Jose J. Diaz · David T. Efron
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Complications in Acute Care Surgery

The Management of Difficult Clinical Scenarios

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Editors
Jose J. Diaz
R Adams Cowley Shock Trauma Center
Acute Care Surgery
University of Maryland School of Medicine
Baltimore, MD
USA

David T. Efron
Acute Care Surgery
John Hopkins Hospital Acute Care Surgery
Baltimore, MD
USA

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To my wife, Dinah, and children, Gabriella, Veronica, and Alejandro, who have been my inspiration to achieve more that I could have ever expected. To my father, J. Jesus Diaz, MD, the community general surgeon, who sparked my life long commitment to the surgical patient.

—Jose J. Diaz

To my father, Gershon Efron, MD, FACS. The consummate master surgeon and clinician.

—David T. Efron

Contents

Contributors

Charles A. Adams, Jr. Division of Trauma and Surgical Critical Care, Rhode Island Hospital, Warren Alpert Medical School of Brown University, Providence, RI, USA

Danielle L. Barnard Department of Surgery, The University of Tennessee Health Science Center, Memphis, TN, USA

James H. Black, III Division of Vascular and Endovascular Surgery, Johns Hopkins University School of Medicine, Baltimore, MD, USA

L.D. Britt Department of Surgery, Eastern Virginia Medical School, Norfolk, VA, USA

Brandon R. Bruns R Adams Cowley Shock Trauma Center, University of Maryland, Baltimore, MD, USA

Michael L. Cheatham Orlando Health Surgical Group, Orlando Regional Medical Center, Orlando, FL, USA

William G. Cioffi Department of Surgery, Rhode Island Hospital, Warren Alpert Medical School of Brown University, Providence, RI, USA

Raul Coimbra Division of Trauma, Surgical Critical Care, Burns and Acute Care Surgery, University of California, San Diego Health Sciences, San Diego, CA, USA

Bryan R. Collier Acute Care Surgery: Trauma, Surgical Critical Care, Emergency General Surgery, Virginia Tech Carilion School of Medicine, Roanoke, VA, USA

Zara Cooper Harvard Medical School, Boston, MA, USA

Edward E. Cornwell, III Department of Surgery, Howard University Hospital, Washington, DC, USA; The LaSalle D. Leffall, Jr., Professor & Chairman of Surgery, Howard University College of Medicine, Department of Surgery, Howard University Hospital, Washington, DC, USA

Martin A. Croce Department of Surgery, Elvis Presley Memorial Trauma Center, University of Tennessee Health Science Center, Memphis, TN, USA

Jose J. Diaz Division of Acute Care Surgery, R Adams Cowley Shock Trauma Center, University of Maryland Medical Center, Baltimore, MD, USA

David T. Efron Division of Acute Care Surgery, Johns Hopkins University School of Medicine, Baltimore, MD, USA

Gregory R. English UPMC Hamot, Erie, PA, USA

Eric W. Etchill Department of Surgery, University of Pittsburgh, Pittsburgh, PA, USA

Timothy C. Fabian Department of Surgery, The University of Tennessee Health Science Center, Memphis, TN, USA

David V. Feliciano IU Division of General Surgery, Indiana University Hospital, Indiana University Medical Center, Indianapolis, IN, USA

Glen A. Franklin Department of Surgery, University of Louisville, Louisville, KY, USA

Nicole M. Garcia Department of Surgery, University of Louisville, Louisville, KY, USA

Andrew Gaugler Jackson Memorial Hospital, Ryder Trauma Center, Miami, FL, USA

Stephen P. Gondek Division of Trauma and Surgical Critical Care, Vanderbilt University Medical Center, Nashville, TN, USA

Sharon M. Henry Program in Trauma, University of Maryland School of Medicine, University of Maryland Medical Center R A Cowley Shock Trauma Center, Baltimore, MD, USA

Sergio E. Hernandez Department of Surgery, University of Pittsburgh, Pittsburgh, PA, USA

Beth R. Hochman Columbia University Medical Center, New York, NY, USA

Joy Hughes Department of Surgery, Mayo Clinic College of Medicine, Rochester, MN, USA

Rao R. Ivatury Department of Surgery, Virginia Commonwealth University, Richmond, VA, USA

Gregory J. Jurkovich Department of Surgery, University of Colorado, Aurora, CO, USA

Steven A. Kahn Department of Surgery, University of South Alabama Medical Center, Mobile, AL, USA

Todd Kellogg Department of Surgery, Mayo Clinic College of Medicine, Rochester, MN, USA

Leslie Kobayashi Division of Trauma, Surgical Critical Care, Burns and Acute Care Surgery, University of California, San Diego Health Sciences, San Diego, CA, USA

Lisa M. Kodadek Department of Surgery, Johns Hopkins University School of Medicine, Baltimore, MD, USA

Narong Kulvatunyou Division of Acute Care Surgery, Department of Surgery, University of Arizona, Tucson, AZ, USA

Alaina M. Lasinski Department of Surgery, Loyola University Medical Center, Maywood, IL, USA

Elizabeth Lilley The Center for Surgery and Public Health at Brigham and Women's Hospital, Boston, MA, USA

Pamela A. Lipsett Department of Surgery, Department of Anesthesiology and Critical Care Medicine, Johns Hopkins University School of Medicine, Baltimore, MD, USA

Katie M. Love Acute Care Surgery: Trauma, Surgical Critical Care, Emergency General Surgery, Virginia Tech Carilion School of Medicine, Roanoke, VA, USA

Fred A. Luchette Department of Surgery, Loyola University Medical Center, Maywood, IL, USA

Addison K. May Division of Trauma and Surgical Critical Care, Vanderbilt University Medical Center, Nashville, TN, USA

Ernest E. Moore Department of Surgery, University of Colorado Denver, Denver, CO, USA

Hunter B. Moore Department of Surgery, University of Colorado, Aurora, CO, USA

Nicholas Namias Daughtry Family Department of Surgery, Jackson Memorial Hospital, Ryder Trauma Center, University of Miami Miller School of Medicine, Miami, FL, USA

Mayur Narayan Division of Acute Care Surgery, Clements University Hospital, UT-Southwestern Medical Center, Dallas, TX, USA

Andrew B. Peitzman Department of Surgery, University of Pittsburgh Medical Center, UPMC Presbyterian, Pittsburgh, PA, USA

Joseph Posluszny Department of Surgery, Loyola University Medical Center, Maywood, IL, USA

Patrick M. Reilly Perelman School of Medicine, University of Pennsylvania, Philadelphia, PA, USA

Peter Rhee Division of Acute Care Surgery, Department of Surgery, University of Arizona, Tucson, AZ, USA

Michael Rotondo Department of Surgery, University of Rochester Medical Center, Rochester, NY, USA

Alaa Sada Department of Surgery, Mayo Clinic College of Medicine, Rochester, MN, USA

Karen Safcsak Orlando Health Surgical Group, Orlando Regional Medical Center, Orlando, FL, USA

Michael Sarr Department of Surgery, Mayo Clinic College of Medicine, Rochester, MN, USA

Thomas M. Scalea R Adams Cowley Shock Trauma Center, University of Maryland, Baltimore, MD, USA

Jason W. Smith Department of Surgery, University of Louisville, Louisville, KY, USA

Jason A. Snyder Department of Surgery, Elvis Presley Memorial Trauma Center, University of Tennessee Health Science Center, Memphis, TN, USA

Nicole Stassen Department of Surgery, University of Rochester Medical Center, Rochester, NY, USA

Carrie Valdez R Adams Cowley Shock Trauma Center, University of Maryland Medical School, Baltimore, MD, USA

Jason B. Young Division of Trauma and Surgical Critical Care, Vanderbilt University Medical Center, Nashville, TN, USA

Syed Nabeel Zafar Department of Surgery, Howard University Hospital, Washington, DC, USA

Brian S. Zuckerbraun Department of Surgery, University of Pittsburgh, Pittsburgh, PA, USA; VA Pittsburgh Healthcare System, Pittsburgh, PA, USA

Chapter 1
Challenging IV Access in the Patient with Septic Shock

Jason B. Young, Stephen P. Gondek, Steven A. Kahn and Addison K. May

Types of Intravenous Access

Decisions regarding the type and location of access must take into account several factors including whether there is a need for hemodynamic monitoring, the rate of fluid administration required, the type of infusion required, availability of accessible site, and the risk/benefit ratio for insertion and maintenance. The need for hemodynamic monitoring and the instillation of fluids that are injurious or caustic if given peripherally may require the placement of central venous access.

The flow of fluids through any IV catheter can be described by Poiseuille's law which states that the flow (*Q*) of fluid is related to the viscosity (*n*) of the fluid, the pressure gradient across the tubing (*P*), the length (*L*) of the tubing, and the radius (*r*) of the tubing [12]. Increasing the viscosity of the fluid (blood products being more viscous than crystalloid solutions) or the length of the IV catheter tubing will decrease the flow rate. Increasing the pressure gradient across the tubing will increase the flow rate. Most importantly, increasing the radius of the tubing will increase the flow rate to the fourth power. The size of an IV catheter is measured as a gauge; the smaller the gauge, the larger the diameter of the catheter. Due to the short length of catheter

J.B. Young (✉) · S.P. Gondek · A.K. May
Division of Trauma and Surgical Critical Care, Vanderbilt University Medical Center,
1211 21st Ave S, 404 Medical Arts Building, Nashville, TN 37212, USA
e-mail: jason.b.young@vanderbilt.edu

S.P. Gondek
e-mail: stephen.p.gondek@vanderbilt.edu

A.K. May
e-mail: addison.may@vanderbilt.edu

S.A. Kahn
Department of Surgery, University of South Alabama Medical Center,
2451 Fillingim Street, Suite 10-I, Mobile, AL 36617, USA
e-mail: skahn@health.southalabama.edu

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Table 1.1 Peripheral IV[a] flow rates

Gauge	Length (mm)	Flow rate (ml/min)[b]
14	32	325
16	30	215
18	30	110
20	30	63

[a]Jelco Protectiv Plus-W Safety IV Catheter, Smiths Medical ASD, Inc., Southington, CT
[b]Flow rates are by gravity at 1 m height

required to achieve peripheral access, flow rates are more rapid than through longer, centrally placed catheters. Fluids can be run at a remarkably rapid rate through various peripheral IV gauges (Table 1.1). Additionally, for red blood cell infusion, cells may lyse if transfused through a smaller gauge IV catheter (less than 24 gauge).

Peripheral Intravenous Access

Obtaining vascular access in critically ill patients is one of the most important elements of clinical care, second only to managing the airway. The peripheral IV is often the first, inexpensive, and least invasive device utilized to obtain intravenous access. Two "large bore," peripheral IVs remain the gold standard for resuscitation of the exsanguinating trauma patient.

Unfortunately, critically ill patients often have factors that complicate obtaining peripheral access, such as hypovolemia, edema, obesity, a history of IV drug abuse, chronic kidney disease, vasculopathy, diabetes, and/or other chronic disease [5]. The placement of the peripheral IV in normal adults is relatively simple and may be performed by nurses, technicians, and physicians. However, in emergency and critical settings, the clinical setting and the need for larger bore catheters frequently requires more experienced care providers and may be aided by adjunctive technologies, such as ultrasound and hand-held venous illumination/visualization devices. The use of ultrasound has been shown to improve success in obtaining access expeditiously compared to standard approaches [12]. Initially shown to be beneficial for central venous catheter placement, ultrasound has now been widely studied for peripheral venous access as well. One downside is that it does require additional training. Both single- and double-operator techniques have been described. The double-operator technique where one provider holds the probe, and the other provider cannulates the vein is associated with higher success rates. Fewer skin punctures and increased patient satisfaction has also been described with this method of IV placement.

Other light-based hand-held devices have been developed to illuminate veins to ease cannulation [2]. These commonly utilize near-infrared light to highlight hemoglobin and visualize the vein. Veins containing hemoglobin appear dark on a red background. Although multiple devices have been developed, currently there is limited literature that demonstrates a clear benefit for their use.

Since peripherally placed short IV catheters infuse into smaller peripheral veins, the complications of infiltration and phlebitis increase dramatically with catheter dwell time. In order to limit the incidence of phlebitis, the Centers for Disease Control and Prevention recommends replacing peripheral venous catheters and rotating the site at least every 72–96 h [7]. In critically ill patients, the ability to maintain adequate access with this schedule may be very limited.

Peripherally Inserted Central Catheter (PICC)

The management of certain patients may require access to the central venous system or may require prolonged dwell time. One alternative to a conventional central line in this setting is a peripherally inserted central venous catheter (PICC). The catheter enters a peripheral vein, then traverses the deep venous system, and is therefore able to remain longer compared to conventional, short peripheral venous catheters. PICC lines are often used for long-term access for antibiotics, chemotherapy, and total parenteral nutrition (TPN) [1]. For placement, a peripheral vein in the arm is accessed and cannulated via a percutaneous approach and the line is advanced under ultrasonic, fluoroscopic, or radiographic guidance until the line reaches the superior vena cava. When compared to conventional central venous catheters, PICCs are longer and have smaller lumens therefore slower flow rates (Table 1.2), and may not be ideal for administration of blood. Placement of PICC lines is associated with a lower rate of major complications such as pneumothorax, air

Table 1.2 Central venous catheter[a] flow rates

Type	Size	Lumens	Lumen size	Flow rate (ml/h)[b]
MAC introducer	9 Fr × 11.5 cm	Distal	9 Fr	30,450
		Proximal	12 gauge	11,950
PSI (cordis)	8.5 Fr × 10 cm	Single	8.5 Fr	7560
Triple lumen	7 Fr × 30 cm	Distal	16 gauge	2300
		Medial	18 gauge	1000
		Proximal	18 gauge	1100
PICC	5 Fr × 70 cm	Single	16 gauge	1300
PICC	5 Fr × 70 cm	Distal	18 gauge	440
		Proximal	20 gauge	120

[a]Arrow International, Inc, Asheboro, NC
[b]Flow rates are by gravity at 1 m height
MAC Multi-lumen access catheter; *PICC* Peripherally inserted central catheter; *PSI* Percutaneous sheath introducer