Annotated Bibliography
Peripherally Inserted Central Catheters

Bar-Joseph G, Galvis AG. Perforation of the Heart by Central Venous Catheters in Infants: Guidelines to Diagnosis and Management. *J Pediatr Surg*. 1983;18:284-287.

Cardiac tamponade related to an indwelling CVC was first described in 1968 and until 1983 there were an additional 40 cases of cardiac tamponade reported throughout the world. This article presents 2 case studies of perforation of the heart resulting in cardiac tamponade from an internal jugular catheter placement. Both cases were in the neonatal /infant population and resulted in death. The article gives recommendations to minimize this risk and stresses the need for practitioner education.

Comment: Even though the over all incidence of Cardiac tamponade is infrequent; **whenever a central line is in place** the practitioner **must always** have a high index of suspicion and be alert for symptoms of acute cardiac tamponade.

Blitt CD, Ed. *Monitoring in Anesthesia and Critical Care Medicine*. Central Venous Pressure Monitoring. New York, NY: Churchill Livingstone:1985:121-165.

Chapter 7 of this textbook is devoted to Central Venous Pressure (CVP) Monitoring and written by Dr. Charles W. Otto. Otto gives a review of the physiology associated with CVP and its importance in patient assessment of their hemodynamic status. He also gives the common indications for central venous cannulation and discusses techniques used to gain central access as well as the routes for catheter insertion.

Comment: Diagrams and pictures enhance descriptions of anatomy used when using anatomical landmarks for CVC insertion as well as descriptions of equipment used for device insertion. Advantages and disadvantages are discussed for each insertion technique.

Bonn J. Venous Access: Peripherally Inserted Central Catheters. 1994 Program, SCIVR 1994, 19th Annual Scientific Meeting. San Diego, CA.

At the 1994 SCIVR (today SIR) Bonn gave an interventional radiologist's perspective on their role in providing central venous access in particular PICCs and peripheral ports. He further discussed the indications, insertion techniques, catheter maintenance and complications.

Comment: None

Brandt RL, Foley WJ, Fink GH, Regan WJ. Mechanism of Perforation of the Heart with Production of Hydropericardium by a Venous Catheter and Its Prevention. *Am J Surg*. 1970;119:311-316.

This historical article presents three case studies of hydropericardium and cardiac tamponade. The authors illustrate the mechanism of cardiac perforation associated with a central venous catheter and give suggestions to decrease the risk of perforation.

Comment: The catheters discussed were made from polyethylene catheters.
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Collier PE, Ryan JJ, Diamond DL. Cardiac Tamponade from Central Venous Catheters - Report of a Case and Review of the English Literature. *Angiology*. September 1984;35:595-600.

Eleven cases of cardiac tamponade were reviewed by house officers, attending physicians and attending radiology staff. The physicians were then queried as to the complication of cardiac tamponade. It was found that there was a lack of awareness of the risk of cardiac tamponade after CVC placement as compared to the insertions complications of pneumothorax and arterial puncture.

Comment: Two tables summarize patient cardiac tamponade data and survey results of physicians and their awareness of cardiac tamponade as a complication as well as correct catheter tip placement.

Conn C. The Importance of Syringe Size When Using Implanted Vascular Access Devices. *J Vasc Access Nurs*. Winter 1993;3:11-18.

Conn reviews the practices of 136 nurses and syringe sizes used for accessing IVAD (Implanted Vascular Access Devices). The survey showed that the selection of syringe size was primarily based on policies and procedures (54%) or personal preferences (56%) and not on manufacturer's recommendations. The majority of nurses knew (51%) that smaller syringes generated higher psi, but 76% did not know the maximum rating for the IVAD and 82% used a smaller size syringe than what was recommended.

Comment: Gives syringe size recommendations associated with specific IVADs and the amount of pressure needed to activate a syringe plunger.

Crnich CJ, Halfmann JA, Crone WC, Maki DG. The Effects of Prolonged Ethanol Exposure on the Mechanical Properties of Polyurethane and Silicone Catheters Used for Intravascular Access. Infection Control Hosp Epidemiol 2005 Aug;26(8):708-14.

The authors research indicated that exposure to a 70% ethanol lock solution does not appreciably alter the integrity of selected commercial polyurethane and silicone catheters. They further stated that given the greatly expanded use of alcoholic solutions with intravascular devices of all types, they believe that manufacturers would be well advised to subject their catheters and other intravascular devices to formal testing of the type employed in this study.

Comment: Practitioners should check with individual manufacturers for their specific recommendations before using alcohol.

Curelaru J, Linder LE, Gustavsson B. Displacement of Catheters Inserted through Internal Jugular Veins with Neck Flexion and Extension. *Intens Care Med*. 1980;6:179-183.

This study compared the displacement of catheters inserted through the internal jugular vein with neck flexion and extension. The data were gathered through estimated measures by x-ray exam. The sample size was 12 adults (6 patients and 6 corpses; equally divided between men and women of normal habitus). Results showed that downward displacement of the catheter with maximum flexion varied 1.0 to 2.0 cm in patients and 1.0 to 2.5 cm in corpses; upward displacement with maximum extension was between 1.5 and 3.0 in patients and 1.5 to 4.0 in corpses. There was no apparent correlation between side and site of the vein puncture, anthropometric measurements and the values of the displacement of the catheters.

Comment: A larger sample size would be valuable to validate these observations. The researchers did not take into account lateral and rotary movements of the neck. The authors were concerned about the rigidity of the catheter material. This research was conducted in the late 70's and published in 1980. During that time period Teflon and polyethylene catheters were still in use. Today most CVCs are made from silastic and

polyurethane. Contains 2 tables which summarize the data and gives details of anthropometric data and individual catheter displacement.

Danek GD, Noris EM. Pediatric IV Catheters: Efficacy of Saline Flush. *Pediatric Nursing*. 1992;18:111-113.

Prospective, randomized, blinded study tested the efficacy of NSS as flush solution to maintain catheter patency in 22 and 24 gauge intermittent access catheters. Patient population was age 0 to 18 years. Even though all catheter sizes were used, only data analysis was completed for the 22 and 24 gauge catheters. This metric was determined to be part of the study design. Results showed that normal saline was less effective than dilute heparin solution in 24 gauge catheters in maintaining catheter function (n=120).

Comment: Statistics used: Univariate analysis of 22 and 24 gauge catheter longevity (in hours) with both NSS and dilute heparin was calculated; Log rank and Wilcoxon (nonparametric) and survival curves using Daplan-Meier estimates. A p value of .05 or less was accepted.

Frey MA. Pediatric Peripherally Inserted Central Catheter Program Report - a Summary of 4,536 Catheter Days. *JIN*.1995;18:280-291.

Observational study conducted on all PICCs inserted in an urban pediatric teaching hospital larger than 100 beds over a 3 year period. 269 PICCs were inserted into 226 patients; 330 were referred. The researcher concluded that PICCs are an efficacious and safe method of IV access in children for intermediate and long term use.

Comment: All PICC insertions were done by one PICC nurse. Products used were Per-QCath by Gesco and the V-cath by HDC. Tables summarized catheters used by manufacturer; program growth and referrals; breakdown of referrals by physician services; complications; and comparison of Saint Christopher's Hospital for Children (Philadelphia PA) program to 8 other comparable PICC programs

Guideline for Hand Hygiene in Health-Care Settings 2002

The hand hygiene guidelines were developed by the CDC's Healthcare Infection Control Practices Advisory Committee (HICPAC), in collaboration with the Society for Healthcare Epidemiology of America (SHEA), the Association of Professionals in Infection Control and Epidemiology (APIC), and the Infectious Disease Society of America (IDSA). The hand hygiene guidelines are part of an overall CDC strategy to reduce infections in health care settings to promote patient safety.

Comment: http://www.cdc.gov/handhygiene/ Website contains free download of the Hand Hygiene Guidelines and a link to the Hand Hygiene Resource Center which contains educational resources.

Also published as: Guideline for Hand Hygiene in Health-Care Settings: recommendations of the Healthcare Infection Control Practices Advisory Committee and the HICPAC/SHEA/APIC/IDSA Hand Hygiene Task Force. Infect Control Hosp Epidemiol. 2002 Dec;23(12 Suppl):S3-40.

Iberti TJ, Katz LB, Reiner MA, Brownie T, Kwun KB. Hydrothorax as a Late Complication of Central Venous Indwelling Catheters. *Surgery*. November 1983:842-846.

The authors describe 2 cases of hydrothorax following central venous catheterization. Both patients had left sided IJ catheters placed with catheter tip placement juxtaposed against the SVC wall. The catheters functioned well for several days before delayed vessel wall

perforation. The conclusions are that left neck CVC insertions should be avoided if possible, CVCs should be routinely checked and the catheter tip should lie parallel to the vessel wall.

Comments: Historical article, but information about catheter tip placement still valid today. CVCs used in these 2 case studies were Arrow 16 gauge single lumen 8 inch PU catheters.

Intravenous Nurses Society (INS). Midline and Midclavicular Catheters. *JIN*. July/August 1997;20:175-178.

The article is a 1997 position paper developed by INS to address the controversies and inconsistent practices involving non central catheters. It defines midline and midclavicular and gives the appropriate catheter tip location for each catheter. It also discusses the necessary professional qualifications needed to insert them as well as patient assessment and indications for use.

Comment: Intravenous Nurses Society (INS) is now Infusion Nurses Society. INS does not reference this position paper on their current website (2007) and 2006 Infusion Nursing Standards of practice does not mention a midclavicular catheter, but discusses Midline catheters in detail.

James L, Bledsoe L, Hadaway LC. A Retrospective Look at Tip Location and Complications of Peripherally Inserted Central Catheter Lines. *JIN*. 1993;16:104-109.

A retrospective study assessing the frequency of correct tip location on initial placement; the success of repositioning by recommended methods; the frequency of complications during indwelling and the successful management of complications. The data reviewed was for a 5 year period.

Comment: None

Jobes DR, Schwartz AJ, Greenhow DE, Stephenson LW, Ellison N. Safer Jugular Vein Cannulation: Recognition of Arterial Punctures and Preferential Use of the External Jugular Route. *Anesthesiology*. 1983;59:353-355.

Jobes and colleagues did both a retrospective and prospective study to determine the frequency and severity of arterial puncture when cannulating the jugular vein. Both study groups used a modified Seldinger technique but in the prospective group a modification in technique was made and choice of access site was based on the results that were found in the retrospective analysis. The changes were as follows; a short 20 GA catheter was always attached to a pressure transducer prior to insertion of the guidewire and CVP waveform was monitored when using the RIJ (right internal jugular) and the right EJ (external jugular) was the preferred access site since the right side was a shorter more direct route.

Comment: The authors give rationale for use of the external jugular versus internal jugular vein and how to help avoid the complication of arterial puncture and inadvertent arterial cannulation. This article gives a historical perspective as to why direct visualization such as US (ultrasound) may assist practitioners to decrease the potential complication(s) of jugular cannulation.

LaFortune S. The Use of Confirming X-rays to Verify Tip Position for Peripherally Inserted Catheters. JIN.1993;16:246-250.

The author relates the tip placement experiences of 42 PICC catheters placed over a 14

month period. All of the catheters had confirming x-rays performed. It was found that 26% of the catheters were malpositioned. Two summarize the radiographic reports of the malpositioned catheters and compares catheter tip position with route of insertion.

Comment: None

Loughran SC, Edwards S, McClure S. Peripherally Inserted Central Catheters - Guidewire Versus Non-guidewire Use: A Comparative Study. *JIN*. 1992;15;152-159.

Comparative study conducted at two acute care facilities, one facility used guidewires (stylet) the other did not. A total of 109 catheters were studied. The results showed no increase in complications with the use of guidewires (stylet).

Comment: Historical article regarding the use of guidewires (stylet) in PICC placement and their impact on potential complications. The authors also recommend that the guidewire (stylet) remains well within the lumen of the PICC during catheter insertion. Both types of products are still available in the market place.

Macklin D. What's Physics Got to Do with It? JVAD. Summer 1999:7-10.

This article reviews the physical principles of fluid administration. Macklin explains the relationship between resistance and pressure and how they impact flow through a catheter or through a patient's vein. Two tables are presented; one identifying the amount of pressure generated using various size syringes with different pressures applied to the plunger and the other describing the amount of force to withdraw a liquid without creating a vacuum.

Comment: The explanations are direct and easily understood. Formulas and diagrams assist in the explanations.

Marx M. The Management of the Difficult Peripherally Inserted Central Venous Catheter Line Removal. *JIN*.1995;18:246-249.

Marx identifies venospasm as the most common cause of difficult PICC removal. Literature reports approximately 7 to 12 % of PICCs encounter difficulty upon removal; Marx's experience was 5%.

He identifies the venotomy site at the skin level as the point of most catheter resistance. He further states that most problems arise in the medium size vessels and is related to the health of the vessel at time of catheter removal, eg both phlebitis and thrombophlebitis can be associated with venous spasm. In Marx's experience mechanical irritation appears to be the most common cause of venous spasm.

Comment: Reviews vein anatomy and physiology in relationship to venous spasm. He does not recommend aggressive pulling on the catheter but rather gives a variety of strategies to relieve venospasm.

Maschke SP, Rogove HJ. Cardiac Tamponade Associated with a Multilumen Central Venous Catheter. *Crit Care Med*. 1984;12:611-612.

Case report on 2 incidents of cardiac tamponade associated with multilumen central venous catheters. Both of these cases represented a delayed occurrence of 24 and 36 hours. Many times delay in occurrence is associated with lack of recognition of the problem. The authors also discuss the impact that the insertion site has on the location of the catheter's tip e.g. abduction of the arm can move the catheter proximal up to 10 cm.

Comment: A high index of suspicion is necessary for early recognition and intervention of cardiac tamponade. Catheters used in both patients were made from polyurethane material.

National Association of Vascular Access Networks. Tip Location: NAVAN Position Statement. J.Vas. Access Devices. 1998;3:8-10.

The 1998 position statement recommended that "the most appropriate location for the tip of peripherally inserted central catheters (PICCs) is the lower one-third of the SVC (superior vena cava), close to the junction of the SVC and the right atrium. This tip location allows the catheter to float freely within the vein lumen and lie parallel to the vessel wall, resulting in a considerable reduction in such complications as thrombosis and infection. The catheter tip should not extend into the right atrium, as cardiac complications may develop with such a placement. Insertion sites in the lower extremity of pediatric and neonatal patients should result in a tip location in the inferior vena cava above the level of the hemidiaphragm."

Comment: NAVAN (National Association of Vascular Access Networks) is now AVA (Association for Vascular Access). The position statement is located on the AVA website and is free to download.

http://www.avainfo.org/website/article.asp?id=1441

Occupational Exposure to Bloodborne Pathogens; Needlestick and Other Sharps Injuries. 66 Federal Register 5317 (2001)(Codified at 29 CFR~1910.1030).

This is the final ruling to the revision of the 1991 Blood Borne Pathogens standards which includes the Needlestick Safety and Prevention Act.

Comment: The document can be retrieved in its entirety from http://www.gpoaccess.gov/fr/retrieve.html; choose Federal Register # 66 and type in page 5318 which will take you to the first page of the document.

Ryder MA. Peripherally Inserted Central Venous Catheters. *Nursing Clinics of North America*. 1993;28:937-971.

Ryder did an extensive review of peripherally inserted central venous catheters (PICCs) literature; the associated anatomy; indications for use; catheter design and the potential complications associated with their use. She also looked at a model for PICC program quality improvement.

Comment: The article contains a Vascular Access Device Selection table that assists the clinician in choosing the right device for the right patient; the right setting and for the right infusion therapy and the specific duration.

Sansuvero GE. Venous Anatomy and Physiology. *J of Intravenous Nursing*. September/ October 1998:21(55);S107-S114.

The author reviews the anatomy and physiology associated with central venous access by way of the peripheral veins of the upper extremities. She identifies patient assessment parameters to be considered in choosing the device and which vein(s) to be utilized.

Comment: The article contains a number of tables; one summarizes co-morbid conditions that may impede conventional vascular access placement and another gives anthropometric measurements for the upper extremity veins.

Sheep RE, Guiney WB Jr. Fatal Cardiac Tamponade. *JAMA*. October 1, 1982;248:1632-1635.

Three case reports associated with left sided IJ placement which resulted in one fatality from cardiac tamponade and 2 nonfatal complications of hydromediastinum and hyrdrothorax. Exact site of perforation was not known. Authors state that catheter tip location should be outside the right atrium and lie in the SVC above the pericardial reflection.

Comment: Catheters were made from "Teflon' material.

Sigurdsson J, Riba P, Sigurdsson S. The Wandering Central Venous Catheter. *Intensive Care Med*. 1985;11:263-264.

Case report which describes a right subclavian CVC that over three weeks of indwelling time moved from the upper SVC to the left IJ and returned to the SVC only to return to the IJ causing thrombosis of the IJ. The authors identify thrombosis as the most serious noninfectious late complication of central venous catheterization.

Comment: Catheter was made from silicone.

Tocino IM, Watanabe A. Impending Catheter Perforation of Superior Vena Cava: Radiographic Recognition. *Am J Roentgenology*. March 1986;146:487-490.

The authors describe an observational study which occurred over a 19 month period in intensive care units and one shock-trauma unit. Nine cases of SVC perforation were observed 4 hrs to 9 days post insertion. Catheter tip post placement was assessed by chest x-ray. X-ray revealed 6 cases of catheters with a gentle curve at the tip; multiple x-ray views were required for this assessment. The authors concluded that a curve of the catheter tip should prompt catheter position reassessment.

Comment: Catheters were made from silastic (5) and polyurethane (4). These authors give a suggestion for preferred catheter tip position.

Tomkins DP, Van Der Walt JH. Needleless and Sharp-Free Anaesthesia. *Anaesthesia and Intensive Care*. 1996;24:164-7.

The authors discuss the risks of sharps injuries as an occupational hazard within the anesthesia profession. They describe 6 specific situations which place them at risk and encourage their colleagues to adopt universal precautions and safe practices.

Comment: The authors are Australian.

Vesley TM. Air Embolism during Insertion of Central Venous Catheters. J Vasc Interv Radiol 2001; 12:1291-1295.

True incidence of air embolism (AE) during central venous access in unknown and is underestimated. Vesley did a retrospective review of 11,583 central venous catheters that were inserted during an approximate 5 1/2 year time frame. Both tunneled and nontunneled catheters were included. 15 cases of AE were reported. Medical record review showed that 4 patients were asymptomatic; 6 had mild symptoms and 4 had moderate symptoms. Fourteen patients recovered after intervention and without incidence; 1 fatality occurred after a full code protocol was implemented. All AE occurred during the catheter insertion through the peel-a-way sheath.

Comment: Catheter types represented were ports, implanted hemodialysis and one pheres-flow. In the discussion section the author reviews the physiology associated with the venous system exposed to atmospheric air during CVC insertion and the symptoms associated with AE and intervention.

Wall JL, Kierstead VL. Peripherally Inserted Central Catheters Resistance to Removal: A Rare Complication. *JIN*.1995;18:251-254.

Wall identifies that the majority of PICC removal resistance is attributed to venospasm. He further makes recommendations for removal of PICCs that are stuck or resistant upon routine removal. The removal procedure includes the application of slight tension and retaping with the application of warm moist compresses to dilate and relax the vein before attempting further removal; a repeat of warmth and compresses; upon catheter removal catheter measurement and if continued difficulty notify the physician.

Comments: 2006 INS Standards recommend that if resistance is encountered upon PICC removal, the catheter should not be forcibly removed but that the physician should be notified.

Black IH, Blosser SA, Murray WB. Central venous pressure measurements: peripherally insereted catheters versus centrally inserted catheters. Critical Care Medicine 200 Dec; 28(12): 3833-6.

They concluded that the PICCs can be used to measure central venous pressure and to follow trends in a clinical setting. Pressure infusion devices need to be used to overcome the natural resistance of the PICC. Central venous pressure recorded via PICCs is slightly higher than that of a CICC but the difference is clinically insignificant.

The authors conducted a bench evaluation and a prospective, non-blinded clinical comparison to determine whether central venous pressure measurements taken from a peripherally inserted central catheter (PICC) correlate with those from a centrally inserted central catheter (CICC).

Comment: During the bench part of the evaluation, a simple manometer system was set up to test the catheters. During the clinical study, measurements of central venous pressure were recorded from patients who had an indwelling CICC and PICC concomitantly. Positions of the catheter tips in the chest were verified by radiography.