Reducing upper extremity deep vein thrombosis when inserting PICCs

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Abstract

While peripherally inserted central catheters (PICC) provide a positive contribution in the delivery of intravenous therapies, complications following insertion can occur. One of the more common of these is upper extremity deep vein thrombosis (UEDVT). Several elements of insertion are contributory factors. Research has been undertaken on patient assessment, catheter materials and size, insertion site, tip position and ultrasound placement, as well as on the value of anticoagulants. The resulting evidence informs opinion and shapes clinical practice. Inserting clinicians and advance-level nurses have a responsibility to reduce the incidence of UEDVT and improve outcomes following PICC insertion.

Keywords: PICC ▪ Venous thrombosis ▪ Upper extremity deep-vein thrombosis ▪ DVT ▪ Central venous catheter ▪ Circulation

Peripherally inserted central catheters (PICCs) have improved the management of patients on long-term drug therapies and their quality of life, by allowing intravenous therapies to be delivered in outpatient departments and the community.

In the late 1990s, a government white paper, *The New NHS: Modern, Dependable* (Department of Health (DH), 1997), highlighted the importance of basing care in the community; this paper indicated the acceptance of delivering intravenous therapies in the community. McCorkle et al (1994), stated it was acceptable to deliver community-based intravenous therapies and recognised the psychological benefits of doing this.

While PICCs provide a positive contribution in delivering treatment for both patient and service providers, problems can arise. One of the more common complications associated with PICC insertion is upper-extremity deep vein thrombosis (UEDVT). This is defined by Hylton et al (2002) as thrombosis of the basilic, brachial, axillary and/or subclavian vein.

This article will examine the mechanism of blood flow and thrombosis and identify the elements of insertion that are considered contributing factors. It will then evaluate the evidence and explore the recommendations and options to reduce the incidence of UEDVTs and improve outcomes following PICC insertions.

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The process of thrombosis

Named after the German physician, Rudolf Virchow who published an account of pulmonary thrombosis in 1856, Virchow's triad (*Figure 1*) describes the three broad factors that contribute to the formation of thrombosis: alteration to blood flow, damage to the endothelium, and hypercoagulability.

Baskin et al (2009) explained the process of coagulation that results in a thrombosis; a plug of platelets becomes wrapped in fibrin molecules, resulting in a painful swelling of the affected limb. Should any part of the thrombus then become free, the resulting embolism can rapidly become life threatening (Grove and Pevec, 2000).

Even when a thrombosis is successfully treated, some patients are left with post-thrombotic syndrome. A large study undertaken by Baskin et al (2009) suggested that 15% of patients who develop UEDVT endure long-term pain.

Incidence of UEDVT

According to Czihal and Hoffman (2011), UEDVTs account for 11% of all thrombosis. They fall into two categories. Primary thrombosis, known as Paget-Schroetter syndrome, results from strenuous, repetitive physical effort. These are rare at around two per million of the general population, with idiopathic primaries accounting for 30% of all UEDVTs (Hylton et al, 2002). Hylton's (2002) study of 592 patients, suggests that, of the cases considered to be primary thrombosis, 25% of patients presenting with idiopathic UEDVTs were found to have malignant disease upon examination; this underlying condition predisposed them to thrombosis.

The study by Czihal and Hoffman (2011) indicates that secondary UEDVTs account for two thirds of cases and result from underlying causes, such as malignant disease, indwelling catheters or pacemakers. A review by Verso and Agnelli (2003) that looked at a wide range of research indicated that the incidence of symptomatic UEDVTs following the placement of a central vascular access device (CVAD) is between 0–3% and 28.3%, with the incidence rising to a much higher 27%–66% when patients were screened by venography. Like many studies, this research concentrated on cancer patients.

Patient assessment

Patient assessment is crucial when considering PICC placement. Hamilton and Bodenham (2009) emphasised the importance of identifying any predisposition resulting from

Hypercoagulable state

- Malignancy
- Pregnancy and peripartum period
- Oestrogen therapy
- Trauma or surgery of lower extremity, hip, abdomen or pelvis
- Inflammatory bowel disease
- Nephrotic syndrome
- Sepsis
- Thrombophilia

Vascular wall injury

- Trauma or surgery
- Venepuncture
- Chemical irritation
- Heart valve disease or replacement
- Atherosclerosis
- Indwelling catheters

Circulatory stasis

- Atrial fibrillation
- Left ventricular dysfunction
- Immobility or paralysis
- Venous insufficiency or varicose veins
- Venous obstruction from tumour, obesity or pregnancy

Adapted from Bayer Schering Pharma, 2008 (www.thromboadviser.com)

Figure 1. Virchow's triad

underlying disease or hypercoagulability. They recommended that any history of thrombosis, previous problems with venepuncture, the condition of the limb, the presence of a pacemaker and any existing indwelling CVADs should be taken into account before insertion.

Therapeutic anticoagulation

Numerous studies have explored the efficacy of anticoagulation in reducing or preventing thrombosis in patients with CVADs.

Two studies undertaken in the 1990s — Bern et al (1990) and Boraks et al (1998) — suggested that low-dose warfarin reduced the incidence of catheter-related thrombosis (CRT).

One of the largest trials, the WARP trial (Young et al, 2005) randomised 1598 patients in a multi-centre trial. This examined the efficacy of giving low-dose warfarin and trialled adjusted doses based on blood results. While the group with adjusted doses had slightly fewer incidences of thrombosis, they also had a higher risk of bleeding. Unlike the studies by Bern et al (1990) and Boraks et al (1998), this trial found no overall difference in the incidence of CRT between those who were given warfarin and those who were not.

Many studies, including those by Young et al (2005) and Baskin et al (2009), focused on cancer and haematology patients. This may explain the lack of heparin-based research, perhaps because of the risk of heparin-induced thrombocytopenia and consequential platelet reduction. One study review (Aki et al, 2011) did include heparin-based anticoagulants. The authors concluded that low molecular-weight heparin may be of benefit but because of the differing modalities of the studies reviewed, no conclusion could be drawn, and they recommended further research.

Type of catheter

Many types and makes of PICCs are available. The ideal catheter should be firm enough to insert, yet soft and flexible to minimise damage to the vessel, and the catheter walls should have low thrombogenicity (Galloway and Bodenham, 2004). Although coating catheters in a material that reduces their thrombogenicity has been effective, coatings that contain anticoagulants have proved to be less so (Bishop et al, 2007).

Choosing a catheter with a view to reducing the risk of CRT is not straightforward. Older materials have been rejected due to their high thrombogenicity in favour of polyurethane or silicone catheters. A review of guidelines by Bishop et al (2007) found that, of these two common materials used in the manufacture of PICCs, silicone offered a lower risk of CRT.

A study by Di Giacomo (2009) compared three types of PICC. This found that, while polyurethane catheters are stiffer and can cause more trauma to the vein, they do have a higher resistance, therefore, allowing an increased flow, which can be useful when infusing blood. Their thinner walls mean the internal diameter is larger and the overall catheter size is smaller. Di Giacomo (2009) explained that silicone is softer so is less traumatic to vessels and more flexible so easier to place, but these catheters do have thicker walls and give a reduced flow. Dougherty (2006) offers a balanced recommendation that clinicians inserting PICCs should be aware of their different characteristics to make an informed choice.

Catheter size

Catheter size and the number of lumens required should be considered. The EPIC guidelines (DH, 2001) recommend the use of single-lumen catheters unless more lumens are essential, such as in the management of parenteral nutrition.

A retrospective study by Grove and Pevec (2000) looked at the medical records of 678 patients who had 813 PICC insertions, matching them with ultrasound, angiography or related interventions. They considered all variables, including placement by nurses (269) and radiologists (544). The authors found a constant overall incidence of 3.9% symptomatic catheter-related DVTs. The only significant variable was that the rate of symptomatic catheter-related DVTs was 1% with 4 fg catheters and rose to 9.8% when a 6 fg catheter was placed.

This figure correlates with research by Nifong and McDevitt (2011), which illustrates the reduction in venous blood flow with different catheter sizes; the smaller the catheter, the less disruption there was to blood flow. The study, undertaken in vitro using equipment that simulated venous blood flow, showed a 4 fg catheter can reduce blood flow by 40%–60%, depending on the size of the vessel, while a 6 fg catheter could reduce flow by up to 80%. This study looked at catheter:vein ratio, not at types of catheter; the equipment used was funded by a catheter manufacturer.

Grove and Pevec (2000) and Nifong and McDevitt (2011) concluded there was a correlation between catheter:vein ratio and the incidence of thrombosis. They recommend that, while larger or multiluminal catheters are at times necessary, the smallest acceptable catheter should be considered and clinicians inserting them needed to balance benefits against risks.

Insertion site

The choice of insertion site can be significant when endeavouring to prevent UEDVT. The EPIC guidelines (DH, 2001) recommend that insertion sites should be

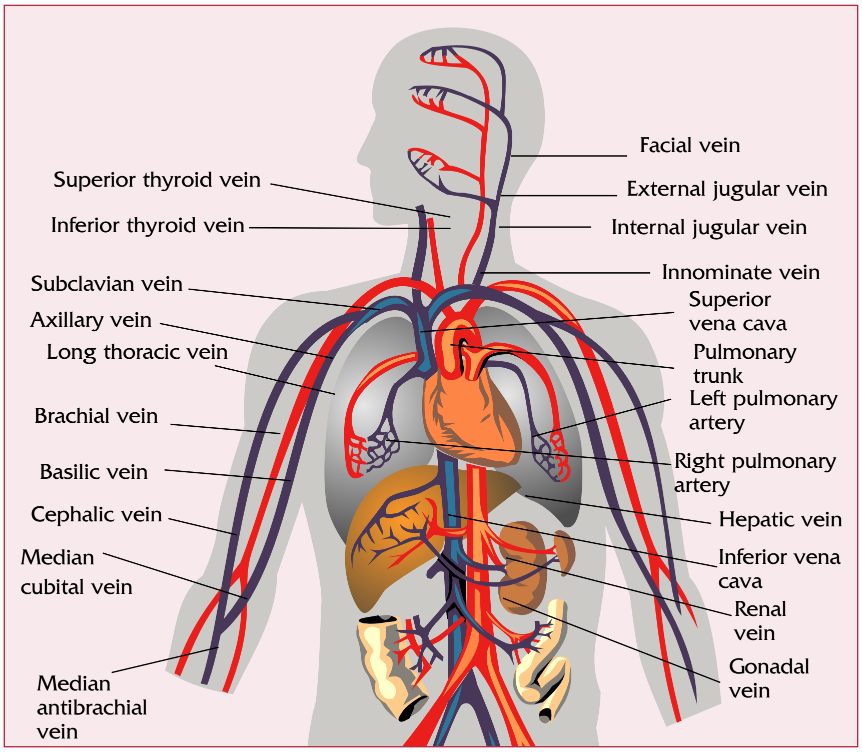

Figure 2. Vascular system

assessed for the risk of mechanical complication.

Dawson (2011) advocates using the zone insertion method (ZIM™). Here, the upper arm is divided and marked into three equal sections and the PICC is inserted in the upper aspect of the middle section. This avoids structures such as muscle and the mechanical movement around the elbow and shoulder, reducing the risk of compression or friction to the vessel. It also means the line is placed in the vein at its optimum size (where the vein lumen is largest). Dawson's (2011) evidence suggests this method greatly reduces the incidence of thrombosis. However, the sample was small and there was no indication of client group or whether any higher-risk cancer patients were included.

It is preferable to place a PICC on the right arm because the route to the superior vena cava is shorter and more direct than that from the left (*Figure 2*). Hamilton (2004) describes the left anatomy as more convoluted and angular. However, left insertions will have to be done when an appropriate vein cannot be identified on the right arm, or breast cancer, renal fistula or the general condition of the right arm prevents its use. Tesselaar et al (2004) noted a 350% increase in the incidence of thrombosis related to central venous catheters (CVCs) with left-sided placements. This study, however, examined tunnelled CVADs and central venous thrombosis, which can be due to vessel wall damage caused as a result of the angle at which the catheter tip abuts the wall of the superior vena cava (Vesely, 2003). While this evidence points to a higher incidence of central thrombosis in patients being linked to CVADs in the left arm, any increase in left UEDVTs can be associated with the extended and more complex route to the superior vena cava.

Ultrasound

The advantages of ultrasound-guided PICC placements are well documented. A search of the CINAHL and MEDLINE databases using the terms 'PICC' and 'ultrasound' resulted in 116 pieces of published evidence.

The National Institute for Health and Clinical Excellence (NICE) (2002) and the National Institute of Health Research (NIHR) (2003) evaluated the benefits and efficacy of using ultrasound when placing catheters. NICE recommended that ultrasound should be 'the preferred method of placement'; however, this specifically referred to catheters placed in the internal jugular vein.

While the NIHR's health technology assessment (2003) concentrates on improving the success rate of insertions, it also highlights how ultrasound can be used to identify structures and assist with assessing the size and patency of vessels. The advantages of placing a line into a vessel of an appropriate size have already been discussed. Hamilton and Bodenham (2009) said ultrasound could be used to examine vessel patency and compressibility, which is extremely useful, particularly where the patient has previously had a PICC inserted.

The use of ultrasound combined with the Seldinger technique (Seldinger, 1953, cited in Hamilton and Bodenham, 2009) improves insertion success rate; the Seldinger technique allows access by passing a guide wire through a small-bore cannula. In a modified version of the Seldinger technique, an introducer is passed over a guide wire. The wire is then removed, allowing the catheter to be passed through the introducer. This makes it easier to place the CVC, and causes less trauma to the vessel, reducing the risk of trauma-induced thrombosis.

Simcock (2008) undertook a retrospective review that followed the introduction of the Seldinger technique used with ultrasound guidance. The review, over a 4-year period, focused on cancer patients who had previously had a high incidence of thrombosis. Data analysis showed the success rate of insertions rose from 86% to 96% with the use of ultrasound and a corresponding reduction of 15% in the rate of UEDVTs.

In a recent methodological review that looked at papers published between 1980 and 2009, Hughes (2011) found that ultrasound guidance reduced the incidence of PICC-related thrombosis. All the papers reviewed supported this finding, with the reduction in UEDVTs varying from 15% to 70%.

From these studies, it could be concluded that ultrasound not only improves the success rate of catheter placement but also contributes to a reduction in the incidence of UEDVTs.

Tip position

Finally, much debate has focused on the position of the catheter tip, with Albrech et al (2004) and Orme et al (2007) discussing the advantages and disadvantages of catheter tip placement inside and above the atrium. Fletcher and Bodenham (2000) suggested a more pragmatic approach, based on individual patient anatomy and post-insertion chest x-ray. All of the above reached their conclusions as a result of clinical experience and numerous studies.

While emerging and proven technologies aim to achieve accurate tip placements, it is Lum (2004) who introduced a widely used method of calculating the optimum length of a PICC. Lum (2004) recommended the tip should lie in the lower third of the superior vena cava.

What is clear from all of the evidence is that catheter tips placed above the brachiocephalic junction are more likely to result in a thrombosis, as tip movement in a small vessel may result in damage the vessel wall (Orme et al, 2007).

Conclusion

The DH's position statement for advanced level nursing (2011) is clear that this autonomous role requires nurses at this level to have the ability and accountability to make decisions in the best interests of patients. Nurses who insert PICCs, therefore, need to keep informed of technology and the evidence-based practice that surrounds it.

The evidence presented in this article shows that many aspects of PICC insertion must be considered to reduce the incidence of UEDVTs.

An appreciation of normal blood flow and the effect that alteration causes as demonstrated by Nifong and McDevitt (2011) is essential.

The physical effect of placing a foreign body such as a PICC through the wall of a vessel and the ensuing processes within the epithelium are unavoidable. However, choices made by the inserter can clearly reduce the risks. From the evidence evaluated and confirmed by Hamilton and Bodenham (2009), every aspect of inserting a PICC — assessing the patient, and considering the type and size of catheter, the site and size of vein and the use of ultrasound to the final tip position — have an impact on the outcome and the incidence of thrombosis.

Much of the research and literature reviews are based on patients with cancers, and alterations to practice have led to a significant reduction in the incidence of UEDVTs in this group; it is reasonable to assume that the practices recommended must also be considered when addressing groups of patients at a lesser risk. It is important and reiterated by the Royal College of Nursing (2010) that, when venous access is requested, all patients are assessed as individuals, the advantages and risks are evaluated and the most appropriate decision is made. Clinicians inserting PICCs must be prepared and able to explain the rationale behind each decision that surrounds insertion. BJN

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KEY POINTS

- Upper extremity deep-vein thrombosis (UEDVT) is one of the common complications associated with peripherally inserted central catheters (PICCs)
- Many aspects of PICC insertion must be considered to reduce the risk of UEDVT, and clinicians need to take these into account when making decisions
- Patients must be assessed before insertion and predisposition to thrombosis identified
- Using of ultrasound with a modified Seldinger technique to guide insertion improves the success rate of catheter placement and reduces UEDVT incidence
- Clinicians should balance benefits against risks when deciding on catheter size and number of lumens and whether to use one made of silicone or polyurethane
- Insertion site and tip placement can be significant in UEDVT prevention
- Knowledge of normal blood flow and how this can be altered by a PICC are essential, and advanced level nurses need to remain up to date on PICC technology and evidence

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