When most nurses think of caring for a patient who has had a percutaneous coronary intervention (PCI), they usually expect a straightforward recovery after the procedure. Thousands of coronary revascularizations are done via various techniques involving balloons, stents, and devices to remove plaque and thrombus. These procedures are generally known as PCIs. After PCIs, nurses monitor vital signs, integrity of the groin site, and circulation in the extremities, and they watch for any chest pain after the procedure, all while maintaining the patient with a period of flat bed rest, drug infusions, fluid intake, and monitoring of urine output.

Most patients walk successfully after the prescribed bed rest, are given instructions on self-care, and are discharged within 24 hours. However, a small group of patients have serious, potentially life-threatening vascular complications after PCIs. These complications can turn a straightforward recovery into...
a catastrophe in which nurses must use critical assessment skills to detect the problem and provide rapid intervention.

More than 500,000 PCIs are performed annually in the United States. Although the procedure is generally safe, complications do occur. For example, the incidence of vascular complications ranges from 1% to 14% in reported studies. These complications may necessitate longer stays and more complex treatment such as surgical repair or blood transfusions. New drugs used to decrease the incidence of restenosis (e.g., glycoprotein IIb/IIIa receptor inhibitors) can increase the risk of bleeding through their inhibitory effect on platelet aggregation. The rate of vascular complications is higher in patients with PCIs involving stents, atherectomies, or thrombolytic therapy than in other PCI patients.

Many studies have been done to determine the risk factors for vascular complications. The most common factors are older age, female sex, and low body weight. In addition, other factors may increase the risk, such as chronic illnesses, type of procedure, and types of drugs administered during the procedure (Table 1). Every complication has the potential to increase patients’ pain, length of stay, cost, further morbidity, and the rate of mortality.

### Crossing Boundaries: Regional Quality Improvement

In 1997, a group of hospitals throughout Michigan started a unique collaborative to improve quality of care for patients undergoing coronary intervention through aggressive collection of data and timely sharing of risk-adjusted data. Information from more than 100,000 consecutive cases has been collected from 17 sites since the inception of the consortium. The Blue Cross Blue Shield of Michigan Cardiovascular Consortium (BMC2) sponsored by Blue Cross Blue Shield of Michigan, is the only registry in the United States that audits for accuracy and consecutive completed cases. Queries must be resolved after each site is audited and before data are included in the registry. Specific interventions based on benchmark data are used to improve care outcomes. Quarterly reports are generated that include data from the collaborative, data from each site, and data on the performance of individual physicians. Each hospital has a physician-nurse coordinator team that provides leadership in quality assessment and improvement efforts at the team’s institution. Data on each PCI are collected by the nurse study coordinator on a form provided by the consortium. Data are submitted quarterly to the coordinating center, where the data are analyzed and a report is generated to compare data for the entire collaborative with data for each site. Consortium performance reports offer a continual source of benchmark data for these improvement initiatives at the hospital level. Staff at each hospital can view their hospital’s own complication rates, performance measures, and risk-adjusted mortality rates. Data from the consortium report allow analysis of demographics, therapies pro-

<table>
<thead>
<tr>
<th>Type of factor</th>
<th>Examples</th>
</tr>
</thead>
<tbody>
<tr>
<td>Related to patient</td>
<td>Advanced age&lt;br&gt;Female sex&lt;br&gt;Low body weight (body surface area &lt;1.73 m²)</td>
</tr>
<tr>
<td>Comorbid conditions</td>
<td>Hypertension&lt;br&gt;Diabetes&lt;br&gt;Gastrointestinal bleeding&lt;br&gt;Atrial fibrillation&lt;br&gt;Cardiogenic shock&lt;br&gt;Acute myocardial infarction&lt;br&gt;Ventricular tachycardia or fibrillation&lt;br&gt;Renal failure or elevated creatinine level</td>
</tr>
<tr>
<td>Medications used</td>
<td>Thrombolytic therapy&lt;br&gt;Preprocedural heparin&lt;br&gt;Heparin therapy with &gt;85 units/kg&lt;br&gt;Clopidogrel or glycoprotein IIb/IIIa receptor inhibitors</td>
</tr>
<tr>
<td>Procedural</td>
<td>Long duration of procedure&lt;br&gt;Long sheath-indwelling time&lt;br&gt;Arterial sheath size &gt;7F&lt;br&gt;Previous femoral artery puncture&lt;br&gt;Femoral artery puncture above inguinal ligament&lt;br&gt;Difficulty in compressing puncture site in obese patients</td>
</tr>
</tbody>
</table>
vided in the periprocedural time frame, case mix, patients’ outcomes during and after the procedure, and specific data on lesions and devices at each hospital. Once quality improvement projects are under way, the consortium data can be used as both a benchmark to set goals and a yardstick to measure progress toward the goals. Examples of quality improvement goals include decreasing the frequency of contrast nephropathy, decreasing the number of blood transfusions needed, or decreasing vascular complication rates.

Quality Improvement in Action
Assessing Our Processes of Care

At our institution, where numerous PCI procedures are performed, we noted that vascular complication rates were significantly higher than the rates for the other health centers in the consortium. Common vascular complications include hematoma at the access site, pseudoaneurysm, arteriovenous fistula, arterial laceration requiring surgical repair, and femoral neuropathy3 (Table 2). The standard definition of hematoma within the BMC2 consortium was hematoma at the access site with blood loss that required a transfusion, caused a decrease in hemoglobin level greater than 3.0 g/dL (30 g/L), or prolonged length of stay.11 Our nurse study coordinator analyzed our processes closely and, along with the nurse manager of the catheterization laboratory, led the change process.

In 2001, our process of care for PCI patients lacked consistency and was not evidence based. For example, use of anticoagulants during PCI, sheath removal, and hemostasis at the groin site were all specific to each practitioner and not dictated by a protocol. Although published reports do not document an increase in vascular complication rates with use of vascular closure devices (VCDs), evidence suggests that excessive anticoagulation and the use of VCDs in certain patients can be significant risk factors for complications.8,9,12

We identified the practice patterns that were contributing to our high complication rates and selected 2 major areas on which to focus our improvement efforts: training for VCD deployment and implementing a weight-based anticoagulation protocol during the PCI procedure. Our process improvement team was co-led by the nurse study coordinator and the medical director in partnership with the catheterization laboratory leaders, interventional physicians, nurses, and technicians, and in collaboration with the nursing staff from the inpatient telemetry unit. This group led the change process by closely examining our practices and clinical outcomes and comparing them with benchmark data from other institutions in the consortium.

VCDs have been used since the early 1990s in an effort to maximize effective hemostasis and decrease recovery time after femoral artery puncture.13 Although initial hopes for VCDs included decreasing the frequency of vascular complications, in fact, that goal has not been uniformly reached. The reasons the complication rate has not decreased include the learning curve required for each of the many devices, the use of more anticoagulants during complex interventions, and the shift toward performing interventions in sicker and older patients.8

Our hospital and physician leaders were committed to using VCDs for a number of reasons, including the desire to have patients walk

Table 2 Types of vascular complications

<table>
<thead>
<tr>
<th>Type of vascular injury</th>
<th>Common physical findings</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hematoma</td>
<td>Swelling or bump at or near insertion site due to blood loss at the site of arterial or venous access or due to a perforation of a traversed artery or vein requiring transfusion and/or prolonging hospital stay, and/or causing a decrease in hemoglobin &gt;30 g/L</td>
</tr>
<tr>
<td></td>
<td>Pain in groin with leg movement</td>
</tr>
<tr>
<td></td>
<td>Possible decrease in blood pressure, increased heart rate</td>
</tr>
<tr>
<td>Pseudoaneurysm</td>
<td>Pain or burning in groin or back</td>
</tr>
<tr>
<td></td>
<td>Swelling at insertion site</td>
</tr>
<tr>
<td></td>
<td>Pulsatile mass, bruise</td>
</tr>
<tr>
<td></td>
<td>Ecchymosis</td>
</tr>
<tr>
<td>Arteriovenous fistula</td>
<td>Swelling and pain in groin or leg</td>
</tr>
<tr>
<td></td>
<td>High-output heart failure</td>
</tr>
<tr>
<td></td>
<td>Tachycardia and decreased diastolic blood pressure</td>
</tr>
<tr>
<td>Retroperitoneal hematoma</td>
<td>Moderate to severe back pain</td>
</tr>
<tr>
<td></td>
<td>Possible pain in groin, flank, or lower abdomen</td>
</tr>
<tr>
<td></td>
<td>Tachycardia and decreased blood pressure</td>
</tr>
<tr>
<td>Arterial occlusion</td>
<td>Pain, pallor, paresthesia, pulselessness of leg</td>
</tr>
<tr>
<td>Femoral neuropathy</td>
<td>Pain, tingling at groin site</td>
</tr>
<tr>
<td></td>
<td>Numbness at site or down leg</td>
</tr>
<tr>
<td></td>
<td>Difficulty moving leg</td>
</tr>
<tr>
<td></td>
<td>Decreased patellar tendon reflex</td>
</tr>
</tbody>
</table>
sooner, decrease manual compression time, and minimize recovery time in our rapidly growing interventional program, which has a limited number of beds. In addition, our patients reported markedly greater satisfaction with the VCDs than with manual compression in terms of comfort and decreased time required for bed rest. Before 2001, a variety of VCDs from 4 manufacturers were used. Training was often done by the vendors at the time of deployment or was “demonstrated” by one staff member to another (see Sidebar).

As we analyzed our use of VCDs after sheath removal, we noted that nursing and cardiovascular technicians in the catheterization laboratories were not uniformly trained or certified in either sheath removal or techniques for deploying VCDs. (Although sheath removal was primarily done by cardiovascular technicians or physicians, nurses were trained in the skill because they shared off-hours on-call responsibilities.) VCDs were becoming more commonly used, and each device required specific training, but we had no uniform education plan or certification process in place. Training was provided either by the vendor at the time of deployment or by one technician demonstrating use of the device to another. Finally, an inpatient staff nurse often had to provide care to a patient with a “new” VCD, without benefit of specific training on the device. This situation was an important concern for the inpatient nursing staff with respect to patients’ safety.

Compared with others in the consortium, our hospital had a high frequency of vascular complications: our highest rate was 6.5% at the end of 2001, compared with a mean rate for the consortium of 3.1%. Our rates were among the highest for vascular complications, transfusions, and morbidity associated with vascular complications (surgical repair, length of stay). Notably, we also had the highest use of VCDs (90% of our patients had VCDs). The range of VCD use in the consortium was from 0% to 90% (mean 20%). Once this information was shared with our interventional team, the decision to improve was strongly supported.

VCDs: The Intervention

Perhaps the most helpful action after our assessment was complete and our commitment to improve was unanimously approved was to limit the number of types of VCDs that were used in our laboratories. On the basis of physicians’ recommendations, our product committee selected a single vendor of a device that uses an absorbable collagen plug who agreed to provide constant ongoing education and support as technicians and physicians were learning.

We developed a certification process that required each new staff member (physicians and technicians) to demonstrate a number of successful VCD deployments before the member was allowed to manage VCDs independently. Further, we had our cardiovascular technicians do all VCD deployments, and the technicians are recertified annually via a written assessment of competency. The assessment covers selection of appropriate patients for VCDs and how to manage complications during and after deployment of the VCD. By limiting the number of personnel who had to be certified and allowing those who were certified to become strongly supported.

Vascular Closure Devices

Vascular closure devices have been developed for dual purposes: to achieve hemostasis reliably and rapidly, thereby allowing the patient to walk again sooner, and to provide an alternative to the current reference standard (manual compression), which is physically taxing and labor intensive for caregivers and uncomfortable for patients.

Many types of devices that use a variety of approaches are available to achieve hemostasis. Some anchor a collagen plug within the artery; others place an extravascular collagen plug. Some devices use a suture or a staple, a sealant gel, or a procoagulant. One device has a balloon catheter that initiates hemostasis and delivers a mixture of procoagulant to the puncture site. Each device comes with a specific delivery system that requires operator training.

A number of devices are currently approved by the Food and Drug Administration. However, no clear evidence of the superiority of any device in terms of effectiveness and safety is apparent at this time. Complications associated with vascular closure devices include hematoma, retroperitoneal bleeding, pseudoaneurysm, late bleeding, and, occasionally, death. These complications are the same as those reported with manual compression.

General guidelines for the use of any vascular closure device include the following:

• Do not use vascular closure devices on patients with double wall punctures. These devices do not close punctures of the posterior wall.
• Weigh the risk of bleeding against the benefits of the device in patients who have received glycoprotein IIb/IIIa receptor inhibitors.
• Monitor the groin site carefully after the percutaneous coronary intervention and deployment of the vascular closure device.
• Follow the manufacturer’s recommendations with respect to deployment of the device and having the patient walk.
expert at the process through repeated performance of the skill, we were able to decrease risks related to selection of patients for VCDs and complications during deployment of VCDs.

Next we expanded our educational efforts to the entire staff. Each physician was given complication rates on the physician’s own patients, and all nurses and technicians in the catheterization laboratory were given the most recent evidence-based information on the VCDs. This information helped the staff select appropriate patients on whom to use the VCDs, thus avoiding some of the more high-risk patients. Each physician’s complication rate included all VCDs that were deployed by technicians. Each physician was responsible for determining the appropriateness of the VCD in each patient and for informing the assigned technician of any anticipated difficulties in the deployment of the device.

Finally, we identified an educational need of the nurses in the inpatient unit where the PCI patients were recovering. Nurses needed to know which VCD was used, and what specific observations were needed after the entire procedure. Nurses also needed to know what to teach patients at discharge about groin care. The nurse managers and educators from the catheterization laboratory and the inpatient telemetry unit partnered to provide a thorough educational effort for the nursing unit. This training included a review of all types of vascular complications with the appropriate nursing assessment and interventions, plus information about VCDs: how they work, what to assess for in terms of impending complications, and how to provide groin care after a VCD is deployed.

Staff feedback after the educational effort was positive, with most nurses indicating an increased comfort level in providing groin care after VCD deployment and detecting and managing vascular complications after PCI.

Anticoagulation
The Problem
A delicate balance is required when anticoagulation with heparin and glycoprotein IIb/IIIa inhibitors such as abciximab (ReoPro), eptifibatide (Integrilin), or tirofiban (Aggrastat) is done. On the one hand, antiplatelet action is necessary to maintain the patency of the stents that are used in most cases. On the other hand, excessive anticoagulation is associated with a high risk of vascular complications and bleeding.14

When we assessed our practice, we found variation in the amount of heparin administered as a bolus during the PCI. For example, some physicians would use a bolus of 10000 units of heparin on every patient and would follow the initial bolus with subsequent boluses during the PCI. In our catheterization laboratory, we used activated clotting time (ACT), a point-of-care test, to assess the effect of heparin because the ACT test is inexpensive and yields a rapid result. In the inpatient unit, we measured activated partial thromboplastin time (aPTT). Analyses of aPTT for general monitoring of heparin therapy are done in the central laboratory.

Both methods of assessing anticoagulation are clinically useful.15 Although ACT testing was readily available in our catheterization laboratory, we did not routinely check the ACT at specified intervals. In fact, the femoral sheaths were routinely removed at the end of the procedure without ACT being checked.

On the basis of the recently published evidence, we determined that our practice of giving heparin was not up to current standards, which recommend that heparin dosing be weight based.16-17 We retrospectively reviewed cases in which PCI was done. A weight-based calculation of heparin dose was done for each patient and compared with the actual dose given. ACTs were tracked, and patients who had received heparin before the PCI were identified. This quality analysis yielded 3 specific areas for improvement: changing heparin administration to follow national guidelines, improving communication between inpatient and laboratory nursing personnel about current heparin administration/discontinuation, and closely monitoring ACT to ensure it is within specific ranges acceptable for sheath removal.18

The Intervention
Over the course of several months, the nurse study coordinator presented the findings of our quality analysis to our physicians during the physicians’ staff meetings. The lead physician for the consortium also provided data from recent research trials indicating that heparin dose should be based on the patient’s weight and closely monitored by measuring ACTs. Physicians agreed to follow a standard protocol that we developed in our multidisciplinary improvement work group. As part of the consortium, our physicians were aware that our hospital had the highest rate of vascular complications, and this was a motivating factor for helping us make change.
Our protocol was simple. Using a Plan, Do, Study, Act (PDSA) quality improvement process, we began with a standardized dose of heparin as a bolus at a maximum of 70 units per kilogram of weight. Staff in the inpatient units were asked to send the medication administration record to the catheterization laboratory with each patient so that we could see when heparin was discontinued before the procedure. Nurses in the catheterization laboratory checked ACTs at the beginning of the procedure for those patients who were already taking heparin.

Patients who were not already receiving heparin were given a bolus dose once the lesion was visualized and the decision to do an intervention was made. When the ACT was between 200 and 300 seconds, the stent was deployed. A repeat ACT test was done with guidewire removal to determine if the sheath could be removed. If the ACT was greater than 250 seconds, we would retest at 10-minute intervals until it was less than 250 seconds, at which point the sheath was removed and the VCD deployed. In order to help ensure compliance with this new protocol, a PDSA analysis was done. This common quality improvement technique, popularized by W. Edwards Deming, is used to clarify the goals of improvement, test actual interventions, and revise efforts accordingly to achieve the desired results.

Our PDSA cycle was led by the nurses, who recorded the heparin dosages, the ACT at the time of sheath removal, and the time of VCD deployment for each procedure (Table 3). Initially the daily results were given to the study coordinator, who collated them and put them into a report format that was shared with physicians. Physicians who removed sheaths before the ACT level was within the acceptable range were able to see their results along with a reminder about the protocol. Results were also shared with the medical director.

Finally, as each patient was transferred to the care of the inpatient nurse, a joint inspection of the patient’s groin was done to check for any oozing, hematoma, or discoloration at the insertion site. The nurse from the catheterization laboratory reported to the inpatient telemetry nurse the time and dosage of heparin given during the procedure and the last ACT along with the other pertinent information about the case. Because ACTs were often still elevated, it was important for the receiving nurse to monitor the patient for bleeding. It was the responsibility of the telemetry nurse to maintain the prescribed period of bed rest, assess the patient’s groin before and after the patient walked, and provide discharge instructions.

**Results**

When we started our effort, our vascular complication rate was 6.5%. This rate was among the highest in

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**Table 3** Plan, Do, Study, Act plan for sheath removal based on the protocol for activated clotting time (ACT)

<table>
<thead>
<tr>
<th>Cycle 1</th>
<th>Plan: Follow protocol to remove sheath when ACT is less than 250 seconds after percutaneous coronary intervention</th>
<th>Do: Nurse records ACT at end of procedure; sheath is removed and time is recorded</th>
<th>Study: Number of cases are identified in which sheath is removed before ACT is less than 250 seconds</th>
<th>Act: Results are given to individual physicians and quality improvement team (medical director and study coordinator)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cycle 2</td>
<td>Plan: Use feedback and reminders to help physicians wait for ACT level to decrease before removing sheath</td>
<td>Do: Nurse reports ACT level at end of procedure and reminds physician of protocol</td>
<td>Study: Nurse tracks times when ACT is measured and sheath is removed during case</td>
<td>Act: Results are reviewed; individual outliers get direct feedback from medical director</td>
</tr>
<tr>
<td>Cycle 3</td>
<td>Plan: Track ongoing success of ACT monitoring during case and appropriate sheath removal</td>
<td>Do: Sheaths are removed when nurse reports acceptable ACT</td>
<td>Study: ACTs and levels are documented on case history along with times when sheath removed</td>
<td>Act: Positive feedback on results is given to reinforce high-quality practice; monitoring continues as part of effort to improve quality</td>
</tr>
</tbody>
</table>
our 17-hospital consortium, which had a mean vascular complication rate of 3.1%. On the basis of the initial consortium data on our outcomes, we began to “drill down” to find variations in practice and analyze complications. Our improvement efforts began in the spring of 2002, when initial data were presented to our cardiology department and hospital leaders. Throughout 2002, we developed protocols, collected data, and prepared for our interventions. In March 2003, we rolled out our new protocols, provided education to the staff, and began to collect data on compliance with the new protocols. By January 2004, our vascular complication rate was 2.5%, which was much closer to the consortium’s mean rate of 1.8%. We think that the education of the staff, the multidisciplinary partnering to develop evidence-based protocols for anticoagulant therapy, the certification of staff in VCD deployment, and the monitoring of and feedback on our performance were key factors in the success of our efforts.

Continuous Improvement

Although we saw dramatic improvement after the implementation of our protocols and the close monitoring and data collection, we wanted to continue to improve. Ongoing efforts include more specific education about the interventions, devices, and protocols used during PCIs for new staff nurses in the inpatient and short-stay units. Catheterization nurses continue to monitor adherence to the protocol, especially with respect to heparin dosing. Individual physicians’ performance reports on vascular complication rates are provided quarterly. Staff from the catheterization laboratory are also provided on a quarterly basis with data about our performance on critical quality indicators, including vascular complication rates. We continue to use our consortium data as a benchmark. Nurses (including the manager of the catheterization laboratory, the study coordinator, and the nursing staff) continue to direct improvement efforts for every aspect of the care of patients undergoing PCI.

Case Study

D.J., a 63-year-old woman had non–insulin-dependent diabetes, hypertension, and a 40 pack-year history of cigarette smoking. She had a positive stress test after initially telling her primary physician that she had shortness of breath, fatigue, and back pain. She was scheduled for a diagnostic heart catheterization and possible PCI. During the procedure, a lesion was visualized that caused a 75% stenosis of the mid left anterior descending coronary artery. On the basis of her weight of 43 kg, she was given 3000 units of heparin as an intravenous bolus, and the lesion was crossed and stented with a 2.5-mm stent.

The patient received a bolus and then a continuous infusion at 2 μg/kg per minute of eptifibatide and 300 mg of clopidogrel by mouth. ACT at the end of the procedure was 198 seconds, and because the ACT was less than 250 seconds (as required by our protocol), the technician removed the sheath and placed a collagen-type VCD. D.J. recovered briefly in the catheterization laboratory’s recovery unit and then was sent to the cardiac unit, where her infusion of eptifibatide was maintained at 2 μg/kg per minute for 18 hours. When she arrived in the inpatient unit, a joint assessment of her groin by the receiving nurse and the nurse from the catheterization laboratory confirmed no bleeding or hematoma. After 4 hours of bed rest, D.J. was able to walk. The groin site remained free of oozing or bleeding. D.J. was discharged the next morning with specific written instructions for groin care, activity, and follow-up appointments, as well as counseling about stopping smoking and a review of all medications.

Conclusion

PCIs continue to occupy an important place in the treatment of coronary disease and acute coronary syndromes. Stents and other intracoronary interventions increase the need for antiplatelet and anticoagulant agents to minimize the risk of restenosis and abrupt closure. A partnership between nurses and physicians to improve care and reduce vascular complications included preventing excessive anticoagulation through weight-based dosing of heparin and close monitoring of ACT. In addition, certification of staff in the use of VCDs and strict adherence to deployment protocols provided uniformity and safety to the processes of sheath removal and groin hemostasis.

In the recovery units, training of nurses about VCDs and the careful assessment of the access site in each patient’s groin helped promote communication and continuity of care. A multidisciplinary approach to protocol development and education that used the PDCA process along with providing regular feedback on outcomes to individual physicians increased awareness and
attentiveness to protocols. Finally, the advantage of participating in a multihospital consortium provided incentive to the entire staff to strive for excellence in quality performance indicators.

References
1. How many percutaneous coronary interventions (PCIs) are performed annually in the United States?
   a. 600,000
   b. 500,000
   c. 400,000
   d. 700,000

2. What is the incidence of vascular complications after PCI in the United States?
   a. 1% to 14%
   b. 5% to 14%
   c. 1% to 16%
   d. 5% to 16%

3. How do new drugs that decrease the incidence of restenosis after PCI increase the risk of bleeding?
   a. By an inhibitory effect on platelet aggregation
   b. Through excessive anticoagulation
   c. Through interruption of the clotting cascade
   d. By elimination of fibrin accumulation

4. Which of the following are the most common risk factors for vascular complications after PCI?
   a. Diabetes, smoking, and body weight
   b. Male sex, excessive body weight, and thrombolytic therapy
   c. Female sex, low body weight, and older age
   d. Female sex, smoking, and chronic illness

5. Which of the following complications are most likely to be seen after PCI?
   a. Hematoma at the site, myocardial infarction, pseudoaneursym, and arterial
   b. Hematoma at the site, myocardial infarction, pseudoaneursym, and arterial
   c. Hematoma at the site, myocardial infarction, pseudoaneursym, and arterial
   d. Hematoma at the access site, pseudoaneursym, stroke, arteriovenous fistula, and

6. What were the 2 areas selected for quality improvement efforts from practice patterns leading to high complication rates for PCI?
   a. Training for vascular closure device (VCD) deployment and implementing a
   b. Sheath removal certification and implementing an evidenced-based heparin protocol
   c. VCD education and deployment
   d. Implementing a weight-based anticoagulant protocol during the PCI procedure

7. Which of the following are the reasons the vascular complications did not decrease with the use of VCDs?
   a. Excessive anticoagulation, earlier ambulation of patients, and inconsistent patient care
   b. Learning curve for VCDs, decreased postprocedure bedrest, and more interventions on older and sicker patients
   c. Sicker and older patients, obesity, and the use of more anticoagulants
   d. Learning curve for VCDs, use of more anticoagulants during complex procedures, and more interventions on sicker and older patients

8. What was the most helpful action taken to improve VCD complications?
   a. Limit the number of types of VCDs
   b. Allow physician selection of VCDs
   c. Limit the patient criteria for VCDs
   d. Allow the product committee to select the VCDs

9. Which of the following did all the VCD deployments after the improvement plan was put in place?
   a. Physicians
   b. Cardiovascular technicians
   c. Nurses
   d. Nurses, physicians, and cardiovascular technicians

10. Which of the following were the components of the VCD intervention for quality improvement of complications?
    a. Limit number of VCD types, VCD certification, limit the number certified, and physician and nursing education
    b. Single vendor for VCDs and VCD certification for cardiovascular technicians, physicians, and nurses annually
    c. Physician decision on candidates for VCD and type of VCD, and physician and nursing education
    d. VCD certification for cardiovascular technicians and physicians annually and physician order for VCD use and type

11. What 3 areas of quality improvement of PCI complications related to anticoagulation were identified?
    a. Weight-based heparin use and improved communication between laboratory and nursing personnel about heparin administration/discontinuation
    b. Monitor activated clotting time (ACT) for ranges acceptable for sheath removal and weight-based anticoagulation
    c. Weight-based heparin administration according to national guidelines and monitor ACT for ranges acceptable for sheath removal and weight-based anticoagulation
    d. Weight-based heparin administration according to national guidelines, improve communication between laboratory and nursing personnel about heparin administration/discontinuation, and monitor ACT for specific ranges acceptable for sheath removal

12. Which of the following were included in a partnership between nurses and physicians to reduce vascular complications?
    a. Preventing excessive anticoagulation through weight-based dosing of heparin and close monitoring of ACT
    b. Monitoring ACT to a specific range for sheath removal
    c. Administering weight-based anticoagulation and monitoring partial thromboplastin times
    d. Close monitoring of ACT and partial thromboplastin times before sheath removal

Test answers: Mark only one box for your answer to each question. You may photocopy this form.

1. 2. 3. 4. 5. 6. 7. 8. 9. 10. 11. 12.  
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Decreasing Vascular Complications After Percutaneous Coronary Interventions: Partnering to Improve Outcomes
Sandra Lins, Denise Guffey, Sharon VanRiper and Eva Kline-Rogers

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