CASE REPORT

Novel MRI of mediastinal masses: internal differentiation of a thymoma and lymphoma with T1 and T2 mapping

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SUMMARY

Routine imaging for mediastinal malignancies includes chest X-ray, CT or MRI. T1 and T2 mapping are novel MRI techniques which may have a role in expanding the assessment of internal tumour characteristics. This case report details two middle-aged women who had similar clinical presentations of mediastinal masses of comparable size and appearance when assessed with routine imaging. T1 and T2 maps were acquired on MRI to investigate whether these tumours could be further differentiated prior to surgery. T1 and T2 mapping supported suspicion for which tumour components were solid and cystic, as subsequently confirmed histologically. Furthermore, comparison between the two tumours showed native T1 values differed within the solid components by 37%, correlating to differences in proteinaceous material within the tumour types. This radiological–pathological correlation provides evidence that T1 and T2 mapping has clinical utility in the assessment and differentiation of mediastinal masses.

BACKGROUND

Thymoma is a rare, indolent tumour which arises from the epithelial cells of the thymus gland, representing approximately 20% of all mediastinal tumours.¹ Thymoma can be benign or malignant, and is classified into histological subtypes depending on the epithelial cell involved.² Thymic tumours are usually first seen on chest X-ray (CXR) or CT and subsequently investigated with MRI. MRI is used to define soft tissues and therefore can provide both definition of the internal morphology of thymic tumours and assessment for localised invasion. This imaging technique is therefore an important preoperative tool, allowing the surgeon prior knowledge of cystic or solid regions of the tumour and preoperative staging.²

T1 and T2 mapping is a rapidly expanding cardiac MRI tool that is predominantly used to assess the left ventricular myocardium. The longitudinal relaxation time of T1 without contrast is termed 'native T1', and is increased in the myocardium with protein, oedema or collagen deposition into the extracellular matrix.³ Examples of myocardial diseases with high T1 values are amyloidosis, cardiac sarcoidosis and ischaemic myocardial scar.^{3,4} T1 mapping values are reduced in areas of fatty infiltration, such as cardiac lipoma and Fabry's cardiomyopathy, or iron deposition in the myocardium as occurs with haemochromatosis.^{3,5}

With administration of MRI contrasts such as gadolinium, collagen scar or vascular tumours that retain the contrast result in T1 shortening, reflected by low T1 values.⁶ T2 mapping refers to a transversal relaxation time and is increased in tissues with high fluid content or oedema, associated with conditions such as acute myocarditis or cardiac myxoma.^{3,7} The case report here presents the use of T1 and T2 mapping in the evaluation of thymoma with comparison to a Hodgkin's lymphoma, to assess the potential of this novel imaging technique beyond the pericardium.

CASE PRESENTATION

A 49-year-old woman presented at a rural emergency department following a syncopal episode preceded by 12 hours of chest pain. The pain had gradually increased in severity and presented as intermittent left-sided chest pain, which was pleuritic, positional and sharp in nature. The patient also reported reduced exercise tolerance over several weeks and a chronic history of menorrhagia. CXR showed an anterior mediastinal mass projecting over the left hilum and middle lung zone. The patient was admitted with a differential diagnosis of thymoma or lymphoma and later transferred to a thoracic surgeon at a tertiary hospital. Transfer was arranged urgently amid concerns that the patient's anaemia (haemoglobin 85 g/dL) was associated with haemorrhage from the tumour or a paraneoplastic process.

INVESTIGATIONS

An MRI of the thorax was performed on a 3T Skyra MRI (Siemens, Erlangen, Germany) with standard sequences, including T1, T1 fat saturation, T2, T2 fat saturation and triplane post-contrast imaging. For this study, we performed a novel sequence which included precontrast (native) T1 maps and T2 maps, acquired using Modified Look-Locker Imaging (MOLLI). The anterior mediastinal tumour measured 124 mm x 86 mm in maximal dimensions and demonstrated a well-defined, enhancing capsule suggesting that the tumour was non-invasive (figure 1). The tumour had internal inhomogeneity with the solid component predominantly on the right lateral aspect of the tumour and the cystic component in the left lateral aspect of the tumour (figure 2A).

Imaging investigation also included ¹⁸F-fluorodeoxyglucose positron emission tomography (PET)/CT. The right lateral, enhancing component of

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Figure 1 Postcontrast MRI of the thorax (A) demonstrated a well-defined, enhancing capsule surrounding the cystic tumour component (red arrows). This correlated pathologically (B, x100) to a thick fibrotic wall lined by viable and necrotic tissue.

the tumour demonstrated mild PET avidity with a maximum standardized uptake value (SUV) of 3.1 (figure 2B). On corresponding CT imaging, this component of the anterior mediastinal mass was solid but contained no calcification. The left lateral component of the tumour appeared photopaenic on the CT chest images and had an internal density of 39 Hounsfield units. Small bilateral pleural effusions were present on CT.

The patient had a diagnostic angiogram to further assess the vascularity of the tumour preoperatively and to exclude internal haemorrhaging. The lateral side of the tumour was supplied by the left internal mammary artery branches, while the medial side was supplied by branches of the thyrocervical trunk.

TREATMENT

The patient proceeded to thoracic surgery with some urgency due to concern for internal haemorrhage within the tumour. Open sternotomy of the chest revealed a large, oedematous anterior mediastinal mass, loosely adherent to the surrounding structures. This was separated from the pericardium, innominate vein, lungs and, with some difficulty, the phrenic nerves. During dissection, the capsule ruptured and released pale pultaceous material. Three chest drains and two catheters were placed and

Figure 2 MRI of the thorax (A) of an anterior mediastinal mass showing the solid component (regions of interest (ROI) 1) in the right lateral aspect and the cystic component in the left lateral aspect (ROI 2 and 3). Corresponding positron emission tomography (PET)/CT (B) showed ROI 1 was photopaenic and mildly PET avid. Native T1 (C) maps gave higher values in ROI 2 and 3, compared with pleural fluid (ROI 4) reflecting proteinaceous nature of cystic fluid. T2 mapping (D) also gave high values in this region due to high water content in this cystic fluid.

Figure 3 Tissue specimen (A, x400) of the solid component of the thymoma (ROI 1) showed a dual population of cells including solid neoplastic thymic epithelial cells (larger cell with oval pale nuclei and small nucleoli) admixed with non-neoplastic T lymphocytes (smaller cells, dark nuclei). Tissue specimen (B, x400) of the cystic component (ROI 2 and 3) demonstrated necrotic thymic epithelial cells and lymphocytes, plus occasional viable lymphocytes and neutrophils.

the sternum was closed. Finally, a bronchoscopy was performed at the end of the operation due to high ventilation pressures. Significant secretions were found on the right lung and drained.

OUTCOME AND FOLLOW-UP

The patient's postoperative recovery was uneventful. The surgical specimen was reviewed by a pathologist and a diagnosis of a type B1 thymoma was made. Macroscopically, the anterior, posterior and left aspect of the tumour were smooth and intact, while the right aspect had a roughened, fatty appearance. The remainder of the posterior and inferior mass was filled with pink, sloughy, necrotic fluid. The surgical specimen was encapsulated, confirming the thymoma was non-invasive, as suggested by the appearance on MRI (figure 1). There was no internal haemorrhage present within the tumour. At a later date, uterine fibroids were observed on pelvic ultrasound and it was elucidated that the patient's anaemia was thus related to the chronic menorrhagia reported on presentation.

Pathological–radiological correlation was performed by undertaking microscopic evaluation of the thymoma components and comparing to the T1 and T2 values of regions of interest (ROI) 1 to 3 (figures 2 and 3, table 1). The solid component (ROI 1) gave a mean native T1 mapping value of 993 (range 812–1141) and a mean T2 value of 57 (range 45–78) (figure 2C,D). On pathological review of the surgical specimen, these high T1 and low T2 values corresponded to solid sheets of neoplastic thymic epithelial cells (figure 3A). In comparison, the cystic component (ROI 2) had a mean native T1 value of 1451 (range 1379–1565), while the mean T2 value was 77 (range 67–95) (figure 2C,D). The high T1 values of both ROI 2 and 3 demonstrate high protein content consistent with pathology findings of necrotic tissue in these areas (figure 3B). The differences in T2 values reflect that ROI 2 had an increased fluid content compared with ROI 3, corresponding to a more cystic area of tumour. However, comparison with a simple pleural effusion (ROI 4) highlighted the high protein content of the fluid within the tumour.

The primary differential diagnosis in this case was lymphoma. A companion case of a 32-year-old woman with Hodgkin's lymphoma limited to the anterior mediastinum has therefore been provided. This companion case was chosen because the imaging appearance of the tumour was very similar to the described thymoma (figure 4A). T1 and T2 mapping was performed to identify if there were any unique factors between the two tumours. A small anterior, cystic component (ROI 1) had a mean native T1 value of 2716 (range 2610–2844) and mean T2 value of 153 (range 124–171) (figure 4B,C). This highlights

Table 1 Correlation of native T1 and T2 values with tumour characteristics

Case	Region of interest (ROI)	Native T1 value (mean)	T2 value (mean)	Pathology correlation
Thymoma	1	993	57	Solid tumour component comprising neoplastic thymic epithelial cells. Region of high protein (T1) and low fluid (T2) content.
	2	1451	77	Cystic component comprising necrotic tissue. Region of high protein (T1) and low-moderate fluid (T2) content.
	3	1420	64	
	4	0	213	Pleural effusion. Region comprised of simple fluid only.
Lymphoma	1	2716	153	Cystic component comprising necrotic, lymphocyte rich fluid. Region of very high protein (T1) and high fluid (T2).
	2	1679	63	Solid lymphoma tissue, comparable to cystic component (ROI 2 and 3) in thymoma case. Region of high protein (T1) and low fluid (T2) content. Postcontrast T1 mapping also performed on this tumour (mean 391) indicated high vascularity.

a cystic area of tissue high in fluid and protein. The larger posterior aspect of the tumour, corresponding with ROI 2, had a mean native T1 value of 1679 (1557–1951) which shortened on 15 min postcontrast imaging to 391 (353–433) indicating highly vascular solid tissue which retained contrast (figure 4B,D). As this area was solid, the mean T2 value was comparably low at 63 (range 56–73), reflecting a solid area containing moderate protein and low fluid.

DISCUSSION

This is the first description of the application of T1 and T2 mapping to mediastinal masses. Anterior mediastinal masses have a broad imaging differential with the most common being thymic malignancies, lymphoma, germ cell origin tumours and metastatic disease. Although CT and MRI can favour a differential diagnosis, there is no pathognomonic imaging feature of mediastinal malignancies. CT scanning is effective for detecting thymoma, with a sensitivity of 88.5% and a specificity of 77%; while MRI has a lower sensitivity of 70%, it has been shown to better characterise thymoma invasiveness.⁸ The incidence of tumour seeding during CT-guided biopsy of the chest wall

is very low at 0.012%–0.061%; however, many centres avoid routine preoperative biopsy given the significance it implies.^{9–11} T1 and T2 mapping provides clinical utility by internally characterising soft tissue, giving it the potential to become a ‘non-invasive biopsy’.¹² Previous case series have already described the ability of T1 mapping to distinguish intraventricular thrombus from cardiac tumours, with T1 mapping particularly useful in defining cardiac lipoma and myxoma.^{5 7 13}

The study presented here has further explored the use of T1 and T2 mapping in the assessment of tumours by providing histological correlation of a large B1 thymoma and a mixed solid–cystic mediastinal lymphoma. The MRI mapping sequence applied here could potentially have incremental value to the standard sequences routinely acquired, particularly through the ability of the sequence to provide quantitative values that reflect the internal composition of a mass. The authors propose that in the future, T1 and T2 reference ranges may help establish tumour diagnosis. Here, we described the native T1 values in the solid components of a B1 thymoma (mean 993) as being 37% lower than the T1 value of a primary mediastinal Hodgkin’s lymphoma (mean 2716). This difference suggests that a larger case series may demonstrate a statistical significance between thymic malignancies and other mediastinal tumours. The hope of this publication is to encourage other centres to trial this technique and expand knowledge of T1 and T2 signals in various subtypes of thymic tumours. Continued development could lead to T1 and T2 mapping value reference ranges with diagnostic utility, thus reducing the need for preoperative biopsy and the associated risks.

Figure 4 Postcontrast MRI of the thorax of Hodgkin’s lymphoma: (A) limited to the anterior mediastinum, showing both cystic (ROI 1) and solid (ROI 2) components. The lymphoma had native T1 values which were high in both the cystic and solid components (B). The T2 values in the cystic component (C) were also high reflecting lymphocyte-rich fluid. In this case, 15 min postcontrast T1 mapping (D) was also acquired with shortening of T1 values reflecting the vascular nature of the solid tissue.

Learning points

- T1 and T2 mapping are novel MRI techniques with clinical utility previously described in cardiac imaging. Here, we report for the first time the application of these techniques to mediastinal masses.
- Routine imaging showed similar appearance of a thymoma and Hodgkin’s lymphoma presenting in two middle-aged women. The additional of T1 and T2 mapping to imaging work-up showed varied internal characteristics related to differences in fluid and protein content, confirmed on pathological investigation.
- Further research may lead to the elucidation of T1 and T2 value reference ranges for specific tumour types. This would allow differentiation of tumour type without the need for invasive biopsy.

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