Ultrasound for central venous cannulation: economic evaluation of cost-effectiveness

Calvert N, Hind D, McWilliams R, Davidson A, Beverley C A, Thomas S M

Record Status
This is a critical abstract of an economic evaluation that meets the criteria for inclusion on NHS EED. Each abstract contains a brief summary of the methods, the results and conclusions followed by a detailed critical assessment on the reliability of the study and the conclusions drawn.

Health technology
Two procedures used in central venous cannulation (CVC) were compared. One was CVC using real-time two-dimensional ultrasound locating devices. The other was an anatomical landmark method of cannulation.

Type of intervention
Screening and treatment.

Economic study type
Cost-effectiveness analysis.

Study population
The study population comprised a hypothetical cohort of 1,000 patients. The characteristics of the population were not described in detail. The authors reported that patients in emergency scenarios were excluded from the study, as were high-risk patients. Also excluded were those who faced higher risk of complications, such as infants, neonates, and adult patients in whom cannulation is more difficult to perform (e.g. obese or short-necked patients). More information on the study population can be found in the three papers cited in the 'Other Publications of Related Interest' section.

Setting
The setting was secondary care. The economic analysis was carried out in the UK.

Dates to which data relate
The effectiveness data were derived from studies published between 1990 and 2003. The cost data were derived from official sources published or electronically accessed in 2001. All prices were reported for the year 2002.

Source of effectiveness data
The effectiveness data were derived from a review and synthesis of published data.

Modelling
A decision analytic model was used to estimate the clinical effectiveness and costs of the two procedures. The authors made several modelling assumptions. It was first assumed that cannulation is unsuccessful in a proportion of patients and successful in the remainder. Only arterial puncture was considered as a complication in the model, while pneumothorax, which is also more costly, was excluded. Contrary to literature evidence that ultrasound-guided cannulation is faster than landmark cannulation, the authors made a conservative assumption that successful punctures have equal duration in both methods. In the case that a procedure was unsuccessful, it was assumed that the operator spends 10 minutes at the initial puncture site before starting to operate at a new site, and only one failed attempt was allowed. In addition, new line equipment was not being used for a second attempt, disregarding the fact that this might be needed in practice. The model assumed that during each procedure a consultant surgeon, a senior house officer, an
E-grade theatre nurse, a consultant anaesthetist and a medical technical officer (grade 2/3) are present in the operating theatre. Finally, any expected time advantages of successful ultrasound-guided CVC were not considered in the model.

**Outcomes assessed in the review**
The authors reported that the following parameters were used in the model:

the initial success rate at insertion of each cannulation method,

the complication rate (for arterial puncture and pneumothorax), and

the number of operator procedures and ultrasound procedures performed per week.

**Study designs and other criteria for inclusion in the review**
The authors reported that they only included randomised controlled trials (RCTs) in their review. In addition, RCTs in which the operator was inexperienced in the use of the comparator landmark were excluded from the review.

**Sources searched to identify primary studies**
Not reported.

**Criteria used to ensure the validity of primary studies**
Apart from the study design, the authors did not report any further criteria to ensure the validity of the primary studies.

**Methods used to judge relevance and validity, and for extracting data**
Not reported.

**Number of primary studies included**
Overall, 5 primary studies were included in the review.

**Methods of combining primary studies**
The authors pooled the data from the primary studies using a fixed-effect model to estimate the relative risks and 95% confidence intervals (CIs).

**Investigation of differences between primary studies**
The authors do not seem to have investigated differences between the primary studies.

**Results of the review**
The failure rate was 9% for the landmark procedure and 2% for the ultrasound procedure.

The arterial puncture rate was 12% for the landmark procedure and 3% for the ultrasound procedure.

The authors stated that pneumothorax complications were not reported in the primary studies included in the review.

There were two operator procedures performed per week and 15 ultrasound procedures.

**Measure of benefits used in the economic analysis**
The authors did not derive a summary measure of benefit in the economic analysis. In effect, a cost-consequences
analysis was performed.

**Direct costs**
The economic analysis was conducted from the perspective of the NHS. The direct costs included were:

- the cost per ultrasound-guided CVC, including the cost of purchasing a modern portable ultrasound machine;
- the cost of maintaining the machine, which depended on the usage of the machine;
- the cost of an operating theatre (per hour);
- the cost for staff on an hourly basis, including overheads, on-costs and education (i.e. the cost of a consultant surgeon, consultant anaesthetist, senior house officer, medical technical officer, E-grade theatre nurse);
- the training cost per ultrasound-guided CVC, adjusted to the usage and length of the trainees' remaining working life;
- the cost of using the ultrasound machine (including cost of gel and disposable cover); and
- the average cost of arterial puncture and pneumothorax.

The unit costs and the quantities were reported separately. The costs were based on actual data from the authors' settings, while the quantities of resources used were derived from authors' assumptions. All the costs incurred in the future (purchasing costs of equipment, maintenance cost, training cost) were appropriately discounted. All the costs were reported for the year 2002.

**Statistical analysis of costs**
The costs were treated deterministically.

**Indirect Costs**
The indirect costs were not included in the economic analysis. This is consistent with the perspective stated.

**Currency**
UK pounds sterling (£)

**Sensitivity analysis**
A univariate threshold sensitivity analysis was conducted on all key input parameters of the model to test variability in the data. The point where the two procedures incur equal costs was used as a threshold.

**Estimated benefits used in the economic analysis**
See the 'Effectiveness Results' section. The model outcome that was not combined with the costs was that the ultrasound procedure resulted in 90 avoided arterial punctures per 1,000 patients.

**Cost results**
The authors only reported the cost-savings. The ultrasound procedure resulted in savings of £2,000 for the NHS per 1,000 patients.

The threshold sensitivity analysis indicated that the results were most sensitive to changes in the cost of the ultrasound procedure. Specifically, although the results (cost-savings) were insensitive to the purchase cost of the machine and the training cost per operator, they were relatively sensitive to the average number of procedures per machine per week.
and the average number of ultrasound procedures per week that were carried out by each trained operator.

**Synthesis of costs and benefits**
The costs and benefits were not combined.

**Authors' conclusions**
The analysis indicated that ultrasound-guided central venous cannulation (CVC) is more cost-effective than the traditional landmark method. The use of this technique is "likely to improve both clinical effectiveness and use of NHS (National Health Service) resources".

**CRD COMMENTARY - Selection of comparators**
The choice of ultrasound-guided CVC was explicitly justified. The landmark method seems to represent the most commonly used method in the authors' setting. You should decide if this represents a widely used health technology in your own setting.

**Validity of estimate of measure of effectiveness**
The authors do not appear to have undertaken a systematic review of the literature. Although this is common practice with modelling studies, it makes it difficult to ascertain whether the best available evidence was used to populate the model. The authors have tried to ensure that the best-quality data were used by only using RCTs as the source of the effectiveness data, but it cannot be established if they used all available RCTs or selectively chose five. The estimates of effectiveness from the primary studies were combined using a fixed-effect model to calculate the relative risks and 95% CIs. However, the authors did not consider the impact of differences between the studies identified when estimating effectiveness. In addition, the authors made several assumptions about the model, some of which contradicted evidence in the literature. The assumptions made were not appropriately justified.

**Validity of estimate of measure of benefit**
The authors did not derive a summary measure of benefit. In effect, a cost-consequences analysis was performed.

**Validity of estimate of costs**
The cost analysis was performed from the perspective of the NHS. As such, it appears that all the relevant categories of costs have been included in the analysis. Most of the costs were reported, thus enhancing the reproducibility of the study in other settings. Although the costs were treated deterministically, an extensive sensitivity analysis was carried out. This improved both the internal validity and the generalisability of the study by demonstrating the robustness of the results to changes in the base-case estimates. The authors appropriately discounted all future costs included in the economic analysis. The price year was reported.

**Other issues**
The authors compared their findings with those from other studies, reporting them to be in agreement. They also directly addressed the issue of the generalisability of the results to other settings. The authors do not seem to have presented their results selectively. The characteristic of the patients were not described in detail, making it difficult to know whether the authors’ conclusions reflected the scope of analysis. The authors did not report any limitations to their study.

**Implications of the study**
The authors did not make any explicit recommendations for changes in policy or practice.
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Other publications of related interest


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