# Performance of chest radiograph and CT scan for lung cancer screening in asbestos-exposed workers

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## ABSTRACT

**Objectives:** The aim was to compare, in a cohort of asbestos-exposed workers, the sensitivity and the specificity of low-radiation helical chest CT scan with chest radiograph for the biennial screening of bronchopulmonary cancer, according to the size of detected nodules.

**Material and methods:** The screening procedure consisted of biennial chest radiograph and monodetector chest CT scan, given to 972 individuals who had been highly exposed to asbestos. A total of 2555 screening procedures were performed. The study focuses on the 1230 screening procedures for which a 2-year follow-up period was available.

**Results:** Twenty-four cases of bronchopulmonary cancer were diagnosed. CT scan detected 20 cancers, 12 of which had not been detected by chest radiograph. Sensitivity of chest radiograph and CT scan were, respectively, 33% and 83%, lesions measuring over 2 mm in diameter being considered as suspect. The specificity of chest radiograph and CT scan were, respectively, 95% and 78%.

Calculation of the differential false positive/true positive (FP/TP) ratio and the receiver operating characteristic curve, performed for both chest radiograph and CT scan, facilitated the determination of the best possible compromise between specificity and sensitivity, according to the diameter threshold applied for considering a nodule as suspect.

**Conclusions:** Although this study confirms the superior sensitivity of chest CT scan compared with conventional chest radiograph, the associated loss in specificity leads to a recommended diameter of 5 mm as the threshold for considering non-calcified lesions as "suspect", for the surveillance of asbestos-exposed individuals.

In France, bronchopulmonary cancer is the leading cause of mortality by cancer among men. Although the influence of tobacco as the primary risk factor involved in the development of these cancers is long established, the role of professional exposure to carcinogenic substances, in particular asbestos, was evidenced much later. Current estimates suggest that asbestos is responsible for 0.5–15% of bronchopulmonary cancers.[1]

The poor prognosis associated with bronchopulmonary cancer (12% survival at 5 years, all stages and histologies taken into account), is due to the lack of efficient screening methods capable of diagnosing early cancers, together with rapid metastatic evolution.[2]

Several studies have looked into the detection rate of bronchopulmonary cancers by low-radiation helical CT scan[3–15]; however, very few have looked to exhaustively report non-detected cancers, in order to precisely quantify the sensitivity of chosen screening methods. Furthermore, even if the increased sensitivity of CT scan, as compared with chest radiograph, no longer remains to be proven, the role of CT scan for the screening of asymptomatic individuals also depends on its specificity. Yet, no study has been able, for the same population, to compare the specificity of chest CT scan with that of chest radiograph. The aim of this study was to quantify and to compare, in a cohort of former asbestos-exposed workers, the sensitivity and the specificity of low-radiation helical chest CT scan with conventional chest radiograph for the biennial screening of bronchopulmonary cancer, according to the size of detected nodules.

## MATERIAL AND METHODS

### Study population

Normandy is a region which is particularly affected by professional asbestos exposure, and regular post-exposure surveillance consultations have been organised since 1991 by University Hospital Occupational Health departments in Caen, Rouen and Le Havre, based on biennial screening recommendations from the French authorities. Our study population was drawn from these consultations. Individuals were professionally active, retired, inactive or unemployed and were either referred by a practitioner or had consulted spontaneously. Four criteria were considered for inclusion in the study population:

- Aged from 50 to 75 years at the date of first examination.
- Previously subjected to what was considered as "important" asbestos exposure during professional activity as per the "Consensus conference to determine a clinical medical surveillance strategy for individuals exposed to asbestos" on 15th January 1999[16] (ie, confirmed, high and continued exposure for a duration of more than 1 year, or confirmed, high discontinued exposure for a duration equal or superior to 10 years).
- Presenting, at the time of inclusion, as asymptomatic for cancer and with no somatic or mental pathology which may contraindicate the surgical treatment of any bronchopulmonary cancer likely to be diagnosed during the study.
- Having signed informed consent to participate in the study, following approval by the regional ethics committee.

The cohort comprises 972 individuals who were examined between 1st January 2000 and 31st December 2006.

On 31st December 2006, it included 920 men (94.7%) and 52 women, a total of 2555 biennial screening procedures having been performed.

This study focuses on the 1230 screening procedures for which a 2-year follow-up period was available: 719 individuals benefited from one screening procedure with a 2-year follow-up period, 248 individuals benefited from two screening procedures with a 2-year follow-up period, and five individuals benefited from three screening procedures with a 2-year follow-up period.

Patients for whom initial screening detected bronchopulmonary cancer were also included in the study.

The mean (SD) age at first examination was 61.29 (6.56) years for men and 61.45 (6.97) years for women. All had worked in various professions dominated by asbestos-based textiles and friction lining, metallurgy and naval construction. Sixty-eight per cent were smokers or former smokers.

### Practical study modalities

Apart from clinical, occupational and functional respiratory data, medical surveillance systematically included a digital chest radiograph, face on, at full inspiration, and a low-dose CT scan of the chest (120 kV, 50 mA), performed in inspiratory apnoea and in supine position using single-slice CT scanners. The CT scan was reconstructed on radiological films with a 5 mm collimation from the pulmonary apex down to the bottom of the costophrenic angles. At the first examination, the protocol was completed with high-resolution millimetric slices in prone position, in order to analyse the pulmonary interstitium.

CT scans and chest radiographs were interpreted, first of all, by the radiologist performing the examination. A second reading of both imaging techniques was then performed, blinded to the initial interpretation and according to a standardised grid, by one of the physicians specialised in professional respiratory diseases from the Caen, Rouen and Le Havre University Hospitals. For each patient, chest radiograph was interpreted independently from CT scan, and each CT scan independently from chest radiograph. When the first two readers failed to reach a consensus, a third independent interpretation was requested, the majority opinion prevailing, only nodules identified by two readers being considered as significant.

On both chest radiograph and CT scan, a pulmonary nodule was considered as suspect, that is, potentially compatible with early bronchopulmonary cancer, when it presented the following characteristics: localised pulmonary opacity, non-linear, unique or multiple, but with no more than six nodules, with an average diameter of over 2 mm in tomodensitometry (TDM), devoid of any radiological marker of benignity (such as a totally calcified aspect, or, on the CT scan, clearly confirmed partly fatty density and/or established stability over time).

The CT scan either revealed no suspect abnormality, in which case further screening including chest radiograph and CT scan was proposed 24 months later, or it confirmed the presence of a suspect nodule and the following surveillance protocol was implemented, as for all CT scan-detected anomalies (table 1):

- *If the nodule measured over 10 mm on the CT scan*, a positron emission tomography (PET) scan was performed and further diagnostic investigations were decided upon within the framework of a pluridisciplinary medical staff meeting in the university hospital pulmonology department: fine needle aspiration, biopsy or simple surveillance.
- *If the diameter of the nodule was equal or inferior to 10 mm*, CT control was performed in fine contiguous slices, focusing on the nodules. The frequency of close surveillance depended on the size of the nodule (or of the largest in the case of multiple nodules): *for size ranging from 2 to 5 mm inclusive*, high-resolution CT scan slices focusing on the nodule were performed at 6-, 12- and 24-month intervals with complete spiral chest CT at the final examination; *for size ranging from 6 to 10 mm inclusive*, high-resolution CT scan slices focusing on the nodule were performed at 3-, 6-, 12- and 24-month intervals with complete spiral chest CT at the final examination.

Surveillance was stopped earlier if suspect nodule(s) were no longer visible on chest CT scan.

However, in the case of nodules presenting an increase in volume, further action was then decided within the framework of a pluridisciplinary medical staff meeting in the university hospital pulmonology department: PET scan, fine needle aspiration, surgical biopsy or pursuance of close surveillance.

In the rare cases for which the protocol did not provide direct information on patient status two years following the last examination, information was obtained from general practitioners. The 28 cases for which this information remained unavailable were excluded from the study (the majority having moved house).

### Data collected for the studied population

Data collected on radiological examinations included: the dates of all chest radiographs and chest CT scans performed (for biennial screening, as well as for close surveillance of nodules); the presence or absence of one or more suspect nodules on the chest radiograph and/or chest CT scan; the characteristics of the most voluminous nodule on the CT scan (lobar localisation; average diameter: from 2 to 5 mm, from 6 to 10 mm, from 11 to 20 mm, or over 20 mm); the results of the successive CT scans (stability, increased volume, disappearance of nodule or appearance of benignity criteria).

In the case of identified bronchopulmonary cancer, be it immediately subsequent to screening or following negative screening (interval cancer), the following data were collected: pulmonary localisation, histological type, and stage according to the tumour nodes metastases classification.

### Statistical analysis method

In order to evaluate the accuracy of a screening programme, the results of the screening test should be compared with those of an ultimate diagnostic test (a ''gold standard''). In our study, the best ''gold standard'' for bronchopulmonary cancer diagnosis was histological analysis following pulmonary puncture and/or biopsy. For obvious ethical reasons, this could not be applied to all subjects participating in the screening programme. Since this confirmatory procedure was restricted to subjects classified as positive by CT scan or chest radiograph the sensitivity and specificity of both methods have been assessed using interval cancers (ie, cancers arising in a 2-year period after a negative screening test). The sensitivity for a given period was estimated by $Se = a/(a+c)$, $a$ being the number of cancers detected by the test and $c$ being the number of cancers occurring within this delay after a negative test. Accuracy of both methods was compared by calculating the ratio of sensitivities (RSN), and the ratio of false positive rates (RFP) as initially suggested by Schatzkin *et al*.[17] The RSN is reduced to the ratio of true positives (test positives for patients with cancer), and the RFP is the ratio of the complement to one of each specificity.

**Table 1** Subjects' surveillance protocol

| | Chest CT scan | |
|---|---|---|
| Chest radiograph | + | − |
| + | Both techniques initially positive + diagnostic procedures and clinical follow-up | Negative initial CT scan stopping further immediate diagnostic procedure but not clinical follow-up |
| − | Positive initial CT scan leading to diagnostic procedures + clinical follow-up | Clinical follow-up |

**Table 2** Detection rate of suspect nodules screened by CT scan and chest radiograph

| No of suspect nodules on radiograph | No of suspect nodules on CT scan | | | | Total |
|---|---|---|---|---|---|
| | 0 | 1 | 2–3 | 4–6 | No |
| 0 | 905 | 186 | 62 | 13 | 1166 |
| 1 | 35 | 16 | 8 | 2 | 61 |
| 2–3 | 2 | 0 | 0 | 0 | 2 |
| 4–6 | 1 | 0 | 0 | 0 | 1 |
| Total (n) | 943 | 202 | 70 | 15 | 1230 |

Therefore these methods do not require the assumption that all individuals have had the "gold standard" test.

With a number of true positives on the CT scan defined as $TP_{Sc}$ and a number of true positives on the chest radiograph defined as $TP_R$, the RSN CT scan/chest radiograph was calculated as follows: $RSN = TP_{Sc}/TP_R$. Similarly, for the RFP, with a number of false positives on the CT scan defined as $FP_{Sc}$ and a number of false positives on the chest radiograph defined as $FP_R$, the RFP CT scan/chest radiograph ratio was $RFP = FP_{Sc}/FP_R$. Confidence intervals of 95% were calculated using the formula developed by Cheng and Macaluso.[18]

The FP/TP ratio provides the number of further false positives which will be generated by the chest CT scan in order to detect one further true positive compared with conventional chest radiograph.[19] The FP/TP ratio was calculated as the ratio between the difference in the number of false positive patients with scanner versus radiography and the difference in the number of true positive patients with scanner versus radiography.

As an example, the sensitivity for the chest radiograph was calculated as the ratio between the true positives on the chest radiograph divided by the sum of the true positives on either the chest radiograph or the CT scan and the interval cancers arising in individuals negative on CT scan and chest radiograph. For the calculation of the specificity, non-diseased individuals were defined as individuals free from CT scan-screened lung cancer (in individuals positive on chest radiograph or chest CT scan) and also free from symptomatic lung cancer (in all individuals, including those negative on both chest radiograph and chest CT scan). The specificity for the chest radiograph was then calculated as the ratio between the true negatives on chest radiograph and the sum of true negatives on chest radiograph and false positives on chest radiograph.

Simultaneous change in the sensitivity and specificity of both screening techniques depending on the size of detected nodule(s) is represented using a receiver operating characteristic (ROC) curve.

All tests were performed at the confidence threshold of 95%. Statistical analysis was carried out using SAS software, version 9.1.

## RESULTS

Table 2 represents the detection rate of suspect nodules screened by CT scan and chest radiograph.

The detection rate of one or more suspect nodules by CT scan was 23% of screening participants versus roughly 5% by chest radiograph.

Suspect nodules detected by CT scan were unique in 70.39% of cases; 24.39% of cases involved from two to three suspect nodules, and 5.22% revealed from four to six suspect nodules.

Ninety-five point three one per cent of positive chest radiographs included only one suspect nodule.

In the studied cohort, 24 patients presented with bronchopulmonary cancer. Twenty clinically asymptomatic cancers were detected (13 at baseline screening, five at the second biennial screening and two at the third biennial screening), a further four appearing within the 2-year period between screening, despite a negative result for both screening tests (R−Sc−) (interval cancers diagnosed following the onset of clinical symptoms), as detailed in table 3.

During the study, five pleural mesotheliomas were detected. One asymptomatic case was discovered fortuitously after the detection of slight pleural effusion, within the framework of the screening protocol, the four other cases having presented with functional symptoms following a negative screening result.

Among screened bronchopulmonary cancers, 11 (57.14%) were stage I.

The detection rate of bronchopulmonary cancer was 0.82% for chest radiograph and 2.16% for chest CT scan.

Table 4 presents the results of radiological examinations with a positivity threshold diameter of 2 mm.

CT scan was 2.5 times more sensitive than chest radiograph; however, it generated 4.77 times more false positives. In fact, comparison between chest radiograph and chest CT scan, at the aforementioned threshold, reveals that each new case of bronchopulmonary cancer detected by CT scan, induced 17.58 TDM false positive results (FP/TP = 17.58).

Table 5 describes the relationship between sensitivity and false positive results and the FP/TP ratio for each positivity threshold adopted.

Figure 1 represents the ROC curve, illustrating the relationship between the sensitivity and specificity of chest radiograph and CT scan, depending on the selected nodule size determined as the positivity threshold.

Whatever the threshold for nodule size, scanner was ever more sensitive but less specific than radiography so that the number of extra false positives associated with the detection of one extra true positive (FP/TP) is high especially for low thresholds such as 2 mm.

At a threshold diameter of 5 mm, divergence between the two techniques is reduced, particularly with regard to specificity, each new lesion detected by CT scan being counter-balanced by only 6.09 further false positive results (FP/TP = 6.09).

## DISCUSSION

This study enables both the quantification and the comparison of the sensitivity and specificity of chest radiograph and CT scan, for screening bronchopulmonary cancer.

Such data are original, since among the many studies dealing with the radiological screening of bronchopulmonary cancer, very few have an equivalent hindsight involving the systematic comparison of these two imaging techniques in the same study population. The superiority of CT scan in terms of sensitivity is confirmed, with a rate of 83.3% against 33.3% for conventional chest radiography, using a positivity threshold of 2 mm for nodule diameter.

**Table 3** Characteristics of identified primary bronchopulmonary cancers

| | R− Sc+ (n) | R+ Sc+ (n) | R− Sc− (n) |
|---|---|---|---|
| Histological type | | | |
| Epidermoid carcinoma | 5 | 3 | 2 |
| Adenocarcinoma | 5 | 4 | 0 |
| Anaplastic small cell cancer | 0 | 1 | 2 |
| Large-cell neuro-endocrine carcinoma | 1 | 0 | 0 |
| Carcinoid | 1 | 0 | 0 |
| Stage | | | |
| IA | 5 | 2 | 2 |
| IB | 1 | 3 | 0 |
| IIA | 0 | 1 | 0 |
| IIB | 0 | 0 | 0 |
| IIIA | 1 | 0 | 1 |
| IIIB | 1 | 1 | 0 |
| IV | 2 | 0 | 1 |
| Stage yet to be confirmed | 2 | 1 | 0 |
| Clinical characteristics | | | |
| Symptomatic | 0 | 0 | 4 |
| Asymptomatic | 12 | 8 | 0 |

R−, negative chest radiograph; R+, positive chest radiograph; Sc−, negative CT scan; Sc+, positive CT scan.

Furthermore, we observed that 59.38% of patients considered as suspect on chest radiograph were considered non-suspect on CT scan. This is by no means surprising, since chest radiography involves the projection of all of the thoracic anatomical structures: radiographical nodular images may therefore be related to extrapulmonary structures such as nipple or other skin, muscle, or bone structures. Moreover, the calcified aspect of benign pulmonary nodules, usually identified by CT scan, may well not be recognised by chest radiograph.

One of our study's most interesting findings is, for the first time to our knowledge, the loss in specificity associated with the gain in sensitivity: according to the chosen threshold size for suspect nodules, the number of extra false positive results for each cancer detected by CT scan varies from 17.58 to 0.20.

A further particularity of this study is the fact that it concerns a cohort of former asbestos-exposed workers: despite recommendations in favour of experimental screening protocols among these populations,[20] very few specific studies have been conducted in this specific population.[21–24] Patients are highly motivated to discover the consequences of former professional exposure on their health, hence the very low rate of patients lost to follow-up in this study (2.8%), providing almost exhaustive follow-up data.

Our study presents certain limitations.

The ideal theoretical approach for estimating cancer screening performance would be to obtain the disease status for all individuals independently of screening method results. For chest cancer, knowledge on disease status is provided by histology by means of biopsy or puncture. For obvious ethical reasons, it was not possible to collect the same information on disease status for individuals presenting with no abnormalities on CT scan or chest radiograph. The sensitivity and specificity of each test were therefore estimated using interval cancers, using the detection method. As initially evoked by Nick Day,[25] interval cancers cannot include slow-growing cancers missed by the test and failing to arise between two screening events (thus overestimating sensitivity). Inversely, interval cancers can include fast-growing cancers not existing at the time of the screening test, but developing in the subsequent 2-year period (thus underestimating sensitivity). This limit is common in screening procedure evaluation and does not invalidate the comparative statistics (RSN, RFP, FP/TP ratio) between two screening tests. Consequently, our study does provide direct comparison of the sensitivity and specificity of the two tests by calculating proper ratios (RSN and RFP) as suggested by Schatzkin and Cheng[17 18] and, thus, quantification of the potential gain in sensitivity and loss in specificity obtained by the substitution of radiography by CT scan. This method allowed the calculation of the 95% confidence interval for each ratio, the RSN ratio for the detection of chest cancer probably being underestimated in our study due to the small number of cases.[26]

The relatively low size of the study population reduces its statistical power, hence the increased confidence intervals.

In our study, diagnostic statistics were calculated using the "screening procedure" as the unit of analysis rather than the "individual". Hence, certain individuals are counted more than once (although cancers are not). This may induce a non-independence effect in the interpretation of results.

A differential verification bias could be evoked, since no tomodensitometric follow-up was implemented for nodules detected by chest radiograph but non-confirmed by initial CT scan. However, since tomodensitometric follow-up was similar independently of the imaging technique having detected the nodule, and was only stopped upon the scanographic disappearance of the initially detected lesion, such bias is improbable.

Finally, the use of monoslice CT scanners, the standard reference at the onset of our study, may appear somewhat obsolete, given the rapid progress in imaging techniques. Nevertheless, the sensitivity and specificity data reported in this study, hitherto unpublished in literature, will provide a useful reference for the evaluation of modern tomodensitometric

**Table 4** Comparison of screening techniques with a 2 mm positivity threshold diameter

| | | Cancer | |
|---|---|---|---|
| | | Yes | No |
| Chest radiograph | Chest CT scan | (n) | (n) |
| Positive | Positive | 8 | 18 |
| | Negative | 0 | 38 |
| Negative | Positive | 12 | 249 |
| | Negative | 4 | 901 |

**Table 5** Sensitivity and false positive ratios according to nodule size (variation in chest radiograph and CT thresholds)

| | Size | | | |
|---|---|---|---|---|
| | >2 mm | >5 mm | >10 mm | >20 mm |
| Se (CT scan) | 0.83 | 0.79 | 0.62 | 0.38 |
| Sp (CT scan) | 0.78 | 0.92 | 0.98 | 1.00 |
| Se (radiograph) | 0.33 | 0.33 | 0.17 | 0.17 |
| Sp (radiograph) | 0.95 | 0.97 | 0.99 | 1.00 |
| RSN | 2.50 [1.46 to 4.28] | 2.38 [1.40 to 4.03] | 3.75 [1.62 to 8.68] | 2.50 [1.17 to 5.34] |
| RFP | 4.77 [3.63 to 6.26] | 3.09 [2.08 to 4.59] | 2.71 [1.14 to 6.46] | 1.50 [0.25 to 8.98] |
| Ratio FP/TP | 17.58 [9.77 to 31.64] | 6.09 [3.09 to 11.99] | 1.09 [0.39 to 3.03] | 0.20 [0.00 to 17.47] |

95% confidence interval is shown in square brackets.
FP, false positive; RFP, ratio of false positive rates; RSN, ratio of sensitivities; Se, sensitivity; Sp, specificity; TP, true positive.

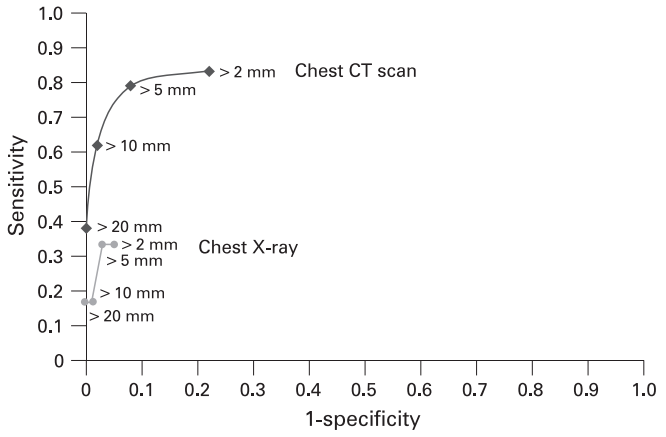


**Figure 1** Sensitivity and specificity of chest CT scan and chest radiograph according to the chosen diameter threshold for pulmonary nodules considered as significant chest CT scan curve in black; chest *x* ray curve in grey.

techniques, yet to be published, for the screening of bronchopulmonary cancers.

On 31 December 2006, the cohort included 972 individuals. The detection rates for bronchopulmonary cancer by chest CT scan (2.15%) and chest radiograph (0.82%) in our study were higher than those observed in the study by the Japanese National Cancer Centre Hospital (0.3% and 0.07%, respectively),[8–10] involving volunteer smokers. Our results are also higher than those observed in the Japanese Shinshu University School of Medicine study (0.48% and 0.05%, respectively).[11 12] In the ELCAP study,[3 4] launched in the USA in a population of 1000 volunteer smokers or former smokers, the detection rate for bronchopulmonary cancers by chest CT scan and chest radiograph were more consistent with the results of the present study, since they were, respectively, 2.7% and 0.07%. The same applies to the Italian Pastorino study,[15] with a detection rate of 2.12% by chest CT scan. In the randomised American study conducted by Swensen[13] among smokers, the detection rate of bronchopulmonary cancers was 4.2% whilst Diederich, in Germany, only observed a rate of 1.22%.[14] It should be noted that both of these studies used new-generation multislice CT scanners.

Globally speaking, bronchopulmonary cancers identified in our cohort follow a relatively balanced distribution between epidermoid cancers and adenocarcinomas, the great majority having been detected at the first examination (72.2%). Our results are consistent with those observed by Markowitz,[27] and are inconsistent with the predominance of adenocarcinomas noted in other cohorts.[3 13 15 28 29]

Among the cancers detected in our study, only 12 were stage I (57.14%), compared with 85.2% in the ELCAP study and 91.6% in the National Cancer Centre Hospital study. The screening protocol for both of the latter studies involved annual examination, and the difference may result from the biennial frequency adopted in our own study. Given the relatively short doubling time for different forms of bronchopulmonary cancer, early screening may have been less advantageous than in studies involving annual tomodensitometric screening.

Based on our own study conditions, the choice of a threshold diameter of 5 mm to define a non-calcified nodule as "suspect" would appear to offer the best compromise between sensitivity and specificity. Thus, the chest CT scan obtains a sensitivity of 0.79 and a specificity of 0.92, generating three times more false positives than chest radiograph. The "rice to be paid for each newly detected true positive by CT scan alone is 6.09 extra false positives compared to chest radiograph".

With regard to radiation exposure associated with the use of chest CT scan in this study, delivered doses based on previously published protocols were moderate, hence representing only an immaterial health risk, particularly when considering the age of the study population.[3–7]

## CONCLUSION

The better sensitivity of helical chest CT scan, compared with conventional chest radiograph, for the detection of bronchopulmonary cancer, is associated with a loss in specificity, hence our recommendation to identify a threshold diameter for non-calcified lesions before considering them as "suspect", within the context of surveillance of asbestos-exposed individuals. Based on our study conditions, the FP/TP ratio, a useful index in evaluating both parameters in order to identify the best sensitivity/specificity balance, leads us to recommend a diameter threshold of over 5 mm to define CT scan-detected non-calcified nodules as "suspect". It would be useful to compare our results with those obtained in studies involving more frequent surveillance in the same population type (annual screening for example) in order to verify the adequacy of French regulatory surveillance modalities for the screening of bronchopulmonary cancer among asbestos-exposed individuals.

It appears logical to suppose that new tomodensitometric techniques, involving multislice scanners, will further accentuate the superiority of CT scan over pulmonary radiography for the screening of bronchopulmonary cancers: thus, the prevalence of nodules observed in the present study, consistent with those observed in studies using comparable tomodensitometric techniques,[3–15] prove to be significantly lower than that observed in studies relying on multislice scanners, and even more so when computer-assisted detection systems are used.[30] However, it is to be feared that these new techniques will also involve an increased loss in specificity. As reported in the present study, analysis of sensitivity–specificity relationships according to a chosen threshold diameter, in order to define which lesions require surveillance, is worthy of further study within the context of new-generation tomodensitometric screening conditions.

### Main message

Based on our own study conditions, the choice of a threshold diameter of 5 mm to define a non-calcified nodule as "suspect" would appear to offer the best compromise between sensitivity and specificity for the biennial screening of bronchopulmonary cancer in asbestos workers.

### Policy implication

It would be useful to compare our results with those obtained in studies involving more frequent surveillance in the same population type (eg, annual screening) in order to verify the adequacy of French regulatory surveillance modalities for the screening of bronchopulmonary cancer among asbestos-exposed individuals.

It is evident that this non-randomised study cannot provide data on the true efficiency of such a screening programme (reduction in bronchopulmonary cancer-specific mortality), hence the relevance of ongoing randomised studies.

Given the reservations expressed, in particular by Campbell *et al* in 2003,[31] a cost-efficiency analysis of these experimental programmes will nonetheless be required in order to identify and to endorse the most effective strategies for monitoring high-risk populations for bronchopulmonary cancer such as individuals having been professionally exposed to asbestos.

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# Performance of chest radiograph and CT scan for lung cancer screening in asbestos-exposed workers

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