12. ANESTHESIA IN THE CATHETERIZATION LABORATORY

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INTRODUCTION

Adequate sedation and anesthesia during cardiac catheterization are essential to facilitate acquisition of meaningful hemodynamic data and to assist during interventional procedures. For the most part, hemodynamic or diagnostic catheterization procedures can be performed under sedation in all age groups. While in many interventional procedures such sedation may be appropriate, in ill patients or those procedures that are lengthy or potentially associated with significant hemodynamic compromise, or are prolonged, general anesthesia is preferable.

Whatever technique is used, it is essential that hemodynamic data be attained in conditions as close to normal as possible. When using sedation, careful monitoring is essential to ensure that respiratory depression is avoided. During anesthesia, the effects of inspired oxygen concentration, mechanical ventilation and hemodynamic side effects of various anesthesia agents must be considered.

Post procedure monitoring either in a recovery room or intensive care unit is mandatory.

NORMAL CARDIO-RESPIRATORY PHYSIOLOGY IN NEONATES AND INFANTS

Neonates have a limited respiratory reserve and are prone to ventilatory failure and hypoxemia. The mechanical disadvantage of increased chest wall compliance results in a reduction in functional residual capacity (FRC) and an increase in closing capacity, such that airway closure may occur during normal tidal ventilation. The reliance on the diaphragm as the main muscle of respiration means that distention of the stomach or positioning on the catheterization table could limit diaphragm excursion and significantly reduce lung volumes, leading to impaired ventilation. The metabolic rate of neonates and infants is increased, and oxygen consumption approaches 2-to-3 times the adult level. This increase in consumption in the face of diminished oxygen reserve from a reduction in FRC, means that airway obstruction or respiratory depression will result in rapid arterial oxygen desaturation.

The immature myocardium of a neonate has a diminished contractile mass, a lower velocity of shortening, a diminished length-tension relationship, and a reduced ability to respond to afterload stress. The stroke volume is relatively fixed and an increase in cardiac output is therefore primarily heart rate dependent.

Further, the cytoplasmic reticulum and T-tubular system are underdeveloped, and the neonatal heart is dependent on trans-sarcolemmal flux of extracellular calcium to initiate and sustain contraction.

The large surface area to body mass ratio of infants and neonates predisposes them to hypothermia, which may increase metabolic rate and delay recovery from
sedation and anesthesia. Hypothermia is a particular concern in the catheterization laboratory because of radiant and convective heat loss; prolonged exposure of the patient after sedation or general anesthesia and during preparation for catheterization may result in significant heat loss. In addition, the use of cold flush solutions and damp towels in contact with the patient will also contribute to hypothermia.

**CATHETERIZATION LABORATORY ENVIRONMENT**

Cardiac catheterization laboratories are often remote from the operating room, and rarely configured to accommodate anesthetic personnel. Relative to patient size, the lateral and anterior-posterior cameras used for imaging are in close proximity to the patient’s head and neck, limiting access to the airway. An anesthetic machine and monitor around the patient will further limit access and confine the space in which the anesthesiologist may work. In addition, the environment is darkened to facilitate viewing of images. Monitoring with capnography and pulse oximetry is mandatory.²

Care must also be taken when positioning a patient on the catheterization table to reduce pressure and nerve traction injury. In particular, brachial plexus injury may occur when patients’ arms are positioned above their heads for a prolonged time to make room for the lateral camera. To facilitate femoral vein and arterial access, the pelvis is commonly elevated from the catheterization table. This may displace abdominal contents cephalad, restricting diaphragm excursion, and increasing the risk for respiratory depression in a sedated patient. For these reasons, and also because of the effects on cardiac structure displacement for imaging purposes, it is important to remove most elevating towels when lines have been placed.

The majority of diagnostic, non-interventional hemodynamic catheterization studies can be performed with the patient sedated, breathing room air or supplemental oxygen. This permits measurement of meaningful hemodynamic data and accurate calculations of cardiac output, shunt fraction, and vascular resistances. To limit the amount of sedation, sufficient local anesthetic at vascular access sites is crucial.

Many interventional procedures that cause limited hemodynamic stress can be performed using sedation alone, including patent ductus arteriosus closure, coil embolization of collaterals, and balloon dilation of pulmonary valve stenosis. However, each patient needs to be carefully evaluated; high risk patients must be identified prior to catheterization.

Appropriate sedation protocols will enable the majority of hemodynamic and some interventional catheterization procedures to be managed by nurses trained in pediatric sedation and the cardiac catheterization environment. Anesthesia staff must nonetheless be readily available to manage respiratory depression and airway obstruction, or provide additional control if the limits of the sedation protocol