Peripheral inserted central catheters (PICCs) are used increasingly for intravenous administration of medications, solutions, and nutrition in hospital and ambulatory care settings. It has been suggested that PICCs are easier to insert than other central venous catheters (CVCs), have fewer insertion-related complications, and may be inserted by specialist nursing teams. Recent evidence suggests that PICCs have an increased rate of deep vein thrombosis (DVT) in comparison with other CVCs and are associated with infection rates similar to those of other central catheters. Symptomatic PICC-associated DVT rates are reported to range from 0% to 20%. DVT is a significant complication that may lead to infection, pulmonary embolism, superior vena cava (SVC) syndrome, and postthrombotic syndrome, all of which increase morbidity and mortality.

**BACKGROUND**

At a community hospital in western Canada, PICCs are inserted by the parenteral therapy (PT) team, composed of 3 specially trained and internally certified registered nurses. If it is anticipated that a patient may require a computed tomography (CT) exam, a power-injectable PICC product is used. If a CT scan is unlikely and the patient will be discharged to a home parenteral therapy (HPT) program,
a Bard Groshong silicone PICC product is chosen. The power-injectable PICC product is a polyurethane catheter with a length of 55 cm. There is a 5- to 7-cm reverse taper located at the hub end of the catheter. The reverse taper gradually increases in diameter and French size as it moves toward the hub. A 0 at the hub end indicates that the catheter should not be inserted past that mark.

The directions for use indicate that "the catheter can be cut to length if a different length is desired." Cutting or trimming catheter tips helps ensure that there is little external catheter length. If the catheter is trimmed appropriately, the tip will dwell in the superior vena cava-right atrial (SVC-RA) junction, and there will be a short length of catheter external to the insertion site. This also will result in the largest diameter of the catheter in the peripheral vein at the insertion site. Anecdotal evidence noted by the PT team identified an increased rate of DVTs concurrent to cutting PICCs. As a result, the purpose of the study was to determine whether cutting the power-injectable PICC tips increased the rate of upper extremity catheter-related DVTs. Approval from the health research ethics board and hospital administration was obtained before conducting the study.

A retrospective descriptive design was used to compare the incidence of DVT between January 1, 2011, and October 23, 2012, among patients whose PICC was cut during insertion (PC) and those whose PICC was left intact (PNC) following PICC insertion. Six hundred thirty-four patients who had a power-injectable PICC product inserted during the study period were included in the study. Data collected throughout the PICC insertion procedure included demographic variables, the indication for study. Data collected throughout the PICC insertion procedure included demographic variables, the indication for the study was to determine whether cutting the power-injectable PICC tips increased the rate of upper extremity catheter-related DVTs. Approval from the health research ethics board and hospital administration was obtained before conducting the study.

The insertion procedure was as follows:

1. Ultrasound was used to assess the target vein health, and the vein pathway was assessed for potential occlusion.
2. Vein diameter was identified and recorded in its natural state, without the use of a tourniquet, using the guideline that only 50% of the vein could be taken up by the catheter.
3. Catheters were chosen to reflect the smallest gauge and fewest lumens to accommodate the vein and therapy.
4. The right-side upper extremity was chosen as the default side, unless condition or physiology required a left-side insertion.
5. PICC tips were cut to calculated patient-specific length until January 2012, when the team stopped cutting tips.
6. The vein was accessed with a modified Seldinger technique and ultrasound guidance.
7. The catheter was advanced using a tip-location system. A chest x-ray was obtained, and a radiologist indicated whether to advance or withdraw the catheter for a distal SVC-RA junction tip placement. The catheter was released for use only when the tip was in SVC-RA placement.

### DVT Complication

All inpatients and outpatients who underwent a PICC insertion were assessed weekly for complications, including symptoms of catheter-related DVT. Monitoring was performed by PT team nurses or HPT home care nurses and physicians. Patients who were discharged with a PICC in situ were also followed up through a review of their electronic health care record for evidence of a positive venous Doppler study. Symptomatic DVT was suspected if (1) patients exhibited neck or shoulder pain; (2) edema was present in the PICC arm; (3) dilated chest vessels were observed; (4) there was leaking blood from the insertion site; or (5) there was a catheter occlusion that could not be restored by alteplase, sodium bicarbonate, or hydrochloric acid, as appropriate for the suspected reason for occlusion. In all cases of suspected DVT, the responsible physician was contacted by the PT or HPT nurse with a suggestion to order a venous Doppler study to rule out DVT of the involved upper extremity. A thrombus identified by venous Doppler of the PICC upper-arm brachial, basilic, axillary, subclavian, and/or jugular veins was considered positive and was entered as a DVT complication in the PICC outcomes database.

Bivariate analyses were conducted using the Fisher exact test or $\chi^2$ test for categorical variables and the $t$ test to identify significant bivariate associations between PC and PNC groups and the development of DVTs. Logistic regression was used to model the association between PICCs being cut and DVT development, controlling for significant confounding variables. A $P$ value of $\leq .05$ was considered significant. IBM SPSS Statistics version 21 was used for data analysis.

### Results

Bivariate comparisons of patients in the PNC and PC groups are shown in Table 1. Patient groups were compared for

- differences in age
- gender
- existing comorbidity at the time of insertion
- surgical procedures that occurred during admission lasting more than 1 hour
- activity level
- blood work the day before PICC insertion
- PICC length
- positive blood cultures at the time of PICC insertion
<table>
<thead>
<tr>
<th>Variables (%)</th>
<th>PICC Not Cut n = 410</th>
<th>PICC Cut n = 224</th>
<th>P Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age in years (mean [SD])</td>
<td>63.7 (17.1)</td>
<td>63.69 (16.7)</td>
<td>.96</td>
</tr>
<tr>
<td>Female</td>
<td>48.8</td>
<td>50.0</td>
<td>.57</td>
</tr>
<tr>
<td>Collagen inflammatory disease</td>
<td>1.5</td>
<td>3.1</td>
<td>.37</td>
</tr>
<tr>
<td>Inflammatory bowel disease</td>
<td>3.9</td>
<td>6.3</td>
<td>.40</td>
</tr>
<tr>
<td>Active cancer</td>
<td>12.0</td>
<td>15.6</td>
<td>.40</td>
</tr>
<tr>
<td>Previous myocardial infarction</td>
<td>2.0</td>
<td>0.4</td>
<td>.24</td>
</tr>
<tr>
<td>Diabetes mellitus</td>
<td>27.3</td>
<td>24.1</td>
<td>.17</td>
</tr>
<tr>
<td>Obesity (BMI &gt; 35)</td>
<td>24.1</td>
<td>20.5</td>
<td>.29</td>
</tr>
<tr>
<td>Previous stroke</td>
<td>1.7</td>
<td>2.7</td>
<td>.70</td>
</tr>
<tr>
<td>Previous DVT</td>
<td>11.2</td>
<td>8.0</td>
<td>.42</td>
</tr>
<tr>
<td>Surgery performed during hospital stay</td>
<td>39.7</td>
<td>40.2</td>
<td>.90</td>
</tr>
<tr>
<td>Activity level</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>On bed rest</td>
<td>47.3</td>
<td>33.0</td>
<td></td>
</tr>
<tr>
<td>Modified activity</td>
<td>35.5</td>
<td>52.0</td>
<td></td>
</tr>
<tr>
<td>Independent</td>
<td>16.7</td>
<td>14.9</td>
<td>&lt;.001</td>
</tr>
<tr>
<td>Blood work (values recorded day before PICC insertion)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Platelets (mean [SD])</td>
<td>260.2 (127)</td>
<td>281 (147)</td>
<td>.06</td>
</tr>
<tr>
<td>White blood cells (mean [SD])</td>
<td>11.68 (17.04)</td>
<td>10.46 (5.39)</td>
<td>.75</td>
</tr>
<tr>
<td>Creatinine (mean [SD])</td>
<td>88.3 (63.8)</td>
<td>118.5 (104.5)</td>
<td>.08</td>
</tr>
<tr>
<td>Length of PICC (cm)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Internal length (mean [SD])</td>
<td>42.3 (4.6)</td>
<td>42.2 (4.0)</td>
<td>.90</td>
</tr>
<tr>
<td>External length (mean [SD])</td>
<td>12.7 (4.6)</td>
<td>4.7 (2.9)</td>
<td>&lt;.001</td>
</tr>
<tr>
<td>Total length of PICC (mean [SD])</td>
<td>55.0 (1.0)</td>
<td>56.9 (3.3)</td>
<td>&lt;.001</td>
</tr>
<tr>
<td>Positive blood culture at time of PICC insertion</td>
<td>10.0</td>
<td>9.4</td>
<td>.51</td>
</tr>
<tr>
<td>Treated for infections</td>
<td>74.7</td>
<td>79.0</td>
<td>.22</td>
</tr>
<tr>
<td>Arm PICC inserted in</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Right arm</td>
<td>79.3</td>
<td>86.2</td>
<td></td>
</tr>
<tr>
<td>Left arm</td>
<td>20.7</td>
<td>13.8</td>
<td>.03</td>
</tr>
<tr>
<td>Vein PICC inserted in</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Basilic</td>
<td>64.7</td>
<td>69.2</td>
<td></td>
</tr>
<tr>
<td>Brachial</td>
<td>33.6</td>
<td>29.9</td>
<td></td>
</tr>
<tr>
<td>Cephalic</td>
<td>1.7</td>
<td>0.9</td>
<td>.425</td>
</tr>
<tr>
<td>Number of days PICC indwelling (mean [SD])</td>
<td>26.5 (24.9)</td>
<td>28.3 (23.8)</td>
<td>.41</td>
</tr>
<tr>
<td>Number of days PICC indwelling (median)</td>
<td>19.0</td>
<td>21.5</td>
<td></td>
</tr>
<tr>
<td>DVT</td>
<td>1.9</td>
<td>9.8</td>
<td>&lt;.001</td>
</tr>
</tbody>
</table>

Abbreviations: PICC, peripherally inserted central catheter; SD, standard deviation; BMI, body mass index; DVT, deep vein thrombosis; cm, centimeter.
• reason for insertion
• side of the body into which the PICC was inserted
• vein into which the PICC was inserted
• number of days the PICC remained in place
• gauge and lumen number of the PICC
• type of prophylactic anticoagulation ordered at the time of insertion
• PICC-related DVT rate.

There were no statistically significant differences between the 2 groups with regard to mean age; proportion of females; active collagen inflammatory disease at time of insertion; inflammatory bowel disease; active cancer; previous myocardial infarction, stroke, or DVT; diabetes mellitus; obesity (BMI > 35); surgery during hospital admission; white blood cell count; internal length of PICC (42.3 cm); positive blood cultures at the time of PICC insertion; PICCs inserted to treat infection; the location of the vein into which the PICC was inserted; or the number of days the PICC remained in place.

Activity level between the PNC and the PC group differed. Patients in the PNC group were more likely to be on bed rest (47.3% vs 33.0%) and less likely to be engaged in modified activities (35.5% vs 52.0%) (P < .001). The external length of the catheter was significantly longer in the PNC group (P < .001) as expected; in the PNC group, the catheter was inserted until the tip was located in SVC-RA. The remainder of the catheter length (mean 12.7 cm; standard deviation [SD] 4.6) was external to the insertion site. Catheters in the PC group had the tip cut to the anticipated length +5 cm to ensure there is sufficient catheter length for the tip to reach the SVC-RA. As in the PNC group, catheters were advanced until the tip was located in the SVC-RA; the remainder of the catheter was external (mean 4.7 cm; SD 2.9). The PNC group had the PICC inserted into the left arm significantly more frequently (20.7%; P = .03) than the PC group (13.8%). Finally, PICCs were inserted to administer parenteral nutrition (PN) more frequently in the PC group than in the PNC group (65.2% vs 37.7%; P < .001).

Table 2 indicates that patients in both groups received anticoagulant at similar rates—PNC (65.2%) and PC (63.4%). Although more patients in the PNC group (45.0%) received prophylactic doses of unfractionated heparin than in the PC group (37.5%), the difference was not significant. There was a significant difference (P = .006) between the PNC group (4.6%) and the PC group (10.3%) in the administration of therapeutic doses of warfarin. Catheter size and number of lumens were similar in the PNC and PC groups: 4F single lumen, 40.1% vs 46.4%; 5F double lumen, 45.3% vs 37.9%; and 5F triple lumen, 14.6% vs 15.6%.

Table 3 shows the unadjusted and adjusted odds ratios (ORs) for the development of DVT in PICCs that were cut and those that were not cut at insertion. After controlling for measured variables between the 2 groups (OR 5.42; 95% confidence interval, 1.5, 16), the study’s findings indicate that patients whose PICC was cut were approximately 5 times more likely to develop a DVT compared with patients whose PICC was not cut.

**DISCUSSION**

As much as 80% of upper extremity DVT is associated with CVCs, with most incidents being asymptomatic. Studies published in the 1980s and 1990s reported rates as high as 66%; more recent trials, however, have reported that 14% to 18% of patients experience DVT when screening venography or ultrasonography is performed. This decrease is attributed to the increasing use of ultrasound guidance for insertion, changes in catheter material and design, and improved maintenance and care. Complications of DVT may lead to pulmonary embolism, infection, SVC syndrome, formation of right atrial thrombus, loss of catheter function and/or permanent loss of venous access, and postthrombotic syndrome.

In a meta-analysis of 5636 patients by Kamphuisen et al, significant risk factors for DVT were identified as (1) the position of the catheter in the subclavian vein compared with the upper arm vein, (2) improper positioning of the catheter tip outside of the distal SVC-RA junction, and (3) a previous history of DVT. A 2013 report in UpToDate identified the same factors that increase the risk for DVT as Kamphuisen et al with the addition of the use of PICCs and subclavian venipuncture...
insertion sites. Bacterial infection has also been linked to the development of DVT.\textsuperscript{1,10-12}

Risk factors specific for PICCs include recent surgery and cancer.\textsuperscript{1} Kamphuisen et al\textsuperscript{19} indicated that the position of the entry site of the catheter might be important because of mechanical factors. Left-sided insertions and difficult insertions may also cause endothelial injury because of the mechanics of the procedure. PICCs are placed in a peripheral vein and traverse the vein until the tip resides within the SVC-RA junction. There is potential for the tip to cause mechanical endothelial damage as it is advanced into position along the curves of the axillary and brachiocephalic vein to enter the SVC. Left-sided insertions and large-diameter catheters increase the risk of DVT.\textsuperscript{10}

The results of this study contradict reports that left-sided insertions increase the risk of DVT. In it, the PNC group had PICCs inserted into the left side more frequently but had significantly fewer incidences of DVT than the PC group.

Discussions exist in neonatal literature that address the safety and efficacy of trimming PICC tips to a patient-specific length, but trimming PICCs in adults has not been discussed. Parvez et al\textsuperscript{13} and Pettit\textsuperscript{14} both viewed trimmed PICC tips under a scanning electron microscope (SEM); photographs were taken of the manufactured and cut tips. The SEM showed that 1 in 5 of the manufactured tips was irregular; tips trimmed with a guillotine created a smooth surface; 1 in 5 of those trimmed with a scalpel was rough; and all tips cut with scissors were rough and had ruptured and broken ends. Parvez et al concluded that tips cut with scalpels or scissors created a rough surface, but it was not known whether this contributed to increased rates of DVT and infection.\textsuperscript{13} The risks associated with trimming catheter tips were speculated to be the risk of catheter fragment embolization and insertion-related trauma to the tunica intima of the vein from the rough catheter tip.\textsuperscript{13} Pettit\textsuperscript{14} identified additional potential complications of inserting cut tips, including thrombosis, phlebitis, infection, and malposition if the PICC is cut too short. It was noted that opposition to trimming catheters focuses on unproved or potential complications. When outcome data were reviewed for 116 neonatal cases, they did not demonstrate an increase in phlebitis and symptomatic DVT.

This study observed a significant relationship between cut tips and the development of PICC-related DVT. However, although there were no other studies found that reported similar associations, other factors have been identified that by themselves or in combination may partially explain our results.

Catheter diameter relative to the size of the vein determines whether blood will flow freely around the catheter or whether flow will be substantially decreased. The incidence of DVT is more likely with larger gauges and multiple-lumen catheters. PICCs may nearly occlude blood flow when inserted into peripheral arm veins. Ensuring that the catheter takes up less than 50% of the native vessel diameter without a tourniquet may minimize the risk of DVT. The presence of the catheter in the vein decreases blood flow, creates stasis, and contributes to venous thrombosis.\textsuperscript{10,15}

The result of cutting a reverse-taper PICC tip is that some part of the reverse taper will dwell in the relatively small peripheral vein at the insertion site. Reverse-taper PICC products gradually increase in gauge by 2F from the beginning of the taper to the hub; therefore, a 4F catheter increases to a 6F and a 5F to a 7F at the hub.

Nifong and McDevitt\textsuperscript{17} identified that the decrease in flow rates with each catheter size is significant and could potentially decrease flow rates by as much as 93%. A tube (vein) size of 4 mm with a 6F catheter within the lumen will decrease flow by 80%. Larger-diameter catheters cause more venous stasis and turbulent flow and, therefore, trigger activation of coagulation factors.\textsuperscript{9} Therefore, an increased risk of catheter-related DVT with increased catheter diameter is evident.\textsuperscript{1,2,10,16}

Similar to previous studies, this study found that when some part of the reverse taper is situated in the peripheral vein, as with the PC group, there is a statistically significant increase in PICC-related DVT when compared with the PNC group.

The administration of parenteral nutrition and other hyperosmolar solutions has been identified as an

\begin{table}[h]
\centering
\caption{Odds Ratios for Development of DVT}
\begin{tabular}{|l|l|l|l|}
\hline
                  & Odds Ratio & 95\% Confidence Interval (LL, UL) & \textit{P} Value \\
\hline
Model 1          &            &                               &           \\
PICC cut (unadjusted) & 5.77 & 2.4, 13.7 & <.001      \\
Model 2          &            &                               &           \\
PICC cut (adjusted) & 5.42 & 1.45, 16.02 & .01        \\
Activity level   &            &                               &           \\
Bed rest         &            &                               &           \\
Modified activity & 1.53 & 0.65, 3.60 & .327       \\
Independent      & 0.79 & 1.98, 3.13 & .725       \\
Arm insertion    &            &                               &           \\
Left arm: right arm & 1.807 & 0.72, 4.52 & .21        \\
Total parenteral nutrition & 1.00 & 0.99, 1.01 & .93        \\
Anticoagulant–heparin & 0.82 & 0.35, 1.89 & .63        \\
Anticoagulant–warfarin & 1.718 & 0.53, 5.61 & .37        \\
\hline
\end{tabular}
\caption*{Abbreviations: DVT, deep vein thrombosis; LL, 95\% lower limit of confidence interval; UL, upper limit of 95\% confidence interval; PICC, peripherally inserted central catheter.}
\end{table}
There is evidence to suggest that altering the reverse-taper PICC by cutting or trimming the tip before insertion may be associated with increased DVTs. Further study is required to determine whether PICCs should be reduced in length or whether there is an appropriate method of trimming the catheter to ensure its stability following insertion.

More patients in the PC group received therapeutic doses of warfarin. Patients who have comorbidities, such as atrial fibrillation or previous DVT, are prescribed warfarin to prevent DVT related to those conditions. While this study controlled for warfarin in its logistic model, a sensitivity analysis was performed that demonstrated that the PC group continued to have significantly higher proportions of DVT compared with the PNC group, when analyzing only patients who were not on warfarin during their hospital stay. The activity level between the PNC and PC groups differed, with the PNC group having higher rates of bed rest and independent activity. Although bed rest has been associated with higher DVT rates in the leg veins, it is not known whether activity plays a role in preventing or assisting in the development of catheter-related DVT in the upper extremities.

When the catheter tip is not cut to patient length, there may be a long external length that must be managed. Pettit described the benefits of trimming PICCs as lessening the risk of inward migration, decreasing resistance in the catheter to forward flow, allowing easier assessment of external length of a catheter so that migration and malposition may be identified early, and easier skin antisepsis when performing dressing changes. With a long external length, dressing changes become technically difficult to perform, with a higher risk of accidentally pulling the catheter further out of the vein, which results in tip malposition into the proximal SVC or brachiocephalic vein. It is difficult to observe that the catheter has been malpositioned during the dressing change, which in turn may put the patient at higher risk of DVT resulting from improper tip position (Figure 1). Positioning of the external length to avoid kinking with arm movement is difficult and often results in weakening of the catheter material, with the potential for catheter fracture (Figure 2).

This study is novel in that, by using real-world data, the authors have identified a gap in the literature and observational evidence to suggest an association between cutting PICCs and DVTs. Nevertheless, the study has a number of limitations. It was not a randomized trial, so the observed differences in DVT rates between the PC and PNC groups may be attributed to unmeasured confounding variables. It is not known whether there is 1 factor—such as the reverse-taper dwelling within the vein—or multiple factors—such as a rough tip plus the reverse taper dwelling within the vein—that influenced the development of DVT in the PC group.
ACKNOWLEDGMENTS

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REFERENCES