Triage of patients to angiography for detection of aortic rupture after blunt chest trauma:
cost-effectiveness analysis of using CT

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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
Detection of aortic rupture in haemodynamically stable patients after blunt chest trauma, by use of chest radiography, angiography and dynamic chest CT.

Type of intervention
Diagnosis.

Economic study type
Cost-effectiveness analysis.

Study population
Patients admitted to the emergency department after sustaining blunt chest trauma who did or did not undergo CT for associated injuries.

Setting
Hospital. The economic study was carried out in the USA.

Dates to which data relate
Effectiveness data were derived from English language medical papers published between 1987 and 1994. Resource use dates were not reported.1993 prices were used.

Source of effectiveness data
Effectiveness data were derived from a review of previously completed studies and expert experience.

Modelling
A decision tree was used to estimate incremental economic costs and benefits.

Outcomes assessed in the review
The outcomes assessed were the prior probability of aortic rupture, the length of time delay due to the use of a diagnostic test, mortality risk, true positive rates (TPR), and false positive rates (FPR).

Study designs and other criteria for inclusion in the review
Studies relating to the identification and treatment of aortic rupture published between 1987 and 1994 were included in the review. Only English language studies were examined. Studies which used CT scans were only included if all scans
were carried out in hospital.

Sources searched to identify primary studies
Not stated.

Criteria used to ensure the validity of primary studies
Not stated.

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

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

Methods of combining primary studies
Where possible data retrieved from studies were pooled in a meta-analysis to derive inputs for baseline decisions in the model. Some data could only be retrieved from one source and thus could not be pooled.

Investigation of differences between primary studies
Not reported.

Results of the review
The prior probability of aortic rupture for clinically suspect patients was 0.05 (range: 0.006 - 0.2). Length of time delay due to additional mediastinal CT scan, if CT is performed for other injuries, was 10 minutes (range: 5 - 15). The probability of death from a reaction and severe adverse reaction to contrast material during CT scanning, was 0.9 (range: 0.3 - 2.6) per 100,000. The probabilities of death during angiography were 31 (range: 2 - 62) per 100,000. The probabilities of systematic complications or a severe adverse contrast reaction during angiography were 33 (range: 29 -162) per 100,000 and 1.7% (range: 0.5 - 3%), respectively. Perioperative mortality of thoracotomy for aortic rupture was 0.22 (range: 0.14 - 0.81).

True positive rates (TPR) and false positive rates (FPR) of the chest radiograph were as follows:

Supine using widened mediastinum, 0.67 and 0.55;
Supine using widened mediastinum or abnormal aortic arch, 0.88 and 0.76 (used in the sensitivity analysis);
Supine using widened mediastinum or abnormal aortic arch or loss of descending aorta or loss of aortopulmonary window, 0.93 and 0.84 (used in the sensitivity analysis);
Erect chest using widened mediastinum, 0.36 and 0.19 (used in the sensitivity analysis);
Erect chest using widened mediastinum or abnormal aortic arch, 0.72 and 0.55 (used in the sensitivity analysis);
Erect chest using widened mediastinum or abnormal aortic arch or loss of descending aorta or loss of aortopulmonary window, 0.89 and 0.58 (used in the sensitivity analysis) respectively.

TPR and FPR of dynamic CT using lenient positivity criteria were 1.0 and 0.22 (range: 0.04 - 0.81) and using strict positivity criteria were 0.83 and 0.21 (used in the sensitivity analysis).
Methods used to derive estimates of effectiveness
Expert opinion and experience were also used to derive estimates of effectiveness.

Estimates of effectiveness and key assumptions
Length of time delay due to the use of initial workup, chest radiography, CT scanning, and angiography were estimated to be 30 minutes, 10 (range: 5 - 15) minutes, 30 (range: 15 - 60) minutes, and 2 (range: 1 - 4) hours, respectively.

Measure of benefits used in the economic analysis
The benefit measure was lives saved.

Direct costs
Costs were not discounted since differential timing of costs and effects was absent in the study. Quantities were not reported separately from the costs except for time delay in hospital admission due to diagnostic tests. Cost components were reported separately. Costs relating to diagnosis and treatment were included. Specifically these included diagnostic tests, costs of and treatment for complications from contrast material, angiographic complications and treating traumatic aortic ruptures. The perspective adopted in the cost analysis was that of society. Cost estimates for the diagnostic tests were provided by the American College of Radiology, and were based on the professional and technical components of the 1993 Medicare physicians fee schedule. This corresponded to 57% of the charge to the patient. The cost of contrast material was based on prices in the pharmaceutical industry and on a dosage of 150ml and was assumed to add to the cost of both the CT scan and angiography. Costs of treating contrast complications were assumed to be the same as the treatment of angiographic complications. These figures were derived from a 1988 economic study. The costs of treating traumatic aortic ruptures were estimated from averaging the cost of coronary artery bypass grafting and that of aortofemoral bypass grafting. These figures were taken from two studies in 1990,1993 prices were used.

Indirect Costs
Not considered.

Currency
US dollars ($).

Sensitivity analysis
A set of one-way sensitivity analyses was performed on all parameters of the model.

Estimated benefits used in the economic analysis
For the cohort already undergoing a CT scan for evaluation of other injuries, immediate angiography and a CT scan followed by angiography where appropriate had equivalent survival rates. Any strategy involving the use of a chest radiograph as the initial diagnostic tool increased the risk of mortality by at least 24:10,000. For the cohort not already undergoing a CT scan the mortality risk was increased because of the time delay. Immediate angiography had the best survival rate. The use of a CT scan to determine if an angiogram should be performed increased the mortality risk by 4:10,000. All strategies which used plain chest angiography as the initial diagnostic tool increased the mortality rate by a minimum of 23:10,00 compared with immediate angiography.

Cost results
In the case of the cohort undergoing CT for the evaluation of other injuries, the cost of AG and CT-AG was $2,508 and $1,468 per patient. Based on the graph in the paper, the costs of other strategies including CXR-CT, CXR-AG, CXR-CT-AG, CXR only were approximately $4,100, $1,500, $1,000, and $300, respectively. The corresponding values for the respective strategies in the case of the cohort not undergoing CT for the evaluation of other injuries were
approximately $2,500, $1,500, $4,000, $1,400, $900, and $0, based on the graph in the paper.

**Synthesis of costs and benefits**

For both cohorts, any strategy involving the use of plain chest radiography was considered inferior. In the cohort which would use the CT scan for evaluating other injuries, the incremental cost-effectiveness ratio compared to chest radiography of using a CT scan followed by angiography where required is $187,000 per life saved. The incremental cost-effectiveness ratio for chest radiography followed by a CT scan and then angiography, compared to chest radiography alone, is $134,000 per life saved. For the cohort with no CT scan for evaluating other injuries, immediate angiography had an incremental cost ratio of $2.2 million per life saved compared with CT followed by angiography. The incremental cost-effectiveness ratio for CT followed by angiography was $242,000 per life saved. If the prior probability of aortic rupture was greater than 5% then the incremental cost-effectiveness ratio for immediate angiography fell below $500,000 per life saved.

**Authors' conclusions**

Selecting haemodynamically stable patients after blunt chest trauma with suspected aortic rupture for angiography on the basis of CT findings is more effective than doing so based on the findings of chest radiography and is cost-effective compared with other accepted health care programmes. Immediate angiography has a high incremental cost-effectiveness ratio in patients not undergoing CT for the evaluation of other injuries who have a prior probability of aortic rupture of 5% or more.

**CRD COMMENTARY - Selection of comparators**

A justification was given for the choice of the comparators: they have traditionally been employed in the context in question.

**Validity of estimate of measure of benefit**

The internal validity of the estimates of benefit cannot be guaranteed given the lack of a quality assessment of the primary studies included in the review.

**Validity of estimate of costs**

Quantities were not reported separately from the costs except for time delay in hospital admission due to diagnostic tests. Adequate details of methods of cost estimation were given. As acknowledged by the authors, the cost estimation was based on charge data rather than true costs. The study lacked prospective cost analysis.

**Other issues**

Because of the absence of both a quality assessment of the primary studies included in the review, and a comprehensive and prospective cost analysis, the results need to be treated with some caution.

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