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Significance of tomographic signs in the diagnosis of bronchial carcinoma

M J TURNER, A S C THORNTON, B GORMAN, L R BAGG, I D COX, N J RUSSELL

From the Departments of Thoracic Medicine and Radiology, London Hospital (Whitechapel), London

ABSTRACT In a previous study the value of conventional tomography was assessed in the diagnosis of 100 potentially malignant opacities on the chest radiograph. To determine which of the radiological signs were most useful the radiologists reviewed 82 of the original 100 radiographs independently, searching for the presence or absence of 36 signs. The five commonest signs of bronchial carcinoma were a mass, coarse linear shadows contiguous to a mass, unilateral hilar enlargement, linear shadows from mass to periphery, and an irregular margin to a mass. The combination of either two or three of these signs was highly sensitive, 95% and 89% respectively, in detecting carcinoma. The most useful specific signs were lobulation of the mass and cavitation with thick or irregular walls.

In a previous paper we compared conventional linear tomography with fibreoptic bronchoscopy in the diagnosis of potentially malignant chest opacities in 100 patients.[1] We found that tomography had an accuracy of 83%, sensitivity 92% and specificity 58%, whereas bronchoscopy had an accuracy of 76%, sensitivity 68% and specificity 100%. In that study three radiologists examined the tomograms and radiographs jointly and gave a majority diagnosis in each case, based on 8 radiological signs regarded as being suspicious of malignancy.[1] The same three radiologists have now reviewed 82 of the same tomograms and radiographs to determine the presence or absence of 36 radiological signs, including the original 8.

Methods

CRITERIA

Thirty six radiological signs were sought in each case (appendix), the additions to the original eight being suggested from the experience of the former study.

PATIENTS

All the patients had a localised abnormality on their chest radiograph and were referred to confirm or exclude a diagnosis of carcinoma. In the original study there were 74 patients with bronchial carcinoma and 26 with benign lesions, but only 82 of the original records were accessible for review. Of these, 61 patients (74%) had bronchial carcinoma and 21 (26%) a benign lesion, preserving the original ratio exactly. The benign diagnoses were predominantly inflammatory conditions or scarring. The original tomograms and radiographs of these 82 patients were re-examined by each of the three radiologists (AT, BG, and MT) without consultation, and the presence or absence of each radiological sign was recorded. A sign was subsequently regarded as being present when detected by at least two observers. If found by only one observer it was considered to be absent. No attempt was made to reach a diagnosis on this review. Our definitions were:

$$\text{Sensitivity} = \frac{TP}{TP + FN}$$

$$\text{Specificity} = \frac{TN}{TN + FP},$$

where TP = true positive, FN = false negative, TN = true negative, and FP = false positive.

Results

The radiological signs of malignancy in descending order of specificity and sensitivity are shown in tables 1 and 2. Values below 60% are omitted. The definition of sensitivity used is identical to the frequency of the sign in those with malignant disease. The frequencies of the 36 signs in carcinoma and benign disease are given in the appendix.

Address for reprint requests: Dr M J Turner, Alexandra Wing X Ray Department, London Hospital, Whitechapel, London E1 1BB.

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Table 1 *Radiological signs of malignancy placed in order of highest specificity*

Rank order	No*	Radiological sign	Specificity (%) $\left(\frac{TN}{TN+FP}\right)$	Sensitivity (%) $\left(\frac{TP}{TP+FN}\right)$
1	36	Bone destruction (rib)	100	3
2	22	Linear shadows—lymphatic	100	5
3	8	Cavitation—wall > 5 mm	95	16
4	6	Cavitation—wall irregular	95	16
5	3	Lobulation of mass	95	49
6	29	Pleural effusion unilateral	76	7
7	18	Linear shadows contiguous to mass, fine	76	38
8	4	Margin of mass irregular	71	66
9	20	Linear shadows from mass to hilum	67	54
10	27	Tracheobronchial deformity	62	44
11	21	Linear shadows from mass to periphery	62	69

*See appendix.

Table 2 *Radiological signs of malignancy placed in order of highest sensitivity*

Rank order	No*	Radiological sign	Sensitivity (%) $\left(\frac{TP}{TP+FN}\right)$	Specificity (%) $\left(\frac{TN}{TN+FP}\right)$
1	1	Mass	97	33
2	19	Linear shadows contiguous to mass, coarse	84	48
3	25	Unilateral hilar enlargement	72	52
4	21	Linear shadows from mass to periphery	69	62
5	4	Margin of mass irregular	66	71

*See appendix.
TN—true negative; FN—false negative; TP—true positive; FP—false positive.

Five signs have a specificity of 95% or more—"rib destruction" (100%), "linear shadows—lymphatic" (100%), "cavitation with wall thickness over 5 mm" (95%), "cavitation with irregular walls" (95%), and "lobulation of mass" (95%). Values for sensitivity are lower, the highest being 97% for "mass" and 84% for "linear shadows contiguous to mass, coarse".

Discussion

CONTRIBUTION OF THE RADIOLOGICAL SIGNS TO DIAGNOSIS

At first these results may appear to contradict our previous finding that tomography has a high sensitivity and a low specificity.[1] The five signs with a high specificity, however, occurred mostly at low frequency; the frequency of the highest ("lobulation") was 49%, whereas the next two ("cavitation with wall thickness over 5 mm" and "cavitation with irregular walls") occurred only in 16%. The other two signs had frequencies of only 5% and 3%. Consequently, despite the impressively high specificity of these five signs, their contribution to the overall performance of tomography was relatively low.

For high sensitivity a test requires a recognisable feature common to a high proportion of positive cases. Although a single radiological sign may be unsuitable, a battery of signs can achieve the required characteristics. The five most frequent signs in bronchial carcinoma (table 2) were "mass" (97%), "linear shadows contiguous to mass, coarse" (84%), "unilateral hilar enlargement" (72%), "linear shadows from mass to periphery" (69%) and "margin of mass irregular" (66%). These five signs can be used collectively, to assess malignancy by the number of signs that are positive. The criterion for carcinoma may be taken arbitrarily as "two signs or more" or "three signs or more" positive. These options give sensitivities of 95% and 89% and specificities of 38% and 57% respectively (tables 3 and 4). Although such a battery of signs was not formally designated in the first study, a review of the original criteria[1] shows that most of them were being used and they would have contributed to the high sensitivity shown by tomography. It is noteworthy that the six most common radiological signs in bronchial carcinoma—the five stated above together with "linear shadows from mass to hilum" (54%)—are all closely related to the primary mass and its known pathways of direct or lymphatic spread.

Table 3 *Incidence of the five most frequent signs in malignancy (see table 2)*

No of these signs present per case	*No of cases*	
	Malignant	*Benign*
5	24	4
4	18	2
3	12	3
2	4	4
1	1	4
0	2	4
Total	61	21

Table 4 *Effect of using two or three of the five most frequent signs of malignancy on diagnosis of malignant and benign conditions*

Criterion	*% of malignant cases detected (sensitivity)*	*% of benign cases misdiagnosed*
2 or more of 5 signs positive	95	62
3 or more of 5 signs positive	89	43

SPECIFIC RADIOLOGICAL SIGNS

Air bronchogram

We expected that "air bronchogram in mass" would be uncommon in malignancy, except in alveolar cell carcinoma or lymphoma,[2] which did not occur in this series. "Air bronchogram within mass lession" was, however, found in no less than 31% of carcinomas, with majority agreement in 72%, showing the sign to be of no value in excluding carcinoma. On the other hand, a recognisable bronchiectatic air bronchogram, whether near or remote from a suspect mass, occurred with only 2% of carcinomas, but was seen in 14% of benign lesions.

Calcification in or near mass

The frequency of "calcification in or within 2 cm of mass" was found to be 13% in carcinoma, a value much higher than the mean of about 2% quoted by several authors.[2-4] Specifying a distance of less than 2 cm might have reduced our figure of 13% but it was difficult in practice to obtain a reasonable level of agreement between observers if smaller distances were chosen.

Cavitating lesions

Our findings concerning wall thickness and irregularity of cavitating lesions were in accord with those of Woodring *et al*,[5] who found that over half of 65 cavities with a wall thickness of 5 mm or more were malignant, as were 81% of those with irregular walls.

LIMITATIONS OF THIS STUDY

Conclusions drawn from a study such as this are limited in the strict sense to the sample taken. Comment about the population from which the sample is derived must be more guarded. Broadly this population represents outpatients presenting to the hospital's department of respiratory medicine with a chest radiograph suspected of showing bronchial carcinoma. In the sample under review the ratio of malignant to benign disease was about 3:1. This explains the surprisingly high specificity of unilateral pleural effusion for carcinoma in the patient population under study.

Another limitation of the survey arises from the small numbers in which some of the radiological signs were found—single figures only in the case of 13 signs, including important ones such as four pleural signs (lesion crossing pleural boundary, unilateral or bilateral pleural effusions, and extensive pleural opacity); cavitation with wall smooth or less than 5 mm thick; lymphatic linear shadows; bilateral hilar enlargement; and bone destruction. Some of these signs would be expected to have a different incidence in patients from different samples. Nevertheless, in our view certain helpful conclusions may be drawn about the usefulness of individual radiological signs in diagnosing bronchial carcinoma, particularly when diagnostic problems arise in connection with chest radiographic appearances in an outpatient.

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APPENDIX: Radiological signs sought on review of tomograms and radiographs

In the following list the percentages in parentheses represent the frequency of the sign in benign lesions and the others the frequency in carcinoma in this series.

MASS

1 Any confluent pulmonary opacity not identified as consolidation, collapse, fibrosis, oedema, or blood vessel: 97% (67%)

SHAPE OF MASS

2 Margin smooth: 31% (24%)
3 Margin lobulated: 49% (5%)
4 Margin irregular: 66% (29%)

CAVITATION OF LESION

5 Wall smooth: 2% (5%)
6 Wall irregular: 16% (5%)
7 Widest part of wall less than or equal to 5 mm: 0% (0%)
8 Widest part of wall greater than 5 mm: 16% (5%)

CALCIFICATION (other than unequivocal costal cartilage or pleural calcification)
9 In mass or within 2 cm of it: 13% (29%)
10 More than 2 cm from mass: 7% (10%)
11 Hilar or mediastinal calcification: 25% (19%)

AIR BRONCHOGRAM (that is, tubular air containing structures that branch or are seen to be contiguous with the bronchus, on serial cuts if necessary)
12 In mass: 31% (24%)
13 Distal to mass: 18% (14%)
14 In another part of same lung: 2% (0%)
15 Major segmental: 21% (29%)
16 Distal segmental: 25% (29%)
17 Bronchiectatic: 2% (14%)

LINEAR SHADOWS
18 Contiguous to mass, fine (less than or equal to 1 mm in width): 38% (24%)
19 Contiguous to mass, coarse (greater than 1 mm): 84% (52%)
20 Extending from mass towards hilum: 54% (33%)
21 Extending from mass towards periphery: 69% (38%)
22 Other linear shadows characteristic of lymphatic infiltration: 5% (0%)
23 Any other linear shadows: 5% (19%)

COLLAPSE
24 Lobar or segmental (other than collapse inferred from the presence of pleural effusion or consolidation): includes displacement of fissures, diaphragm, hilum, ribs, or vessels (for example, vessel crowding): 44% (43%)

HILAR ENLARGEMENT (A local or general increase in hilar shadow not completely explicable in terms of normal structures or enlarged vessels; thus any opacity in the lung adjacent to the hilum and contiguous with it is called hilar enlargement)
25 Unilateral: 72% (48%)
26 Bilateral: 3% (10%)

TRACHEAL AND BRONCHIAL DEFORMITY
27 Narrowing, deformity, or displacement of bronchi or alteration of carinal angles (affecting trachea or main bronchial divisions, or main or subsidiary carina): 44% (38%)
28 Bronchial wall thickening—that is, with thickened parallel lines or ring shadows (except bronchus intermedius and right border of trachea, where evidence of one thickened wall suffices): 12% (43%)

PLEURAL CHANGES
29 Unilateral pleural effusion: 7% (24%)
30 Bilateral pleural effusion: 2% (0%)
31 Blunting of costophrenic angle: 23% (19%)
32 More extensive pleural opacity: 3% (24%)
33 Thickening of fissures: 39% (43%)
34 Adhesions (distortion or "tenting" of diaphragm or other structures) 12%: (24%)
35 Lesion seen to cross pleural boundary: 7% (0%)

BONE DISEASED
36 Bone destruction: 3% (0%)

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