Left ventricle accessory antero-septal papillary muscle: an echocardiography and cardiac MRI case-series report

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Background: We studied by means of echocardiography and cardiac MRI (CMR) the occurrence of an accessory papillary muscle that unites mostly the left ventricle (LV) apex with the basal antero-septum in the immediate vicinity of left ventricle outflow tract (LVOT) in patients with and without hypertrophic cardiomyopathy (HOCM).

Methods: We included all good quality echocardiography and CMR studies as reviewed by two cardiologists and assessed the occurrence of a contractile papillary muscle situated between the LV apex and antero-septum.

Results: A contractile accessory papillary muscle situated between the LV apex and the antero-septum was seen in 100% of HOCM patients and 62% of control patients (p=0.05) in the CMR images acquired from a total of 9 HOCM and 13 control patients. The same structure was observed in 241 patients representing 69.5% of all-comers echocardiography studies. The age was 69 ± 17 years on average in the echocardiography arm, patients harboring the antero-septal accessory muscle being older (71.6 + 15.7 years old vs 63.5 ± 18.1 for those without, p=0.0005). We exemplify this structure by parasternal long axis still echocardiography images and clips from 24 patients and CMR SSFP still images and a clip from two HOCM patients and one control.

Conclusion: A contractile accessory papillary muscle was observed in more than half of the all-comer echocardiography studies, and in all HOCM patients in the CMR arm. Further research is needed to fully characterize the anatomical and physiological significance as well as the possible structural interventional consequences of this structure attaching in the immediate vicinity of the LVOT in HOCM and control patients.

Key words: antero-septum, accessory papillary muscle, left ventricle, cardiac MRI, echocardigraphy.

INTRODUCTION

Anteriorly displaced papillary muscles are known to be present in hypertrophic cardiomyopathy (HOCM) and more recently anomalous myocardial bundles inserting into the antero-septum have been documented as well in HOCM by our group [1–4]. We studied the occurrence of an accessory papillary muscle bundle that unites the left ventricle (LV) apex with the basal or mid antero-septum. Two groups of patients were analyzed by two cardiologists: an echocardiography as well as a cardiac MRI (CMR) arm.

Myocardial structures attaching to the antero-septum in the vicinity of the LV outflow tract (LVOT) can pose a possible risk of LVOT obstruction during systole when any myocardial bundle that will thicken can cause a reduction in the diameter of LVOT. Along this line, one can imagine a possible structural intervention that could eliminate such a relatively bulky structure from the vicinity of the LVOT and in this way relieving completely or partially the LVOT obstruction.

MATERIAL AND METHODS

Patients were included if they were 18 or older. Echocardiography images were analyzed in the parasternal long and short axis. All-comers from an interval time of 21 months were included in the echocardiography arm and poor image resolution studies were excluded. Since this was an all-comer group, we did not focus on the presence of HOCM in these studies.

In the CMR arm, a HOCM as well as an age- and gender-controlled control group were selected. CMR patients and controls were scanned using a Siemens Espree machine. Images were acquired using SSFP 2, 3, and 4 chamber as well as short axis views.

A CMR diagnosis of HOCM was made if left ventricular hypertrophy accompanied by systolic anterior motion (SAM) of the mitral valve apparatus with obstruction of the left ventricle outflow tract flow were noted on SSFP images. Since the gold-standard diagnosis of HOCM is CMR-based and CMR is superior
to echocardiography in this regard, we did not list and analyzed the echocardiography results in the CMR cohort [5]. An IRB exemption was granted.

**Results. Echocardiography arm.** In this arm of the study, we identified and described the presence or absence of the antero-septal papillary muscle in all newcomers to the echocardiography laboratory, without driving a comparison between an eventual active HOCM group and a control group. 371 echocardiography studies were reviewed. 24 were excluded due to poor echocardiographic definition of the LV antero-septal region, leaving 347 patients to be analyzed. The accessory antero-septal papillary muscle was seen in 241 patients representing 69.5% of all good quality studies. The age was 69 ± 17 years on average, the age was 69 ± 17 years on average, patients harboring the antero-septal accessory muscle being older (71.6 ± 15.7 years for patients with this structure vs 63.5 ± 18.1 years for those without, p=0.0005). 47% of patients included were women. The occurrence of the antero-septal accessory muscle was similar in men and women (70% vs 69%).

We further describe various features of the accessory papillary muscle particular to four separate patients (Clips 1–4, Figs. 1–3) in the echocardiography and 2 HOCM patients and one control in the CMR arm (supplemental file Clip 5, Fig. 4), and also list for abundant proof figures and clips of an additional 20 patients (Clips 6–25, Figs. 5–25) in the echocardiography arm as a supplementary electronic material.

**Fig. 1a and 1b** (diastolic frames) and Clips 1 and 2 show the structure in an 87-year-old patient admitted for severe anemia and fatigue. The thickness is approximately 8 mm in these views and it has the same echogenic appearance as the rest of the myocardium. At the LV base the myocardial structure can be seen in the short axis view straddling between the antero-lateral wall and the antero-septum forming a short roof beneath the antero-septal basal wall (Figs. 1 and 2) continuing thereafter with the roof of the LVOT.

The papillary accessory muscle (5 mm thick) is seen in diastole using an echo contrast method (Figs. 2a and 2b and as well as Clips 3 and 4) in a 63-year-old admitted for a non-occlusive pulmonary embolism.

Figs. 3a and 3b and Clips 3 and 4 identify two parallel accessory pap antero-septal muscle strands (systolic frames, 5 mm thick) in a 54-year-old admitted for atrial fibrillation. One bundle inserts into the mid antero-septum (yellow arrow) while the second into the basal septum (red arrow). They are both parallel with the antero-lateral and postero-medial papillary muscles (pink and yellow dots respectively) creating together, along with the mitral anterior leaflet, a tunnel leading into the LVOT.

In these first three patients one can notice the bulky basal antero-septum (15 mm at level of mitral valve leaflets in diastole, Fig. 1a) with a very convex shape – “sigmoid septum”, onto which the accessory papillary structure inserts itself.

The thickness of the antero-septum at the level of the mitral valve leaflets was 15, 14, and 10 mm respectively in these three patients.
CMR arm. After detecting and describing the novel structure with echocardiography, we used CMR to drive a comparison in terms of presence/absence of an antero-septal accessory papillary muscle between an active HOCM group and a control group without HOCM. 100% of 9 HOCM patients and 62% (8 of 13, P=0.05) of controls demonstrated an accessory papillary muscle connecting the left ventricle basal antero-septum with the apex, noticeable on the long axis view. This particular structure contracts during systole as seen in Fig. 4 (red arrow) in panels “b” and “e” (midsystole) and “c” and “f” (end-systole) in two HOCM patients (panels a-c and d-f respectively). A severe and a moderate SAM of the mitral apparatus are seen in panels a-c and d-f respectively in these two HOCM patients. Supplemental file Clip 5 demonstrates a third patient with HOCM and severe LV hypertrophy with SAM of the mitral valve along with moderate mitral regurgitation. One can distinctly notice a thin contractile myocardial strand uniting the basal anteroseptum with the LV apex.

The papillary muscle was not present in panels g-i of one control subject. There was no LVOT obstruction at end systole in this patient and no accessory antero-septal papillary muscle – as depicted in panel “i”.

An additional 21 patients’ parasternal echocardiography long axis clips (clips 5–25 in the supplementary electronic material) are presented along with their corresponding still frames (Figs. 5–25 in the supplementary material), all demonstrating an accessory papillary muscle with features similar with those illustrated above. In one patient the accessory papillary muscle stretches from the basal antero-septum to the mid infero-lateral wall instead of the apex (Fig. 7).

Fig. 2 and Supplemental Clips 3 and 4. Longitudinal (2a) and short axis (2b) contrast echo images in a 63 year old illustrating the accessory papillary muscle in diastole with a contrast enhanced empty space seen between the anteroseptum and the papillary muscle.

Fig. 3. Systolic view of long (3a) and short axis (3b) representing two accessory papillary muscle inserting into the mid and basal anteroseptum. The muscle fascicles are parallel with the postero-medial (yellow) and antero-lateral (pink) papillary muscles creating along with the anterior mitral leaflet a tunnel leading into the LVOT.
Fig. 4. CMR 3-chamber view images of a two HOCM patients and one control. Panels a-f HOCM patients and g-i controls; panels a, d and g – diastole; b,e and h – mid-systole; c, f and i – end-systole.

**Supplemental Clip 5.** Steady state free precession CMR clip of a 65-year-old patient with hypertrophic obstructive cardiomyopathy. One can notice the SAM of mitral valve as well as the antero-septal hypertrophy with a thin contractile antero-septal accessory muscle uniting the apex with the basal antero-septum.

Fig. 5. 1 mm thick accessory muscle fiber inserting into the mid anteroseptum (PLAX and SAX).
Fig. 6 and Supplemental Clip 6. 63-year-old with HTN and COPD admitted for small bowel obstruction and surgery (PLAX).

Fig. 7 and Supplemental Clip 7. 74-year-old with HTN and hydrocephalus admitted for shunt placement. In this particular patient the pap muscle inserts at the base antero-septum and then in the mid infero-lateral wall (PLAX).
Fig. 8 and Supplemental Clip 8. Echo-contrast image in a 77-year-old with HTN, CAD, CABG, CHF admitted for complete AV block (PLAX).

Fig. 9 and Supplemental Clip 9. 89-year-old seen in the office for dizziness and a cardiac murmur (PLAX).
Fig. 10 and Supplemental Clip 10. 48-year-old with HTN, status post aortic dissection, aortic root repair and AVR (PLAX).

Fig. 11 and Supplemental Clip 11. 74-year-old with HTN, CAD, diabetes, admitted for CP (PLAX).
Fig. 12 and Supplemental Clip 12. A 72-year-old with hyperlipidemia and no significant cardiac history (PLAX).

Fig. 13 and Supplemental Clip 13. Echo contrast image in a 58-year-old with HTN admitted for CP (PLAX).
Fig. 14 and Supplemental Clip 14. 76-year-old with HTN, diabetes and CAD seen in office for sleep apnea (PLAX).

Fig. 15 and Supplemental Clip 15. 72-year-old with HTN, diabetes, obesity admitted for dyspnea on exertion (PLAX).
Fig. 16 and Supplemental Clip 16: 71-year-old with HTN admitted for dyspnea and hypertensive urgency (PLAX).

Fig. 17 and Supplemental Clip 17: 72-year-old with paroxysmal A Fib, tri-fascicular atrioventricular block admitted for syncope (PLAX).
Fig. 18 and Supplemental Clip 18. Echo-contrast image in a 70-year old with HTN, hyperlipidemia and CAD admitted for CP (PLAX).

Fig. 19 and Supplemental Clip 19. 43 year-old with HTN, diabetes admitted for numbness of left side of his body (PLAX).
Fig. 20 and Supplemental Clip 20. 80-year-old with HTN, hyperlipidemia admitted for dyspnea (PLAX).

Fig. 21 and Supplemental Clip 21. 61-year-old with HTN, admitted for bleeding (PLAX).
Fig. 22 and Supplemental Clip 22] 91-year-old with HTN admitted for small bowel obstruction (PLAX).

Fig. 23 and Supplemental Clip 23] 76-year-old admitted for hernia repair (PLAX).
Fig. 24 and Supplemental Clip 24 82-year-old seen in the office for aortic valve stenosis (PLAX).

Fig. 25 and Supplemental Clip 25 78-year-old with HTN, status post aortic root replacement and AVR (PLAX).
DISCUSSION

We present in this report 241 echocardiography studies where a contractile papillary myocardial structure (thickness from 8 to 1 mm) is seen stretching between the LV apex and the basal or mid antero-septum. The structure runs parallel with the antero-lateral and posteromedial papillary muscles and the three papillary muscular bundles along with the mitral anterior leaflet form a tunnel leading into the LVOT. One can imagine a possible LVOT obstructive phenomenon between the four structures in systole. Supplemental electronic file Clip 5 is a steady SSFP CMR clip demonstrating this phenomenon in a 65 year-old. Several reports have described “false tendons” in the LV with no significant physiological consequence [6]. We document in the current report a myocardial contractile structure situated in the LVOT, possibly participating to the LVOT systolic obstruction in HOCM patients.

The antero-septal accessory papillary muscle was present both in HOCM and more commonly in non-HOCM patients – as seen in the CMR arm and it was more common in older patients as noticed in the echocardiography arm. This could be related to the fact that LV hypertrophy is more common with advanced age [1]. Two of the four echocardiography cases illustrated had moderate LV hypertrophy and three presented a prominent “sigmoid septum” at the level of the accessory muscle insertion [7]. While false LV cords with no apparent contraction and an anteriorly displaced papillary muscle inserting onto the base of the anterior mitral leaflet [1,8] or elongated anterior mitral valve leaflet have been previously described, no reports have looked at a contractile papillary muscle inserting into the antero-septal area [9]. At the same time, no reports to date have described a series of patients with an antero-septal papillary muscle present both in patients with and without HOCM – as seen by CMR, more often though detectable in HOCM patients.

As a likely therapeutic consequence of this report [10], one can imagine a possible structural cardiology procedure where a skilled structural interventionist can advance into the LVOT and be able to approach the anomalous papillary muscle we describe here, secure it, advance a sheath on top of the muscle, cut the two areas of insertion in the basal antero-septum and apex and then retrieve the myocardial structure through the sheath, relieving in this way the LVOT obstruction in HOCM patients.

Limitations. We analyzed in this report all contractile myocardial bundles inserting into the antero-septum, including those with a low thickness such as 1 mm. Also, a certain selection bias in a first study describing a new structure cannot be excluded. Larger additional studies are needed to exactly determine the occurrence and definition of the antero-septal accessory papillary muscle. We demonstrated in the echocardiography group that patients that harbor the newly described structure are older. For the remaining clinical characteristics (such as reason for admission) we have presented clinical data only selectively in this report, in those cases from which illustrations were chosen to be included in the manuscript. Further studies are needed to fully describe the clinical and therapeutic implications of the antero-septal papillary muscle.

CONCLUSION

We describe in this report an accessory papillary muscle uniting mostly the LV apex with the basal anteroseptum in the LVOT vicinity. Further research is needed to fully characterize the anatomical and physiological significance and the possible structural interventional consequences of this structure attaching in the immediate vicinity of the LVOT in HOCM and control patients.
de la 24 pacienți în grupul de ecocardiografie și prin imagini statice RMNc și un clip RMNc SSFP de la doi pacienți CMHO și un control.

**Concluzii:** Un mușchi papilar accesoriu contractil a fost observat în mai mult de jumătate din studiile ecocardiografiei analizate în acest report și la toți pacienții CMHO din grupul RMNc. Este posibil ca mai multe studii vor fi necesare pentru a caracteriza deplin semnificația anatomică și fiziologică a acestei structuri, precum și posibilele consecințe intervenționale direcționate spre diminuarea obstrucției în tractul de ejeție a VS în pacienți cu CMHO folosind această stuctură.

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**REFERENCES**


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