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Assessment of the importance and impact of the use of Chest Magnetic Resonance in a Cancer Center

Avaliação da importância e impacto do uso da Ressonância Magnética de Tórax em um Centro de Câncer

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ABSTRACT

For several decades, technical limitations discouraged the use of magnetic resonance imaging (MRI) for the diagnosis of diseases of the chest cavity. However, recent technological advances have made it possible to overcome these challenges, and MRI is currently recognized for offering numerous advantages in chest imaging, such as high resolution, soft tissue contrast and the possibility of functional assessment of the lung and thoracic masses. In this study, the main indications for chest MRI in patients diagnosed with malignancy and its relevant role in distinguishing benign and malignant lesions and in the detection of metastases are described, aiming to identify the main indications and findings of chest MRI and its impact on clinical management of an oncology center. This is a single-center, retrospective, analytical study carried out by reviewing the medical records of all patients diagnosed with cancer undergoing chest MRI at the Department of Images of the AC Camargo Cancer Center from January 2014 to December 2016. The main indication for chest MRI was post-treatment follow-up. Chest MRI was most frequently requested by the Departments of Thoracic Surgery and Clinical Oncology. In most cases, chest MRI results led to maintenance of the current treatment plan rather than a change in management. Magnetic resonance imaging has several applications in the assessment of the chest and can be used by different specialties and subspecialties. In the present study, it was concluded that chest MRI was most frequently used for post-treatment follow-up, and the most common response to MRI findings was to continue current treatment.
Keywords: Magnetic resonance imaging; Oncology; Diagnosis.

RESUMO

Por várias décadas, as limitações técnicas desencorajaram o uso da ressonância magnética (RM) para o diagnóstico de doenças da cavidade torácica. No entanto, os avanços tecnológicos recentes tornaram possível superar esses desafios, sendo atualmente a RM reconhecida por oferecer inúmeras vantagens em imagens de tórax, como alta resolução, contraste de partes moles e a possibilidade de avaliação funcional do pulmão e massas torácicas. Neste estudo, são descritas as principais indicações da RM de tórax em pacientes com diagnóstico de malignidade e seu papel relevante na distinção de lesões benignas, malignas e na detecção de metástases, objetivando identificar as principais indicações e achados da RM de tórax e seu impacto no manejo clínico de um centro oncológico. Trata-se de um estudo unicêntrico, retrospectivo, analítico realizado através da revisão de prontuários de todos os pacientes com diagnóstico de câncer submetidos à RM de tórax no Departamento de Imagens do AC Camargo Cancer Center, de janeiro de 2014 a dezembro de 2016. A principal indicação para a RM de tórax foi o acompanhamento pós-tratamento. A RM de tórax foi solicitada com mais frequência pelos Departamentos de Cirurgia Torácica e Oncologia Clínica. Na maioria dos casos, os resultados da RM de tórax

levaram à manutenção do plano de tratamento atual, em vez de uma mudança no manejo. A ressonância magnética tem diversas aplicações na avaliação do tórax, podendo ser utilizada por diversas especialidades e subespecialidades. Concluiu-se que a ressonância magnética de tórax foi usada com mais frequência para o acompanhamento pós-tratamento, e a resposta mais comum aos achados da ressonância magnética foi continuar o tratamento atual.
Palavras-chave: Imagem por Ressonância Magnética; Oncologia; Diagnostico.

INTRODUCTION

Medical imaging has become a determining factor in the management of patients with thoracic neoplasms. It is an essential part of screening, diagnosis, staging, evaluation of treatment response, and post-treatment follow-up. Plain chest radiography (CXR) and computed tomography (CT) are the most frequently used modalities. The advantages of CXR include low cost and universal availability. CT is a more comprehensive modality, which allows detailed analysis of the pulmonary parenchyma. As the name implies, it allows imaging by cross-sections, but also multiplanar reconstructions and three-dimensional (3D) imaging of the lung. However, these modalities are not risk-free, with exposure to ionizing radiation being a particular concern. Certain subgroups of patients, such as pregnant women, children, or young adults who require repeated imaging for prolonged periods (such as patients with cancer), are exposed to increased radiation hazards.[1-2] Magnetic resonance imaging (MRI), despite being less commonly used, is an interesting alternative to conventional methods for chest imaging, especially since it is free from the risks of ionizing radiation.[3]

Chest MRI offers many advantages. It is capable of producing 3D images with high special resolution in a noninvasive manner. It provides excellent soft-tissue contrast without exposing patients to radiation. In addition, it does not employ iodinated contrast media, but gadolinium (Gd)-based paramagnetic contrast agents, which have a lower incidence of adverse reactions and complications. [4]

MRI has recently been shown to be an effective method for evaluating pulmonary nodules, lung cancer, interstitial lung disease, mediastinal lesions, lymph nodes, pleural lesions and effusions, and thoracic vascular structures; it is a particularly useful method for the diagnosis of pulmonary embolism.[5] It also allows functional evaluation of several physiological processes of the tumor microenvironment, such as cell permeability, density, and tissue viability.[6]

However, evaluation of the pulmonary parenchyma still poses a major challenge. Generally, MRI is indicated only as a supplemental modality to CXR or CT, due to its limitations for chest imaging, which include the low proton density of normal lung tissue and occurrence of magnetic susceptibility artifacts due to air and movement (breathing, heartbeats, vessel pulsations) during image acquisition.[7-8] Recent technological advances have been implemented in the last decade to overcome these difficulties, potentiating the use of MRI in clinical practice. These advances include very short echo times, ultra-fast turbo-spin-echo acquisitions, projection reconstruction techniques, breath-hold imaging, cardiac and respiratory gating, as well as development of new paramagnetic contrast agentes.[6-7]

Thus, MRI is becoming increasingly established as a valuable tool in the evaluation of chest pathology, especially cancers. It plays a relevant role in distinguishing benign from malignant lesions, better localization and staging of neoplastic lesions, biopsy planning, patient management, and relapse detection during post-treatment follow-up. The aim of the present study was to identify the main indications and findings of chest MRI and their impact on clinical management at a cancer center.

MATERIAL AND METHODS

This was a single-center, retrospective, analytical imaging and chart-review study of all patients with a diagnosis of cancer who underwent chest MRI at the Imaging Department of A.C. Camargo Cancer Center from January 2015 through December 2016.

Imaging was performed in a 1.5-Tesla scanner (Signa Excite HD; GE Healthcare, Milwaukee, WI, USA) with body coil in the axial, sagittal, and coronal planes, using 2DbSSFP (FIESTA), T2 STIR, axial 3D IN/OUT PHASE, diffusion (b 50 and 600), and T1 gradient-echo (LAVA) 3D dynamic sequences. Data were collected from three sources: a review of images archived in hospital PACS (Picture Archiving and Communication System), radiology reports available from the hospital RIS (Radiology Information System), and each patient's electronic medical record (EMR). The variables of interest were patient demographics, which hospital department had requested MRI, the indications for MRI, and the impact of MRI findings on patient management.

The patients were classified according to the requesting Department as well as to indication: 1- Staging; 2- Evaluation of response to treatment; 3- Post-treatment follow-up; and 4- Evaluation of complications related to treatment or to the underlying disease. The indications were also classified according to the type of lesion imaged: 1- Chest wall soft-tissue lesions or masses; 2- Lung nodule or mass; 3- Pulmonary consolidation; 4- Pleural effusion; 5- Pericardial effusion; Pulmonary embolism; 7- Abscesses or fluid collections; 8- Mediastinal, axillary, or supraclavicular lymphadenopathy ; 9- Bone lesion suspicious for malignancy; 10- Aortic aneurysm or enlargement; 11- Minor findings such as lipoma, atheromatosis, bronchial disease, interstitial lung disease, simple cysts, lymphocele, or degenerative bone changes.

Regarding management after chest MRI, we evaluated whether current management was maintained or changed in any way: 1- Maintenance; 2- Surgery; 3- Chemotherapy; 4- Radiation therapy; 5- Combination treatment; 6- Biopsy. Finally, patients were distributed as follows according to clinical outcome 30 days after chest MRI: 1- Status unchanged; 2- Hospital discharge; 3- Hospital admission; 7- Death.

Information was collected through an electronic questionnaire and imported into the SPSS 20.0 software environment. Descriptive analysis was conducted by calculation of absolute and relative frequencies, as well as conventional measures of central tendency (mean, median, mode) and dispersion (range, variance, standard deviation, and coefficient of variation. And When positive result, pairwise comparisons of proportions were performed to identify which variable had a statistically significant difference (<0.05). This project received approval from the institutional Research Ethics Committee (number 2124/15).

RESULTS

During the period of analysis, 328 chest MRIs were performed: 185 (56.4%) in male and 143 (43.6%) in female patients. Mean patient age was 49.7 years (standard deviation, 19.5; range, 4 to 89 years). The most common requesting departments were Thoracic Surgery (48 scans, 14.6%), Clinical Oncology (47 scans, 14.3%), Head and Neck Surgery (41 scans, 12.5%), Ophthalmology (27 scans, 8.2%), Cutaneous Tumors (18 scans, 5.5%), and Pediatrics (16 scans, 4.9%). In 92 cases (28.2%), the requesting department could not be identified (Table 1).

The main oncologic indications for chest MRI were: post-treatment follow-up (164 scans, 50.0%), staging (81 scans, 24.7%), evaluation of treatment response (44 scans, 13.4%), and evaluation of complications related to treatment or to the underlying disease (27 scans, 8.2%), as shown in Table 2.

Table 1. Distribution of chest MRI scans according to requesting department

Requesting department	***n***	**%**
Thoracic Surgery	48	14.6
Clinical Oncology	47	14.3
Head and Neck Surgery	41	12.5
Ophthalmology	27	8.2
Cutaneous Tumors	18	5.5
Pediatrics	16	4.9
Urology	13	4.0
Breast Surgery	11	3.3
Colorectal Tumors	8	2.4
Orthopedics	4	1.2
Emergency, Outpatient, and Internal Medicine	2	0.6
Other*	1	0.3
Not available	92	28.2
Total	328	100

*One each from the departments of Vascular Surgery, Pain, Endocrinology, Gynecology, Infectious Diseases, Biomolecular Medicine, Nephrology, Interventional Radiology, and field hospital.

Table 2. Oncologic indications for chest MRI

Indication	***n***	**%**
Post-treatment follow-up	164	50.0
Staging	81	24.7
Evaluation of treatment response	44	13.4
Complications*	27	8.2
Not reported	12	3.7

Total	328	100

*Complications related to underlying disease or treatment.

The most common abnormalities found on chest MRI were: bone lesions in 88 cases (26.8%); lymph node enlargement in 67 (20.4%); pleural effusion in 41 (12.5%); lung nodule or mass in 38 (11.6%); pulmonary consolidation in 36 (11.0%); soft-tissue lesions of the chest wall in 26 (7.9%); pericardial effusion in 21 (6.4%); aortic aneurysm in 12 (3.7%); pulmonary embolism in 9 (2.7%); and abscess or fluid collection in 6 (2.5%), as shown in Table 3.

Table 3. Abnormalities found on chest MRI

Abnormalities	***n***	**%**
Bone lesions	88	26.8
Lymphadenopathy	67	20.4
Pleural effusion**	41	12.5
Lung nodule or mass	38	11.6
Pulmonary consolidation	36	11.0
Soft-tissue lesions***	26	7.9
Pericardial effusion	21	6.4
Aortic aneurysm/enlargement	12	3.7
Pulmonary embolism	9	2.7
Intrathoracic abscess or fluid collection	6	2.5
No abnormality	71	21.6
Minor findings****	58	17.7
Total	328	100

*Bone lesion suspicious for malignancy, primary or metastatic;
**Mediastinal, supraclavicular, or axillary lymphadenopathy;
***Cellulitis, nodule, mass, or fluid collection in the chest wall;
****Lipoma, atheromatosis, bronchial disease, interstitial lung disease, simple cysts, lymphoceles, degenerative bone changes.

We then evaluated changes in treatment or management plan as a result of chest MRI findings. The most common behavior was maintenance of current therapy (160 patients, 48.7%), followed by chemotherapy in 57 patients (17.4%); surgery in 26 (7.9%); radiation therapy in 19 (5.8%); combined therapy in 42 (12.8%); and biopsy in 14 (4.3%) patients, as shown in Table 4.

Finally, clinical outcome 30 days after chest MRI was assessed. Most patients (182, 55.5%) had their status unchanged, followed by hospital admission in 89 cases (27.1%); hospital discharge in 36 (11.0%); and death in 7 (2.1%) cases, as shown in Table 5.

Table 4. Patient management after chest MRI findings

Management	***n***	**%**
Maintenance*	160	48.7
Chemotherapy	57	17.4
Surgery	26	7.9
Radiation therapy	19	5.8
Combination therapy	42	12.8
Biopsy	14	4.3
Not reported	10	3.1
Total	328	100

*Patient management continued as before the scan. There was no change in the clinical management plan.

Table 5. Clinical outcome 30 days after chest MRI

Indication	***n***	**%**
Maintenance*	182	55.5
Hospital admission	89	27.1
Hospital discharge	36	11.0
Death	7	2.1
Not reported	14	4.3
Total	328	100

*Patient status remained as before the scan.

DISCUSSION

Magnetic resonance imaging is becoming an established addition to the diagnostic armamentarium for diseases of the chest. For several decades, respiratory and vascular movement artifacts discouraged its use for this purpose. However, recent technical advances have

allowed clinicians to overcome these challenges, providing an image quality capable of positively impacting the diagnosis and treatment of selected patients.[9] Despite this remarkable technological progress and the numerous advantages afforded by MRI, such as high resolution and contrast for soft-tissue imaging, absence of ionizing radiation, use of paramagnetic instead of iodinated contrast, and the possibility of functional evaluation of the lung, chest MRI remains underutilized.[10]

At our facility, one of the largest cancer referral centers in Brazil, approximately 164 MRI scans of the chest were performed per year during the 2-year study period, corresponding to a mere 0.01% of all tests performed at the hospital. This was slightly less than the 218 scans per year performed at the Mayo Clinic between 2011 and 2012, which corresponded to 0.3% of all scans performed during this period.[9]

The numbers found in the present study may be at least partly explained by the fact that only patients with chest MRI requests were included. Those with requests such as brachial plexus MRI, clavicle MRI, sternum MRI, and breast MRI, in which protocols were directed to the area of interest rather than to evaluation of the chest as a whole, were excluded.

Another reason is that performance of chest MRI at A.C. Camargo Cancer Center (ACCCC) became more frequent after the year 2011, when a more modern MRI scanner was acquired, which allowed the development of specific protocols for thoracic evaluation. Thus, as a method that has not been available for long at the facility, there has been a natural learning curve in its implementation and interpretation of its findings, as well a process of gradual familiarization by the requesting physicians. This is in line with a 2013 survey of members of the Society of Thoracic Radiology, which revealed that, in this group composed mainly of specialists in cardiothoracic imaging, there is still discomfort regarding protocols, interpretation, and recommendation of non-vascular chest MRI due to a lack of training during residency and specialization, although radiologists recognize the importance of this new technique.[11]

Most scans in our series were requested by the Department of Thoracic Surgery (14.6%), followed by Clinical Oncology (14.3%) and Head and Neck Surgery (12.5%), demonstrating a certain heterogeneity among the requesting specialties. The most common clinical indication was post-treatment follow-up of patients who had already undergone surgery for a primary tumor (50.0%). Of these, 57.4% were asymptomatic and undergoing MRI only for periodic follow-up.

These findings demonstrate that the most frequent reason for requesting MRI was follow-up of patients with a previously treated malignant tumor. We believe the main reason for this is the lack of ionizing radiation, an important factor in cancer patients who need to undergo control imaging for many years.

Regarding vascular causes, chest MRI was used to evaluate PE and aortic aneurysm in 21 patients, two of whom had a history of iodine allergy. Although it is not the imaging modality of choice for evaluation of PE, MRI has nearly 100% sensitivity in the detection of emboli in the central and lobar arteries.[12-13] The most common course of action, both immediately after the scan and 30 days after MRI, was to continue current management.

In the periodic follow-up of cancer patients, when pulmonary evaluation is necessary, CT is the modality of choice, especially for evaluation of pulmonary nodules. Chest MRI, despite rather low sensitivity in the identification of small pulmonary nodules, has proven efficiency in the detection of malignant nodules, with some studies finding no statistically significant difference between CT and MRI in the detection of these nodules.[14-15] In addition, the high resolution for soft-tissue imaging provided by MRI is useful in the identification of small lesions, including metastases.

There is still no consensus as to the best and most comprehensive chest MRI protocol. To date, most centers have developed their own, according to their needs, available time, and patient population served; the protocol used at our center covers the main sequences cited in the literature.[2-3-7-10]

Limitations of this study include incomplete information in the EMR, absence of standardization of the wording used in MRI requests, requests with no description of clinical indication, and unavailability of some images in the PACS system; in the latter case, only the report was evaluated, which made it impossible to verify measurements and radiological features.

The results of the present study demonstrated the profile of the requesting specialties and main indications for chest MRI at a large cancer center. The most common use of this imaging modality was for follow-up of patients after completion of treatment. Chest MRI is a useful alternative to CT when seeking to mitigate the risks of ionizing radiation, especially in high-risk patients such as children, young adults, and women of childbearing age.

CONCLUSION

Magnetic resonance imaging has several applications in evaluation of the chest cavity, and can be used by several specialties to evaluate a variety of malignant lesions; its findings can have an impact on clinical management. In the present study, chest MRI was more frequently used for post-treatment follow-up, and the most common response to MRI findings was to continue current management.

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