

Jose J. Diaz · David T. Efron
Editors

Complications in Acute Care Surgery

The Management of
Difficult Clinical Scenarios

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To my wife, Dinah, and children, Gabriella, Veronica, and Alejandro, who have been my inspiration to achieve more than 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

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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 (η) 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

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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

^aJelco Protectiv Plus-W Safety IV Catheter, Smiths Medical ASD, Inc., Southington, CT

^bFlow 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

^aArrow International, Inc, Asheboro, NC

^bFlow rates are by gravity at 1 m height

MAC Multi-lumen access catheter; PICC Peripherally inserted central catheter; PSI Percutaneous sheath introducer