Use of Peripherally Inserted Central Catheters As an Alternative to Central Catheters in Neurocritical Care Units

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Background Patients in neurological critical care units often have lengthy stays that require extended vascular access and invasive hemodynamic monitoring. The traditional approach for these patients has relied heavily on central venous and pulmonary artery catheters. The aim of this study was to evaluate peripherally inserted central catheters as an alternative to central venous catheters in neurocritical care settings.

Methods Data on 35 patients who had peripherally inserted central catheters rather than central venous or pulmonary artery catheters for intravascular access and monitoring were collected from a prospective registry of neurological critical care admissions. These data were cross-referenced with information from hospital-based data registries for peripherally inserted central catheters and subarachnoid hemorrhage.

Results Complete data were available on 33 patients with Hunt-Hess grade IV-V aneurysmal subarachnoid hemorrhage. Catheters remained in place a total of 649 days (mean, 19 days; range, 4-64 days). One patient (3%) had deep vein thrombosis in an upper extremity. In 2 patients, central venous pressure measured with a peripherally inserted catheter was higher than pressure measured concurrently with a central venous catheter. None of the 33 patients had a central catheter bloodstream infection or persistent insertion-related complications.

Conclusions Use of peripherally inserted central catheters rather than central venous catheters or pulmonary artery catheters in the neurocritical care unit reduced procedural and infection risk without compromising patient management.

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for measurement of CVP in an operative situation confirmed that PICCs are a reliable alternative to traditional CVCs for CVP measurement.

For CVP monitoring, a catheter lumen of 20 gauge or larger is recommended. The Power PICC (Bard Access Systems, Inc, Salt Lake City, Utah) is preferred for patients with subarachnoid hemorrhage because these patients often have computed tomography (CT) angiography, and this catheter is approved for power injection of CT contrast agents.

Relatively little has been reported about the prolonged use of PICCs in adult neurosurgical intensive care patients. PICCs are an effective tool in outpatients for long-term parenteral nutrition, prolonged administration of antibiotics, and administration of chemotherapeutic agents, but whether or not PICCs will be a safe and reliable alternative device for long-term delivery of intravenous therapy and nutritional formulas and for measurement of CVP in neurointensive care patients is unclear.

When triple-lumen PICCs were approved by the Food and Drug Administration in October 2005, Kaiser Permanente Sacramento Medical Center, Sacramento, California, largely switched to these peripherally placed catheters for the added benefits of CVP monitoring in addition to reliable vascular access. Subsequent development of PICCs (eg, Power PICC) that can safely withstand high flow-rate injections for CT imaging (eg, CT angiography) made the devices more useful than before. At the time of the study reported here, several devices were approved by the Food and Drug Administration for use, including the single- and dual-lumen Poly Per-Q-Cath PICC, 5F and 6F dual-lumen Power PICC, and 6F triple-lumen Poly Per-Q-Cath (all Bard Access Systems, Inc).

We report our experience with the transition to using PICCs for CVP monitoring and reliable vascular access without the risks of traditionally placed CVCs.

**Methods**

The study was a prospective descriptive study of the first 35 patients in whom PICCs were used as an alternative to CVCs for long-term venous access and CVP monitoring in a neurological ICU. The study was approved by the appropriate institutional review board. Data were collected from a prospective registry of neurological ICU admissions at the medical center.

**Devices**

Devices approved for use in the study included the 6F triple-lumen Per-Q-Cath, 4F Per-Q-Cath, Solo 5F triple-lumen Power PICC, Solo 5F dual-lumen Power PICC, and Solo 4F single-lumen Power PICC. Catheter selection for each patient was based on recommended guidelines for appropriate catheter gauge, vessel lumen diameter, and catheter availability.

**Placement**

All PICCs were placed by a specialized team of experienced nurses who used sterile technique. For bedside insertion, ultrasound for vein localization and the modified Seldinger technique were used. Before insertion, patients were assessed, including history of insertion of central catheters, presence of a pacemaker, history of mastectomy, and diameter of the vein to be used for access. Triple-lumen PICCs were...
placed in veins with a diameter of 0.5 cm or larger. Placement in the cephalic veins was avoided because of the high risk for thrombosis. The brachial or basilic vein was selected on the basis of the suitability of the site.

Maximal barrier precautions were used. The insertion site was cleansed with a 2% chlorhexidine gluconate 70% isopropyl alcohol solution (ChloraPrep, Enturia, Inc, Leawood, Kansas) and allowed to dry. An antibiotic-impregnated disk (Biopatch, Ethicon, Inc, Somerville, NJ) was placed directly over the site after insertion of the catheter. The catheter was secured by using a stabilizing device (Statlock, Bard Medical Division, Covington, Georgia), and an occlusive dressing was applied. After 24 hours the site was redressed by using a new antibiotic-impregnated disk and a transparent dressing.

**Data Collection and Analysis**

All data collection was done according to the guidelines of the institutional review board. Study data were collated, patient identities were removed in accordance with guidelines of the Health Insurance Portability and Accountability Act, and the resultant information was entered into an Excel spreadsheet for data analysis. Descriptive statistics were calculated by using standard formulas.

**Results**

A total of 35 patients were enrolled in the study during a 20-month period. Of these, 2 were excluded because of incomplete data. The final sample consisted of 33 patients. Most of the patients had intracranial bleeding such as subarachnoid hemorrhage, intracranial hemorrhage, or subdural hematoma (Table 1). Mean duration of PICC access was 19 days. Catheters remained in place a total of 649 catheter days. All patients in the study received subcutaneous heparin as prophylaxis for deep vein thrombosis (DVT) within 48 hours of admission to the ICU unless severe thrombocytopenia or excessive bleeding prohibited use of the drug.

One patient experienced an upper extremity DVT resulting in catheter removal (Table 2). This patient was an obese woman with Hunt Hess grade V subarachnoid hemorrhage and minimal upper extremity movement with trace extensor posturing to pain only. The upper extremity edema resolved without further treatment, and long-term anticoagulation was not required. The PICC was removed unintentionally by 1 patient as a result of the patient’s cognitive impairment. Because of persistent fever of unknown source, 3 patients had PICCs removed to exclude catheter-related bloodstream infection. Cultures of blood samples or specimens obtained from the catheter tip were negative for microorganisms for all 3 patients.

Among the patients with PICCs, 11 also had a second central catheter present for comparison of accuracy of CVP measurements. The central catheters were placed emergently for acute management at the time of admission to the ICU. The PICC nursing staff does not provide 24-hour

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Valuea</th>
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<tbody>
<tr>
<td>Male sex</td>
<td>11 (37)</td>
</tr>
<tr>
<td>Age, mean (SD), y</td>
<td>62 (16.5)</td>
</tr>
<tr>
<td>Subarachnoid hemorrhage</td>
<td>15 (45)</td>
</tr>
<tr>
<td>Encephalopathy</td>
<td>7 (21)</td>
</tr>
<tr>
<td>Intracerebral hemorrhage</td>
<td>6 (18)</td>
</tr>
<tr>
<td>Other</td>
<td>3 (9)</td>
</tr>
<tr>
<td>Subdural hematoma</td>
<td>2 (6)</td>
</tr>
<tr>
<td>Length of stay, mean (SD), d</td>
<td>25.6 (12.8)</td>
</tr>
<tr>
<td>Discharge to home</td>
<td>15 (48)</td>
</tr>
<tr>
<td>Discharge to skilled nursing facility</td>
<td>9 (27)</td>
</tr>
<tr>
<td>Discharge to rehabilitation center</td>
<td>4 (12)</td>
</tr>
<tr>
<td>Died</td>
<td>5 (15)</td>
</tr>
<tr>
<td>Days with peripherally inserted central catheter, mean (SD)</td>
<td>19 (6)</td>
</tr>
</tbody>
</table>

a Values are No. (%) of patients unless otherwise indicated.

<table>
<thead>
<tr>
<th>Results</th>
<th>% of cases</th>
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<tbody>
<tr>
<td>Insertional injury</td>
<td>0</td>
</tr>
<tr>
<td>Bloodstream infection</td>
<td>0</td>
</tr>
<tr>
<td>Catheter-associated deep vein thrombosis</td>
<td>3</td>
</tr>
</tbody>
</table>

a Data from Taylor and Paladiri.2
on-call personnel to establish intravenous access, so the PICCs were placed by hospital day 3 electively.

Observations were made when CVCs and PICCs were placed concurrently. Overall accuracy of CVP monitoring in the entire sample of 33 patients cannot be reported because only a subset of patients was monitored by using both methods. Erroneous measurements were detected for 2 PICCs. No injuries related to insertion of a PICC or central catheters occurred.

Two patients had spontaneous nonsustained ventricular tachycardia after a PICC insertion (Figure 1). In both instances, the tachycardia ceased when the catheters were repositioned.

Case Illustration

A 78-year-old woman initially had a headache and lethargy that progressed to decerebrate posturing and coma. CT of the brain showed extensive subarachnoid hemorrhage with posterior fossa predominance and hydrocephalus. Her score on the Glasgow Coma Scale was 4 (E1VTM2), and she was grade 5 on the Hunt Hess scale. Her condition was stabilized with intubation and external ventricular drainage. Systolic blood pressure was reduced by 30 points in the left arm compared with the right arm.

Findings on brain CT angiography suggested an aneurysm at the vertebrobasilar junction, and this abnormality was confirmed with catheter angiography (Figure 2A). The aneurysm was flow-related due to left subclavian steal from a severe proximal left subclavian stenosis. After 4 days, the patient’s neurological status improved and she could follow commands intermittently. She underwent stenting of the left subclavian stenosis, coil embolization of the distal right vertebral artery, and occlusion of the flow-related aneurysm with preservation of the right posterior inferior cerebellar artery. CVP monitoring with a Power PICC and minimally invasive cardiac output monitoring (Vigileo monitor, Edwards Lifesciences, Irvine, California) via either femoral artery or radial artery waveform (Figure 2B) during the patient’s ICU stay was used to guide fluid management and facilitated safe resolution of pulmonary vascular congestion without excessive diuresis.

The patient initially had pulmonary vascular congestion with moderately elevated CVP but adequate cardiac output. Periodic surveillance CT and magnetic resonance angiography were used to monitor for vasospasm. Avoidance
of excessive diuresis was a clinical goal both to prevent nephropathy associated with contrast medium and to avoid dehydration, which can increase the risk for vasospasm.

The patient’s neurological status improved gradually during a 2-month period. She was discharged to a community skilled nursing facility for subacute rehabilitation initially and then to home at 3-month office follow-up. She currently is living at home with her family. She is self-sufficient with basic activities of daily living, can walk independently within her home but not in the community, and needs assistance with instrumental activities of daily living (modified Rankin score of 3: moderate disability but able to walk).

Discussion

We report our initial experience with the use of PICCs rather than traditional central catheters. Some patients in the sample also underwent less invasive cardiac output monitoring (Vigileo monitor); the results of that monitoring are not included here. Other researchers have reported few catheter-related complications such as insertional injury and catheter-related bloodstream infection with PICCs. In the year preceding our study, 3 insertion-related complications associated with central catheters occurred: 1 subclavian artery catheterization and 2 pneumothoraces. These complications had no long-term sequelae. None of our patients had catheter-related bloodstream infection. This lack of complications may be related to the use of a specialized nursing team that managed the insertion of PICCs and supervised subsequent catheter care or the length of treatment.12,13 Catheter-associated bloodstream infection may be less common with PICCs than with CVCs, and the PICCs can still be used for hemodynamic monitoring, volume replacement, phlebotomy, and administration of medications. Patel et al performed a retrospective review of a 4-year period in which traditional central catheters were replaced with PICCs in ICU patients to capitalize on the advances in catheter technology, reduce risks associated with catheter insertion, and provide a cost-effective alternative to central catheters. By the third intervention year, nearly two-thirds of all hemodynamic monitoring was accomplished with PICCs and the rate of catheter-related bloodstream infection had decreased by 81% (P < .001).

In another large-scale study in which PICCs were compared with traditional CVCs in the ICU, the median time to infection was significantly longer (P = .03) with PICCs (23 days) than with traditional CVCs (13 days).

Catheter-associated DVT has become a concern with increased use of PICCs.7,10,12,14 Few data are available on upper extremity DVT; most of the observational studies have focused on lower extremity DVT. In one study, compared with nonobese patients, obese patients had a 23-fold increase in upper extremity DVT. Other risk factors for lower extremity DVT include presence of a hypercoagulable state, recent major surgery, thrombogenic effects of cancer, and prolonged immobility. Use of prophylactic anticoagulants can reduce the incidence of venous thrombosis associated with PICCs.15 Neurosurgical ICU patients may be among the groups at highest risk for venous thrombotic events because of prolonged immobility due to neurological injury, underlying tumors, and early contraindications to anticoagulation therapy. The pathogenesis of upper extremity DVT may be multifactorial, related to direct endothelial trauma caused by the presence of the catheter, an underlying hypercoagulable state, and reduced venous return in paretic arms. One of the most important variables may be correct lumen-to-catheter sizing.13 The patient in our study who had DVT was an obese woman with Hunt Hess grade V aneurysm and a score of 6 on the Glasgow Coma Scale. As our experience with PICC has increased, we have learned to replace PICCs in nonparetic arms and to use small, single-lumen catheters in patients at high risk for upper extremity DVT.

As expected, insertion-related complications of PICCs were favorable compared with complications associated with insertion of central catheters. We had no complications related to arterial puncture or pneumothorax from PICC placement. Insertion-related complications associated with placement of central catheters decreased from 3 in the year before our study to zero with the increased use of PICCs. Two patients with nonsustained ventricular tachycardia after PICC insertion were asymptomatic, and the dysrhythmias resolved with repositioning of the catheter. Spontaneous nonsustained ventricular tachycardia due to drifting of the PICC from the superior vena cava to the right atrium or the right ventricle after
PICC insertion has been documented in other medical centers. In our patients, the tachycardia and cardiomyopathy were greater when the reduction in bloodstream infections was considered.

Two previous studies documented the reliability of CVP measurement with PICCs, and we did not seek to directly compare CVCs with PICCs. Retrospectively, we found that the 2 PICCs with erroneously high CVP measurements had in-line needless access caps, which were associated with falsely high measurements in the previous reports. Reliable CVP data depend on a continuous, patent column of fluid traveling like a wave from the catheter tip to the pressure transducer. Interferences such as kinks, air, or needless injection caps may dampen the waveform or alter the signal.

In conclusion, patients in neurological ICUs often have lengthy stays and require extended periods of vascular access. As neurocritical care providers strive to lower complication rates related to vascular access and bloodstream infections, less invasive approaches such as use of PICCs, use of minimally invasive cardiac monitoring devices, and dedicated vascular access nursing teams will become increasingly important elements in the effort to advance patient care.

References

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