T2* Cardiac Magnetic Resonance (CMR) for the evaluation of Thalassemia Major (TM) patients: prevalence of incidental extracardiac findings

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CMR has become the most useful imaging technique in the evaluation and follow-up of TM patients because it provides a non-invasive means of measuring the amount of iron deposition in the tissues. The technique relies on the measurement of $T2^*$ relaxation from gradient-echo sequences. When the storage capacity of ferritin is exceeded, iron is deposited in the myocardium as a particulate haemosiderin, which is a form of ferrihydrite. This disrupts the local magnetic field homogeneity causing reduced $T2^*$ values in inverse relation to iron concentration.

Heart failure due to iron-overload cardiomyopathy is the main cause of mortality; this form of cardiomyopathy can be reversible if detected early and appropriately treated, but once heart failure develops, prognosis is poor.

Heart iron overload is often preceded by liver iron overload, and consequently by a possible liver dysfunction; for this reason $T2^*$ sequences acquisition is also important for the liver.

The field of view of CMR sequences in these studies includes the thorax and upper abdomen, often revealing incidental extra-cardiac abnormalities. The purpose of this study is to determine the prevalence and significance of these findings.
Methods and Materials

102 Thalassemia Major patients (57 M and 45 F mean age 37,80± 12,84 yrs) underwent CMR in order to quantitatively evaluate myocardial and hepatic iron overload and to estimate cardiac functional parameters.

CMR studies were obtained with a 1.5-Tesla scanner using a cardiac and a body phased array coil and cardiac gating. Each study was composed of 12 sequences, including axial and coronal True-FISP localizer, axial and coronal Haste T2 weighted sequences, CINE GE sequences for the evaluation of cardiac chambers and for the left and right ventricular outflow tract, Heart T2* bright and black blood and Liver T2* gradient multi-echo sequences. In some cases, in addition to the standard protocol, we completed the examination using some acquisitions focused on adrenal glands and pancreas iron overload (axial and coronal True-FISP and adrenal-pancreas T2*).

All images were retrospectively reviewed by two experienced radiologists in order to assess non-cardiac findings.
Results

Among 102 participants, 12 (12.24%) had myocardial overload (4 slight, 3 mild, 5 severe) and 36 (36.72%) had liver overload (22 slight, 12 mild, 4 severe).

31.37 % (32 Patients) had extra-cardiac findings and 7%(7 Patients) showed multiple findings.

A total of 42 extra-cardiac findings were visualized and categorized according to significance in two groups: clinically significant findings (requiring further clinical or radiological work-up) (n= 18 ;42%), and not clinically significant (no needed further work-up) (n=24; 58%). (Fig 1; Fig.2).

Among not clinically significant findings most common were benign and related to the patients’ own pathologic condition, so they were defined TYPICAL FINDINGS, including: hepatomegaly, splenomegaly, splenomegaly, extramedullary erythropoiesis, splenosis, pulmonary hypertension and gynecomastia (n= 12; 28,6%). In these cases we did not recommend further investigation. They have been also encountered some not clinically significant findings, not strictly related to the patients condition and so defined ATYPICAL, including: kidney (n = 7) and hepatic cysts (n = 5).

The most common clinically significant findings were hemangiomas (n= 6), for which an ultrasound exam was only required to confirm the diagnosis, if the finding was unknown in the patient's history, or to compare the size of the lesion when already previously reported.

Similarly for gallstones (n =2) a deeper ultrasound exam was recommended.

Micro-kidney (n=1) and adrenal adenoma (n=1) were detected for the first time during the CMR. These patients were referred to a CT or MRI imaging to study the abdomen.

Some of these findings have not only led to a new diagnosis, but also determined a modification in the management. Pulmonary consolidation (n=1) made it necessary to complete the diagnosis workup with a CT examination and consequently a medical treatment. Two cases of ascending aorta aneurysm have been detected during CMR and further studied using CT Angiography.

Chest CT scan was required in two cases of detected pulmonary nodules by CMR and in one case Patient underwent to lesion biopsy with the consequent diagnosis of pulmonary malignancy.

True-FISP axial and coronal localizer, axial and coronal HASTE T2 weighted sequences were the most sensitive ones in the detection of ancillary findings. In particular True-FISP axial and HASTE axial were more sensitive in chest findings detection and axial and coronal True-FISP for upper abdominal findings.
EXTRACARDIAC FINDINGS

- Clinically significant findings
- Not clinically significant findings

58% 42%

Fig. 1:

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Fig. 3: Hepatomegaly

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**Fig. 4:** Splenoma

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Fig. 5: Splenomegaly

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**Fig. 6:** Paravertebral extramedullary erythropoiesis

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Fig. 7: Ribs localization of extramedullary erythropoiesis

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Fig. 8: Ribs localization of extramedullary erythropoiesis_Haste Coronal acquisition

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Fig. 9: Pulmonary hypertension, dilatation of pulmonary trunk

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Fig. 10: Gynecomastia

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**Fig. 11:** Pulmonary consolidation

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Fig. 12: Pulmonary nodule_ Haste axial acquisition

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**Fig. 13:** Pulmonary nodule TC acquisition

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Fig. 14: Micro kidney

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**Fig. 15:** Adrenal adenoma

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Fig. 16: Liver hemangioma

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**Fig. 17: Kidney cyst**

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Fig. 18: Kidney cyst

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Fig. 19: Liver cyst

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**Fig. 20:** Liver cyst

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Fig. 21: Ascending aorta aneurysm_Haste coronal acquisition

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Fig. 22: Ascending aorta aneurysm_Haste axial acquisition

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**Fig. 23:** Gallstones

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Conclusion

The field of view of the sequences used includes the upper part of the abdomen, and commonly leads to incidental non-cardiac findings in the course of T2* CMR. It is mandatory for the radiologist to look beyond the heart and carefully assess the entire field of view looking for abnormalities, and to report them. Because of the young age of this setting of patients, the knowledge of the most frequent TYPICAL findings related to the patient's own pathology is essential in order to avoid unnecessary follow-up examinations.

On the other hand, these sequences may show previously unknown and unreported pathologies, thus allowing specific medical treatment and prognosis improvement.
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