

Atlas of Ultrasound-Guided Central Venous Catheter Placement

Neonatal and Pediatric
Approach

Fernando Montes-Tapia



Springer

Atlas of Ultrasound-Guided Central Venous Catheter Placement

Fernando Montes-Tapia

Atlas of Ultrasound-Guided Central Venous Catheter Placement

Neonatal and Pediatric Approach



Springer

Fernando Montes-Tapia
Pediatrics Department
Hospital Universitario “Dr. José Eleuterio González”
Universidad Autónoma de Nuevo Leon
Monterrey, Mexico

ISBN 978-3-031-61886-4 ISBN 978-3-031-61887-1 (eBook)
<https://doi.org/10.1007/978-3-031-61887-1>

© The Editor(s) (if applicable) and The Author(s), under exclusive license to Springer Nature Switzerland AG 2024

This work is subject to copyright. All rights are solely and exclusively licensed 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.

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.

The publisher, the authors and the editors are safe to assume that the advice and information in this book are believed to be true and accurate at the date of publication. Neither the publisher nor the authors or the editors give a warranty, expressed or implied, with respect to the material contained herein or for any errors or omissions that may have been made. The publisher remains neutral with regard to jurisdictional claims in published maps and institutional affiliations.

This Springer imprint is published by the registered company Springer Nature Switzerland AG
The registered company address is: Gewerbestrasse 11, 6330 Cham, Switzerland

If disposing of this product, please recycle the paper.

I wish to dedicate this book first to Him, for without His wisdom, this endeavor would not have been possible.

“A truly good wife is the most precious treasure a man can find! Her husband depends on her, and she never lets him down.” Her name is Rosario; thank you.

To Félix and Fernando, I hope to have been a good steward.

To my parents, who gave me the chance to exist.

To my siblings, who are always here despite the distance.

To my in-laws, for welcoming me into their family.

To my patients, for whom I have always strived to provide a quality experience, especially warmth when a vascular access was required.

Foreword

Undoubtedly, the placement of a central venous catheter is an essential procedure in the management of hospitalized pediatric patients. Central venous catheters constitute a vital line for fluid volume management, venous access, medication infusion, and provide a safe and consistent means of monitoring the short-, medium-, and long-term treatment of critically ill patients.

Acquiring the skill to place a central venous catheter is therefore of paramount importance in clinical hospital training, both in infants and adults. In the specific case of pediatric patients, the size of the patient and the dimensions of the vessels to be cannulated are distinctive factors in the difficulty of the procedure, presenting an additional challenge to the patient's clinical condition. Evidently, the size and weight of pediatric patients can range widely from neonates to adolescents, making the learning and mastery of techniques across different pediatric ages highly relevant. Precision, assertiveness with the patient, and good judgment complement the operator's knowledge of regional anatomy, the venous system, and nerve branches. All of this must now be integrated with the ability to handle ultrasound equipment, which has facilitated the execution of this meticulous and indispensable procedure.

For the successful execution of this vascular access technique, the guidance, recommendation, and visual support from experienced practitioners are always welcome. This is where a work like the present *Atlas of Ultrasound-Guided Central Venous Catheter Placement: Neonatal and Pediatric Approach* shows its value and relevance. This atlas is a reliable guide that, step by step, image by image, illustrates the path that the operator must follow when placing a central venous catheter in neonates and pediatric patients. The guide in this vascular procedure is the pediatric surgeon Fernando Montes-Tapia, MD, PhD, professor in the Department of Pediatrics at the "Dr. José Eleuterio González" University Hospital of the Universidad Autónoma de Nuevo León, who, through his experience and collaboration with pioneers in pediatric catheterization like Antonio Rodríguez-Tamez, MD, has made the practice of ultrasound-guided vascular access a significant clinical science in hospital practice.

Professor Montes-Tapia guides the operator through the process of placing a central venous catheter, marking each step, each detail, and warning of possible

difficulties and causes of errors throughout 23 chapters, organized by vascular access route. In these chapters, he provides a detailed and meticulous overview, supported by 469 photographs of patient positioning, procedures, anatomical access, and ultrasound transducer positioning. Additionally, through 472 ultrasound images parallel to the procedure photographs, he shows in a detailed and schematic manner the vascular structures, nerves, and tissues, presenting the catheter's position within the vascular pathway. In summary, the procedure is illustrated to be performed safely and expertly.

As the author rightly points out, this invasive medical procedure is not a minor one. It demonstrates not only the skills and competence of the individual operator but also the high quality and teamwork capabilities of the clinical services where it is performed. Under certain circumstances, achieving this can become a true challenge for the medical team.

It is a great satisfaction for me and for the academic medical community of the university hospital that our colleague, Dr. Montes-Tapia, publishes this atlas and makes it available to health professionals worldwide who need to perform vascular access from the neonatal stage to adolescence. I conclude by reiterating this atlas as a useful, relevant, accessible work with a didactic format for precise follow-up. Equally and fundamentally important, it will benefit patients undergoing this procedure under reliable and effective guidance.

Dean of the Faculty of Medicine and Hospital
Universitario "Dr. Jose E. González"
Universidad Autónoma de Nuevo León
Monterrey, Nuevo León, Mexico

Oscar Vidal-Gutierrez

Preface

Central venous catheter (CVC) placement is the most frequently performed invasive procedure in pediatric and adult patients. The indications for a CVC include hemodynamic monitoring, administration of parenteral solutions, antibiotics, parenteral nutrition, among others.

Traditionally, vascular access is performed using anatomical guides; however, its effectiveness depends on the expertise of the operator. The success of the anatomical guide procedure decreases as the patient's age and weight decrease or the patient has had previous catheterizations or abnormal anatomy. In addition, the risk of associated complications such as hematomas, pneumothorax, cardiac tamponade, or deaths is reported when using this technique.

Ultrasound-guided central venous catheter placement is recognized by the National Institute for Clinical Excellence (2002) recommendations, which state that ultrasound guidance is the preferred method for elective CVC insertion in both adults and children. However, it has not yet become the standard due to lack of training or adequate equipment (ultrasound) to perform it.

This atlas aims to contribute to the development of the knowledge component and, potentially, facilitate the acquisition of skills through the photographic demonstration of techniques within the competence of performing ultrasound-guided vascular access procedures. This atlas is the first in the literature to present a graphic/clinical step-by-step format for each of the 23 types of vascular access in neonatal and pediatric ages.

The decision to share this knowledge stems from a commitment to improving the quality and safety of a procedure often minimized by many physicians as "just vein puncture." However, facing a 0.500 kg newborn or a 100+ kg adolescent presents challenges often associated with complications and fatal incidents.

More than 41 years ago, my mentor Dr. Antonio Rodríguez Taméz began with anatomical guide-based vascular accesses, quickly transitioning to ultrasound-guided placement with the first Site Rite® in Mexico in 1992. His expertise over the years and the use of various ultrasound devices made him a great expert. Thus, in 2002, I started my training in ultrasound-guided vascular access under my mentor, later learning other vascular accesses that I now share with him.

A competitive advantage of ultrasound-guided vascular access lies not only in its quality and safety but also in the psychological impact on the operator. Faced with patients who have multiple previous punctures, difficult vascular access due to weight, clinical condition, or congenital anomalies, the use of ultrasound provides fundamental confidence, ensuring the location of a suitable vein. This confidence gives the operator a decisive initial advantage, approaching the procedure with a mindset of assured success.

Regarding the chapters:

- When the venous access technique is applicable to both neonatal and pediatric stages, we dedicate a chapter to the puncture of the same vein in each age group, acknowledging their unique peculiarities. Conversely, if the technique is strictly for pediatric patients, the description will focus solely on this age group.
- We include chapters illustrating the venous puncture technique from both long-axis (LAX) and short-axis (SAX) views, allowing for the learning of both techniques, and giving the reader the freedom to choose the one they feel more comfortable with and can learn more effectively.

The atlas chapters start with the internal jugular vein access, which I recommend as the first to learn because it is easy to locate and has a direct path to the superior vena cava. In neonates, due to the neck size, the LAX view is impossible, making the SAX view optimal.

Regarding the SAX view technique, described as out of the plane, thus potentially puncturing unvisualized structures (out of the plane), this is mitigated by performing ultrasound-guided dynamic needle-tip positioning (DNTP) to guide the intravenous catheter puncture or the introducer needle; in other words, you must learn to perform a sweep down or up the transducer as you progress with the puncture, ensuring at all times that the needle does not puncture other structures.

We will then describe the puncture technique of the most used vein in my series, the subclavian vein via the infraclavicular route. The puncture is performed in LAX view, which is more difficult to learn, but mastering it will eliminate the major complication described as pneumothorax from my incident scenario. As I always say when teaching this approach, the major incident is not cannulating the vein, but the cervicothoracic region has other veins and other subclavian access routes, such as the supraclavicular route described next, which I only describe in the pediatric stage.

The technique for puncturing the extrathoracic subclavian vein, originally described for pacemaker placement, has a limited margin for location. Anatomically, the subclavian vein starts after the confluence of the cephalic vein with the axillary vein, located in the deltopectoral groove. Thus, there is a short segment of the extrathoracic subclavian vein between this junction and the clavicle before its subclavicular passage. In patients older than 8 years, this segment measures approximately 3 cm in length, increasing as the individual's weight and height increase. Furthermore, the closer the vein is to the clavicle, the larger its diameter. I propose puncturing this specific segment of the subclavian vein, not the axillary vein. Although you will see that the suggested reading for these two chapters only contains literature on pacemaker placement.

Another vein in the cervicothoracic region is the brachiocephalic vein, notable for being a large vessel even in the neonatal stage; I only describe the puncture technique in LAX view.

We continue with the demonstration of femoral vein puncture, particularly in neonatal patients of very low weight (less than 1.5 kg), where many punctures are performed on the iliac vein due to its larger caliber. It can be confirmed in LAX view that the puncture is executed above the femoral head.

Finally, I present the technique for puncturing the upper extremity veins such as the brachial, basilic, and cephalic veins. These are used for the placement of a peripherally inserted central catheter (PICC), which can be punctured using either SAX or LAX views, though I suggest starting with SAX view.

It is my hope that this atlas serves as your guide whenever you perform a venous puncture to place a central venous catheter and that you adopt ultrasound-guided puncture as your standard for quality and safety. Our patients, whom we are privileged to serve, deserve nothing less.

Monterrey, Mexico

Fernando Montes-Tapia, MD PhD

Acknowledgments

I wish to express my gratitude to the Universidad Autónoma de Nuevo León, through the Hospital Universitario “Dr. José E. González”, for providing the setting for most of my professional practice, a place I consider home. To Dr. Oscar Vidal Gutiérrez, for his trust and the anticipation of better things to come. To Dr. Antonio Rodríguez-Taméz, who is undoubtedly my mentor in the field of ultrasound-guided vascular access; without your expertise and, above all, your friendship, I would not have acquired this skill. To my colleagues Dr. Ulises Garza-Luna and Guillermo Martínez-Flores, for their invaluable support and experience in the field of pediatric surgery. To my fellow faculty members in the Department of Pediatrics for considering me a peer. To the various generations of residents from the Department of Pediatrics at the Hospital Universitario “Dr. José E. González”, for their valuable assistance during “the catheter time.” To my research interns, Antonio Castillo, Zelenia García-Alcudia, Madeline Nuñez-Ku, who inspired me to excel, Evelyn González and Emilia González for believing in my project, and Karen Cantú for continuing the legacy of her colleagues. To Berenice Ricardez, for her invaluable support in photography. To Sergio Lozano M.D., who assisted me in conveying the knowledge contained in this book in English.

About the Book

This atlas provides a detailed illustration of the venous puncture technique under real-time ultrasonographic guidance, specifically for neonatal and pediatric patients for the insertion of central venous catheters. Comprising 23 chapters, it thoroughly covers all documented venous accesses to date. Each chapter is enhanced with clinical images capturing each phase of the procedure, alongside their corresponding ultrasonographic images, offering a detailed, step-by-step guide for executing each technique.

Contents

1	General Principles	1
1.1	Informed Consent	1
1.2	Universal Protocol	1
1.3	Patient Monitoring	2
1.4	Sedation	2
1.5	Sterile Procedure	2
1.6	Anesthesia	3
1.7	Ultrasound-Guided Vascular Access	3
1.8	Pre-Procedure Scan	6
1.9	Puncture Technique	6
1.10	Catheter Fixation	13
2	Right Internal Jugular Vein in Pediatrics	15
2.1	Patient Positioning	15
2.2	Scanning Technique	16
2.3	Local Anesthesia Application	17
2.4	Steps for Real-Time Ultrasound-Guided Access to the Right Internal Jugular Vein in Pediatrics	18
2.4.1	Step 01	18
2.4.2	Step 02	20
2.4.3	Step 03	21
2.4.4	Step 04	21
2.4.5	Step 05	23
2.4.6	Step 06	25
2.4.7	Step 07	27
2.4.8	Step 08	30
2.4.9	Step 09	31
2.4.10	Step 10	34
	Sources	34

- 3 Right Internal Jugular Vein in Neonates 35**
 - 3.1 Patient Positioning 35
 - 3.2 Scanning Technique 36
 - 3.3 Local Anesthesia Application 38
 - 3.4 Steps for Real-Time Ultrasound-Guided Access
to the Right Internal Jugular Vein in Neonates 40
 - 3.4.1 Step 01 40
 - 3.4.2 Step 02 42
 - 3.4.3 Step 03 43
 - 3.4.4 Step 04 43
 - 3.4.5 Step 05 44
 - 3.4.6 Step 06 47
 - 3.4.7 Step 07 48
 - 3.4.8 Step 08 49
 - 3.4.9 Step 09 51
 - 3.4.10 Step 10 53
 - Sources 53

- 4 Left Internal Jugular Vein in Pediatrics 55**
 - 4.1 Patient Positioning 55
 - 4.2 Scanning Technique 56
 - 4.3 Local Anesthesia Application 58
 - 4.4 Steps for Real-Time Ultrasound-Guided Access
to the Left Internal Jugular Vein in Pediatrics 59
 - 4.4.1 Step 01 59
 - 4.4.2 Step 02 59
 - 4.4.3 Step 03 60
 - 4.4.4 Step 04 61
 - 4.4.5 Step 05 62
 - 4.4.6 Step 06 66
 - 4.4.7 Step 07 68
 - 4.4.8 Step 08 70
 - 4.4.9 Step 09 70
 - 4.4.10 Step 10 71
 - Sources 72

- 5 Left Internal Jugular Vein in Neonates 75**
 - 5.1 Patient Positioning 75
 - 5.2 Scanning Technique 76
 - 5.3 Local Anesthesia Application 77
 - 5.4 Steps for Real-Time Ultrasound-Guided Access
to the Left Internal Jugular Vein in Neonates 81
 - 5.4.1 Step 01 81
 - 5.4.2 Step 02 83
 - 5.4.3 Step 03 83
 - 5.4.4 Step 04 86

5.4.5	Step 05	87
5.4.6	Step 06	89
5.4.7	Step 07	91
5.4.8	Step 08	92
5.4.9	Step 09	94
5.4.10	Step 10	96
5.4.11	Step 11	96
Sources		98
6	Intraclavicular Right Subclavian Vein in Pediatrics	99
6.1	Patient Positioning	99
6.2	Scanning Technique	100
6.3	Local Anesthesia Application	103
6.4	Steps for Real-Time Ultrasound-Guided Access to Intraclavicular Right Subclavian Vein in Pediatric	104
6.4.1	Step 01	104
6.4.2	Step 02	104
6.4.3	Step 03	107
6.4.4	Step 04	109
6.4.5	Step 05	112
6.4.6	Step 05	112
6.4.7	Step 06	113
Sources		113
7	Intraclavicular Right Subclavian Vein in Neonates	115
7.1	Patient Positioning	115
7.2	Scanning Technique	116
7.3	Local Anesthesia Application	119
7.4	Steps for Real-Time Ultrasound-Guided Access to Intraclavicular Right Subclavian Vein in Neonates	120
7.4.1	Step 01	120
7.4.2	Step 02	122
7.4.3	Step 03	122
7.4.4	Step 04	124
7.4.5	Step 05	128
7.4.6	Step 06	130
7.4.7	Step 07	130
7.4.8	Step 08	131
Sources		134
8	Intraclavicular Left Subclavian Vein in Pediatrics	137
8.1	Patient Positioning	137
8.2	Scanning Technique	138
8.3	Local Anesthesia Application	140
8.4	Steps for Real-Time Ultrasound-Guided Access to Intraclavicular Left Subclavian Vein in Pediatrics	141

- 8.4.1 Step 01 141
- 8.4.2 Step 02 142
- 8.4.3 Step 03 144
- 8.4.4 Step 04 146
- 8.4.5 Step 05 147
- 8.4.6 Step 06 149
- 8.4.7 Step 07 151
- Sources 152
- 9 Infraclavicular Left Subclavian Vein in Neonates 155**
 - 9.1 Patient Positioning 155
 - 9.2 Scanning Technique 156
 - 9.3 Local Anesthesia Application 158
 - 9.4 Steps for Real-Time Ultrasound-Guided Access
to Infraclavicular Left Subclavian Vein in Neonates 159
 - 9.4.1 Step 01 159
 - 9.4.2 Step 02 161
 - 9.4.3 Step 03 161
 - 9.4.4 Step 04 163
 - 9.4.5 Step 05 164
 - 9.4.6 Step 06 166
 - Sources 168
- 10 Supraclavicular Right Subclavian Vein in Pediatrics 169**
 - 10.1 Patient Positioning 169
 - 10.2 Scanning Technique 170
 - 10.3 Local Anesthesia Application 175
 - 10.4 Steps for Real-Time Ultrasound-Guided Access
to Supraclavicular Right Subclavian Vein in Pediatrics 176
 - 10.4.1 Step 01 176
 - 10.4.2 Step 02 177
 - 10.4.3 Step 03 178
 - 10.4.4 Step 04 180
 - 10.4.5 Step 05 182
 - 10.4.6 Step 06 182
 - 10.4.7 Step 07 182
 - 10.4.8 Step 08 185
 - 10.4.9 Step 09 185
 - Sources 187
- 11 Supraclavicular Left Subclavian Vein in Pediatrics 189**
 - 11.1 Patient Positioning 189
 - 11.2 Scanning Technique 190
 - 11.3 Local Anesthesia Application 193
 - 11.4 Steps for Real-Time Ultrasound-Guided Access
to Supraclavicular Left Subclavian Vein in Pediatrics 194

11.4.1	Step 01	194
11.4.2	Step 02	195
11.4.3	Step 03	196
11.4.4	Step 04	198
11.4.5	Step 05	198
11.4.6	Step 06	199
11.4.7	Step 07	200
11.4.8	Step 08	203
Sources	203
12	Extrathoracic Right Subclavian Vein in Pediatrics	205
12.1	Patient Positioning	205
12.2	Scanning Technique	206
12.3	Local Anesthesia Application	208
12.4	Steps for Real-Time Ultrasound-Guided Access to Extrathoracic Right Subclavian Vein in Pediatrics	210
12.4.1	Step 01	210
12.4.2	Step 02	211
12.4.3	Step 03	212
12.4.4	Step 04	214
12.4.5	Step 05	215
12.4.6	Step 06	218
12.4.7	Step 07	219
12.4.8	Step 08	223
Sources	224
13	Extrathoracic Left Subclavian Vein in Pediatrics	227
13.1	Patient Positioning	227
13.2	Scanning Technique	228
13.3	Local Anesthesia Application	232
13.4	Steps for Real-Time Ultrasound-Guided Access to Extrathoracic Left Subclavian Vein in Pediatrics	234
13.4.1	Step 01	234
13.4.2	Step 02	235
13.4.3	Step 03	236
13.4.4	Step 04	241
13.4.5	Step 05	245
13.4.6	Step 06	247
13.4.7	Step 07	250
Sources	251
14	Right Brachiocephalic Vein in Pediatrics	253
14.1	Patient Positioning	253
14.2	Scanning Technique	254
14.3	Local Anesthesia Application	258

- 14.4 Steps for Real-Time Ultrasound-Guided Access to Right Brachiocephalic Vein in Pediatrics. 260
 - 14.4.1 Step 01 260
 - 14.4.2 Step 02 260
 - 14.4.3 Step 03 262
 - 14.4.4 Step 04 263
 - 14.4.5 Step 05 265
 - 14.4.6 Step 06 268
 - 14.4.7 Step 07 268
- Sources 270
- 15 Right Brachiocephalic Vein in Neonates 273**
 - 15.1 Patient Positioning 273
 - 15.2 Scanning Technique 274
 - 15.3 Local Anesthesia Application 277
 - 15.4 Steps for Real-Time Ultrasound-Guided Access to Right Brachiocephalic Vein in Neonates 278
 - 15.4.1 Step 01 278
 - 15.4.2 Step 02 280
 - 15.4.3 Step 03 281
 - 15.4.4 Step 04 284
 - 15.4.5 Step 05 285
 - 15.4.6 Step 06 286
 - 15.4.7 Step 07 286
- Sources 292
- 16 Left Brachiocephalic Vein in Pediatrics 293**
 - 16.1 Patient Positioning 293
 - 16.2 Scanning Technique 294
 - 16.3 Local Anesthesia Application 298
 - 16.4 Steps for Real-Time Ultrasound-Guided Access to Left Brachiocephalic Vein in Pediatrics. 300
 - 16.4.1 Step 01 300
 - 16.4.2 Step 02 301
 - 16.4.3 Step 03 302
 - 16.4.4 Step 04 308
 - 16.4.5 Step 05 310
 - 16.4.6 Step 06 312
 - 16.4.7 Step 07 312
- Sources 314
- 17 Left Brachiocephalic Vein in Neonates 315**
 - 17.1 Patient Positioning 315
 - 17.2 Scanning Technique 316
 - 17.3 Local Anesthesia Application 318

17.4	Steps for Real-Time Ultrasound-Guided Access to the Left Brachiocephalic Vein in Neonates	320
17.4.1	Step 01	320
17.4.2	Step 02	322
17.4.3	Step 03	322
17.4.4	Step 04	324
17.4.5	Step 05	329
17.4.6	Step 06	329
17.4.7	Step 07	330
	Sources	332
18	Right Femoral Vein in Pediatrics	333
18.1	Patient Positioning	333
18.2	Scanning Technique	334
18.3	Local Anesthesia Application	338
18.4	Steps for Real-Time Ultrasound-Guided Access to the Right Femoral Vein in Pediatrics	340
18.4.1	Step 01	340
18.4.2	Step 02	341
18.4.3	Step 03	343
18.4.4	Step 04	346
18.4.5	Step 05	348
18.4.6	Step 06	349
18.4.7	Step 07	351
	Sources	351
19	Right Femoral/Iliac Vein in Neonates	353
19.1	Patient Positioning	353
19.2	Scanning Technique	354
19.3	Local Anesthesia Application	358
19.4	Steps for Real-Time Ultrasound-Guided Access to the Right Femoral/Iliac Vein in Neonates	360
19.4.1	Step 01	360
19.4.2	Step 02	363
19.4.3	Step 03	365
19.4.4	Step 04	367
19.4.5	Step 05	368
19.4.6	Step 06	371
19.4.7	Step 07	373
	Sources	374
20	Left Femoral Vein in Pediatrics	375
20.1	Patient Positioning	375
20.2	Scanning Technique	376
20.3	Local Anesthesia Application	379

- 20.4 Steps for Real-Time Ultrasound-Guided Access to Left Femoral Vein in Pediatrics 381
 - 20.4.1 Step 01 381
 - 20.4.2 Step 02 381
 - 20.4.3 Step 03 386
 - 20.4.4 Step 04 388
 - 20.4.5 Step 05 390
 - 20.4.6 Step 06 391
 - 20.4.7 Step 07 394
- Sources 394
- 21 Left Femoral/Iliac Vein in Neonates 395**
 - 21.1 Patient Positioning 395
 - 21.2 Scanning Technique 396
 - 21.3 Steps for Real-Time Ultrasound-Guided Access to Left Femoral/Iliac Vein in Neonates 400
 - 21.3.1 Step 01 400
 - 21.3.2 Step 02 401
 - 21.3.3 Step 03 402
 - 21.3.4 Step 04 405
 - 21.3.5 Step 05 410
 - 21.3.6 Step 06 410
 - 21.3.7 Step 07 411
 - 21.3.8 Step 08 411
 - Sources 415
- 22 Brachial Vein in Pediatrics 417**
 - 22.1 Patient Positioning 417
 - 22.2 Scanning Technique 418
 - 22.3 Local Anesthesia Application 419
 - 22.4 Steps for Real-Time Ultrasound-Guided Access to Left Brachial Vein 420
 - 22.4.1 Step 01 420
 - 22.4.2 Step 02 421
 - 22.4.3 Step 03 423
 - 22.4.4 Step 04 427
 - 22.4.5 Step 05 427
 - 22.4.6 Step 06 429
 - 22.4.7 Step 07 434
 - Sources 436
- 23 Cephalic Vein in Pediatrics 437**
 - 23.1 Patient Positioning 437
 - 23.2 Scanning Technique 438
 - 23.3 Local Anesthesia Application 440

- 23.4 Steps for Real-Time Ultrasound-Guided Access to the Right Cephalic Vein 442
 - 23.4.1 Step 01 442
 - 23.4.2 Step 02 442
 - 23.4.3 Step 03 445
 - 23.4.4 Step 04 447
 - 23.4.5 Step 05 448
 - 23.4.6 Step 06 451
 - 23.4.7 Step 07 452
- Sources 456
- 24 Basilic Vein in Pediatrics 457**
 - 24.1 Patient Positioning 457
 - 24.2 Scanning Technique 458
 - 24.3 Local Anesthesia Application 461
 - 24.4 Steps for Real-Time Ultrasound-Guided Access to Left Basilic Vein. 462
 - 24.4.1 Step 01 462
 - 24.4.2 Step 02 464
 - 24.4.3 Step 03 465
 - 24.4.4 Step 04 468
 - 24.4.5 Step 05 468
 - 24.4.6 Step 06 469
 - 24.4.7 Step 07 471
 - Sources 473
- Index 475**

About the Author

Fernando Montes-Tapia, MD PhD is a pediatric surgeon and chief of the Department of Pediatrics at the Hospital Universitario “Dr. José E. González and professor at the Faculty of Medicine, Universidad Autónoma de Nuevo León, Monterrey, Mexico. He teaches both undergraduate and graduate courses and is a researcher with National Council of Humanities, Science and Technology (Consejo Nacional de Humanidades, Ciencias y Tecnología - CONAHCYT). His research focuses on ultrasound-guided vascular accesses in neonatal and pediatric patients, for which he has won national research awards in this area. He has participated in multiple conferences to promote the use of ultrasound as the standard for vascular access and offers workshops on ultrasound-guided vascular accesses. He has received various grants for his research and the acquisition of ultrasound equipment (Rotary Club International).

Abbreviations

BCV	Brachiocephalic vein
CA	Carotid artery
CV	Cephalic vein
DNT	Dynamic needle tracking
DNTP	Dynamic needle-tip positioning
ETSCA	Extrathoracic subclavian artery
ETSCV	Extrathoracic subclavian vein
FV	Femoral vein
IJV	Internal jugular vein
IVC	Inferior vena cava
LAX	Long axis
LBCV	Left brachiocephalic vein
LBrV	Left brachial vein
LBV	Left basilic vein
LCA	Left carotid artery
LCV	Left cephalic vein
LETSCA	Left extrathoracic subclavian artery
LETSCV	Left extrathoracic subclavian vein
LFA	Left femoral artery
LFV	Left femoral vein
LIA	Left iliac artery
LIJV	Left internal jugular vein
LIV	Left iliac vein
LSCA	Left subclavian artery
LSCV	Left subclavian vein
RBcV	Right brachial vein
RBCV	Right brachiocephalic vein
RBV	Right basilic vein
RCA	Right carotid artery
RCV	Right cephalic vein
RETSCA	Right extrathoracic subclavian artery

RETSCV	Right extrathoracic subclavian vein
RFA	Right femoral artery
RFV	Right femoral vein
RIA	Right iliac artery
RIJV	Right internal jugular vein
RIV	Right iliac vein
RSCA	Right subclavian artery
RSCV	Right subclavian vein
SAT	Subcutaneous adipose tissue
SAX	Short axis
SCA	Subclavian artery
SCM	Sternocleidomastoid
SCV	Subclavian vein
SVC	Superior vena cava

Chapter 1

General Principles



Due to the nature of this atlas, indications and contraindications are not covered. However, every time a decision is made to perform vascular access, these details must be analyzed and discussed with the attending physician to evaluate the best venous access according to the intended use.

1.1 Informed Consent

- It should be obtained from all patients or legal guardians before performing the procedure.
- This process is carried out with each family member and patient who is mature enough to understand the purpose of the procedure and the benefits, risks, and complications according to the patient's clinical condition.

1.2 Universal Protocol

- Since it is an invasive procedure, all patients should be considered for the pre-procedure, time-out, and post-procedure evaluation.

1.3 Patient Monitoring

- Vascular access is an invasive and high-risk procedure which is performed in the operating room but that can be performed outside the operating room. Quality and safety during the procedure must be guaranteed, so all patients must have at least the following:
 - Cardiac monitoring.
 - Pulse oximeter.
 - Oxygen therapy.
 - Equipment for invasive airway management.

1.4 Sedation

- Our hospital protocol uses the following drugs: midazolam associated with ketamine, fentanyl, or propofol. The combination of these is administered according to the patient's clinical status.
- In infants and anxious patients, start with a dose of midazolam when starting positioning and pre-procedure scanning.
- In patients who do not have vascular access, sedation can be provided intranasally, intramuscularly, intraosseously, or with a combination of these routes, according to the biosorption of each drug.
- In our institution, more than 95% of vascular accesses are performed under sedation outside the operating room.

1.5 Sterile Procedure

- Antiseptic solutions such as chlorhexidine-alcohol or chlorhexidine are used to disinfect the area chosen for the procedure.
- Operator cap and mask.
- Operator handwashing.
- Sterile gown and gloves.
- Protection barriers such as sterile cloth or synthetic fiber fields. These should cover a large area so that they can be placed over a 50-cm guidewire.
- Central venous catheter placement kit: See Fig. 1.1.



Fig. 1.1 The set we use at our institution

1.6 Anesthesia

- In all patients, local infiltration with 1% lidocaine is performed at the puncture site, catheter route, and fixation site. This procedure can be done under ultrasonographic guidance in real time or after previous ultrasound marking.
- In premature patients, local infiltration with lidocaine can cause a hyperechoic area in the tissues that later prevents visualization of the vessels or intravenous catheter below the infiltration. Therefore, the patient is sedated in these cases, and the vessel is punctured with a 24-G intravascular catheter. Once the vein is cannulated, and the guidewire is inserted into the vessel, lidocaine is infiltrated to perform the following steps, which are more painful, such as dilation of the trajectory and fixation with skin suture.

1.7 Ultrasound-Guided Vascular Access

- This atlas only presents the real-time ultrasound-guided vascular access technique.
- It is recommended to use a linear array probe, especially high frequency with a range of more than 10 Mhz. The high frequency allows the visualization of structures close to the skin with greater clarity. In this atlas, we used 13–6 MHz.
- Type of footprint (contact area of the transducer with the skin). There are different sizes according to the brand. The smallest is in the shape of a hockey stick

(with which most of the procedures presented in this atlas were performed), and there are others with a larger footprint of up to 6 cm. However, the choice will depend on the size of the patient. For example, if a patient weighs less than 1500 g, a 5-cm transducer would be too large for the neck or supraclavicular fossa. In contrast, a hockey stick would not be suitable for a teenager weighing 80 kg.

- Transducer and cable coverage equipment. There are covers designed for each type of transducer with suitable alternatives that each hospital designs. In our institution, we usually use a condom or a sterile glove to cover the transducer and a cloth or synthetic fiber field to cover the cable, which you hold with gauze or garters. The objective is that the equipment in contact with the sterile area should also be sterile.
- It is convenient to wash the transducer and the cable to keep them clean, according to the handling standards of each piece of equipment.
- The ultrasound screen is placed ergonomically. It is preferred to place it in front of the operator. Sometimes the patient's position does not allow it, so it is necessary to know how to adapt the screen position, so it does not impede adequate visualization and comfort for the procedure.
- In knobology, we must identify and know how to modify the following parameters:
 - *Position indicator or orientation marker* refers to a reference point on the body of the transducer that serves as a reference point to orient the image on the monitor, that is, which side of the transducer corresponds to the side of the monitor.

In the procedures demonstrated in this atlas, the mark is placed on the left side of the screen, indicating the tip of the hockey stick probe or the mark on the linear transducer with the largest footprint. The mark on the screen can be of different types. In this atlas, with the equipment we use, it appears as an aqua-colored dot in the upper left corner (Fig. 1.2).

Before starting to scan, the probe's orientation must be checked, placing gel on the transducer and moving it over the patient to confirm if it moves to our left or right. Another way is by touching one of the ends of the footprint and identifying if the left and right of the transducer correspond to the left or right of the screen and the right and left of the operator.

- *Depth*: This parameter should allow the chosen vessel to be displayed as close to the top of the screen because the top of the screen is the patient's skin. When using the short-axis (SAX) view, the vessel to be punctured is intended to be displayed in the center of the screen. In the images in this atlas, which are ultrasound screen images, the depth in centimeters (1,9, 2,2, etc.) appears in the lower right corner (Fig. 1.2).

Certain equipment has the zoom function. It is identified in the upper left of the monitor as an indicator on the side of the probe in the equipment we use for the procedures. In zoom mode, it is a "z" within an aqua circle (Fig. 1.3).

Fig. 1.2 Indicator position and depth marker

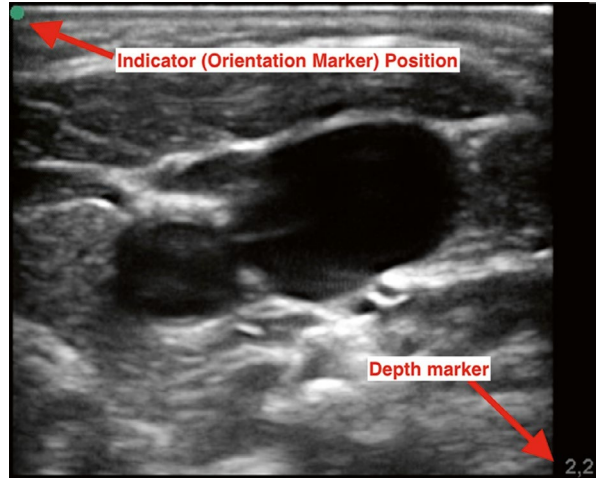
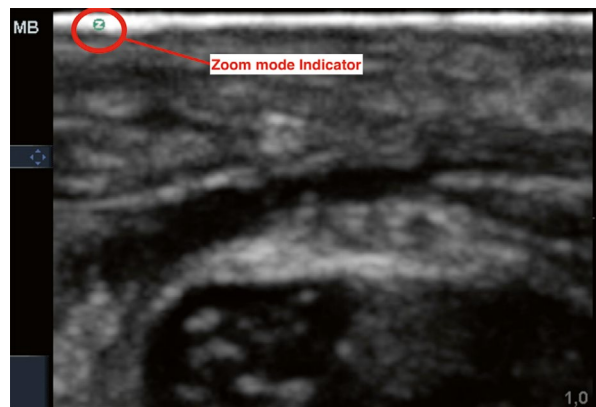


Fig. 1.3 Zoom mode indicator



Although zoom mode allows better visualization of vessels less than 0.5 cm, movements are also magnified, and it is necessary to know how to move when scanning. Movements and displacements must be short and slow.

- *Gain*: This will cause the scanned structures to appear darker in the monitor image (low gain) or the structures to be whiter (high gain).

This setting is important when the puncture is performed in the SAX view since the tip of a needle is normally displayed as hyperechoic. If we have a high gain (very white image), the tip of the intravenous catheter or the introducer needle will not be recognized. Therefore, the gain must be lowered (to see the image darker), and contrast the needle tip with the surrounding tissue to dynamic needle tip positioning (DNTP).

1.8 Pre-Procedure Scan

- The choice of the vein is made after performing:
 - Rapid central vein assessment (RaCeVA) of the cervicothoracic region for the jugular, subclavian, extrathoracic subclavian, or brachiocephalic veins.
 - RaCeVA of the brachial region for the basilic, brachial, or cephalic veins.
 - Rapid femoral vein assessment (RaFeVA) for the femoral/iliac vein.

1.9 Puncture Technique

- Non-sterile ultrasound gel is placed between the transducer and the sterile cover. Then, to achieve good contact with the skin, saline solution is used since, especially in patients punctured with a very small intravenous catheter, such as 24 G, it can become occluded with gel and obstruct the intravascular cannula.
- In-plane technique. The scan is performed in long-axis (LAX) view (Fig. 1.4); the vessel is visualized longitudinally (Fig. 1.5). In the puncture with this

Fig. 1.4 Transducer in longitudinal position on the right arm

