Diagnosis of vascular catheter-related bloodstream infection: a meta-analysis
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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
Diagnostic tests for vascular catheter-related bloodstream infection in hospitalised patients.

Type of intervention
Diagnosis.

Economic study type
Cost-effectiveness analysis.

Study population
Intensive care patients.

Setting
Secondary care. The study was carried out in Israel and the United States.

Dates to which data relate
The effectiveness data were taken from studies published between 1977 and 1992. The resource data were taken from studies published between 1992 and 1994, although, the source for part of the cost data was not specified. The price year was not specified.

Source of effectiveness data
Review and synthesis (meta-analysis) of previously completed studies.

Outcomes assessed in the review
The authors assessed the sensitivity and specificity characteristics of 6 diagnostic methods. The Youden index (sensitivity plus specificity minus 1) was reported as a summary statistical criterion for test performance. Another summary statistical measure (mean "D" value) was obtained from receiver operating characteristic (ROC) analysis.

Study designs and other criteria for inclusion in the review
Studies focussing upon the evaluation of methods for the diagnosis of catheter-related infection were included. Studies primarily addressing risk factors, management or prevention of catheter-related infection were excluded. Studies which focused upon diagnoses other than catheter-related bloodstream infections and those which did not clearly state their "gold standard" were excluded.

Sources searched to identify primary studies
MEDLINE was searched for English language journal articles from 1966 to 1994 addressing the techniques for the
diagnosis of catheter-related infections. Review articles, textbook chapters and references in MEDLINE were also
searched.

Criteria used to ensure the validity of primary studies
Only studies supplying primary data and using epidemiologic study methods similar enough to be statistically grouped
by diagnostic test method were included in the review.

Methods used to judge relevance and validity, and for extracting data
All studies were reviewed by at least two authors, and decisions regarding exclusion were made by consensus of the
authors. Primary data published in individual studies were used. Studies that could not be pooled due to differences in
technique were not pooled.

Number of primary studies included
22 primary studies were included in the review.

Methods of combining primary studies
A meta-analysis was conducted to obtain pooled sensitivity and specificity characteristics, by simple pooling of the
primary data from individual studies for each one of the six diagnostic methods. Studies were not weighted.

Investigation of differences between primary studies
The authors investigated alternative explanations of the accuracy of test results (such as the variable pathogenesis of
catheter related bloodstream infection). The possibility existed of incorporation bias in some of the studies and this
could compromise the validity of the results, by inflating the accuracy of the tests. The small number of studies
available for each test method limited the statistical power to assess the dependence of accuracy on study quality versus
patient characteristics and test threshold. Statistical tests for homogeneity were conducted for the pooled sensitivity and
specificity results. Specificity was heterogeneous for all six methods. Sensitivity was heterogeneous in 4 out 6 methods.

Results of the review
Qualitative catheter segment culture had 95% sensitivity and 75% specificity. Semi-quantitative catheter culture had
85% sensitivity and 85% specificity. Quantitative catheter segment culture had 94% sensitivity and 92% specificity.
The unpaired qualitative catheter blood culture method had 91% sensitivity and 86% specificity. The unpaired
quantitative catheter blood culture method had 78% sensitivity and 96% specificity. Paired quantitative blood culture
methods had 79% sensitivity and 94% specificity.

The mean Youden index (the higher the index, the more accurate the test) scores were:
catheter segment culture 0.65 (qualitative method), 0.70 (semi-quantitative method) and 0.85 (quantitative method).
blood culture from catheter methods, 0.70 (unpaired qualitative), 0.67 (unpaired quantitative) and 0.74 (paired
quantitative).

The mean D value obtained from the ROC curve analysis for the catheter segment culture was 3.30 (qualitative
method), 3.61 (semi-quantitative method) and 4.86 (quantitative method).

For the blood culture from catheter methods, the mean Youden index was 3.86 (unpaired qualitative), 4.41 (unpaired
quantitative) and 4.98 (paired quantitative). These were the principal results used to derive an estimate of benefit
(correct diagnoses).
Measure of benefits used in the economic analysis

Although not explicitly stated, the measure of benefits was the number of patients whose condition was correctly diagnosed. To obtain these benefits, the sensitivity and specificity of the diagnostic methods were used and a 10% prevalence of catheter-related bloodstream infection assumed amongst febrile patients.

Direct costs

The only quantity reported was the number of peripheral blood cultures drawn for each patient, otherwise only costs were reported. Costs were not discounted since they were incurred within a year. Direct costs included the costs of laboratory tests (including costs for personnel, minutes of test time, supplies and reagents, equipment and maintenance, logging specimens into the system, computer support and laboratory overhead) and the costs of administering vancomycin to false positive patients for 10 days. The cost boundary adopted was that of the hospital. The source of the costs for some of the procedures (replacement of catheter, chest radiograph, coagulation studies) was not specified. The source of the estimate of the number of peripheral blood cultures drawn for each patient was not reported. The time needed to complete each procedure was taken from the literature (The College of American Pathologists' Workload Recording method). The cost of administering vancomycin to patients was not specified. The price year was not specified.

Statistical analysis of costs

Statistical analysis of the costs was not performed.

Indirect Costs

Indirect costs were not included in the cost analysis.

Currency

US dollars ($).

Sensitivity analysis

Sensitivity analysis was not performed.

Estimated benefits used in the economic analysis

Estimated benefits were not reported separately. The reader is referred to the effectiveness results reported above.

Cost results

The estimated costs per test were as follows:

- $57.05 for the qualitative catheter segment culture,
- $38.63 for the semi-quantitative catheter culture,
- $88.71 for the quantitative catheter segment culture,
- $37.77 for the unpaired qualitative catheter blood culture method,
- $60.22 for the unpaired quantitative catheter blood culture method,
- $120.44 for the paired quantitative blood culture methods.

Incremental costs were not reported.
Synthesis of costs and benefits
The estimated costs and benefits were combined to obtain a cost per accurate test result, using the cost of the test and the pooled sensitivity and specificity of the tests. The calculation involved the assumptions that the prevalence of catheter-related bloodstream infection among febrile patients was 10%, that two sets of peripheral blood cultures would be drawn for each patient, and that patients with false positive test results for blood cultures drawn from the catheter would receive antibiotic therapy for an average of 10 days.

No costs were added for infectious complications related to false negative tests.

The estimated costs per accurate test were as follows:
- $467 for the qualitative catheter segment culture,
- $401.38 for the semi-quantitative catheter culture,
- $415.62 for the quantitative catheter segment culture,
- $271.44 for the unpaired qualitative catheter blood culture method,
- $198.18 for the unpaired quantitative catheter blood culture method,
- $282.17 for the paired quantitative blood culture methods.

An incremental analysis was not performed.

Authors’ conclusions
The test with the lowest cost to the entire hospital per accurate test result was the unpaired quantitative catheter blood culture. Among catheter segment cultures, the semi-quantitative method was the most cost-effective.

CRD COMMENTARY - Selection of comparators
The rationale for the selection of the different tests was clear. However, the authors’ search of the literature revealed a total of 16 test procedures and 17 variations, and therefore all possible comparators were not included in the analysis.

Validity of estimate of measure of benefit
The implicit measure of benefit was the number of people correctly diagnosed, obtained by using sensitivity and specificity results of the meta-analysis and assuming a 10% prevalence of the disease. A sensitivity analysis on these three parameters would have strengthened the analysis, given that the source of the prevalence estimate was not referenced and that some of the pooled sensitivity and specificity estimates needed to be considered with caution because of the presence of heterogeneity. The issue of other possible alternatives (see Selection of Comparators above) meant that other, more effective strategies may exist which could not be addressed in the present study due to lack of available analyses suitable for inclusion.

Validity of estimate of costs
The source of some of the costs was not referenced and no sensitivity analysis was conducted on the cost estimates. The lack of price year and use of local data limits the generalisability of the results to other settings.

Other issues
The cost-effectiveness analysis could have been strengthened by more detailed information on the calculation of the cost per accurate test. Although the authors stated that these costs represented the cost to the entire hospital, this is unlikely since the costs of not treating false negatives were not included. However such an analysis would require using a more complex measure of benefits. Comparison of results from other studies on diagnostic methods have
corroborated the results of the meta-analysis. However, the authors did not mention any other cost-effectiveness studies of diagnostic methods for catheter-related bloodstream infection. Improved generalisability of the study results would require sensitivity analysis to be conducted on the costs of the tests and the prevalence of the disease. Finally, an incremental analysis should have been performed rather than reporting average costs per accurate test, as average costs tend to be misleading by producing favourable results for low cost alternatives with low effectiveness.

**Implications of the study**
More studies are required where patients are given several types of tests; this would enable the assessment of the dependence of the accuracy of the test on study quality versus patient characteristics and test threshold.

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