ISSN: 2690-4004

Journal of Clinical Images

Open Access | Case Report

Feasibility of Virtual 3D Cardiac CT Angioscopy to Help Discriminate Left Ventricular Non-Compaction from Hypertrabeculations. A Preliminary Case Control Report

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Received: Jul 24, 2023
Accepted: Aug 09, 2023
Published Online: Aug 16, 2023
Journal: Journal of Clinical Images
Publisher: MedDocs Publishers LLC
Online edition: http://meddocsonline.org/

Keywords: Noncompaction; Cardiac CT; Anatomy; Cardiomyopathy; Trabeculations.

Introduction

Left Ventricular Non-Compaction (LVNC) is a congenital cardiomyopathy characterized by an alteration of myocardium structure secondary to incomplete embryogenesis. Usually the Left Ventricle (LV) is dilated and hypokinetic with a spongy appearance of the myocardium, consisting in protruding trabeculae separated by crypts, located at the apex and lateral wall [1]. Recent publications consider excess of trabeculations as a phenotype more than a disease [2]. Indeed, the phenotype "excess of trabeculation" could be found in hypertrophic or dilated form of cardiomyopathy, and several morphologic cardiac imaging criteria [3] of trabeculated, Non-compact (NC) and compacted myocardium (C) such as a NC/C ratio of >2.3 at cardiac magnetic resonance imaging (Petersen criterion), the trabeculated LV mass (Jacquier criterion), the trabeculated LV volume (Choi criterion), and the trabeculated LV mass and distribution (Grothoff criterion) have been proposed to isolate LVNC among these phenotypes. Hence, in vivo recognition of LVNC is somewhat difficult, even with the use of ultrasound and Cardiac Magnetic Resonance Imaging (CMR) parameters, and correct diagnosis is often missed because insufficient knowledge of this uncommon disease. Clinical consequences of misrecognition may be desastrous, leading to cardiac failure and dilated cardiomyopathy.

Cite this article: Laissy JP, Hasina A, Haioun K, Wlachovska B, BenDriss A. Feasibility of Virtual 3D Cardiac CT Angioscopy to Help Discriminate Left Ventricular Non-Compaction from Hypertrabeculations. A Preliminary Case Control Report. J Clin Images. 2023; 6(2): 1147.

The potential of cardiac Computed Tomography (CT) has seldom been tested in the diagnosis of LVNC [4-5], in particular using a 3D virtual gross pattern approach [6-7]. Therefore, the purpose of this study was to determine the feasibility of cardiac CT angiography associated to virtual 3D reality to validate the diagnosis of LVNC.

Material and Methods

In 19 patients with Jenni's criteria of LVNC: A NC/C ratio> 2 at end-systole, a thin epicardial layer and a thick endocardial non-compacted layer with prominent trabeculations and deep intertrabecular recesses deeply perfused at color Doppler, and normal LV volumes at echocardiography [3-4], contrast-enhanced ECG-gated Cardiac CT Angiography (CTA) was performed at the arterial phase of iodine injection (Xenetix 350, Guerbet, France) on a 64 or higher detector CT system. Anonymized images were reconstructed on a Vitrea workstation (Vital Images, Minnetonka, USA) and compared to anonymized cardiac CT images of 19 matched controls, selected on the basis of a normal examination after ruling out coronary artery disease by cardiac CTA. No control displayed dilated or hypertrophic cardiomyopathy. Five controls had moderately hypertrophic LV trabeculations with a NC/C ratio< 2 at cardiac ultrasonography.

All images were reviewed in a standard cineloop axial, bidimensional (2D) Multiplanar (MPR) and Three-Dimensional (3D) Volume Rendering (VRT) mode. This last mode was used in a navigator mode to better assess papillar muscle abnormalities, as it provides images looking like open surgery.

Trabeculations thickness was measured perpendicular to the compact myocardium on MPR views and their orientation was assessed both on short-axis MPR and VRT angioscopic views. The inner dimensions of the LV were calculated (telediastolic base-apex distance, and transverse diameter 1cm close to the mitral valve) and resulted in the definition of an eccentricity index [8]. Papillary muscle morphology was assessed semi quantitatively as normal, dysmorphic or absent, both on 2D MPR and 3D angioscopic images.

Statistical analysis was performed to exhibit significant differences between patients and controls. The quantitative values were presented as means ± standard deviations.

The differences in the quantitative results were assessed using Wilcoxon signed-rank test. Mc Nemar's $\chi 2$ test was used to compare qualitative variables. A p value < 0.05 was considered statistically significant.

This study was designed as a retrospective analysis of patients treated at a single institution. Informed consent was waived with the approval of the institutional review board.

Results

Main LVNC patterns (Table) were an abnormal LV geometry (Figure 1a) with ballooning and papillar muscles dysmorphism (n=9) or absence (complete, n=6; partial, n=4), and presence of trabeculations parallel to the endocardium or anarchic (n=19), most of them being thinner than 2 mm (n=15). In controls (Figure 1b), trabeculations when present were perpendicular to the endocardium in a radial distribution and were thicker than 3 mm. Differences in eccentricity indexes and papillar muscle features (Figure 2) between LVNC and controls were significant (Table), including controls with hypertrabeculations (p < 0.001 for all).

Virtual 3D angioscopy helped exhibit papillary muscle dysmorphism and fiber disorganization that were hardly analyzable on MPR reformations in 8 LVNC subjects and 3 controls.

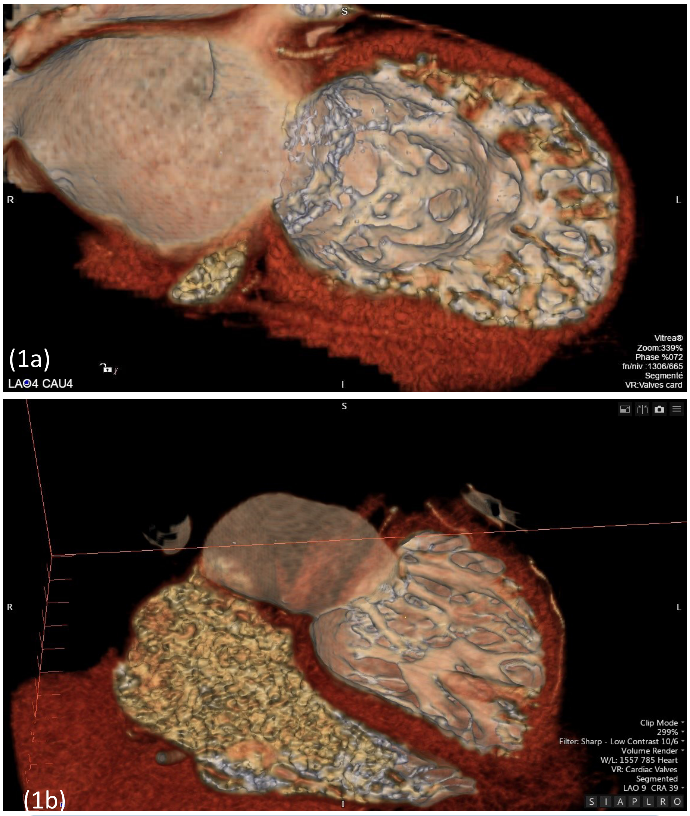

Figure 1: Virtual 3D surgery in long axis CT view. Dense non-compact fibrillar meshwork without any papillary muscles identified in LVNC **(a)**, and normal papillar muscle architecture in a control **(b)**.

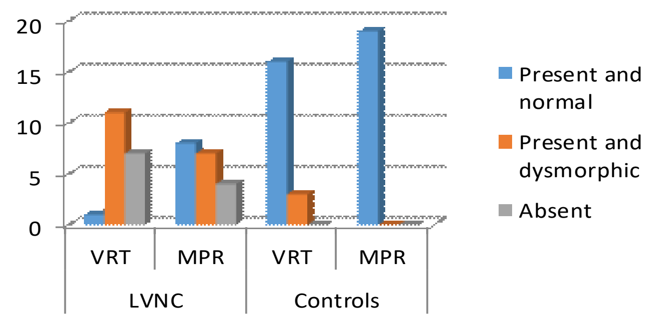

Figure 2: Histogram comparing papillary muscle assessment between LVNC subjects and controls, according to the CT reconstruction mode.
VRT=3D angioscopic volume rendering technique; MPR=2D multiplanar reformations.

Table 1: Distinctive features between LVNC and controls.

	LVNC n=19	Controls n=19	Significance
LV eccentricity index	0.66 ± 0.06	0.54 ± 0.08	p<0.0001
Papillary muscles characterization			
- Present and normal	1 (5%)	16 (84%)	p<0.0001
- Present and dysmorphic	11 (58%)	3 (16%)	
- Absent	7 (37%)	0	
Trabeculations			
- Perpendicular		14 (74%)	p<0.0001
- Disorganized	13 (68%)		
- Both	6 (32%)	5 (26%)	

Discussion

LVNC is characterized by prominent endocardial hypertrabeculations and deep recesses within the left ventricle. At autopsy, the absence of well-formed papillary muscles is a clue to the diagnosis, even when intertrabecular recesses are microscopic [1-5].

Echocardiography and CMR are currently used to confirm this specific morphological feature, both techniques displaying a ratio NC/C ≥2 [9]. Indeed on 2D imaging, it is often difficult to differentiate the papillary muscles and trabeculations from false tendons and aberrant bands [10]. The present results show that 3D VRT achieved virtual 3D images of cardiac chambers that allowed an overall characterization of papillary muscles and trabeculations. In particular, the absence of normal papillary muscles was quite pathognomonic of LVNC patients. Cardiac CT with 3D virtual angioscopy can further provide a gross anatomy equivalent to autopsy, which is a specific advantage over other techniques. CT could be a useful adjunct to these other methods at the price of limited radiation exposure according to recent CT systems. Along with the measurement of the eccentricity index, it could improve the diagnostic accuracy; a recent report [8] indicated geometric alterations such as LV eccentricity as a robust auxiliary landmark in LVNC.

Conclusion

CT VRT can help display the outer shape of papillary muscles and trabeculations. Improvements in spatial resolution are mandatory to achieve proper cardiac fibers evaluation.

References

1. Burke A, Mont E, Kutys R, Virmani R. Left ventricular noncompaction: A pathological study of 14 cases. Hum Pathol. 2005; 36: 403-11.

2. Anderson RH, Jensen B, Mohun TJ, Petersen SE, Aung N, et al. Key Questions Relating to Left Ventricular Noncompaction Cardiomyopathy: Is the Emperor Still Wearing Any Clothes? Can J Cardiol. 2017; 33: 747-757.

3. Masso AH, Uribe C, Willerson JT, Cheong BY, Davis BR. Left Ventricular Noncompaction Detected by Cardiac Magnetic Resonance Screening: A Reexamination of Diagnostic Criteria. Tex Heart Inst J. 2020; 47: 183-193.

4. Sidhu MS, Uthamalingam S, Ahmed W, Engel LC, Vorasettakarnkij Y, et al. Defining left ventricular noncompaction using cardiac computed tomography. J Thorac Imaging. 2014; 29: 60-6.

5. Melendez-Ramirez G, Castillo-Castellon F, Espinola-Zavaleta N, Meave A, Kimura-Hayama ET. Left ventricular noncompaction: A proposal of new diagnostic criteria by multidetector computed tomography. J Cardiovasc Comput Tomogr. 2012; 6: 346-54.

6. Tandon A, Burkhardt BEU, Batsis M, Zellers TM, Velasco Forte MN, et al. Sinus Venosus Defects: Anatomic Variants and Transcatheter Closure Feasibility Using Virtual Reality Planning. JACC: Cardiovasc Imaging. 2019; 12: 921-924.

7. Yao LP, Zhang L, Mei J, Ding FB, Li HM, et al. A pilot study of a cardiovascular virtual endoscopy system based on multi-detector computed tomography in diagnosing tetralogy of Fallot in pediatric patients. Exp Ther Med. 2018; 15: 1552-1559.

8. Boban M, Pesa V, Gabric ID, Manola S, Persic V, et al. Auxiliary diagnostic potential of ventricle geometry and late gadolinium enhancement in left ventricular non-compaction; non-randomized case control study. BMC Cardiovasc Disord. 2017; 17: 286.

9. Zuccarino F, Vollmer I, Sanchez G, Navallas M, Pugliese F, et al. Left ventricular noncompaction: imaging findings and diagnostic criteria. AJR Am J Roentgenol. 2015; 204: W519-30.

10. Stöllberger C, Finsterer J. Pitfalls in the diagnosis of left ventricular hypertrabeculation/non-compaction. Postgrad Med J. 2006; 82: 679-83.