RECENT INTERVENTIONAL CATHETER THERAPY IN PEDIATRIC CARDIOLOGY

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ESSAY

BY

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Dina Awad Ragab

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AF	Atrial fibrillation
AP	Accessory pathway
ASD	Atrial septal defect
AV	Atrio ventricular
AVNRT	Atrioventricular nodal re-entrant tachycardia
CNS	Central nervous system
CUSPH	Cairo University Specialized Pediatric Hospital
EAT	Ectopic atrial tachycardia
EMLA	Eutectic mixture of lidocaine and prilocaine
EP	Electrophysiologic
F	French
FDA	Food and drug administration in United states
HLHS	Hypoplastic left heart syndrome
IVC	Inferior vena cava
LBBB	Left bundle branch block
LV	Left ventricle
MVSDs	Muscular ventricular septal defects
NIH	National institutes of health
PAPCA	Prospective assessment after pediatric cardiac Ablation
PAS	Pulmonary artery stenosis
PDA	Patent ductus arteriosus
PFM	Pulsed field magnetization
PFO	Patent foramen ovale
PL	Posterior limb
RBBB	Right bundle branch block
RF	Radiofrequency
RV	Right ventricle
SVC	Superior vena cava
TEE	Transesophageal echocardiography
TGA	Transposition of great arteries
UGCR	Ultrasound guided compression repair
US	Ultrasound
USCI	United states catheter and Instrument cooperation
VSD	Ventricular septal defect
VT	Ventricular tachycardia

REVIEW OF LITERATURE

PEDIATRIC CARDIAC CATHETERIZATION

HISTORICAL REVIEW

According to **Andre Cournand, (1975)** cardiac catheterization was first performed (and so named) in 1844 by Claude Bernard, who catheterized both the right and left ventricles of a horse by means of a retrograde approach from the jugular vein and carotid artery. This followed an era of cardiovascular investigations in animals that resulted in the development of many important techniques and principles-including pressure manometry and the application of the Fick's principle for measuring cardiac output method- subsequently applied to the study of patients with heart disease.

In 1905 Fritz Bleichroeder had a ureteral catheter placed in his axillary vein from the arm and his inferior vena cava from the thigh **(Franch, 1978).**

Although others had previously passed catheters into the great veins, **Werner Forssmann (1929)** is generally credited as the first person to pass a catheter into the heart of a living person-himself. At age 25, he passed a catheter 65 cm through one of his left antecubital veins, guiding it by fluoroscopy (he looked through a mirror held by his nurse in front of the fluoroscope screen) until it entered his right atrium. He then walked to the Radiology Department, Where the catheter position was documented by a chest X-ray. During the next two years, Forssmann continued to perform catheterization studies, including six additional attempts to catheterize himself **(Barry and Grossmann, 1984).**

It is of interest that Forssmann's primary goal in his catheterization studies was to develop a therapeutic technique for the direct delivery of drugs into the heart **(Grossmann, 1986).**

The potential of Forssman's technique was appreciated by other investigators, and in 1930; Klein reported catheterization of the right ventricle in 11 patients and measurement of cardiac output. Except for these studies, application of cardiac catheterization to evaluate the circulation in normal and disease states was limited and fragmentary until the work of **Corunna and Richards (1941),** which began a remarkable series of investigations of right-heart physiology in humans.

Further developments come rapidly. Some of the highlights include the following: Zimmerman and Limon Lason and their respective coworkers first introduced retrograde left heart catheterization in 1950. The percutaneous technique developed by **Seldinger in 1953** was soon applied to cardiac Catheterization of both the left and right heart chambers. Transseptal left heart catheterization was developed and applied clinically by Ross, Braunwald and Morrow and it quickly became accepted as a standard technique. Selective coronary arteriography was developed by **Sones in 1959** and was perfected in the ensuing years.

In 1970 a practical balloon-tipped flow-guided catheter technique was introduced by Swan and Ganz, making possible the applicability of catheterization Outside the Catheterization laboratory **(Barry and Grossman, 1984).**

In the more recent past, investigators have focused once again on the therapeutic potential of the cardiac catheter. In **1977, Gruntzig** introduced the technique of coronary angioplasty. In the ensueing years, the method was widely applied and with rapidly evolving technology

appears to be developing a firm position rivaling coronary bypass surgery as a therapeutic modality for coronary artery disease **(Grossman, 1986).**

Angiocardiography is the most comprehensive method for studying the intracardiac anatomy. The anatomical and hemodynamic information derived from angiocardiograms is often essential for establishing a correct diagnosis and planning a logical therapeutic approach.

Angiocardiography is an invasive procedure in that it is usually carried out in conjunction with cardiac catheterization (Digital radiographic examinations can be carried out with intravenous injection of contrast medium) **(Baron, 1989).**

Balloon occluding angiography has been introduced for improving anatomic details. This technique is especially useful in lesions involving the aortic arch, such as coarctation or interruption, and also in babies with tetralogy of Fallot and pulmonary atresia **(Keane and Freed, 1986).**

APPLICATION OF CARDIAC CATHETERIZATION

INDICATIONS

Diagnostic indications

Cardiac catheterization may be defined as a combined hemodynamic and angiographic procedure undertaken for diagnostic purposes.

As with any diagnostic procedure, the decision to perform cardiac catheterization must be based upon a careful balance of the risk of the procedure against the anticipated value of the information. Cardiac catheterization is generally recommended when there is a need to confirm the presence of a clinically suspected condition, define its anatomic and physiologic severity and determine the presence or absence of associated conditions. This need most commonly arises when the clinical assessment suggests that the patient is approaching the stage of rapid deterioration, incapacitation and death. Cardiac catheterization may yield information that will be crucial in defining the need for cardiac surgery as well as its tuning, risks, and anticipated benefit in a given patient **(Barry and Grossman, 1984).**

Although few would disagree that consideration of heart surgery is an adequate reason for the performance of catheterization, there are differences of opinion about whether all patients being considered for heart surgery should undergo preoperative cardiac catheterization. The operating room is not a good place for surprises: cardiac catheterization can provide the surgical team with a precise and complete road map of the course ahead, and thereby permit a carefully reasoned and maximally efficient operative procedure. Furthermore, information obtained by cardiac catheterization may be invaluable in the assessment of crucial

determinants of prognosis such as left ventricular function and the patency of the coronary arteries.

Improved non-invasive diagnostic techniques -three dimension echocardiography, Doppler, multislide C.T - have narrowed the indications for diagnostic cardiac catheterization **(Ketner et al., 2005).**

Therapeutic indications

Pediatric interventional cardiology was born 40 years ago in **1966**, when **William Rashkind** developed balloon septostomy in neonates with transposition of the great arteries.

However, in the last two decades, development of devices to close septal defects and extra cardiac shunts, as well as techniques to open up stenosed valves and vessels, has revolutionized therapy for congenital heart disease. Transcatheter therapy has replaced open heart surgery for simple intra- and extra- cardiac lesions, but surgery still remains a necessity for many complex lesions **(Ketner et al., 2005).**

Recent advances in interventional pediatric cardiac catheterization can be broadly subdivided into:

- Device closures for septal defects and other vascular structures;
- Balloon dilatation of valves, vessels and stenting of narrowed vessels, baffles, and conduits;
- Percutaneous transcatheter valve implantation; and
- Hybrid techniques involving transcatheter as well as surgical interventions **(Ketner et al., 2005).**

CONTRAINDICATIONS

If it is important to carefully consider the indication for cardiac catheterization in each patient, it is equally important to determine whether there are any contraindications.

Relative contraindications

Ventricular irritability; can increase the risk and difficulty of left heart catheterization, hypertension; increases predisposition to ischemia and should be controlled prior and during catheterization, intercurrent febrile illness, decompensate left sided heart failure, correctable anemia, digitalis toxicity, hypokalemia, allergy to radiographic contrast agent, severe renal insufficiency and/or anuria, infective endocarditis and anticoagulant therapy.

Anticoagulant therapy is a more controversial contraindication, some experienced physicians in this field have cautioned against catheterization in patients receiving anticoagulants, particularly when the percutaneous approach is used **(O'Brien et al., 1970)** whereas others suggest that anticoagulation in such patients may be safe or even desirable **(Walker et al., 1973).**The prothrombin time must be maintained less than 18 seconds and heparin administration must be avoided for 4 to 6 hours prior to the procedure **(Segel and Francis, 2000).**

Absolute contraindications

As there is no absolute contraindication to cardiac catheterization, increased risk is expected in the severely cyanotic infant, in the infant with markedly elevated pulmonary venous pressure, and in those with severe semilunar valve stenosis **(Vitiello et al., 1998).**

CATHETERS SELECTION

Right heart catheters

A variety of catheters are available for right heart catheterization. The most commonly used catheter for entry into the right heart chambers is a balloon flotation (Swan-Ganz) catheter **(Peterson, 1997).** This catheter can be used equally for right heart catheterization when using the femoral, brachial, internal jugular, or subclavian vein approach. A variety of features have been added to the basic balloon flotation catheter since its introduction, including a thermistor to measure cardiac output by the thermodilution method, additional infusion ports, and pacing electrodes.

The advantages of a balloon-tipped catheter include ease of passage through right heart chambers of normal dimensions and it's relatively atraumatic nature. This is particularly important when undertaking cardiac catheterization in a patient with complete left bundle branch block (LBBB) **(Peterson, 1997).**

In this instance, if one uses a stiff catheter and it impinges on the septum, it is possible to induce complete right bundle branch block (RBBB).

The combination of RBBB and LBBB, of course, results in complete heart block and may require emergent pacing. This risk is minimized (but not eliminated) with the use of balloon-tipped catheters **(Peterson, 1997).**.

The second most commonly used right heart catheter is the woven Dacron end-hole Cournand catheter (United States Catheter and Instrument Corporation {USCI}, Billerica, MA). This catheter is stiffer than the balloon floatation catheter. It must be actively manipulated

through the right cardiac chambers under fluoroscopic visualization and usually provide good fidelity pulmonary artery wedge pressure recordings. It is used commonly from both femoral and brachial venous approaches **(Peterson, 1997).**

Pulmonary and right ventricular angiography is usually performed via a standard closed end, multiple side-hole NIH catheters (USCI). Other catheters that can be used to good advantage include a specially modified standard pigtail catheter with a larger curve (USCI), the Berman angiographic balloon catheter or the Grollman pulmonary angiography catheter, which is a pigtail catheter with a reverse curve at its end to allow rapid insertion in the pulmonary artery **(Furdon et al., 2006).**

Left Heart Catheters

The most common catheter used for retrograde left heart catheterization via the femoral artery is the pigtail catheter in either the standard or angled configuration (USCI). This is an excellent catheter that usually traverses normal and mildly stenotic aortic valves easily, gives good fidelity pressure recordings, and can be used for left ventriclography and aortography as well. Other catheters used via the transfemoral approach include the Gensini end-hole and side-hole catheter and multipurpose coronary arteriography catheter**.** The first choice for retrograde left heart catheterization is always the pigtail catheter, and resort to other catheters only when dealing with severe aortic stenosis that requires special catheter configurations to cross aortic valve **(Furdon et al., 2006).**