Percutaneous coronary interventions (PCIs) have changed dramatically since the 1990s. The devices used have expanded from balloon dilation catheters to cutters, shavers, lasers, and specialized stents. Newer hemostasis devices have supplemented or replaced traditional methods. Routine treatment with heparin and warfarin postoperatively has been replaced with newer antithrombin and antiplatelet therapies.

In this article, I provide updated guidelines for management of patients after elective PCIs. I review the coronary vasculature; discuss different types of PCI procedures, including management of patients and complications; and present key topics of patients’ education and outcomes.

Distribution of the Coronary Arteries

Figure 1 shows the left and right coronary artery systems.1 The left main coronary artery bifurcates into the left anterior descending artery and the left circumflex artery.2,3 In some persons, the left main coronary artery may not end as a bifurcation, but as a trifurcation. The third branch (not illustrated) is the ramus intermedius. Branches of the left anterior descending artery include the diagonals and the septal perforators.
Diagonal arteries traverse the anterolateral surface of the left ventricle. The septal perforator branches supply most of the intraventricular septum, the right bundle branch, and the anterior fascicle of the left bundle branch. The left circumflex artery travels toward the inferior surface of the heart, supplying the obtuse marginal branches. In a small percentage of persons, the circumflex artery ends as the posterior descending artery.

In most persons, the right coronary artery supplies the sinus node and the atrioventricular nodal branch. The first branch of the right coronary artery, the conus, may be a source of collateral circulation between the right and left coronary systems. The right coronary artery gives rise to acute marginal branches and terminates as the posterior descending artery in at least 80% of the population, supplying septal perforator arteries to the posterior intraventricular septum. These arteries form an anastomosis with the septal perforator arteries from the left anterior descending artery, establishing another source of collateral circulation.\(^2\)\(^3\)

Nurses caring for patients with coronary disease must be skilled in correlating coronary anatomy with electrocardiographic (ECG) changes and the part of the myocardium affected (eg, recognizing that ST elevation in contiguous leads indicates injury in a specific region of the myocardium due to an occlusion in the corresponding artery). Table 1 gives the interrelationships between the ECG leads, the myocardium, and the coronary anatomy.

**Percutaneous Coronary Interventions**

PCIs include a broad category of procedures: angioplasty, placement of stents, atherectomy, laser treatment, cutting balloon angioplasty, and brachytherapy\(^2\)\(^5\) (Table 2).

Angioplasty enlarges the lumen of a vessel by displacing the plaque and overstretching the vessel with balloon inflation.\(^2\) Residual stenosis of less than 20% is considered an optimal result.\(^6\) Angioplasty is preferred in patients with single- or double-vessel disease in whom large

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**Author**

Bridget Shoulders-Odom is a cardiology nurse practitioner at Tampa VA Hospital, Tampa, Florida.

Corresponding author: Bridget Shoulders-Odom, MS, ACNP-BC; CCN; 31047 Whitlock Dr, Wesley Chapel, FL 33543 (e-mail: Bso1029@aol.com).

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Coronary artery bypass surgery provides a patent bypass graft to the left anterior descending artery or the left circumflex artery), because of the large amount of myocardium at risk.

**Coronary Stents**

PCI with stents has surpassed coronary artery bypass surgery as the most common coronary revascularization procedure. Coronary stents have contributed to marked reductions in restenosis and the need for emergency open heart surgery. These wire mesh tubes are constructed from metallic alloys (eg, stainless steel) and act as scaffolding to support the vessel wall (Figure 2); the intent is to prevent abrupt closure of the vessel and subsequent restenosis. Although stents are usually inserted as an adjunct to angioplasty, direct stenting (without dilating the vessel first) is safe. The benefits of direct stenting include decreased length of procedure, use of a smaller amount of contrast material, and decreased risk for vessel injury.

Bare metal stents were the first devices used to maintain lumen patency. This technology helped solve one problem but created another: in-stent restenosis. In order to overcome this problem, drug-eluting stents were developed to inhibit the response to injury that was primarily responsible for restenosis in patients with bare metal stents. A drug-eluting stent delivers therapeutic levels of anti-inflammatory drugs locally to prevent cell proliferation. Sirolimus, an immunosuppressant initially used to prevent allograft rejection, and paclitaxel, a chemotherapeutic agent, are the 2 commercially available drugs currently used most often in drug-eluting stents.

### Table 1

<table>
<thead>
<tr>
<th>Leads</th>
<th>Myocardium</th>
<th>Artery</th>
</tr>
</thead>
<tbody>
<tr>
<td>II, III, AVF</td>
<td>Inferior wall</td>
<td>Right coronary</td>
</tr>
<tr>
<td>I, AVL, V5, V6</td>
<td>Lateral wall</td>
<td>Left circumflex</td>
</tr>
<tr>
<td>V1, V2</td>
<td>Septal wall</td>
<td>Left anterior descending (proximal)</td>
</tr>
<tr>
<td>V2, V3, V4</td>
<td>Anterior wall</td>
<td>Left anterior descending</td>
</tr>
<tr>
<td>V3R, V4R, V5R, V6R, V7, V8, V9</td>
<td>Right ventricle</td>
<td>Right coronary (proximal)</td>
</tr>
</tbody>
</table>

*a Reciprocal changes in V1, V2 could be an indication of posterior involvement.

*b An expanded electrocardiogram allows for recording of posterior and right ventricular electrical activity.

### Table 2

<table>
<thead>
<tr>
<th>Procedure</th>
<th>Description/comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Atherectomy</td>
<td>Devices are used to cut, shave, or pulverize plaque. Directional and rotational atherectomy are options for anatomically difficult lesions. The number of atherectomy procedures has decreased because stents provide a simpler and less costly option.</td>
</tr>
<tr>
<td>Laser angioplasty</td>
<td>Laser produces ablation of plaque and, via generation of heat and shock waves, plaque disruption. Adjunctive percutaneous transluminal coronary angioplasty is usually required. Increased rates of dissection and higher restenosis rates limit use of this technique.</td>
</tr>
<tr>
<td>Cutting balloon angioplasty</td>
<td>A device with blades mounted on a specially designed balloon is used to produce clean, longitudinal incisions. The incised areas are then dilated to compress the plaque. Procedure is designed for lesions resistant to traditional dilation.</td>
</tr>
<tr>
<td>Intravascular brachytherapy</td>
<td>Local intracoronary radiation is delivered within a stent, through a special catheter, to treat in-stent restenosis. The radiation is withdrawn after a specified time. Use of this procedure has decreased with the advent of drug-eluding stents.</td>
</tr>
<tr>
<td>Intravascular ultrasound</td>
<td>Ultrasound provides a cross-sectional image of the vessel wall. The procedure is used to evaluate plaque and tissue characteristics and verify results of percutaneous coronary interventions and stent deployment. The images may reveal possible causes of stent thrombosis (eg, stent underexpansion, malposition, or residual dissection).</td>
</tr>
<tr>
<td>Coronary pressure measurement</td>
<td>Measurement of fractional flow reserve is used to determine the maximal myocardial blood flow in the presence of coronary stenosis. Flow is measured by using a pressure wire. Fractional flow reserve &lt;0.75 indicates a significant lesion (the maximum blood flow in the presence of a stenosis is expressed as a proportion of its normal expected value in the absence of stenosis; ie, the normal value for fractional flow reserve is 1.00).</td>
</tr>
</tbody>
</table>

Lesions (70% or greater occlusion) are approachable via a catheter. Coronary artery bypass surgery remains the preferred approach for lesions in the left main artery, particularly if unprotected (ie, no
Pathogenesis of Restenosis

Restenosis involves a series of events that result in significant narrowing of the lumen of the treated vessel. After PCI, the body attempts to repair the damage caused by the procedure-related mechanical injury. Every treated vessel undergoes some degree of loss of the lumen diameter, but this loss is usually negated by the net gain of the lumen diameter. Different arteries and interventions appear to be associated with different degrees of proliferation and contraction of the vessel wall. Stented vessels renarrow exclusively via neointimal hyperplasia, a complex inflammatory process. Nonstented lesions restenose because of remodeling of the treated vessel, in addition to neointimal hyperplasia.

Restenosis typically occurs within 3 to 12 months after intervention and is suspected if angina recurs. Untreated angina can lead to unstable angina or acute myocardial infarction.

Restenosis may be detected during a stress test or confirmed by repeat angiography. Two beneficial treatments of restenosis are brachytherapy and drug-eluting stents.

Stent Thrombosis

Stent thrombosis usually occurs suddenly and is suspected when a patient has an acute ischemic event and ECG changes in the distribution of the treated vessel. This serious complication almost always results in acute myocardial infarction. Most incidents occur acutely (within 24 hours of stent placement) or subacutely (within the first 30 days).

Information about the pathogenesis of stent thrombosis is limited; however, current evidence suggests that delayed healing and reendothelialization, particularly in patients with drug-eluting stents, results in potentially enhanced thrombogenicity. A combination of procedure-related (eg, placement of multiple stents), lesion-related (eg, complex lesions), and patient-related (eg, diabetes) factors may all contribute to the development of stent thrombosis. Stent thrombosis can be treated with emergency angioplasty or thrombectomy. Concerns have recently emerged about the risk of thrombosis in patients with drug-eluting stents. Very late thrombosis (eg, 3 years) after implantation of such stents has been reported. In an investigation of late stent thrombosis in patients who received drug-eluting stents, Ong et al found that thrombosis could occur not only in patients who prematurely stopped clopidogrel and aspirin therapies but also in patients who completed clopidogrel therapy and continued aspirin therapy.

In a prospective observational study of the incidence and outcomes of thrombosis after implantation of drug-eluting stents, Iakovou et al found a higher rate of stent thrombosis (1.3%) than the rate reported in major clinical trials (0.4%-0.6%). Of concern, the incidence of thrombosis with paclitaxel-eluting stents was almost twice that of thrombosis with sirolimus-eluting stents. Premature discontinuation of antiplatelet therapy was the most important predictor of stent thrombosis. Thrombosis occurred in 29% of patients who prematurely discontinued dual platelet therapy.

The appropriate duration of long-term dual antiplatelet therapy for prevention of thrombosis has not been determined. A panel convened by the Food and Drug Administration concluded that late stent thrombosis in patients with drug-eluting stents was excessive and concurred with the recommendation for 12 months...
of dual antiplatelet therapy in patients who are not at high risk for bleeding. Larger scale studies are needed to assess the true risk of thrombosis associated with use of drug-eluting stents and the appropriate duration for dual antiplatelet therapy.

Magnetic resonance imaging is considered unsafe in patients with recent stenting because of the fear that dislodgement of the stent could trigger stent thrombosis, although many of the current metals used in stents are not ferromagnetic and do not interfere with the imaging. The traditional recommendation has been to postpone magnetic resonance imaging for 8 weeks after stent placement, to allow reendothelialization. Gerber et al15 studied the risk of stent thrombosis associated with magnetic resonance imaging and suggested that the imaging can be safely performed in less than 8 weeks after stenting.

**Stents of the Future**

Future stents will be designed with the goals of increased safety and decreased complications. New developments include biodegradable stents that remain in place only as long as necessary to prevent recoil and remodeling and then completely dissolve. Biocompatible polymer coatings that mimic the surface of normal cells are being developed. On the horizon are drugs designed to inhibit neointimal hyperplasia and thrombosis.

**Methods to Facilitate Hemostasis**

Using manual compression to achieve hemostasis requires using 2 or 3 fingers to apply continuous downward pressure above the puncture site. Sufficient pressure is applied to stop bleeding without obscuring the distal pulses. Pressure is held for approximately 20 minutes, or until hemostasis occurs.

Mechanical compression devices (eg, FemoStop) have the advantages of hands-free operation, less contact with blood, and controlled pressure. When bleeding is marked, the pressure is increased to initiate hemostasis and then decreased every few minutes to the lowest pressure that stops bleeding. The puncture site can be easily visualized via the transparent dome and closely observed while the pressure is slowly released. Maintaining pressure for a prolonged period (eg, 2 hours) is not recommended because of the risk for tissue damage or nerve compression. Use of this device is contraindicated in patients with severe peripheral vascular disease or femoral artery or venous grafts. Compression may be inadequate in patients who are markedly obese.

In an evaluation of vascular complications associated with manual and mechanical compression, Chlan et al46 found no difference in complication rates between the compression methods. The most frequent vascular complications were ecchymosis (37%), hematoma (20%), and oozing (15%).

Vascular closure devices are alternative methods for achieving

<table>
<thead>
<tr>
<th>Category</th>
<th>Description</th>
<th>Device (brand name)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Collagen plugs</td>
<td>Hemostasis is achieved by delivering collagen extravascularly to the surface of the femoral artery. The collagen attracts platelets to the arterial puncture site, resulting in a seal at the site. Collagen reabsorbs during a 6-week period.</td>
<td>VasoSeal</td>
</tr>
<tr>
<td>Absorbable anchors</td>
<td>The device consists of an absorbable suture material and a small collagen plug. It creates a mechanical seal by sandwiching the arteriotomy between the suture anchor and the collagen sponge. The material dissolves within 90 days.</td>
<td>Angio-Seal</td>
</tr>
<tr>
<td>Topical hemostasis patches</td>
<td>Topical patches with a marine toxin, thrombin, or a biopolymer as a hemostasis agent seal the tissue tract without arteriotomy. This external device leaves no foreign matter. Manual compression is still required. Longer duration of compression may be needed in patients who are hypertensive or obese.</td>
<td>Syvek patches Chito-Seal Clo-Sur P.A.D. D-Stat</td>
</tr>
<tr>
<td>Suture-mediated devices</td>
<td>The devices suture the arteriotomy site to achieve immediate hemostasis. Potential complications include infection, laceration, and partial dissection.</td>
<td>Perclose</td>
</tr>
<tr>
<td>Staple-mediated devices</td>
<td>Staples create a purse-string suture closure, allowing for hemostasis.</td>
<td>StarClose Angioline</td>
</tr>
<tr>
<td>Biosealants</td>
<td>A liquid procoagulant mixture of thrombin and collagen is delivered to the puncture site to seal the site. Accidental injection into the femoral artery could lead to acute leg ischemia.</td>
<td>Duett</td>
</tr>
</tbody>
</table>
and maintaining hemostasis. The devices range from topical patches, collagen plugs, and procoagulants to suture- and staple-mediated devices\(^2\) (Table 3). Figure 3 illustrates an example of a vascular closure device. Compared with other compression methods, vascular closure devices are associated with decreased compression time, improved patient comfort, and earlier ambulation but not with significant decreases in bleeding or vascular complications.\(^2\)

A minor annoying problem with many closure devices is persistent oozing around the closure site, particularly in patients receiving antiplatelet and anticoagulation therapy. Infection at the femoral access site is rare, but increased occurrence of infection has been noted with closure devices introduced in the tissue tract.\(^2\) Prophylactic antibiotic therapy may be prescribed for patients at higher risk (eg, those with diabetes) before the PCI procedure if a vascular closure will be used for hemostasis. All vascular closure devices are subject to failure, and manual and/or mechanical pressure may be required if bleeding occurs despite their use.

In a retrospective analysis of the 3 generations of the Angio-Seal device, Applegate et al\(^2\)\(^4\) found no significant differences between the 3 devices and manual compression. Successful closure rates were similar for diagnostic and PCI procedures; the overall success rate was greater than 98%. The vascular complication rates were similar to those associated with manual compression.

In a meta-analysis of the safety of vascular closure devices, Nikolsky et al\(^2\)\(^5\) found no significant difference in vascular complications between Angio-Seal and Perclose devices compared with mechanical compression. The VasoSeal device appeared to have a higher incidence of vascular complication compared with mechanical compression. With the rapidly changing technology and newer generation devices, along with the gain in operator experience, complication rates associated with the newer devices
are lower than those associated with the early generation devices.

**Adjunct Pharmacotherapy**

Pharmacological agents help provide short- and long-term stent patency and decrease the incidence of abrupt closure and stent thrombosis. Heparin treatment is generally maintained during the PCI procedure to prevent thrombus formation and then discontinued before sheath removal. Routine use of heparin after an uncomplicated PCI is no longer recommended. Avoiding use of heparin after a PCI procedure has decreased the incidence of bleeding and vascular complications. In some instances (eg, ST-segment elevation myocardial infarction), at the physician’s discretion, heparin may be restarted, typically 4 hours after the sheath has been removed and hemostasis achieved.

Stents are inherently thrombogenic because of their metallic alloy composition. A standard regimen of antiplatelet therapy is prescribed to decrease the risk of thrombosis. Typical antiplatelet agents include inhibitors of the glycoprotein IIb/IIIa complex (GPIIb-IIIa), thienopyridines, and aspirin. These agents exert their antiplatelet effects at various sites along the antiplatelet pathways (Figure 4).

GPIIb-IIIa inhibitors bind to the GPIIb-IIIa receptor sites, blocking the final common pathway of platelet aggregation and thus decreasing the incidence of acute thrombosis. GPIIb-IIIa inhibitors currently available include eptifibatide, abciximab, and tirofiban. These agents are administered by intravenous infusion for 12 to 24 hours after a bolus dose is given. Platelet counts are closely monitored because of the risk for thrombocytopenia. Abciximab has the longest half-life and may cause more profound thrombocytopenia than the other GPIIb-IIIa inhibitors. Abciximab does not require dose adjustment in patients with renal disease.

Bivalirudin (Angiomax) is a direct thrombin inhibitor that can be administered as an alternative to heparin and GPIIb-IIIa inhibitors during PCIs. Compared with heparin and GPIIb-IIIa inhibitors, bivalirudin is less dependent on renal clearance; in addition, it does not activate platelets and has a short half-life of 25 minutes. These benefits make bivalirudin suitable for patients with heparin-induced thrombocytopenia and chronic renal failure.

The thienopyridines clopidogrel and ticlopidine are oral antiplatelet drugs that inhibit the receptors for adenosine diphosphate. These drugs are prescribed after PCI for a specified period, depending on the type of stent used. Clopidogrel has essentially replaced ticlopidine because of the former’s less potent hematologic adverse effects.

Aspirin inhibits the synthesis of thromboxane A₂, resulting in irreversible inhibition of platelet function. Aspirin is prescribed in combination with clopidogrel, as dual antiplatelet therapy, to decrease the risk of stent thrombosis.

**Nursing Management After PCI**

 Patients were traditionally monitored in the intensive care unit after PCI procedures. Many hospitals now have telemetry units staffed with specialty skilled nurses to care for PCI patients. Nursing care includes assessment, recognition, and effective management of complications; patient comfort and safety; and providing education to patients and their families.

Chest pain may occur in up to 50% of patients after PCI. Potential causes include benign stent sensation, acute stent thrombosis, abrupt vessel closure, transient coronary spasms, side branch occlusion, and distal embolization of debris. All episodes of chest pain should be reported to a physician.

Continuous ECG monitoring is used to assess for acute ischemic...
events. The EASI telemetry system provides the ability to monitor 12 leads continuously. The modified ECGs, derived from 4 chest electrodes and a reference electrode, obtained with this system allow multilead monitoring.20 If the EASI system is not available, telemetry monitoring of ST segments should include leads that reflect the revascularized artery, for prompt recognition of possible abrupt closure. ST-segment monitoring may not be appropriate in patients with left bundle branch block, ventricular paced rhythms, or excessive artifact because of the inability to reliably interpret changes in the ST segment.20 Standard 12-lead ECGs are obtained after PCI procedures and whenever a patient has new cardiac signs or symptoms.

Assays for cardiac markers may be ordered as part of an institution’s protocol, although any patient experiencing persistent chest pain or after complicated PCI should have serial tests for cardiac markers. Measurements of troponins have a higher sensitivity and specificity for diagnosis of acute myocardial infarction than do measurements of creatine kinase MB. Although troponin elevations are common after PCI procedures and minor elevations do not appear to have prognostic value, marked elevations (>5 times normal) are associated with worsened outcomes.5

Early sheath removal decreases the incidence of vascular and bleeding complications.27 Specific protocols and competency-based education programs should be in place for nurses responsible for removing sheaths. The American Association of Critical-Care Nurses has published guidelines for sheath removal.18 A hemostasis device is typically used at the time of the removal.

Bed rest guidelines vary with institutional policy, the technique used for hemostasis, the size of the sheath, and use of antiplatelet therapy after the PCI procedure. Tagney and Lackie21 conducted a study to determine if bed rest times could be shortened without increasing complication rates in patients after diagnostic catheterization and PCI. They found that bed rest times could be reduced from 6 hours to 3 hours without an increase in complication rates.

Standard assessment of the PCI access sites includes monitoring the arterial and venous puncture sites for bleeding, hematoma, ecchymosis, localized tenderness, a pulsating mass, and new bruits. Assessment of peripheral circulation includes evaluation of bilateral pulses for comparison, warmth and color of the affected extremity, and capillary refill. Immobilization of the affected extremity is indicated during the period of bed rest. An extremity immobilizer may be necessary in patients who have restless leg syndrome or are unable to comply with keeping the extremity straight.

Patients with brachial puncture sites are on bed or chair rest with the arm straight for a minimum of 2 hours. Using the affected arm for blood pressure checks should be avoided during the recovery period. The brachial site is monitored for bleeding, swelling, distal pulses, sensation, and motor function.22 Weak pulses or lack of pulses could be a sign of arterial spasm. Numbness and weakness may indicate medial nerve compromise or impaired circulation. The puncture sites should be checked to determine if the dressing is too tight or if a hematoma is compressing a nerve.

Benefits of the radial artery approach include decreased bleeding at the access site and earlier ambulation. The arterial sheath is usually removed immediately after the PCI procedure. A specially made tourniquet (eg, HemoBand) may be applied at the puncture site, and then pressure is gradually released until hemostasis is achieved. If such a tourniquet is not available, manual compression is adequate. After hemostasis is achieved, a pressure bandage may be applied. A wrist splint may be used to decrease episodes of wrist flexion. Patients may ambulate once sedation wears off. They are advised to avoid flexion and extension of the wrist for the remainder of the day.21

The radial and ulnar pulses are both monitored as part of the assessment. Loss of a radial pulse may be due to thrombosis, dissection, inappropriate suturing, or spasms. Local swelling is treated with ice and analgesics. Rebleeding is treated with elevation of the hand of the affected extremity and local pressure. Persistent bleeding may be due to a lacerated artery. An inflatable blood pressure cuff can be used to control bleeding22; however, surgical intervention may be indicated. Other potential complications include arteriovenous fistula, hematoma, and ischemia due to occlusion of the radial artery.

Nurses caring for PCI patients must be alert to recognize vascular related complications (Table 4), including hematomas, retroperitoneal bleeding, pseudoaneurysms, arteriovenous fistulas, nerve compression, and atheroembolism. Other potential
<table>
<thead>
<tr>
<th>Complication</th>
<th>Description</th>
<th>Signs and symptoms/comments</th>
<th>Management</th>
</tr>
</thead>
</table>
| Hematomas               | Blood collects in soft tissue                                                                                                                 | Expanding mass surrounding puncture site  
Any hardened area under the skin  
Slowly expanding hematomas, even from venous sites, can be dangerous because of their insidious nature | Acute management includes providing hydration, applying pressure, marking area to monitor for expansion, maintaining bed rest, and serial monitoring of complete blood cell count  
Anticoagulant and antiplatelet therapies may be interrupted, and blood transfusion may be indicated  
Hematomas usually resolve within a few weeks as the blood gradually spreads and is absorbed from the soft tissue |
| Pseudoaneurysms         | Thrombus does not develop in the puncture site when the arterial sheath is removed, creating a communicating tract  
Causes include inadequate compression after sheath removal and impaired hemostasis | A large painful hematoma, pulsatile mass, and a bruit or thrill in the groin  
Pedal pulses are usually unchanged because blood flow is not affected in the main artery  
Pseudoaneurysms may rupture, leading to sudden massive swelling and severe pain  
Nerve compression should be suspected when the pain is out of proportion to the size of the hematoma.  
Nerve compression from groin hematomas may lead to quadriceps weakness that may take weeks or months to resolve | Any large or painful hematoma should be evaluated for pseudoaneurysm by using ultrasound  
If the pseudoaneurysm is small (<2 cm), it may be observed and monitored clinically  
A large pseudoaneurysm may require ultrasound-guided compression or surgical intervention  
Ultrasound-guided thrombin injection is another treatment option |
| Retroperitoneal hematoma| Retroperitoneal hematoma may occur if the arterial wall puncture is made above the inguinal ligament  
The hematoma extends into the retroperitoneal space, which lies deep in the abdominal cavity  
This serious complication could be fatal if not recognized early | Blood collecting in the retroperitoneal space may not produce obvious swelling and may not be evident on the surface  
Signs and symptoms include unexplained hypotension, ipsilateral flank pain, vague abdominal or back pain, or abdominal distension.  
Decreasing levels of hemoglobin and hematocrit and ecchymosis are late signs | Diagnosis is confirmed by using computed tomography or abdominal ultrasound  
Management includes hydration, transfusion, serial blood cell counts, and bed rest |
| Arteriovenous fistula    | A direct communication forms between an artery and a vein  
Risk for this complication increases with multiple access attempts, punctures above or below the correct site, or impaired clotting | Continuous bruit at access site, swollen tender extremity, and claudication due to limb ischemia | Ultrasound is ordered to confirm diagnosis  
Most arteriovenous fistulas spontaneously close, so surgical repair is rarely required |
| Atheroembolism           | Friable atherosclerotic plaque in the abdominal aorta is disrupted, creating potentially embolic debris  
Showers of microemboli may result in microvascular glomerular obstruction, necrotizing fascitis, and blue toe syndrome  
Even small amounts of debris can have severe consequences if embolized to the kidneys, viscera, or brain | This complication may not be recognized for weeks to months after the percutaneous coronary intervention | Management is generally conservative: providing hydration, monitoring urine output, and controlling hypertension  
Surgical management (ie, embolectomy) may be indicated  
Distal embolic protection devices are used whenever feasible in patients undergoing percutaneous coronary interventions associated with high risk of distal embolization (eg, saphenous vein grafts) |
complications (Table 5) include dissection, tamponade, perforation, stroke, vasovagal reaction, infection, contrast-mediated nephropathy, and allergic reaction. The clinical pathway in Table 6 summarizes the components of routine care after PCI procedures.

**Patient and Family Education**

Patients are usually discharged the day after an uncomplicated PCI procedure. With shorter lengths of stay, education must begin immediately after admission. Teaching methods should be tailored for each patient, involve the patient’s family, and make use of resources available. Key topics include site assessment, potential complications, activity limitations, follow-up care, when to seek medical assistance, medication therapy, and modification of risk factors.

Patients should be reassured that the small hard lump palpable in the groin region will gradually disappear. Ecchymosis, the result of a hematoma, may take several weeks to resolve. Patients should be told that the discoloration will most likely expand and change color from dark blue to greenish yellow before disappearing. If femoral nerve compression occurred, leg weakness may persist for weeks to several months.

Patients should be advised to avoid strenuous activity the week after the PCI procedure, but they may resume walking and driving in 48 hours. Patients should seek medical assistance if they have expansion of and/or pulsation in the groin swelling, new or significantly worsening discoloration, leg weakness, numbness, or pallor, redness, warmth at the access site, or puslike drainage from the site.

**Table 5** Other potential complications of percutaneous coronary interventions

<table>
<thead>
<tr>
<th>Complication</th>
<th>Key points</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dissection</td>
<td>This complication can be reversed by balloon dilatation across the lesion to “tack” up the dissected area via repeated balloon inflations</td>
</tr>
<tr>
<td>Tamponade</td>
<td>Most common cause is perforation due to rupture of a coronary artery Signs and symptoms include tachypnea, tachycardia, hypotension, jugular venous distention, and muffled heart sounds Pericardiocentesis is performed in patients with compromised hemodynamic status</td>
</tr>
<tr>
<td>Perforation</td>
<td>Signs and symptoms include hemoptysis, hypotension, and bradycardia Balloon inflation may seal the site of leakage Transesophageal echocardiography is used for evaluation</td>
</tr>
<tr>
<td>Stroke</td>
<td>Stroke is almost always embolic, due to dislodged plaque If computed tomography shows no evidence of stroke, patient may have transient neurological deficit Intracranial hemorrhage may occur with aggressive anticoagulation</td>
</tr>
<tr>
<td>Vasovagal reaction</td>
<td>Signs and symptoms include bradycardia, hypotension, nausea, and diaphoresis This complication could lead to shock if left untreated Management includes providing intravenous hydration, administering atropine, and elevating the legs or placing the patient in the Trendelenburg position</td>
</tr>
<tr>
<td>Infection</td>
<td>Signs and symptoms may include shaking chills with brief fever Morphine in small doses may alleviate shivering Continued fever and leukocytosis warrant further investigation to determine the cause</td>
</tr>
<tr>
<td>Contrast-induced nephropathy</td>
<td>This complication is usually due to contrast material when the patient has preexisting renal dysfunction and/or diabetes mellitus Renal dysfunction can be temporary or permanent Most increases in creatinine levels are nonoliguric, and the level usually returns to baseline in a week Limiting the volume of contrast material, withdrawing nephrotoxic drugs before the percutaneous coronary procedure, and providing hydration (sodium bicarbonate infusion may be used) before the percutaneous coronary intervention are the best preventive strategies Patients with renal insufficiency are commonly given with acetylcysteine (Mucomyst) before the percutaneous coronary procedure to decrease the incidence of contrast-induced nephropathy, although this treatment is not consistently effective Hemodialysis is effective in removing contrast material</td>
</tr>
<tr>
<td>Allergic reaction</td>
<td>A reaction to contrast material is the most common cause Signs and symptoms include urticaria, hives, sneezing, and bronchospasms The risk is higher in patients allergic to penicillin or shellfish Patients with known prior reaction to contrast material or shellfish are usually given prednisone, antihistamines, and H2-blockers before the coronary procedure Anaphylaxis is a potentially serious complication that should always be reported and documented; treatment includes epinephrine and intravenous saline for hydration</td>
</tr>
<tr>
<td>Category</td>
<td>Before procedure</td>
</tr>
<tr>
<td>----------</td>
<td>------------------</td>
</tr>
<tr>
<td><strong>Assessment/monitoring</strong></td>
<td>Assess and document allergy to contrast material or shellfish&lt;br&gt;Check quality of pulses at potential access sites&lt;br&gt;Ensure patient receives nothing by mouth before the procedure&lt;br&gt;Ensure diuretic and diabetes medical therapy are stopped per institution's guidelines</td>
</tr>
<tr>
<td><strong>Diagnostic/laboratory tests</strong></td>
<td>Ensure that preoperative tests and ECG are done</td>
</tr>
<tr>
<td><strong>Interventions</strong></td>
<td>Complete preprocedure checklist&lt;br&gt;Prepare and shave access sites</td>
</tr>
</tbody>
</table>
Patients taking metformin are generally advised to stop the therapy before any PCI procedure and for at least 48 hours afterward because of the potential risk for lactic acidosis, particularly in patients with renal dysfunction. An assay for serum creatinine level may be required before the metformin therapy is resumed. At the time of discharge, patients should receive reinforcement about the use of dual antiplatelet therapy (clopidogrel and aspirin), with emphasis on the potential risk of stent thrombosis if the therapy is not continued.

Nurses are in a unique position to educate patients on the importance of modifying cardiovascular risk factors. Smoking cessation, medical therapy, diet, and regular exercise are key areas to be addressed with patients and their families.

**Nursing Outcomes**

In a critique of the literature on nursing outcomes and PCI procedures, Leeper provided the following summary. A nurse-sensitive outcome was defined as a result influenced by nursing care. A review of patients in cardiac care units vs telemetry units indicated that most patients were in stable enough condition to be on telemetry units after a PCI procedure. Reduced length of stay and cost, with no significant difference in complication rates, was noted.

Delayed removal of sheaths placed patients at greater risk for complications. Complication rates associated with sheaths removed by nurses did

---

**Table 6 Continued**

<table>
<thead>
<tr>
<th>Category</th>
<th>Before procedure</th>
<th>After procedure, day 0</th>
<th>1 Day before discharge</th>
<th>Expected outcomes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Psychosocial needs</td>
<td>Encourage patient and patient’s family to discuss anxieties and concerns related to the procedure</td>
<td>Reassure patient and patient’s family</td>
<td>Monitor patient’s activity: bed rest with affected extremity straight for specified period ordered and then progression in activity</td>
<td>Remind patient of activity limitations (eg, avoid bending affected site for 24-48 hours)</td>
</tr>
<tr>
<td>Patient/family education</td>
<td>Review cardiac catheterization and percutaneous coronary procedure</td>
<td>Encourage successful coping strategies</td>
<td>Instruct patient to notify nurse of chest or back pain, abdominal pain, bleeding, or discomfort at the access site</td>
<td>Teach patient to assess the puncture site</td>
</tr>
<tr>
<td></td>
<td>Provide hydration the day before the procedure</td>
<td></td>
<td>Initiate teaching of basic disease pathophysiology, type of procedure performed, and postprocedure routine</td>
<td>Review discharge medications</td>
</tr>
<tr>
<td></td>
<td>Ensure patient has nothing by mouth after midnight</td>
<td></td>
<td></td>
<td>Reinforce importance of mandatory dual antiplatelet therapy after stent procedures</td>
</tr>
<tr>
<td></td>
<td>Obtain informed consent from patient</td>
<td></td>
<td></td>
<td>Resume treatment with metformin per institution’s protocol</td>
</tr>
<tr>
<td></td>
<td>Provide patient and family with opportunities to ask questions</td>
<td></td>
<td></td>
<td>Reinforce lifestyle changes for modifying cardiovascular risk factors</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Use of appropriate coping mechanisms by patient and patient’s family members</td>
</tr>
</tbody>
</table>

| Discharge planning | Address patient’s need for driver before and after the procedure | Refer patient to social worker or appropriate resources, if indicated | Arrange follow-up care and appointments before discharge | Patient discharged to home with understanding of planned follow-up care |
| | | | Confirm transportation arrangements | |
| | | | Refer patient for cardiac rehabilitation, as indicated | |
| | | | | |

**Abbreviation:** ECG, electrocardiogram.
not differ from the rates for sheaths removed by physicians. Studies suggested that the time required to achieve hemostasis was shorter with mechanical compression than with manual compression. The incidence of hematoma formation was higher with the use of Femostop than with manual compression. No evidence indicated that sandbags were effective in supplying sufficient pressure to control bleeding.

Continuous ST-segment monitoring was useful in detecting acute coronary artery closure. The lead showing the greatest ST-segment deviation during the PCI procedure was beneficial in detecting acute ischemic events. Keys to avoiding bleeding complications included meticulous attention to the access site and recognition of predisposing factors (eg, insufficient duration of pressure to obtain hemostasis).

Leeper concluded that there was a lack of standardized care. This lack was partly attributed to the limited nursing research on PCI. Most PCI practice guidelines to date are based on expert opinion. Research has shown that many nursing interventions are not research based, confirming the need for clinical research on PCI. Nurses are in a key position to recognize areas of practice that need further research and to evaluate outcomes in nursing practice.

**Summary**

PCI procedures have undergone major changes since first introduced in the 1970s. In order to ensure that nurses provide quality care to patients who have PCI procedures, knowledge and skill must keep pace with technology and evidence-based practices.

Now that you’ve read the article, create or contribute to an online discussion about this topic using eLetters. Just visit http://ccn.aacnjournals.org and click “Respond to This Article” in either the full-text or PDF view of the article.

Financial Disclosures

None reported.

**References**

28. Barman N, Bhatt DL. Antithrombotic ther-
Management of Patients After Percutaneous Coronary Interventions

**Table** Other percutaneous coronary interventions and adjunct procedures

<table>
<thead>
<tr>
<th>Procedure</th>
<th>Description/comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Atherectomy</td>
<td>Devices are used to cut, shave, or pulverize plaque</td>
</tr>
<tr>
<td></td>
<td>Directional and rotational atherectomy are options for anatomically difficult lesions</td>
</tr>
<tr>
<td></td>
<td>The number of atherectomy procedures has decreased because stents provide a simpler and</td>
</tr>
<tr>
<td></td>
<td>less costly option</td>
</tr>
<tr>
<td>Laser angioplasty</td>
<td>Laser produces ablation of plaque and, via generation of heat and shock waves, plaque disruption</td>
</tr>
<tr>
<td></td>
<td>Adjunctive percutaneous transluminal coronary angioplasty is usually required</td>
</tr>
<tr>
<td></td>
<td>Increased rates of dissection and higher restenosis rates limit use of this technique</td>
</tr>
<tr>
<td>Cutting balloon angioplasty</td>
<td>A device with blades mounted on a specially designed balloon is used to produce clean, longitudinal incisions</td>
</tr>
<tr>
<td></td>
<td>The incised areas are then dilated to compress the plaque</td>
</tr>
<tr>
<td></td>
<td>Procedure is designed for lesions resistant to traditional dilation</td>
</tr>
<tr>
<td>Intravascular brachytherapy</td>
<td>Local intracoronary radiation is delivered within a stent, through a special catheter, to treat in-stent restenosis</td>
</tr>
<tr>
<td></td>
<td>The radiation is withdrawn after a specified time</td>
</tr>
<tr>
<td></td>
<td>Use of this procedure has decreased with the advent of drug-eluding stents</td>
</tr>
<tr>
<td>Intravascular ultrasound</td>
<td>Ultrasound provides a cross-sectional image of the vessel wall</td>
</tr>
<tr>
<td></td>
<td>The procedure is used to evaluate plaque and tissue characteristics and verify results of percutaneous coronary interventions and stent deployment</td>
</tr>
<tr>
<td></td>
<td>The images may reveal possible causes of stent thrombosis (eg, stent underexpansion, malposition, or residual dissection)</td>
</tr>
<tr>
<td>Coronary pressure measurement</td>
<td>Measurement of fractional flow reserve is used to determine the maximal myocardial blood flow in the presence of coronary stenosis</td>
</tr>
<tr>
<td></td>
<td>Flow is measured by using a pressure wire</td>
</tr>
<tr>
<td></td>
<td>Fractional flow reserve &lt;0.75 indicates a significant lesion</td>
</tr>
</tbody>
</table>

**Facts**

- Percutaneous coronary intervention with stents is now the most common coronary revascularization procedure.
- Stented vessels renarrow via neointimal hyperplasia; nonstented vessels, via neointimal hyperplasia and remodeling of the treated vessel.
- The incidence of thrombosis with paclitaxel-eluting stents is almost twice that of thrombosis with sirolimus-eluting stents.
- Complication rates do not differ between manual and mechanical compression.
- Early sheath removal decreases the incidence of vascular and bleeding complications.
- Keys to avoiding bleeding complications include meticulous attention to the access site and recognition of predisposing factors.


This article and an online version of the CE test may be found online at http://ccn.aacnjournals.org.
1. The left circumflex artery supplies which branches of the heart?
   a. The anterior fascicle
   b. Intraventricular septum
   c. The obtuse marginal
   d. The anterior fascicle of the left bundle branch

2. Which of the following arteries may be a source of collateral circulation between the right and left coronary systems?
   a. The first branch of the right coronary artery
   b. The posterior descending artery
   c. The ramus intermedius
   d. The left circumflex artery

3. Which of the following statements is true regarding drug-eluting stents?
   a. Were developed to inhibit the response to injury
   b. Deliver a therapeutic level of anti-inflammatory drugs
   c. Contain sirolimus or paclitaxel
   d. All of the above

4. Restenosis typically occurs within what time frame after intervention?
   a. 30 days
   b. 3-12 months
   c. 24 hours
   d. 12-18 months

5. Acute stent thrombosis usually occurs within what time frame after stent placement?
   a. 3 to 12 months
   b. 45 days
   c. 24 hours
   d. 12-18 months

6. What was the most important predictor of very late stent thrombosis?
   a. Inappropriate use of dual therapy
   b. Use of biodegradable stents
   c. Premature discontinuation of antiplatelet therapy
   d. Essential thrombocytopenia

7. Up to what percentage of patients may experience chest pain after percutaneous coronary intervention (PCI)?
   a. 25%
   b. 65%
   c. 50%
   d. 35%

8. Which of the following are 2 potential causes of chest pain after PCI?
   a. Side branch occlusion and prolonged bed rest
   b. Abrupt vessel closure and contract induced nephropathy
   c. Pseudoaneurysms and arteriovenous fistula
   d. Transient coronary spasm and distal embolization of debris

9. What is the traditional recommendation for magnetic resonance imaging after PCI with stent placement?
   a. 8 weeks
   b. 6 months
   c. 12 weeks
   d. 8 days

10. What is the minimum time for chair or bed rest for patients with brachial artery puncture sites?
    a. 2 hours
    b. 4 hours
    c. 8 hours
    d. 12 hours

11. Which of the following drugs increases the risk of lactic acidosis if taken within 48 hours of PCI?
    a. Glipizide
    b. Metformin
    c. Pioglitazone
    d. Glimepiride

12. Which of the following vascular closure devices could lead to acute leg ischemia if accidentally injected into the femoral artery?
    a. Collagen plugs
    b. Topical hemostasis patches
    c. Suture-mediated devices
    d. Biosealant

13. Which of the following is used to verify results of PCI and stent deployment?
    a. Coronary pressure measurements
    b. Ultrasound
    c. Laser angioplasty
    d. Brachytherapy

14. Unexplained hypotension, ipsilateral flank pain, and abdominal distention are signs of which of the following?
    a. Retroperitoneal hematoma
    b. Atheroembolism
    c. Pseudoaneurysm
    d. Dissection

Test ID: C085  Form expires: October 1, 2010  Contact hours: 1.5  Fee: AACN members, $0; nonmembers, $11  Passing score: 11 correct (78%)  Category: A, Synergy CERP A
Test writer: Laura McNamara, RN, CNS, MSN, CCRN, CCNS

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