No Going Back: Advantages of Ultrasound-Guided Upper Arm PICC Placement

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Background, Method and Purpose: *The use of peripherally inserted central catheters (PICCs) in the UK has been steadily increasing since they were first introduced in 1995. Ultrasound-guided upper arm placement - which has become prevalent in the USA over the last few years - is gradually attracting interest amongst PICC placers in the UK. The literature shows that upper arm placement improves insertion success rate (Hockley, Hamilton, Young, Chapman, Taylor, Creed et al, 2007; Hunter, 2007; Krstenic, Brealey, Gaikwad & Maraveyas, 2008) and patient satisfaction (Polak, Anderson, Hagspiel, & Mungovan, 1998; Sansivero, 2000; McMahon, 2002). Following a switch to upper arm placement at her institution, the author examined audit data from before and after the change in practice to see if there were other measurable clinical improvements.*

Results: *Comparison of data from a four-year period shows that upper arm placement in our patient population increased insertion success rate and line longevity, while reducing exit site infection, thrombosis and catheter migration.*

Implications for Practice: *This data shows that ultrasound-guided upper-arm placement improves patient outcomes. PICC placers still using the more traditional antecubital approach should consider a change in practice.*

Introduction

The use of Peripherally Inserted Central Catheters (PICCs) in the UK (United Kingdom) dates back to the mid 90s. Janice Gabriel, who was working at the time as an Oncology Nurse Specialist, had observed the use of PICCs in the USA on a study visit and started placing PICCs at Portsmouth Hospitals NHS Trust in November, 1995 (Gabriel, 1996). Since then, PICC use within the National Health Service has been gradually increasing. PICC placers tend to be nurses but in some hospitals interventional radiologists and other medical colleagues have also begun inserting PICCs as these devices become more widely known. Ultrasound-guided upper arm PICC placement, which has become prevalent in the USA over the last few years, is gradually attracting interest in the UK, though anecdotally it would appear that nurse inserters at most institutions are still using the more conventional antecubital approach. Lack of funding to purchase ultrasound equipment and the relative difficulty in learning ultrasound placement are obstacles many PICC placers have yet to overcome. In this article the author describes the advantages that the switch to upper arm placement has brought to patients in her own practice in a London teaching hospital.

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Literature Review

Some advantages of placing PICCs in the upper arm using ultrasound rather than a more conventional technique have already been described in the literature. Increased insertion success rate is the main focus for most authors (Hockley, Hamilton, Young, Chapman, Taylor, Creed et al, 2007; Hunter, 2007; Krstenic, Brealey, Gaikwad & Maraveyas, 2008). Also highlighted is the fact that enabling nurses to use ultrasound at the bedside leads to fewer Interventional Radiology referrals (Falkowski, 2006). Improved patient safety (in terms of avoidance of sclerosed or thrombosed veins) is mentioned by Moureau (2006). However, accounts of the advantages to patients *following* insertion are relatively sparse. Patients' preference for upper arm placement is noted by several authors (Polak, Anderson, Hagspiel, & Mungovan, 1998; Sansivero, 2000; McMahon (2002) and Royer (2001) describes a reduction in mechanical phlebitis and PICC migration. Otherwise the emphasis is on insertion-related benefits.

Setting

The PICC service within the Oncology department at UCL Hospitals NHS Trust was set up in 2001. There were two main groups of patients requiring central venous access devices (CVADs). First, patients receiving ambulatory infusional chemotherapy and second, those with sarcomas undergoing more intensive inpatient chemotherapy.

Existing provision for CVAD insertion was unsatisfactory. Tunnelled lines were the only option for most patients. There was no dedicated insertion team, audit or quality control and patients frequently experienced delays and cancellations.

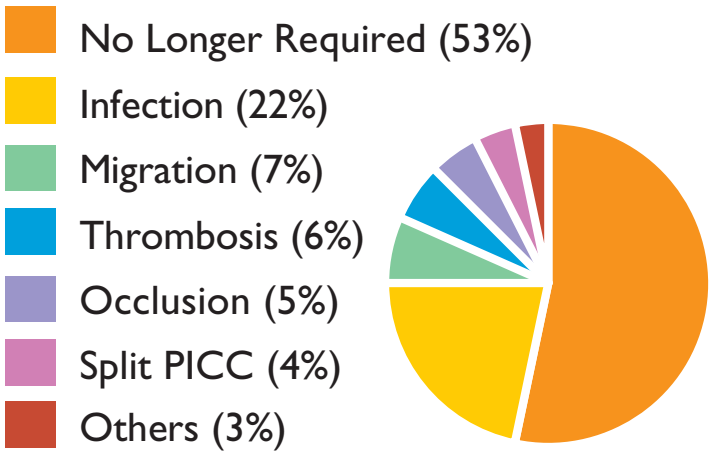
The author's expectations in setting up the PICC service were high. The intention was that there would be a seamless "one-stop" patient-centered service with consistently high standards. PICCs could be inserted in the outpatient setting, and the service would be audited on a regular basis. PICCs would be cost effective and the new service would also relieve pressure on available patient beds and reduce delays in patient treatment and by the factor of time. Much of the literature supported the idea that PICCs would also reduce CVAD-related complications (Todd, 1998; Aston, & Maughan,1998; Loughran,& Borzatta,1995).

After a short period of training, the author began inserting PICCs in July 2001. Within a few months it was clear that despite strenuous attempts to adhere to current best practice, the switch to PICCs was creating a significant number of problems and was not providing the instant panacea that had been envisioned. PICCs seemed to be proving unpopular with nurses and patients alike, and whilst to some extent this could be ascribed to unrealistic expectations and training issues, it was not the whole story. In the inpatient group, nurses and patients were frustrated by patients having to keep their arm straight during the three days of treatment to prevent the infusion pump from alarming. In the outpatient setting it became common for ambulatory infusers to over-run by several hours or more, presumably because of kinking of the PICC during the patients' normal arm movements. Blood sampling anecdotally proved more problematic in both settings than with tunnelled CVADs, with withdrawal occlusion a significant irritation to both patients and nurses. More worrying still, it was felt that PICCs were causing *more* complications than tunnelled catheters rather than less, although this could not be proved as we did not have comparative data.

A retrospective audit of the first 145 PICCs placed to summer 2003 revealed that 47% of the 120 lines that had already been removed at the time of the audit had been removed prematurely because of complications. In other words, only just over half had lasted as long as they were needed. Despite using optimal theatre-style aseptic technique during PICC insertion, removal of PICCs occurred in 22% of patients due to infection or suspected infection, 7% for PICC migration, 6% for thrombosis, 5% for occlusion and 4% because of a split line (Figure 1).

It should be remembered that many of these PICCs were placed in patients undergoing relatively intense chemotherapy regimens which cause prolonged episodes of neutropenia. These patients are at high risk from neutropenic sepsis whether or not they have a central venous catheter in situ. The audit did not attempt to discover what proportion of PICCs removed for suspected infection were actually colonised. The difficulties of accurately distinguishing CRBSI from bacteraemias caused by other factors while the line is in situ are well documented (Kite,et al., 1997; Tighe et al., 1996; Hall & Farr, 1996). In addition, PICCs are much easier to remove than tunnelled CVADs, making it more likely for PICCs to be removed "just in case" they were implicated in the patient's septic episode.

Fig 1: Reasons for Removal of PICC. From the 2003 Audit (120 PICCs placed in antecubital fossa)



One of the most disappointing factors was the number of patients developing proven thrombosis, which had not seemed to be a common clinical problem with tunnelled catheters. Of the 145 successfully placed PICCs, 17 patients (12%) developed thromboses diagnosable by Doppler ultrasound. This was despite the routine use of minidose warfarin and a policy of lower SVC tip placement. The thromboses did not appear to be related to tip position, since most cases of thrombosis involved the veins of the arm. The risk of developing a thrombosis did not seem to be affected by choice of vein, gender, diagnosis or the make or size of the PICC. Interestingly, though, patients seemed to be more at risk when the PICC was placed in the right arm with 17% of patients with right arm PICCs developing clinically evident thrombosis in comparison to only 5% of those with left arm PICCs. We had in fact deliberately placed most PICCs in the right arm believing this to be best practice. This belief was based on anecdotal advice from existing PICC placers, and was possibly related to the idea that the route to the SVC is shorter from the right, and from evidence in the literature that CVADs inserted via the right jugular and subclavian veins are associated with less thrombotic complications than those placed in the left side (Puel, et al., 1993; Craft, May, Doringo, Hoy & Plant, 1996) presumably because the route to the SVC is less convoluted from the right. The author now believes that this phenomenon is not significant in PICCs because in most patients the curve is fairly similar whether the catheter is placed in the left or the right side. It seems probable that the higher rate of thrombotic problems seen in right-sided PICCs was the result of mechanical trauma to the arm veins caused by arm movements. Most patients are right-handed and therefore more frequently use their right arms. When the PICC is placed in the antecubital fossa, bending of the elbow can result in movement of the catheter within the vein, resulting in mechanical damage and increasing the risk of clotting.

Overall the 2003 audit showed a disappointingly high level of complications. A closer look at the literature, including papers written since our PICC service was set up, revealed that others had similar experiences. In an audit of 75 PICCs in can-

cer patients Hendy (2001) reported that "61% of PICCs had at least one complication…" (page 32). Walshe, Malak, Eagan, & Sepkowitz, (2002) concluded that "Complications occur frequently among cancer patients with PICCs, and long-term follow-up is onerous" (page 3276).

On the specific question of thrombosis, the thrombosis rate in our patient group seemed to be significantly higher than some published figures (Allen et al 2000). The explanation for this may be that most of our patients were receiving chemotherapy. Grove & Pevec (2000) found that thrombosis rates differed by patient group. In their study of 678 patients with 813 PICCs, thrombosis rates were 8.3% in patients receiving cancer chemotherapy as compared with 1.6% in those receiving antibiotics and 4.2% parenteral nutrition. Similarly, Ong, Gibbs, Cathcpole, Hetherington, & Harper (2006) found that 7% of PICCs inserted for chemotherapy resulted in symptomatic thrombosis in comparison to 1% inserted for other reasons.

In 2004 we switched to upper arm placement using a modified Seldinger technique and ultrasound guidance. As noted above, this technique seemed to have several advantages over the more traditional anticubital approach including increased insertion success and greater patient satisfaction.

This author also hoped that the technique might decrease rates of thombosis. This seemed logical, since it was likely that upper arm thrombosis in PICC patients was associated with mechanical damage to the veins which might well be reduced if the patient's elbow movements were not transmitted so immediately to the PICC. Also the veins of the upper arm are known to be larger than the antecubital veins, so it was hoped that this might also decrease the likelihood of thrombosis as there would be greater blood flow around the catheter, at least for the first few centimetres above the insertion site.

Switching to ultrasound-guided insertion was not without its challenges. The first obstacle was the cost of the ultrasound scanner which was around £10,000. We were able to purchase a machine thanks to the generous help of the Teenage Cancer Trust. Secondly, accessing the relatively small vessels of the arm using ultrasound involved a steep learning curve and it took several months before the author and her colleague gained confidence in the technique.

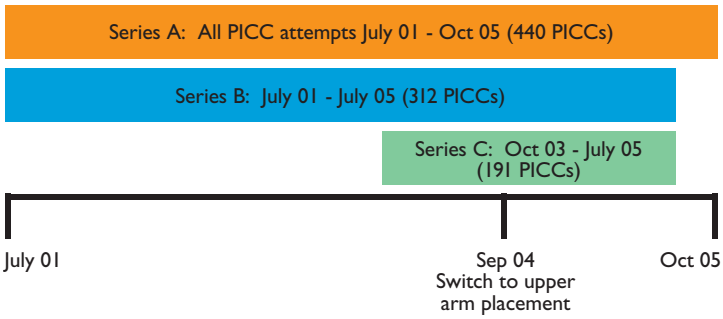
During the learning phase it was immediately apparent that this change in practice had advantages. There were fewer patients in whom we could not place a PICC. Patients no longer complained of discomfort at the exit site and in the upper arm in the days following insertion. Inpatients were able to use their arms freely during infusions, and reports of infusers failing to empty on time became uncommon. Mechanical phlebitis (Penney-Timmons & Sevedge, 2004) ceased altogether.

In the year 2005, after we had placed 227 upper arm PICCs we audited our practice again, this time aiming to compare PICCs placed in the antecubital fossa with those placed in the upper arm.

Purpose, Methods and Limitations.

The purpose of the approved audit was to determine the impact of switching to upper arm placement on insertion success rates, PICC longevity, and complication rates. It was obvious that upper arm placement had made PICCs more popular amongst referring teams, nurses and patients. We wanted to know if there were also measurable clinical improvements.

Fig 2: Three groups of PICCs for the purpose of analysis

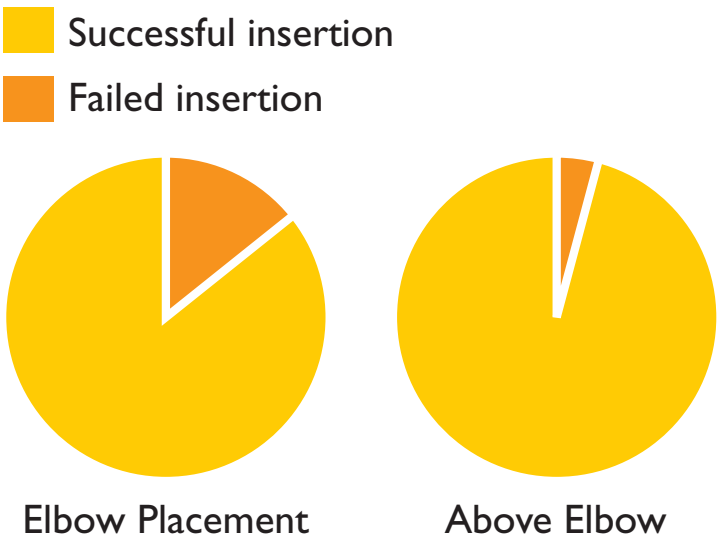


Data relating to the PICCs placed since the 2003 audit was gathered. Information about insertion, reasons for removal and the incidence of thrombosis could be compared with previous data from the 2001 audit, giving us a relatively large group to study. Other more detailed information about complications during the life of the PICC could only be analysed for PICCs inserted since 2003 because prior to this it had not been recorded.

Thus for the purposes of analysis, there were three main groups of patients (figure 2):

- **Series A** included all PICC insertion attempts between July 2001 and October 2005. This group included 485 attempted PICC insertions and 440 successfully placed PICCs and provided comparative data on insertion success rates before and after the switch to upper arm placement.
- **Series B** consisted of 312 PICCs drawn from the 375 PICCs placed between July 2001 and July 2005. Of these 324 (87%) had been successfully audited and of these 312 had been removed. With this series we were able to look at reasons for removal and incidence of thrombosis and pulmonary embolism.
- **Series C** overlapped with series B and was a shorter series of 191 drawn from 228 PICCs successfully placed between

Fig 3: PICC Insertion Success Rates



October 03 and July 05. Of these 205 (90%) were successfully audited, and of these, 191 had been removed at the time of audit. This series provided more comprehensive data relating to complications during the life of the PICC.

Insertion data was recorded contemporaneously by the PICC team and so can be considered to be very reliable. However, subsequent data concerning complications and reasons for PICC removal was collected retrospectively via the patient's medical records. This limits the audit's reliability in various ways. First, there were gaps in the data due to incomplete record-keeping and missing notes. Second, only data recorded in the medical records could be audited, which in all probability meant that our study underestimated complication rates. Interpretation of the results should also take into account the fact that all PICCs placed before September 2004 were placed in the antecubital fossa, whereas all those placed after that time were inserted in the upper arm, and so it is possible that some of the differences between the groups were caused not by the the switch to upper arm placement but other factors such as changes in management of complications, improvements in care for PICCs generally, ongoing education, changes in personnel etcetera.

Despite these limitations, the author believes that the findings of this audit do represent the real benefits of upper arm placement that were immediately apparent to those placing and caring for PICCs during the period studied.

Findings

Finding 1: Improved insertion success (Figure 3).

In Series A we found that 14% of insertion attempts had failed using the non-ultrasound technique and only 4% of attempts had failed using ultrasound.

Finding 2: Fewer PICCs removed prematurely (Figure 4)

In Series B, only 42% of the 176 antecubital PICCs had stayed in as long as they were needed. In the upper arm group, this had increased to 62% (out of 134 PICCs). The number of PICCs removed for infection or suspected infection had dropped from 23% to 19%, the number removed for "mechanical reasons" (i.e.: blockage, migration or breakage of the PICC) had dropped from 18% to 8%.

These changes were particularly noticeable in the group of patients having relatively non-intensive, ambulatory chemotherapy, where the number of lines lasting as long as they were needed increased from 57% to 79%. The change was less marked in the patients receiving intensive, myelosuppressive chemotherapy for sarcoma, but nevertheless, the number of lines removed because of infection/suspected infection had reduced from 35% to 24%.

These results must be interpreted with caution. First, the numbers of patients are not large, the groups of patients not matched, and in addition it may be that other factors contributed to the changes. For example, it may be that as time went on and medical teams became more used to PICCs, they also became more effective at assessment and evaluation and less likely to remove the PICC just in case it was implicated in a patient's septic episode

Fig 4: Reasons for PICC Removal

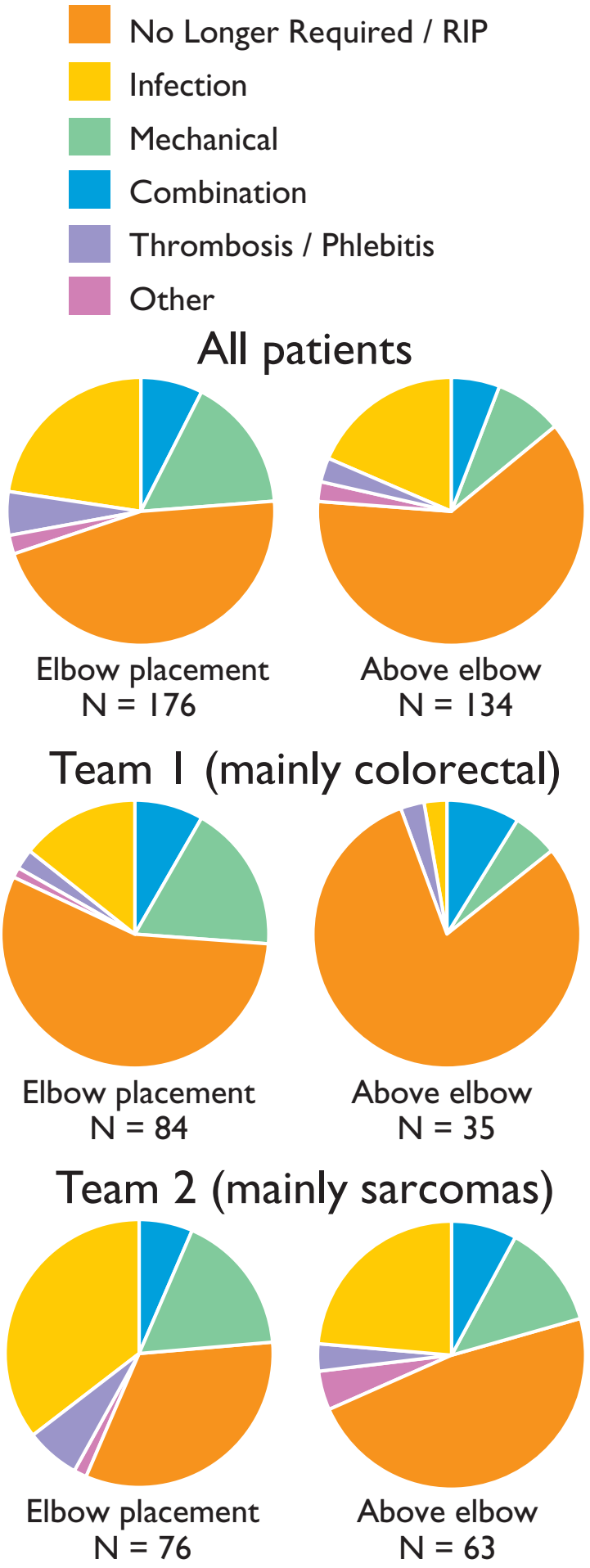
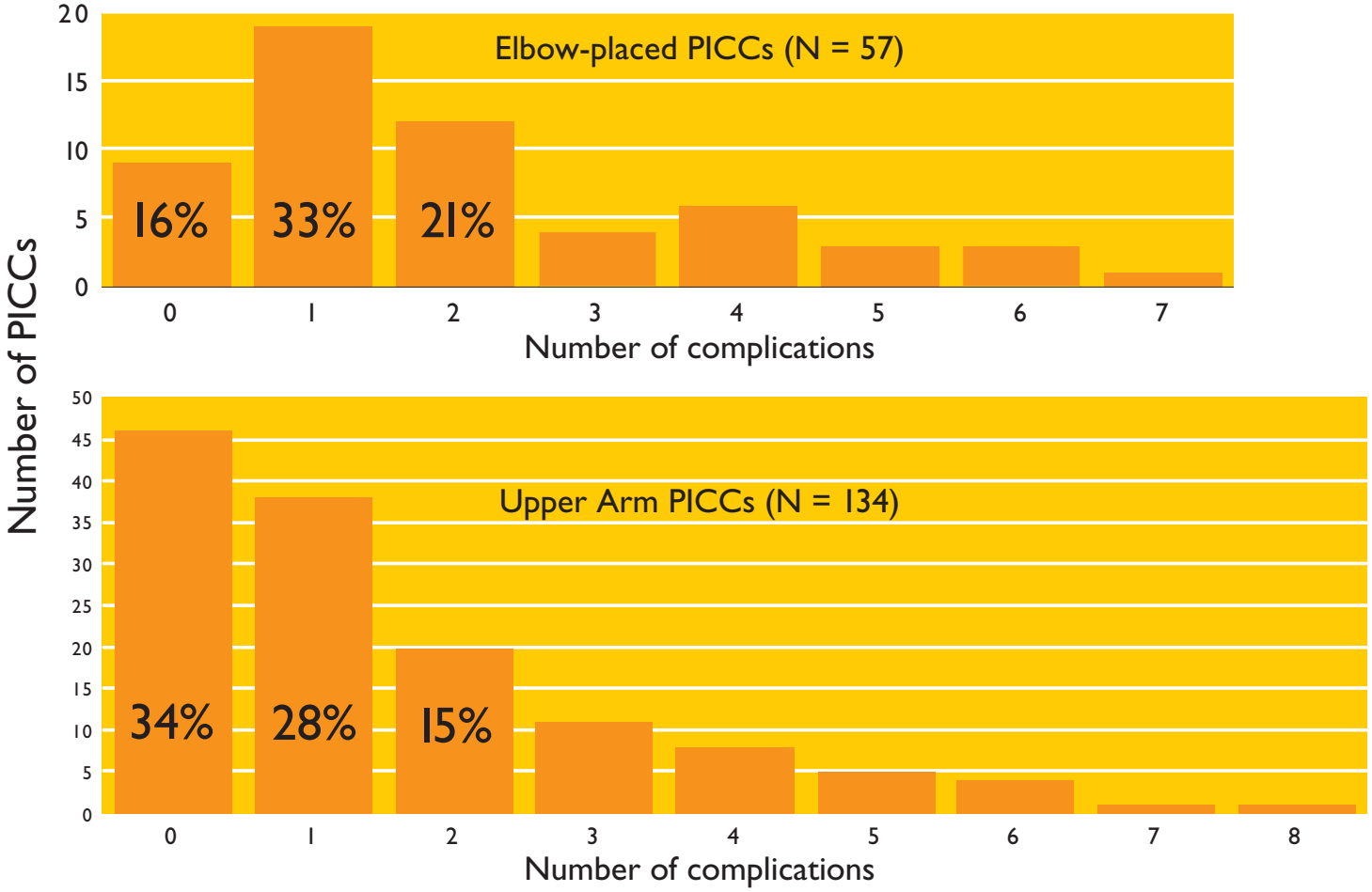


Fig 5: ***Number of complications per PICC (Series C: N = 191 PICCs)***



Finding 3. More "complication-free" PICCs (Figure 5).

Series C consisted of 191 PICCs. Patients were classified as having a "complication" each time there was a record in their notes of any of the following:

- Sepsis (defined as a pyrexia of >38 degrees Celsius without another obvious cause)
- Exit site infection (suspected or proven)
- Mechanical complications including blockage, breakage or migration of the line
- Thrombosis
- "Palpitations" reported by the patient and thought to be related to the PICC.
- Pulmonary embolus: suspected or proven
- Other: anything else of note

Of the 57 antecubital PICCs in this group, only 16% had no documented complications. In the upper arm group – 134 patients – the number of patients who had no record of complications rose to 34%.

Fig 6: ***PICC Thrombosis Rates***

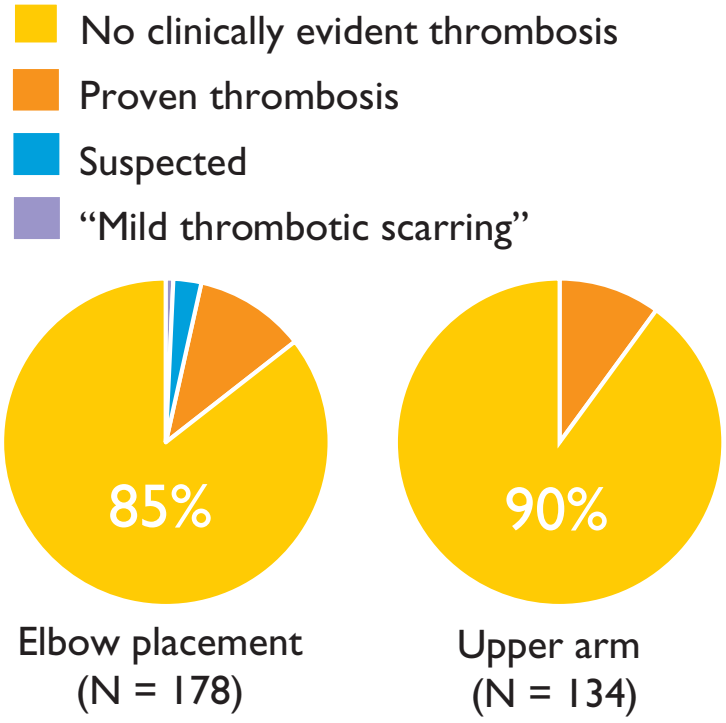


Fig 7: Number of PICCs with proven or suspected exit site infection (Series C: N = 191 PICCs)

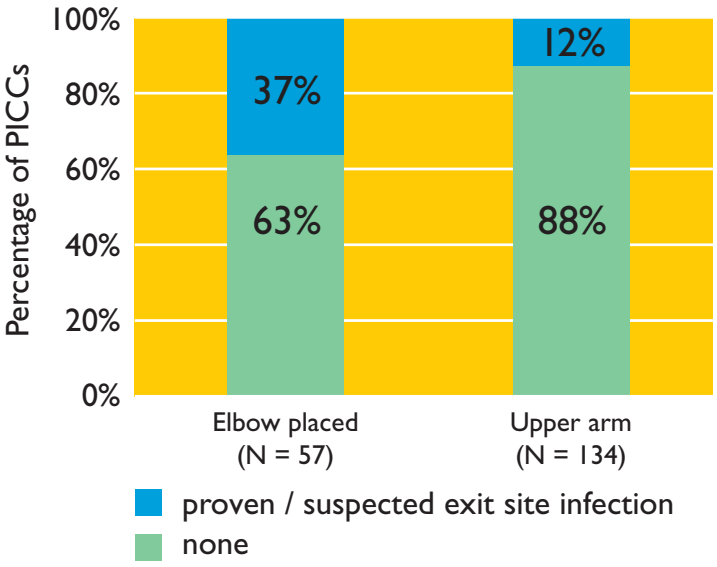
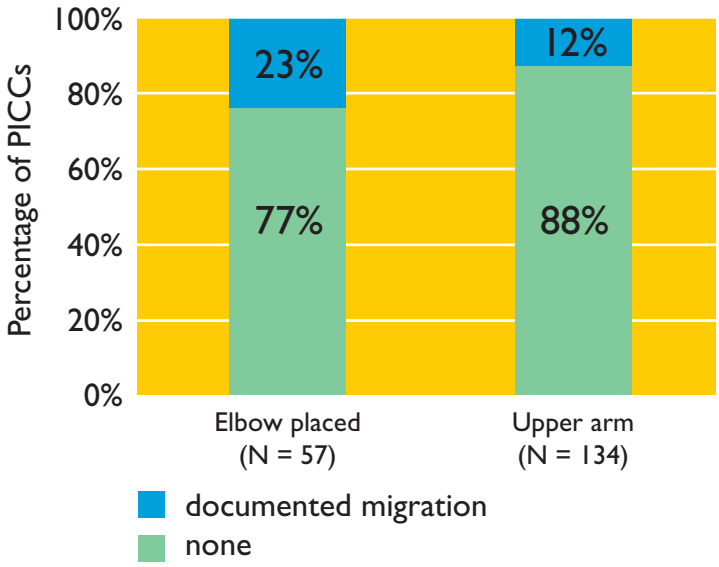


Fig 8: Number of PICCs where migration occurred (Series C: N = 191 PICCs)



Finding 4: Upper arm PICC placement seems to have reduced thrombosis (Figure 6).

In the non-ultrasound group there had been 20 thromboses diagnosed by Doppler ultrasound. In a further five patients no Doppler study was carried out but signs and symptoms recorded in their medical notes were highly suggestive of thrombosis: i.e. significant pain and swelling in the upper arm. One patient had an ultrasound carried out a week after line removal which reported "mild thrombotic scarring." These 26 patients taken together represented 15% of the antecubital PICCS, although only 11% had actually proven thrombosis.

In the upper arm group, the incidence of proven thrombosis was 9.7%, and there were no additional cases where symptoms existed but were not investigated. While this was still a significant proportion, it nevertheless represents a substantial drop from 15%.

Finding 5: Upper arm PICC placement has reduced actual / suspected exit site infection (Figure 7).

In Series C the proportion of patients having proven or suspected exit site infections dropped from 37% in antecubital PICCs to only 12% in upper arm PICCs. This reduced incidence would seem to be easily explained by the fact that there are more sweat glands in the antecubital fossa than in the upper arm, thus creating a less favourable environment for bacteria, and also that PICCs placed in the upper arm are less likely to move "to and fro," transferring bacteria from the epidermis to the deeper layers.

Finding 6: The switch to upper arm PICCs appears to have reduced the number of episodes of PICCs migrating (Figure 8).

The number of PICCs where migration of the PICC was mentioned in the notes occurred in 23% of PICCs placed in the antecubital fossa, in comparison to only 12% of upper arm PICCs.

Conclusions

Changing our practice in the PICC team at University College Hospital was a challenging project. Learning a new insertion technique required determination and a willingness to unlearn our existing skills and almost to become beginners again, in order to take the service forward in the longer term. Since this audit data was gathered, use of our service has increased, with more clinicians preferring to refer patients for PICCs rather than another form of central venous access device. Intuitively we felt from very early on that placing PICCs in the upper arm improved the patient's experience and reduced complications. Analysis of this audit data has enabled us to demonstrate the improvement in more objective terms. Changing our practice to upper arm PICC insertions within our particular patient population has increased insertion success rate from 86% to 96%. It has eliminated mechanical phlebitis and also appears to have increased PICC longevity and reduced exit site infection, thrombosis and catheter migration. The author urges other PICC placers to consider making this change in practice.

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