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# MRI-Guided Percutaneous Biopsy of Mediastinal Masses Using a Large Bore Magnet: Technical Feasibility

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## Abstract

*Objective* To evaluate the diagnostic accuracy and safety of magnetic resonance imaging (MRI)-guided percutaneous biopsy of mediastinal masses performed using a wide-bore high-field scanner.

*Materials and Methods* This is a retrospective study of 16 consecutive patients (8 male, 8 female; mean age 74 years) who underwent MRI-guided core needle biopsy of a mediastinal mass between February 2010 and January 2014. Size and location of lesion, approach taken, time for needle placement, overall duration of procedure, and postprocedural complications were evaluated. Technical success rates and correlation with surgical pathology (where available) were assessed.

*Results* Target lesions were in the anterior (n = 13), middle (n = 2), and posterior mediastinum (n = 1), respectively. Mean size was 7.2 cm (range 3.6–11 cm). Average time for needle placement was 9.4 min (range 3–18 min); average duration of entire procedure was 42 min (range 27–62 min). 2–5 core samples were obtained from each lesion (mean 2.6). Technical success rate was 100 %, with specimens successfully obtained in all 16 patients. There were no immediate complications. Histopathology revealed malignancy in 12 cases (4 of which were surgically confirmed), benign lesions in 3 cases (1 of which was false negative following surgical resection), and one inconclusive specimen (treated as inaccurate since repeat CT-guided biopsy demonstrated thymic hyperplasia). Sensitivity, specificity, positive predictive value, negative predictive value, and accuracy in our study were 92.3, 100, 100, 66.7, and 87.5 %, respectively.

*Conclusion* MRI-guided mediastinal biopsy is a safe procedure with high diagnostic accuracy, which may offer a non-ionizing alternative to CT guidance.

**Key words:** MRI guidance – percutaneous image-guided biopsy – mediastinal masses

## Key points :

- performing percutaneous biopsy of mediastinal masses with MRI-guidance is feasible, accurate and safe
- MRI-guidance offers real-time multiplanar imaging
- MRI may help to target viable parts of the tumor in case of a necrotic mass
- MRI-guidance offers a non-ionizing alternative to CT-guidance

## Abbreviations:

MRI magnetic resonance imaging

CT computed tomography

PET positron emission tomography

TP true positive  
TN true negative  
FP false positive  
FN false negative  
NPV negative predictive value  
PPV positive predictive value

## **Introduction**

In recent years, magnetic resonance imaging (MRI)-guided intervention has emerged as a viable technique, facilitated by the development of open and wide-bore high-field scanners, MRI-compatible equipment, and MR fluoroscopy sequences which utilize rapid acquisition protocols to create a continuous one image-per-second frame-rate display, enabling “real-time” visualization of the advancing needle [1–4]. MRI offers superior soft tissue contrast, good depiction of vessels, and multiplanar imaging capabilities, which may enable relatively inconspicuous and inaccessible lesions to be targeted [1, 2, 5]. There is a growing body of literature reporting its safety and effectiveness for head and neck, abdominopelvic, and musculoskeletal interventions [1–8]. However, to our knowledge, there is only one prior report investigating the utility of MRI-guided biopsy for mediastinal masses, performed in a low-field open scanner [9]. The purpose of this study is to report the first series of MRI-guided mediastinal biopsies in a wide-bore high-field scanner, detailing its technical feasibility, diagnostic accuracy, and advantages and drawbacks over CT guidance.

## **Materials and methods**

This single-center retrospective study was approved by the institutional review board at our hospital.

### *Study population*

16 consecutive patients undergoing MRI-guided mediastinal biopsy between February 2010 and January 2014 were included in the study (8 male, 8 female; mean age 74 years, range 18–82 years). Patients were referred for biopsy following consensus discussion at a multidisciplinary meeting involving thoracic surgeons and pulmonologists. Biopsies were preferentially scheduled under MRI rather than CT guidance, in order to reduce radiation dose to the patient and radiologist, since MR fluoroscopy sequences are completely radiation-free. Patients were excluded from MRI-guided procedures if they were unable to lie flat for at least 30 min, claustrophobic, had pacemakers or incompatible devices, required trans-osseous access, or were scheduled for biopsy when the MRI suite was unavailable.

### *Procedures*

Written informed consent was obtained from all patients. Anticoagulants and anti-platelet agents were stopped prior to the procedure, and clotting profile was tested within 48 h of the procedure, as per SIR and CIRSE guidelines [10]. Minimum required prothrombin time and platelet count were 50 % and 50,000/mm<sup>3</sup>, respectively. All biopsies were performed under local anesthesia by five senior interventional radiologists (each with at least 6 months experience in MR-guided interventions) using a 1.5 Tesla MRI (MAGNETOM Aera,

Siemens, Germany) with a large bore (70 cm) gantry. Initially, a non-breath hold T2-weighted (T2 W) fast spin echo sequence with radial k-space filling (T2 BLADE sequence, TE/TR 178/3420 ms, flip angle 150°, 30 slices, field-of-view 400 mm × 400 mm, reconstructed in-plane resolution 2 mm × 2 mm, slice thickness 4 mm, total acquisition time 96 s) was acquired in the axial plane using the body coil. This was used as a planning sequence to localize the mass and determine the needle trajectory. In one case, a complementary non-breath hold T1-weighted (T1 W) fast spin echo sequence was acquired following intravenous injection of a gadolinium chelate-based agent (Dotarem®, Guerbet, France), in order to more precisely target the viable portions of a large necrotic tumor. All lesions were accessed extra-pleurally, using a parasternal approach for anterior mediastinal lesions, and a paravertebral approach for posterior and middle mediastinal lesions, with the patient in supine and prone positions, respectively. Cutaneous marking of the entry point was determined by measuring the distance between the central laser and the entry point determined on the axial planning sequence. After administration of the local anesthetic, a 16G coaxial needle (MRI coaxial puncture needle®, Somatex medical, Teltow, Germany) was percutaneously advanced using freehand technique through a small skin incision into the tumor under real-time MR-fluoroscopic guidance in two orthogonal planes, using a non-breath hold interactive, multi-slice balanced SSFP pulse sequence (BEAT-IRTTT sequence, Siemens Corporate Research & Technology, Center for Applied Medical Imaging, Baltimore, MD, USA) (TE/TR 2.2/5.35 ms, flip angle 50°, field-of-view 400 mm × 400 mm, reconstructed in-plane resolution 1.8 mm × 1.8 mm, slice thickness 4 mm, acquisition time per slice 815 ms). Prior to obtaining a biopsy, accuracy of needle position was confirmed on a T2 W BLADE or realtime sequence in the axis of the needle. Between 2 and 5 core biopsy samples were obtained using a coaxially placed 18G semi-automatic biopsy needle (MRI biopsy handy®, Somatex medical, Teltow, Germany). Post-biopsy, a final T2 W sequence was performed to check for any immediate complications. Patients were kept under observation for 3 h in the department, and had a chest radiograph prior to discharge. Any adverse finding or event occurring between the biopsy and the time of discharge was considered an immediate complication.

### *Data collection and Analysis*

We reviewed the size and location of mediastinal lesions, and calculated their mean diameter. We assessed patient position, approach taken, entire duration of the intervention (from planning MR-scan to final post-biopsy control), and time required to position the biopsy needle (from local anesthesia to first biopsy pass). Technical success and postprocedural complications were evaluated. Finally, Histopathology results of biopsies and surgical specimens (whenever a patient underwent surgical resection) were acquired. Results were defined as true positive (TP), true negative (TN), false positive (FP), or false negative (FN) based on the definitions shown in Table 1.

## **Results**

### *Lesions and Procedural Details*

Mediastinal lesions ranged from 3.6 to 11 cm in diameter, with a mean value of 7.2 cm. Biopsies were performed in the supine position in 13 cases using a parasternal approach (anterior masses; Fig. 1), and in the prone position in 3 cases using a paravertebral approach (middle and posterior masses; Fig. 2). Average duration of the entire procedure was 42 min (range 27–62 min), with a mean time to position the biopsy needle of 9.4 min (range 3–18 min).

Between 2 and 5 core biopsies were obtained from each lesion (mean: 2.6). Whenever possible, areas of viable tumor were targeted using signal characteristics of the mass identified on real-time images (Fig. 3). In one case with a large necrotic mass, contrast-enhanced MR was obtained to target accurately the viable part of the tumor. Residual contrast enhancement seen around the needle on T1 W images confirmed accurate placement (Fig. 4). Technical success was 100 %, with biopsy specimens successfully obtained in all 16 patients. There were no immediate complications; in particular there was no hemorrhage on post-biopsy imaging, and no pneumothorax on routine pre-discharge chest radiograph. No patient was readmitted to hospital in the week following discharge.

#### *Histopathological Results and Follow-Up*

Histopathology revealed malignancy in 12 out of 16 cases (75 %). 4 of these patients underwent surgical resection for thymoma, and there was accurate correlation between surgical pathology and pre-operative histopathology in all cases.

3 masses were reported as benign. 2 of these cases were confirmed as TN based on stability at follow-up imaging. However, one case (reported as “reactive mesothelial hyperplasia”) was subsequently resected in view of an aggressive CT appearance, and proven to be a thymoma at surgical pathology; this was classified as FN.

The last case was reported as a non-representative sample (normal thymic and fatty cells) by the pathologist. Repeat biopsy performed under CT guidance (since the MR suite was unavailable) was reported as thymic hyperplasia. In view of the discrepancy, this case was excluded from the statistical analysis of sensitivity, specificity, PPV and NPV. However, it was included in the calculation of accuracy and considered as an inaccurate biopsy.

#### *Diagnostic Accuracy*

Sensitivity, specificity, positive predictive value (PPV), negative predictive value (NPV), and accuracy in our study were 92.3, 100, 100, 66.7, and 87.5 %, respectively. Results are summarized in Table 2.

## **Discussion**

There is a growing body of research examining the clinical effectiveness and safety of MRI-guided biopsy for head and neck, abdominopelvic, breast, and musculoskeletal interventions [1–8]. However, its utility for thoracic biopsies has been little investigated, with just a few recent studies reporting lung nodule biopsy [11, 12], and only one prior case series of MRI-guided mediastinal biopsies, performed using an open 0,23 magnet [9]. To the best of our knowledge, our study is the first reporting the feasibility and safety of MRI-guided mediastinal biopsy using a wide bore scanner.

Our study demonstrates a 100 % technical success rate and illustrates the feasibility of MRI guidance in accessing mediastinal lesions. The diagnostic accuracy of 87.5 % is comparable to that of published CT-guided case series [13– 15]. Specificity, sensitivity and PPV are also similar to published reports, including the previous MR-guided study [9, 13–15]. However, Accuracy and NPV (87.5 and 66.7 %) were lower in our series than in the report of Lu et al. (94.7 and 81.2 %). This could reflect the effect of a smaller sample, heterogeneous size and histology of lesions, differences in approach, or differences in sampling technique [9].

In our early experience, MRI guidance presents several practical advantages over CT. The needle can be advanced in real-time multiplanar imaging, which is helpful for oblique or steep angles in the sagittal plane. Vessels are clearly seen as hyperintense structures on real-time sequences, without need for contrast injection. This delineation is especially useful when a mass is in contact with or encompasses the mediastinal great vessels. The high intrinsic

contrast resolution of T2 and real-time sequences help target viable portions of the tumors, usually without need for Gadolinium injection. However, contrast administration can further improve the detection of viable tumor, not only on planning sequences but also during the biopsy due to its persistence for longer periods. Finally, the major advantage of MRI guidance over CT is the complete lack of ionizing radiation to the patient and radiologist. It may therefore confer significant radiation protection compared with relatively high-dose CT fluoroscopy (approximately 296–561.6 mGy [16, 17] ), particularly in young hematologic patients at risk of significant cumulative effective doses (up to 70.8 mSv [18] ).

Unfortunately, MRI guidance has its own set of drawbacks. Artifacts around the needle may locally degrade image quality, which may limit successful targeting of sub-centimeter lesions such as small renal tumors [5]. Moreover, visualization of the lesion can be variable from one patient to another, especially on the real-time sequence. One explanation for this could be the location of mediastinal tumors in the vicinity of large vessels. The great vessels and heart produce movement artifacts which, if transposed along the needle trajectory, can significantly decrease real-time image quality and obscure small lesions. Inverting the phase and frequency-encoding directions should theoretically shift motion artifacts away from the needle and improve lesion visualization [19], but in practice this effect is often insufficient. Procedure times are longer with MRI guidance, mostly because of patient preparation, which is time-consuming and accounts for more than 60 % of the procedure [20]. This can be improved with increasing experience of technicians and radiologists. Finally, MR-associated costs are high and may be double that of CT-guided procedures [21].

The principal limitation of this study is the small sample size. However, our results are comparable to a previous larger study [9]. We selected larger lesions early in our experience, which may result in overestimation of technical success rate.

Finally, the generalisability of this machine and operator dependent technique to other centers remains unclear. In conclusion, our study shows that MRI-guided biopsy of mediastinal masses is technically feasible, accurate, and safe. Larger studies are required to refine the technique and evaluate its role in the coordinated management of mediastinal lesions.

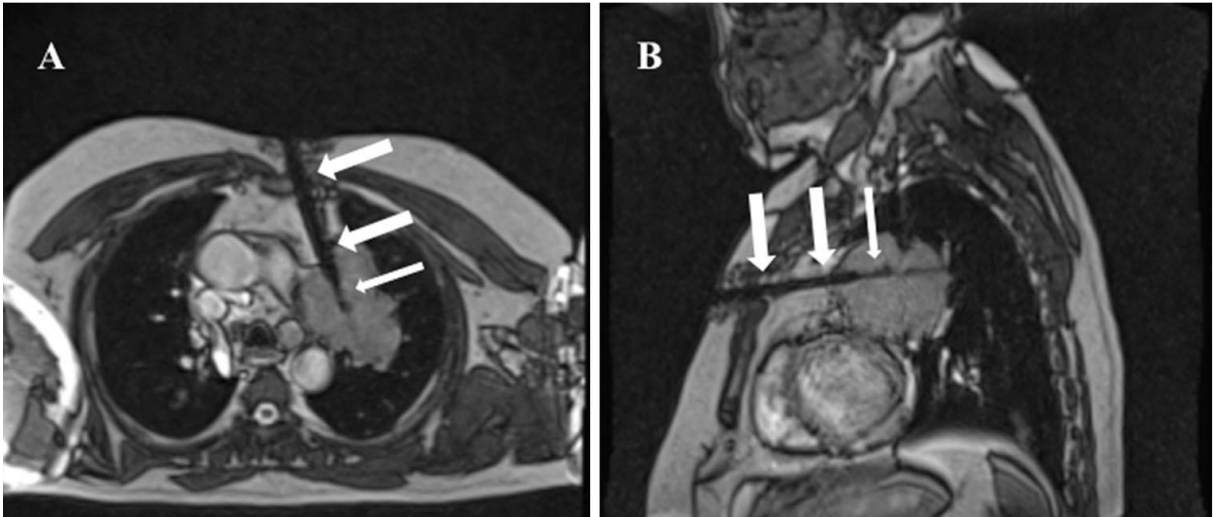
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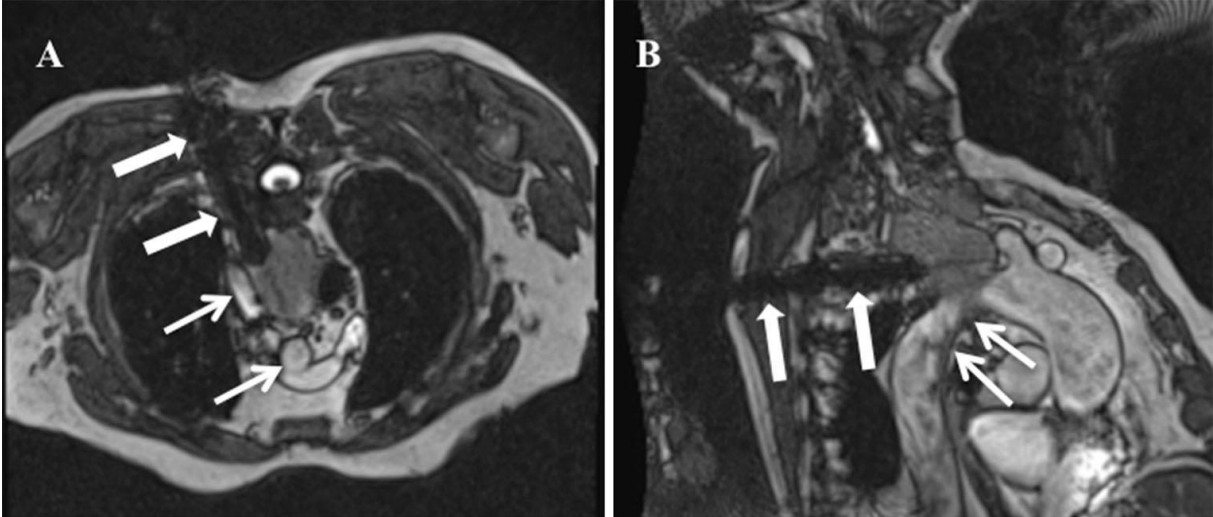
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**Figures**

**Fig.1:** Biopsy of a mediastinal mass using an anterior parasternal approach. **A** Axial oblique and **B** sagittal oblique interactive multislice balanced SSFP pulse sequence (real-time sequence). The coaxial needle in its whole length (large arrows), with the biopsy needle within the mass (thin arrow), is seen in two orthogonal planes.

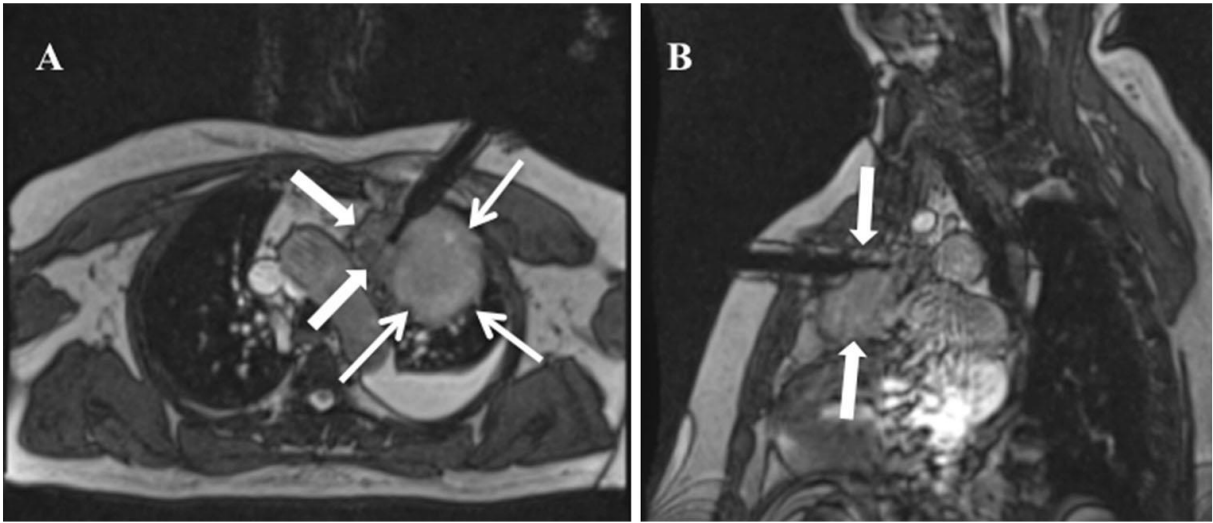


**Fig.2:** Biopsy of a middle mediastinal mass using a posterior paravertebral and intercostal approach. **A** Axial oblique and **B** sagittal oblique interactive multi-slice balanced SSFP pulse sequence (realtime sequence). The coaxial cannula (large arrow) is seen in its whole axis on both planes providing excellent positioning of the needle. Note that the great vessels (thin arrows) of the mediastinum are nicely seen as bright structures on this real-time sequence

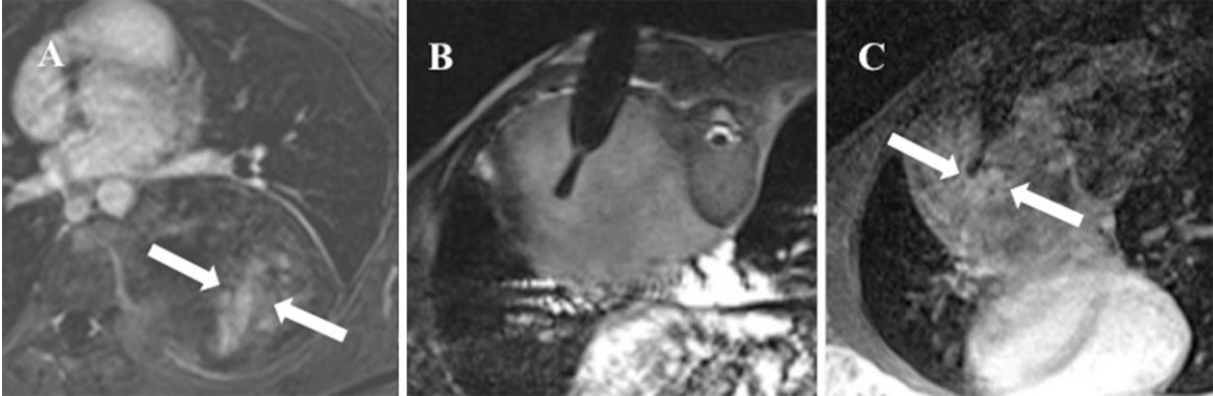




**Fig.3:** biopsy of an anterior mediastinal mass with necrosis. The high intrinsic contrast resolution of the real-time sequence helps to target the viable part of the lesion and to avoid the necrotic area of the tumor.



**Fig.4** Biopsy of an anterior mediastinal mass with necrosis. **A** Axial oblique and **B** sagittal oblique interactive multi-slice balanced SSFP pulse sequence (real-time sequence). The high intrinsic contrast resolution of the real-time sequence help target the viable part of the lesion (large arrows) and to avoid the necrotic area of the tumor (thin arrows)



**Table 1 Classification of biopsy**

Classification of the biopsy	Definition
True positive (TP)	Malignant histology (biopsy)
True negative (TN)	Benign histology (biopsy) and no suspicion of malignancy at follow-up imaging of at least 12 months or benign histology (surgical specimen)
False positive (FP)	Malignant histology (biopsy) but no suspicion of malignancy at follow-up imaging of at least 12 months or benign histology (surgical specimen)
False negative (FN)	Benign histology (biopsy) but suspicion of malignancy at follow-up imaging or malignant histology (2nd biopsy) or malignant histology (surgical specimen)

**Table 2: Results of percutaneous biopsy of mediastinal masses**

Patient	Location of the mass in the mediastinum	Histology on percutaneous samples	Final diagnosis (surgery or follow-up)	Classification of the biopsy	Classification of the biopsy
1	anterior	Lung adenocarcinoma	Lung adenocarcinoma	accurate	True positive
2	anterior	Thymoma	Thymoma	accurate	True positive
3	posterior	ganglioneuroma	ganglioneuroma	accurate	True negative
4	anterior	Small cell carcinoma	Small cell carcinoma	accurate	True positive
5	anterior	Small cell carcinoma	Small cell carcinoma	accurate	True positive
6	anterior	Reactive mesothelial hyperplasia	Thymoma	inaccurate	False negative
7	anterior	thymoma	thymoma	accurate	True positive
8	anterior	thymoma	thymoma	accurate	True positive
9	anterior	lymphoma	lymphoma	accurate	True positive
10	anterior	thymoma	thymoma	accurate	True positive
11	middle	Lung adenocarcinoma	Lung adenocarcinoma	accurate	True positive
12	anterior	No conclusion	Thymic hyperplasia	inaccurate	-
13	anterior	Small cell carcinoma	Small cell carcinoma	accurate	True positive
14	middle	Epidermoid carcinoma	Epidermoid carcinoma	accurate	True positive
15	anterior	epithelioid and gigantocellular granulomatous inflammation	Sarcoïdosis	accurate	True negative
16	anterior	lymphoma	lymphoma	accurate	True positive