

CLINICAL PRACTICE

**Effect of the implementation of NICE guidelines for ultrasound guidance on the complication rates associated with central venous catheter placement in patients presenting for routine surgery in a tertiary referral centre**

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**Background.** The National Institute for Clinical Excellence (NICE) guidelines of 2002 recommended the use of ultrasound (US) for central venous catheterization in order to minimize complications associated with central line placement. An ongoing audit of line placement by anaesthetists in the theatre complex of a tertiary referral centre looked at the associated complication rates. The objective of the study was to compare complication rates pre- and post-implementation of NICE guidelines.

**Methods.** This prospective, single centre audit looked at all patients in whom a central venous catheter was placed for surgery. Complication rates were assessed for procedures that were performed pre- and post-implementation of NICE guidelines. In total, 438 patients were identified for the study, and the procedures were performed either by trainee or by consultant anaesthetists.

**Results.** The pre- and post-implementation complication rates were 10.5% (16/152) and 4.6% (13/284), respectively, representing an absolute risk reduction of 5.9% (95% CI 0.5–11.3%). Comparison of those procedures in which US was used when compared with the landmark technique after implementation found a reduction of 6.9% in complications (95% CI 1.4–12.4%). The reduction in complication rates was larger for specialist registrars than for consultants (11.2% vs 1.6%).

**Conclusions.** The implementation of NICE guidelines has been associated with a significant reduction in complication rates in our tertiary referral centre. In the light of the cross-speciality evidence of US superiority and our results, it is imperative that routine use of US guidance becomes more widespread.

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The National Institute for Clinical Excellence (NICE) guidelines formulated in September 2002 and reviewed in August 2005 recommended two-dimensional imaging ultrasound (US) guidance as the preferred method of both elective and emergency central venous cannulations.<sup>1</sup> A commissioned meta-analysis by NICE including 18 randomized control trials comparing US with the landmark method for central venous access concluded that US

was more effective than landmark for all outcomes for cannulation of the internal jugular vein, and the relative risks of failed attempts, complications, and failed first attempts were 86%, 57%, and 41%, respectively.<sup>2,3</sup>

Complications of central venous cannulation include arterial puncture, pneumothorax, neck or mediastinal haematoma, and haemothorax.<sup>4,5</sup> US has been shown to decrease all of these in a series of individual studies and

in two meta-analyses. It has also been shown to decrease time to cannulation and the number of attempts.<sup>4–6</sup> The superiority of US over the landmark method has been demonstrated in a range of clinical settings, including paediatrics,<sup>7–9</sup> renal medicine,<sup>10,11</sup> intensive care,<sup>12,13</sup> and the emergency department.<sup>14,15</sup> However, there are surprisingly few studies involving anaesthetists or patients presenting for routine surgery.

The uptake of NICE guidelines across the UK has been variable and inconsistent<sup>16</sup> and to our knowledge ours is the first study to date that has looked at the impact of implementation of these guidelines and the direct effects on complication rates. Our tertiary referral centre has had an ongoing audit looking at complications associated with central venous cannulation since February 2005, and results before introduction of routine US guidance in October 2005 showed a complication rate of 10.5% (16/152).

## Methods

### Study design

This was a prospective audit performed in the theatre complex of a tertiary referral centre. The protocol was approved by our audit committee before commencement of the study and was discussed with the Chair of the research ethics committee who stated that ethics committee approval was not required.

### Selection of participants

All patients older than 18 yr presenting for surgery between October 2005 and November 2006 who required central venous access as part of their anaesthetic were included. The patient population represented a heterogeneous group with advanced malignancies and often had risk factors for difficult cannulation.

### Interventions

All central venous cannulations were performed by senior specialist registrars (post-fellowship SpRs in Anaesthesia) or consultant anaesthetists. In line with NICE guidance, the choice of whether to use the landmark technique or US guidance was left to the operator.

Ultrasonic guidance was with the portable SonoSite™ (SonoSite Inc., Bothell, WA, USA) iLook25 with a 10–5 MHz linear array. Insertion was performed aseptically with the probe being covered by a sterile sleeve and gel. Training was provided by Trust Anaesthetic consultants who had been on the SonoSite™ vascular access course.

The landmark technique was performed aseptically according to operator experience and preference.

Chest radiographs were reviewed after each procedure, and assessment of incorrect positioning and associated complications was made.

### Data collection

For each attempted cannulation, operator (consultant or SpR), site (internal jugular, left or right side), method of insertion, complications (with exact details), and number of attempts were documented on a pre-printed data collection sheet.

Complications were defined as arterial puncture, pneumothorax, haematoma, and other.

The insertion was deemed a failure if the operator was unable to cannulate the first site attempted or had to change technique.

### Statistical analysis

Results were analysed with SPSS v12.0 (SPSS Inc., Chicago, IL, USA). Analyses were conducted using the  $\chi^2$  test and confidence intervals for difference were calculated using the continuity corrected Wald confidence interval.

## Results

In total, 284 insertions were performed in the 13 month period after implementation of the guidelines. 169 (59.5%) were conducted using US guidance and 115 (41.5%) with the landmark technique.

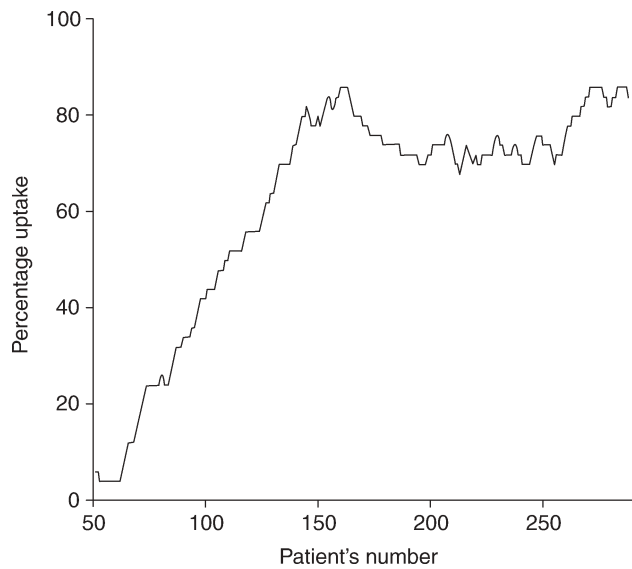
Table 1 summarizes the main outcome measures. Consultants (42.1% and 44.4%) and SpRs (57.9% and 55.6%) inserted a similar proportion of central venous catheters (CVCs) before and after implementation of guidelines. All lines were placed in the internal jugular vein.

The overall uptake rate of US guidance after implementation was 59.5% (60.3% for consultants and 62.0% for SpRs). Uptake increased markedly as the audit progressed (Fig. 1).

There were 19/152 complications during the pre-guideline audit (18 of which involved the landmark technique) and 13/286 complications after. Ten of these were in the landmark group (8.7% complication rate) and three were in the US-guided group (1.7% complication rate). This is an absolute risk reduction in favour of US of 6.9% (95% CI 1.4–12.4%). There were five carotid artery punctures, one pneumothorax, and four haematomas in the

**Table 1** Main outcome measures pre- and post-implementation of NICE guidelines. \*In eight cases, both SpR and consultant attempted insertion on the same patient

	Before implementation of NICE guidelines (n=152)	After implementation of NICE guidelines (n=284)
Operator		
Consultant	64 (42.1%)	126 (44.4%)
SpR	88 (57.9%)	158 (55.6%)
Ultrasound uptake	19 (12.5%)	169 (59.5%)
Complications		
Overall	16 (10.5%)	13 (4.6%)



**Fig 1** Ongoing percentage uptake of US guidance after guideline implementation. Calculated at patient number  $n$  as  $[\text{number of times ultrasound used from case } (n-50 \dots n)]/50$ .

landmark group. In the US group, there were three carotid artery punctures.

Table 2 compares the incidence of complications for SpRs and consultants with and without US guidance. It can be seen that in our institution the positive effect is most marked for SpRs (12.3% vs 1.1% complication rate, an absolute risk reduction (ARR) of 11.2%, 95% CI 2.9–19.5%).

There was a significantly greater number of failed insertions in the landmark technique group (7/115 vs 1/169,  $P < 0.01$ ). In five of the cases of failed insertion using the landmark technique, US was used successfully in further attempts. However, we did not demonstrate any difference in the average number of attempts to successful cannulation.

## Discussion

The insertion of CVCs is a common practice that is associated with significant morbidity.<sup>5</sup> There is increasing cross-speciality evidence for the superiority of US guidance in central venous cannulation, both in terms of reduction in insertion complications,<sup>5</sup> decreased time to insertion,<sup>6</sup> improved cost-effectiveness,<sup>17</sup> and possibly even decreased risk of catheter-related sepsis.<sup>13</sup> This has resulted in the formulation of NICE guidelines recommending the use of

US guidance in the insertion of CVCs. The NICE guidelines refer particularly to insertions in the internal jugular vein, but there are a number of papers that show benefit for insertions in other sites.<sup>12–18</sup> Despite the evidence supporting these guidelines, there has been considerable debate among anaesthetists about the necessity of their implementation. In a recent survey of the practice of paediatric anaesthetists, only 39% routinely used US,<sup>19</sup> whereas a more recent survey (again of paediatric anaesthetics) by Tovey and colleagues<sup>20</sup> found only 26% always used US. A survey of N. American cardiovascular anaesthesiologists found only 15% always used US<sup>21</sup> with the most common reason given for not using US being ‘no apparent need’. Other reasons advanced for the reluctance to take up US range from the relative paucity of studies involving anaesthetists to the lack of representation on the NICE committee of anaesthetic consultants.<sup>22</sup> The argument that US machines are not available no longer seems to hold water after the publication of a survey by Harris and colleagues<sup>23</sup> that showed 86% of departments had a US locating device.

Before our department adopted the routine use of US, we found we had a 10.5% complication rate, which is broadly in line with accepted figures for the landmark technique.<sup>24</sup> In our study, the implementation of the guidelines by the anaesthetic department of a hospital performing a wide range of procedures in a population with major pathology resulted in a significant reduction in complications from 10.5% to 4.6% ( $P < 0.01$ ). Comparing US use and the landmark technique after implementation of the guidelines, there was a 6.9% reduction in complications, representing a number needed to prevent one complication of 14.5. Similar significant reductions in the number of failures were also seen with US.

Interestingly, our results would suggest that US afforded more benefit to SpRs than to consultants. The complication rate for SpRs has decreased from 12.3% with the landmark technique to 1.1%, an ARR of 11.2% (95% CI 2.9–19.5%) whereas that of consultants has seen a non-significant decrease from 4% to 2.6% (95% CI –5.2% to 7.8%). This is consistent with the meta-analysis by Keenan,<sup>5</sup> which found that US conferred the greatest benefit for inexperienced clinicians and in our case is probably because the underlying complication rate for consultant performed insertions using the landmark technique was much lower than for the SpRs.

**Table 2** Comparison of the failure and complication rates for the landmark technique and US guidance after guideline implementation

Outcome	Landmark technique	Ultrasound-guided group	Absolute reduction with ultrasound use
Failure	7/115 (6.1%)	1/169 (0.6%)	5.5% (95% CI 0.1–9%)
Complication rate	10/115 (8.7%)	3/169 (1.8%)	6.9% (95% CI 1.4–12.4%)
Complication rate for SpRs	8/65 (12.3%)	1/93 (1.1%)	11.2% (95% CI 2.9–19.5%)
Complication rate for consultants	2/50 (4%)	2/76 (2.6%)	1.6% (95% CI –5.2% to 7.8%)
Average number of attempts	1.31	1.23	

Although the use of the US now stands at 86%, uptake was initially poor. This was related to the time taken for individual practitioners to be trained in and to become comfortable with its use. Despite the NICE guidelines, there is no national recommendation for training. The Royal College of Radiology recommends that practical training in vascular US should involve at least two US lists per week over a period of no less than 3 months and up to 6 months, with approximately four to six examinations performed by the trainee under supervision per session.<sup>25</sup> This is obviously impractical for the general anaesthetist who simply wishes to perform vascular access procedures.

Our training consisted of individual consultants attending the SonoSite™ 1 day training course and then disseminating their training to others. New SpRs are now required to watch five US-guided insertions and then be supervised in performing a further five. The establishment of an agreed training programme may be a significant stumbling block that slows uptake in some centres.

Ours was an observational study, not blinded, or randomized. Practice changed during the second part of the audit as clinicians became more confident with the use of the US. It is also possible that awareness of our audit may have influenced practice. This is a potential source of bias.

In summary, our study of the effects of implementation of NICE guidelines on the complication rates of CVC insertion for an anaesthetic department in a busy tertiary referral centre supports the routine use of US by anaesthetists.

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