up for special clinical and anesthesiological questions. Later on Professor Feigl started to arrange similar courses at the Institute for Anatomy, Medical University of Graz (Head Professor Dr. Anderhuber). During this time we were able to discuss various questions pertaining to peripheral blocking techniques. Together we carried out scientific research at the Department of Anatomy in order to clarify specific problems. Our special thanks go to all our colleagues and friends at Innsbruck University and the Medical University of Graz.

Other colleagues in Germany and Austria, both in Anesthesia and in Anatomy, have kindly cooperated with the authors over years. There has been a long-standing exchange of experience among them Profs. J. Jage and Stofft (Mainz University, Germany), Profs. Kessler and H.-W. Korf (Frankfurt University, Germany), Profs. T. Standl and Z. Halata (Hamburg University, Germany), Dr. M. Gründling and Prof. Fanghänel (Greifswald University, Germany), and Prof. B. Freitag and Dr. S. Rudolph (Klinikum Südstadt Rostock, Germany) were very collegial and helpful and their cooperation lead to many new findings. In these institutes the authors also had the chance to regularly clarify anatomical details relevant to peripheral blocking. We received support from numerous colleagues and apologize that we are unable to mention all of them here. We thank all the members of the institutes.

We are especially grateful that the anatomists allowed us to take photographs of their specimens. Many of the anatomical drawings for this book were produced by Mr. N. Lechenbauer. This was only possible with the support of B. Schmalz and R. Ploenes (AstraZeneca Co.). We also received active support in our own hospitals. Surgeons patiently waited for clinical pictures to be taken and members of staff made themselves available as test persons. Special thanks go to our staff. Dr. M. Neuburger (Klinikum Achern, Germany) has been kind enough to let us have research results and took additional photographs and performed extra examinations. Drs. D. Lang, F. Reisig, T. Geiser (Trauma Center, Murnau) and B. Bünten, A. Heuckerodt (Oberammergau Center for Rheumatology, Germany) have supported us in taking clinical pictures. Support from our own and other departments of our hospitals was so great that it is impossible to name everybody. We received a great deal of encouragement and many useful tips. This book is the result of many years of cooperation between anatomy and anesthesia. We would like to express our thanks to all those who have supported us along the way.

The *Atlas of Peripheral Regional Anesthesia* has won a lot of approval and recognition within the first month of publication in the German-speaking world. We thank Thieme Publisher's, notably Angelika Findgott and Joanne Stead, for their excellent cooperation and for making an English edition of this Atlas possible. We are proud to have acquired Dr. Dag



Selander for revision of the translation of the 2nd Edition. Dr. Selander was internationally renowned for his many publications in the field of regional anesthesia, including his article *Catheter technique in axillary plexus block* (Acta Anaesth Scand 1977; 21:324-329). He was the first to describe continuous percutaneous axillary brachial plexus anesthesia. We are honored that Dr. Selander agreed, as a specialist in this field, to edit the translation of the 2nd Edition and also supported us amicably with competent suggestions. We are grateful for this special support without which an English edition would have been impossible.

Panta rhei (Everything is in flux)

Heraklit (540-480 BC)

*Gisela Meier, MD*  
*Johannes Buettner, MD*

# Contributors

## Editors:

### **Gisela Meier, MD**

Former Head of the Department of Anesthesia  
and Interventional Pain Therapy  
Oberammergau Center for Rheumatology  
Oberammergau, Germany

### **Johannes Buettner, MD**

Former Head of the Department of Anesthesia  
Trauma Center  
Murnau, Germany

## Contributors:

### **Georg Feigl, MD**

Associate Professor  
Institute for Anatomy  
Medical University of Graz  
Graz, Austria

### **Ralf Hillmann, MD**

DESA  
Pediatric Center Olga Hospital, Klinikum Stuttgart  
Department of Anesthesia and Intensive Care Medicine  
Stuttgart, Germany

# List of Videos

## **General Aspects of Ultrasound-guided Peripheral Regional Anesthesia**

General Principles of Ultrasound-guided Peripheral Nerve Blocks

### **Upper Limb**

General Overview

Interscalene Techniques of Brachial Plexus Block

Supraclavicular and Infraclavicular Techniques of Brachial Plexus Block

Suprascapular Nerve Block

Axillary Block

Selective Blocks of Individual Nerves in the Upper Arm, at the Elbow and Wrist

### **Lower Limb**

General Overview

Psoas Block

Inguinal Paravascular Lumbar Plexus Anesthesia (Femoral Nerve Block)

Proximal Sciatic Nerve Blocks

Blocks at the Knee

Peripheral Blocks (Conduction Blocks) of Individual Nerves of the Lower Limb

Peripheral Nerve Blocks at the Ankle

### **General Aspects**

General Principles for Performing Peripheral Blocks

# Abbreviations

a.	artery
ACT	activated clotting time
ASS	acetyl salicylic acid
BART	blue away, red toward
CFM	color flow modus
CNB	central neuraxial block
COPD	chronic obstructive pulmonary disease
CRPS	complex regional pain syndrome
CW	continuous wave
ECT	ecarin clotting time
IP	in plane
IV	intravenous
LAST	local anesthetic systemic toxicity
LAX	long axis
LMH	low molecular weight heparin
LOR	loss of resistance
MRI	magnetic resonance imaging
OOP	out of plane
PCA	patient-controlled analgesia
PNS	peripheral nerve stimulation
PONV	postoperative nausea and vomiting
PRF	pulse repetition frequency
PW	pulsed wave
SAX	short axis
TAP	transversus abdominis plane
TGC	time gain concentration
THI	tissue harmonic imaging
v.	vein
VIB	vertical infraclavicular (plexus) block

## **Part 1**

# **General Aspects of Ultrasound-Guided Peripheral Regional Anesthesia**

### **1 General Principles of Ultrasound-Guided Peripheral Nerve Blocks**

# 1 General Principles of Ultrasound-Guided Peripheral Nerve Blocks

## 1.1 Technical Requirements

### 1.1.1 Equipment

Portable, high-resolution ultrasound machines with interchangeable transducers now constitute devices that are well suited for use in anesthesiology and intensive medicine.

#### Types of Visualization

► **B-mode (brightness mode).** Every signal received from the transducer is displayed in a certain gray tone depending on its amplitude (intensity). The B-mode is used only in conjunction with the two-dimensional (2D) real-time mode. A two-dimensional image is made from the numerous ultrasound waves transmitted and received (► [Fig. 1.1](#)). Depending on the penetration depth and the type of probe used, just a few images or up to 200 images per second can be visualized.

► **M-mode (or TM-mode, time–motion).** An impulse is transmitted with a high pulse repetition rate (1,000–5,000/s). The amplitudes of the signals received are displayed on the vertical axis (one dimensional) in various gray tones; the horizontal axis is the time axis on which the signals received over time are displayed at short intervals according to frequency.

#### Note

The M-mode has almost no role in ultrasound-guided regional anesthesia.

The M-mode can be helpful for diagnosing pneumothorax (see below). When the visceral pleura glide normally along the parietal pleura, a homogeneous granular pattern can be visualized below the pleura in M-mode—in contrast to the horizontal lines that can be seen above the pleura in immobile tissue (► [Fig. 1.2](#)). If pneumothorax is present, the granular pattern below the pleura is replaced by horizontal lines (► [Fig. 1.3](#)).

#### Transducers

Linear array and curved array transducers are used (► [Fig. 1.4](#)).

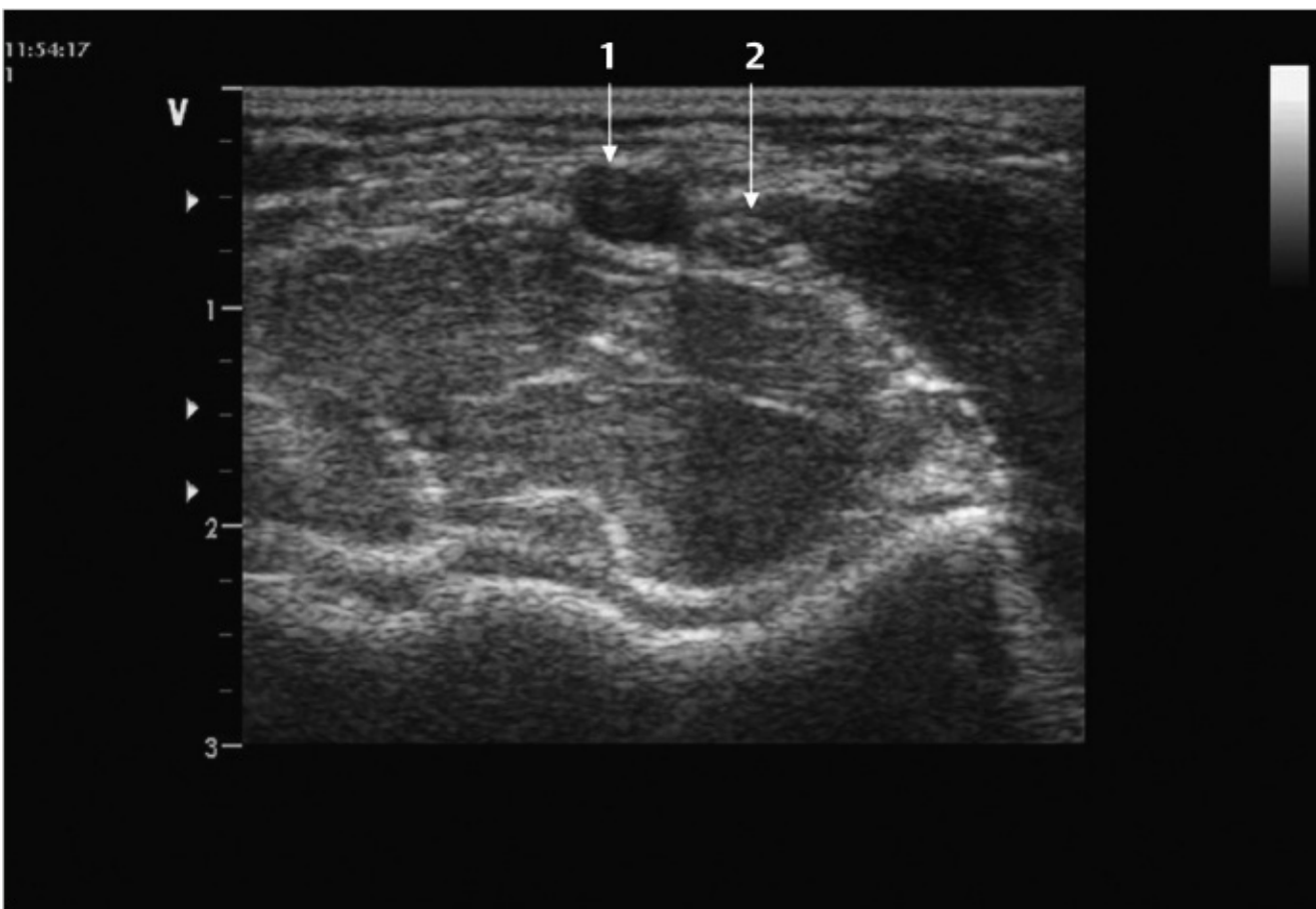
► **Linear array transducer.** The *standard transducer* is the high-frequency linear array transducer. A multi-frequency transducer (e.g., 4.0–16 MHz), with the option of varying the frequency depending on the penetration depth required, is generally used. A special form of high-frequency linear probe known as a hockey stick linear array transducer is shaped so that it

can be used in small anatomical situations. Modern multi-frequency linear broadband transducers use an electronic phased array technique, allowing the beam to be directed at various angles (sector scanning by electronic pan both in the transmission and the receptor field).

► **Curved array transducer.** The curved array transducer (2.0–6.0 MHz) is used for blocks of deeper nerves.

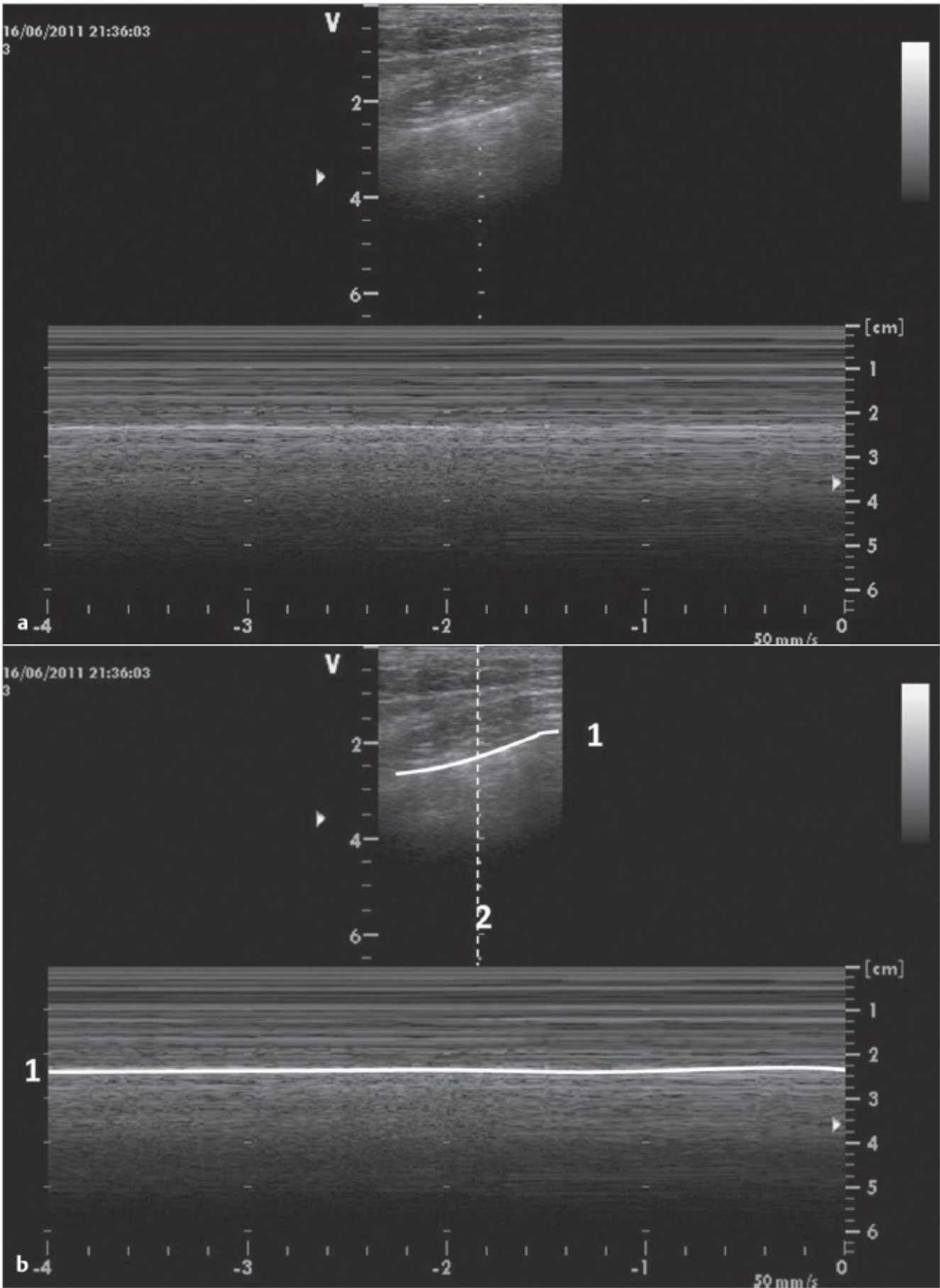
### Practical Note

The higher the frequency, the better the resolution—but the lower the penetration depth.



**Fig. 1.1** Visualization of the elbow in B-mode (2D real-time mode).

- 1 Brachial artery
- 2 Median nerve



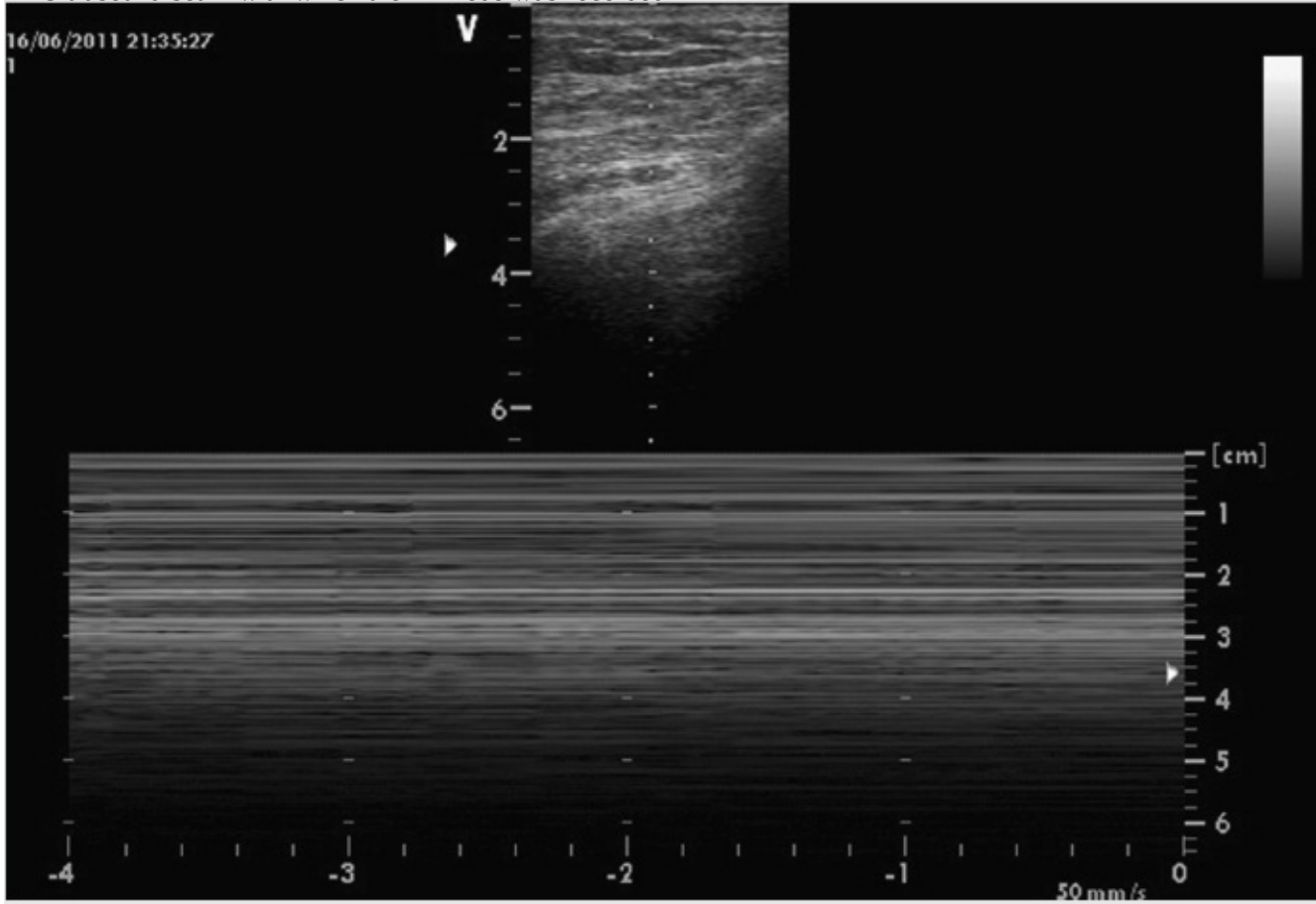
**Fig. 1.2** Intact pleura in M-mode. **a** Small image at top: Pleura in B-mode indicating the ultrasound beam in which the M-mode was recorded.



**b** Intact pleura in M-mode labeled.

1 Pleura

2 Ultrasound beam with which the M-mode was recorded



**Fig. 1.3** Pleura in pneumothorax.