Cost-effectiveness of intraoperative imaging in carotid endarterectomy
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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
The study examined the use of intraoperative imaging as an adjunct to carotid endarterectomy. The strategies examined were intraoperative ultrasound scanning (IUS), completion angiography, and no intraoperative imaging. The study assessed a contemporary technique for IUS involving intraoperative duplex ultrasonic scanning. Completion angiography was also referred to as completion arteriogram and completion angiogram.

Type of intervention
Screening.

Economic study type
Cost-utility analysis.

Study population
The hypothetical study population comprised patients undergoing carotid endarterectomy.

Setting
The setting was secondary care. The economic study was carried out in the USA.

Dates to which data relate
The data referred to the period 1988 to 2004. The price year was 2004.

Source of effectiveness data
The effectiveness data were derived from a review of published studies. Utility values for the model were based on authors' assumptions.

Modelling
A decision tree was used to model the costs and effects of the three intraoperative imaging strategies. The time horizon for the model covered the postoperative period, although this was not defined in terms of length of time. Patients identified with major abnormalities following intraoperative imaging were assumed to be re-opened for repair. Following surgery, patients could die, experience a nonfatal cerebrovascular accident (CVA), or have no event. The model was evaluated using patient-level simulation, where 10,000 individuals were simulated for each run of the model. A probabilistic analysis was conducted using a two-dimensional Monte Carlo simulation, where the parameter values were varied 1,000 times, and for each set of parameter values, 10,000 patients were simulated.

Outcomes assessed in the review
The review was used to identify data to inform the model parameters. Such parameters included the probabilities of
surgical complications with and without intraoperative imaging, surgical mortality, and the probability and outcomes of nonfatal CVA.

**Study designs and other criteria for inclusion in the review**
The authors excluded case reports, letters, reviews without original data, duplicative investigations and laboratory investigations.

**Sources searched to identify primary studies**
The authors searched PubMed utilising the Related Articles feature. In addition, they examined the bibliographies of selected articles.

**Criteria used to ensure the validity of primary studies**
Not reported.

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

**Number of primary studies included**
The authors stated that the review included 52 reports. They stated that 27 case series examined IUS, 10 case series examined completion arteriography, and 11 multi-centre trials examined carotid endarterectomy without routine intraoperative imaging.

**Methods of combining primary studies**
The authors stated that the parameter values for the decision model were based on a weighted average of the available estimates.

**Investigation of differences between primary studies**
Not reported.

**Results of the review**
The probability that a patient would be identified with abnormal imaging results requiring them to be re-opened was 0.0597 (95% confidence interval, CI: 0.038 to 0.860) with IUS and 0.0804 (95% CI: 0.055 to 0.116) with completion arteriogram.

The probability of peri-operative stroke with normal imaging results was 0.0155 (95% CI: 0.007 to 0.031) for IUS and 0.0127 (95% CI: 0.008 to 0.018) for completion arteriogram.

The probability of peri-operative stroke with abnormal imaging results was 0.0041 (95% CI: 0.0001 to 0.023) for IUS and 0.0362 (95% CI: 0.018 to 0.066) for completion arteriogram.

**Methods used to derive estimates of effectiveness**
Where estimates from the literature were unavailable for health-related quality of life (utility) values, author consensus was used.

**Estimates of effectiveness and key assumptions**
The authors estimated utility values for re-opening (0.99) and recovery from peri-operative stroke (0.70, 95% CI: 0.67 to 0.73).

**Measure of benefits used in the economic analysis**
The study authors described the measure of health benefits used in the economic analysis as health utilities. They stated that the utility values were applied to health states in the model to quality-adjust them. The authors did not explicitly discuss the time spent in each health state, or give an overall time horizon for the model, so these health utilities may not be equivalent to quality-adjusted life survival.

**Direct costs**
The authors did not report the resource use quantities separately to the costs. The study included the direct costs to a third-party payer. The direct costs were based on Medicare reimbursements and probably do not reflect opportunity costs. Discounting might not have been relevant if the model covered a time period of less than 1 year, but the time horizon of the model was unclear. The study reported the average costs. The price year was 2004.

**Statistical analysis of costs**
Individual patient-level data were not available for statistical analysis.

**Indirect Costs**
The indirect costs were not included in the analysis. This indicates that the authors were incorrect in asserting that the study was conducted from a societal perspective.

**Currency**
US dollars ($).

**Sensitivity analysis**
The effectiveness parameters and a selected number of utility estimates were varied within their 95% CIs in a probabilistic analysis. A fully probabilistic analysis was not conducted, as the health state costs and some utility values were entered deterministically (as a fixed mean value) into the model. The authors did not describe which distributions were used to characterise the uncertainty around parameters in the probabilistic analysis.

**Estimated benefits used in the economic analysis**
The estimated health utilities were 0.9875 (95% CI: 0.9828 to 0.9936) for IUS, 0.9873 (95% CI: 0.9823 to 0.9919) for completion angiography and 0.9667 (95% CI: 0.9577 to 0.9757) with no intraoperative imaging. The authors accounted for additional disutility caused by re-opening patients following abnormal imaging results.

**Cost results**
The cost were $396.50 (95% CI: 248.38 to 571.98) for IUS, $840.90 (95% CI: 749.77 to 941.07) for completion angiography and $721.30 (95% CI: 488.00 to 963.32) with no intraoperative imaging. The study included the additional costs of re-opening patients following abnormal imaging results.

**Synthesis of costs and benefits**
The costs and benefits were not combined as IUS was found to be the dominant treatment strategy (i.e. most effective and least costly).
Authors' conclusions
Intraoperative ultrasound scanning (IUS) is significantly more cost-effective than either completion angiography or no imaging.

CRD COMMENTARY - Selection of comparators
The authors stated that a range of measures are available for reducing the risk of peri-operative complications of carotid endarterectomy, but they did not explicitly justify why they chose to focus on IUS and completion angiography. You must decide whether this comparison is relevant in your own setting.

Validity of estimate of measure of effectiveness
The effectiveness data were derived from a review of published studies. The authors did not claim that the review was systematic. The methods of the review were adequately reported. The authors pooled the estimates from the primary studies by taking a weighted average. This method reflects the differences in uncertainty relating to the size of the study sample. However, the authors did not investigate differences between the primary studies. As the primary source of the data was case series, some of which were prospective and some retrospective, there may have been important differences between the studies and in the quality and validity of the available estimates. Of particular importance is the fact that different studies were used to inform separate parameter estimates for each treatment strategy, thus the validity of the study results depends on the strong assumption that the study populations were all directly exchangeable. The authors provided no evidence to support this strong assumption.

Validity of estimate of measure of benefit
The estimation of health benefits, as measured by health utilities, was modelled. It was unclear what these health utilities represented, and the method by which they were derived was not reported. The failure to adequately describe the measure of health benefits severely inhibits the interpretation of the study results.

Validity of estimate of costs
The authors stated that the study was performed from a societal perspective. However, they included only the direct costs from the perspective of a third-party payer. The indirect costs were omitted from the analysis. The costs and the quantities were not reported separately, which limits the generalisability of the study results. The cost data were based on Medicare reimbursements, which further limit the generalisability of the study results to other third-party payers or other countries. Medicare reimbursements may not reflect opportunity costs. The costs were entered deterministically in the decision model, and uncertainty or variability around the cost estimates was not explored in sensitivity analyses. The price year was reported.

Other issues
The authors stated that there is a lack of randomised trials and cost-effectiveness studies assessing intraoperative imaging as an adjunct to carotid endarterectomy. The issue of generalisability to other settings was not addressed. The authors did not present their results selectively. The conclusions that the study results are robust and that IUS is significantly more cost-effective than either completion angiography or no imaging were beyond the scope of the analysis. The authors did not report the probabilistic results of a simultaneous comparison of all three treatment strategies. The methods used to inform parameters for the decision model introduced the possibility of systematic bias and, as such, the incremental comparison of each strategy could alter with data from more rigorous sources. The authors acknowledged that by limiting the time horizon of the model to the peri-operative period, they omitted the effect of intraoperative imaging on rates of restenosis. However, they stated that if intraoperative imaging was found to be cost-effective with this omission, then it would appear more so were it included, as they assumed a nil or protective effect against restenosis.

Implications of the study
The authors stated that IUS should be used as a routine component of carotid endarterectomy.
Source of funding
None stated.

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