More than 5 million diagnostic and interventional cardiac catheterizations are performed each year in the United States. Cardiac catheterization is considered the gold standard for the diagnosis, evaluation, and treatment of cardiac diseases. Although it has reduced morbidity and mortality for cardiovascular disease, this invasive procedure is not free of complications.

From June 2004 through December 2006, PA-PSRS received more than 1,400 reports referencing cardiac catheterization procedures. Almost half of the reports were classified as complication of the procedure. More than 230 of these complications were vascular complications associated with the access site, including bleeding, hematoma formation, retroperitoneal bleed, pseudoaneurysm, and arteriovenous fistula (A-V) formation. Of the 230 vascular complications reported, the most often stated causes of the problem were medication errors, inconsistencies in patient assessments, unrecognized changes in patient condition, sheath removal, and lack of appropriate interventions when complications occurred.

This article presents strategies for reducing vascular complications associated with cardiac catheterizations through identification of associated risk factors and implementation of risk reduction strategies. Both cardiologists and nurses play a vital role in the early recognition and management of these complications.

For example, the following report submitted to PA-PSRS demonstrates a missed opportunity to recognize signs and symptoms of bleeding at the access site, which led to serious vascular complications that required additional intervention in the operating room (OR).

Patient underwent a cardiac catheterization on Friday. The sheath was removed Saturday morning. Patient developed a large hematoma in the right groin area in the afternoon. Pressure applied to the site for 15 minutes. Sandbag applied for more than two hours. By evening, hemoglobin and hematocrit had dropped to 6.6 and 21.8. Patient had to return to the OR to stop the bleeding and evacuate the hematoma. Patient was transferred to CVU post-op.

The following case demonstrates the importance of early recognition of problems at the access site and the positive outcome when interventional strategies are implemented.

Cath lab RN [registered nurse] notified of patient’s groin being firm at the site. When I arrived in his room, no one was holding pressure to the site. I immediately began holding pressure to the hematoma that was forming. I pushed the nurse call bell. When nurse arrived, I asked her to alert the monitor techs that I was holding pressure on the hematoma. She then left the room. The patient started to vagal; three RNs responded. Fluids were opened up wide, and he quickly responded without the need for atropine to be given. After holding pressure for 20 minutes manually, the groin was soft and hemostasis achieved.

Complications

Major complications in cardiac catheterizations occur infrequently (i.e., in approximately 3% of all procedures). These complications include death, acute myocardial infarction, emergency bypass surgery, and stroke. Minor complications occur more frequently and include vascular complications, arrhythmias, transient ischemic attack, renal insufficiency, and infection. Of these complications, vascular complications associated with the access site occur most frequently. As discussed previously, vascular complications include: conditions of bleeding at the site, hematoma formation, retroperitoneal bleeding, pseudoaneurysm, and A-V formation.
Strategies to Minimize Vascular Complications following a Cardiac Catheterization (Continued)

Complication Rate
The American College of Cardiology’s benchmark for the incidence of all cardiac catheterization complications is no more than 1% for diagnostic and 3% for interventional procedures. However, the incidence of vascular access complications alone has ranged from 0.1% to 61%, depending on the definition of complications, the type of procedure, anticoagulation, closure devices, age, sex, and other patient co-morbidities. Vascular complications expose patients to additional discomfort, extended hospital stay, and higher hospital costs. They may require additional treatment, such as blood transfusions and vascular surgery. Some estimate that complications related to the access site result in more than 75,000 surgical procedures annually. A goal following cardiac catheterization is to reduce vascular complications, especially hematoma formation, the most common access site complication.

Risk Factors and Risk Reduction Strategies
Factors that influence vascular complications include the following: patient characteristics, interventional cardiologist technique, medications used during the catheterization, use of manual and/or mechanical compression at the access site, use of closure devices, and nursing care.

In addition to benefiting patient care, risk reduction strategies benefit hospitals through cost reduction and improved catheterization laboratory flow. Risk reduction strategies can be implemented in the cardiac catheterization laboratory and the post interventional unit. The following strategies focus on identification of risk factors associated with complications and early implementation of methods to reduce complications.

Patient Characteristics
Identifying individual patient risk factors is an important aspect of care during cardiac catheterization. The following list summarizes patient characteristics that may increase the risk for development of vascular complications:

- Age (i.e., older than 70)
- Female gender
- Extremely thin or morbidly obese
- Presence of peripheral vascular disease
- Hypertension
- Renal failure
- Low platelet count and low hematocrit at baseline
- Congestive heart failure; chronic obstructive pulmonary disease
- Coagulopathies

Interventional cardiologists and RNs should perform a comprehensive review of patient’s history and physical including a review of current medications and assessment of risk factors. Facilities may consider developing a risk factor identification tool to be completed by the admitting physician or nurse; and placed in the patient’s record for easy access to all healthcare providers.

Interventional Cardiologist Technique
Techniques employed by the interventional cardiologist can impact vascular complications. Techniques include careful entry into the artery, use of smaller sheaths (e.g., less than 8 Fr), avoidance of venous sheath whenever possible due to adverse effects, early sheath removal, use of low dose heparin, and minimizing procedure time. A report of the American College of Cardiology Task Force on Clinical Expert Consensus states that quality assurance issues in the cardiac catheterization laboratory begin with an assessment of the clinical proficiency of the interventional cardiologist. Furthermore, a team approach during invasive procedures can promote safety and improve patient outcomes. Facilities may wish to consider team training for all catheterization staff members. In addition, catheterization laboratories may also consider expanding “time out” verification (i.e., pausing for verification of patient’s identity, procedure, and operative site) to include discussion of individual patient risk factors, medications received and equipment to be used, such as sheath size. This could alert staff to potential complications.

Use of Medications Pre- and Postcatheterization
Catheterizations present a fundamental dilemma—the need to prevent thrombosis of the target vessel while promoting hemostasis of the vascular access site after the procedure. Several potent anticoagulating drugs are administered before, during, and after catheterization. The following case demonstrates the risk associated with a failure to reconcile medications resulting in harm to a patient.

Patient was placed on a heparin drip post cath. The heparin drip order was actually
Strategies to Minimize Vascular Complications following a Cardiac Catheterization (Continued)

written in the emergency room prior to patient going to the cath lab. The order sheet for the heparin was placed in front of the post cath order sheet. Patient was on ReoPro and heparin at the same time and developed a hematoma to the groin.

Nurses administering these medications should be familiar with the drug action, correct dosing, and potential side effects. The verbal and written communication to other team members regarding the type, dose, time, and patient reaction can be instrumental in preventing errors that can lead to vascular complications. Drug classifications to consider include the following:

**Antiplatelet agents.** Aspirin and other antiplatelet agents, such as ticlopidine hydrochloride (Ticlid), clopidogrel (Plavix), eptifibatide (Integrilin), tirofiban hydrochloride (Aggrastat), or abciximab (ReoPro) do not need to be stopped prior to catheterization.3

These antiplatelet agents reduce the frequency of ischemic complications after an interventional catheterization.3,4 Plavix may be given as 300 mg loading dose at least six hours prior to the catheterization.3

**Coumadin.** Patients on warfarin (Coumadin) undergoing a diagnostic procedure should discontinue their medication for three doses before the catheterization. For patients undergoing an emergent interventional catheterization, stopping their Coumadin may not be possible. An acceptable INR before catheterization varies among interventional cardiologists and laboratories (calibration of INR may vary among laboratories), but an INR less than 1.8 is acceptable in reducing risk for vascular complications post procedure.3

**Antithrombin agents.** Patients receiving heparin may undergo catheterization but may require longer time for hemostasis.3 Heparin may be given during the catheterization to prevent thrombosis during the procedure.15 Heparin activity may be estimated by the automated coagulation timer (ACT), an instrument designed to determine coagulation endpoints in whole blood. ACT levels should range between 250 to the 300s during the catheterization.3 Upon sheath removal, the ACT should be 150 to 200.1,4,5,9,12,13 Heparin is associated with a higher incidence of vascular complications than if heparin is not given.13

A newer antithrombin, Angiomax (bivalirudin), is being used as a replacement for heparin. Trials have shown Angiomax to be more effective than heparin.3,15 Advantages to using Angiomax include less bleeding at the access site and early sheath removal without the need for ACT testing.16

**Glycoprotein Iib/IIia inhibitor (GP Iib/IIia).** These medications are given to reduce the frequency of restenosis of arteries that have had an intervention.3 A glycoprotein inhibitor should be administered with interventional catheterization in patients not receiving Plavix and should be considered in those already taking Plavix.3

**Management of Hemostasis**

Hemostasis at the access site after cardiac catheterization is important to reduce complications, increase patient comfort and safety, and decrease hospital stay. Management of the arterial access site after diagnostic and or interventional catheterization continues to evolve.17 The data are insufficient to construct universal guidelines to minimize complications and patient discomfort. The methods currently used to obtain hemostasis postcatheterization include manual or mechanical compression of the site and/or deployment of a vascular closure device (VCD).

**Manual versus mechanical compression.** Traditionally, manual or mechanical compression for 20 to 30 minutes has been the standard of practice following sheath removal.18 Mechanical compression is as effective as manual compression for femoral artery hemostasis after cardiac catheterization.19 Vascular complications at the puncture site did not differ significantly when either a mechanical compression device or manual compression was applied.20 Manual compression and mechanical devices have their limitations, including patient discomfort and prolonged bed rest.20

**VCDs.** An alternative to manual or mechanical compression is a VCD. These devices were introduced in 1995 to decrease hemostasis time, improve patient comfort, and reduce time in bed.21 Studies have concluded that VCDs are safe and offer advantages that include early ambulation and patient comfort.4,10 Although the ability of these devices to reduce vascular access complications is controversial, their use is rapidly growing in most busy cardiac catheterization laboratories.1,22 Interventional cardiologists using VCDs should receive training before using these devices.3,4 Improper deployment of these devices causes vascular complications as noted in the following case reported to PA-PSRS.

*Post diagnostic catheterization closure device failed to close. Hematoma scale II developed. Manual pressure applied. Residual bruise noted.*
Strategies to Minimize Vascular Complications following a Cardiac Catheterization (Continued)

Medical staff governing bodies that provide credentialing of cardiologists to perform cardiac catheterizations should include the use of these VCDs in their process.

Available VCDs can be placed in the following categories:

- **Patches.** These are superficial dressings coated with either vasoconstrictors or biopolymers. They both promote clotting or topical hemostats. An advantage with these patches is decreased bed rest and early ambulation.21

- **Sutured mediated closure devices.** These devices deliver a stitch to the access site. Some advantages are patients have decreased bed rest and early ambulation and immediate reaccess can be performed at the site.21 A disadvantage is the learning curve for interventional cardiologist using this device.3,4

- **Sealant closure devices.** These devices work by a combination of mechanical forces and a collagen plug that stimulates clot formation. An advantage to this device is the simple design and easy deployment for the interventional cardiologist. It also promotes early ambulation. A disadvantage is the requirement to obtain a femoral angiogram prior to use to rule out peripheral vascular disease and to confirm femoral artery sheath placement.21

- **Staple-mediated closure device.** These devices introduce either a tiny circumferential flexible clip or staple onto the surface of the femoral artery through the introducer. Advantages to this device are quick and easy deployment by the interventionalist and rapid hemostasis. If future studies continue to show the efficacy for hemostasis and low complication rates, the use of suture-medicated and sealant closure devices may become obsolete.21

Nursing

**Education.** Providing comprehensive education and training for nurses who care for cardiac catheterization patients lays the foundation for safe, quality care. Facilities should consider the following:

- Provide seminar or educational modules for care of cardiac catheterization patients.

- Facilitate simulation labs to observe and demonstrate interventions, including sheath removal, palpation of access sites, manual compression, and application of mechanical compression devices.

- Develop a competency skills list that is validated by an experienced practitioner.

- Perform annual competency skills assessment.

Nursing care. Some PA-PSRS reports, such as those below, illustrate cases in which patients were transferred to nursing units where nurses were not trained to care for cardiac catheterization patients; this resulted in failure to recognize the patients’ developing complications. Administration and nursing leaders should consider establishing special skilled nursing units for the care of cardiac catheterization patients to improve safety and patient care.

**Called by floor for groin bleed. Nursing told to hold pressure until staff from cath laboratory available. On arrival to unit, no one was holding pressure to a hematoma of right groin.**

**Patient was post heart cath. The right groin site had oozing, and the left groin site had a hematoma. The hematoma was noted to increase in size. The heart center was called and came to the unit. During the assessment of the hematoma, the patient’s blood pressure dropped to 41/25. The patient was placed in Trendelenburg [position] and was given IV fluid bolus; the blood pressure increased to 86/51. The physician was notified, and the patient was transferred to a critical care unit for observation.**

The start of safe, quality care begins with a thorough review of the patient’s history and physical, current medications, risk factors for development of complications, and summary of the events in the cardiac catheterization lab.15 Catheterization laboratories may consider developing standardized communication tools that include the components discussed previously. The verbal report to the receiving nurse would validate the written report.

Nurses play a critical role in the management of patients after cardiac catheterization. Early detection
Strategies to Minimize Vascular Complications following a Cardiac Catheterization (Continued)

and management of vascular complications are key to minimizing complications. Consider the following:

- Signs and symptoms of hematoma formation at the groin site are identified by swelling and pain at the site.\(^5\) Knowledge and assessment of these early signs and symptoms of bleeding at the access site are pivotal in minimizing vascular complications.

- Hematoma characteristics vary widely from patient to patient. Variations include covert bleeding into subcutaneous tissue, which may be difficult to assess, and/or obvious bleeding from the site with additional signs and symptoms of compromised vascular flow (e.g., weak or absent pedal pulses).\(^7\)

- Retroperitoneal bleed is a significant vascular complication occurring after catheterization. Signs and symptoms of retroperitoneal bleed are nonspecific, such as back or groin discomfort, lower abdominal pain, diaphoresis, hypotension and bradycardia.\(^23\) If retroperitoneal bleed is suspected; nursing protocols should include obtaining a type and cross to assure availability of blood products if needed.

Although there are no consistent standards of care in the literature, nursing care activities are essential to preventing vascular complications. Facilities should develop protocols and policies to ensure a consistent approach to the care of catheterization patients in their facility. Consider incorporating the following nursing care elements into nursing protocols and practice.

- Ensure compression time of 20 to 30 minutes after sheath removal with either manual or mechanical compression devices.\(^20,24\) Compression time may be decreased to 10 minutes following diagnostic catheterization.\(^25\)

- Assess vital signs and site every 15 minutes for 1 hour after sheath removal and then every hour until the patient is allowed to walk (i.e., 3 to 6 hours).\(^7\)

- During site assessment, palpate site and assess temperature, color, and pulses present in the extremity used for access.\(^7\)

- Assess for patient discomfort at the site.\(^7\)

- Ensure bed rest for two to six hours for interventional catheterization after hemostasis.\(^11,16\) Ambulate patients one hour after diagnostic catheterization if hemostasis is maintained.\(^25\)

- Ensure head of bed is not elevated more than 30 degrees.\(^7,11\)

- Assess for a bruit, which indicates compromised vascular flow indicative of pseudoaneurysm or AV fistula.

- Include the following in documentation about the access site: hematoma measurement in centimeters, skin color and temperature, hematoma character (e.g., soft or firm), and the presence of pedal pulses and/or bruit.

- Provide patient education that includes explanation of the procedure, common complications, and methods to prevent bleeding. Key teaching points for patients are actions they can perform; for example, manual splinting of the access site with transfers or any forceful coughing. If bleeding occurs, instruct patients to apply pressure to the site and call for the nurse immediately.\(^7\) Cardiac catheterization laboratories could provide written information for patients and their families prior to the procedure explaining the procedure, potential complications, and patient involvement.

Nurses on the front line caring for patients before, during and after cardiac catheterization play a key role in the prevention of complications. With the increasing number of cardiac catheterizations performed, evolving technology, and advances in pharmaceutical therapy comes an increase risk of vascular complications. The strategies described in this article can be incorporated into the daily practice of cardiologists and nurses caring for these patients.

Notes

Strategies to Minimize Vascular Complications following a Cardiac Catheterization (Continued)


The *PA-PSRS Patient Safety Advisory* is issued quarterly, with periodic supplements. Previous issues are available on the Patient Safety Authority Web site at [http://www.psa.state.pa.us](http://www.psa.state.pa.us). Click on “Advisories and Related Resources” in the left-hand menu bar.

Selected articles in previous issues include:

- “Airway Fires during Surgery” (March 2007)
- “Bone Cement Implantation Syndrome” (December 2006)
- “Delays in the OR: Stress between ‘Running Two Rooms’ and ‘Time Outs’” (September 2006)
- “Forgotten But Not Gone: Tourniquets Left on Patients” (June 2005)
- “I’m Stuck and I Can’t Get Out! Hospital Bed Entrapment” (December 2006)
- “Improving Safety of Telephone or Verbal Orders” (June 2006)
- “Risk of Fire from Alcohol-Based Solutions” (June 2005)
- “Safety in Using Promethazine (Phenergan)” (March 2007)
- “Skin Tears: The Clinical Challenge” (September 2006)
- “Who Administers Propofol in Your Organization?” (March 2006)
ECRI Institute, a non-profit organization, dedicates itself to bringing the discipline of applied scientific research in healthcare to uncover the best approaches to improving patient care. As pioneers in this science for nearly 40 years, ECRI Institute marries experience and independence with the objectivity of evidence-based research. More than 5,000 healthcare organizations worldwide rely on ECRI Institute’s expertise in patient safety improvement, risk and quality management, and healthcare processes, devices, procedures and drug technology.

The Institute for Safe Medication Practices (ISMP) is an independent, nonprofit organization dedicated solely to medication error prevention and safe medication use. ISMP provides recommendations for the safe use of medications to the healthcare community including healthcare professionals, government agencies, accrediting organizations, and consumers. ISMP’s efforts are built on a non-punitive approach and systems-based solutions.

The Patient Safety Authority is an independent state agency created by Act 13 of 2002, the Medical Care Availability and Reduction of Error (“Mcare”) Act. Consistent with Act 13, ECRI Institute, as contractor for the PA-PSRS program, is issuing this publication to advise medical facilities of immediate changes that can be instituted to reduce Serious Events and Incidents. For more information about the PA-PSRS program or the Patient Safety Authority, see the Authority’s Web site at www.psa.state.pa.us.