Cervical spine screening with CT in trauma patients: a cost-effectiveness 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
Computer tomography (CT) was compared with conventional radiography for cervical spine screening in trauma patients.

Type of intervention
Screening.

Economic study type
Cost-utility analysis.

Study population
The study population consisted of patients who were screened for possible cervical spine fracture in trauma centres or emergency departments, and who were scheduled to undergo CT scanning of the head. The study population was divided into 3 sub-groups according to risk (high, moderate or low). Fracture probabilities were reported for each sub-group.

Patients who sustained severe head injury were selected as the reference group at high risk of cervical spine fracture (fracture risk 11.2%, 95% confidence interval, CI: 9.4 - 15.3). The reference group at moderate risk of cervical spine fracture (fracture risk 4.2%, 95% CI: 2.7 - 6.9) were patients aged 50 years or younger with a high-energy mechanism. The reference group at low risk of cervical spine fracture (fracture risk 2.1%, 95% CI: 1.6 - 3.2) were patients aged 50 years or younger with a moderate-energy mechanism.

Setting
The setting was secondary care. The economic analysis was conducted in Seattle, USA.

Dates to which data relate
The effectiveness data came from studies published between 1983 and 1994 and a case-control study of patients between 1992 and 1995. The price year was not stated.

Source of effectiveness data
The effectiveness data were derived from the medical literature and from the collection of original data.

Modelling
A decision analysis model was constructed to compare the incremental cost-effectiveness ratios (ICERs) of radiography and CT screening. A sub-group analysis was conducted for the different risk groups.
Outcomes assessed in the review
The clinical parameters assessed in the review and used as model inputs were the probability of cervical spine fracture, the sensitivity and specificity of radiography, the sensitivity of CT, and the probability of paralysis from undetected fracture.

Study designs and other criteria for inclusion in the review
To determine the risk of fracture, the authors adapted a clinical prediction rule that they had developed (see Other Publications of Related Interest). They also conducted a case-control study to determine the specific risk of fracture in the head CT population. A review of English-language literature was conducted for the other parameters.

To determine the sensitivity of cervical spine radiography, the number of true-positive and false-positive images had to be reported. In addition, the reference standard in each study analysed for inclusion in the review had to be the eventual clinical presentation with fracture. To determine the specificity of cervical spine radiography, the authors referred to a published study (see Other Publications of Related Interest) from which they measured the specificity directly from the medical records of randomly selected trauma patients.

To determine the sensitivity of CT, research articles in which there was a defined cohort of patients who underwent screening CT were included in the analysis.

To determine the probability of severe secondary deficit, the authors included the published studies encompassing 137 cervical spine fractures of which there was a delay in diagnosis.

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
Thirteen studies overall were referenced for all of the estimates.

Methods of combining primary studies
To determine the sensitivity of cervical spine radiography, the authors pooled the reported sensitivities, using a chi-squared test to exclude heterogeneity, (p=0.24). To determine the sensitivity of CT, the authors pooled the available data.

Investigation of differences between primary studies
To determine the probability of severe secondary deficit, a conservative estimate between the measured probabilities (5%) was chosen as the reference value for the probability because heterogeneity in the methodology of the studies limited the ability to combine the data.

Results of the review
On the basis of the clinical prediction rule results, the authors selected three clinical scenarios to represent conditions with high, moderate and low risk for cervical spine fracture.
The sensitivity of radiography was 94% (range: 92 - 96).

The specificity of radiography was 89% (range: 85 - 94) in high-risk patients, 89% (range: 80 - 98) in moderate-risk patients, and 96% (range: 94 - 97) in low-risk patients.

The sensitivity of CT was 98% (range: 96 - 100).

The specificity of CT was derived on the basis of the authors' experience and consultations with physicians at other trauma centres.

The probability of fracture was 11% (range: 9 - 13) in high-risk patients, 4% (range: 3 - 7) in moderate-risk patients, and 2% (range: 2 - 3) in low-risk patients.

The probability of paralysis was 5% (range: 1 - 15).

Methods used to derive estimates of effectiveness
The specificity of CT was derived on the basis of the authors' experience and consultations with physicians at other trauma centres.

Estimates of effectiveness and key assumptions
The specificity of CT was 95% (range: 90 - 100).

Measure of benefits used in the economic analysis
The summary measure of health benefit used in the economic analysis was the quality-adjusted life-years (QALYs) gained. This was derived from the number of cases of paralysis prevented and the utility weights for the health states. The Health Utilities Index (HUI) Mark 2 was used to estimate the utility adjustment for life with a severe neurological deficit. Three physiatrists were asked to select the specific level of health status defined by the HUI for each of seven attributes. The resultant levels of health status were converted into utility scores. The life-expectancy of a 43-year-old person in the USA (14 years) was used to measure the QALYs. The QALYs were discounted at an annual rate of 3%.

Direct costs
The direct costs included were for cervical spine radiography, full cervical spine CT scanning and screening cervical spine CT, and the lifetime costs of spinal cord injury. The total cost of screening cervical spine CT was the sum of the professional and technical components. The lifetime costs of spinal cord injury included the direct medical costs as well as rehabilitation and home care costs. The costs for the radiological procedures were derived from the 1995 Medicare reimbursement schedules. For the cost of cervical spine radiography, the reference-case estimate was the global reimbursement for a four-view cervical spine study. The lifetime costs of spinal cord injury were derived from the literature. The costs and the quantities were not reported separately. All of the costs were adjusted to 1995 dollars using the Medical Care Consumer price index. The costs were discounted at an annual rate of 3%. The time horizon to estimate the lifetime costs was 14 years.

Statistical analysis of costs
No statistical analysis of the costs was carried out.

Indirect Costs
The indirect costs were not included.

Currency
US dollars ($).
**Sensitivity analysis**
Univariate sensitivity analyses were performed over the range of plausible estimates for all variables. Multivariate sensitivity analyses were performed to study the effects of systematic over- and underestimations of the sensitivity and specificity of radiography and CT. Monte Carlo simulations (1,000 iterations) were performed using triangular distributions for the major variables.

**Estimated benefits used in the economic analysis**
In a hypothetical cohort of 100,000 high-risk patients, the screening CT protocol prevented 23 additional cases of paralysis in comparison with the radiography protocol. There were 11.2 (CT) and 34.1 (radiography) cases of paralysis, respectively. The screening CT protocol also saved 373 additional QALYs (182 versus 556).

In the moderate-risk group, the screening CT protocol prevented 8.5 additional cases of paralysis (4.2 versus 12.7), and saved 139 additional QALYs (69 versus 207).

In the low-risk group, the screening CT protocol prevented 4.2 additional cases of paralysis (2.1 versus 6.3), and saved 69 additional QALYs (34 versus 103).

**Cost results**
The total costs and incremental costs were reported in tabular format only.

In the high-risk group, the total cost was $24,000,000 for the radiography protocol and $20,600,000 for the CT protocol. The incremental cost of the CT protocol compared with radiography was $-3,400,000.

In the moderate-risk group, the total cost was $13,700,000 for the radiography protocol and $16,000,000 for the CT protocol. The incremental cost of the CT protocol was $2,300,000.

In the low-risk group, the total cost was $8,800,000 for the radiography protocol and $14,700,000 for the CT protocol. The incremental cost of the CT protocol was $5,800,000.

**Synthesis of costs and benefits**
In the high-risk group, the screening of cervical spine CT was a dominant strategy. It prevented 373 additional QALYs and saved $3.4 million. The CT strategy was dominant in the best- and worse-case multivariate analyses. At the lower probability of paralysis, CT screening had an ICER of $55,000 per QALY saved. In the Monte Carlo simulations, the CT screening was dominant 84% of the time. The ICER was less than $20,000 per QALY saved in 98% of the iterations.

In the moderate-risk group, the ICER of the CT strategy over radiography was $16,500 per QALY saved. The ICER was less than $50,000 per QALY saved throughout the range of the sensitivity analysis, except at the lowest estimate of paralysis risk (with a 1% probability of paralysis, the ICER of CT was $180,000 per QALY saved) and highest cost estimate for screening CT. The ICER of CT was $26,000 per QALY saved when using the highest sensitivity and specificity of CT screening, and $7,600 when using the lowest sensitivity and specificity. In the Monte Carlo simulations, the CT strategy was dominant in 38% of the 1,000 iterations and the ICER was less than $50,000 per QALY saved in 94% of the iterations. The most important factor was the lower radiography sensitivity.

In the low-risk group, the ICER of the CT strategy was $84,000 per QALY saved. The ICERs at the extreme ranges of the sensitivity analysis varied from $12,000 to $526,000 per QALY. When using the highest and lowest sensitivity and specificity, the ICERs were $72,000 (highest) and $90,000 (lowest) per QALY saved, respectively.

**Authors' conclusions**
Computed tomography (CT) is the preferred cervical spine screening modality in trauma patients at high and moderate risk of cervical spine fracture.
CRD COMMENTARY - Selection of comparators
The authors justified conventional radiographic screening as the comparator because it was the traditional method. You should consider whether this is a widely used technology in your own setting.

Validity of estimate of measure of effectiveness
The principal input parameters for the model were derived from published studies. The review appears to have been systematic for one or two parameters, but not for the others. The authors reported clearly the methods used to derive the estimates of effectiveness. When effectiveness estimates were derived from the authors' assumptions, the authors justified their assumptions with reference to the physicians' opinion. The authors noted that they selected estimates with a bias in favour of radiography. The estimates were investigated over what appear to have been appropriate ranges using sensitivity analyses.

Validity of estimate of measure of benefit
The estimation of benefits was modelled. The decision analysis model used to derive a measure of health benefit was appropriate. The quality of life estimates were derived from physiatrists' preferences using the HUI. They did not reflect the aggregated preferences of patients for different health outcomes.

Validity of estimate of costs
The authors reported that the costs were estimated from the societal perspective, but the indirect costs were not included in the analysis. This might have biased the results in favour of conventional radiographic screening. The authors reported that this bias was intentional. No details were given of the cost items included in the direct costs. The costs and the quantities were not reported separately. Consequently, it is uncertain whether all the relevant costs were included in the analysis. A sensitivity analysis of the costs was conducted. Since all the costs occurred over 14 years, discounting was appropriately undertaken and a sensitivity analysis on the discount rate was performed.

Other issues
The issue of generalisability to other settings was not addressed. However, the authors made appropriate comparisons of their findings with those from other studies. The results do not seem to have been presented selectively. The study modelled three sample populations with different risks of cervical spine fracture and this was reflected in the authors' conclusions. The authors reported further limitations of their study. First, the complexities of each clinical scenario were simplified to permit analysis. Second, the study was dependent on estimates and assumptions derived from various sources. Finally, the greatest uncertainty was in the probability of developing a severe neurological deficit from an undiagnosed cervical spine fracture.

Implications of the study
The authors recommended CT as the primary cervical spine screening modality for selected victims of major trauma who are examined in high-volume urban emergency departments and trauma centres. Additional technology assessment is needed to confirm the superior sensitivity of CT over radiography and to determine the optimal technique for CT screening.

Source of funding
None stated.

Bibliographic details
Other publications of related interest


Indexing Status
Subject indexing assigned by NLM

MeSH
Adult; Aged; Cervical Vertebrae /injuries /radiography; Cost-Benefit Analysis; Decision Support Techniques; Female; Head Injuries, Closed /economics /radiography; Humans; Male; Mass Screening /economics; Middle Aged; Paralysis /economics /radiography; Quality-Adjusted Life Years; Retrospective Studies; Risk Factors; Sensitivity and Specificity; Spinal Fractures /economics /radiography; Spinal Injuries /economics /radiography; Tomography, X-Ray Computed /economics

Date bibliographic record published
31/01/2004

Date abstract record published
31/01/2004