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Percutaneous needle biopsy of the mediastinum: review of 94 procedures

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Abstract

***Background*—A number of reports of radiologically guided percutaneous biopsy of mediastinal masses have been described but techniques have varied, particularly the type of needle used. In this study mediastinal biopsies with fine aspiration needles and cutting needles have been compared, sometimes in the same patient. The results are reviewed with particular emphasis on the choice of biopsy needle and its influence on pathological diagnosis.**

***Methods*—A retrospective review was undertaken of radiologically guided mediastinal biopsies performed between 1981 and 1991.**

***Results*—Sixty fine needle aspiration biopsies (FNA) and 34 Tru-Cut biopsies of mediastinal masses were performed in 75 patients with fluoroscopic or computed tomographic guidance. Overall sensitivity and specificity in terms of diagnosis of malignant disease were 90% and 100% respectively for FNA biopsies, and 96% and 100% for Tru-Cut biopsies. Diagnostic accuracy in terms of precise diagnosis of the malignant or benign nature of a mass and its origin was 77% for FNA biopsies and 94% for Tru-Cut biopsies. For FNA biopsies sensitivity and accuracy were higher for carcinomatous lesions (96% and 88%) than for non-carcinomatous lesions (81% and 69%). The only significant complication encountered was a pneumothorax following a biopsy which required intercostal drainage.**

***Conclusions*—Radiologically guided percutaneous needle biopsy is a safe procedure which provides useful diagnostic information in the majority of cases. Fine needle aspiration techniques usually suffice for carcinomatous lesions but a cutting needle biopsy should be performed whenever possible when lymphoma, thymoma, or neural masses are suspected to obtain larger specimens for more accurate histological diagnosis.**

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Radiologically guided percutaneous needle biopsy has become an accepted technique in the assessment of mediastinal masses.[1] When successful the procedure may obviate the need for more invasive diagnostic procedures such as mediastinoscopy, anterior mediastinotomy, or exploratory thoracotomy. There have been a number of published series but the methods used, both in terms of choice of needle and mode of needle guidance, have varied. Most groups have used fine needle aspiration cytological techniques which only provide small tissue samples,[2–6] while others have used larger cutting needles in order to gain histological specimens.[7–10] Our experience includes the use of both types of needle, in some instances in the same patient. The results are presented, together with the role of fine needle or cutting needle techniques, in relation to suspected clinical diagnoses.

Methods

A retrospective study was undertaken of radiologically guided needle biopsies of the mediastinum performed at our centre between January 1981 and December 1991. For the purposes of this study a mediastinal mass was defined as a mass clearly arising from the mediastinum or inseparable from the mediastinum with radiological techniques available at that time. Hilar lesions were excluded. Apart from one paediatric case where the biopsy was performed under general anaesthesia, all procedures were performed with local anaesthesia and mild sedation if required by one of two experienced radiologists with an interest in chest disease. During the period 1981–7 all procedures were carried out under fluoroscopic guidance following localisation of the mediastinal mass from posteroanterior and lateral chest radiography or plain tomography. In 1988 our radiology department acquired a computed tomographic scanner and this subsequently replaced fluoroscopy as the method of needle guidance.

The fine needle biopsies or aspirations were performed with a Rotex needle (Ursus Konsult AB, Stockholm, Sweden) where a solid lesion was anticipated, or a 19–22 gauge spinal needle if a cystic lesion was suspected. Cytological material was smeared onto glass slides which were immersed in 95% alcohol and sent to the department of histopathology for immediate staining and cytological examination. If the initial aspirate failed to provide sufficient cellular material to permit diagnosis, the procedure was repeated at the same session until the radiologist was convinced that the needle had been accurately placed within the lesion and that further attempts at aspiration were unlikely to provide additional information. Up to six aspirations were performed in an individual case.

Tru-Cut biopsies were performed using

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either a 14 gauge Tru-Cut needle (Travenol Laboratories, Deerfield, Illinois, USA) with a manual technique, or an automated biopsy gun (Biopty, Bard Urological Division, Covington, Georgia, USA). Samples were immersed in formalin and subsequently processed for formal histological examination. If a good core of tissue was obtained only a single biopsy was taken, or if only small fragments of tissue could be obtained up to three passes were made.

For the purpose of analysis of the results mediastinal masses were designated as arising from the anterior (including superior), middle, or posterior mediastinum. Where a mass appeared to occupy more than one compartment the major site of disease or the site from which biopsies were obtained was recorded.

The results of the biopsies were classified as positive or negative on the basis of the presence or absence of malignant cells in the fine needle aspiration or cutting needle samples. A needle biopsy was regarded as giving a positive result if reported as showing evidence of malignancy. In addition, since prediction of malignancy in thymoma is difficult to make on purely cellular features, all thymomas diagnosed in this series were considered potentially malignant and therefore a needle biopsy showing thymoma was also classified as positive. A negative needle biopsy was defined as one reported as showing no evidence of malignancy. A biopsy was therefore regarded as negative if reported as showing benign tumour, or where the tissue obtained showed no evidence of malignancy even if a specific diagnosis could not be made—for example, if only blood, fat or fibrous tissue were obtained. Sensitivity and specificity were calculated using these definitions of positive (malignant) and negative (benign) biopsy results. To further evaluate our results a biopsy was regarded as being accurate if sufficient information was obtained to allow appropriate clinical management of the patient, and where clinical follow up, subsequent investigations or surgery, or post mortem examination failed to establish an alternative diagnosis. Any biopsy result not meeting these criteria was deemed inaccurate and included those where subsequent investigation or follow up yielded an alternative final diagnosis, or where the biopsy provided insufficient information for diagnosis and therefore patient management. With this classification, for example, a needle biopsy correctly diagnosing a benign neural tumour based on the presence of characteristic cells in the sample would be regarded as truly negative (in terms of malignant disease) and accurate, whereas if the same lesion was biopsied and insufficient material obtained for diagnosis, the biopsy would still be regarded as truly negative in terms of malignant disease but would be deemed inaccurate.

Results

Ninety patients underwent mediastinal biopsy during the study period but 15 were excluded because of incomplete pathological data or lack of validation of the final diagnosis, leaving a final group of 75 patients (38 men, 37 women) of age range 8–78 years. A total of 60 fine needle aspiration biopsies and 34 cutting needle biopsies were performed, with 17 patients undergoing both procedures at the same visit and two patients having repeat biopsies well separated in time (three weeks and nine months). A final total of 94 biopsies was therefore included in the analysis. The first 24 mediastinal biopsies were performed between 1981 and 1987 with fluoroscopic guidance. Following the introduction of computed tomography (CT) in 1988 fluoroscopy was gradually superseded as the imaging method of choice, and after a transition period the last 21 consecutive biopsies have been performed under CT control over 14 months (fig 1).

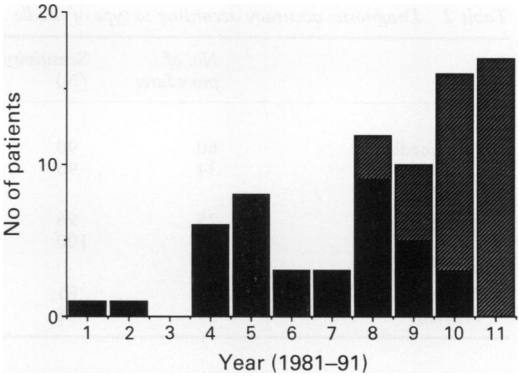

Figure 1 Numbers of procedures per annum according to modality (solid, fluoroscopy; hatched, computed tomography).

The pathological conditions found ranged widely, with lymphomas, thymomas and carcinomas predominating in the anterior mediastinum, central carcinomas in the middle mediastinum, and neural tumours in the posterior mediastinum (table 1). The method of establishing the final diagnosis in each case varied. On the basis of clinicoradiological correlation and adequacy of biopsy material the result of the needle biopsy was accepted by the clinician as being the true diagnosis in 42 patients and no further invasive diagnostic procedure was undertaken. Of the remaining 33 patients, surgical or necropsy confirmation of the diagnosis was available in 26, needle aspiration showed a mediastinal mass to be cystic with complete disappearance or consid-

Table 1 Final diagnosis according to mediastinal compartment

	Mediastinal compartment		
Diagnosis	*Anterior*	*Middle*	*Posterior*
Carcinoma	7	16	2
Lymphoma	14	4	2
Thymoma	6	1	–
Neural	–	–	7
Cyst	2	3	2
Goitre	4	–	–
Non-specific inflammatory	1	1	–
Teratodermoid	1	–	–
Sarcoma	–	–	1
Castleman's disease	1	–	–
Total	36	25	14

Table 2 Diagnostic accuracy according to type of needle

	No. of procedures	Sensitivity (%)	Specificity (%)	Accuracy (%)
Overall				
Fine needle	60	90	100	77
Tru-Cut	34	96	100	94
Carcinomas				
Fine needle	25	96	-	88
Tru-Cut	5	100	-	100
Non-carcinomas				
Fine needle	35	81	100	69
Tru-Cut	29	96	100	94

erable reduction in the size of the mass after aspiration in three, in two patients distant organ disease became evident with further radiologically guided biopsy proving the diagnosis of Hodgkin's disease (liver lesions) or malignant thymoma (lung metastases), and in two patients with anterior mediastinal masses radiolabelled iodine scintigraphy supported a diagnosis by needle biopsy of retrosternal thyroid.

Fine needle biopsy produced 37 true positive (malignant) results, 19 true negative (benign) results, and four false negative results. Importantly, there were no false positive diagnoses of malignant disease. This gave an overall sensitivity for the diagnosis of malignant disease of 90% and a specificity of 100% (table 2). According to our definition 14 results (23%) were inaccurate (tables 3 and 4). This was due to true negative but non-diagnostic aspirates in seven patients with benign lesions, false negative biopsies in four patients with malignant disease, and incorrect prediction of malignant cell type in three patients with true positive biopsies. Of the seven cases subsequently proven to have benign lesions where insufficient material was obtained by fine needle aspiration for accurate diagnosis, two of these patients had diagnostic Tru-Cut biopsies obtained at the same session showing benign neural tumours, while the remaining five proceeded to mediastinoscopy or open surgery for diagnosis. Of the four patients with false negative biopsies, repeat fine needle biopsy three weeks after the initial event provided the diagnosis of adenocarcinoma in one case. Two of these patients had diagnostic Tru-Cut biopsies obtained at the initial session. The fourth patient had a diagnosis of Hodgkin's disease made by subsequent biopsy of a liver lesion. Finally, of the three cases of inaccurate diagnosis where malignancy was correctly diagnosed but an incorrect prediction of cell type was made, one patient was diagnosed as having non-Hodgkin's lymphoma (NHL) on initial fine needle aspiration but small cell carcinoma was correctly diagnosed nine months later by repeat fine needle biopsy and Tru-Cut biopsy after he had failed to respond to treatment for NHL. In the second case, although a diagnosis of large cell carcinoma was made on fine needle biopsy, Tru-Cut biopsy performed at the same time showed thymoma and this was subsequently proven surgically. In the third case fine needle biopsy suggested thymoma but Tru-Cut biopsy unequivocally showed adenocarcinoma.

Table 3 Accuracy of needle biopsy diagnoses

Diagnosis	FNA	Tru-Cut
Carcinoma	22/25	5/5
Hodgkin's disease	3/4	6/8
Non-Hodgkin's lymphoma	2/3	9/9
Thymoma	6/7	5/5
Neural	2/5	6/6
Cyst	7/7	–
Goitre	2/4	–
Non-specific inflammatory	0/2	–
Sarcoma	1/1	–
Teratodermoid	1/1	1/1
Castleman's disease	0/1	–
Total	46/60	32/34

FNA—fine needle aspiration.

In the group of 34 patients undergoing Tru-Cut biopsy there were 27 true positive (malignant) diagnoses, six true negative (benign) diagnoses, one false negative diagnosis, and no false positive diagnoses. This gave a sensitivity of 96% and a specificity of 100% (table 2). In 23 cases (68%) the patient was managed on the basis of the Tru-Cut histological findings without further diagnostic procedure, while in a further eight patients a confident diagnosis of thymoma, teratodermoid, or neural tumour led to planned surgical resection. In only three patients, all with Hodgkin's disease, was a further invasive diagnostic procedure necessary. In one case, although Tru-Cut biopsy permitted a diagnosis of lymphoma, mediastinoscopy and node biopsy was performed for more precise classification. Two results (6%) were deemed inaccurate (tables 3 and 4). In the first case the true diagnosis of Hodgkin's disease was made by surgical lymph node biopsy after Tru-Cut biopsy of a mediastinal mass had shown only sparse cells interspersed in a dense fibrous stroma. In the second case, while malignancy

Table 4 Final diagnoses in cases of inaccurate needle biopsy results (needle biopsy results in parentheses)

	FNA		Tru-Cut	
Non-diagnostic aspirate/benign lesion	Neural tumour	2		
	Thyroid mass	2		
	Inflammatory mass	2		
	Castleman's disease	1		
False negative aspirate or biopsy	Adenocarcinoma	1	Hodgkin's disease	1
	NHL	1		
	Neurofibrosarcoma	1		
	Hodgkin's disease	1		
Positive aspirate or biopsy/inaccurate diagnosis	Small cell carcinoma (NHL)	1	Hodgkin's disease (thymoma)	1
	Thymoma (large cell carcinoma)	1		
	Adenocarcinoma (thymoma)	1		

FNA—fine needle aspiration: NHL—non-Hodgkin's lymphoma.

Table 5 Comparison of fine needle and Tru-Cut techniques in the same patient (incorrect fine needle results in parentheses)

	No. of cases	*Final diagnosis*
Fine needle, true negative but inaccurate/Tru-Cut, accurate	2	Benign neural tumour [2]
Fine needle, false negative/Tru-Cut, accurate	2	Non-Hodgkin's lymphoma Neurofibrosarcoma
Fine needle, true positive but inaccurate/Tru-Cut, accurate	2	Thymoma (large cell carcinoma) Adenocarcinoma (thymoma)
Tru-Cut, more definite diagnosis or additional information	9	Thymoma [3] Carcinoma [2] Hodgkin's disease [2] Benign neural tumour Non-Hodgkin's lymphoma
Little or no gain from Tru-Cut	2	Teratodermoid Thymoma

was correctly predicted, thymoma was the preferred diagnosis by Tru-Cut biopsy but subsequent surgery proved the true diagnosis to be Hodgkin's disease.

A comparison of the results of fine needle and Tru-Cut biopsies in patients undergoing both procedures during the same session is presented in table 5. In 14 cases the final diagnosis was of a non-carcinomatous lesion while there were three carcinomas. In only two of 17 cases (12%) Tru-Cut biopsy failed to provide a more accurate or confident diagnosis.

The ratio of fine needle aspiration biopsies to Tru-Cut biopsies with fluoroscopic and CT guidance was similar being approximately 2:1. Similar results were achieved with both imaging methods, combined accuracy for fine needle aspiration and Tru-Cut biopsy being 78% for fluoroscopic guidance and 86% for CT guidance.

In only three of the 75 patients (4% of patients or 3% of procedures) did complications arise. Two patients developed minor complications, one case of transient haemoptysis following Tru-Cut biopsy and one pulmonary haematoma following fine needle aspiration. The other patient, with a middle mediastinal mass resulting from small cell carcinoma, developed a moderate pneumothorax requiring intercostal drainage following fine needle aspiration. We have reviewed the radiological records of the 15 patients excluded from this series because of incomplete pathological or diagnostic data and can find no record of procedural difficulties or complications in these cases, suggesting that the overall complication rate may actually be lower than that stated above.

Discussion

Needle biopsy of the mediastinum is an established technique and provides a relatively safe minimally invasive method for diagnosis of masses in this region. Because of the proximity of major vascular structures many earlier series have limited biopsies to fine needle techniques with predominantly fluoroscopic guidance.[2 4-7] With the advent of transaxial methods of imaging there has been a shift towards computed tomographic or sonographic guidance of the needle tip.[1 3 8-10] Since its arrival in our department CT has completely replaced fluoroscopy as the imaging method of choice during mediastinal needle biopsy (fig 1). It permits ready identification of the major vessels, the needle tip can be clearly identified within the lesion, and it is relatively easy to maintain a sterile field during the procedure. As a result of being able to plan a biopsy route more accurately, CT also allows larger cutting needles to be used in relative safety. Our results show that, compared with fluoroscopic guidance, the use of CT has not greatly improved the diagnostic accuracy of our mediastinal biopsies, but increased confidence due to better visualisation of the mass and adjacent blood vessels has almost certainly contributed to the greater number of biopsies now being performed. Although not used for this purpose at our centre, ultrasound may also permit accurate localisation of the biopsy needle and recognition of major mediastinal structures. Ultrasound has the advantage over CT of allowing real time imaging leading to a quicker procedure, but it cannot be used if aerated lung is interposed between mass and chest wall as this prevents adequate visualisation.

The incidence of complications in this series is very small and compares favourably with several previously published series where the rate varied from 11% to 24%.[2-7] As this was a retrospective series it is possible that we have underestimated the frequency of minor complications such as small pneumothoraces as these may not have been recorded in the radiological records or case notes. A further possible explanation is the exclusion of hilar masses. In many cases the mediastinal lesion would have been directly accessible without traversing the lung or pleura. This explanation is supported by the low incidence of pneumothorax in several reported series of ultrasound guided biopsy of the mediastinum[8-10] where the lesions would necessarily be in direct contact with the chest wall in order to create an acoustic window. In our only case requiring an intercostal drain for a moderate pneumothorax it was necessary to cross two pleural surfaces in order to access enlarged subcarinal lymph nodes (fig 2A and B).

The types of mediastinal mass examined by biopsy in this series broadly reflect the range of pathological conditions seen in our clinical practice. All the biopsies were primary

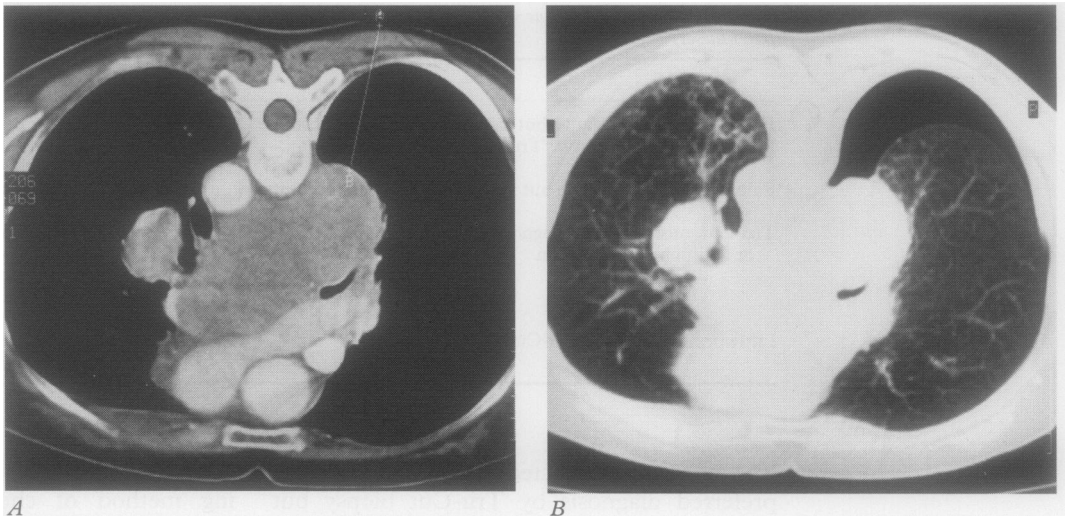

Figure 2 Biopsy of a middle mediastinal mass: patient prone, right posterior approach. (A) The planned biopsy route crosses two pleural surfaces in order to access enlarged subcarinal lymph nodes (CT window width (WW) 400 Hounsfield units (HU), window level (WL) +20 HU). (B) Scan immediately after the procedure showing a moderate pneumothorax (WW 850 HU, WL −750 HU).

diagnostic procedures and were not for staging of known or suspected metastatic tumour. Despite this, the final diagnosis was of carcinoma in a third of our cases as these were either central lung tumours which were indistinguishable radiographically from primary mediastinal masses (fig 3), or mediastinal nodal masses where the primary tumour could not be seen.

A potential pitfall in this type of series is that needle biopsy is the method by which the final diagnosis is reached in many cases without collaborative support by open surgical biopsy or necropsy. As this study spans a period from 1981 to 1991, however, clinical follow up of these cases is available for intervals ranging from nine months to 11 years. Any major errors of diagnosis should have become apparent during follow up due to an atypical clinical course or lack of expected response to therapeutic regimes. In fact only one such case was documented, leading to a repeat biopsy nine months later and a revised diagnosis.

Both fine needle and cutting needle biopsies were undertaken in this series. A major advantage of fine needle techniques is that immediate cytological examination of the specimen is possible and the pathologist can then direct the radiologist appropriately. Our experience of fine needle biopsy compares well with previously published series[2-6] with our overall sensitivity being 90%, specificity 100%, and diagnostic accuracy 77%. As in previous studies our best results were achieved in the diagnosis of carcinomatous lesions (96% sensitivity, 88% accuracy), with lower figures for the diagnosis of non-carcinomatous lesions (sensitivity 81%, accuracy 69%). On the basis of our experience we suggest that, when carcinoma is suspected, fine needle aspiration should be performed as the initial procedure. If this provides an unequivocal diagnosis of carcinoma further biopsy is usually unnecessary (fig 4). If insufficient material is obtained for diagnosis further fine needle aspirates may be obtained before considering the need for cutting needle biopsy. If fine needle aspirates suggest a non-carcinomatous lesion, cutting needle biopsy should then be performed whenever practical for greater diagnostic accuracy (fig 4). Although the majority of lesions in this series were solid, there were several masses of low CT attenuation which were believed to be mediastinal cysts. In these cases spinal type needles were used in preference to our usual Rotex needles to permit cyst aspiration.

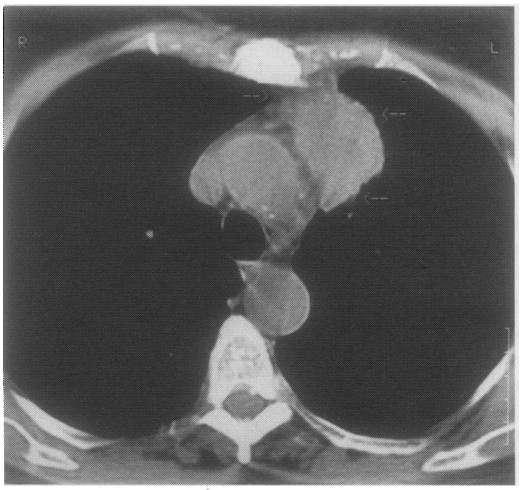

Figure 3 Central bronchogenic carcinoma (arrowed) indistinguishable radiologically from a primary mediastinal mass (WW 400 HU, WL +20 HU).

There have been some reports of the use of larger cutting needles for mediastinal biopsies but these series have been relatively small compared with those in which a fine needle has been used.[7-10] Sensitivity (96%), specificity (100%), and accuracy (94%) in our series of Tru-Cut biopsies were very high even for non-carcinomatous lesions. In the 17 patients who underwent both Tru-Cut and fine needle biopsies the diagnosis was changed by Tru-Cut biopsy in six cases. However, Tru-Cut biopsy provided a more confident diagnosis or important additional information in nine of the 11 remaining cases. This confirms the

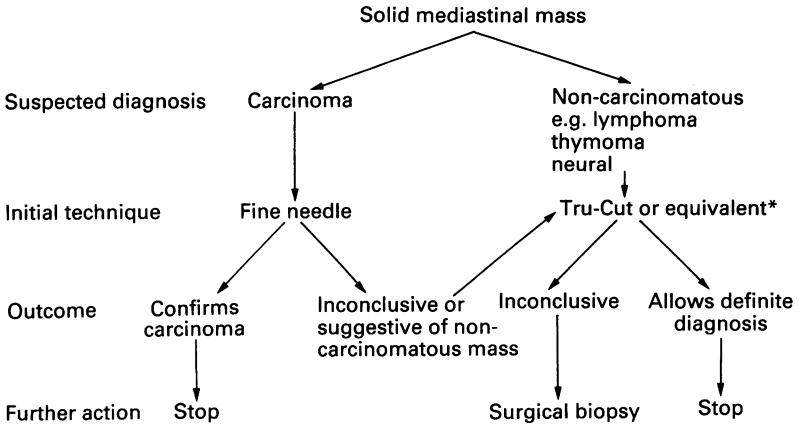

*Figure 4 Suggested algorithm for biopsy of solid mediastinal masses (*assuming lesion is accessible to larger cutting type needles).*

experience of previous groups who have found that the use of larger cutting needles in combination with fine needle aspiration improves diagnostic accuracy,[8 10] particularly for non-carcinomatous masses such as lymphomas and thymomas, and for benign masses. As a result it is now our practice to proceed directly to Tru-Cut biopsy in selected cases with readily accessible lesions, especially when the likelihood of carcinoma is small and the likelihood of lymphoma, thymoma, or a benign tumour is high (fig 4). Although fine needle techniques may suggest a diagnosis of lymphoma, differentiation between Hodgkin's disease, non-Hodgkin's lymphoma, and thymoma can be difficult. Larger core specimens from cutting needle biopsies are usually required for more precise diagnosis, allowing histological rather than cytological evaluation and special staining methods including immunohistochemical techniques. Not all mediastinal masses are amenable to Tru-Cut type biopsy, however. Previous workers have restricted the use of cutting needles to masses greater than 3 cm in diameter[8 10] and, in other cases, biopsies with larger needles might be avoided because of interposition of aerated lung between mass and chest wall, or the close proximity of major vascular structures. This is particularly true of middle mediastinal masses, but many of these will be carcinomas and suited to fine needle biopsy.

Radiologically guided percutaneous mediastinal biopsy is therefore a safe procedure which can provide accurate diagnostic information and avoid the need for more invasive procedures in many cases. We recommend the use of fine needle techniques as the initial procedure when the probability of central lung cancer is high, or when a mediastinal cyst is suspected. The use of cutting needle techniques to obtain larger pathological specimens is recommended when fine needle diagnosis of carcinomatous lesions is uncertain, or when a non-carcinomatous lesion is likely.

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