Whether and under what conditions FDG-PET might be cost-effective in evaluating solitary pulmonary nodules depicted on lung cancer screening in Japan

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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 fluorine-18 fluorodeoxyglucose positron emission tomography (FDG-PET) for the evaluation of solitary pulmonary nodules detected on lung cancer screening. The three evaluation strategies that were compared were computerised tomography (CT) alone, PET alone and CT plus PET.

Type of intervention
Screening.

Economic study type
Cost-effectiveness analysis.

Study population
The population comprised hypothetical patients who required the characterisation of solitary pulmonary nodules detected on lung cancer screening. Lung cancer cases of Stage IIIA were excluded.

Setting
The setting was secondary care. The economic study was carried out at the Department of Radiology, Motojima General Hospital and the Department of Diagnostic Radiology and Nuclear Medicine, Gumna University Hospital, Japan.

Dates to which data relate
The effectiveness data were derived from studies published between 1985 and 2002. The resource use data related to studies published between 1994 and 2000. The unit cost and price year data were not provided, but were based on data derived at the study's institution. The price year was not stated.

Source of effectiveness data
The effectiveness data were derived from a review of studies.

Modelling
Decision trees were used to carry out the cost-effectiveness analysis of the three examination strategies (CT alone, PET alone and CT plus PET). TreePlan Decision Tree Add-In and Clinical Decision Making Calculators were used for the calculations. The time horizon appears to have been to the point of diagnosis.

Outcomes assessed in the review
The outcomes assessed and used as input parameters for the model were:
the cancer prevalence rate among those who were tested for characterisation of solitary pulmonary nodules;

the pneumothorax rate after CT-guided needle biopsy and after bronchofiberscopy;

the hospitalisation period for the treatment of pneumothorax and lung cancer; and

the sensitivity and specificity of chest CT, FDG-PET, CT-guided needle biopsy, bronchofiberscopic biopsy, serial Xps, and thoracotomy.

**Study designs and other criteria for inclusion in the review**
The following criteria were principally used for data selection:

the newest possible data were searched;

when meta-analysis studies were available their data were used;

when there were domestic studies they had priority over overseas studies.

**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**
Twelve studies were used.

**Methods of combining primary studies**
The studies were used selectively to derive specific estimates.

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

**Results of the review**
The cancer prevalence rate among those who were tested for characterisation of solitary pulmonary nodule were 4.34% and 3.44%.

In decision tree models, 10% was used as the prevalence rate.

The pneumothorax rate was 2.9% after CT-guided needle biopsy and 2% after bronchofiberscopy.

The hospitalisation period was 6.3 days for the treatment of pneumothorax and 28.76 days for lung cancer.

The sensitivity of chest CT was 0.99 and the specificity was 0.63.
The sensitivity of FDG-PET was 0.968 and the specificity was 0.778.

The sensitivity of CT-guided needle biopsy was 0.769 and the specificity was 0.936.

The sensitivity of bronchofiberscopic biopsy was 0.80 and the specificity was 0.968.

The sensitivity of serial Xps was 1.0 and the specificity was 0.90.

The sensitivity of thoracotomy was 1.0 and the specificity was 1.00.

These formed the principal effectiveness input parameters for the model.

**Measure of benefits used in the economic analysis**

Four benefit measures were used:

- the number of cases for CT-guided biopsy;
- the number of cases who undergo bronchofiberscopy with biopsy;
- the number of patients who undergo surgical resection of benign lung nodules; and
- the number of patients in whom the lung carcinoma is misdiagnosed as a benign nodule, followed up by serial chest Xps.

**Direct costs**

The direct costs included were for:

- chest CT (including the costs for CT and examination fees),
- FDG-PET (including the costs for FDG and examination fees),
- CT-guide needle biopsy (including the costs for CT, biopsy and hospitalisation, and examination fees),
- for bronchofiberscopic biopsy (including the costs for biopsy and hospitalisation, examination fees),
- serial Xps (including the costs for X-rays and examination fees), and
- thoracotomy (including the costs for operation, medication, general anaesthetic and hospitalisation, and examination fees).

The costs and the quantities were reported separately (in an appendix to the original paper). Discounting was not relevant because of the short period of analysis. The costs were based on the actual costs recorded at the hospital. The price year was not stated.

**Statistical analysis of costs**

No statistical analysis of the costs was carried out.

**Indirect Costs**

The indirect costs were not included.

**Currency**

Japanese yen (Y).
Sensitivity analysis
A two-way sensitivity analysis was carried out by changing the prevalence of cancer between 0 and 100%, and the cost of PET between 0 and Y400,000. In the analysis, the cost-savings associated with using CT plus PET in comparison with CT alone were examined.

Estimated benefits used in the economic analysis
The number of cases for CT-guided biopsy was 199.8 for with CT alone, 119.9 with PET alone, and 83.2 with CT plus PET.

The number of cases who undergo bronchofiberscopy with biopsy was 66.6 with CT alone, 40.0 with PET alone, and 27.7 with CT plus PET.

The number of patients who undergo surgical resection of benign lung nodules was 138.2 with CT alone, 118.9 with PET alone, and 77.7 with CT plus PET.

The number of patients in whom the lung carcinoma is misdiagnosed as a benign nodule, followed up by serial chest Xps, was 17.7 with CT alone, 17.3 with PET alone, and 19.8 with CT plus PET.

Cost results
The total costs per person were Y489,948 with CT alone, Y479,845 with PET alone, and Y426,382 with CT plus PET.

Synthesis of costs and benefits
The costs and benefits were not combined. Although the PET-only strategy had the highest sensitivity, the CT plus PET strategy had the highest specificity and accuracy among the three strategies. As shown in the benefits results, this high specificity and accuracy resulted in less follow-up CT-guided biopsies, bronchofiberscopic biopsies and thoracotomies and, therefore, lower costs. The prevalence rate of lung cancer among solitary pulmonary nodules detected during screening was less than 10%. At this rate, the CT plus PET strategy is the most cost-effective alternative to the CT-only strategy, as it reduces the costs by Y64,000 per patient and increases accuracy (0.90 versus 0.84).

The sensitivity analysis showed that even if the costs for PET itself increased to be three times more expensive (Y220,000), CT plus PET was still less costly than CT alone. With the present costs for PET, when the prevalence of cancer increases up to 50%, CT plus PET is still less costly than CT alone.

Authors’ conclusions
The strategy of computed tomography (CT) plus positron emission tomography (PET) was accurate and cost-effective for the characterisation of solitary pulmonary nodules detected on lung cancer screening in Japan.

CRD COMMENTARY - Selection of comparators
The rationale for the choice of the comparators was clear. CT represented normal practice in Japan at the time of the study. In addition, it has a high sensitivity for solitary pulmonary nodules but a low specificity. PET has been found to be cost-effective in European countries and the USA. The authors sought to compare various combinations or single test strategies. You should determine if these technologies are applicable to your own setting.

Validity of estimate of measure of effectiveness
The authors sought to use data from publications more relevant for the Japanese population and, as such, the parameters used in the model should have good validity for this group. Meta-analyses were used where available which, coupled with the use of sensitivity analyses to assess the impact of prevalence, enhances the validity of the results. However, it was not apparent from the article whether a systematic review was undertaken to obtain all relevant literature. It should
also be noted that sensitivity analyses on the effectiveness parameters (sensitivity and specificity of each test) were not undertaken. The structure and method of populating the decision trees were clearly presented.

**Validity of estimate of measure of benefit**
The benefit measures indicated how improved accuracy could avoid further invasive tests and procedures and, as such, they were appropriate for the analysis. The use of a cost-utility study using quality-adjusted life-years, if feasible, would have captured the disutility of such procedures and permitted comparisons with other health care programmes.

**Validity of estimate of costs**
The authors provided clear and thorough data and good explanations of their methods for the generation of cost results. In addition, the costs and the quantities were reported separately. However, some details (e.g. the price year) were not provided and this hinders reflection exercises. Discounting was not carried out, but this was appropriate given the short time horizon of the model. To enhance the validity of the cost results, appropriate sensitivity analyses were undertaken.

**Other issues**
In terms of generalisability, the authors discussed the use of PET in other cancers and provided cautionary remarks regarding this - essentially the results of this study relate only to those with suspected lung cancer and not to other types of cancer. In terms of comparisons with other studies, the authors cited several studies that had evaluated the cost-effectiveness of PET for the studied condition and had found similar results. The present study builds on these comparisons to determine the relative cost-effectiveness of PET in a Japanese context.

The authors noted some limitations of their study. First, in their decision tree, lung cancer is eliminated by surgery but, in practice, some tumours may not be operable and, as such, a simplification has been introduced. Second, CT-guided biopsy and thoracotomy can, in rare cases, lead to mortality but these outcomes were not included in the analysis. Third, the cost of thoracotomy in Japan varies widely among different hospitals and the present study employed only data from one institution. Fourth, the cost-effectiveness results of PET cannot be generalised to other tumour sites and other analyses would be necessary to address these questions.

**Implications of the study**
The results of this study suggested that CT plus PET is accurate and cost-effective in the characterisation of solitary pulmonary nodules detected on lung cancer screening in Japan. The results were based on Japanese-specific data and caution should be exercised when applying the results to other settings. The authors pointed out that the use of PET in other patient domains should be studied separately in future research.

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None stated.

**Bibliographic details**

**Indexing Status**
Subject indexing assigned by NLM

**MeSH**
Cost-Benefit Analysis; English Abstract; Feasibility Studies; Humans; Japan; Lung Neoplasms /diagnosis /economics; Mass Screening /economics; Sensitivity and Specificity; Solitary Pulmonary Nodule /diagnosis /economics; Tomography, Emission-Computed /economics; Tomography, X-Ray Computed /economics