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Cardiac Catheterization Risks and Complications

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Continuing Education Activity

Cardiac catheterization is one of the most widely performed cardiac procedures. In the United States, more than 1,000,000 cardiac catheterization procedures are performed annually. As expected, in any invasive procedure, there are some patient related and procedure-related complications. This activity reviews the indications, contraindications and technique of cardiac catheterization and highlights the role of the interprofessional team in the management of patients with CAD.

Objectives:

- Identify the technique of cardiac catheterization.
- Describe the indications for cardiac catheterization.
- Review the complications of cardiac catheterization.
- Outline the importance of improving care coordination among the interprofessional team to enhance the delivery of care for patients undergoing cardiac catheterization.

Earn continuing education credits (CME/CE) on this topic.

Introduction

Cardiac catheterization is one of the most widely performed cardiac procedures. In the United States, more than 1,000,000 cardiac catheterization procedures are performed annually.[1] As expected, in any invasive procedure, there are some patient related and procedure-related complications. With significant advances in the equipment used for cardiac catheterization, the improved skill of the operators, and newer techniques, the rates of these complications have been reduced significantly. The term cardiac catheterization can be used to refer to either right heart catheterization or left heart catheterization or both. The procedure can be either diagnostic or therapeutic, and interventional cardiologists can perform a variety of interventions depending on the clinical need. This review provides a brief review of the expected risks and complications for a routine, diagnostic, cardiac catheterization procedure.

Indications

Cardiac catheterization can be either a diagnostic or a therapeutic procedure. The procedure is done in the evaluation and the treatment of the following conditions.

- Coronary artery disease
- Measuring the hemodynamics in the right and left side of the heart
- Evaluate the left ventricular function

- Evaluation and treatment of cardiac arrhythmias
- Evaluation and treatment of valvular heart disease
- Assessment pericardial and myocardial diseases
- Assessment of the congenital heart diseases
- Evaluation of heart failure

Contraindications

There are no absolute definitive contraindications for the cardiac catheterization procedures. Most of the contraindications are relative depending on the indication for the procedure and the associated comorbidities of the patient. When the risk of complications is expected to be more than what is considered acceptable for the procedure, alternative modes of imaging and assessment can be used to answer the clinical question. Experienced operators will modify the technique of the procedure in a way as to get the best possible outcomes for the patient with the least amount of risk. Before planning for this procedure, the clinician should have a clear understanding of the clinical question that needs to be answered.

Personnel

Cardiac catheterization procedure is usually performed in a cardiac catheterization laboratory with the help of fluoroscopy to guide and position the catheters in the appropriate position. Along with the experienced operator, support from registered nurses and radiologic technologists is needed for safely performing the procedure. Most of the procedures can be performed with minimal or moderate sedation with the help of a local anesthetic, but some procedures will require anesthesia services for providing deep sedation or general anesthesia. Some of these procedures can be performed at the bedside in a coronary care unit, and the common ones performed bedside include right heart catheterization and temporary pacer wire insertion.

Preparation

Preparation for the cardiac catheterization procedure starts with a thorough history of the patient along with a detailed examination. After defining the clinical question, the performing interventional cardiologist will decide on the access for the procedure. These procedures may need either arterial or venous access or both. Physical examination should specifically focus on assessing the suitability of the patient for the planned procedure. Special attention has to be paid in reviewing drug allergies of the patient and routine lab work. Basic workup includes a complete blood count (CBC), basic metabolic panel (BMP), prothrombin time, electrocardiogram and chest x-ray. Patients with documented allergy to radio-iodinated contrast material will need premedication with corticosteroids and antihistamines. Patients with chronic kidney disease will also need adequate planning and pre-hydration to reduce the risk of worsening of the renal function.

Technique

For cardiac catheterization procedures that require arterial access, the 2 common sites used include common femoral artery and radial artery.

The target for femoral puncture is the midpoint of the common femoral artery between the origin of the inferior epigastric artery, and the bifurcation of the superficial and profunda branches and this is usually at the center of the femoral head. The femoral artery crosses the inguinal ligament

at its midpoint, and an imaginary line joining the bony landmarks of the iliac crest and pubic symphysis defines the path of the inguinal ligament. Placing a metal clip at the proposed puncture site and performing a quick fluoro exam to confirm the relationship to the femoral head can improve the accuracy of the puncture site. Some centers routinely acquire femoral access under ultrasound guidance.[2] This has shown to decrease the risk of complications by 49% in one published series. It is essential to access the femoral artery at the appropriate site as adequate hemostasis can be achieved by applying the manual compression over the artery against the femoral head. Higher puncture sites will increase the risk of retroperitoneal bleed, and lower puncture sites will increase the risk of pseudoaneurysm formation.

Optimizing vascular access using fluoroscopy or ultrasound to visualize the anatomical landmarks and accessing the artery using lower profile catheters including micropuncture sheaths can minimize the risk of access site complications.

In the hand, the common site of access is the radial artery, even though the ulnar artery and brachial artery are also used in some situations.[3] The ideal place to access to the radial artery is 2-cm proximal to the radial styloid. Before accessing the radial artery, an Allen test or Barbeau test is to be performed to confirm adequate collateral circulation to the palm. Allen test is performed by compressing both the radial and ulnar arteries until the palm blanches and then the ulnar artery is released. The blush response in the hand is noted and if the color in the palm returns before 10 seconds, blood supply to the hand via the ulnar artery and palmar arch is considered satisfactory. Barbeau test removes the subjectivity of the Allen test, and a pulse oximeter is placed on the ipsilateral thumb. Similar to Allen test compression of both the arteries is performed until pulse oximetry trace is blunted. The test is considered normal if the pulse oximetry tracing returns to normal within 10 seconds of releasing the pressure on the ulnar artery.

Transradial versus Transfemoral Approaches

Since its first description in 1989, a transradial approach for coronary angiography has been increasing in comparison to the transfemoral approach. Several randomized controlled trials and meta-analyses have demonstrated reduced mortality, decreased major bleeding, access site complications, reduced length of stay, and comparable stroke rate by using a transradial approach.[4] The findings have been reproduced in non-emergency diagnostic and percutaneous interventional procedures and as well as in urgent settings of ST-segment elevation myocardial infarction. Radial access procedures also enhance patient comfort, reduce post-procedure bed rest and eventually length of hospital stay.

Complications

The risk of major complications during diagnostic cardiac catheterization procedure is usually less than 1%, and the risk and the risk of mortality of 0.05% for diagnostic procedures.[5] For any patient, the complication rate is dependent on multiple factors and is dependent on the demographics of the patient, vascular anatomy, co-morbid conditions, clinical presentation, the procedure being performed, and the experience of the operator. The complications can be minor as discomfort at the site of catheterization to major ones like death.

Local Vascular Complications

Hematoma/Retroperitoneal Bleeding

These are among the most common complications seen after cardiac catheterization procedures. Hematomas are usually formed following poorly controlled hemostasis post sheath removal. Most hematomas are self-limiting and benign, but large rapidly expanding hematomas can cause hemodynamic instability requiring resuscitation with fluids and blood. The incidence of this

complication is significantly reduced in transradial access. In patients with transfemoral access, retroperitoneal bleeding should be suspected if there is a sudden change in the hemodynamic stability of the patient with or without back pain as there may not be any visible swelling in the groin for some of these patients. The incidence of this complication is less than 0.2%.[6] Strong clinical suspicion along with immediate imaging, usually with CT scan, helps make a diagnosis of this problem. Identification of the bleeding source is essential for patients with continued hemodynamic deterioration. These life-threatening bleeds are more frequent when the artery is punctured above the inguinal ligament. Most patients are managed with a reversal of anticoagulation, application of manual compression and volume resuscitation and observation. Patients with continued deterioration with need coiling of the bleeding source vessel, or balloon angioplasty or covered stents for bleeding from larger vessels.

Pseudoaneurysm

When the hematoma maintains continuity with the lumen of the artery, it results in the formation of a pulsatile mass locally, defined as a pseudoaneurysm. This will be associated with bruit on examination. They happen following low access in the superficial femoral artery as opposed to the common femoral artery. These are usually diagnosed by ultrasound Doppler imaging or CT angiography. Small pseudoaneurysms of the less than 2 to 3 cm in size may heal of spontaneously and can be followed by serial Doppler examinations. Large symptomatic pseudoaneurysms can be treated by either ultrasound-guided compression of the neck of pseudoaneurysm or percutaneous injection of the thrombin using ultrasound guidance or may need surgical intervention.

Arteriovenous Fistula

Direct communication between the arterial and venous puncture sites with ongoing bleeding from the arterial access site leads to the fistula formation and are associated with a thrill or continuous bruit on examination. These usually will require surgical exploration as they are unlikely to heal spontaneously and may expand with time.

Dissection

This is an infrequent complication and occurs in patients with an increased atherosclerotic burden, tortuous arteries, or traumatic sheath placement. Non-flow limiting dissections usually heal spontaneously following sheath removal. A flow limiting large dissections could lead to acute limb ischemia and should be treated immediately with angioplasty and stenting. Vascular surgery is usually reserved for patients with failed percutaneous techniques.

Thrombosis and Embolism

This complication is extremely rare with the use of the low profile catheters and predisposing factors include small vessel lumen, and associated peripheral arterial disease, diabetes mellitus, female sex, large diameter sheath, and prolonged catheter dwell time. Treatment involves removal of the occlusive sheath, percutaneous thrombectomy in conjunction with vascular surgery consultation.

Vascular Complications after Transradial Access

The most frequent complication after transradial access is about a 5% risk of radial artery occlusion. This is a clinically insignificant complication if the Allen test is normal. Patients with incomplete palmar arch and abnormal Allen test may have symptoms of hand ischemia after radial artery occlusion.

Radial artery spasm is another frequent complication, and this can be avoided by the use of local vasodilatory medications and systemic anxiolytics. Perforation of the radial artery is an extremely rare complication and is usually managed with prolonged external compression and rarely requires vascular surgery intervention.

Other Major Complications

Death

The incidence of death with cardiac catheterization has decreased progressively and is less than 0.05% for diagnostic procedures. Patients with depressed left ventricular systolic function and those presenting with shock in the setting of acute myocardial infarction are at increased risk. In some subsets of patients, the risk of mortality can be more than 1%. Other factors that would increase the risk include old age, the presence of multivessel disease, left main coronary artery disease, or valvular heart disease like severe aortic stenosis.

Myocardial Infarction

The reported incidence of periprocedural myocardial infarction for a diagnostic angiography is less than 0.1%. This is mostly influenced by patient-related factors like the extent and severity of underlying coronary artery disease, recent acute coronary syndrome, diabetes requiring insulin, and technique-related factors.

Stroke

The overall risk of stroke in recently reported series is low at 0.05% to 0.1% in diagnostic procedures and can increase to 0.18% to 0.4% in patients undergoing intervention.[7] This can be a very debilitating complication associated with a high rate of morbidity and mortality. The risk is higher in patients with extensive atherosclerotic plaque in the aorta and aortic arch, complex anatomy, procedures requiring multiple catheter exchanges or excessive catheter manipulation, or the need for large-bore catheters and stiff wires.

Dissection and Perforation of the Great Vessels

Dissection of the aorta, perforation of the cardiac chambers, perforation of the coronary arteries is an extremely rare complication. The risk is higher in procedures with intervention as opposed to diagnostic procedures only. Patients with type A aortic dissection involving the ascending aorta will require surgical correction. Patients with a cardiac chamber or coronary perforation resulting in the accumulation of the blood in the pericardial space will need urgent pericardiocentesis to restore hemodynamic stability and immediate surgical consultation.

Atheroembolism

Cholesterol emboli from friable vascular plaques can give rise to distal embolization in multiple vascular beds. These are usually recognized by digital discoloration (blue toes), livedo reticularis. This can also manifest as a neurological squeal or renal impairment. The risk of this complication is minimized by exchanging catheters over a long wire and minimizing the catheter exchanges. Retinal artery occlusion causes Hollenhorst plaque.

Allergic Reactions

Allergic reactions can be related to the use of local anesthetic, contrast agents, heparin or other medications used during the procedure. Reactions to the contrast agents can occur in up to 1% of the patients, and people with prior reactions are pretreated with corticosteroids and antihistamines. Use of iso-osmolar agents decreases the risk compared to high osmolar agents.

When severe reactions do occur, they are treated similarly to anaphylaxis with intravenous (IV) epinephrine (initial dose 1 ml of 1:10000 epinephrine).

Acute Renal Failure

The incidence of the reported contrast nephropathy is quite variable (range 3.3% to 16.5%) in the patients undergoing cardiac catheterization resulting in a transient increase in the serum creatinine levels after exposure to contrast material. In the National Cardiovascular Data Registry, the incidence of contrast-induced acute kidney injury was 7.1%, among the patients undergoing elective and urgent coronary intervention.[8] The risk is higher in patients with underlying moderate to severe renal disease, people with diabetes, elderly, females, patients on diuretics, ACEI, and metformin. Adequate pre-hydration, use of iso-osmolar agents, and techniques to minimize the amount of dye used will help prevent this complication. Renal atheroemboli can also cause renal failure and are associated with other signs of embolization.

Infection

Cardiac catheterization is performed using sterile technique, and local or systemic infection is extremely rare. Routine prophylaxis for endocarditis is not recommended during cardiac catheterization procedures.

Radiation Injury

Radiation skin injury can occur if a patient is exposed to excessive doses of radiation to one particular area of the body and manifestation could range from mild erythema to deep ulceration. Skin biopsies should be avoided for these lesions as they would make the underlying condition worse. This complication should be managed by a combined team of cardiologists, dermatologists, and plastic surgeons.

Arrythmias

The occurrence of the ventricular fibrillation or ventricular tachycardia during the procedure could be related to irritation or ischemia of the myocardium by the catheter, contrast material or occlusive balloons. These arrhythmias occur more frequently in people presenting with acute ST-elevation myocardial infarction and treatment includes cardioversion along with anti arrhythmic drugs and restoration of the flow to the occluded artery. Atrial tachyarrhythmias can occur following the irritation of the right atrium during right heart catheterization and is usually self-limiting.

Transient brady arrhythmias are also a common occurrence in the cardiac cath lab. Prolonged episodes resulting in hypotension will need treatment with intravenous atropine, or temporary transvenous pacing. In people with preexisting right bundle branch block, development of the left bundle branch block during right heart catheterization may result in complete heart block, and this can be avoided by minimal catheter manipulation in right ventricular outflow tract.

Clinical Significance

With the advent of the small catheters, increased use of the transradial approach, and improving technical skills of the operators, the risks and complications associated with cardiac catheterization have decreased significantly. Utmost care has to be taken with each procedure to decrease the risk of complications of this commonly used life-saving procedure.

Enhancing Healthcare Team Outcomes

Cardiac catheterization is usually done by an interventional cardiologist with assistance from nurses and radiologic technologists. During the procedure, a nurse is dedicated to the monitoring of the vital signs. After the procedure, the nurse is also responsible for ensuring that the access site is not bleeding and the distal extremity pulses are intact. In addition, the nurse will monitor the urine output to ensure that there has been no adverse reaction of the dye to the kidney.

There is increasing evidence that transradial approach for cardiac catheterization reduces associated complications and improves patient comfort compared to transfemoral approach. Using ultrasound/fluoroscopy for access, small sized catheters coupled with increasing operator experience will decrease the complications further. The technology associated with cardiac catheterization procedures is changing rapidly, and interventionalists should embrace new advances and work toward making these procedures as safe as possible for the patients.

Continuing Education / Review Questions

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