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## DIGITAL AND FOREARM ISCHEMIA

Digital and Forearm Ischemia in the
Newborn Infant Following Intravenous Therapy
Neonatologist from New York

Ischemia and resultant loss of digits and of the forearm may occur as a consequence of presumed intravenous therapy. This term, presumed intravenous therapy, is utilized above because the catheter or Peripheral Intravenous Central Catheter (PICC) is introduced into a peripheral artery in the upper extremity rather than a vein. Multiple case reports of this entity have been published in peer-reviewed pediatric literature; and surgical approaches to revascularization through microsurgery have been delineated in several reports.

Radial artery thrombosis occurs often following percutaneous cannulation but most of these cannulations are asymptomatic. Recannulation of the thrombosed artery takes place within 7-14 days. To ensure that there is collateral circulation to the hand, the Allen test should be performed prior to radial artery cannulation. However, in a study performed among adults undergoing elective operations requiring radial artery cannulation for intraoperative monitoring, Slogoff et al. found that the Allen test was not a predictor of ischemia of the hand during or after radial artery cannulation. Cannulation of the brachial artery may take place during an attempt at placement of a peripheral intravenous line into the antecubital vein or a PICC into the antecubital vein or a more peripheral upper extremity vein which is then advanced into the axillary or subclavian artery. Subsequent thrombosis of the brachial artery in an infant, who has had percutaneous punctures of the ipsilateral radial artery for arterial blood gases and/or other blood testing with resultant radial artery thrombosis and absent ulnar artery collateral circulation, may then occur resulting in ischemic injury with subsequent necrosis of the digits and hand. An infant who has had a PICC advanced into the more central subclavian or axillary artery may have more extensive ischemia and resultant necrosis of the forearm especially if hyperosmotic fluids (normal serum osmolarity is ~288-293 mosm/dL [deciliter]) such as dextrose solutions of >7.5 grams/dL or medications are infused via the PICC. Although an x-ray should be obtained after the placement of a PICC and is the standard of care, the subclavian artery/axillary artery runs parallel to the subclavian vein/axillary vein and, therefore, the placement of the PICC into a peripheral artery may be interpreted to be venous rather than arterial.

If the caregiver placing the catheter or PICC is appropriately observant, then he/she would and should see that the blood return into the catheter or PICC is bright red, if placed intra-arterially rather than the maroon to dark color of venous blood or, alternatively, a pulsatile flow of blood could be seen identifying the vessel to be arterial rather than venous. The caregiver could confirm and/or differentiate the blood to be arterial rather than venous by obtaining a blood gas. If the blood was arterial rather than venous, a paO2 (partial pressure of arterial oxygen) would likely be greater than 40 mm Hg and correlate with the pulse oximeter reading at the time of the blood draw. Although this is not standard practice, obtaining a blood gas would assist in identifying the catheter/PICC to be arterial vs. venous.

The placement of a blood pressure transducer in-line may also identify the catether or PICC to be arterial rather than venous. However, such a claim by the caregiver would only be credible if the catheter or PICC was of a caliber and had wall characteristics that would not dampen the pulsatile nature of arterial flow so that an arterial pressure wave form with systolic and diastolic measurements could be determined. Most to all of the PICCs utilized in newborn infants are of narrow caliber and have wall characteristics that dampen flow such that measurement of blood pressures through an in-line transducer would not be possible.

If there is a question of arterial integrity or patency, diagnosis can be undertaken utilizing the noninvasive technique of Doppler ultrasound to evaluate the qualitative and quantitative aspects of arterial flow. This technique extends the capability of the clinician beyond frequent examination

for color and temperature changes and capillary refill of the portion of the extremity or extremity under question.

Although vascular and pediatric surgeons have delineated approaches to microvascular reconstruction of upper extremity vessels, the time window for such repair is short. LaQuaglia et al. stated: "It is clear that vascular injuries in older children can be approached in a manner analogous to adults. It is well established that absence of pulses in a pale, cool, or mottled extremity requires exploration within 6 hours of injury. Restoration of pulses by primary anastomosis or bypass grafting is a routine goal. However, when the patient is a neonate with life-threatening congenital anomalies whose vascular injury was incurred secondary to resuscitative or diagnostic attempts at arterial access, the same approach to revascularization has not been supported. In particular, use of bypass grafting in neonates and very small children has not been widely reported. In these situations, apart from balloon catheter thrombectomy, a more cautious approach relying on the use of thrombolytics or anticoagulants has been associated." However, the Neonatal Health Care Team is often loathe to utilize these agents in view of the risk of Germinal Matrix Hemorrhage/Intravascular Hemorrhage and other sites of bleeding due to the use of the coagulants; and such therapy may be, therefore, contraindicated.