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ORIGINAL ARTICLE

Correlation Between Computed Tomography, MRI of the Chest, and Medical Thoracoscopic Findings in Primary Pleural Tumors

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Abstract

Objective: **Malignant pleural mesothelioma (MPM) routine diagnostic procedures often include computed tomography (CT) and MRI. Histological confirmation by pleural biopsy is required for the MPM diagnosis to be finalized.**

Aim: **To compare among findings of chest CT, MRI, and medical thoracoscopy (MT) for MPM identification.**

Patients and methods: **Fifty patients (30 males and 20 females) with definitive MPM diagnosis after MT biopsy, underwent chest CT and MRI chest.**

Results: **There was statistically significant parameters for MRI versus CT for pleural thickening, it was 64 versus 44 % ($P = 0.044$). Postcontrast enhancement in MRI was 68 versus 62 % for CT ($P = 0.006$). Chest wall, vascular, or mediastinum invasion in MRI was 24 versus 0 % for CT ($P = 0.001$). Pleural nodularity in CT was 36 versus 12 % for MRI ($P = 0.005$). Comparing MT and CT features, there was highly statistically significant difference with P value less than 0.001, as regards nodularity (90 vs. 36 %), and increased pleural thickening (88 vs. 44 %) for MT and CT, respectively. Comparing CT and MRI findings, there was a very significant difference in terms of statistics with P value less than 0.001, for nodularity, 90 versus 12 %, and increased pleural thickening, 88 versus 64 % for MT and MRI, respectively, with P value less than 0.004.**

Conclusion: **MRI diagnostic performance is comparable or superior to CT in suspicion of MPM except for nodular pleural thickening. An early and significant identification of MPM may be reached, providing MRI as a tool for diagnosis.**

Keywords: Computed tomography, MRI, Medical thoracoscopy, Malignant pleural mesothelioma

1. Introduction

Mesothelial cells lining the pleural cavity give rise to the aggressive tumor known as malignant pleural mesothelioma (MPM). Because asbestos exposure was so common in previous decades, MPM incidence is rising globally and is predicted to rise in the following 10−20 years.[1]

The ability of imaging to detect pleural disease early, distinguish between benign and malignant processes, stage patients, and assess treatment response are all important aspects of MPM management.[2]

Limitations of locoregional staging and significant interobserver variability are present in chest computed tomography (CT).[3] Chest MRI may be the solution to overcome some limits of CT, as MRI has been demonstrated to have a higher spatial resolution.[4] MRI allows superior help in the assessment of the tumor spread than CT in neighboring structures, being very useful in those patients with potentially resectable MPM.[5]

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This study's objective was to compare MPM identification results from CT, MRI, and medical thoracoscopy (MT) of the chest.

2. Patients and methods

All subjects participated voluntarily and received a small compensation. The participants provide their written informed consent to participate in this study. The Declaration of Helsinki was adequately addressed.

This analytical study involved 50 patients, aged more than 18 years. They were diagnosed with MPM after MT for pleural biopsy in the Chest Department (Al-Hussein University Hospital), Faculty of Medicine, Al-Azhar University from June 2022 to May 2023.

We excluded patients with contraindications to thoracoscopy or those with no confirmation of MPM after histopathology.

Written informed consent, a thorough medical history review, clinical examination, standard tests, and pleural fluid analysis had all been administered to every patient. MT was performed under local anesthesia. Pleura macroscopic findings were evaluated. Pleural samples had been sent for histopathological examination. CT and MRI chest to identify pleural radiological variables were done.

3. Results

Version 24 of the Statistical Program for the Social Sciences (SPSS) was used to analyze the data. Demographic data for our patients included 60 % males, their mean age was 56.5 ± 9.5 years, and a mean BMI of 29.7 ± 4.3 kg/m^2. Dyspnea was the most typical presenting symptom (94 %); chest pain (64 %) while coughing was seen in 60 %. Common comorbidities were smoking (62 %), diabetes mellitus (38 %), family history of malignancy (20 %), and family history of malignant pleural effusion (MPE) (18 %) of patients.

Considering pleural fluid analysis, the means of studied parameters were as follows: 340.2 ± 248.1 for total white cell count, with a neutrophil % of 14.3 ± 4.7 and lymphocytes % of 85.4 ± 5.0. The means of lactate dehydrogenase (LDH), total protein (TP), and adenosine deaminase (ADA) were 421.5 ± 205.4, 4.4 ± 0.8, and 16.2 ± 10, respectively.

Furthermore in our study, regarding CT chest there was 22 (44 %)patients with pleural thickening, and 11 (22 %) of them showed a thickening of more than 1 cm. Eight (16 %) patients had mediastinal pleural thickening, five (10 %) patients with circumferential thickening, 18 (36 %) patients with pleural nodularities, three (6 %) patients with mediastinal lymphadenopathy, 12 (24 %) patients with pulmonary consolidation or infiltration, four (8 %) patients with pulmonary mass or nodules, nine (18 %) patients with collapsed lung, 31 (62 %) patients with postcontrast enhancement, and two (4 %) patients with chest wall bone invasion (Table 1).

MRI findings showed nearly same percentage of site and severity of effusion as CT. Pleural thickening was found in 64 %, 36 % with thickening more than 1 cm. Other parameters were as follows: mediastinal pleural thickening (16 %), circumferential thickening (10 %), pleural nodularity (12 %), mediastinal lymphadenopathy (6 %), consolidation or infiltration of the lungs (24 %), nodules or masses in the lungs (8 %), collapsed lung (18 %), postcontrast enhancement (86 %), diffusion restriction (86 %) and chest wall, vascular, or mediastinal invasion (24 %) (Table 2).

When CT and MRI results were compared, no statistically significant difference was found ($P > 0.05$) between both for most of parameters. There was statistically significant difference for MRI versus CT for pleural thickening, it was 64 versus 44 % ($P = 0.044$). Post-contrast enhancement in MRI was 68 versus 62 % for CT ($P = 0.006$). Chest wall, vascular, or mediastinum invasion in MRI was 24 versus 0 % for CT ($P = 0.001$). Pleural nodularity in CT was 36 versus 12 % for MRI ($P = 0.005$) (Fig. 1).

Table 1. Description of computed tomography results for each patient under study.

	Studied patients ($N = 50$) [n (%)]	
Pleural effusion side		
Right side	32	64
Left side	18	36
Pleural effusion grade		
Mild	6	12
Moderate	32	64
Massive	12	24
Findings		
Thickening of the pleura	22	44
Thickening of more than 1 cm	11	22
Mediastinal pleural thickening	8	16
Circumferential thickening	5	10
Pleural nodularities	18	36
Mediastinal lymphadenopathy	3	6
Consolidation or infiltration of the lungs	12	24
Nodules or masses in the lungs	4	8
Collapsed lung	9	18
Postcontrast enhancement	31	62
Chest wall, vascular, or mediastinal invasion	0	0
Bone invasion on the chest wall	2	4

Table 2. Description of MRI findings in all studied patients.

	Studied patients ($N = 50$) [n (%)]	
Pleural effusion side		
Right side	32	64
Left side	18	36
Pleural effusion grade		
Mild	7	14
Moderate	32	64
Massive	11	22
Bright T2 signal of the pleural lesion or thickening		
No	28	56
Yes	22	44
Bright T2 signal of the pleural lesion or thickening		
Mild	11	50
Intermediate	11	50
Findings		
Thickening of the pleura	32	64
Thickening more than 1 cm	18	36
Mediastinal thickening of the pleura	8	16
Circumferential thickening	5	10
Pleural nodularities	6	12
Mediastinal lymphadenopathy	3	6
Consolidation or infiltration of the lungs	12	24
Nodules or masses in the lungs	4	8
Collapsed lung	9	18
Postcontrast enhancement	43	86
Diffusion restriction	43	86
Chest wall, vascular, or mediastinal invasion	12	24
Bone invasion on the chest wall	0	0

Macroscopic data of MT revealed that the mean effusion amount was 2.9 ± 1.4 l. There was visceral pleural nodule, erythema, and pleural thickening in 52, 52, and 62 %, respectively. There were nodules, pleural lymphangitis, erythema, and pleural thickening in 78, 66, 70, and 74 %, respectively, for costo-parital pleura. Same previous parameters were 52, 32, 30, and 44 %, respectively, in diaphragmatic pleura.

Comparing thoracoscopy and CT finding, there was highly statistically significant difference, as

Table 3. Computed tomography and thoracoscopy are compared with regard to nodularity and pleural thickening.

	CT ($N = 50$) [n (%)]		Thoracoscopy ($N = 50$) [n (%)]		Statistical test	P value
Nodularity						
No	32	64	5	10	$\chi^2 = 31.2$	<0.001 HS
Yes	18	36	45	90		
Pleural thickening						
No	28	56	6	12	$\chi^2 = 21.5$	<0.001 HS
Yes	22	44	44	88		

HS, P value less than 0.001 is considered highly significant; χ^2, χ^2 test.

Table 4. MRI and thoracoscopy are compared in terms of pleural thickening and nodularity.

	MRI ($N = 50$) [n (%)]		Thoracoscopy ($N = 50$) [n (%)]		Statistical test	P value
Nodularity						
No	44	88	5	10	$\chi^2 = 60.9$	<0.001 HS
Yes	6	12	45	90		
Pleural thickening						
No	18	36	6	12	$\chi^2 = 7.8$	0.004 S
Yes	32	64	44	88		

HS, P value less than 0.001 is considered highly significant; S, P value less than 0.05 is considered significant; χ^2, χ^2 test.

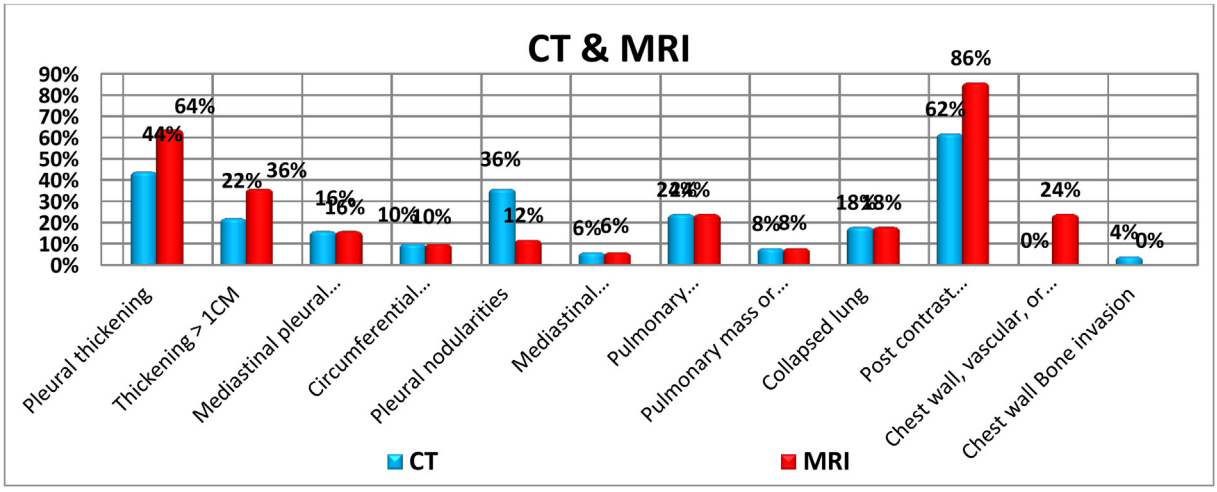

Fig. 1. Comparison between CT and MRI results in the studied patients. CT, computed tomography.

regards nodularity (90 vs 36 %) and pleural thickening (88 vs 44 %) for MT and CT, respectively ($P < 0.001$) (Table 3).

Comparing MRI and MT features in this study, there was a statistically significant increased nodularity detected through thoracoscopy versus MRI (90–12 %) ($P < 0.001$). Besides, pleural thickening by MT was 88 % compared with 64 % by MRI ($P = 0.004$) (Table 4).

Pathologic subtypes of thoracoscopic-guided biopsy were 90 % with epithelioid mesothelioma and 10 % with sarcomatiod mesothelioma. Neither of our patients showed the biphasic nor the undifferentiated varieties.

4. Discussion

Demographic data for our patients included that males were 60 %, mean age was 56.5 ± 9.5 years, with a mean BMI of 29.7 ± 4.3 kg/m^2. The male majority could be interpreted by the more opportunity of exposure to asbestos particles when compared with females. It was documented by Beckett *et al.*[6] who reported a male predominance of 4 : 1 in MPM patients.

Likewise, the same sex percentage was found in research by Patel *et al.*[7] with an average age of 70.3 years.

Regarding our study, the vast majority of patients were symptomatic at presentation. Dyspnea was the most typical presenting symptom in 94 %, chest pain in 64 %, while cough was seen in 60 %.

Similar results were observed by Ferrer and colleagues, as subacute dyspnea was a very common symptom among their patients. Patients were found to have MPE if they met the four criteria: clinical symptoms (dyspnea, chest pain, constitutional symptoms), duration of more than 1 month, absence of fever, blood-tinged effusion, and chest CT scan suggesting malignancy,[8] while Rudd[9] found dyspnea in 70 % of patients at presentation.

Considering pleural fluid analysis in this work, the mean lymphocytes % was 85.4 ± 5.0. The means of LDH and ADA were 421.5 ± 205.4 and 16.2 ± 10, respectively.

When pleural fluid (PF) is routinely analyzed in MPE, exudative features with a predominance of mononuclear cells are often seen. Lymphocytic count predominance coincides with Arnold and Maskell,[10] who found that lymphocyte predominance is seen in more than 50 % of MPEs with 60 % sensitivity. Because PF ADA concentration in TB is higher than in MPE (median 86 U/l against median 23 U/l), it can aid in the differentiation of two diseases, which completely coincides with our results.[11]

A recent retrospective trial indicated that a higher MPE diagnostic yield did correspond with a higher pleural fluid LDH. However, they discovered that neither the pH nor the glucose of the pleural fluid was linked to an improvement in the cytological diagnostic yield.[12]

In CT findings, there was 64 % with right and 36 % with left side pleural effusion. There was 12, 64, and 24 % for mild, moderate, and massive effusion, respectively. These results correspond to those of Porcel *et al.*[13] who documented that MPE is generally unilateral, and in 11 % of cases, bilateral effusions were detected. MPEs were huge or moderate in almost half of cases.

Furthermore, pleural thickening affected 44 % of our study participants, half of them with thickening more than 1 cm. Mediastinal pleural thickening was in 16 % and circumferential thickening was in 10 %. Pleural nodularities, mediastinal lymphadenopathy, lung infiltration or consolidation, nodules or masses in the lungs, collapsed lung, postcontrast enhancement, and chest wall bone invasion was found in 36, 6, 24, 8, 18, 62, and 4 %, respectively.

This finding merges with the Cardinale et al.[14] results, which found that up to 80 % of patients have a unilateral pleural effusion, and about 25 % have a pleural-based mass in the absence of an effusion. About half of the cases had diffuse pleural thickening or large lobular pleural-based masses. Although the specificity of malignant disease features on CT is significantly lower (78 %), the sensitivity of these features is higher than previously reported (68 %).[15,16] In another study, malignancy results were 71 % with 71 % sensitivity and 68 % specificity.[17]

Dogan and colleagues discovered that the most typical CT finding is pleural thickening (90–92 %).

Its extent, thickness, and nodularity are all highly variable. In 8–38 % of cases, focal pleural masses larger than 3 cm were found. In 73–86 % of patients, interlobar fissure involvement was found as thickening and/or nodularity. Pleural effusions and plaques were seen in ~75 and 20 % of cases, respectively, as well as in other CT findings.[18]

Arnold et al.[10] found that a sensitivity of CT findings was only 32 %. The accuracy of CT features of pathologic visceral pleural invasion ranges from 62.7 to 72.3 %.[19] The difference between our results and others may be attributed to variability in pathological subtypes of MPM, patient's criteria, or CT interpretation by operators.

In MRI findings, there was 14 % of patients with mild effusion, 64 % with moderate effusion, and 22 % with massive effusion. Alongside, there was 64 % with pleural thickening, 36 % with thickening more than 1 cm, 16 % with mediastinal pleural

thickening, 10 % with circumferential thickening, 12 % with pleural nodularities, 6 % with mediastinal lymphadenopathy, 24 % with pulmonary consolidation or infiltration, 8 % with pulmonary mass or nodules, 18 % with collapsed lung, 86 % with post-contrast enhancement, 86 % with diffusion restriction, and 24 % with chest wall, vascular, or mediastinal invasion.

Numerous developments have been made to enhance the MRI's diagnostic capabilities and image quality.[20] A thorough examination of the pleural cavity is necessary to distinguish between a localized and diffuse MPM.[21] Because diffuse pleural mesothelioma can appear similar to a localized variant on imaging, it is crucial for these patients to have an MRI and intraoperative examination of the pleural cavity.[22]

For the majority of parameters, there were no statistically significant differences between the CT and MRI results ($P > 0.05$).

Matching with our results, in MPM patients undergoing thoracotomy, concentrating on mediastinum, chest wall, and local diaphragm invasion. For predicting lesion resectability, MRI demonstrated marginally higher sensitivity than CT (100 vs. 93–94 %, respectively).[14]

Likewise, another two studies found that although staging accuracy between MRI and CT was nearly equal, MRI performed better at identifying single chest wall foci, mediastinal, and diaphragmatic invasions.[23,24]

In our study, statistically significant results for MRI versus CT revealed that pleural thickening was observed in 64 % using MRI versus 44 % using CT ($P = 0.044$). Postcontrast enhancement was detected in 68 % by MRI versus 62 % in CT ($P = 0.006$). Chest wall, vascular, or mediastinum invasion was found in 24 % by MRI versus 0 % for CT ($P = 0.001$). Pleural nodularities were explored in 36 % by CT versus 12 % by MRI ($P = 0.005$).

In a study by Tsim et al.[25] the sensitivity and specificity of MRI and CT scans as well as the general diagnostic accuracy, negative predictive value, and positive predicative value were higher for MRI versus CT. However, signs of malignancy were low, varying from 30 to 60 % depending on the series, and the discovery of a normal pleural surface on a CT scan does not rule out the possibility that the effusion is malignant.[14]

MRI and CT each have advantages and disadvantages. Therefore, a combined use is crucial in deciding on the best course of treatment for MPM patients.[26]

MT is an effective and secure tool for MPE diagnosis.[27] Twenty-two case series involving MT were combined for analysis, and the results showed 92.6 % sensitivity for pleural malignancy diagnosis.[28]

Comparing thoracoscopy and CT finding, there was a highly statistically significant difference in our study as regards nodularity (90 vs. 36 %) and pleural thickening (88 vs. 44 %) for MT and CT, respectively ($P < 0.001$). This agrees with Hallifax et al.[29] who found that the sensitivity and specificity of CT were 68 and 78 %, respectively, when using the results of a thoracoscopic biopsy as the gold standard.

Comparing MRI and MT features in our study, there was a statistically significant increased nodularity detected through thoracoscopy versus MRI (90–12 %) ($P < 0.001$). Pleural thickening by MT was 88 % when compared with 64 % by MRI ($P = 0.004$).

Quite identical to our observations, Zahid et al.[30] concluded that open pleural biopsy is superior to CT and MRI for diagnosing MPM.

Ultimately, as regards the pathologic subtypes of thoracoscopic-guided biopsy in our study, there were 90 % with epithelioid mesothelioma and 10 % with sarcomatiod mesothelioma. Neither of our patients showed biphasic nor undifferentiated varieties. These results match with those of Patel et al.[7] who recorded that the majority of their MPM patients were of epithelioid histology (86 %), followed by sarcomatoid and biphasic subtypes (7 % for each).

4.1. Conclusion

Radiologists must overcome a challenge when imaging MPM. Each imaging technique has its advantages and disadvantages. CT confirms its efficacy in the presence of nodular pleural thickening, while MRI provides additional information, concerning tumor invasion. When it comes to differentiating MPM from other cancers, MRI is on par with or even better than CT. With MRI as a potential tool, pleural disease may be identified more accurately.

Conflicts of interest

All the authors have no conflicts of interest to declare.

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