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NICE guidelines for central venous catheterization in children. Is the evidence base sufficient?

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Background. Recent guidelines from the National Institute for Clinical Excellence (NICE) recommend the use of ultrasound guidance for central venous catheterization in children. This study prospectively examined the use of ultrasound guidance for central venous catheterization in children undergoing heart surgery.

Methods. One hundred and twenty-four infants and children were randomized to either ultrasound-guided or traditional landmark-guided central venous catheterization.

Results. Success rates were significantly greater in the landmark group compared with the ultrasound group (89.3% *vs* 78%, $P<0.002$), and arterial puncture rates were significantly lower in the landmark group (6.2% *vs* 11.9%, $P<0.03$). There was no significant difference between the two groups in the time taken to perform the catheterization.

Conclusions. These results are different from the published results on which the NICE guidelines were based; however, the evidence base in children is small. There is currently insufficient evidence to support the use of ultrasound guidance for central venous catheterization in children.

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Central venous cannulation in infants can be difficult and challenging, predominantly because of their small size, and carries an associated morbidity and mortality.[1] There is a learning curve for this procedure; regular practice is required to achieve and maintain skill and competence. The success rate and occurrence of complications will depend on factors which include the size and condition of the child, operator experience, the site of cannulation and the presence of vascular anomalies, coagulation abnormalities or previous cannulation.

In September 2002, the National Institute for Clinical Excellence (NICE) produced a document entitled '*Guidance on the use of ultrasound locating devices for placing central venous catheters*'.[2] This document recommends the use of ultrasound guidance as the preferred method for elective insertion of central venous catheters into the internal jugular vein in adults and children. One implication of this document is that complications of central venous cannulation where ultrasound has not been used will be difficult to defend in court.[3] Despite this, many doctors, and in particular cardiothoracic anaesthetists, are not following the NICE guidelines. Ultrasound equipment is not available in all operating theatres and many anaesthetists remain unconvinced of its usefulness for regular practitioners.[4 5]

Central venous cannulation is routinely required during paediatric cardiac surgery; in our unit this is performed by consultant anaesthetists. This study was designed to examine the effect of introducing ultrasound guidance into this paediatric cardiac anaesthetic practice.

Methods

With hospital ethics committee approval and informed parental consent, paediatric patients presenting for cardiac surgery were prospectively randomized into two groups. Block randomization was performed by the anaesthetic assistant immediately before anaesthesia, and the anaesthetist was then informed of the technique to be used. In the landmark group, cannulation of the right internal jugular

vein was attempted using a Seldinger wire technique guided by traditional surface landmarks. In the ultrasound group, a Baird Site-Rite 3 ultrasound probe with attached needle guide (Dymax Corp., Pittsburgh, PA, USA) was used (within a sterile sheath) to assist cannulation of the right internal jugular vein, using the same Seldinger wire technique. All procedures were undertaken by one of three consultant paediatric cardiac anaesthetists, all of whom had some experience of using the ultrasound probe. The amount of previous experience varied, but the least experienced operator had performed five cannulations with the ultrasound probe before the start of the study.

Head-down position and hepatic compression were used to distend the jugular vein. The time from the moment of needle insertion through the skin to the time at which the guide wire was successfully placed within the internal jugular vein was measured. The attending anaesthetic assistant noted the time and recorded the occurrence of any complications. No time limit was set, but the procedure was recorded as a failure if right internal jugular cannulation was abandoned and an alternative site was used for central venous cannulation.

Comparison between groups of the success rates, rates of arterial puncture and time taken for the procedure was made using the Student's *t*-test or χ^2-test with Yates correction for small samples, as appropriate.

Results

The two groups of children were similar with respect to age and weight (Table 1). One hundred and thirty-four patients were randomized, 65 into the landmark group and 69 into the ultrasound group. On 10 occasions, the ultrasound probe was either not available or the batteries were uncharged. These 10 cases were therefore excluded from further analysis, so that a total of 59 patients were included in the ultrasound group (Table 1).

In the landmark group, there were seven failures to cannulate the internal jugular vein (10.8%). Three of these were associated with arterial puncture and formation of a haematoma. In the remainder, although venous blood was aspirated, the guide wire could not be inserted. In one further case, there was an inadvertent carotid arterial puncture with formation of haematoma, but internal jugular vein cannulation was subsequently successful at the same site.

In the ultrasound group, there were 13 failures to cannulate the vein (22%), seven of these being associated with carotid arterial puncture, four of which developed a haematoma. In three other cases, haematoma formation was observed without arterial puncture. Again, the most common problem was inability to pass a guide wire despite successfully aspirating venous blood.

No other complications occurred in either group. There was a significant overall difference between the two groups when comparing failure rates (χ^2=10.58, P<0.002) and arterial puncture rates (P=0.03), with both failure and arterial puncture being more common in the ultrasound-guided group (Table 1). All failures except one occurred in patients who were less than 10 kg in weight and under 1 yr old.

Guide wire insertion was achieved within 1 min in 46 (70.8%) of the landmark group, compared with 24 (40.7%) of the ultrasound group. The median time to insertion of the guide wire was 48 s in the landmark group and 1 min in the ultrasound group. The range of times was similar between the two groups: 0.2–10.5 min in the landmark group and 0.3–6.0 min in the ultrasound group.

Discussion

The results from our study are markedly different from those published previously. Real-time ultrasound guidance did not reduce the time taken to achieve guide-wire placement in the internal jugular vein, and appeared to increase the incidence of complications and failure to cannulate when used by this group of paediatric cardiac anaesthetists.

It is not clear what the overall success and complication rates are in internal jugular vein cannulation in infants and children; presumably this will vary with all the factors previously listed. Success rates in earlier studies using landmark techniques have been reported as varying from 59.6% up to 97.2%, with an incidence of carotid arterial puncture varying from 11% to 23%.[6 7] Generally, success rates are greater with children older than 2 yr; this is to be expected given that the target vein will be larger in older children. Examining the anatomy of the jugular vein in 50 infants by ultrasonography, Alderson and colleagues[8] found

Table 1 Patient characteristics and study results

	Landmark group	Ultrasound group	Statistical significance
n	65	59	
Age range	2 days to 7 yr	1 day to 8 yr	
Weight, mean (SD), range (kg)	8.89 (5.99), 2.4–24.6	8.57 (5.39), 2.0–23.8	NS
Successful cannulation	58 (89.2%)	46 (80%)	P<0.002
Mean time to guide wire placement (min) (range)	1.54 (0.2–10.5)	1.63 (0.3–6)	NS
Median time to guide wire placement (min)	0.8	1.0	
Arterial puncture	4 (6.2%)	7 (11.9%)	P<0.03

that the vein was of unusually small calibre in 4% of children, and could not be seen at all in 2%. This would suggest that difficulties might be expected in at least 6% of infants.

Why are our results different from previously reported figures? The evidence in children was based on three published randomized controlled studies of jugular venous cannulation, with sample sizes of 40, 95 and 45 respectively, a total of 180 patients.[8–10] In the first of these studies, ultrasound was used to mark the projection of the internal jugular vein on the neck, and this line was used as a guide for cannulation (i.e. this study did not use 'real-time' location). The two remaining studies were by the same authors and may have included some or all of the same cases. Procedures in these two latter studies were performed by anaesthetic fellows (i.e. trainees) rather than by experienced practitioners. All three studies concluded that ultrasound guidance reduced the time taken to achieve cannulation—but by a relatively negligible amount when taken within the clinical context. In the first report by Verghese and colleagues,[9] the median time to cannulation using ultrasound guidance was 4.2 min, which was a significant reduction from a median time of 14 min for the landmark technique. In their second report,[10] the mean time to cannulation using ultrasound imaging was 4.5 min, a non-significant reduction from the mean time of 6.6 min using the landmark technique. All of these times are prolonged, and may represent inadequate operator experience. In the study by Alderson and colleagues,[8] in which cannulation was performed by experienced cardiac anaesthetists, mean times were similar to those in our study. They reported a mean time of just less than 1 min to aspiration of venous blood using the landmark technique, which is comparable to our mean time of approximately 1.5 min to aspirate blood and place the Seldinger wire, irrespective of technique.

Two of the three studies found that ultrasound use increased the success rate and reduced the incidence of complications (Table 2). These variables are obviously related, since the occurrence of arterial puncture with haematoma formation was deemed to be a technique failure. Editorial comment in the *British Medical Journal* pointed out that there were concerns about sample size and suggested that the sample size of reliable studies should substantially exceed 100 patients.[11] Nevertheless, these studies were deemed to provide "firm evidence for the application of … ultrasonography in children".[11] Equally, a recent meta-analysis looking at studies in adults and children commented that studies in infants had small sample sizes, but made no further reference to the level of evidence available.[12] The fact that the three previous studies of ultrasound-guided cannulation reported 100%, 100% and 94% success rates in their ultrasound groups (Table 2) may be a function of their small sample sizes of 20, 43 and 16 patients, respectively.[8–10]

It appears that our performance with the landmark-guided technique lies within the acceptable range. Our success rates were higher and arterial puncture rates lower than in the other three studies (Table 2). This may relate to operator experience. The anaesthesia fellows performing the procedures in Verghese and colleagues' studies were each 'trained' in the landmark technique on five patients before the study. The arterial puncture rates of 25% and 19% reported for the landmark technique in these two studies (Table 2) would appear to be on the high side, and are perhaps a function of the early learning curve for a group of inexperienced operators.

We failed, however, to emulate the success rates with ultrasound reported by Alderson and colleagues[8] and Verghese and colleagues.[9 10] Our failures may have been related to inexperience with the use of the ultrasound probe. However, all three anaesthetists had used this device before the study, and an editorial in the *British Journal of Anaesthesia* has suggested that minimal training is required to use ultrasound scanning for this purpose.[3] Certainly, we would accept that inadequate operator experience might be a factor, although there was no trend towards improved results over the time period of this study. Whilst all three operators appreciated the ability to image the internal jugular vein, all found that the ultrasound probe was too bulky to use easily in small infants, and that the needle guide was cumbersome.

There may have been a tendency to abandon the procedure earlier when ultrasound-guided cannulation was used, thus increasing the number of failures in this group. In Verghese and colleagues' initial paper,[9] failure was defined as inability to cannulate the internal jugular vein within

Table 2 Comparison of our results with the published studies on which NICE guidelines are based

	Landmark success	Landmark arterial puncture	Ultrasound success	Ultrasound arterial puncture	Operators
Present study	58/65 (89.2%)	4/65 (6.2%)	46/59 (80%)	7/59 (11.9%)	Consultant paediatric anaesthetists
Alderson and colleagues[8]	16/20 (80%)	2/20 (10%)	20/20 (100%)	1/20 (5%)	Experienced cardiac anaesthetists
Verghese and colleagues[9]	40/52 (77%)	13/52 (25%)	43/43 (100%)	0/43 (0%)	Paediatric anaesthesia fellows
Verghese and colleagues[10]	13/16 (81.3%)	3/16 (19%)	15/16 (94%)	1/16 (6%)	Paediatric anaesthesia fellows

45 min, the need for more than seven attempts or the occurrence of a complication (e.g. carotid arterial puncture with haematoma). We deliberately did not prescribe a time period, but left it to the operator's discretion to abandon a particular technique or site of cannulation; we defined prolonged cannulation as one that took longer than 6 min.

In conclusion, the use of ultrasound guidance did not help three experienced paediatric cardiac anaesthetists to achieve better success rates in internal jugular cannulation in children. It is disturbing that the NICE guidelines, which are relatively prescriptive and which may have medicolegal implications, should be based on such a small body of evidence. In our view, the NICE guidelines should be amended to remove reference to infants and children until the results of further assessment are available.

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