www.cardiol.br

www.dicsbc.org

ABC Imagem Cardiovascular

Sociedade Brasileira de Cardiologia • ISSN 2318-8219 • Volume 32, N° 2, Abril/Maio/Junho 2019

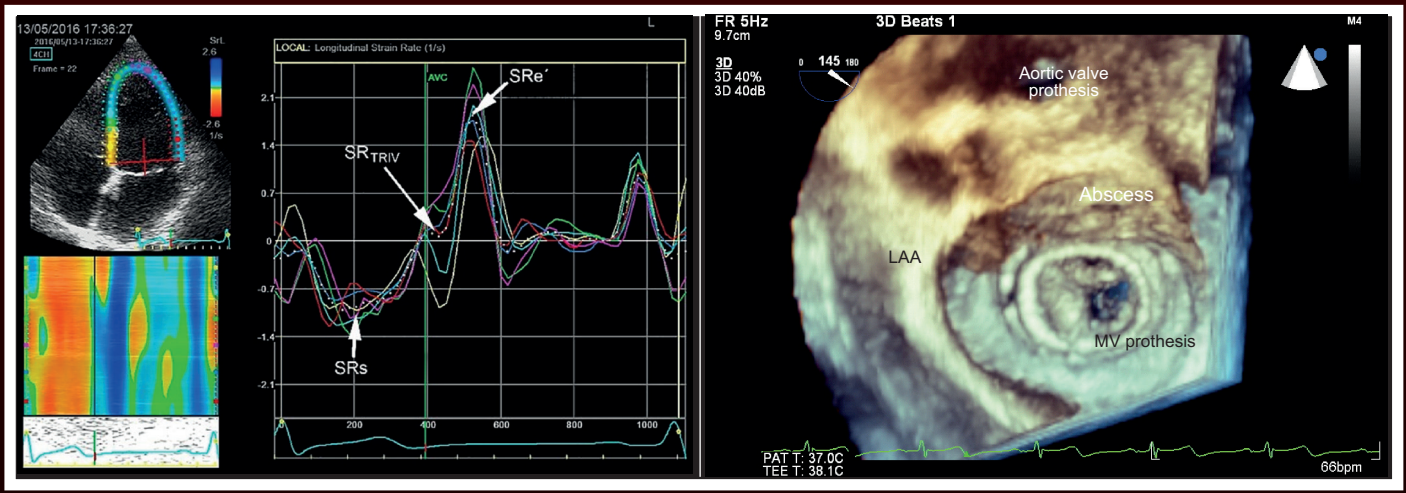


Figura 2 – Determination of strain rate from the 4-apical chamber position. The image reveals the following components: systolic strain rate (SRs), strain rate during isovolumetric relaxation time (SRIVRT), early diastolic strain rate (SRe'). AVC: aortic valve closure. Pág. 112; *Figura 4 – Three-dimensional echocardiogram images showing aortic periprosthesis neocavity extending to the mitroaortic junction. Pág. 136*

www.cardiol.br
www.dicsbc.org

ABC Imagem Cardiovascular

Departamento de Imagem Cardiovascular

Diretoria SBC

Conselho Editorial Nacional

Conselho Editorial Internacional

Arquivos Brasileiros de Cardiologia - Imagem Cardiovascular

Volume 32, Nº 2, Abril/Maio/Junho 2019

Indexação: LILACS - Literatura Latino-Americana e do Caribe em Ciências da Saúde - www.bireme.br, LATINDEX - Sistema Regional de Información en Línea para Revistas Científicas de América Latina, El Caribe, España y Portugal - www.latindex.unam.mx

SBC/Departamento de Imagem Cardiovascular
Rua Barata Ribeiro nº 380 cj.54
01308-000 - São Paulo - SP - Brasil
Fone/Fax: +55 (11) 3259-2988
Fones: +55 (11) 3120-3363
+55 (11) 3259-2988 / +55 (11) 2589-4168

Coordenação Editorial
Atha Comunicação e Editora
Rua Machado Bittencourt, 190 - conj. 410
São Paulo, SP, Brasil
Tel.: (11) 50879502

Secretaria Editorial
revista@dicsbc.com

Os Arquivos Brasileiros de Cardiologia - Imagem Cardiovascular é o órgão oficial do Departamento de Imagem Cardiovascular da Sociedade Brasileira de Cardiologia.

www.cardiol.br
www.dicsbc.org
ABC Imagem Cardiovascular

Sumário - *Contents*

www.cardiol.br
www.dicsbc.org
ABC Imagem Cardiovascular

Imagens - Images

Editorial

Study of Carotid Atheromatous Plaque using Magnetic Resonance Imaging

Germana Titoneli dos Santos[1,2,3]

1. Universidade de São Paulo, SP - Brazil

2. Hospital Alemão Oswaldo Cruz, São Paulo, SP - Brazil

3. Laboratório Fleury, São Paulo, SP - Brazil

By examining the cervical arteries, we sought to identify high-risk atheromatous plaques that could cause future stroke. Currently, risk stratification of carotid atheromatous plaques is basically centered on the degree of stenosis that it causes in the carotid bifurcation and in the internal carotid artery, being measured by angiography and Doppler.

Despite the importance that this traditional model attributes to the vessel lumen size, hypoflow is not a frequent cause of stroke. About 90% of infarction caused by carotid atheromatosis are due to plaque rupture and consequent distal embolization.

Carotid atheromatous plaque is considered unstable when it has a hemorrhagic component (Figure 1, for exemple), greasy core >40% and thin or broken capsule. Carotid atheromatous plaques were first studied in vivo by magnetic resonance imaging in 1996 by Toussaint et al. Since then, several studies have been conducted and it is now well established that magnetic resonance imaging is the most accurate method to identify the constituents of plaque instability and the presence of these elements significantly increases the risk of stroke.

Despite the usefulness of magnetic resonance imaging, it takes time to be incorporated into clinical practice, as it demands specific high-cost equipment and a long scanning time. About two years ago, the black-blood 3D sequences (T1 FSE with variable flip angle) became available. These sequences significantly increased the spatial definition of vessel wall images and allowed us to identify the characteristics of atheromatous plaques using conventional equipment (neurovascular coil). This change made the test accessible and enabled it to be incorporated into the clinical routine.

The tests of choice for carotid assessment are still Doppler ultrasound, computed tomography angiography and magnetic resonance angiography. When these methods reveal atheromatous plaques causing stenosis above 50%, magnetic resonance imaging of the plaques is recommended.

Keywords

Atherosclerotic; Nuclear Magnetic Resonance; Carotid Stenosis.

Mailing Address: Germana Titoneli dos Santos •

E-mail: germanatitoneli@gmail.com

DOI: 10.5935/2318-8219.20190018

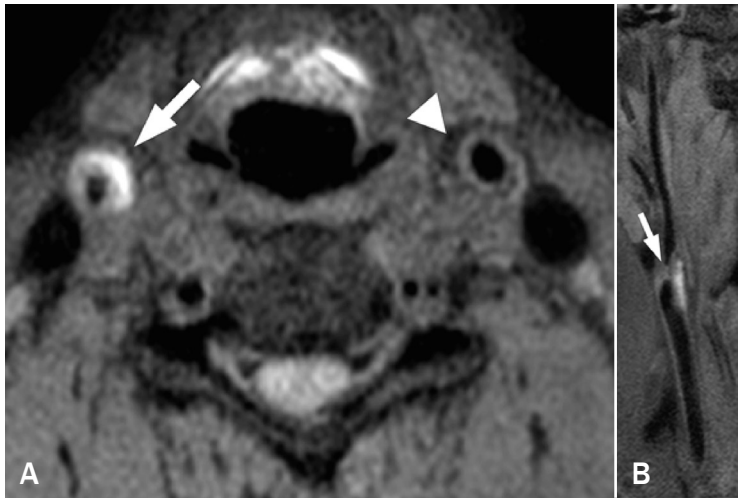


Figure 1 – *Magnetic resonance imaging, T1 3D black-blood sequence. The plaque to the right on the axial plane (A) presents hypersignal in T1 compatible with hemorrhage, while the left side plaque presents hyposignal, compatible with protein/collagen component. Image on the sagittal plane of the right-side plaque (B) demonstrates the extent of plaque hemorrhage.*

The characterization of instability components in magnetic resonance imaging suggests that the plaque is of high risk and favors the choice of surgical and endovascular procedures or even close clinical follow-up.

Even when Doppler ultrasound, computed tomography angiography or magnetic resonance angiography do not find stenoses above 50%, the carotid plaque may be the cause of a stroke or transient ischemic attack of undetermined origin. When the plaque grows out of the vessel lumen (positive remodeling), the luminal repercussion is small and does not cause any relevant stenosis that can be assessed by angiographic methods. In these cases, magnetic resonance imaging can identify the plaque, as it sees the tissue around the vessel and not just the lumen. If the plaque is hemorrhagic or lipid-derived, stroke or transient ischemic attack are no longer cryptogenic, and the etiology turns out to be the carotid artery.

At present, it is possible to use magnetic resonance imaging to distinguish hemorrhagic and lipid (unstable) plaques from fibrous plaques (stable), and to know whether the plaque actually represents high risk for a future stroke or even the cause of stroke hitherto considered cryptogenic.

References

1. DeMarco JK, Spence DJ. Plaque assessment in the management of patients with asymptom- atic carotid stenosis. Neuroimag Clin N Am. 2016;26:111-27.
2. DeMarco JK, Shih R, Lanzino G, Rabinstein AA, et al. Diagnostic Accuracy of a Clinical Carotid Plaque MR Protocol Using a Neurovascular Coil Compared to a Surface Coil Protocol. J Magn Reson Imaging. 2018 Nov;48(5):1264-1272.
3. Gupta A, Baradaran H, Schweitzer AD, Kamel H, Pandya A, Delgado D, et al. Carotid plaque MRI and stroke risk a systematic review and meta-analysis. Stroke. 2013;44:3071-7.
4. Saam T, Ferguson MS, Yarnykh VL, Takaya N, Xu D, Polissar NL, et al. Quantitative evalua- tion of carotid plaque composition by in vivo MRI. Arterioscler romb Vasc Biol. 2005;25:234- 9.
5. Toussaint JF, LaMuraglia GM, Southern JF, Fuster V, Kantor HL. Magnetic resonance images lipid, brous, calci ed, hemorrhagic, and thrombotic components of human atherosclerosis in vivo. Circulation. 1996;94(5):932-8.

Editorial

Computed Tomography Angiography and Cardiac Catheterization: Allies in the Treatment of Chronic Coronary Obstruction

Leonardo Sara da Silva, Juliana Kelendjian
CDI - Centro de Diagnóstico por Imagem, Goiania, GO - Brazil

In the first years after the advent and popularization of coronary computed tomography angiography (CT angiography), part of the medical community began to design it as a substitute test for catheterization for diagnostic purposes, relegating the latter only for therapeutic purposes. Over time, the diverse and robust evidences that, every day, consolidate clinical recommendations for CT angiography show that these methods are not necessarily competitive. Both have distinct recommendations and may actually be complementary and synergistic. This is seen both in the clinical management of chronic coronary artery disease (CAD), in which CT angiography can better select patients that should or should not undergo catheterization, and in situations where computed tomography angiography provides information that are essential for the planning of percutaneous procedures, such as Transcatheter Aortic Valve Implant (TAVI).[1]

Another situation in which computed tomography angiography attracts special interest as an ally in interventional procedures is the treatment of chronic coronary artery occlusion. Defined as total obstruction of coronary artery lumen, with zero thrombolysis in myocardial infarction (TIMI) flow in the occluded segment and estimated duration of ≥3 months,[2] chronic arterial occlusion is frequently found in patients with CAD, with an estimated prevalence of 10 to 25% of cases managed with diagnostic angiography.[3] Chronic coronary occlusions are known to be associated with worse prognosis, and their recanalization leads to relief of symptoms, improved ejection fraction, reduced arrhythmias and decreased need for coronary artery bypass grafting.[4] Although some observational studies point out to a potential reduction in mortality rates, evidence in this respect is conflicting and, to date, not proven by well-designed randomized trials.

Treatment of chronic coronary occlusion should be considered in the presence of symptoms or objective evidence of viability/ischemia at the site of the occluded artery and follows the general recommendations of coronary artery bypass grafting in CAD.[2] Its recommendation also depends on the chances of success of the procedure and appropriate patient selection. However, percutaneous treatment of this clinical situation is extremely challenging and highly complex from a technical perspective. It is also of long duration and high rates of failure and complications, especially in centers of lower expertise.[3]

The main technical obstacle is the difficulty of passing the guidewire through the occluded arterial segment. Many scores have been developed with the purpose of estimating the chances of success of the procedure. J-CTO Score and PROGESS-CTO[3] are the most used ones. In general, with the development of new apparatuses, devices and techniques for catheter coronary artery bypass grafting, the main angiographic predictors of recanalization failure of the occluded artery are the degree of calcification, extension of the occluded arterial segment, tortuosity and unfavorable morphology of the blunt stamp.[6]

Coronary computed tomography angiography with recognized diagnostic accuracy for the detection of significant luminal reduction, also reveals occluded arterial segments, and allows the analysis of the degree of arterial tortuosity, identification of the distal bed to the occlusion and presence of collateral branches. Its role in patient evaluation and planning of recanalization procedures has been previously studied.[7] Some authors have tested scores using tomography-derived parameters similar to those obtained by conventional angiography, with quite similar performance. In particular, Fujino et al. developed a J-CTO Score based on the computed tomography angiography findings and compared with the traditional J-CTO Score, where the former was superior in the prediction of success of percutaneous recanalization.[8] In general, the main predictors of failure of the procedure obtained by computed tomography angiography are the extension of the occluded arterial segment >15 mm, moderate to severe calcification (taking >50% of the luminal cross-sectional area) and unfavorable morphology of the blunt stamp.

Computed tomography angiography can also be used to help choose the interventionist approach strategy. By analyzing the precise site of calcifications, their degree and extent, and the presence or absence of collateral vessels distal to occlusion, the method can be used to decide which approach to use (antegrade or retrograde), to choose guidewires, devices, stents and specific catheters (rotablator), and to predict the best projections and angulations for the procedure, saving time, radiation and volume of contrast medium.[9] Some centers even use hybrid imaging, by combining tomography with fluoroscopy images, and virtual reality.[10]

Despite this, computed tomography angiography is still underused in patient selection and assistance in chronic obstruction approach strategy. This interventional procedure is less used in Brazil than it should, due to limitations to the access of new technologies in the area. The current hemodynamics guidelines have not yet incorporated routine

Keywords

Computed Tomography Angiography; Coronary Occlusion; Cardiac Catheterization.

Mailing Address: Leonardo Sara da Silva •
CDI – Centro de Diagnóstico por Imagem - Avenida Portugal, 1155, Setor Marista, Goiânia-GO, CEP: 74150-030. Goiania, GO - Brasil
E-mail: leosara@hotmail.com

DOI: 10.5935/2318-8219.20190019

recommendation of computed tomography angiography in these cases, mainly because there are no longer any major randomized trials evaluating the importance of the method for decision making and the real benefit of using their information prior to interventional procedures. However, current evidence is encouraging and, with the impressive progress of interventional techniques, tomography equipment and analysis software, it is expected that the use of computed tomography angiography, combined with conventional invasive angiography, will become standard practice, leading to better patient selection and safer and more successful procedures for recanalization of chronically occluded arteries.

References

1. Blanke P, Weir-McCall JR, Achenbach S, Delgado V, Hausleiter J, Jilaihawi H, et al. Computed Tomography Imaging in the Context of Transcatheter Aortic Valve Implantation (TAVI)/Transcatheter Aortic Valve Replacement (TAVR): An Expert Consensus Document of the Society of Cardiovascular Computed Tomography. JACC Cardiovasc Imaging. 2019;12(1):1–24.
2. Feres F, Costa RA, Siqueira D, Costa Jr JR, Chamié D, Staico R, et al. Diretriz da Sociedade Brasileira de Cardiologia e da Sociedade Brasileira de Hemodinâmica e Cardiologia Intervencionista sobre Intervenção Coronária Percutânea. Arq Bras Cardiol. 2017;109(1 Suppl 1):1–81.
3. Anantha-narayanan M, Garcia S. Contemporary Approach to Chronic Total Occlusion Interventions Prevalence of CTOs. Curr Treat Options Cardiovasc Med. 2019;9:1–15.
4. Achenbach S, Tröbs M. Coronary Computed Tomographic Angiography Can Predict Chronic Total Occlusion Recanalization Success: Where Do We Go From Here? JACC: Cardiovascular Imaging. 2018;11(2P1):218–20.
5. Salisbury AC, Karmpaliotis D, Grantham JA, Sapontis J, Meng Q, Magnuson EA, et al. In-Hospital Costs and Costs of Complications of Chronic Total Occlusion Angioplasty. JACC Cardiovasc Interv. 2019;12(4):323-31.
6. Cheung SCW, Lim MCL, Chan CWS. The role of coronary CT angiography in chronic total occlusion intervention. Heart Asia. 2010;2(1):122–5.
7. Opolski MP, Knaapen P, Witkowski A, Min JK. Coronary Computed Tomography Angiography to Predict Successful Percutaneous Coronary Intervention for Chronic Total Occlusion: Ready for Prime Time? JACC Cardiovasc Imaging. 2017 Oct;10(10 Pt A):1206-8.
8. Fujino A, Otsuji S, Hasegawa K, Arita T, Takiuchi S, Fujii K, et al. Accuracy of J-CTO Score Derived From Computed Tomography Versus Angiography to Predict Successful Percutaneous Coronary Intervention. JACC Cardiovasc Imaging. 2018;11(2P1):209–17.
9. Opolski MP. Cardiac Computed Tomography for Planning Revascularization Procedures. J Thorac Imaging. 2018 Jan;33(1):35-54.
10. Opolski MP, Debski A, Borucki BA, Staruch AD, Kepka C, Rokicki JK, et al. Feasibility and safety of augmented-reality glass for computed tomography-assisted percutaneous revascularization of coronary chronic total occlusion: A single center prospective pilot study. J Cardiovasc Comput Tomogr. 2017 Nov;11(6):489-96.

Echocardiography on Prehypertension and Stage I Hypertension

Carolina Bertoluci[1], Murilo Foppa[1], Angela Barreto Santiago Santos[1], Sandra C. Fuchs[1], Flávio Danni Fuchs

1. Division of Cardiology, Hospital de Clínicas de Porto Alegre, Universidade Federal do Rio Grande do Sul, RS, Brazil; Postgraduate Studies Program in Cardiology, School of Medicine, Universidade Federal do Rio Grande do Sul, RS, Brazil

Abstract

Background: Prehypertension and stage I hypertension are associated with left ventricular (LV) remodeling. In this study, we compared echocardiographic parameters of preclinical hypertensive target organ damage in individuals with prehypertension and stage I hypertension selected from the same population.

Methods: We compared baseline echocardiogram measurements of participants included in the PREVER study with prehypertension (PREVER-prevention; n=106) or stage I hypertension (PREVER-treatment; n=128). Sex-specific differences in echocardiographic parameters were also investigated.

Results: Mean systolic and diastolic BP were significantly higher in the stage I hypertension group (141.0/90.4 mmHg) than in the prehypertension group (129.3/81.5 mmHg, P<0,001 for both). Mean age was 55 years old (30 to 70), with an almost equal number of men and women, of which 80% were white and 7% had diabetes. Most parameters of LV mass, LA size and diastolic function were similar between the prehypertension and stage I hypertension groups. Hypertensive individuals had larger LA diameter and posterior wall thickness, and lower lateral e' velocities, even after adjustment for age, sex and body mass index. Sex-specific analysis showed higher LV mass in stage I hypertension compared to prehypertension only in women (141.1 ± 34.1 g vs. 126.1 ± 29.1 g, P<0.05).

Conclusions: In middle-aged individuals with low cardiovascular risk, differences in echocardiographic parameters related to target organ damage are likely subtle between prehypertension and stage I hypertension, although women with stage I hypertension had significantly higher LV mass, which may indicate sex-specific adaptive response to blood pressure in earlier stages of hypertension.

Keywords: Prehypertension; Hypertrophy, Left Ventricular; Cardiac Volume.

Introduction

According to the Eighth Joint National Committee (JNC 8) guidelines on hypertension,[1] prehypertension is defined as SBP ranging from 120 to 139 mmHg and/or DBP from 80 to 89 mmHg, without the use of any antihypertensive medication.[1] Prevalence of prehypertension among adults is approximately 30%, and is markedly higher among men than women (39 and 23%, respectively).[2]

Prehypertension independently elevates the risk of cardiovascular disease.[3,4] In addition, the presence of hypertensive target organ damage in patients with high blood pressure increases the risk for cardiovascular disease.[1] Blood pressure (BP) in high-normal range is associated with long-term consequences on left ventricular (LV) structure and function.[5] Also, increased LV mass predicts progression of prehypertension to hypertension, regardless of baseline BP,[6-8] with the probability of developing hypertension in 4 years being increased by 39% for each 7.9 g/m^2 in LV mass index.[8]

Echocardiography is an important tool to evaluate hypertensive target organ damage, providing a better estimate of patients' cardiovascular risk and prognosis.[9,10] It is a sensitive and accessible imaging method which detects parameters that are known to correlate independently with cardiovascular events, such as alterations in LV mass, LV geometric pattern, left atrial (LA) size and LV diastolic function.[10-14]

LV mass was similar in patients with masked hypertension and prehypertension,[15] and was higher in middle-aged individuals with prehypertension and few cardiovascular risk factors than in individuals with optimal BP.[16] In young adults with high prevalence of obesity and diabetes mellitus[17] and in older population of men and women,[18] prehypertension was associated with higher LV remodeling and impaired diastolic function than in individuals with optimal BP. There are few studies comparing left ventricular parameters in individuals with prehypertension and hypertension stage I.[17,18] Also, whether there are sex-specific differences in cardiac remodeling in prehypertensive individuals is not so well studied.

The purpose of this study is to investigate the pattern of echocardiographic parameters of preclinical hypertensive

Mailing Address: Carolina Bertoluci •
Departamento de Cardiologia, Hospital de Clínicas de Porto Alegre, Universidade Federal do Rio Grande do Sul, Rua Ramiro Barcelos, 2350, 2º andar, 90035-003, Porto Alegre, RS - Brasil.
E-mail: cbertoluci@hcpa.edu.br
Artigo recebido em 20/08/2018; revisado em 10/10/2018; aceito em 28/11/2019

DOI: 10.5935/2318-8219.20190020

target organ damage (LV mass, LA size and diastolic function) in low cardiovascular risk middle-aged men and women with prehypertension, and compare it with individuals presenting stage I hypertension.

Methods

Study design

The PREVER study is a multicenter randomized controlled trial (RCT), designed to evaluate the management of prehypertension (PREVER-prevention) and stage I hypertension (PREVER-treatment). Population, methods and results of the PREVER study are described in detail elsewhere.[19,20] The participants were screened through advertising, campaigns of BP measuring in hospitals, squares and shopping malls in 21 clinical centers across 10 Brazilian states. They were invited to clinical and BP assessment in the study clinics and allocated to the PREVER-prevention or PREVER-treatment trial according their BP classification. An automatic electronic device Microlife BP 3BTO-A, licensed for fabrication by Micromed Biotecnologia Ltda (Brasília, Brazil), was used to measure BP and an average of two readings at each study visit was used to estimate the level of BP. The study was approved by each study center institutional review board and written informed consent was obtained from all participants.

An echocardiographic investigation was performed at a single center of PREVER-treatment and PREVER-prevention studies. All participants from the Hospital de Clínicas de Porto Alegre (HCPA) center were invited to participate in the ancillary echocardiographic study, where the transthoracic echocardiography was performed at baseline and after 18 months of treatment. Baseline tests were used for this analysis.

Population

All eligible participants of the PREVER study, aged 30-70, were submitted to a pre-enrollment lifestyle intervention phase. Those whose BP remained between 120-139/80-89 mmHg (PREVER-prevention study) or ≥140/90 mmHg (PREVER-treatment study) after 3 months of lifestyle intervention were enrolled in the RCT. Participants of the PREVER-prevention study were randomly assigned to a chlortalidone/amiloride 12.5/2.5 mg combination pill or to placebo, and the ones of the PREVER-treatment study were randomly assigned to a chlortalidone/amiloride 12.5/2.5 mg combination pill or to losartan 50 mg, with a follow-up of 18 months. Exclusion criteria included, in addition to the clinical trial criteria, baseline echocardiographic examination with image quality unsuitable for reading.

Echocardiographic study

All echocardiographic examinations were performed using the same equipment (Envisor C HD or HD 11, Philips, USA) with a standard multifrequency sectorial transducer by two trained cardiologists blinded to clinical trial information and treatment allocation. Images were acquired following a standardized protocol. Cine loops and static images of 3 consecutive beats were recorded of standard 2D, M-mode, Doppler and tissue Doppler echocardiographic views and were digitally recorded for central reading.

Echocardiographic studies were blindly read by a single physician using a dedicated workstation (Image Arena version 4 – TomTec, Germany). Measurements were performed in accordance with international society guidelines.[21] LV mass was calculated using the corrected American Society of Echocardiography method (LV mass = 0.8 x [1.04 x (IVST + LVDD + PWT)^3 – LVDD^3] + 0.6) and was indexed for body surface area (LV mass index – LVMI). LV hypertrophy was considered if LVMI was >115 g/m^2 for men and >95 g/m^2 for women. RWT was calculated as (2 x PWT)/LVDD, and increased RWT was defined when >0.42, from which geometric patterns (normal, concentric remodeling, concentric hypertrophy and eccentric hypertrophy) were derived.[21]

LV ejection fraction was calculated using the Teicholz formula from the parasternal long-axis view. LA volume was measured at ventricular systole, just before mitral valve opening, and calculated from apical 4- and 2-chamber views using biplane method of disks. LA diameter was measured at the end of LV systole, between the leading edge of the posterior aortic wall and the leading edge of the LA posterior wall. LV diastolic function was evaluated with transmitral pulsed Doppler (peak E velocity, peak A velocity, E/A ratio and deceleration time) and mitral annulus tissue Doppler velocity (early diastolic velocity – e', late diastolic velocity – a'). Normal diastolic function was defined as: medial e' ≥7 cm/s, lateral e' ≥10 cm/s and LA volume index <34 ml/m^2, in the absence of pulmonary hypertension.[22]

Statistical methods

Comparisons between groups were assessed by independent-samples t-tests for continuous variables and Chi squared test for categorical variables, and also stratified by sex. Multivariate analysis was performed for adjustment of echocardiographic outcomes to age and body mass index. Intraobserver reproducibility was evaluated in 20 randomly chosen studies using intraclass correlation coefficient; it varied between 0.99 and 0.67, with lower reproducibility for the posterior wall thickness measurement, and was similar to previous studies.[23-25] Data analysis was performed with PASW Statistics 18. Data are expressed as mean ± SD or number (percentage). P<0.05 was considered statistically significant.

Results

From the 1,385 participants of the PREVER study, the 398 participants from Hospital de Clínicas de Porto Alegre center were invited to participate in the echocardiographic evaluation, 247 of them were willing to participate, and 234 of these fulfilled the inclusion criteria; there were 106 individuals with prehypertension and 128 with stage I hypertension. (Figure 1)

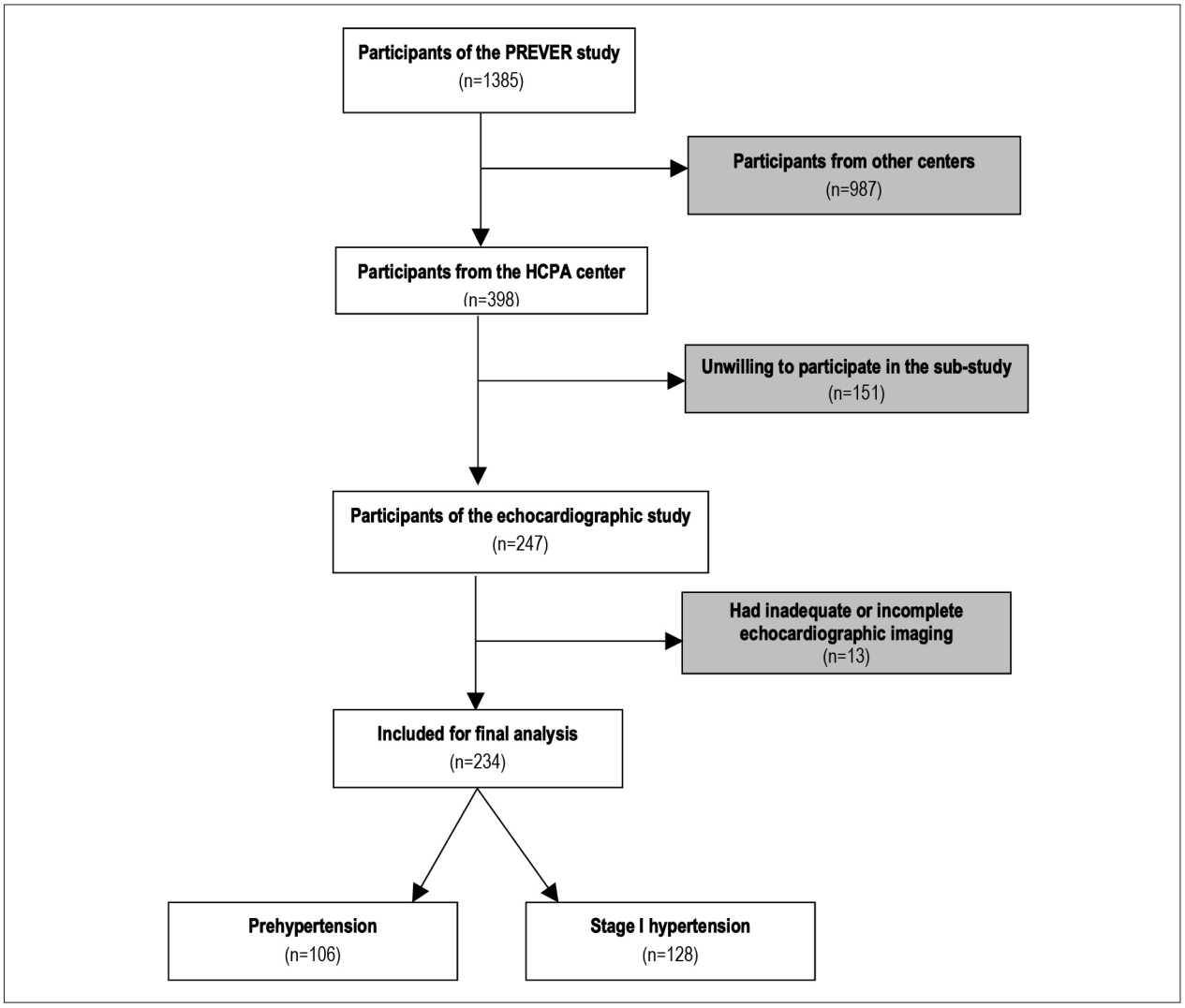


Figure 1 – *Study flow diagram.*

Distribution of clinical characteristics was similar between groups (Table 1), with the exception of systolic and diastolic BP, which were higher in stage I hypertension group (141.0 ± 7.0 / 90.4 ± 5.8 mmHg) than in prehypertension group (129.3 ± 5.1/81.5 ± 5.4 mmHg, P<0.001 for both). The mean age of the study sample was 55 years, with an almost equal number of men and women, and most participants (80%) were white.

Comparison of echocardiographic parameters of cardiac structure and function between groups is shown in Table 2. Most parameters of LV mass, LA size and diastolic function were similar between the prehypertension and stage I hypertension groups. Participants with stage I hypertension had a significantly higher LA diameter, LV diastolic diameter, LV mass, posterior wall thickness, and smaller lateral e'. The proportion of individuals with normal LV diastolic function was similar between prehypertension and hypertension (62.3% vs. 54.7%, P=0.24, respectively). After multivariate adjustment for age, sex and body mass index, only LA diameter, posterior wall thickness and lateral e' remained different between groups.

We also performed a sex-specific analysis (Table 3). LA diameter was larger in both men and women with stage I hypertension. Only in women LV mass and LV mass index were higher in stage I hypertension (141.1 ± 34.1 g and 79.2 ± 16.0 g/m^2) than in women with prehypertension (126.1 ± 29.1 g and 73.4 ± 15.6 g/m^2, P=0.05 and 0.04, respectively). After adjustment for age and body mass index, men with stage I hypertension had a smaller lateral e'. Other parameters of LA size, relative wall thickness and diastolic function were similar between prehypertensive and hypertensive men and women.

LV geometric patterns analysis (Table 4) showed a similar prevalence of normal geometry, concentric LV remodeling, concentric LV hypertrophy and eccentric LV hypertrophy between groups, with similar distribution in men and women

Table 1 - Sample clinical characteristics.

Characteristic	Pre-hypertension (n=106)	Hypertension (n=128)	*P*
Sex (male)	50 (47.2)	71 (55.5)	0.24
Age (years)	55.6 ± 8.9	54.4 ± 7.8	0.29
Skin color (white)	83 (78.3)	105 (82.0)	0.51
Education (years)	11.5 ± 3.8	11.2 ± 3.9	0.58
BSA (m²)	1.83 ± 0.19	1.87 ± 0.17	0.07
BMI (kg/m²)	27.6 ± 4.0	28.4 ± 4.4	0.14
SBP (mmHg)	129.3 ± 5.1	141.0 ± 7.0	<0.001
DBP (mmHg)	81.5 ± 5.4	90.4 ± 5.8	<0.001
Total cholesterol (mg/dl)	193.7 ± 34.8	194.3 ± 35.3	0.90
HDL cholesterol (mg/dl)	49.6 ± 12.6	49.8 ± 13.1	0.90
LDL cholesterol (mg/dl)	120.4 ± 31.9	116.5 ± 30.9	0.34
Creatinine (mg/dl)	0.83 ± 0.18	0.84 ± 0.18	0.46
Diabetes	5 (4.7)	12 (9.4)	0.21
Smoking*	49 (46.2)	68 (53.1)	0.36
Alcoholic beverage consumption*	100 (94.3)	111 (86.7)	0.08
Heart rate (bpm)	70 ± 12	72 ± 11	0.17

** Current or past. BMI, body mass index; BSA, body surface area; SBP, systolic blood pressure; DBP, diastolic blood pressure. Data are expressed as mean ± SD or as number (percentage).*

Table 2 - Echocardiographic parameters of cardiac structure and function.

Parameter	Pre-hypertension (n=106)	Hypertension (n=128)	P*	P**
LAD (mm)	34.6 ± 4.2	36.5 ± 4.2	0.001	0.002
LAV (ml)	47.5 ± 11.5	50.2 ± 13.7	0.10	0.27
LAVI (ml/m2)	25.8 ± 5.8	26.8 ± 7.2	0.27	0.28
LVDD (mm)	43.6 ± 4.5	45.1 ± 4.8	0.01	0.08
LVSD (mm)	26.1 ± 4.0	26.9 ± 3.9	0.13	0.32
LVEF Teichholz (%)	70.6 ± 7.7	70.6 ± 7.4	0.99	0.92
LVM (g)	145.8 ± 34.5	156.6 ± 39.2	0.03	0.12
LVMI (g/m²)	79.3 ± 15.4	83.0 ± 17.0	0.08	0.15
IVST (mm)	10.2 ± 1.4	10.0 ± 1.2	0.29	0.08
PWT (mm)	9.6 ± 1.2	10.0 ± 1.1	0.01	0.04
RWT	0.44 ± 0.06	0.45 ± 0.06	0.80	0.76
LV stroke volume (ml)	72.3 ± 20.0	74.3 ± 16.0	0.42	0.99
Cardiac index (l/m²)	2.6 ± 1.0	2.8 ± 0.6	0.08	0.08
Lateral e' (cm/s)	14 ± 3	13 ± 3	0.05	0.01
Medial e' (cm/s)	9 ± 2	9 ± 2	0.33	0.19
Lateral E/e' ratio	6.1 ± 7.1	5.7 ± 1.5	0.61	0.33
Medial E/e' ratio	8.1 ± 2.1	8.4 ± 2.2	0.35	0.24
Mitral E/A ratio	1.0 ± 0.2	1.0 ± 0.3	0.76	0.80
DTE (ms)	225 ± 45	229 ± 46	0.51	0.71

** Unadjusted. ** Adjusted for sex, age and body mass index. LAD, left atrial diameter; LAV, left atrial volume; LAVI, left atrial volume index; LVDD, left ventricular diastolic diameter; LVSD, left ventricular systolic diameter; LVEF, left ventricular ejection fraction; LVM, left ventricular mass; LVMI, left ventricular mass index; IVST, interventricular septum thickness; PWT, posterior wall thickness; RWT, relative wall thickness; LV, left ventricle; DTE, deceleration time of E wave. Data are expressed as mean ± SD or as number (percentage).*

(data not shown). When dichotomized for the presence of normal or abnormal LV geometry, the prevalence of abnormal LV geometry was also similar between groups (70% for prehypertension, 68.5% for stage I hypertension, P=0.80).

Discussion

This study shows that most echocardiographic parameters of preclinical hypertensive target organ damage are similar among individuals with prehypertension and stage I hypertension. This finding suggests that there are few differences between prehypertension and individuals diagnosed with high blood pressure.

There are few studies comparing echocardiographic parameters in patients with prehypertension and hypertension,[16-18] but they investigated individuals in different age and clinical conditions. The Strong Heart Study compared the cardiac structure and function of American Indians (adolescents and young adults) with a high prevalence of obesity and diabetes in different groups according to BP (optimal BP, prehypertension and hypertension);[17] in this population, there was a progressive increase in LV mass and a lower prevalence of normal LV geometry according to the rise of BP, but the difference between groups was less evident when prehypertension and hypertension were compared. In a sample of middle-aged individuals,[16] there was no difference in LV mass between prehypertension and stage I hypertension (215 g and 218 g, respectively, P=0.94), even with higher differences of systolic BP between prehypertensive (122 mmHg) and hypertensive individuals (151 mmHg). The ARIC study[18] compared echocardiographic abnormalities in elderly participants with optimal, prehypertensive and hypertensive stages, and they were progressively more frequent from optimal BP to true hypertension. Our findings concerning the comparison between prehypertension and hypertension extend the ARIC observation to younger individuals. Although alterations in BP have a pathophysiological continuum, there is evidence that an increase in LV may be a predictor of hypertension, and not only a consequence of it.[8]

We had a higher prevalence of LV concentric remodeling than previous studies[26] possibly for two reasons: our measurements were made using second harmonic 2D images instead of M-mode images, and we used 0.42 as cut-off for RWT, according to recent guidelines for chamber quantification[21] – while most previous studies used higher cut-offs (>=0.44 or <= 0.45).

Interestingly, we found that LV mass was higher in stage I hypertension compared to prehypertension only in women. A difference of 12 mmHg in SBP and 9 mmHg in DPB between groups had an impact on LV mass in women, and as far as we know, this is the first time that this is shown in this population. Cardiac structure is known to be different between men and women, since left ventricular chamber size and mass are 15-40% lower in women even after adjustment for body size.[27] Moreover, the consequences of pressure overload and systolic hypertension differs between sexes. Rohde et al. reported that women responded to chronic pressure overload with a disproportionally greater

Table 3 - Echocardiographic parameters of cardiac structure and function by sex.

	Female				Male			
	Prehypertension (n=56)	Hypertension (n=57)	P*	P**	Prehypertension (n=50)	Hypertension (n=71)	P*	P**
LAD (mm)	33.3 ± 4.0	35.3 ± 4.2	0.01	0.01	36.0 ± 4.1	37.6 ± 4.0	0.04	0.05
LAV (ml)	45.7 ± 12.4	48.1 ± 14.7	0.37	0.64	49.4 ± 10.4	51.9 ± 12.9	0.27	0.30
LAVI (ml/m2)	26.4 ± 6.0	27.0 ± 7.9	0.64	0.83	25.2 ± 5.4	26.7 ± 6.6	0.23	0.20
LVDD (mm)	42.0 ± 4.7	43.5 ± 4.6	0.08	0.15	45.4 ± 3.4	46.4 ± 4.6	0.21	0.29
LVSD (mm)	24.7 ± 3.7	25.2 ± 3.5	0.41	0.51	27.7 ± 3.7	28.2 ± 3.8	0.45	0.48
LVEF Teichholz (%)	71.8 ± 8.1	72.5 ± 6.8	0.62	0.67	69.3 ± 7.1	69.1 ± 7.6	0.89	0.80
LVM (g)	126.1 ± 29.1	141.1 ± 34.1	0.01	0.05	167.9 ± 25.5	169.0 ± 38.9	0.87	0.95
LVMI (g/m2)	73.4 ± 15.6	79.2 ± 16.0	0.05	0.04	86.0 ± 12.3	86.1 ± 17.2	0.97	0.93
IVST (mm)	9.6 ± 1.3	9.7 ± 1.1	0.81	0.89	10.3 ± 1.2	10.8 ± 1.1	0.01	0.01
PWT (mm)	9.0 ± 1.0	9.6 ± 1.0	0.002	0.001	10.2 ± 0.9	10.2 ± 1.1	0.92	0.80
RWT	0.43 ± 0.07	0.45 ± 0.06	0.32	0.26	0.45 ± 0.05	0.44 ± 0.06	0.41	0.43
LV stroke volume (ml)	64.2 ± 13.4	69.8 ± 15.4	0.06	0.13	81.5 ± 22.4	77.8 ± 15.6	0.36	0.26
Lateral e' (cm/s)	13 ± 3	13 ± 3	0.27	0.15	14 ± 3	13 ± 3	0.08	0.03
Medial e' (cm/s)	9 ± 2	8 ± 2	0.12	0.06	9 ± 2	9 ± 2	0.89	0.97
Lateral E/e' ratio	5.8 ± 1.4	6.0 ± 1.5	0.41	0.43	6.4 ± 1.5	5.5 ± 1.5	0.46	0.46
Medial E/e' ratio	8.6 ± 2.4	8.9 ± 1.9	0.53	0.64	7.5 ± 1.6	8.0 ± 2.2	0.18	0.23
Mitral E/A ratio	1.0 ± 0.2	1.0 ± 0.3	0.61	0.43	1.0 ± 0.3	1.0 ± 0.3	0.90	0.66
DTE (ms)	220 ± 44	223 ± 44	0.76	0.71	231 ± 46	234 ± 48	0.73	0.41

** Unadjusted. ** Adjusted for age and body mass index. LAD, left atrial diameter; LAV, left atrial volume; LAVI, left atrial volume index; LVDD, left ventricular diastolic diameter; LVSD, left ventricular systolic diameter; LVEF, left ventricular ejection fraction; LVM, left ventricular mass; LVMI, left ventricular mass index; IVST, interventricular septum thickness; PWT, posterior wall thickness; RWT, relative wall thickness; LV, left ventricle; DTE, deceleration time of E wave. Data are expressed as mean ± SD.*

Table 4 – LV geometric patterns.

LV geometric pattern	Pre-hypertension (n=106)	Hypertension (n=127)	*P*
Normal geometry	32 (30.2)	40 (31.5)	0.83
Concentric LV remodeling	67 (63.3)	75 (59.1)	0.51
Concentric LV hypertrophy	2 (1.8)	7 (5.5)	0.14
Eccentric LV hypertrophy	5 (4.7)	5 (3.9)	0.76

LV, left ventricle. Data are expressed as number (percentage).

degree of hypertrophy compared to volume.[28] In individuals with isolated hypertension, the relative odds of LV hypertrophy were 2.58 (95% CI 0.97-6.86) in men and 5.94 (3.06-11.53) in women, with an increase in LV mass at the expense of LV dilation in men and an increment in wall thickness in women.[29] There is also evidence that women may have a greater sensitivity to pressure overload and/or greater left ventricular structural plasticity in specific populations,[30] and it seems like even small BP differences may have a similar effect. The clinical consequences of LV hypertrophy are also different between sexes, with a higher risk of cardiovascular death in women than in men (HR 7.5 - 95% CI 1.6-33.8 and HR 1.3 - 95% CI 0.4-3.7, respectively) compared with individuals without LV hypertrophy.[31] This also leads to question whether prehypertension and hypertension have a different phenotypic presentation of target organ damage according to sex, and may contribute to the increased prevalence of heart failure with preserved ejection fraction (HFpEF) in women.[32]

In our study, LA volume and LA volume index were similar between groups, although hypertensive individuals had a significantly higher LA diameter than prehypertensive peers. Most previous studies do not present data of LA size when these stages of hypertension are compared; however, it is known that LA volume is more accurate to estimate real LA size, with a higher performance for the prediction of cardiovascular events.[33] Parameters of diastolic function were similar between groups, with the exception of lateral e' velocity, which was lower in hypertensive individuals (13 vs. 14 cm/s, P=0.05); however, E/e' ratio and other. This may suggest that structural changes precede detectable abnormalities in diastolic function Doppler parameters, and are consistent with recent guidelines on diastolic function evaluation, which propose a more specific and conservative approach to call the presence of mild diastolic dysfunction.[22]

In general, as recommended in JNC8, individuals with prehypertension should be treated with non-pharmacological therapies such as weight reduction, increased physical activity, sodium restriction and avoidance of alcohol excess.[1] However, there is growing evidence of benefits of pharmacological treatment of prehypertension. In the

PREVER-prevention study, the incidence of hypertension was significantly lower in the chlorthalidone/amiloride group compared to placebo. There was an interaction of treatment with sex, with an apparent greater benefit of chlorthalidone/amiloride treatment in women compared to men.[19] Since women are likely to be more sensitive to high blood pressure cardiac adaptive changes, a more accurate stratification in this population may translate into strategies for HF prevention.

Some limitations of our study should be noted. First, we did not have participants with optimal BP. Nonetheless, previous studies have shown that prehypertension is associated with higher frequency of echocardiographic abnormalities than optimal BP.[16] The characteristics of our population, originated from a single study center, mostly of middle-aged Caucasian individuals with few cardiovascular risk factors, should be taken into account to extend our findings to other populations.

In summary, in middle-aged individuals with low cardiovascular risk, differences in echocardiographic parameters related to preclinical target organ damage are likely subtle between prehypertension and stage I hypertension, although women with stage I hypertension had significantly higher LV mass, which may indicate sex-specific adaptive response to blood pressure in earlier stages of hypertension. These sex differences in LV remodeling should be explored in further studies.

Authors' contributions

Conception and design of the study, acquisition of data, analysis and interpretation of data, drafting the article and revising it critically for important intellectual content, final approval of the version to be submitted: Bertoluci C, Foppa M

Conception and design of the study, analysis and interpretation of data, drafting the article and revising it critically for important intellectual content, final approval of the version to be submitted: Santos ABS, Fuchs SC e Fuchs FD.All authors have approved the final article.

Sources of Funding

This study was supported by Departamento de Ciência e Tecnologia (DECIT), Health Ministry; Conselho Nacional de Desenvolvimento Científico e Tecnológico (CNPq) and Financiadora de Estudos e Projetos (FINEP), Science and Technology Ministry; Instituto de Avaliação de Tecnologia em Saúde (IATS); and Fundação Instituto de Pesquisas Econômicas (FIPE), Hospital de Clínicas de Porto Alegre, all in Brazil. The sponsors had no participation in the design and conduct of the study, preparation and approval of the manuscript.

Potential Conflicts of Interest

All authors reported they had no conflicts of interest and financial disclosures with regard to the subject of this manuscript.

References

1. James PA, Oparil S, Carter BL, Cushman WC, Dennison-Himmelfarb C, Handler J, et al. 2014 evidence-based guideline for the management of high blood pressure in adults: Report from the panel members appointed to the Eighth Joint National Committee (JNC 8). JAMA. 2014; 311:507–20.
2. Greenlund KJ, Croft JB, Mensah GA. Prevalence of heart disease and stroke risk factors in persons with prehypertension in the United States, 1999-2000. Arch Intern Med. 2004; 164:2113-8.
3. Guo X, Zhang X, Guo L, Li Z, Zheng L, Yu S, et al. Association between pre-hypertension and cardiovascular outcomes: a systematic review and meta-analysis of prospective studies. Curr Hypertens Rep. 2013 Dec;15(6):703-16.
4. Huang Y, Wang S, Cai X, Mai W, Hu Y, Tang H, et al. Prehypertension and incidence of cardiovascular disease: a meta-analysis. BMC Med. 2013; 11:177.
5. Lorber R, Gidding SS, Daviglus ML, Colangelo LA, Liu K, Gardin JM. Influence of systolic blood pressure and body mass index on left ventricular structure in healthy African-American and white young adults: the CARDIA study. J Am Coll Cardiol. 2003; 41(6):955-60.
6. Post WS, Larson MG, Levy D. Impact of left ventricular structure on the incidence of hypertension. The Framingham Heart Study. Circulation. 1994; 90(1):179-85.
7. De Marco M, de Simone G, Roman MJ, Chinali M, Lee ET, Russell M, et al. Cardiovascular and metabolic predictors of progression of prehypertension into hypertension: the Strong Heart Study Hypertension. 2009; 54(5):974-80.
8. de Simone G, Devereux RB, Chinali M, Roman MJ, Welty TK, Lee ET, et al. Left ventricular mass and incident hypertension in individuals with initial optimal blood pressure: the Strong Heart Study. J Hypertens. 2008; 26(9):1868-74.
9. Mancia G, Fagard R, Narkiewicz K, Redon J, Zanchetti A, Böhm M, et al.; Task Force Members. 2013 ESH/ESC guidelines for the management of arterial hypertension: the Task Force for the Management of Arterial Hypertension of the European Society of Hypertension (ESH) and of the European Society of Cardiology (ESC). Eur Heart J. 2013 ; 34(28):2159-219.
10. Lee JH, Park JH. Role of echocardiography in clinical hypertension. Clin Hypertens. 2015; 21:9.
11. Vakili BA, Okin PM, Devereux RB. Prognostic implications of left ventricular hypertrophy. Am Heart J. 2001; 141(3):334-41.
12. Pierdomenico SD, Lapenna D, Bucci A, Manente BM, Cuccurullo F, Mezzetti A. Prognostic value of left ventricular concentric remodeling in uncomplicated mild hypertension. Am J Hypertens. 2004;17(11 Pt 1):1035-9.
13. Eshoo S, Ross DL, Thomas L. Impact of mild hypertension on left atrial size and function. Circ Cardiovasc Imaging. 2009; 2(2):93-9.
14. Kitzman DW, Little WC. Left ventricle diastolic dysfunction and prognosis. Circulation. 2012; 125(6):743-5.
15. Shimbo D, Newman JD, Schwartz JE. Masked hypertension and prehypertension: diagnostic overlap and interrelationships with left ventricular mass: the Masked Hypertension Study. Am J Hypertens. 2012; 25(6):664-71.
16. Manios E, Tsivgoulis G, Koroboki E, Stamatelopoulos K, Papamichael C, Toumanidis S, et al. Impact of prehypertension on common carotid artery intima-media thickness and left ventricular mass. Stroke. 2009; 40(4):1515-8.

17. Drukteinis JS, Roman MJ, Fabsitz RR, Lee ET, Best LG, Russell M, et al. Cardiac and systemic hemodynamic characteristics of hypertension and prehypertension in adolescents and young adults: the Strong Heart Study. Circulation. 2007 ; 115(2):221-7.

18. Santos AB, Gupta DK, Bello NA, Gori M, Claggett B, Fuchs FD, et al. Prehypertension is associated with abnormalities of cardiac structure and function in the atherosclerosis risk in communities study. Am J Hypertens. 2016 ; 29(5):568-74.

19. Fuchs SC, Poli-de-Figueiredo CE, Figueiredo Neto JA, Scala LC, Whelton PK, Mosele F, et al. Effectiveness of Chlorthalidone Plus Amiloride for the Prevention of Hypertension: The PREVER-Prevention Randomized Clinical Trial. J Am Heart Assoc. 2016; 5(12). pii: e004248.

20. Fuchs FD, Scala LC, Vilela-Martin JF, de Mello RB, Mosele F, Whelton PK, et al. Effectiveness of chlorthalidone/amiloride versus losartan in patients with stage I hypertension: results from the PREVER-treatment randomized trial. J Hypertens. 2016; 34(4):798-806.

21. Lang RM, Badano LP, Mor-Avi V, Afilalo J, Armstrong A, Ernande L, et al. Recommendations for cardiac chamber quantification by echocardiography in adults: an update from the American Society of Echocardiography and the European Association of Cardiovascular Imaging. J Am Soc Echocardiogr. 2015; 28(1):1-39.e14.

22. Nagueh SF, Smiseth OA, Appleton CP, Byrd BF 3rd, Dokainish H, Edvardsen T, et al. Recommendations for the Evaluation of Left Ventricular Diastolic Function by Echocardiography: An Update from the American Society of Echocardiography and the European Association of Cardiovascular Imaging. J Am Soc Echocardiogr. 2016; 29(4):277-314.

23. Tognon AP, Foppa M, Luft VC, Chambless LE, Lotufo P, El Aouar LM, et al. Reproducibility of left ventricular mass by echocardiogram in the ELSA-Brasil. Arq Bras Cardiol. 2015; 104(2):104-11.

24. Gottdiener JS, Livengood SV, Meyer PS, Chase GA. Should echocardiography be performed to assess effects of antihypertensive therapy? Test-retest reliability of echocardiography for measurement of left ventricular mass and function. J Am Coll Cardiol. 1995; 25(2):424-30.

25. Ogah OS, Adebanjo AT, Otukoya AS, Jagusa TJ. Echocardiography in Nigeria: use, problems, reproducibility and potentials. Cardiovasc Ultrasound. 2006;4:13.

26. Verdecchia P, Schillaci G, Borgioni C, Ciucci A, Battistelli M, Bartoccini C, et al. Adverse prognostic significance of concentric remodeling of the left ventricle in hypertensive patients with normal left ventricular mass. J Am Coll Cardiol. 1995 Mar 15;25(4):871-8.

27. de Simone G, Devereux RB, Daniels SR, Meyer RA. Gender differences in left ventricular growth. Hypertension. 1995; 26(6 Pt 1):979-83.

28. Rohde LE, Zhi G, Aranki SF, Beckel NE, Lee RT, Reimold SC. Gender-associated differences in left ventricular geometry in patients with aortic valve disease and effect of distinct overload subsets. Am J Cardiol. 1997; 80(4):475-80.

29. Krumholz HM, Larson M, Levy D. Sex differences in cardiac adaptation to isolated systolic hypertension. Am J Cardiol. 1993; 72(3):310-3.

30. Petrov G, Regitz-Zagrosek V, Lehmkuhl E, Krabatsch T, Dunkel A, Dandel M, et al. Regression of myocardial hypertrophy after aortic valve replacement: faster in women? Circulation. 2010; 122(11 Suppl):S23-8.

31. Liao Y, Cooper RS, Mensah GA, McGee DL. Left ventricular hypertrophy has a greater impact on survival in women than in men. Circulation. 1995; 92(4):805-10.

32. Scantlebury DC, Borlaug BA. Why are women more likely than men to develop heart failure with preserved ejection fraction? Curr Opin Cardiol. 2011; 26(6):562-8.

33. Tsang TS, Abhayaratna WP, Barnes ME, Miyasaka Y, Gersh BJ, Bailey KR, et al. Prediction of cardiovascular outcomes with left atrial size: is volume superior to area or diameter? J Am Coll Cardiol. 2006; 47(5):1018-23.

Risk of Infection Associated with Transesophageal Echocardiography and Prevention Measures: Literature Review

Juliana Barros Becker, Fernanda Crosera Parreira, Cláudio Henrique Fischer, Valdir Ambrósio Moisés

Universidade Federal de São Paulo (UNIFESP), São Paulo, SP - Brazil.

Abstract

Background: Transesophageal echocardiography is an exam widely used in clinical practice for investigation and diagnosis of cardiac and noncardiac diseases. Although safe, it is a semi-invasive and non-risk-free examination. Cases of infection associated with transesophageal echocardiography were described and, due to the potential risk of transmission of infection during its implementation, the objective of this work was to review literature data regarding the transmission of infection during the examination, as well as prevention methods. Methods: Review of literature on the subject between December 2017 and January 2018, through research in public domain scientific portals, in the different health science databases, including original articles, guidelines, simple and systematic reviews, case reports, published in periodicals indexed in the last 20 years. Results: Thirteen articles fulfilled the established criteria: a systematic review of transesophageal echocardiography-related complications, six articles describing transesophageal echocardiography-related bacterial outbreaks, the British guideline on cleaning and disinfection for transesophageal echocardiography probes, four articles on adverse reactions to orthophthaldehyde residues in transesophageal echocardiography probes and an article regarding the use of protective covers for the probes. Conclusion: The risk of infection associated with transesophageal echocardiography exists, although poorly described in the literature. It is recommended to establish specific protocols for disinfection of transesophageal echocardiography probes and routine inspection of probes. The strengthening of infection control teams is also essential for the detection and resolution of transesophageal echocardiography-related outbreaks.

Introduction

Transesophageal Echocardiography (TEE) is an ultrasound scan of the heart and large vessels via the esophagus. This requires intubation of the esophagus using a probe provided with a transducer at its tip.[1] This scan is widely used in clinical practice for the investigation of cardiac and non-cardiac diseases. Since its introduction in 1976, up to these days, the technique has been progressing, especially with the development of biplane and three-dimensional transducers, as well as improved quality and definition of images, which enabled more accurate diagnoses and made TEE a complementary option and, sometimes essential to Transthoracic Echocardiography (TTE).[2,3]

Although TEE is considered a safe diagnosis and monitoring tool, it is a non-risk-free test, as sedation is used to perform it, and the insertion and handling of the probe can cause oropharyngeal, esophageal and gastric trauma.[3-5] Studies show that the incidence of complications related to TEE ranges from 0.2 to 1.2% and mortality below 0.01%.[4] The main complications reported are related to the gastrointestinal, respiratory and cardiovascular systems, such as dysphagia, gastroesophageal perforation and bleeding, accidental intubation of the trachea, laryngospasm, bronchospasm, bronchoaspiration, cardiac arrhythmias (atrial fibrillation and ventricular tachycardia) and transient hypotension. Complications related to sedation, reaction to the anesthetic drug, meta-hemoglobinemia, ultrasound cavitation, lesions related to probe contamination and infection are also described.[2,4,6-8]

Although the cases of infection associated with TEE are rare, they have been described in the literature. Because it is a semi-invasive test, there is potential for transmission of pathogens among sequential patients, with implications for the protection of patients and the healthcare team.[9] The TEE probe, as it is semi-critical equipment, must undergo high-level disinfection procedures, following institutional protocols and the guidelines from the local health authority.[10]

Given the increasing number of TEE tests performed and the potential risk of infection during its execution, as well as the scarcity of specific disinfection guidelines for TEE probes in the national and international literature, the objective of this study is to review literature data concerning infection during the test, as well as methods of prevention, in particular the cleaning and disinfection of TEE probes.

Objective

To search the scientific literature and look for information on the transmission of infection related to transesophageal echocardiography, as well as to investigate prevention methods such as disinfection and protective covers for transesophageal echocardiography probes.

Methods

Search for manuscripts

The search in the literature was conducted between December 2017 and January 2018 on public domain portals, such as the Latin American and Caribbean Center for Health

Keywords

Transesophageal Echocardiography; Disinfection; Diagnosis.

Mailing Address: Juliana Barros Becker •
Rua Pedro de Toledo, 720, 2° andar, Setor de Ecocardiografia, Vila Clementino. CEP 04039-002, São Paulo, SP, Brazil.
E-mail: juliana.becker@unifesp.br

DOI: 10.5935/2318-8219.20190022

Sciences Information (BIREME), with searches on the databases Latin American and Caribbean Literature (LILACS), *Índice Bibliográfico Espanol en Ciencias de la Salud* (IBECS), MEDLINE® of the National Library of Medicine (NLM), Scientific Electronic Library Online (SciELO), The Cochrane Library, PubMed of the NLM and AskMEDLINE. Due to the scarcity of published manuscripts addressing this subject, the search included manuscripts published over the last 20 years.

The following descriptors were used with the help of Boolean connectors: "ecocardiografia transesofagiana" *AND* "complicação" *OR* "sonda" *OR* "desinfecção" *OR* "infecção". For the English-language searches, Medical Subject Heading (MeSH) terms were used: "*transesophageal echocardiogram*" *AND* "*probe*" *AND* "*disinfection*". At askMEDLINE, the following sentence was formulated: "contamination in transesophageal echocardiogram."

Criteria for inclusion of manuscripts

Original manuscripts, guidelines, simple or systematic literature reviews and case reports written in Portuguese, English and Spanish were included in the study and published in journals indexed in the databases searched on the topic proposed in the study. This included studies on the incidence of scan-related infections, technical standards with disinfection guidelines and methods of prevention of TEE-related infections, as well as manuscripts reporting complications secondary to the disinfection methods.

Results

The search identified 13 manuscripts that met the established criteria and were published between 2003 and 2016. Six manuscripts described bacterial outbreaks associated with TEE in 143 patients. Regarding the disinfection process of the TEE probe, in 2011, the British Society of Echocardiography (BSE) published a guideline on cleaning and disinfection for TEE probes. Also related to the disinfection process, four manuscripts described mouth, tongue, pharynx and esophagus injuries in five patients undergoing TEE due to orthophthaldehyde residues found in the probe, and one manuscript, published in 1993, was related to the use of TEE probe covers. We also found a systematic review published in 2008 that evaluated 207 manuscripts and covered 44,005 patients, on all complications associated with TEE, and described 35 complications related to the scan, including cases of infection.

Cleaning and disinfection of transesophageal echocardiography probes

The process of cleaning and disinfecting flexible endoscopes is well documented in the literature, but regarding the disinfection of TEE probes, there is only the BSE guideline, published in 2011. This document was used as a basis for the subsequent paragraphs.

According to Spaulding's criteria,[11] the TEE probe is considered a semicritical equipment since, during its use, there is contact with intact mucous membranes and potential contact with non-intact mucous membranes and must undergo high-level disinfection.[9,10] Although the TEE probe is similar to that of gastrointestinal endoscopy, has no internal channels, which reduces the risk of contamination and makes the cleaning process easier. On the other hand, the TEE probe cannot be completely immersed in any liquid for cleaning and disinfection, which makes it harder to disinfect the parts that cannot be immersed in the disinfectant solution.

The TEE test should be performed in a suitable area, preferably with two rooms, one for its execution and another separate room for the disinfection of the probe. The procedure room must feature an area for hand washing, waste disposal and safe storage of the probe. The disinfection room should have a sink for cleaning the probe, a hand-washing sink, a countertop and containers for disinfecting the probe. The workflow in this room should be clear, with distinction between dirty and clean areas. In health facilities where test and disinfection take place in the same room, areas pre-designated "dirty" (pre-disinfection) and "clean" (post-disinfection) should be in place to ensure that disinfected probes are not mixed up with probes not yet decontaminated. For storage of disinfected probes, there must be a clearly identified location in the "clean" area of the room. If the test and processing of the probes occur in two rooms, it is recommended to provide a rigid box to transport the probes.[9]

The process of cleaning and disinfecting the probes should be preceded by a pre-evaluation phase, which includes the adoption of precautionary measures for all patients and evaluation of patients with the greatest potential for transmission of infectious microorganisms, placing them at the end of the list of scans to reduce the risk of cross-contamination. The probe must be cleaned immediately after its removal from the patient, using wipes soaked in detergent solution. The non-immersible parts should also be preferably cleaned with proper cleaning wipes soaked in detergent solution.[9] After immediate cleaning, the probe should be immersed in detergent solution for a period of time recommended by the manufacturer in order to remove all organic matter which may inhibit the action of the disinfectant. Afterwards, the probe must be thoroughly rinsed with potable water to remove any residual detergent, as it is incompatible with the disinfectant.

The choice of the disinfectant should involve microbicidal range, safety and compatibility with the TEE probe. The most commonly used agents include aldehydes, hydrogen peroxide, peracetic acid, chlorine dioxide, superoxidized water and alcohols. It is not advisable to use alcohols and aldehydes as disinfectants because of their fixing properties, resulting in retention of proteins (including prion proteins) in the probe.[9]

Disinfection can be manual or automated. Some automated endoscope reprocessors allow immersion of the TEE probe and protect the non-immersible parts of the probe, which require manual disinfection.[9]

After the time of exposure to the disinfectant, the probe should be rinsed with sterile, filtered or high-quality drinking water.[11] This process is essential for the removal of potentially toxic waste from disinfectants.

The probe must be dried after rinsing in order to reduce the chance of recontamination by microorganisms, which

may be present in the water.[11] Ideally, the probes should be hung up in a locked cabinet. An alternative would be storing it on a rigid tray for 2 days at the most, since longer storage times may cause the probe axis to twist. Using tray liners and covers can be beneficial in the transport of the probes.[9]

National standards

In Brazil, there is no specific guideline on cleaning and disinfecting TEE probes. In addition to Resolution RE 2606, which provides for the reprocessing of health products, Brazil's Health Authority (ANVISA), in partnership with the Brazilian Society of Nursing in Gastrointestinal Endoscopy (SOBEEG), published the Guidebook on Cleaning and Disinfection of Endoscopes, both in 2006. Regarding the use of disinfectants, the main ones used for flexible endoscopes in Brazil are: 2% glutaraldehyde, peracetic acid, hydrogen peroxide, 0.55% orthophthalaldehyde and electrolytic acid water (it requires a device that performs the electrolysis of sodium chloride). Using these substances requires periodic training and personal protective equipment (gloves, apron, goggles and mask) preferably following institutional protocols. Besides that, the products should be used according to the probe manufacturer's guidelines and recommendations.[12-15]

Protective covers

Only one study on protective covers for TEE probes was found in this review. The manuscript was published in 1993 and analyzed a latex device. Despite few publications, this apparatus is commonly used in daily practice. These covers are characterized by physical barriers in addition to contamination and protection against damage, but using these covers does not rule out the need for disinfection, since it does not cover the entire probe and is prone to perforations, thereby causing cross contamination.[9-16]

Adverse effects of orthophthalaldehyde

Adverse effects of orthophthalaldehyde, a disinfectant widely used on flexible endoscopes and TEE probes, have been reported in the literature. A manuscript from 2003 reports the case of a man undergoing intraoperative TEE without a protective cover on the probe, which progressed with denaturation lesions on the tongue and lips. In the immediate postoperative period, the patient presented odynophagia with progressive worsening. The lesions became ulcerated and, after 3 days from the onset of symptoms, an Upper Gastrointestinal Endoscopy (UGIE) revealed ulceration near the upper esophageal sphincter and stomach. Despite the proposed therapy, the patient needed an enteral diet and hospital stay for 20 days, when he presented improvement of the symptoms and was discharged.[17]

Another article reports the case of a 5-year-old child, who underwent intraoperative TEE, without the use of a TEE probe cover. The child presented black lesions due to lip, tongue and esophagus denaturation. The child developed esophageal stenosis and underwent monthly esophageal dilatation procedures for more than one year after the injury.[18]

In 2011, a manuscript reported the case of two patients who underwent TEE and developed lesions due to lip, tongue and pharynx denaturation. In both cases, the probes were fitted with protective covers, which were not damaged. The patients evolved with intense pharynx pain, preventing the intake of liquids and foods orally, and intravenous nutritional therapy was required. Remission of symptoms occurred within one week and the patients were discharged without sequelae. Orthophthalaldehyde residues were evaluated by means of chromatography on the equipment used in the TEE and were found in all of the samples collected. From the location of the lesions, it was concluded that the contact of the mucosa with the proximal part of the probe/transducer contaminated with orthophthalaldehyde residues, which is not covered by the protective cover, was responsible for the lesions.[8]

In a report published in 2003, researchers from the Massachusetts General Hospital, Harvard Medical School, reported that after adopting orthophthalaldehyde for disinfecting the TEE probes, found dark spots in the oral cavities of patients undergoing the test, despite thoroughly rinsing the probes, especially in patients undergoing cardiac surgeries, in which the probe remains for long periods in the patient. According to the report, although the labial spots were difficult to remove, they disappeared in a few hours, without any apparent sequelae. The authors concluded that regardless of thorough rinsing with water, small orthophthalaldehyde residues remain in the probe. When these probes treated with orthophthalaldehyde are gently cleaned with 3% hydrogen peroxide solution, after disinfection, these residues are not found.[19]

A study evaluating orthophthalaldehyde rinsing concluded that the disinfectant adsorbs polymer materials from flexible endoscopes and other medical devices and cannot be thoroughly rinsed. Any material disinfected with orthophthalaldehyde can induce an allergic reaction or mucosal injury regardless of serial rinsing procedures, so the use of protective covers is recommended.[20]

Bacterial outbreaks involving transesophageal echocardiography

Even though bacterial outbreaks involving TEE are rare, they have been described in the literature. In a French manuscript published in 2003, a case-control study involving three cases of *Legionella pneumophila* was described, in which TEE was identified as a risk factor. The patients underwent TEE while in hospital and developed pneumonia after the procedure. After environmental, process and molecular biology analyses (pulsed field gel electrophoresis), it was found that the rinsing water used on the TEE probes was contaminated with *L. pneumophila*, which reinforces the importance of high-quality water to rinse the probes.[21]

In 2007, a case-control study involving 17 patients, conducted at a large Japanese university hospital, found, from routine supervision procedures, a significant increase in the incidence of Enterobacter cloacae, isolated from sputum and oropharyngeal cultures in the hospital's cardiovascular ward. An investigation measured exposure to intubation, history of stay at the Intensive Care Unit (ICU) and oral care among patients positive and negative for E. cloacae. The odds ratio suggested cross-contamination through the

TEE probe at the ICU prior to transfer to the cardiovascular ward and this information was corroborated by pulsed field gel electrophoresis and antibiogram patterns. An intervention was carried out, in which disinfection of the probes was standardized, using 0.55% orthophthalaldehyde as a disinfectant and protective cover on the probes in order to avoid recontamination. After the intervention, the incidence rate returned to previous levels.[22]

In a manuscript published in 2013, an outbreak of multiresistant *Pseudomonas aeruginosa* occurred between May and June 2004 at a university hospital in Osaka, Japan. Sputum and pharyngeal culture showed that eight ICU patients were infected with a strain of *P. aeruginosa*, one developing severe pneumonia and evolving to death, two with less severe pneumonia and five with no infection. All patients had been monitored with the same TEE probe during their cardiac surgeries and the probe in question was found to have a 5-mm diameter crack. Pulsed field gel electrophoresis showed that the strain isolated from the patients and the probe were genetically the same. There were no flaws in the probe disinfection process, but the use of protective cover for the probes was not standardized. Once the faulty probe was withdrawn from operation and the use of a protective cover during the test was adopted, no further test-related outbreaks were observed in the subsequent eight years.[23]

A *P. aeruginosa* outbreak was also been reported in an American article published in 2013, related to the contamination of an ultrasound transmission gel during a TEE scan. In December 2011, the infection control commission of a large tertiary hospital in Beaumont, Michigan, noticed an abnormal increase in patients with *P. aeruginosa*-positive respiratory tract cultures, all from the same ICU. All the patients concerned had undergone cardiac surgeries and all of the isolated patients had the same sensitivity profile. The cases were defined as patients undergoing cardiac surgery with respiratory tract cultures positive for *P. aeruginosa* with similar antibiotic susceptibility, after December 1, 2011. Epidemiological investigation found that the only common aspect of cardiovascular surgeries was the intraoperative use of TEE. All of the probes were inspected and the cultures were collected from the probes, from the environment and from the ultrasound transmission gel. From December 9, 2011 to January 20, 2010, 16 cases were found. Of these, two developed pneumonia, five developed tracheobronchitis and nine had colonization of the respiratory tract. There was a significant increase in hospital stay among the cases, compared to controls ($p<0.0001$). During the outbreak investigation, ultrasound transmission gel bottles used in the TEE were collected and cultured. Growth of *P. aeruginosa* was detected in one of them. Molecular typing evidenced more than 95% similarity between the *P. aeruginosa* of the ultrasound gel bottle, and ten very similar cases and strains between two cases and the gel bottle. To determine if the ultrasound gel was intrinsically contaminated or if there was contamination after opening, two closed and sealed bottles were cultured, and P. aeruginosa growth was found. With this result, the brand of the contaminated gel was recalled. The local and state health authorities, the Center for Disease Control and Prevention (CDC) and the Food and Drug Administration (FDA) were notified, which generated national safety alert by the FDA for the recall of contaminated lots. After the outbreak, sterile single-use ultrasound gel was used for TEE scans and no further outbreaks were reported.[24]

An *Escherichia coli* outbreak related to TEE was described in an American manuscript published in 2013. A community hospital reported to the Los Angeles health authority a group of patients with *E. coli* positive blood and sputum cultures 1 to 4 days after undergoing cardiac surgery. Extensive epidemiological investigation was carried out with revision of processes and procedures in the cardiovascular surgery room and TEE scans, as well as collection of environmental cultures (surgical room and ICU), staff, TEE probe and ultrasound gel. Eight patients had positive *E. coli* and TEE probe cultures. All other environmental cultures were negative. Molecular typing of five samples isolated from *E. coli* patients was performed. In three samples, the genetic profile was the same as that of the sample isolated in the TEE probe; in one sample, there was only one band of difference; and another one had more than seven bands of difference. There were flaws in the probe cleaning and disinfection process, such as no visual inspection prior to cleaning, the probe was washed very close to the waste basket and was stored in a container (a briefcase) on top of the refrigerator, where the temperature is generally high. On inspection, cracks were noticed in the probe. Once the probe was withdrawn from operation and the cleaning, disinfection and storage process was improved, there were no more cases of *E. coli* in sputum cultures of cardiac surgery patients.[25]

Finally, a Swiss manuscript reported an outbreak of *Serratia marcescens* in 2012 in an educational hospital. The outbreak lasted 12 months and involved 91 patients. The onset of the outbreak occurred with three patients with infection or colonization of *S. marcescens* in the respiratory tract, at the ICU of cardiac surgery. Epidemiological investigation and surveillance cultures for *S. marcescens* were started in cardiac surgery patients. Molecular typing showed two different groups of *S. marcescens* involved in the outbreak. The first group included 74 patients with different epidemiological profiles and the second one included 17 patients with respiratory tract cultures positive for *S. marcescens* after intraoperative TEE, presenting the same molecular profile as the one isolated in the TEE probe. Analysis of the probe revealed a crack, so the probe was withdrawn from operation. During the investigation period, it was also found that the disinfectant solution was contaminated. After revising the whole process of diluting and storing the disinfectant solution at the hospital, it was chosen to purchase diluted solution and store it in disposable containers. With the implementation of corrective measures, such as improvement of disinfection procedures and preparation of TEE probes and taking samples from the probe as a routine conducted by the infection control team, no similar outbreak was found in the institution until the manuscript was published in 2016.[26]

Regarding the transmission of Hepatitis B (HBV) and C (HCV) virus, although there are cases described during gastrointestinal endoscopy, there are no literature reports of

transmission during TEE scans. Regarding the HIV virus, it seems to be sensitive to the disinfection process, and no cases of transmission during endoscopic tests, such as TEE, have been found in the literature.[2,27]

Discussion

Although the TEE is widely used in clinical practice, with major importance in cardiac surgery, the literature review evidenced that the risk of infection associated with the test is mainly related to flaws in the cleaning and disinfection of the probes and equipment maintenance.

There is a lack of studies related to the risk of TEE infection, as well as in the disinfection of the probes, considering that only BSE has produced a specific guideline on the disinfection process of TEE probes, which is not observed in other countries, where gastrointestinal endoscope disinfection protocols are used as a reference, without considering the specificities of the TEE probe, such as not fully immersing it in disinfectant solutions.[9]

The studies showed that small flaws in the probe, such as cracks, may be responsible for biofilm formation, preventing penetration of the disinfectant and compromising the whole disinfection process, also causing outbreaks related to the scan. This reinforces the importance of periodic inspection of probes and withdrawal of damaged probes from operation. As the device is very expensive, many institutions do not replace probes with minor faults, which may expose patients to higher risk of infection.

Flaws in the disinfection process, such as improper disinfection areas, contaminated rinsing water, untrained personnel and improper storage, were also responsible for the outbreaks described, which reinforces the importance of paying close attention to this process, including institutional protocols specific to the TEE scan, as well as appropriate areas for the disinfection and storage of the probes. Echocardiography societies should develop specific protocols for cleaning and disinfecting the probes, as BSE did.

Regarding the use of probe covers during the TEE scans, although there is no recent study on the use of such covers, it was recommended by most authors as an additional measure of protection against infections, as well as protection against the potential adverse effects of orthophthalaldehyde residues adsorbed by the probes.

The work done by the infection control teams in the identification of outbreaks related to TEE scans is of paramount importance. In all published manuscripts, epidemiological investigation and the adoption of surveillance cultures as a routine for patients staying at critical units were key to the identification and resolution of the outbreaks. Unfortunately, it is known that most health institutions from developing countries, such as Brazil, do not have the necessary structure to carry out surveillance cultures and molecular typing, which greatly limits the identification and resolution of the outbreaks, which possibly means that the number of unidentified TEE outbreaks is exponentially higher. Raising the awareness of echocardiographic teams on the subject and empowering the infection control teams, as well as the means for the investigation and detection of outbreaks, are indispensable for the improvement of the care provided to patients undergoing TEE scans.

Conclusion

The risk of infection related to transesophageal echocardiography exists, although there are few cases described in the literature. The establishment of specific protocols for disinfection and storage of the probes is recommended for the improvement of the procedure and reduction of the risk of infection related to the scan, as well as routine and careful inspection of the probes. Raising the awareness of echocardiographic teams and empowering the infection control teams are also essential for the detection and resolution of transesophageal echocardiographic outbreaks.

Authors' contributions

Research creation and design: Becker JB; Data acquisition: Becker JB; Data analysis and interpretation: Becker JB, Moisés VA; Manuscript writing: Becker JB; Critical revision of the manuscript for important intellectual content: Parreira FP, Fischer CH, Moisés VA.

Potential conflict of interest

The authors declare that there is no relevant conflict of interest.

Referências

1. Silva CE, Tasca R, Weitzel LH, Moisés VA, Ferreira LD, Tavares GM, et al. Normatização dos Equipamentos e Técnicas de Exame para Realização de Exames Ecocardiográficos. Arq Bras Cardiol. 2004;82(Suppl 2):1-10.
2. Côté G, Denault A. Transesophageal echocardiography-related complications. Can J Anesth. 2008;55:622-47.
3. Cury AF, Vieira MLC, Fischer CH, Rodrigues ACT, Cordovil A, Monaco C, et al. Segurança da ecocardiografia transesofágica em adultos: estudo em um hospital multidisciplinar. Arq. Bras. Cardiol. 2009;93 (5):478-83.
4. Hilberath JN, Oakes DA, Shernan SK, Bulwer BE, D'Ambra MN, Eltzschig HK. Safety of transesophageal echocardiography. J Am Soc Echocardiogr. 2010. Nov; 23(11):1115-27.
5. Min JK, Spencer KT, Furlong KT, DeCara JM, Sugeng L, Ward RP, et al. Clinical features of complications from transesophageal echocardiography: a single-center case series of 10,000 consecutive examinations. J Am Soc Echocardiogr. 2005;18(9):925-9.
6. Jacka MJ, Kruger M, Glick N. Methemoglobinemia after transesophageal echocardiography: a life-threatening complication. J Clin Anesth. 2006;18 (1):52-4.
7. Jaffery Z, Ananthasubramaniam K. A rare side effect of transesophageal echocardiography: methemoglobinemia from topical benzocaine anesthesia. Eur J Echocardiogr. 2008; 9(2):289-90.
8. Irie T, Miura N, Sato I, Okamura M, Echigo N, Goto T. The occurrence of injury and black denaturalization of the lips, tongue, and pharynx because of phtharal use for disinfection of transesophageal echocardiographic equipment and establishment of a safe disinfection method. J Cardiothorac Vasc Anesth. 2012;26(2):e18-9.

9. Kanagala P, Bradley C, Hoffman P, Steeds RP; British Society of Echocardiography. Guidelines for transoesophageal echocardiographic probe cleaning and disinfection from the British Society of Echocardiography. Eur J Echocardiogr. 2011;12(10):i17-23.

10. Rutala WA, Weber DJ. Reprocessing semicritical items: Current issues and new technologies. Am J Infect Control. 2016;44(5 Suppl):e 53-62.

11. Rutala WA, Weber DJ, et al. Guideline for Disinfection and Sterilization in Healthcare Facilities, 2008. Centers for Disease Control and Prevention. [Last update: Feburary 15, 2017]. [Cited 2017 Dec 5] Available from: https://www.cdc.gov/infectioncontrol/guidelines/disinfection/

12. Brasil. Ministério da Saúde. Agência Nacional de Vigilância Sanitária. Resolução – RE nº 2606 de 11 de agosto de 2006. Dispõe sobre as diretrizes para elaboração, validação e implantação de protocolos de reprocessamento de produtos médicos e dá outras providências. [Cited 2017 Dec5]. Available from: http://bvms.saude.gov.br/bvs/saudelegis/anvisa/2006/res2606_11_08_2006.htlm

13. Alvarado CJ, Reichelderfer M. APIC guideline for infection prevention and control in flexible endoscopy. Am J Infect Control. 2000; 28:138-55.

14. Rey JF, Bjorkman D, Nelson D, Duforest-Rey D, Axon A, Sáenz R, et al. Desinfecção de Endoscópios— um enfoque sensível aos recursos. WGO/WEO Global Guideline Endoscope disinfection, 2011. [Cited 2017 Dec 5] Available from: http://www.worldgastroenterology.org/UserFiles/file/guidelines/endoscope-disinfection-portuguese-2011.pdf

15. Brasil. Ministério da Saúde. Agência Nacional de Vigilância Sanitária. Manual de Limpeza e Desinfecção de Aparelhos Endoscópicos. Sociedade Brasileira de Enfermagem em Endoscopia Gastrointestinal. 2006. [Cited 2017 Dec 5] Available from: http://www.anvisa.gov.br/servicosaude/manuais/sobeeg_manual.pdf

16. Fritz S, Hust MH, Ochs C, Gratwohl I, Staiger M, Braun B. Use of a latex cover sheath for transesophageal echocardiography (TEE) instead of regular disinfection of the echoscope? Clin Cardiol. 1993;16(10):737-40.

17. Venticinque SG, Kashyap VS, O'Connell RJ. Chemical Burn Injury Secondary to Intraoperative Transesophageal Echocardiography. Anesth Analg. 2003; 97(5):1260-1.

18. Horikiri M, Park S, Matsui T, Suzuki K, Matsuoka T. Ortho-phthalaldehyde-induced skin mucous membrane damage from inadequate washing. BMJ Case Rep. 2011 Feb 2, 2011. pii: bcr0220102709.

19. Streckenbach SC, Alston TA. Perioral stains after Ortho-phthalaldehyde disinfection of echo probes. Anesthesiology. 2003; 99(4):1032.

20. Miner N, Harris V, Lukomski N, Ebron T. Rinsability of Orthophthalaldehyde from Endoscopes. Diagn Ther Endosc. 2012;2012: 853781.

21. Levy PY, Teysseire N, Etienne J, Raoult D. A nosocomial outbreak of Legionella pneumophila caused by contaminated transesophageal echocardiography probes. Infect Control Hosp Epidemiol.2003;24(8):619-22.

22. Kanemitsu K, Endo S, Oda K, Saito K, Kunishima H, Hatta M, et al. An increased incidence of Enterobacter cloacae in a cardiovascular ward. J Hosp Infect. 2007;66(2):130-4.

23. Seki M, Machida H, Yamagishi Y, Yoshida H, Tomono K. Nosocomial outbreak of multidrug-resistant Pseudomonas aeruginosa caused by damaged transesophageal echocardiogram probe used in cardiovascular surgical operations. J Infect Chemother. 2013;19(4):677-81.

24. Chittick P, Russo V, Sims M, Robinson-Dunn B, Oleszkowicz S, Sawarynski K, et al. An outbreak of Pseudomonas aeruginosa respiratory tract infections associated with intrinsically contaminated ultrasound transmission gel. Infect Control Hosp Epidemiol. 2013;34(8):850-3.

25. Bancroft LA, English T, Terashita D, Yasuda L. Outbreak of Escherichia coli Infections Associated with a Contaminated Transesophageal Echocardiography Probe. Infect Control Hosp Epidemiol. 2013;34(10):1121-3.

26. Vetter L, Schuepfer G, Kuster SP, Rossi M .A Hospital-wide Outbreak of Serratia marcescens, and Ishikawa's "Fishbone" Analysis to Support Outbreak Control. Qual Manag Health Care. 2016;25(1):1-7.

27. Morris J, Duckworth GJ, Ridgway GL. Gastrointestinal endoscopy decontamination failure and the risk of transmission of blood-borne viruses: a review. J Hosp Infect. 2006;63:1-13.

Applications of Strain and Strain Rate in the Evaluation of Left Ventricular Diastolic Function

José Maria Del Castillo[1,2], Carlos Mazzarollo[1,2], Waldemiro Carvalho[1,3], Jonny Vitor Diniz[1,2], Katarina Barros Oliveira[1,2], Deborah Costa Lima Araujo[1,2], Eugenio Soares Albuquerque[1,2]

[1]Escola de Ecografia de Pernambuco, Recife, PE; [2]Universidade Católica de Pernambuco, Recife, PE; [3]Hospital de Messejana, Fortaleza, CE – Brazil

Abstract

The analysis of diastolic function using conventional echocardiography (two-dimensional method, spectral Doppler and tissue Doppler) may not determine some cases of diastolic dysfunction or high left atrial pressure. The parameters that study myocardial strain (left atrial strain rate and longitudinal strain) may help diagnosis. This study describes the diastolic strain rate methods during isovolumetric relaxation time and at peak filling, apical twisting rate and maximal longitudinal left atrial strain, analyzing their applications and advantages.

Introduction

Abnormalities in ventricular, systolic and diastolic function play an important role among the factors that determine the prognosis of cardiovascular diseases. It has also been found that patients with preserved diastolic dysfunction and ejection fraction (EF) present unfavorable evolution as well as patients with depressed EF.[1] In order to understand the current state of the recommendations on diastolic dysfunction, it is necessary to divide patients into two large groups: normal left atrial pressure (LAP), which is the lighter form, and increased LAP, in which patients are more symptomatic and have a worse prognosis.[2]

Ventricular function is a consequence of the mechanisms that regulate myocardial contractility, determined by the heart's helical shape, which generates the twisting and untwisting movements.[3] Systolic and diastolic ventricular functions are closely interrelated, working the myocardium during the cardiac cycle, in a continuous and uninterrupted manner. We found, as a normal myocardial function, the one that maintains adequate cardiac output in all conditions of activity, leaving the filling and emptying pressures of the cavities within normal limits, according to the patient's age and the physiological conditions to which the patient is accustomed. The conditions of normality differ between young, elderly, sedentary and non-sedentary patients.

The diastolic function is that which regulates ventricular filling, which initially occurs by the untwisting mechanism, in which the contraction of the ascending segment of the ventricular apical band tends to distort the ventricle, promoting a rapid drop in intraventricular pressure without volume change (Isovolumetric Relaxation Time — IVRT), creating a negative pressure gradient between the base and the apex of the Left Ventricle (LV).[4] The decrease in intraventricular pressure between the closure of the aortic valve and the opening of the mitral valve occurs linearly according to time, known as the tau constant (τ). Once the intraventricular pressure falls below the LAP, the mitral valve opens and the intraventricular negative pressure rapidly sucks the blood contained in the atrial cavity during rapid ventricular filling. At this time, the ventricular myocardium undergoes a process of rapid untwisting. Then, the passive phase of diastole occurs, culminating with atrial contraction, the pressure-volume ratio of which depends on the LV wall complacency. Correlating these observations with the regime of intracavitary pressures, Figure 1 summarizes this ratio.[5]

Diastolic dysfunction, when assessed by conventional Doppler echocardiography, is divided into three types: grade 1 or abnormal relaxation, in which LAP is normal; grade 2 or pseudonormal, in which the mitral flow seems normal, but there are signs of increased LAP; and grade 3, restrictive, in which there are clear signs of increased LAP. The way in which diastolic dysfunction and elevation of LAP cannot be determined is called indeterminate.

The most recent recommendation on diastolic function[6] separates the methods used to measure it in major, secondary, and new indices.

Main echocardiographic methods for assessing diastolic function

Among the main parameters, mitral Doppler flowmetry is the method that should be used first to evaluate diastolic function, but may be insufficient to define the patient's actual situation, and other methods of measurement should often be used. In young adults, mitral Doppler presents, after mitral opening, a rapid increase in the flow velocity (D-E segment), culminating in the E wave. The velocity of this wave, however, decreases significantly with age and is less than 50 cm/s and the E/A ratio is lower than 0.8 in individuals older than 60. In young people, by contrast, the E/A ratio is often higher than 2.0.[7] This means that the age group plays a key role in the analysis of diastolic function.

Keywords

Ventricular Dysfunction; Strains; Systolic Pressure; Diastolic Pressure.

Mailing Address: José Maria Del Castillo •
Rua Jorge de Lima, 245, apto. 303, Salute, Imbiribeira. CEP: 51160-070, Recife, PE – Brazil.
E-mail: castillojmd@gmail.com

DOI: 10.5935/2318-8219.20190023

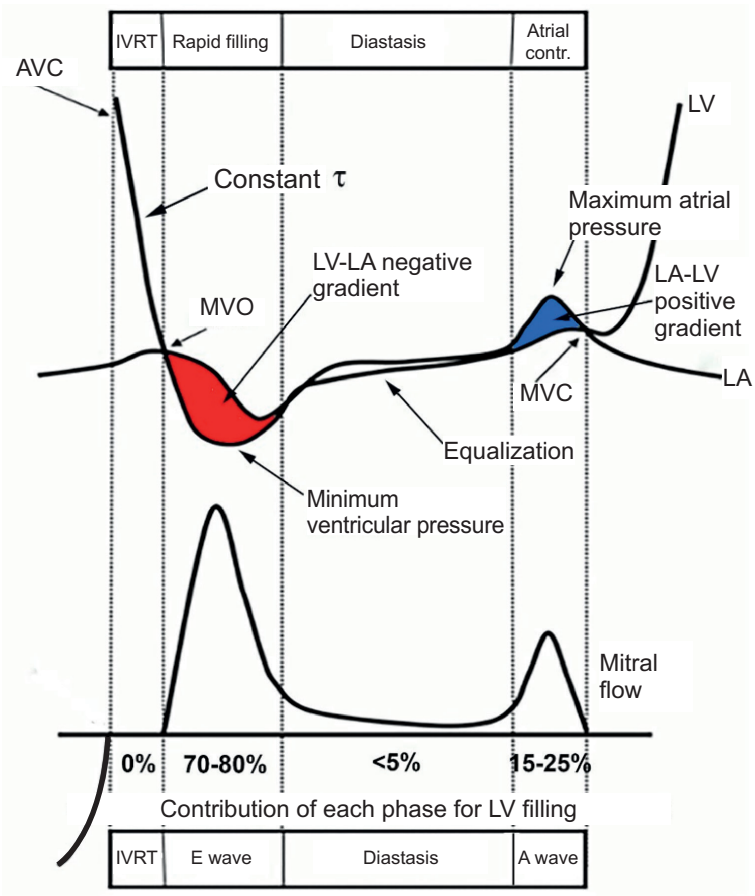


Figure 1 – *Schematic representation of the ventricular diastolic phase. Ventricular and atrial diastolic pressures are observed. In red, the gradient between the left ventricle (LV) and the left atrium (LA), negative, promotes rapid ventricular filling. In blue, the gradient between the LA and LV, positive, completing ventricular filling with the atrial contraction. Diastolic phases and the contribution of each phase to the ventricular filling are observed. AVC: aortic valve closure; MVC: netral valve closure; IVRT: isovolumetric relaxation time. MVO: mitrae valve opening.*

Another major feature used to measure diastolic function is Tissue Doppler (TD) of the mitral annulus, whose wave e' represents the ventricular untwisting velocity. The velocity is greater in the lateral annulus than in the septal annulus and corresponds to the velocity with which this area moves along the Doppler line.[8] The mitral annulus velocity can be influenced by extrinsic constraints, as in pericarditis, in which the inversion of septal and lateral velocities is observed.[9] According to the current recommendations, the normal values are > 10 cm/s for the lateral annulus and > 7 cm/s for the septal annulus, but these values are disputed because in higher age groups the velocities may be lower. Mitter et al.[10] proposed normal values for the lateral annulus > 10 cm/s for patients younger than 55, > 9 cm/s for patients aged between 55 and 65, and > 8 cm/s for individuals older than 65. The e' wave velocity must be related to the mitral flow E wave velocity. The current recommendation establishes the following normal values: lateral E/e' ratio < 13; septal E/e' ratio < 15; mean E/e' ratio < 14. Higher values are a sign of increased LAP. The study by Mitter et al. proposes the following ratio: E/e' ratio < 8 corresponds to the really normal LAP; E/e' ratio of 8 to 12 indicates undetermined LAP; E/e' ratio > 12 indicates an increase in LAP.

LA volume is undoubtedly an important indicator of increased atrial, ventricular, diastolic and pulmonary capillary (PCP) pressures. It is the main method for the evaluation of these pressures, according to the current recommendation on diastolic function.[6] Its calibration is easy and the 4-chamber and 2-chamber apical views should be used, at the end of ventricular systole, excluding the atrial appendage and the mouth of the pulmonary veins. Its body surface indexation is critical for the correct analysis. However, there are disagreements as to its limit value. Until the 2009 recommendation, the indexed LA volume considered normal was up to 28 mL/m^2,[7] and volume ≥ 34 mL/m^2 was considered an independent predictor of death, heart failure, atrial fibrillation, and ischemic stroke.[11] In 2015, in the new guideline on quantification of cavities,[12] the normal value was increased to 34 mL/m^2, a criterion followed by the current recommendation on diastolic function. Mitter et al.,[10] however, suggest maintaining the value of 28 mL/m^2 and argue that higher values are

associated with diastolic dysfunction. Mitral reflux in patients with or without diastolic dysfunction causes LA dilation and may lead to misinterpretations.

The flow of pulmonary veins is another major measurement. Obtaining the right inferior[13] pulmonary vein flow from the apical 4-chamber position depends on the echocardiographic image quality, since the depth at which the pulsatile Doppler sample volume should be positioned is usually large. Because of this, the image is not often satisfactory. As during the diastole, the pulmonary veins, LA and LV form a communicating chamber, diastolic abnormalities can be measured by this flow. Under normal conditions, the ratio of S/D waves is greater than 1 (S > D) and reverse atrial flow has a velocity <35 cm/s and duration up to 30 ms longer than the mitral A wave duration. In young people, the S/D ratio may be smaller than 1.

Another major parameter considered by the current recommendation on diastolic function[6] is the tricuspid reflux velocity. Due to the increase in LAP and, therefore, PCP, there is an increase in pulmonary vascular resistance, a consequence of reactional pulmonary arteriolar vasoconstriction. This causes right ventricular (RV) remodeling with hypertrophy, dilatation and increased systolic pressure of the cavity and, usually, tricuspid valve reflux, whose velocity corresponds to the systolic pressure gradient between the RV and the Right Atrium (RA). The normal RV pressure is up to 31 mmHg (corresponding to a tricuspid reflux velocity of 2.8 m/s). Higher values, in the presence of LV diastolic dysfunction, are considered indicative of increased LAP. This parameter should be used with caution in the presence of pulmonary disease or valvopathy that may increase pulmonary pressure.

The Valsalva maneuver, another major measure, consists in forcing expiration with the mouth and nose closed for at least 10 seconds and is intended to increase intrathoracic pressure and, as a consequence, decrease the systemic and pulmonary venous return. Reduction of pulmonary venous return causes a decrease in LAP and LV and PCP diastolic pressure. The response should vary according to whether there is diastolic dysfunction or not: normal individuals respond with a global decrease in mitral flow, that is, with an equal decrease in the velocity of waves E and A. Patients with diastolic dysfunction and high LAP should have this pressure decreased, hence improving such dysfunction, which causes reduced E wave velocity and increased A wave, turning into grade 1 dysfunction. The Valsalva maneuver is a good method to reveal diastolic dysfunction with increased LAP, but it has the drawback of its execution in practice: many patients cannot sustain the maneuver for the minimum recommended time, and others cannot even begin the maneuver.

Secondary echocardiographic methods for assessing diastolic function

The intraventricular flow Velocity of Propagation (VP), or color M mode of the LV inflow tract, records the blood flow progression from the mitral annulus to the apex of the cavity during the rapid ventricular filling phase. It responds to a complex mechanism in which the spatial-temporal distribution of intraventricular flow velocity is governed by Euler's hydrodynamic equation,[14] which correlates pressure, space, time and velocity, representing the rapid ventricular filling due to the intraventricular negative pressure caused by helical band untwisting. Its relationship with mitral E-wave (E/VP) > 2.5 in patients with depressed EF correlates reasonably with PCP > 15 mmHg, but should not be used in patients with preserved EF.[6]

Another secondary measure is IVRT, which corresponds to the interval between aortic valve closure and mitral valve opening, in which ventricular untwisting causes a rapid reduction of intracavitary pressure, without volume modification, and generates the so-called constant τ. The determination of IVRT should be performed with continuous Doppler from the 3-chamber or 5-chamber apical positions, placing the Doppler line between the LVOT and the mitral valve, thus simultaneously recording both flows. This time varies considerably with age. Table 1 shows the reference values.

Another secondary method, according to the current recommendation on diastolic function,[6] is the TE-e' interval. This calculation, which identifies PCP > 12 mmHg with 95% sensitivity and 88% specificity in patients with atrial fibrillation, relates the time between the electrocardiogram (ECG) R wave and the beginning of the mitral E wave (ET), which is subtracted from the time between the ECG R wave and the beginning of the mitral annulus tissue Doppler e' wave.[15] The measurement must be very precise, requiring the simultaneous recording of mitral flow Doppler and mitral annulus tissue Doppler, which limits its practical use.

New echocardiographic methods for assessing diastolic function

The new echocardiographic indexes for the detection of diastolic dysfunction use the parameters of myocardial strain and are mentioned in the recommendation as potentially useful, but still without sufficient evidence for its routine use.[6] Normally, patients with diastolic dysfunction and decreased EF have a decreased LV Global Longitudinal Strain (GLS), but because of the dispersion of results, it is not recommended to use this index to detect diastolic dysfunction. Diastolic strain rate during IVRT and early diastolic e' wave strain rate correlates better with diastolic dysfunction and both analyze the ventricular untwisting period. Another potentially useful index is the untwisting rate that is calculated during untwisting or apical LV twisting analysis. LA longitudinal strain which correlates with left atrial pressure, is also mentioned.

Table 1 – Reference values for isovolumetric relaxation time (IVRT) estimated by spectral Doppler.

	Age group, years			
	16-20	21-40	41-60	>60
IVRT, milliseconds	50±9 (32-68)	67±8 (51-83)	74±7 (60-88)	87±7 (73-101)

Source: adapted from Nagueh SF et al. J Am Soc Echocardiogr 2009; 22(2):107.

Strain rate during isovolumetric relaxation time

The strain rate measures the time used to produce myocardial strain, is expressed in s^{-1} and represents the efficiency of the strain. Its determination must be performed during the isovolumetric phase (Figure 2), but it may have the drawback of determining the aortic valve closure, at which point the Strain Rate is calculated during IVRT (SR_{IVRT}).[16] This may partly limit its results, since the aortic closure varies in the different cardiac cycles and in multiple echocardiographic projections, mainly if there is arrhythmia or atrial fibrillation. Its ratio with the mitral E wave (E/SR_{IVRT}) adds sensitivity, but it does not seem to be superior to the E/e' ratio. In an experimental study performed in dogs, complemented with right catheterization in 50 patients, it was found that SR_{IVRT} showed a strong correlation with constant τ (decrease in intraventricular pressure during the isovolumetric relaxation time), with r = -0.83 and p = 0.001, and that the E/SR_{IVRT} ratio showed the best correlation with PCP (r = 0.79 and p = 0.001), being more useful when the mean E/e' ratio was between 8 and 15, considered intermediate or indeterminate.[17] A recent intraoperative study in patients who underwent coronary artery bypass grafting, comparing PCP with strain rate during IVRT (SR_{IVRT}), showed that SR_{IVRT} was superior to the E/e' ratio to estimate PCP > 15 mmHg (Receiver Operating Characteristic Curve — ROC 0.94 vs. 0.47).[18]

Early diastolic strain rate

The strain rate obtained at peak e' wave is easier to obtain but appears to correlate less efficiently with diastolic dysfunction than SR_{IVRT}. Its ratio with the mitral E wave (E/early diastolic strain rate — SRe) also shows results not higher than those obtained with the E/e' ratio (Figure 2).[16]

In a recent study,[19] SRe lower than 1.0 s^{-1}, using the ROC statistical method, Area Under the Curve (AUC) of 0.95, p < 0.0001, separated with good sensitivity (83.9%) and excellent specificity (100%), normal individuals of patients with different grades of diastolic dysfunctions, allowing to reclassify 92% of patients with undetermined diastolic dysfunction into normal diastolic function (48%), diastolic dysfunction grade 1 (40%) and diastolic dysfunction grade 2 (4%), with 8% remaining in the indeterminate form.

A study with patients with acute myocardial infarction with a 29-month follow-up showed that an E/SRe ratio > 1.25 correlated with a higher rate of post-infarction complications, such as death, heart failure, stroke and atrial fibrillation, also pointing out that when clinical data, E/e' ratio and mitral deceleration time < 140 ms were added, the incremental value of the method was highly significant.[20] Another study with 120 patients with coronary artery disease and preserved LV systolic function undergoing elective coronary artery bypass grafting, correlating diastolic strain rate with PCP determined by Swan-Ganz™ pulmonary artery catheter showed that the diastolic strain rate at the mitral E-wave peak (E/SRd ratio) ≥ 1.2 presented high specificity and sensitivity (100% and 96.63%, respectively; AUC 0.99) to predict PCP > 15 mmHg. In the same study, the correlation E/e' ≥ 13 presented 74.19% sensitivity and 75.28% specificity with AUC 0.84.

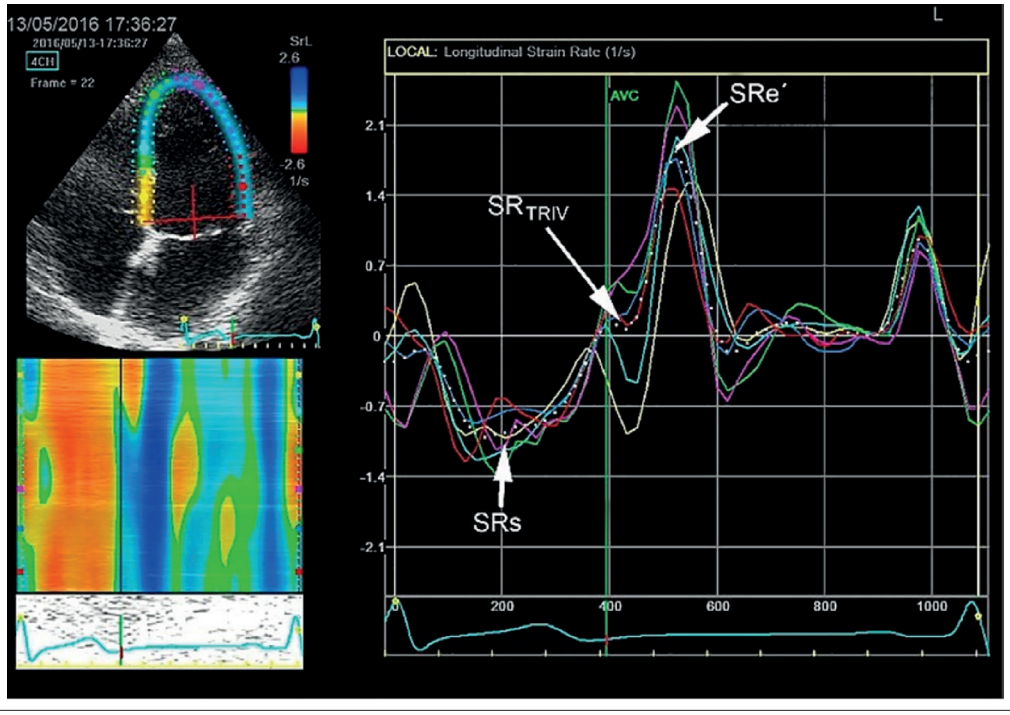


Figure 2 – *Determination of strain rate from the 4-apical chamber position. The image reveals the following components: systolic strain rate (SRs), strain rate during isovolumetric relaxation time (SRIVRT), early diastolic strain rate (SRe'). AVC: aortic valve closure.*

Untwisting rate and untwisting time

This index measures the Untwisting Rate ($SR_{untwist}$) the same way the strain rate measures the strain. The reference values are estimated in degrees/s^{-1}, with normal values in healthy individuals of -91±18 °/s^{-1}.[22] $SR_{untwist}$ precedes other variables such as intraventricular gradient peak and rapid ventricular filling peak. Any condition affecting $SR_{untwist}$ can also affect diastolic filling, end diastolic volume and ejection volume.[23] Untwisting time seems to correlate better with diastolic dysfunction in patients with preserved EF.[24] Comparison of $SR_{untwist}$ with myocardial velocities shows that $SR_{untwist}$ precedes the velocities (Figure 3).[25] This methodology is only present in some equipment, which makes it difficult to apply it in practice.

Left atrial longitudinal strain

Some studies have shown a correlation between the LA Longitudinal Strain (LS_{LA}) reduction in the reservoir phase (maximum strain) and LAP increase.[26,27] The correlation between the E/e' ratio and the LS_{LA} in patients with chronic myocardiopathy in the chronic phase of the Chikungunya virus infection, with decreased longitudinal LA strain related to an increase in the E/e' ratio has been found (Figure 4).[28]

A study of 229 cases, including controls and patients with different grades of diastolic dysfunction, analyzed the LA and LA_{LA} volumes and showed that the indexed LA volume gradually increased in grades of diastolic dysfunction, but did not separate patients with grade 1 from grade 2 diastolic dysfunction. The LS_{LA}, in the reservoir phase (maximum longitudinal strain), showed different cutoff values to detect the different grades of diastolic dysfunction, better separating the patients.[29] (Table 2)

A recent updated review on the evaluation of LA function by longitudinal strain and volumetric measurements (expansion index, total emptying fraction and active LA emptying fraction) shows that the strain methods correlate better with clinical cardiovascular events than with dynamic volumetric methods (atrial function) and static volumetric methods (volume index and LA dimension), even when these data are not altered yet.[30]

Conclusion

The analysis of ventricular diastolic function using conventional methods of analysis (two-dimensional echocardiography, spectral Doppler and tissue Doppler) is useful to diagnose diastolic dysfunction in most cases, provided that a thorough and systematic analysis is performed using all echocardiographic resources. However, some patients are considered intermediate or indeterminate, either in determining the diastolic dysfunction grade or the diagnosis of high left atrial pressure, especially those with preserved ventricular function. In these cases, the evaluation of strain and strain rate can be very useful in the classification and/or identification of diastolic dysfunction and elevation of left atrial pressure. An increasing number of studies corroborate the usefulness of cardiac strain and, especially, diastolic strain rate, in the identification of these dysfunctions. An important role is played by the left atrial longitudinal strain, whose pathophysiology has been intensively studied.

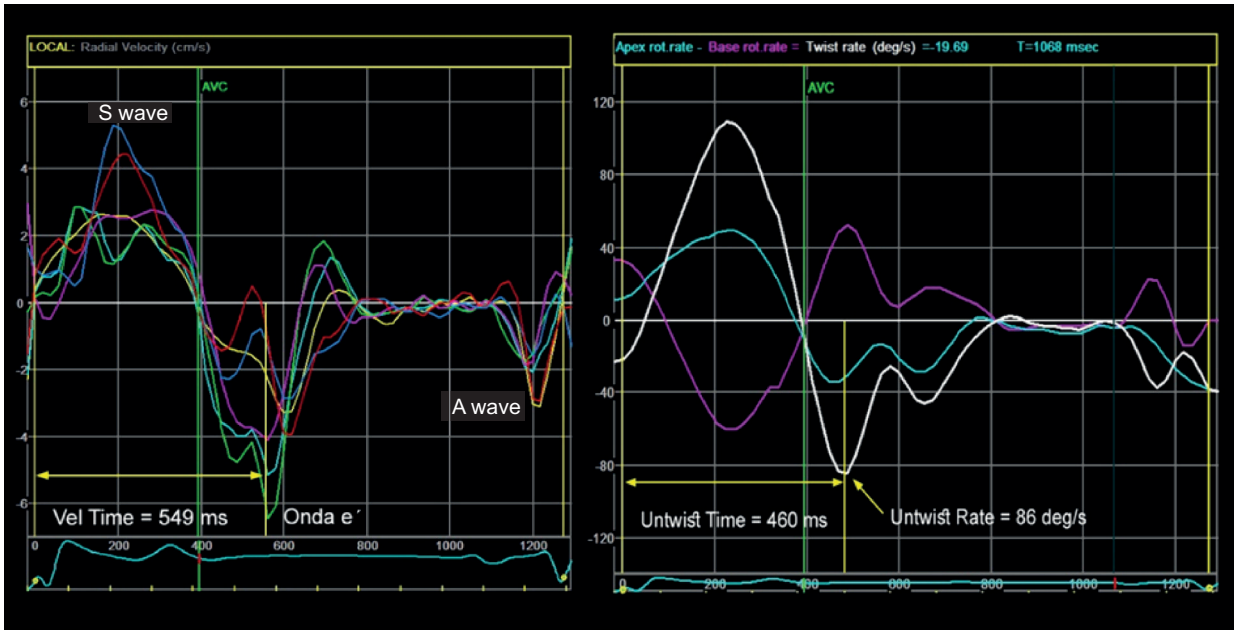


Figure 3 – *Left ventricular radial velocity (left) and twisting rate (to the right) during systole and initial diastole in normal individuals at rest in the same cardiac cycle. In the velocity image, the left ventricular filling velocity time (Vel Time) is significantly greater than the untwist time, revealing that the untwisting time precedes the myocardial velocity. AVC: aortic valve closure.*

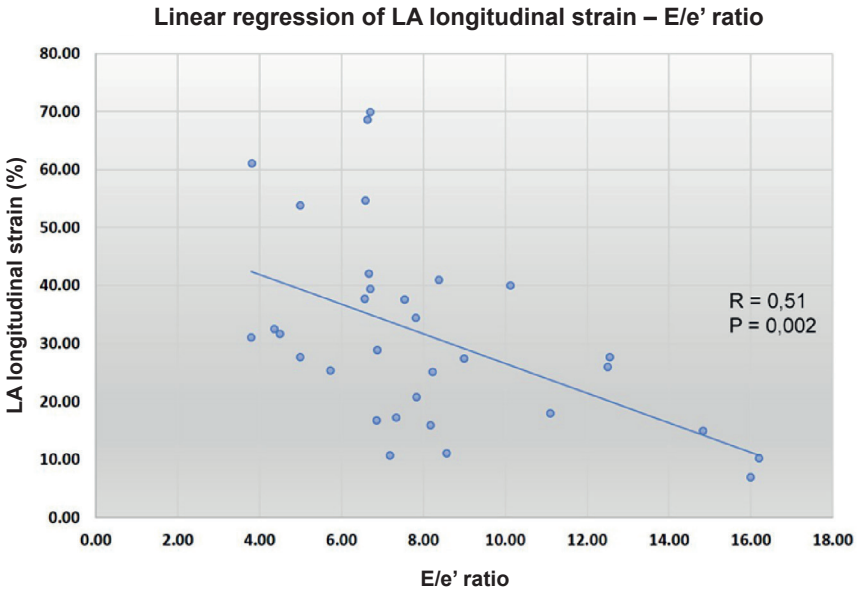


Figure 4 – *Linear regression curve between left atrial (LA) strain and E/e' ratio of mitral flow and tissue Doppler, showing a decrease in LA longitudinal strain with increased E/e' ratio.*

Table 2 – Analysis of area under the curve (AUC) for left atrial longitudinal strain in the validation of groups using the 2009 diastolic function guideline.

By-group	Validation group						
	AUC	Cut-off value (%)	Sensitivity	Specificity	PPV	NPV	Precision
Grade 0 vs. grade 1-3	0,86	35	90	59	61	90	72
Grade 0-1 vs. grade 2-3	0,89	24	75	92	75	92	88
Grade 0-2 vs. grade 3	0,91	19	90	95	64	99	95

PPV: positive predictive value; NPV: negative predictive value. Source: adapted from Singh et al., JACC Cardiovasc Imaging 2017; 10:735).

Authors' contributions:

Research creation and design: Castillo JMD; Data acquisition: Castillo JMD, Mazzarollo C, Carvalho W, Oliveira KB, Araujo DCL e Albuquerque ES; Diniz JV; Data analysis and interpretation: Castillo JMD, Diniz JV; Manuscript writing: Castillo JMD; Critical revision of the manuscript for important intellectual content: Castillo JMD e Diniz JV.

Potential conflict of interest

The authors declare that there is no relevant conflict of interest.

References

1. Redfield MM. Heart Failure with preserved ejection fraction. N Engl J Med. 2016; 375:1868-77.
2. Moller JE, Sondergaard E, Poulsen SH, Egstrup K. Pseudonormal and restrictive filling patterns predict left ventricular dilation and cardiac death after a first myocardial infarction: a serial color M-mode Doppler echocardiographic study. J Am Coll Cardiol. 2000;36:1841-6.
3. Buckberg GD. Basic science review: the helix and the heart. J Thorac Cardiovasc Surg. 2002;124:863-83.
4. Courtois M, Kovacs SJ, Ludbrook PA. Physiological early diastolic intraventricular pressure gradient is lost during acute myocardial ischemia. Circulation. 1990;81:1688-96.
5. https://thoracickey.com/evaluation-of-left-ventricular-diastolic-function/ Jun 22, 2016 | Posted by drzezo in CARDIOLOGY | Comments Off on Evaluation of Left Ventricular Diastolic Function.
6. Nagueh SF, Smiseth OA, Appleton CP, Byrd, III BF, Dokainish H, Edvardsen T, et al. Recommendations for the Evaluation of Left Ventricular

Diastolic Function by Echocardiography: An Update from the American Society of Echocardiography and the European Association of Cardiovascular Imaging. J Am Soc Echocardiogr. 2016;29:277-314.

7. Nagueh SF, Appleton CP, Gillebert TC, Marino PN, Oh JK, Smiseth OA, et al. Recommendations for the evaluation of left ventricular diastolic function by echocardiography. J Am Soc Echocardiogr. 2009;22(2):107-33.

8. Matsumura Y, Elliott PM, Virdee MS, Sorajja P, Doi Y, McKenna WJ. Left ventricular diastolic function using Doppler tissue imaging in patients with hypertrophic cardiomyopathy: relation to symptoms an exercise capacity. Heart. 2002;87:247-51.

9. Brandt RR, Oh JK. Constrictive pericarditis: role of echocardiography and magnetic resonance imaging. E-Journal of Cardiology Practice. 2017;15(23).

10. Mitter SS, Shah SJ, Thomas JD. A test in contest. E/A and E/e´to assess diastolic disfunction and LV filling pressure. J Am Coll Cardiol. 2017;69(11):1451-64.

11. Abhayaratna WP, Seward JB, Appleton CP, Douglas PS, Oh JK, Tajik AJ, et al. Left atrial size: physiologic determinants and clinical applications. J Am Coll Cardiol. 2006;47:2357-63.

12. Lang RM, Badano LP, Mor-Avi V, Afilalo J, Armstrong A, Ernande L, Flachskampf FA, et al. Recommendations for cardiac chamber quantification by echocardiography in adults: An update from the American Society of Echocardiography and the European Association of Cardiovascular Imaging. J Am Soc Echocardiogr. 2015;28:1-39.e14

13. Huang X, Huang Y, Huang T, Huang W, Huang Z.Individual pulmonary vein imaging by transthoracic echocardiography: an inadequate traditional interpretation. Eur J Echocardiogr. 2008;9:655-60.

14. Garcia MJ, Smedira NG, Greenberg NL, Main M, Firstenberg MS, Odabashian J, et al. Color M-mode Doppler flow propagation velocity is a preload insensitive index of left ventricular relaxation: animal and human validation. J Am Coll Cardiol. 2000;35:201-8.

15. Wada Y, Murata K, Tanaka T, Nose Y, Kihara C, Uchida K, et al. Simultaneous Doppler tracing of transmitral inflow and mitral annular velocity as an estimate of elevated left ventricular filling pressure in patients with atrial fibrillation. Circ J. 2012;76:675-81.

16. Kasner M, Gaub R, Sinning D, Westermann D, Steendijk P, Hoffmann W, et al. Global strain rate imaging for the estimation of diastolic function in HFNEF compared with pressure-volume loop analysis. Eur J Echocardiogr. 2010;11:743-51.

17. Wang J, Khoury DS, Thohan V, Torre-Amione G, Nagueh SF. Global diastolic strain rate for the assessment of left ventricular relaxation and filling pressures. Circulation. 2007;155:1376-1383.

18. Ebrahimi F, Kohanchi D, Gharedaghi MH, Petrossian V. Intraoperative assessment of left-ventricular diastolic function by two-dimensional speckle tracking echocardiography: relationship between pulmonary capillary wedge pressure and peak longitudinal strain rate during isovolumetric relaxation in patients undergoing coronary artery bypass graft surgery. J Cardiothorac Vasc Surg 2018; pii: S1053-0770(18)30401-4.

19. Del Castillo JM, Albuquerque ES, Silveira CAM, Lamprea DP, Sena ADM. Avaliação da função diastólica utilizando ecocardiografia Doppler e strain bidimensional. Arq Bras Cardiol Imagem Cardiovasc. 2017; 30:46-53.

20. Ersboll M, Andersen MJ, Valeur N, Mogensen UM, Fahkri Y, Thune JJ, et al. Early diastolic strain rate in relation to systolic and diastolic function and prognosis in acute myocardial infarction: a two-dimensional speckle-tracking study. Eur Heart J. 2014;35:648-56.

21. Magoon R, Malik V, Choudhury A, Chauhan S, Hote MP, Ramakrishnan S, et al. A comparison of the strain and tissue Doppler-based indices as echocardiographic correlates of the left ventricular filling pressures. J Cardiothorac Vasc Anesth. 2018;32(3):1297-304.

22. Cooke S. Left ventricular twist mechanics during exercise in trained and untrained men. A report submitted in partial fulfilment of the requirements for the Degree of Master of Science Physical Activity and Health. Cardiff School of Sport. Cardiff Metropolitan University. March 2016. [Citado em 12 de março de 2019]. Disponível em: https://repository.cardiffmet.ac.uk/handle/10369/8113

23. Beladan CC, Calin A, Rosca M, Ginghina C, Popescu BA. Left ventricular twist dynamics: principles and applications. Heart. 2014;100(9):731-40.

24. Wang J, Khoury DS, Yue Y, Torre-Amione G, Nagueh SF. Left ventricular untwisting rate by speckle tracking echocardiography. Circulation. 2007;116(22):2580-6.

25. Notomi Y, Martin-Miklovic MG, Oryszak SJ, Shiota T, Deserranno D, Popovic ZB, et al. Enhanced ventricular untwisting during exercise. A mechanistic manifestation of elastic recoil described by Doppler tissue imaging. Circulation. 2006;113:2524-33.

26. Kurt M, Wang J, Torre-Amione G, Nagueh SF. Left atrial function in diastolic heart failure. Circ Cardiovasc Imaging. 2009;2(1):10-5.

27. Wakami K, Ohte N, Asada K, Fukuta H, Goto T, Mukai S, et al. Correlation between left ventricular end-diastolic pressure and peak left atrial wall strain during left ventricular systole. J Am Soc Echocardiogr. 2009;22(7):847-51.

28. Del Castillo JM, Alencar GMP, Nóbrega MVD, Mazzarollo C, Diniz JV, Albuquerque ES, et al. Echocardiographic evaluation of myocardiopathy and late heart changes caused by Chikungunya fever. Arq Bras Cardiol Imagem Cardiovasc. 2018;31(3):183-90.

29. Singh A, Addetia M, Maffessanti F, Mor-Avi V, Lang RM. LA Strain categorization of LV diastolic function. JACC Cardiovasc Imaging. 2017;10(7):735-43.

30. Medeiros MA, Pedrosa RP, Silveira CAM, Del Castillo JM. Função atrial esquerda pelo método de speckle tracking. Além da avaliação volumétrica. Arq Bras Cardiol Imagem Cardiovasc. 2018 (ahead of print).

Ecocardiographic Findings in Patients with Mucopolissacaridose II And VI: Report of Two Cases

Stella de Souza Carneiro[1], Elisangela Gonçalves Vescovi[1], Patrick Ventorim Costa[1]
[1]Universidade Federal do Espírito Santo, Vitória, ES – Brazil

Introduction

Mucopolysaccharidoses (MPS) are disorders of lysosomal storage characterized by functional deficiency caused by the genetic mutation of one of the lysosomal enzymes that act in the catabolism of Glycosaminoglycans (GAG), previously known as mucopolysaccharides.[1] It is a hereditary disease of an autosomal recessive form, or X-linked recessive, and with different phenotypes.[2] Cardiovascular involvement is common, occurring more frequently in types I, II and VI.[1,3,4] Two-dimensional transthoracic echocardiography is the method of choice for diagnosis and follow-up when there is cardiac involvement. It is extremely relevant for the echocardiographers to be familiar with this entity. We report the case of two patients diagnosed with MPS (types II and VI), with valvular heart impairment.

Case report

Case 1

Male patient, 13 years old, with MPS type II (iduronate-sulfatase deficiency) diagnosed at 6 years of age. On physical examination, he presented a coarse face, light thoracic kyphosis, clawed hands especially caused by impairment of the distal interphalangeal joints and pes cavus. Normal heart sounds. Echocardiogram shows valve impairment, thickening of the aortic, mitral and tricuspid valves, and prolapse of the mitral valve cusps with mild to moderate regurgitation (Figures 1 and 2; Video 1). The patient is under Enzymatic Replacement Therapy (ERT) with elaprase, showing good evolution.

Case 2

Female patient, 14 years old, with MPS type VI (arylsulfatase B deficiency) diagnosed at 4 years of age. On physical examination, coarse face, continually hyper-extended head, noisy breathing, joint stiffness. Heart sounds with regular rhythm, normophonetic sounds and grade III/VI systolic murmur in mitral focus irradiating to the left axillary region. Polysomnography compatible with severe obstructive sleep apnea. Electrocardiogram with biatrial overload. Echocardiogram with mild left ventricular (LV) concentric hypertrophy and preserved systolic function (77% ejection fraction), mitral valve thickening with significant stenosis and moderate regurgitation (valve area of 0.9 cm^2); moderate biatrial increase (Figures 3 and 4; Videos 2 to 4); right ventricular (RV) dilatation with preserved systolic function; mild tricuspid regurgitation with high (60 mmHg) pulmonary artery systolic pressure (PSAP) and mild pericardial effusion. Patient under ERT with Naglazyme and multidisciplinary follow-up.

Discussion

MPS were clinically described by Hunter in 1917[5] and were considered a group of lysosomal storage disorders resulting from lack of enzymes in GAG degradation. These accumulate in the cell lysosomes, leading to progressive tissue and organ dysfunction, which varies with the specific GAG deposited and enzymatic mutation. It is known that deficiency of 11 different enzymes causes seven MPS phenotypes that are hereditary, autosomal recessive (MPS I, III, IV, VI, VII and IX) or X-linked recessive (MPS II).[1,2]

Cardiac involvement was reported in all MPS syndromes, consisting of a common and early characteristic, particularly for those with MPS I, II and VI, which are the syndromes in which the dermatan sulfate catabolism is impaired.[1] Heart valve thickening, valvular dysfunctions and ventricular hypertrophies are commonly present; conduction disorders, coronary artery disorders and other vascular complications may also occur.[1,6] Cardiac signs and symptoms are underestimated because the disease affects other organs.[1,4]

MPS II (or Hunter syndrome) has X-linked inheritance and is caused by the deficient activity of the enzyme iduronate-sulfatase (IDS), with consequent increase in the urinary concentration of GAG dermatan sulfate and heparan sulfate. The incidence of MPS II is estimated at 1:68,000 to 1:320,000 live births. In Brazil, MPS II seems to be one of the most frequent types.[5,7]

It is clinically characterized by coarse face, skeletal disorders, short stature, joint contractures, delayed neuropsychomotor development, recurrent infections of upper and lower airways, deafness and cardiopathy. MPS II is associated with major clinical heterogeneity and is usually classified according to the presence of developmental delays and/or mental retardation, in neuropathic or non-neuropathic forms.[5,7]

MPS VI (or Maroteaux-Lamy syndrome) is a rare autosomal recessive transcript with an incidence of 0.05 to 0.43 in 100,000 live births. It is caused by the deficient activity of

Keywords

Mucopolysaccharidosis II; Mucopolysaccharidosis IV.

Mailing Address: Stella de Souza Carneiro •
Rua Dom Pedro II, 354 - Bloco 6 apto 310. CEP 29167-168, Colina de Laranjeiras – Serra, ES – Brazil.
E-mail:

DOI: 10.5935/2318-8219.20190024

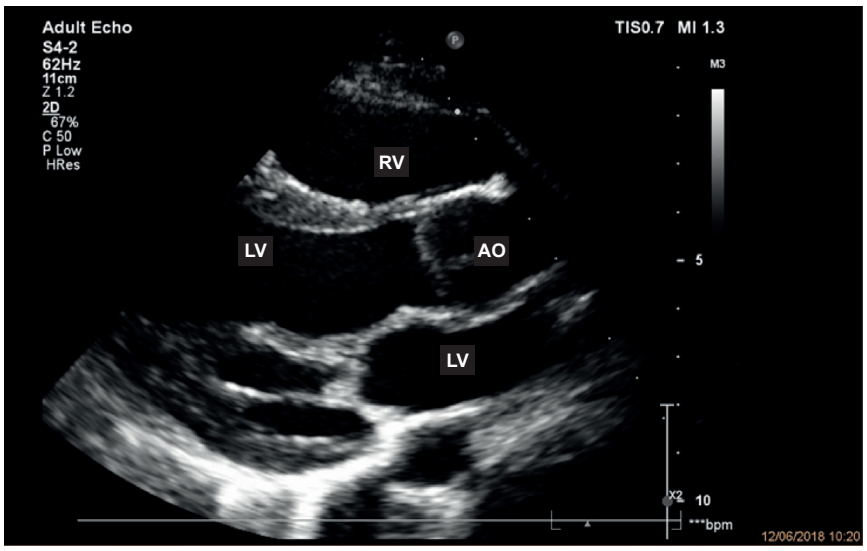


Figure 1 – *Parasternal longitudinal view evidencing mitral valve thickening and discrete aortic valve prolapse. RV: right ventricle; LV: left ventricle; AO: aorta; LV — left ventricle.*

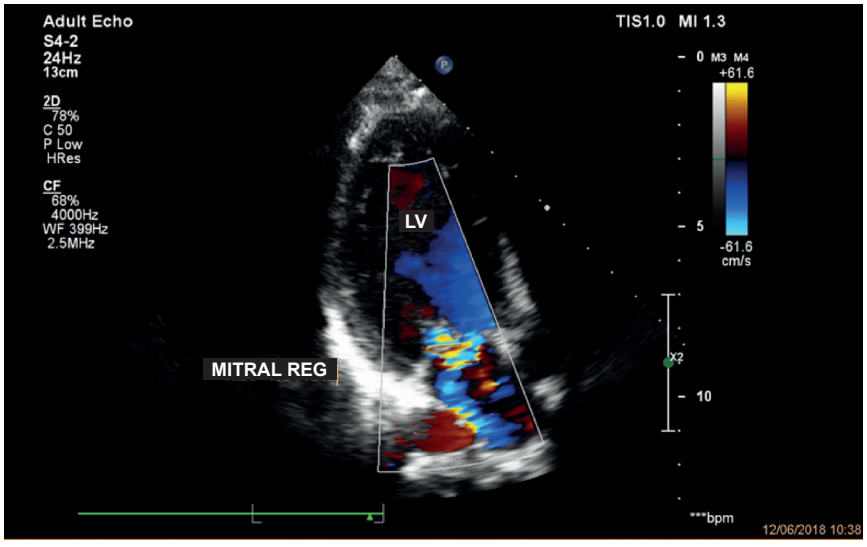


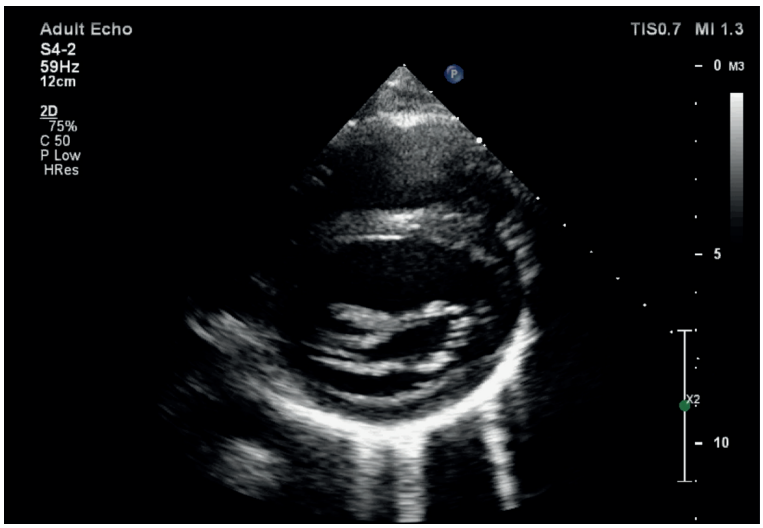
Figure 2 – *Longitudinal apical view evidencing mitral valve insufficiency with eccentric jet graduated as mild to moderate.*

arylsulfatase B (N-acetylgalactosamine-4-sulfatase) resulting in intra- and extracellular accumulation of GAG, especially dermatan sulfate.[3]

The clinical manifestations of MPS VI and its severity are variable, but usually include facial dysmorphism, short stature, hepatosplenomegaly, multiple dysostosis, joint stiffness, corneal turbidity and craniocervical stenosis. However, irrespective of the rate of progression, all patients develop multiple debilitating and often life-threatening conditions. There is a small sample of studies and case reports available describing the cardiac conditions of this disease, but nearly all of them describe substantial and progressive cardiovascular impairment, valvular impairment and ventricular hypertrophy.[3] Cardiorespiratory disease tends to progress with age and is the most common death cause.[3]

Regardless of the phenotype, all forms of MPS are associated with early morbidity and mortality.

Regarding diagnosis, transthoracic two-dimensional echocardiography is the imaging method of choice to evaluate anatomy and cardiac function in patients with MPS. Magnetic Resonance Imaging (MRI) and Computed Tomography (CT) are advanced techniques, but not routinely used.[1]



Video 1 – *Parasternal short axis view showing mitral valve thickening.*
Watch the video here: http://departamentos.cardiol.br/dic/publicacoes/revistadic/2019/v32_2/video_v32_2_achados_ingles.asp

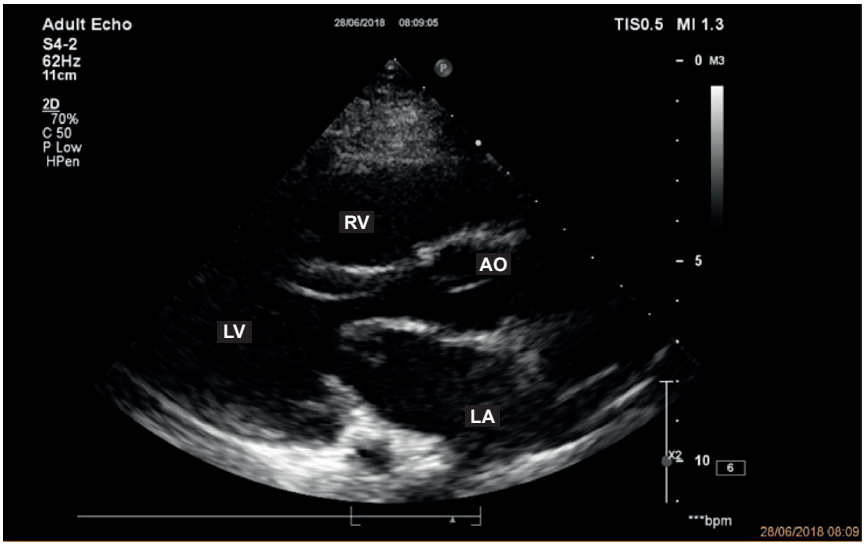


Figure 3 – *Parasternal longitudinal view evidencing mitral valve with thickening mainly at the tip of the cusps. RV: right ventricle; LV: left ventricle; AO: aorta; LA: left atrium.*

Progressive cardiac valve disease is the most prominent and uniform cardiac condition (60 and 90%) of patients with MPS. Cardiac valve thickening with associated dysfunction has been reported in more than 80% of patients with MPS I (including slowly evolving phenotypes), 57% of patients with MPS II, and in all individuals with MPS VI, except for the more slowly progressive ones.[1]

Most studies have reported that valve regurgitation is more common than stenosis, and the mitral valve is more commonly affected than the aortic valve. In general, the mitral and aortic valves are more severely affected than the others. The mitral valve cusps are markedly thickened and similar to cartilage, with particularly thick edges. The subvalvular mitral valve apparatus may have shortened chordae tendineae and thick papillary muscles, resulting in dysmorphic and poorly movable leaflets.[1]

Moreover, concomitantly with valve impairment, Pulmonary Hypertension (HP) is a major cause of morbidity and mortality in these patients, especially in childhood.[6,8] Therefore, it is necessary to pay attention to its detection and early treatment in this population.[6]

Factors implicated in the genesis of pulmonary

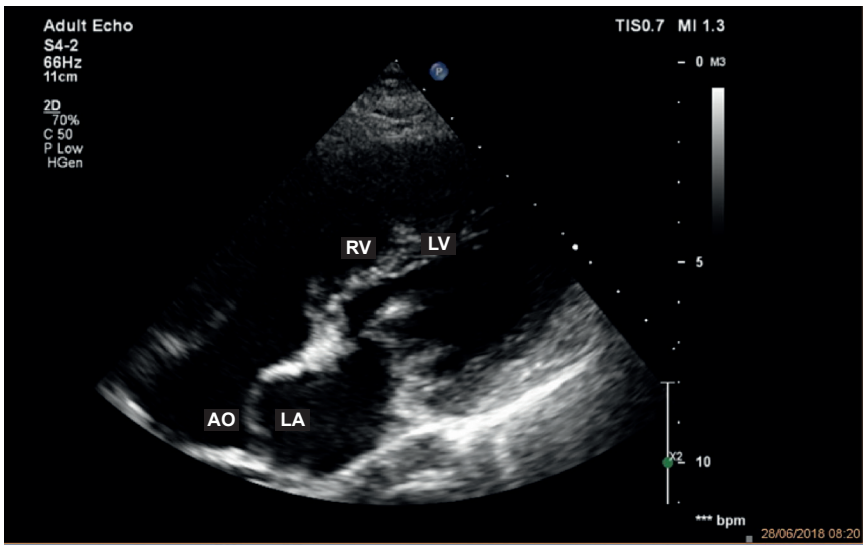
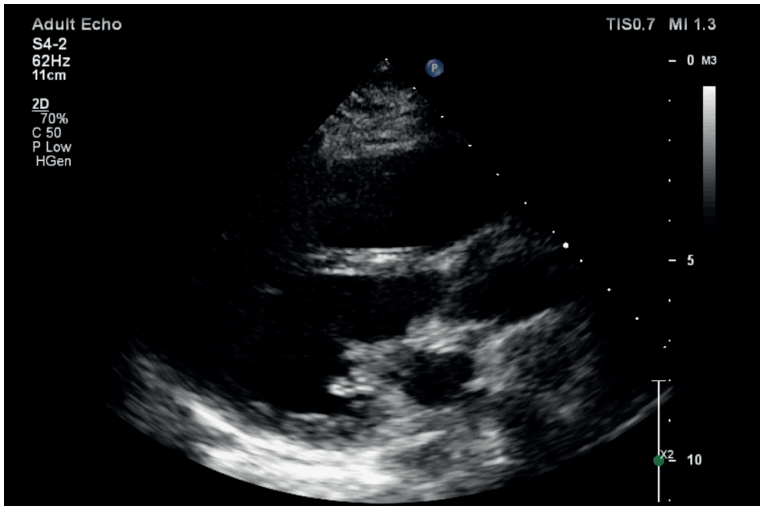


Figure 4 – *4-chamber apical window modified, evidencing significant mitral impairment with subvalvular thickening and impairment, as well as interatrial septum deviation to the right. RV: right ventricle; LV: left ventricle; AO: aorta; LA: left atrium.*

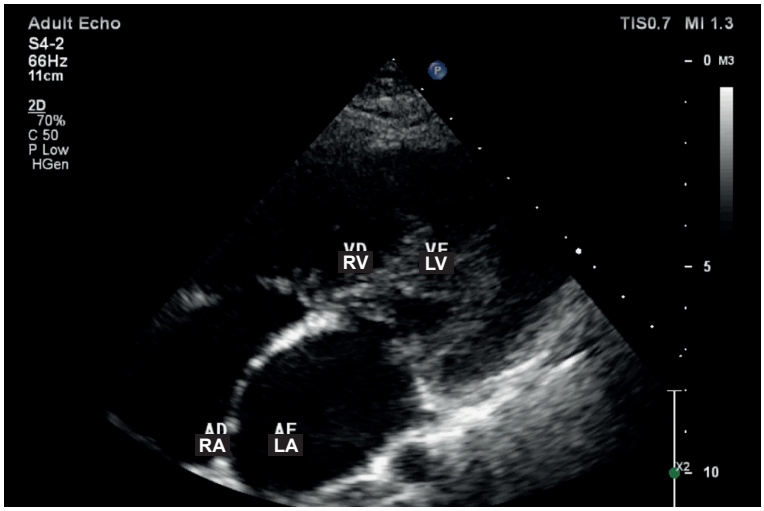


Video 2 – *Parasternal longitudinal window showing severe mitral valve thickening with restricted opening.*
Watch the video here: http://departamentos.cardiol.br/dic/publicacoes/revistadic/2019/v32_2/video_v32_2_achados_ingles.asp

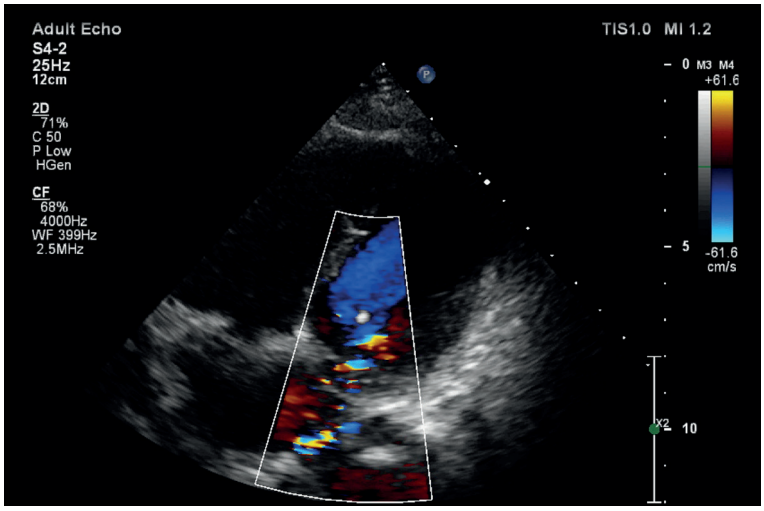
hypertension are frequent in patients with MPS: left heart valve lesions, GAG deposits in the pulmonary and systemic vascular beds and lymphatic tissue, thoracic deformities, frequent upper and lower airway infections and obstructive apnea.[6]

Accumulation of GAG in the lymphatic tissue provides gum, tonsils and adenoid thickening, thereby causing obstruction of the airways. This progressive obstruction may result in sleep apnea, leading to severe hypoxemia. There is also a group of central apnea-prone patients due to high medullary compression caused by atlantoaxial instability and odontoid dysplasia. Chronic hypoxemia due to airway obstruction and pulmonary disease may lead to pulmonary hypertension, which, in turn, may exacerbate right heart failure caused by the mitral disease.[8]

Treatment of MPS is done with enzyme replacement, which can be used in MPS I, II, IV and VI.[4] This therapy consists in infusion of recombinant enzyme to replace the absent or deficient activity of the involved enzyme.[1,3]



Video 3 – *4-chamber apical window modified showing mitral valve thickening.*
Watch the video here: http://departamentos.cardiol.br/dic/publicacoes/revistadic/2019/v32_2/video_v32_2_achados_ingles.asp



Video 4 – *Apical 4-chamber view modified showing double mitral lesion.*
Watch the video here: http://departamentos.cardiol.br/dic/publicacoes/revistadic/2019/v32_2/video_v32_2_achados_ingles.asp

Transplantation of hematopoietic stem cells can also be performed. Both therapies may change the overall progression of the disease with regression of ventricular hypertrophy and maintenance of ventricular function. Cardiac valve disease does not generally respond or, at best, stabilizes, although ERT in the first months of life may prevent valvular involvement or serious cardiac damage, which emphasizes the importance of early diagnosis and treatment in MPS.[1,9,10]

Authors' contributions

Acquisition of data: Carneiro SS, Vescovi EG, Costa PV; Analysis and interpretation of the data: Carneiro SS, Costa PV; Writing the manuscript: Carneiro SS; Critical revision of the manuscript for important intellectual content: Carneiro SS, Vescovi EG, Costa PV.

Potential Conflicts of Interest

There are no relevant conflicts of interest.

References

1. Braunlin EA, Harmatz PR, Scarpa M, Furlanetto B, Kampmann C, Loehr JP, et al. Cardiac disease in patients with mucopolysaccharidosis: presentation, diagnosis and management. J Inherit Metab Dis. 2011;34(6):1183-97.
2. Sweet ME, MestroniHYPERLINK "https://www.ncbi.nlm.nih.gov/pubmed/?term=Mestroni%20L%5BAuthor%5D&cauthor=true&cauthor_uid=29525649" L, Taylor MRG. Genetic Infiltrative Cardiomyopathies. Heart Fail Clin. 2018;14(2):215-24.
3. Kampmann C, Lampe C, Whybra-Trümpler C, Wiethoff CM, Mengel E, Arash L, et al. Mucopolysaccharidosis VI: cardiac involvement and the impact of enzyme replacement therapy. J Inherit Metab Dis. 2014;37(2):269-76.
4. Andrade MFA, Guimarães ICB, Acosta AX, Leão EKEA, Moreira MIG, Mendes CMC. Left ventricular assessment in patients with mucopolysaccharidosis using conventional echocardiography and myocardial deformation by two-dimensional speckle-tracking method. J Pediatr (Rio J). 2018. pii: S0021-7557(17)31009-4.
5. Wraith JE. The mucopolysaccharidoses: a clinical review and guide to management. Arch Dis Child. 1995 Mar;72(3):263-7.
6. Leal GN, de Paula AC, Leone C, Kim CA. Echocardiographic study of paediatric patients with mucopolysaccharidosis. Cardiol Young. 2010 Jun;20(3):254-61.
7. Pinto LLC, Schwartz IVD, Puga ACS, Vieira TA, Munoz MV, Giugliani R. Prospective study of 11 Brazilian patients with mucopolysaccharidosis II. J Pediatr (Rio J). 2006;82(4):273-8.
8. Semenza GL, Pyeritz RE. Respiratory complications of mucopolysaccharide storage disorders. Medicine (Baltimore). 1988;67(4):209-19.
9. Quaio CR, Grinberg H, Vieira ML, Paula AC, Leal GN, Gomy I, et al. Report of a Large Brazilian Family With a Very Attenuated Form of Hunter Syndrome (MPS II). JIMD Rep. 2012;4:125-8.
10. Leal GN, de Paula AC, Morhy SS, Andrade JL, Kim CAJ. Advantages of early replacement therapy for mucopolysaccharidosis type VI: echocardiographic follow-up of siblings. Cardiol Young. 2014;24(2):229-35.

Transitory Apical Hypokinesia in Hyperthyroidism

Luis Eduardo da Rocha Silveira[1]

[1]*Hospital e Maternidade Marieta Konder Bornhausen, Itajaí, SC – Brazil*

Introduction

Cardiovascular symptoms are a frequent and, sometimes, predominant clinical manifestation in patients with hyperthyroidism. Reports of palpitations is present in most cases. Increased heart rate results both from increased sympathetic tone and reduced parasympathetic tone. It is common to observe frequency above 90 bpm at rest, dull diurnal variation and exaggerated elevation on exertion. A subgroup of patients may develop precordial pain similar to angina. In rare patients, generally young women, resting chest pain syndrome is associated with ischemic abnormalities on electrocardiogram. Cardiac catheterization demonstrates that most have angiographically normal coronary arteries. However, coronary vasospasms similar to those found in Prinzmetal angina are reported. Myocardial infarction rarely develops, and these patients seem to respond to calcium channel blockers or nitroglycerin.

Case report

Patient A.S.P., female, 59 years old, on a routine visit to the general practitioner. She had healthy habits, exercised regularly and had no risk factors for coronary artery disease. Laboratory tests, echocardiogram and carotid Doppler were requested.

Carotid Doppler revealed a slight increase in the medial-intimal thickness located in both bifurcations and, as an additional finding, two nodules were detected in the left lobe of the thyroid. Echocardiogram showed normal cavity diameters, normal parietal thickness, cardiac valves without anatomical abnormalities and undetermined diastolic function (E/E' ratio 10, left atrial volume 35 mL/m^2, lateral e' velocity 0.89 m/s and tricuspid regurgitation velocity <2.8 cm/s). Evaluation of segmental motility revealed hypokinesia in the apical region (Videos 1 to 3). Ejection fraction by the Simpson method was 53% and left ventricular global longitudinal strain was -15.5% (Figure 1). Longitudinal strain of the 2-chamber apical window revealed post-systolic contraction in several segments (Figure 2).

Laboratory tests revealed thyroid stimulating hormone (TSH) <0.01, anti-TPO 372.

Coronary angiography was requested to rule out coronary artery disease in a low-risk asymptomatic patient with segmental disorders. The only disorder found was a calcified plaque at the origin of the anterior descending artery, which promotes discrete luminal reduction.

Keywords

Hypothyroidism; Hypokinesia; Vasospasm.

Mailing Address: Luis Eduardo da Rocha Silveira •
Rua 200, 70, apto. 801, Centro. CEP 88330-648, Balneário Camboriú, Santa Catarina – Brazil
E-mail: luisrsilveira@gmail.com

DOI: 10.5935/2318-8219.20190025

Two weeks after the first echocardiogram, the second test (still untreated) revealed normal segmental contractility (Videos 4 to 6), same diastolic function pattern, ejection fraction 60% and global longitudinal strain -22.6% (Figure 3). Strain improved on all segments, but the most expressive increase was in the anterolateral and inferior apical regions. Two-chamber longitudinal strain shows a more uniform strain pattern with no post-systolic contraction (Figure 4).

Due to the absence of ischemic origin for the segmental disorders and spontaneous improvement, even before specific treatment, it was decided to start the treatment with tiamazol 20 mg/day, and the patient was referred to the endocrinologist for follow-up and functional evaluation of the thyroid nodules.

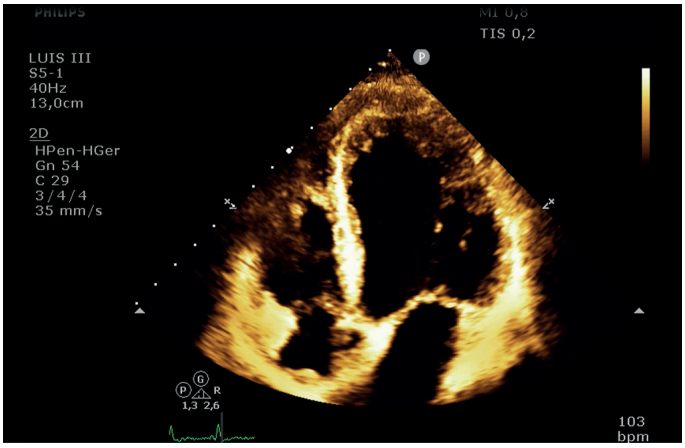
Discussion

Thyroid hormones have different effects on cardiovascular hemodynamics, such as reduced peripheral vascular resistance, activation of the renin-angiotensin-aldosterone system and increased preload and cardiac output. Excessive adrenergic activity may create a state of tachycardiomyopathy and progressive deterioration of left ventricular systolic and diastolic functions. Animal studies prior to the development of speckle tracking have found that one of the first abnormalities of hyperthyroidism on echocardiogram is left atrial increase and free wall hypertrophy. Today, it is believed that this is already a late event, as minor studies show a reduced left ventricular longitudinal strain before any structural disorder. Global longitudinal strain reduction is reported in both hypo and hyperthyroidism, and reduced ejection fraction depends on more intense myocardial impairment. In this particular case, as the patient never presented any symptoms of myocardial dysfunction, and the disorders presented spontaneous remission in two weeks without any specific treatment, we deduced that vasospasm was responsible for the abnormalities detected on the echocardiogram. The theory of vasospasm is largely based on the cellular disorders that occur in hyperthyroidism, which end up increasing cytoplasmic calcium.

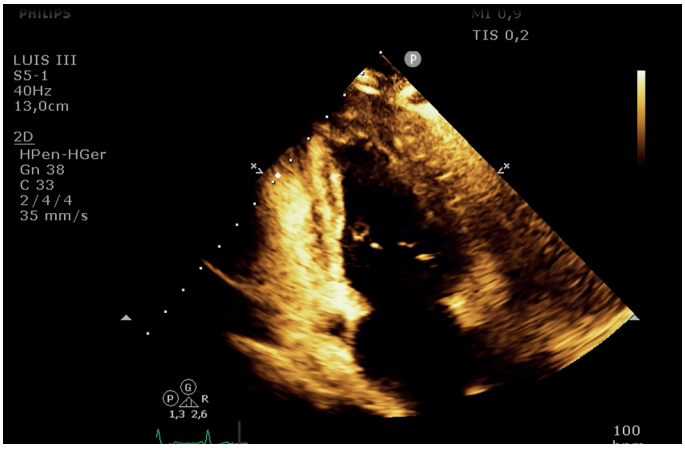
Cardiologists often encounter disorders in thyroid function. Most of these disorders are due to hypothyroidism and, occasionally, to hyperthyroidism. On routine echocardiogram in asymptomatic and low-risk patients, it is not common to find segmental contractility disorders. Because it is a myocardial region irrigated by the anterior descending artery, anatomical evaluation of the coronary circulation was required. As coronary angiotomography has a high negative predictive value, it was chosen over invasive study. Due to the absence of other explanations for the clinical condition presented and suppression of the thyroid stimulating hormone, we deduced that reversible segmental disorder was caused by excessive circulating thyroid hormone.

Potential conflict of interest

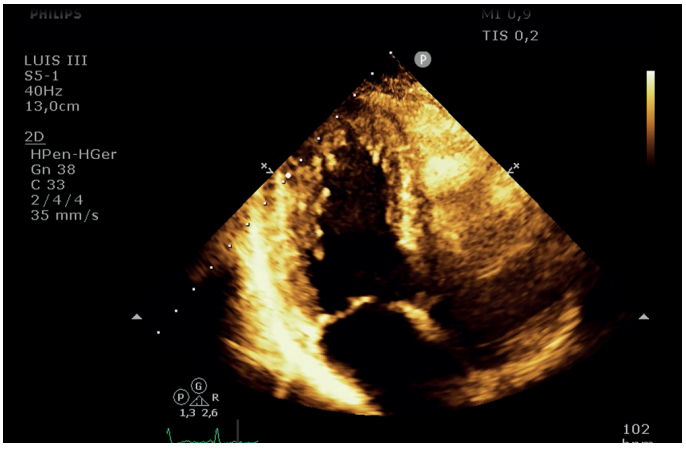
The authors declare that there is no relevant conflict of interest.



Video 1 – *Apical 4-chamber view of the first echocardiogram with apical hypokinesia.*
Watch the video here: http://departamentos.cardiol.br/dic/publicacoes/revistadic/2019/v32_2/video_v32_2_hipocinesia_ingles.asp



Video 2 – *Apical 2-chamber view of the first echocardiogram with apical hypokinesia.*
Watch the video here: http://departamentos.cardiol.br/dic/publicacoes/revistadic/2019/v32_2/video_v32_2_hipocinesia_ingles.asp



Video 3 – *Apical 3-chamber view of the first echocardiogram with apical hypokinesia.*
Watch the video here: http://departamentos.cardiol.br/dic/publicacoes/revistadic/2019/v32_2/video_v32_2_hipocinesia_ingles.asp

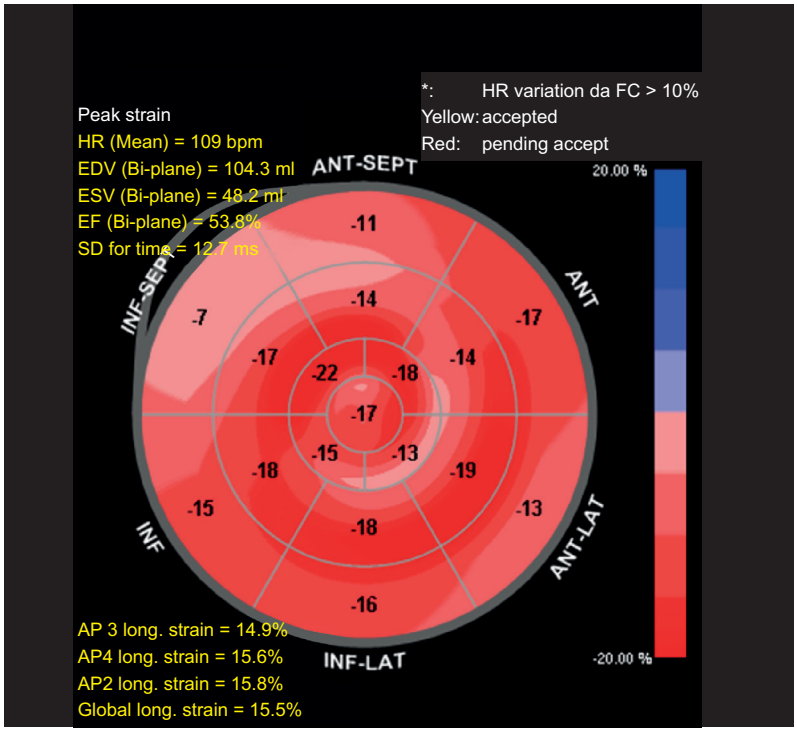


Figure 1 – *Global longitudinal strain of the first echocardiogram with discrete reduction.*

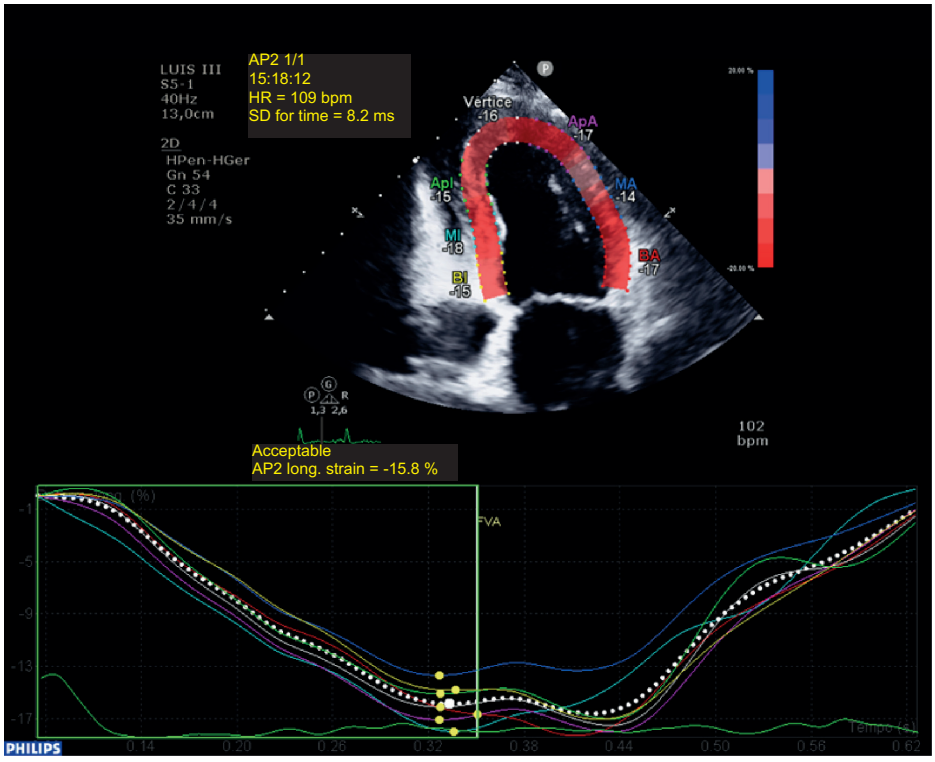
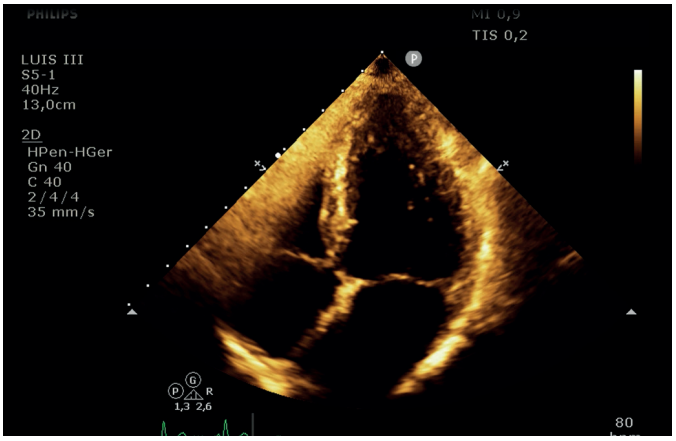
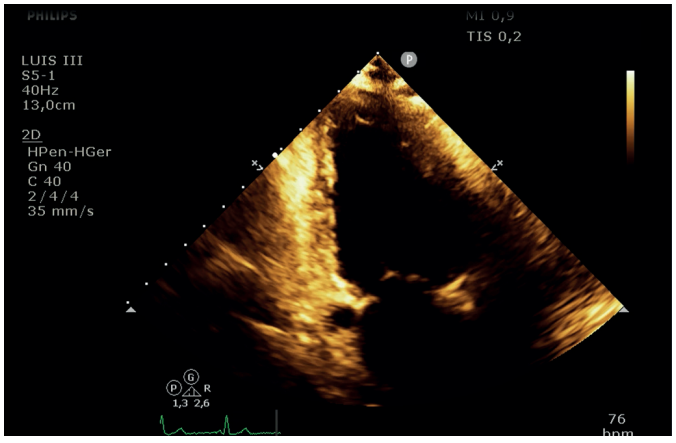


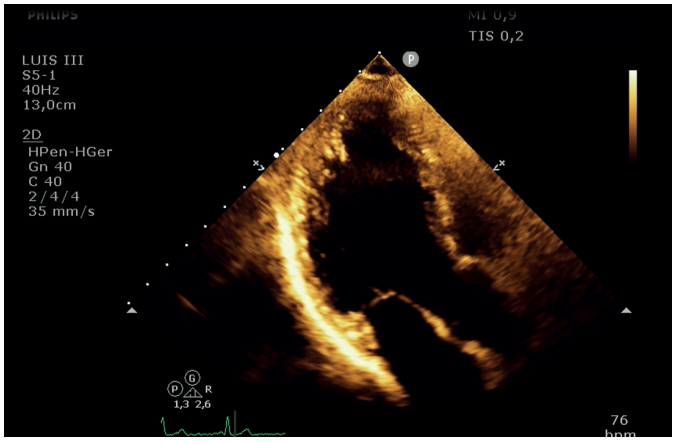
Figure 2 – *Two-chamber apical longitudinal strain of the first echocardiogram with reduced values and post-systolic contraction.*



Video 4 – *Apical 4-chamber view of the second echocardiogram with normal contractility.*
Watch the video here: http://departamentos.cardiol.br/dic/publicacoes/revistadic/2019/v32_2/video_v32_2_hipocinesia_ingles.asp



Video 5 – *Apical 2-chamber view of the second echocardiogram with normal contractility.*
Watch the video here: http://departamentos.cardiol.br/dic/publicacoes/revistadic/2019/v32_2/video_v32_2_hipocinesia_ingles.asp



Video 6 – *Apical 3-chamber view of the second echocardiogram with normal contractility.*
Watch the video here: http://departamentos.cardiol.br/dic/publicacoes/revistadic/2019/v32_2/video_v32_2_hipocinesia_ingles.asp

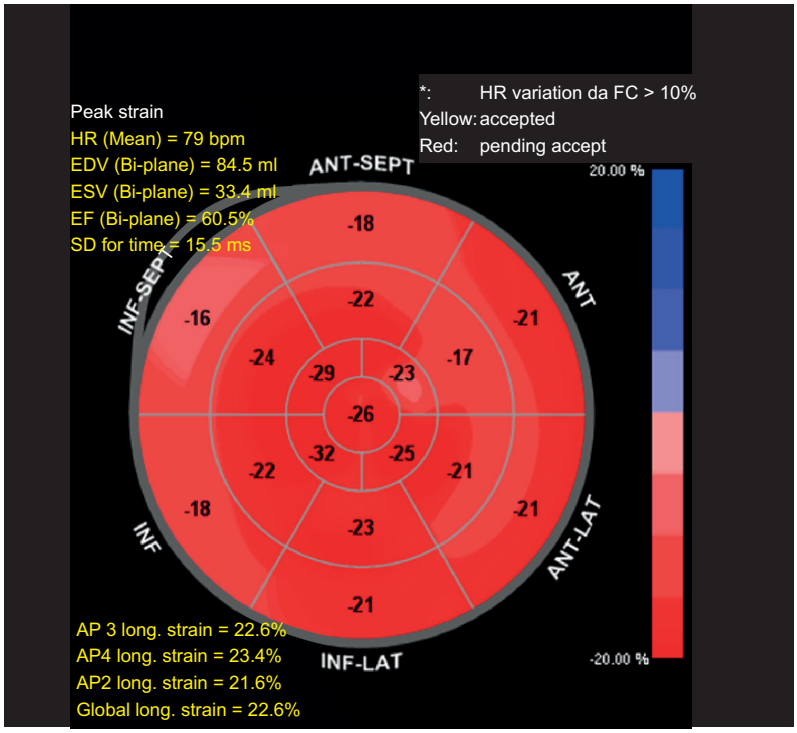


Figure 4 – *Global longitudinal strain of the second echocardiogram with normal value.*

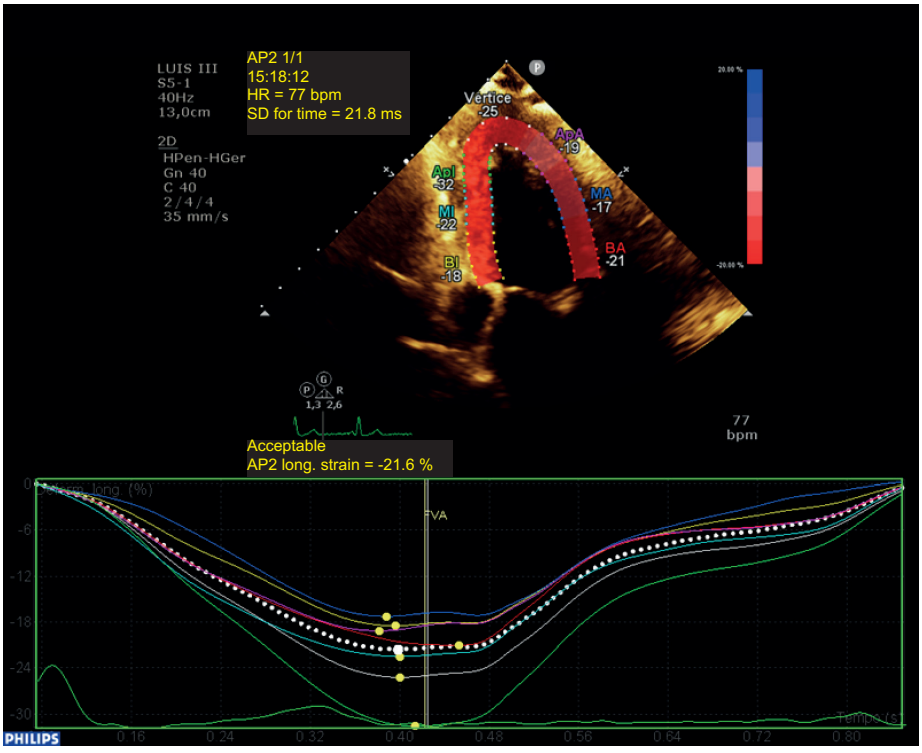


Figure 4 – *Two-chamber apical longitudinal strain of the second echocardiogram with normal values and without post-systolic contraction.*

References

1. Mann DL, Zipes DP, Libby P, Bonow RO. Tratado de Doenças Cardiovasculares. 10ª Edição Elsevier; 2016.
2. Klein I, Ojamaa K. Thyroid hormone and the cardiovascular system. N Eng J Med. 2001; 344(7):501-9.
3. Carr AN, Kranias EG. Thyroid hormone regulation of calcium cycling proteins. Thyroid. 2002;12(6):453-7.
4. Ojamaa K, Kenessey A, Klein I. Thyroid hormone regulation of phospholamban phosphorylation in the rat heart. Endocrinology. 2000;141(6):2139-44.
5. Bronner F. Extracellular and intracellular regulation of calcium homeostasis. ScientificWorldJournal. 2001 Dec 22;1:919-25.
6. Zhang L, Kelley J, Schmeisser G, Kobayashi YM, Jones LR. Complex formation between junctin, triadin, calsequestrin and the ryanodine receptor: proteins of the cardiac junctional sarcoplasmatic reticulum membrane. J Biol Chem. 1997 Sep 12;272(37):23389-97.

Agenesia of Right Pulmonary Artery Associated with High Output Coronary Fistula for Superior Vena Cava and Intrapulmonary Artery Branches: Case Report

Aline Valério de Lima, Stella Souza Carneiro, José Augusto Murad, José Ayrton Arruda, José Guilherme Caselli, Edson Egashira

Hospital UNIMED Vitória,[1] Vitória, ES – Brazil; Hospital Universitário Cassiano Antonio Moraes,[2] Vitória, ES – Brazil

Introduction

Unilateral Pulmonary Artery Agenesis (UPAA) is a rare congenital anomaly that occurs due to malformation of the sixth aortic arch of the affected side during embryogenesis, and may occur in isolation or in combination with other cardiovascular anomalies.[1,2] Diagnosis usually occurs in adolescence, but individuals may be asymptomatic and receive late diagnosis. We report a case of symptomatic patient with right pulmonary artery agenesis accompanied by high-output fistula of the Circumflex Artery (CXA) to the Superior Vena Cava (SVC).

Case report

Female patient, 60 years old, hypertensive, with pulmonary fibrosis, bronchiectasis and anxiety disorder. She was admitted to the emergency room reporting typical precordial pain, hemodynamically stable, with no ischemic disorders on electrocardiogram and negative myocardial necrosis markers. Chest X-ray showed only right lung volume reduction (Figure 1). She reported previous episodes of a similar condition and undergone coronary angiography 2 years before in another hospital. A previous test suggested CXA high-output coronary fistula to intrapulmonary artery branches and SVC (Figure 2).

Computed tomography angiography was performed to investigate the coronary artery and lungs, revealing CXA of great anatomical importance, originating two marginal arteries, without obstructive lesions, with anomaly characterized by coronary fistula originating in its proximal third and retroaortic path flowing into the SVC, and right lung with volume reduction and left buffalo chest (Figure 3). Absence of right pulmonary artery was found, and pulmonary irrigation originated in the collaterals from the aorta and its branches. Myocardial scintigraphy did not demonstrate ischemia and echocardiogram was also normal. The patient remained stable while in hospital and clinical treatment was chosen.

Keywords

Pulmonary Artery Agenesis; Fistula; Ischemia.

Mailing Address: Aline Valério de Lima •
Rua Carijós, 625, apto. 114, Jardim da Penha. CEP 29060-700, Vitória, ES – Brazil
E-mail: alinevalerio1@hotmail.com

DOI: 10.5935/2318-8219.20190026

Discussion

The first reported case of UPAA was published in 1868 by Frantzel. Since then, about 420 cases have been reported.[1,2] Its prevalence is around 1:200,000 individuals, with no gender differences. UPAA occurs due to malformation during embryogenesis, with persistence of the pulmonary artery connection to the sixth distal aortic arch, where the ductus arteriosus connects to the primitive dorsal aorta.[1,3] Some studies point out a relationship between absence of pulmonary artery with absence of the ipsilateral ductus arteriosus, obtained in radiological, surgical or post-mortem documentation.[3] Transient systemic-pulmonary collateral arteries may arise over two long periods, even during initial embryonic development, and remain if there is obstruction in the pulmonary outflow tract.[3] When this obstruction occurs at a very late stage of fetal development or after birth, the bronchial arteries may turn into systemic-pulmonary collateral arteries. These collaterals, in turn, arise mainly from the bronchial arteries but have also been documented as arising from other arteries, such as the coronary arteries.[3] It has been shown that in congenital heart diseases some aortopulmonary collateral arteries have a marked histological similarity to the ductus arteriosus.[3]

Patients with UPAA have a normal pulmonary trunk and unilateral absence of one branch of the pulmonary artery,[4,5] with the right side being affected in two thirds of the cases.[1,2] Intrapulmonary vasculature and the distal portion of the trunk can develop normally and receive vascularization of bronchial vessels,[4,5] resulting in small and hypovascular lung on the affected side. In about 4% of the cases, communication between coronary and bronchial arteries is present.[6-8]

The disease presents clinically in several ways, but the most common manifestations are contralateral pulmonary hypertension, present in about 25% of the cases, determining long-term survival, and hemoptysis.[2,9] UPAA can still remain asymptomatic in about of 30% of patients.[1,2] The most common causes of death include right heart failure, respiratory failure, massive hemoptysis hemorrhage and pulmonary edema. The gold standard for diagnosis is digital subtraction angiography, but because it is an invasive test, it is reserved for cases of hemoptysis embolization or coronary artery bypass grafting, and diagnosis is established through other imaging tests such as computed tomography angiography of the lung, which may reveal, in addition to vascular disorders, parenchymal findings, such as bronchiectasis and mosaic attenuation pattern, possibly caused by the increased perfusion of the affected lung, besides the development of pulmonary hypertension.[2,10] The presence of associated malformations can also be well demonstrated by tomography.[2]

Treatment includes surgical, pharmacological and behavioral

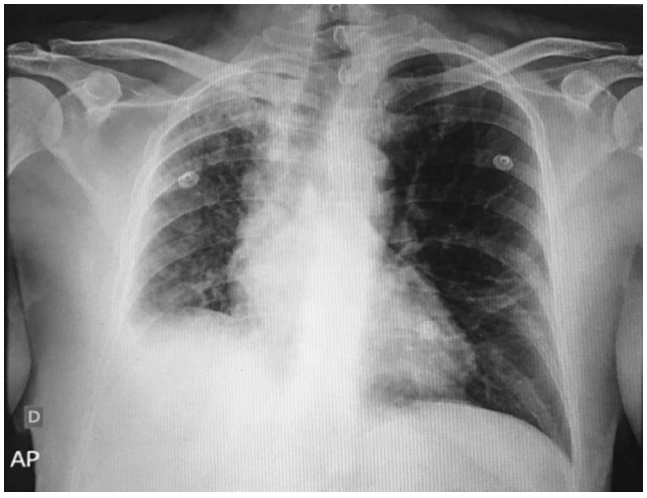


Figure 1 – *Chest X-ray showing right lung volume reduction.*

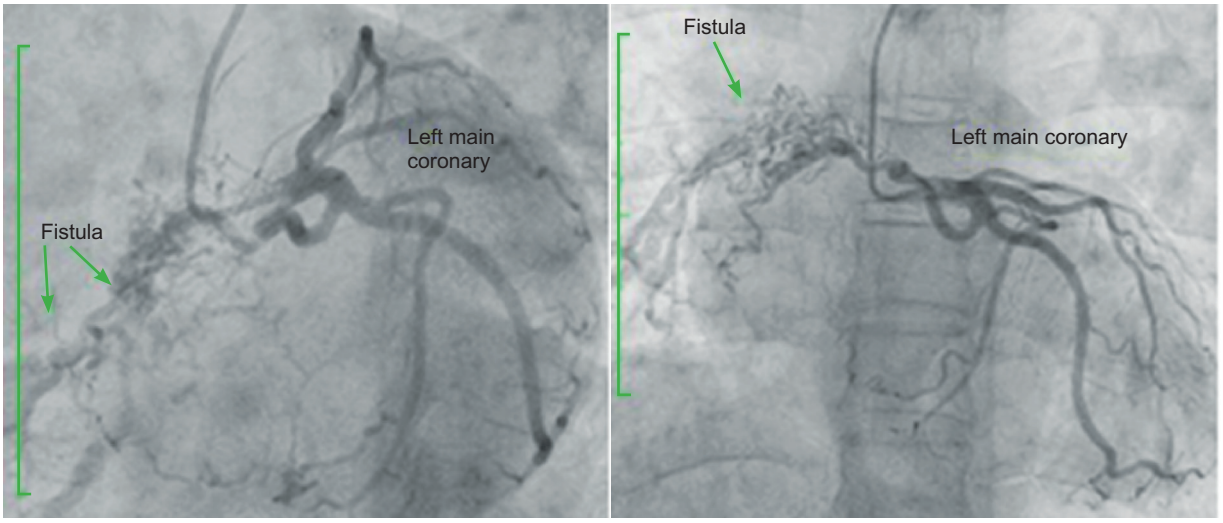


Figure 2 – *Coronary angiography suggesting high-output fistula to the intrapulmonary artery branches.*

management, with pneumonectomy and/or coronary artery bypass grafting being considered in cases of hemoptysis, pulmonary infections and pulmonary hypertension, and pharmacological measures are recommended only for refractory patients or those that cannot be operated.[2] Asymptomatic patients should undergo serial echocardiography to monitor the development of pulmonary hypertension, which represents a sign of worse prognosis.

Conclusion

unilateral pulmonary artery agenesis is a rare congenital anomaly that can go asymptomatic for many years, leading to late diagnosis in many cases, despite the various imaging options that may contribute to the investigation. Because it is a rare disease, clinicians should keep in mind the possibility of unilateral pulmonary artery agenesis undiagnosed in adulthood.

Authors' contributions

Data acquisition: Lima AV, Carneiro SS, Arruda JA, Caselli JG, Egashira E; Data analysis and interpretation: Arruda JA, Caselli JG; Manuscript writing: LimaAV; Critical revision of the manuscript for important intellectual content: LimaAV, Carneiro SS, Murad JA, Arruda JA.

Potential conflict of interest

The authors declare that there is no relevant conflict of interest.

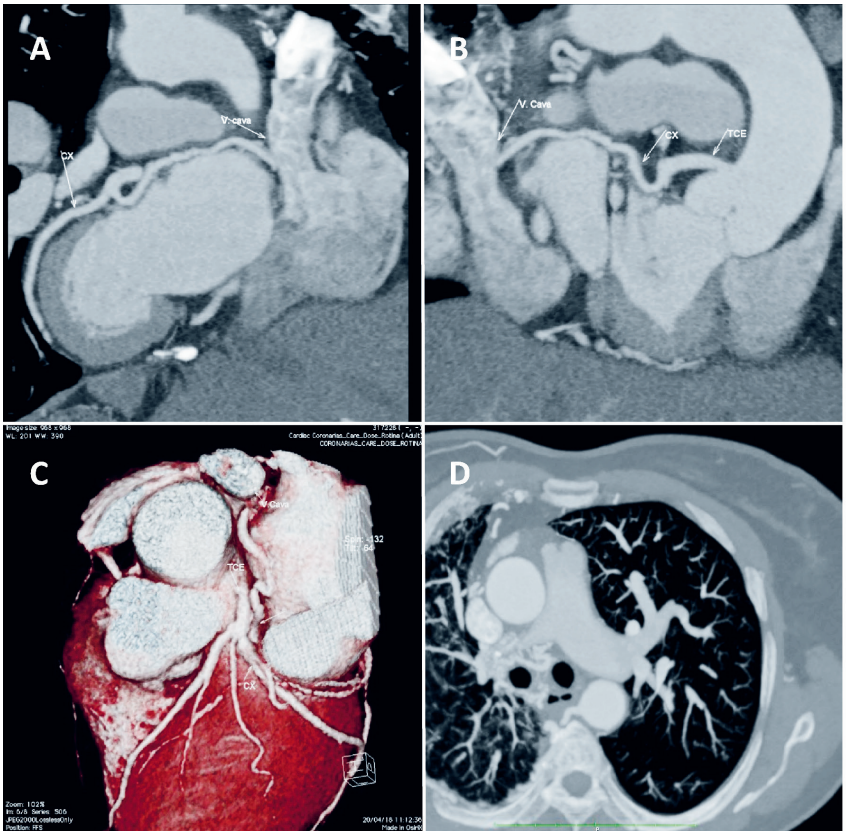


Figure 3 – *Coronary and pulmonary artery computed tomography angiography. (A and B) Multiplanar reconstruction showing the path of the circumflex fistula - superior vena cava. (C) Three-dimensional reconstruction of the coronary arteries. (D) Axial view at the pulmonary trunk bifurcation level, showing the unilateral pulmonary artery on the right.*

References

1. Saladi L, Roy S, Diaz-Fuentes G. Unilateral pulmonary artery agenesis: An unusual cause of unilateral ARDS. Respir Med Case Rep. 2018; 23:148-151
2. Steiropoulos P, Archontogeorgis K, Tzouvelekis A, Ntolios P, Chatzistefanou A, Bouros D. Unilateral pulmonary artery agenesis: a case series. Hippokratia. 2013;17(1):73-6.
3. Adán Lanceta V, Jiménez Olmos A, Martín de Vicente C, García Íñiguez JP. Agenesia aislada de la arteria pulmonar derecha. An Pediatr (Barc). 2017 ;86(1):45-46.
4. Nana-Sinkam P, Bost TW, Sippel JM. Unilateral pulmonary edema in a 29-year-old man visiting high altitude. Chest. 2002;122(6):2230-3.
5. Vergauwen S, Bracke P, De Schepper A. Unilateral absence of a pulmonary artery. J Belge Radiol. 1998;81(5):254.
6. Bockeria LA, Makhachev OA, Khiriev TKh, Abramyan MA. Congenital isolated unilateral absence of pulmonary artery and variants of collateral blood supply of the ipsilateral lung. Interact Cardiovasc Thorac Surg. 2011;12(3):509-10.
7. Heper G, Korkmaz ME. High-pressure pulmonary artery aneurysm and unilateral pulmonary artery agenesis in an adult. Tex Heart Inst J. 2007;34(4):425-30.
8. De Dominicis F, Leborgne L, Raymond A, Berna P. Right pulmonary artery agenesis and coronary-to-bronchial artery aneurysm. Interact Cardiovasc Thorac Surg. 2011;12(3):507-9.
9. Atik E, Tanamati C, Kajita L, Barbero-Marcial M.Agenesia isolada da artéria pulmonar direita ou esquerda: avaliação da evolução natural e a longo prazo, após intervenção corretiva. Arq Bras Cardiol. 2006;87(4):423-8.
10. Sakai S, Murayama S, Soeda H, Furuya A, Ono M, Ro T, Akamine T, et al. Unilateral proximal interruption of the pulmonary artery in adults: CT findings in eight patients. J Comput Assist Tomogr. 2002;26(5):777-83.

Differential Diagnosis of Biatrial Masses on Hemodialitic Patient with Secondary Hyperparathyroidism

Andréa Bezerra de Melo da Silveira Lordsleem[1,2], Sandro Gonçalves de Lima[1,2], Eveline Barros Calado[1], Marcelo Antônio Oliveira Santos-Veloso[2], Lucas Soares Bezerra[2], Talma Tallyane Dantas Bezerra[1]

Department of Cardiology, Universidade Federal de Pernambuco;[1] Epidemiology and Cardiology Research Group (EPICARDIO), Universidade Federal de Pernambuco,[2] Recife-Brazil

Introduction

Masses in the heart of chronic kidney disease (CKD) hemodialysis patients are most commonly due to extensive valve calcifications, thrombi, vegetations and tumors.[1] In this group of patients, cardiac amorphous tumor (CAT) should be considered as differential diagnosis.

CAT is an extremely rare non-neoplastic cardiac mass firstly described as pedunculated mass with multiple calcifications.[2] Some authors describe this mass as late phase of a thrombus associated with abnormal calcium metabolism in patients with severe renal dysfunction and pro-inflammatory state related to hemodialysis. Regardless of little scientific evidence about treatment approaches to CAT, surgical excision has been recommended and it is generally curative with complete resection.[3]

Case Report

A 37-year-old female patient, hypertensive, diabetic, and on hemodialysis for five years was admitted to the hospital for preoperative assessment for parathyroidectomy. The medications in use were losartan, carvedilol, acetylsalicylic acid and cilostazol. The patient attended the hemodialysis sessions using a long-term catheter in the right subclavian vein. She complained of palpitation, weakness and pain on lower limbs. At examination, a 2/6 ejective systolic murmur in accessory aortic focus with no irradiation, was audible. The 12-lead electrocardiogram presented sinus rhythm and signs of left ventricular hypertrophy.

Transesophageal echocardiography (TEE) revealed a free mobile filamentary structure attached to the left atrial (LA) posterior wall measuring 22 mm in length and right atrial (RA) mass sitting next to the superior vena cava (SVC) outlet measuring about 26x13 mm. (Figure 1) Magnetic resonance imaging (MRI) was performed utilizing a 1.5 tesla equipment (Philips Achieva; Philips Medical Systems) and multiple atrial masses were visualized on cine-RM (SSFP) sequence: RA mass was mobile, irregularly shaped, lobulated and attached to the vascular catheter extending from the SVC to the inferior vena cava outlet and measuring about 30x23x20 mm. Two masses were found attached to the LA lateral wall measuring 6x7x8 mm. (Figure 2)

Her condition worsened with sudden dyspnea evident on minimal exertion, chills, peripheral cyanosis (SatO2 67%) and bilateral diffuse rhonchi. CT confirmed the diagnosis of pulmonary embolism, with the image of calcified thrombus in the pulmonary artery branches. (Figure 3) The patient underwent immediate surgical resection of cardiac masses, whose macroscopic aspects were compatible with calcified thrombus and presented negative culture.

Discussion

Symptoms of cardiac tumors basically occur from obstruction, embolization, arrhythmias or for constitutional symptoms.[4] Some factors related to the development of CAT are female, elderly, CKD undergoing hemodialysis, basal cardiovascular diseases and hypercoagulability state. Patients with CAT have increased risk of developing stroke and embolic events.[5] Regarding the clinical presentation, most patients are asymptomatic. In symptomatic presentation, dyspnea (45%) and syncope (21%) are the most common symptoms.[6]

The diagnosis is made by echocardiographic tests, especially TEE. Imaging investigation could be complemented with MRI and CT, which would help in the differential diagnosis, assessment for surgical resection and evaluation of complications. On CT, hypodense masses are seen as a result of partial or diffuse calcifications. On MRI, CAT can present homogeneous images with T2 hyposignal of ovoid or irregular shape. On cine-MRI sequences, the masses could be mobile or static, when it is firmly attached to the ventricular wall.[7]

Possible differential diagnosis of CAT is fibroma. However, it is more common in children and present smaller central calcification. Calcification is also present in cardiac myxoma (which is the most prevalent cardiac mass) on the right side (about 14%). Nonetheless, hypersignal on T2 and late and heterogeneous enhancement of contrast are present as anterior systolic movement in

Keywords

Neoplasm; Cardiac Surgical Procedures; Heart Diseases; Chronic Renal Failure; Differential Diag-nosis.

Mailing Address: Andréa Bezerra de Melo da Silveira Lordsleem •
Rua Carijós, 625, apto. 114, Jardim da Penha. CEP 29060-700, Vitória, ES – Brazil
E-mail: alinevalerio1@hotmail.com

DOI: 10.5935/2318-8219.20190027

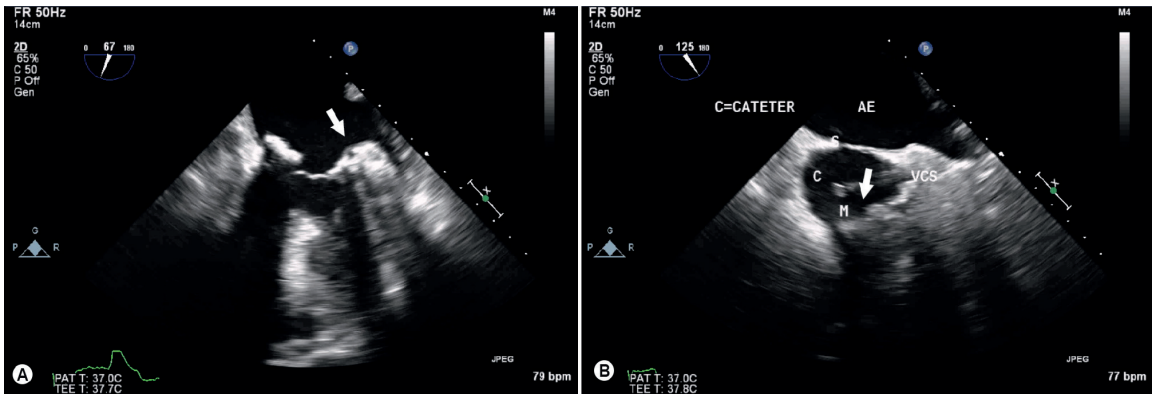


Figure 1 – *Transesophageal echocardiogram (TEE). A – mass attached (white arrow) to the left atrial wall, adjacent to mitral valve annulus, measuring 22 mm. B – mass (white arrow) attached to the right atrium, adjacent to the opening of superior vena cava. C = central line catheter, LA – left atrium, S = interatrial septum, M = mass, SVC = superior vena cava.*

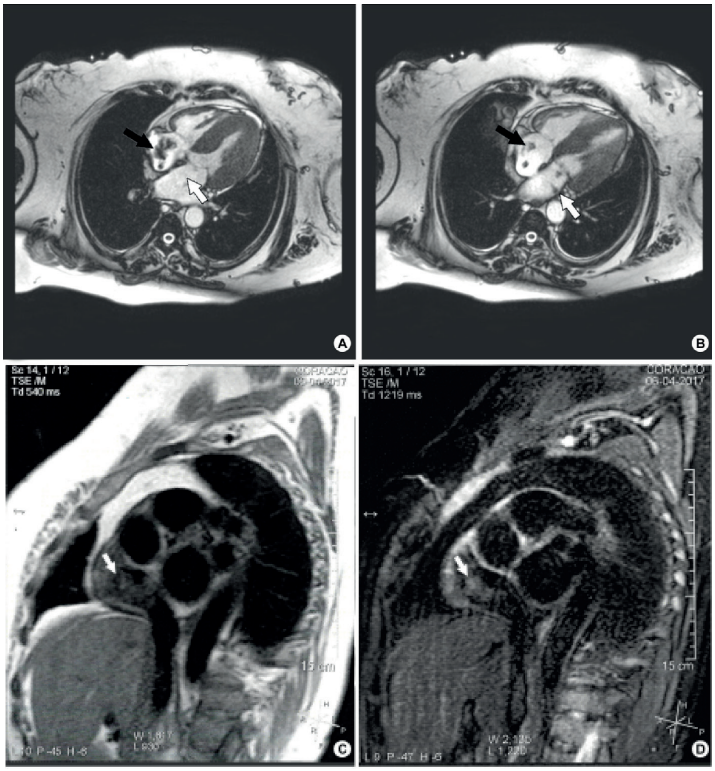


Figure 2 – *Cardiac MRI. A and B shows an irregular shaped mass, in the right atrium (black arrow), as well as two smaller masses attached to the left atrium (white arrow). C – perfusion sequence. D – late enhancement sequence.*

16% of patients after valvar repair.[8,9] Calcification is present on osteosarcoma, but it has irregular borders and is very aggressive, characterized by T2 hypersignal e marked enhancement of contrast.[7]

The patient presented atrial volumes close to normal and sinus rhythm. Such facts increase the specificity for the diagnosis of CAT. Calcified thrombus is often located in the apical areas of the dyskinetic ventricle, which is not the case. Calcifications in thrombi are usually seen in few focuses, large focuses or rare diffuse calcification. Vegetation and calcified thrombus are the most likely differential diagnosis, since they present the same patterns of T1 and T2.[7] In the presented case, the culture was negative. In these cases, MRI is very useful for a precise diagnosis.

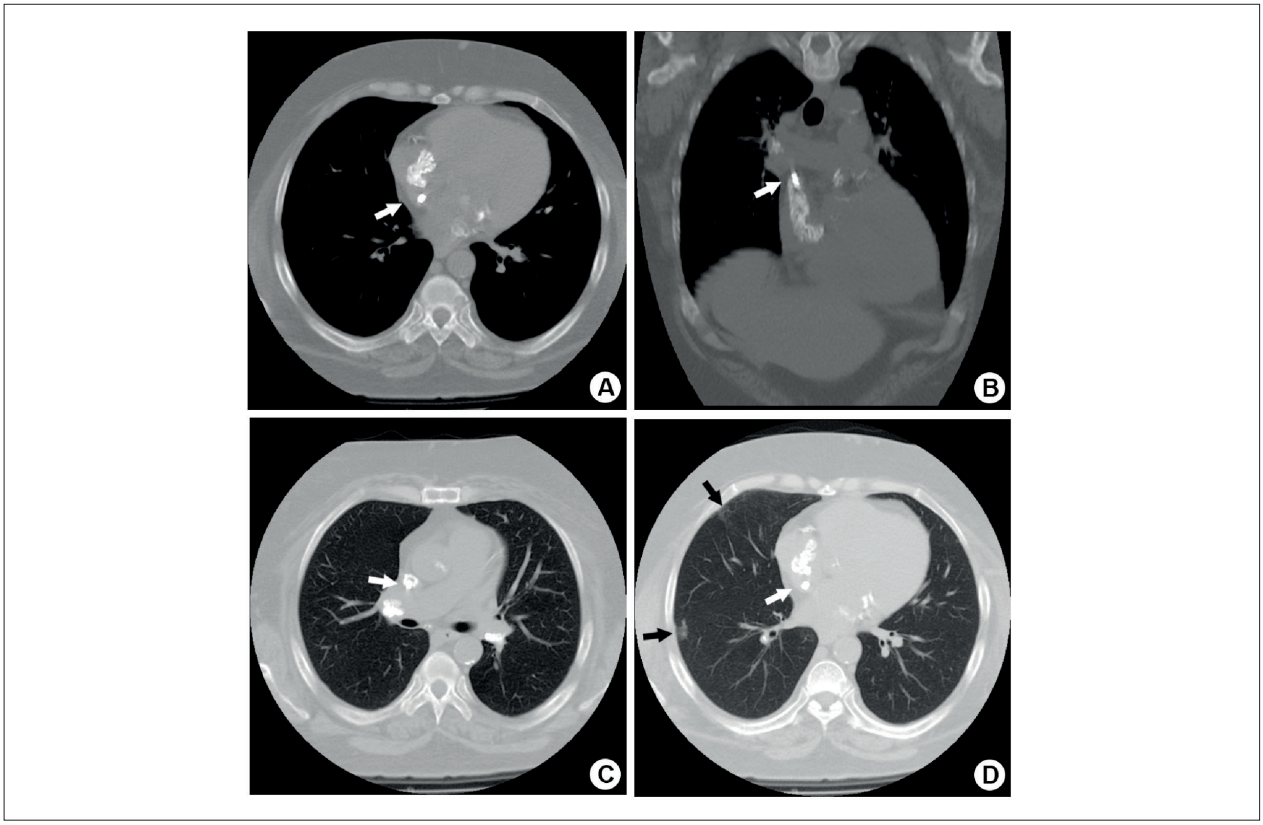


Figure 3 – *CT-scan of the chest. A and B show an image of calcium density, measuring about 31 x 22 x 19 mm in the right atrium (white arrow), attached to the hemodialysis catheter. C – calcified thrombus in the pulmonary artery branches (white arrow). D – pulmonary infarction in the periphery of the right lung (black arrow).*

Authors' contributions

Conception and design of the study: Lordsleem ABMS, Lima SG. Acquisition of data: Lordsleem ABMS, Calado EB, Santos-Veloso MAO, Bezerra LS. Analysis and interpretation of the data: Lordsleem ABMS, Lima SG, Calado EB, Santos-Veloso MAO. Writing the manuscript: Lordsleem ABMS, Lima SG, Calado EB, Bezerra LS. Critical revision of the manuscript for important intellectual content: Lordsleem ABMS, Lima SG, Calado EB.

Potential conflict of interest

The authors declare that there is no relevant conflict of interest.

References

1. Nishimura M, Hashimoto T, Kobayashi H, Fukuda T, Okino K, Yamamoto N, et al. The high incidence of left atrial appendage thrombosis in patients on maintenance haemodialysis. Nephrol Dial Transplant. 2003;18(11):2339–47.
2. Sousa JS, Tanamati C, Marcial MB, Stolf NAG. Tumor amorfo calcificado do coração. Rev Bras Cir Cardiovasc. 2011;26(3):500–3.
3. Elbardissi AW, Dearani JA, Daly RC, Mullany CJ, Orszulak TA, Puga FJ, et al. Survival After Resection of Primary Cardiac Tumors: A 48-Year Experience. Circulation. 2008;118(14_suppl_1):S7–15.
4. Menti E, Gonzalez VL, Paula A, Osorio APS, Cocco LD. Right Atrial Myxoma: Rare Occurrence of an Uncommon Disease. Arq Bras Cardiol:Imagem Cardiovasc. 2016;29(2):63–6.
5. Choi EK, Ro JY, Ayala AG. Calcified amorphous tumor of the heart: case report and review of the literature. Methodist Debakey Cardiovasc J. 10(1):38–40.
6. de Hemptinne Q, de Cannière D, Vandenbossche JL, Unger P. Cardiac calcified amorphous tumor: A systematic review of the literature. Int J Cardiol Heart Vasc. 2015;7:1–5.
7. Yılmaz R, Demir AA, Önür İ, Yılbazbayhan D, Dursun M. Cardiac calcified amorphous tumors: CT and MRI findings. Diagn Interv Radiol. 2016;22(6):519–24.
8. Salgado-Filho MF, Morhy SS, Vasconcelos HD de, Lineburger EB, Papa F de V, Botelho ESL, et al. Consenso sobre Ecocardiografia Transesofágica Perioperatória da Sociedade Brasileira de Anestesiologia e do Departamento de Imagem Cardiovascular da Sociedade Brasileira de Cardiologia. Arq Bras Cardiol: Imagem Cardiovasc. 2018;31(3):135–67.
9. Vieira TA, Negreiros S BC, Sousa DW S. Association between Aortic Valve Fibroelastoma and Acute Myocardial Infarction. Arq Bras Cardiol:Imagem Cardiovasc. 2015;28(4):247–50.

Fistulous Periprosthetic Aortic Abscess to the Left Ventricle Viewed on Three-Dimensional Transesophageal Echocardiography

Debora Tabosa de Almeida, Leticia Braga Paciello da Silva, Vanessa G Esmanhoto Andrioli, Marcos Valerio de Resende, Marcelo Luiz Campos Vieira

Hospital TotalCor, São Paulo, SP; Hospital Santa Paula, São Paulo, SP; Instituto do Coração, Faculdade de Medicina, Universidade de São Paulo, São Paulo, SP; Hospital Israelita Albert Einstein, São Paulo, SP – Brazil

Introduction

Infectious Endocarditis (IE) is an inflammatory process of the endocardium, especially that one located in the heart valves,[1] and it is still a major cause of mortality and morbidity.[2] Its incidence ranges from 3 to 9 cases per 100,000 people.[2] The main causes of death are cardiac complications, such as perivalvarial abscess, fistula formation, systemic embolism, ventricular pseudoaneurysm and heart failure.[2] Early detection of these disorders is of paramount importance for prognosis. We report the case of periprosthetic aortic abscess diagnosed after 4 months of mitral aortic valve replacement surgery. Diagnosis was confirmed by Transesophageal Echocardiography Three-dimensional (3D ETE).

Case Report

A 35-year-old male patient with a history of rheumatic carditis had an aortic bioprosthesis implanted 15 years before and, 4 years prior, underwent biological aortic valve repair and biological mitral valve replacement due to IE.

He was transferred to our service to investigate fever using empiric antibiotic therapy (ceftriaxone, vancomycin and gentamicin). The patient reported intermittent fever of 38.5 to 39ºC, dyspnea on unusual exertion, inappetence and weight loss of 2 kg in 15 days.

On physical examination, he was flushed, eupneic in the horizontal dorsal decubitus position, blood pressure of 115 × 78 mmHg, heart rate of 80 bpm and axillary temperature of 36.8ºC. Cardiovascular examination: regular heart rhythm with two sounds, systolic murmur in the mitral area (+2/+6) and diastolic murmur in the aortic area (+2/+6). Examination of the respiratory tract, abdomen and lower limbs revealed no abnormalities. Electrocardiogram with sinus rhythm and normopositive axis, normal PR and no ventricular repolarization disorders. Hemoculture from the hospital of origin identified Gram-positive bacteria: *Streptococcus sanguinis* sensitive to penicillin.

Keywords

Endocarditis; Abscess; Echocardiography.

Mailing Address: Debora Tabosa de Almeida •
E-mail: deborat.almeida@cardiol.br

DOI: 10.5935/2318-8219.20190028

TEE revealed normally functioning biological prosthesis in the aortic position and periprosthetic aortic neocavity extending to the mitroaortic junction, with thick walls and evidence of internal flow with externalisation to the left ventricular outflow tract, compatible with periprosthetic abscess (Figures 1 to 3). Biological prosthesis in mitral position, thickened, preserved aperture, mean transprosthetic gradient of 7 mmHg and mitral prosthesis area of 1.9 cm^2. Two-dimensional images were complemented by 3D echo for better analysis of the mitral valve junction and mitral valve apparatus (Figure 4).

Aortic prosthesis was replaced with 25 mm porcine prosthesis and closure of the abscess area with sequential points and reinforcement with bovine pericardium.

The patient progressed well, was discharged after treatment with ceftriaxone for 6 weeks and maintained outpatient follow-up with the cardiology, infectiology and cardiac surgery team and in the rehabilitation group.

Discussion

EI can affect the endothelial surface of the heart and the most susceptible structures are the atrioventricular valves. It may also occur in the endocardium of the atria, ventricles and large vessels.[3] Most (80%) EI cases occur in patients with risk factors that include structural heart disease, cardiac valve prosthesis, intravenous drug use, HIV/AIDS and history of EI. Currently, more cases have been observed in the elderly (institutionalized/hospitalized and handled with invasive procedures).[4]

There are geographic differences in the epidemiology of IE.[3] In developing countries, such as Brazil, the subacute form of the disease is still frequently encountered.[3] In developed countries, nosocomial endocarditis is more common. In Brazil, we are in a transition period and we observed a pattern of endocardial infection in countries with greater economic development in large private hospitals and, at the same time, patients with classic streptococcal endocarditis underserved populations. On a global level, IE is also associated with invasive procedures.[3]

IE is caused by a variety of bacteria and fungi. The most incident ones include *Streptococcus viridans*, *Enterococcus sp.* (20,8%) and *Staphylococcus aureus* (about 80%).[5] Other less common microorganisms such as -negative *Gram* bacteria from the HACEK group (*Haemophilus aphrophilus*, *Actinobacillus actinomycetemcomitans, Cardiobacterium hominis,*

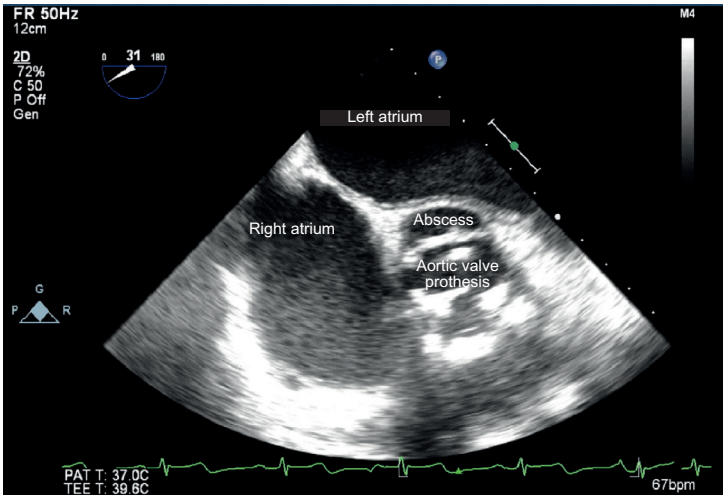


Figure 1 – *Two-dimensional transesophageal echocardiogram showing aortic prosthesis with abscess at the mitroaortic junction.*

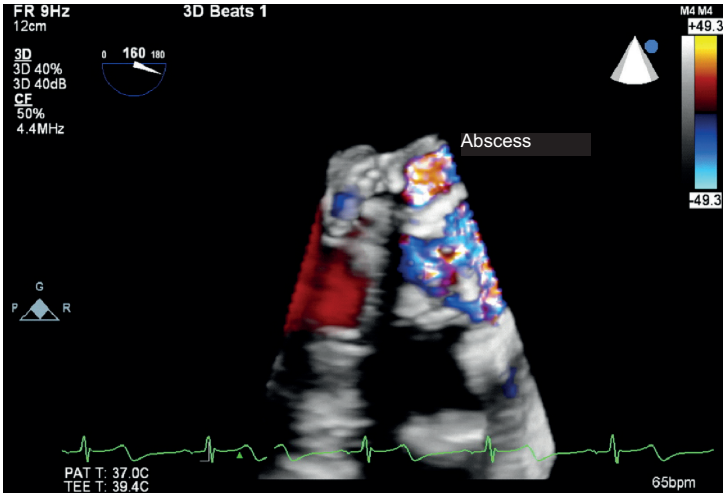


Figure 2 – *Three-dimensional echocardiogram showing periprosthetic neocavity flow.*

Eikenella corrodens and *Kingella kingae*) and fungi affect the other patients.[3]

While streptococci predominate in South America, India and Southeast Asia, *S. aureus* is the most common cause in better developed countries.[3] The importance of this pathogen as a potentially lethal infection is a source of concern, given its increasing antimicrobial resistance, including vancomycin.[4]

Population aging has also resulted in a higher prevalence of endocarditis associated with *Streptococcus bovis*, mainly in Europe. Reports have found an increased incidence of the HACEK group in Europe, in addition to cases of *Coxiella burnetti* and *Bartonella*. Changes in the etiological and epidemiological profile of IE with increased nosocomial cases suggest that rigorous measures to prevent bloodstream infections should be applied in hospitals. Hospitalized elderly should be carefully investigated if they present any fever or bacteremia. IE is still a disease with high morbidity (37%) and lethality despite progress in therapy and diagnosis.[7]

Diagnosis of IE is based both on medical history, detailed physical examination, laboratory tests and imaging scans. Clinical, pathological, echocardiographic and microbiological parameters must be considered for definitive diagnosis of the disease. To diagnose IE, the modified Duke criteria for diagnosis are used. These are divided into major criteria and minor criteria.[6] The presence of two major criteria, a major one associated with three minor ones, or five minor ones alone, is considered sufficient to define the diagnosis.[3]

Echocardiography is recommended as the first-line imaging modality for IE diagnosis. Diagnostic echocardiographic

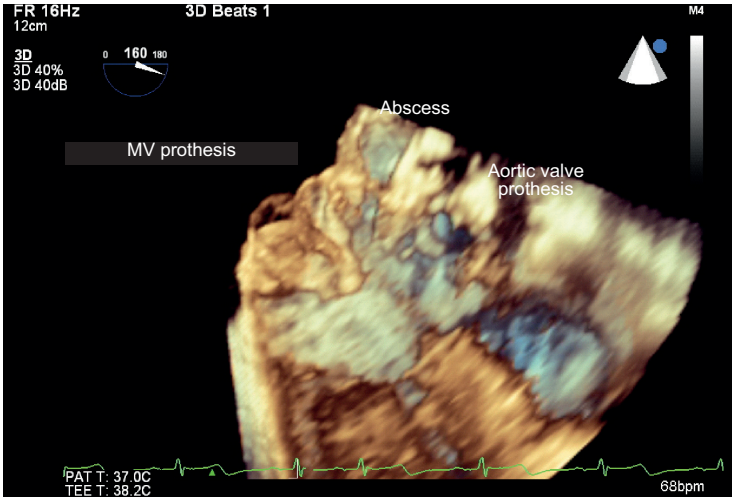


Figure 3 – *Three-dimensional transesophageal echocardiogram showing aortic periprosthesis neocavity extending to the mitroaortic junction.*

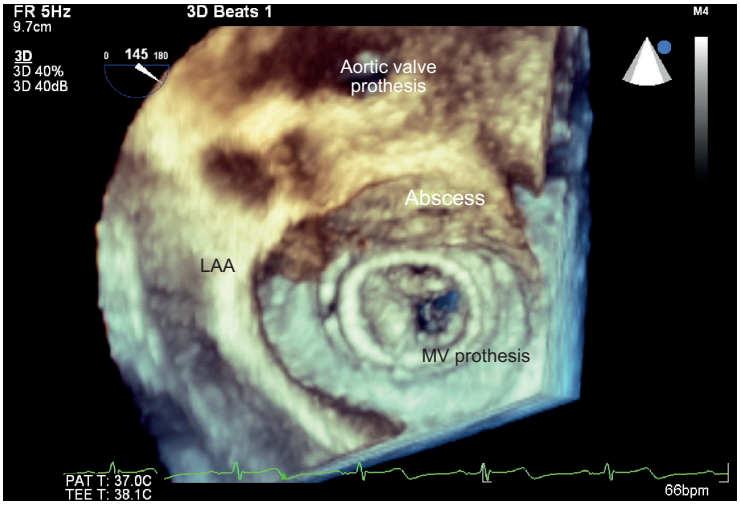


Figure 4 – *Three-dimensional transesophageal echocardiogram images showing aortic periprosthesis neocavity extending to the mitroaortic junction.*

criteria include the identification of images compatible with vegetation, perivalvular abscess or new dehiscence of a prosthetic valve. Cardiac computed tomography allows the detection of abscesses, pseudoaneurysms, fistulas and prosthetic valve dehiscence. Additional methods, such as Positron Emission Tomography-Computed Tomography (PET-CT), may be useful to identify inflammatory activity, suggesting a local inflammatory or infectious process, especially in patients with cardiac valve prostheses or periprosthetic abscesses.

Major care should occur in the differential diagnosis of situations of inflammatory yet not infectious processes, considering the use of PET-CT for the diagnostic investigation of patients with suspected IE.

Transthoracic echocardiography (TTE) is a rapid and noninvasive diagnostic modality, with excellent specificity for the diagnosis of native valve endocarditis (98%), but with general sensitivity of only 40-60%, whereas TEE has high sensitivity (75% to 95%) and specificity (98%).[9] However, in prosthetic valve endocarditis, the amount of prosthetic material in the supra and infravalvular regions, and the occurrence of acoustic shade resulting from prosthetic structures reduce the sensitivity and specificity for the diagnosis of IE. Progress in 3D allowed better spatial resolution and viewing of cardiac structures, allowing the identification of any valvular vegetations (above 2 mm), abscess or nodules.[10]

The use of 3D TEE makes it possible to view the cardiac structure from unconventional observation planes, as well as the simultaneous observation of the different prosthesis faces. This characteristic allows the identification of structural

lesions, such as pannus, small thrombi adhered to the prosthesis elements and small vegetations.

In prostheses in aortic position, the simultaneous observation of the prosthetic face, from the coaxial and *en face* view of the left ventricular outflow tract and the ascending aorta, provides the most detailed and best anatomical identity of the prosthesis, as observed recently.[13]

In the case presented, two-dimensional echocardiography delivered the correct diagnosis, but the 3D images allowed to establish the anatomical spatial relationship of the structures involved, with better planning for the proposed intervention.

Some studies suggest that 3D TEE can improve diagnostic investigation in suspected cases with typical bacteria. The use of 3D imaging was documented in prosthetic endocarditis with Transcatheter Aortic Valve Replacement (TAVR), which compared the diagnosis based on three parameters: presence of small moving structures, focal thickening of leaflets and irregular surfaces on valves, thus increasing the sensitivity of diagnosis compared to two-dimensional echo.[10] New perspectives exist on 3D echo, mainly regarding lesions in the mitral valve cusps, providing information about the valvular apparatus.[11]

The patient met the modified diagnostic criteria of Duke for IE, since he had two major and two minor criteria, namely: two hemocultures positive for *S. sanguinis*, echocardiogram with fistulated periprosthetic abscess, fever above 38ºC and predisposition to endocarditis — history of endocarditis and intracardiac prosthesis.

Complications of IE are due to the progression of the disease with valvular and perivalvar impairment, whether due to late diagnosis or ineffective treatment. These complications include HF, abscess, perivalvar fistula and embolic phenomena. Prosthetic valve endocarditis with abscess is a devastating complication of the replaceable heart valve.[6] The myocardium may suffer the consequences of infections when there is association with abscesses and regional infarction. As a result, the patient may present ventricular arrhythmia and myocardial systolic dysfunction.

In a series of 233 patients with perivalvular abscesses associated with IE, mean survival ranged from 3 months to 75% of them.[8] Mortality was higher in older patients with staphylococcal infection, preoperative renal failure and concomitant fistula.[8]

Recognition of the presence of aortic root abscess during the course of endocarditis is of extreme prognostic importance, due to the possibility of progression to heart failure, sepsis or both.[6]

Surgery may be used to treat the complications existing on diagnosis and to prevent these complications. However, there are reports with conservative medical treatment.[9] The possibility of percutaneous approach has been recently reported.

Conclusion

Valve prosthesis vegetation is a serious disease and early diagnosis with early introduction of effective treatment reduces mortality. Diagnosis of these geometric relationships, although it is also defined by two-dimensional echocardiography, can be facilitated by that of 3D echo, mainly aiming at an efficient communication with the surgical team, since many cases of prosthesis endocarditis are surgically handled.

Finally, we present a case report illustrating this relevant recommendation of 3D echo, which assisted in the evaluation of a vegetation complicated by periprosthetic abscess, allowing better planning of the surgical strategy, which resulted in the patient's good evolution.

Potential Conflicts of Interest

There are no relevant conflicts of interest.

References

1. Que YA, Haefliger JA, Piroth L, Francois P, Widmer E, Entenza JM, et al. Fibrinogen and fibronectin binding cooperate for valve infection and invasion in Staphylococcus aureus experimental endocarditis. J Exp Med. 2005;201:1627- 35.
2. Prendergast BD, Tornos P. Valvular heart disease: changing concepts in disease management. Surgery for infective endocarditis. Who and when? Circulation. 2010;121(9):1141-52.
3. Braunwald.Tratado de Doenças Cardiovasculares. 10ª Ed. Elsevier; 2017 p. 3934- 42.
4. Tratado de Cardiologia SOCESP. 3ª Ed. São Paulo: Manole; 2015.
5. Tleyjeh IM, Abdel-Latif A, Rahbi H, Scott CG, Bailey KR, Steckelberg JM, et al. A systematic review of population based studies of infective endocarditis. Chest. 2007;132(3):1025-35.
6. Chow WH, Leung WH, Tai YT, Lee WT, Cheung KL. Echocardiographic Diagnosis of an Aortic Root Abscess after Mycobacterium Fortuitum Prosthetic Valve Endocarditis. Clin Cardiol. 1991 Mar;14(3):273-5.
7. Wallace SM, Walton BI, Kharbanda RK, Hardy R, Wilson AP, Swanton RH. Mortality from infective endocarditis: clinical predictors of outcome. Heart. 2002;88(1):53-60.
8. Choussat R, Thomas D, Isnard R, Michel PL, Iung B, Hanania G, et al. Perivalvular abscesses associated with endocarditis. Clinical features and prognostic factors of overall survival in a series of 233 cases. Eur Heart J. 1999;20:232-41.
9. Hasin T, Reisner SA, Agmon Y. Large pseudoaneurysms of the mitral-aortic intervalvular fibrosa: long-term natural history without surgery in two patients. Eur J Echocardiogr. 2011;12(3):E24.
10. Xie M, Li Y, Cheng TO, Wang X, Lu Q, He L, et al. Pseudoaneurysm of the mitral-aortic intervalvular fibrosa. Int J Cardiol. 2013;166 (1):2-7.
11. Osler W. The Gulstonian Lectures, on Malignant Endocarditis. Lectures. Br Med J. 1885 Mar 7;1(1262):467-70.
12. Gonzales YO, Ung R, Blackshear JL, Laman SM. Three-Dimensional Echocardiography for diagnosis os trancatheter prosthetic Aortic Valve Encocarditis. CASE (Phila). 2017;1(4):155–8. -
13. de Brito FS Jr, Caixeta AM, Vieira ML, Nomura C, Figueiredo GL, Perin M, et al. Pseudo early degeneration of a transcatheter aortic valve prosthesis due to thrombosis. EuroIntervention. 2015 ;10(11):1367.

Cardiac Metastasis Secondary to Endometrial Cancer: an Extremely Rare Presentation

Marcos Danillo Peixoto Oliveira, Marina Tulher Florenzano, Laura Frontana C. Santos, Pedro Luiz Barbosa Navarro, Roney Cesar Signorini Filho

Centro de Referência da Saúde da Mulher, Hospital Pérola Byington, São Paulo-SP-Brazil

Endometrial malignancy is the most common gynecologic cancer in developed countries.[1] Metastasis to the pelvic and para-aortic nodes is common. The most usual sites for distant metastasis are lungs, liver, brain, and bones.[2] Cardiac metastasis of infradiaphragmatic tumors are much less frequent. We report a very rare case of metastatic cardiac mass involving the right ventricle secondary to endometrial cancer.

Case presentation

A 70-year-old woman, without known comorbidities, was diagnosed with endometrial adenocarcinoma locally advanced, without any evidence of distant metastases at the initial imaging and clinical evaluation. She was then successfully submitted to the proposed surgical resection of the reproductive pelvic organs with adjuvant chemotherapy (paclitaxel and carboplatin) and radiotherapy treatment.

At the post-operative six months follow-up, multidetector computed tomography (MDCT) angiography revealed (Figures 1 and 2) a bulky and poorly delimited infiltrative lesion, with areas of internal necrosis, affecting the cardiac right ventricle (RV), notably its tip and its lateral and anterior walls, as well as a little portion of the distal interventricular septum, measuring 9.3 x 6.7 x 5.0 cm (mean 8.3 x 6.5 x 3.7 cm). The lesion extended through the whole myocardial thickness, obliterating the apical portion of the RV with protrusion into the pericardial space, associated with moderate pericardial effusion. There was neither evidence of intracavitary thrombi nor of pulmonary embolism. Superior vena cava, inferior vena cava, aorta and pulmonary artery showed normal dimensions and contours. In addition to strongly suggesting cardiac metastatic mass, cranial magnetic resonance imaging (MRI) revealed a gadolinium-enhanced expansive lesion (0.9 cm) at the right temporal lobe, highly suggestive of brain metastasis of the primary endometrial cancer. Surprisingly, there were not any associated specific cardiac or cerebrovascular symptoms or signals. The initial chemotherapy regimen was, then, modified to liposomal doxorubicin and megestrol acetate.

Despite the adequate treatment strategy, the patient passed away nine months after documentation of cardiac metastasis, which was monitored with echocardiogram and MDCT angiography.

Discussion

Secondary heart tumors are really rare, but are anticipated to increase with extended survival of oncologic patients due to improved diagnostic and therapeutic modalities.[3]

Malignant cells may reach the heart through the hematogenous or lymphatic routes. Cardiac metastases are most frequently secondary to breast, lung, lymphoma, leukemia and melanoma primary cancer sites. Cardiac implants due to infradiaphragmatic tumors are much less frequent.[2] Most of such tumors (over 90%) remain clinically silent and are often only diagnosed post-mortem.[3]

Noninvasive imaging has a crucial role in the diagnosis of cardiac masses. Certain characteristics identified on imaging may help distinguish neoplastic versus non-neoplastic masses and benign versus malignant tumors. Echocardiography remains the first-line method for cardiac mass evaluation due to its widespread availability, lack of iodinated contrast or radiation exposure, and its dynamic assessment of cardiac masses in relation to the surrounding chambers, valves and pericardium. However, it provides limited assessment of soft-tissue characteristics and extracardiac structures and may be limited by poor acoustic windows. Cardiac MRI is often the preferred imaging modality for cardiac masses because of its superior soft-tissue characterization, high temporal resolution, multiplanar imaging capabilities and unrestricted field of view. Cardiac MDCT is a fast imaging technique that provides high-quality images with superior spatial resolution. Compared to other modalities, it is optimal for the evaluation of calcified masses, global assessment of the chest and lung tissue and corresponding vascular structures, and for ruling out obstructive coronary artery disease or masses which involve the coronary arteries. Cardiac MDCT is also useful to detect metastasis in suspected malignancies especially when coupled with ^{18}F-fluorodeoxyglucose (FDG) positron emission tomography (PET), whose ability to detect increased metabolism of glucose may help distinguish malignancy from a benign neoplasm.[4]

Although in this case the metastasis was diagnosed in short-term post-operative follow-up (six months), cardiac metastasis has been reported in long-term postoperative follow-up (>15 years).[5]

Keywords

Metastasis; Endometrial Neoplasms; Computed Tomography Angiography.

Correspondência: Marcos Danillo P. Oliveira •
Unidade de Terapia Intensiva, Hospital Pérola Byington, Av. Brigadeiro Luís Antônio, 683 - Bela Vista, São Paulo-SP, Brazil; CEP: 01317-000.
E-mail: marcosdanillo_dr@yahoo.com.br

DOI: 10.5935/2318-8219.20190029

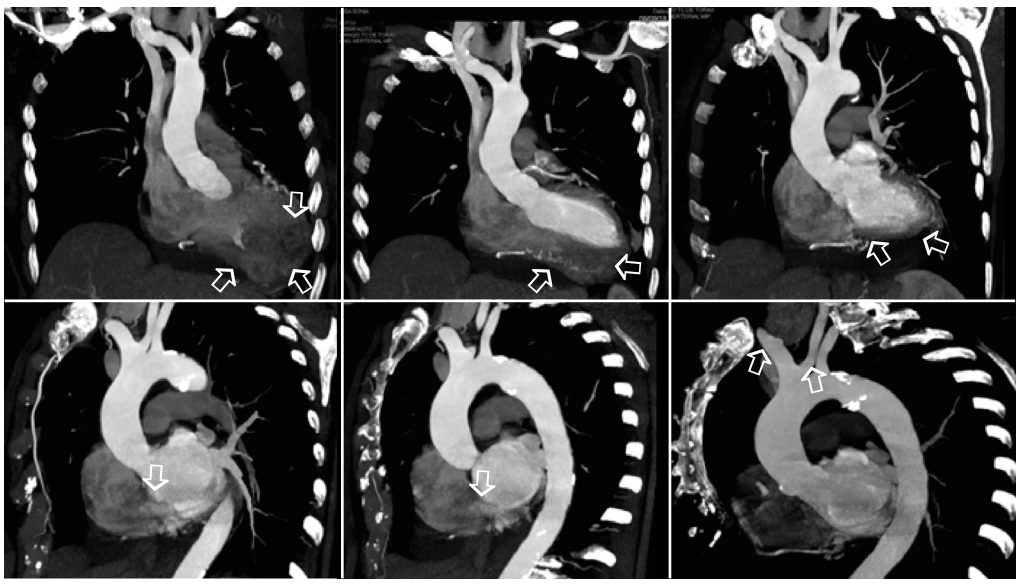


Figure 1 – *MDCT angiography: the bulky and poorly delimited infiltrative lesion (white arrows) affecting the RV, notably its tip and its lateral and anterior walls, as well as the distal interventricular septum, extending through the whole myocardium thickness with protrusion into the pericardial space, associated to moderate pericardial effusion. MDCT, multidetector computed tomographic; RV, right ventricle.*

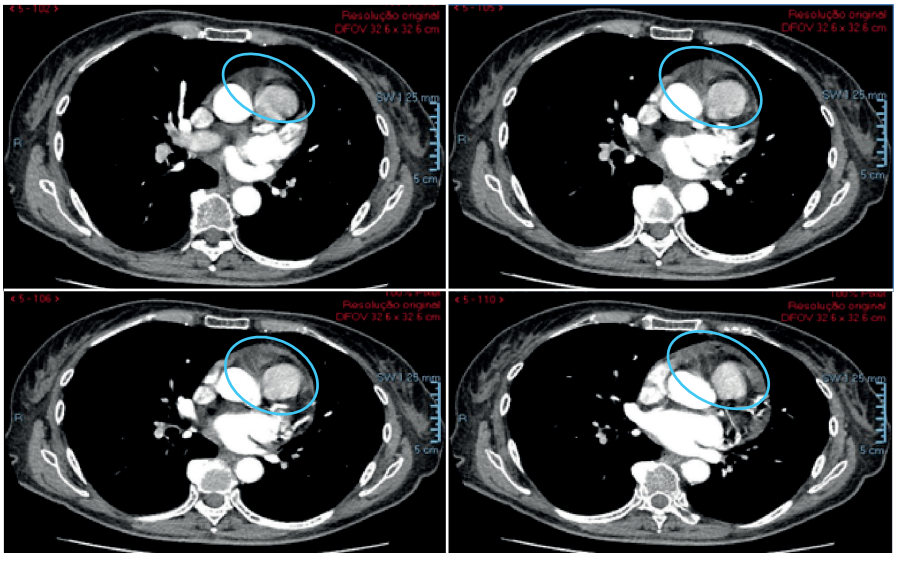


Figure 2 – *MDCT angiography: the bulky and poorly delimited infiltrative lesion (blue circles) affecting the RV, notably its tip and its lateral and anterior walls, as well as the distal interventricular septum, extending through the whole myocardium thickness with protrusion into the pericardial space, associated to moderate pericardial effusion. MDCT, multidetector computed tomographic; RV, right ventricle.*

As the histopathological analysis of the cardiac mass was not performed in this case, it is not completely possible to rule out the very low possibility of other pathologies, such as a fast-growing primary cardiac tumor or a secondary lesion from a different primary site. Nevertheless, in this scenario of primary endometrial adenocarcinoma with rapid distant spread by imaging screening, this bulky and poorly delimited infiltrative cardiac lesion was strongly compatible with metastasis from the endometrial malignancy.

Authors' contributions

Oliveira MDP, Florenzano MT, Santos LF, Navarro PLB, Signorini Filho RC. Acquisition of data: Oliveira

MDP, Florenzano, Santos LF, Navarro PLB, Signorini Filho RC. Analysis and interpretation of the data: Oliveira MDP, Florenzano, Santos LF, Navarro PLB, Signorini Filho RC. Writing the manuscript: Oliveira MDP. Critical revision of the manuscript for important intellectual content: Oliveira MDP, Florenzano, Santos LF, Navarro PLB, Signorini Filho RC.

Potential Conflicts of Interest

There are no relevant conflicts of interest.

References

1. Oldenburg C, Boll D, Nicolaije K, Vos M, Pijnenborg J, Coebergh J, et al. The relationship of body mass index with quality of life among endometrial cancer survivors: A study from the population-based PROFILES registry. Gynecol Oncol. 2013;129:216–21.
2. Liu T, Khan S, Behr S, Aparici CM. Diagnosis of Cardiac Metastasis from Endometrial Cancer by F-18 FDG-PET/CT. Nucl Med Mol Imaging. 2014;48(3):237–40.
3. Burazor I, Aviel-Ronen S, Imazio M, Goitein O, Perelman M, Shelestovich N, et al. Metastatic cardiac tumors: from clinical presentation through diagnosis to treatment. BMC Cancer. 2018;18:202.
4. Kassop D, Donovan MS, Cheezum MK, Nguyen BT, Gambill NB, Blankstein R, et al. Cardiac Masses on Cardiac CT: A Review. Curr Cardiovasc Imaging Rep. 2014;7:9281.
5. Manuel V, Dinato FJ, Gutierrez PS, Siqueira SAC, Gaiotto FA, Jatene FB. Cardiac metastatic endometrial stromal sarcoma 17 years after hysterectomy. J Card Surg. 2017;32:636–8.

Giant Left Atrium Due to Severe Rheumatic Double Mitral Valve Dysfunction

Glenda Alves de Sá, Danilo Bora Moleta, Rogério Simões Miranda, Geórgia C. S. Souza, Marcos Danillo Peixoto Oliveira

Department of Echocardiography, Hospital Regional de São José dos Campos, São Paulo, Brazil

CASE PRESENTATION

A 59-year-old woman, active smoker, with permanent atrial fibrillation under oral anticoagulation and long-term diagnosed double mitral valve dysfunction secondary to rheumatic heart disease (RHD), was admitted to the emergency department due to refractory dyspnea at minimal exertion. Transthoracic echocardiography at rest revealed rheumatic severe double mitral dysfunction: mitral valve area - 0.79 cm²; maximum and medium transmitral gradient - 22 and 13 mmHg, respectively. There were also moderate aortic and mild tricuspid regurgitations and moderate pericardial and pleural effusion. The left atrium was markedly enlarged with an anteroposterior diameter of 128 mm and indexed volume of 1004 mL/m². (Figure 1 and Videos 1, 2 and 3) Left ventricular ejection fraction was 0.56 (Simpson's method) and the estimated systolic pulmonary pressure was 65 mmHg. A markedly large hyperechogenic sessile mass (729 x 798 mm) adhered to the lateral left atrial wall, suggestive of a massive thrombus, was also seen. (Figure 1 and Videos 1, 2 and 3) EUROSCORE II: 2.52% (high risk of mortality); Society of Thoracic Surgeons (STS) mortality score: 3.53%; STS morbidity or mortality score: 24.61%.

Despite being recommended by the experts as the default treatment, surgical mitral valve replacement combined with left atrial reduction was, for this patient, contraindicated by the heart team, due to those high risks. Notorious left atrial enlargement, like in this case, is strongly associated with RHD, especially when there is severe double mitral valve dysfunction.[1,2]

Keywords

Left Atrium; Echocardiography; Diagnosis.

Mailing Address: Marcos Danillo Peixoto Oliveira •
Hospital Regional de São José dos Campos. Rua Goiânia, 345 - Parque Industrial, São José dos Campos, São Paulo, Brazil; 12235-625.
E-mail: marcosdanillo_dr@yahoo.com.br

DOI: 10.5935/2318-8219.20190030

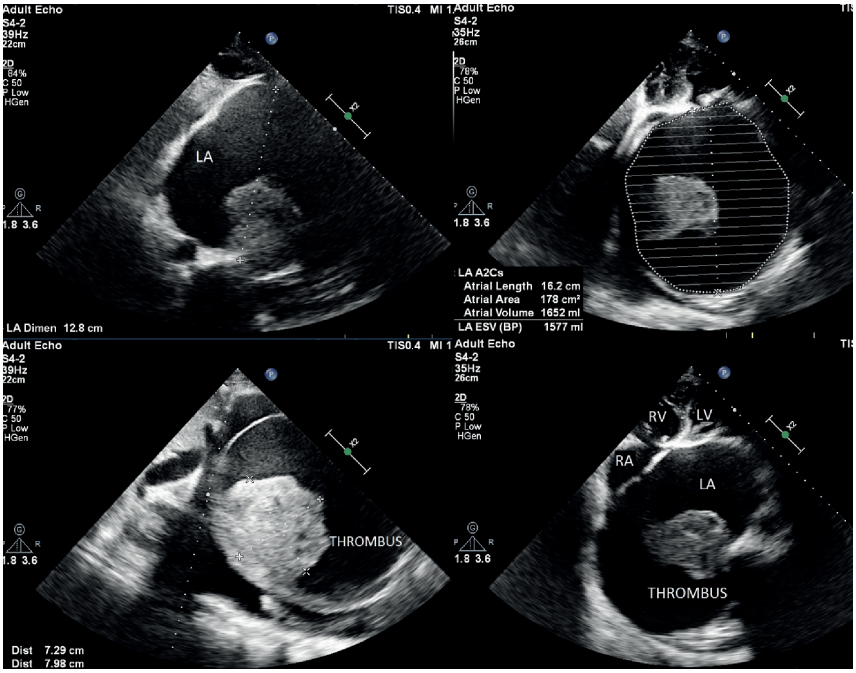
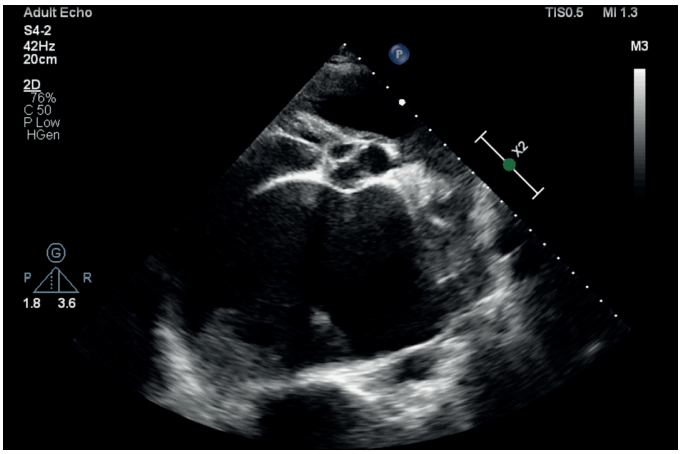
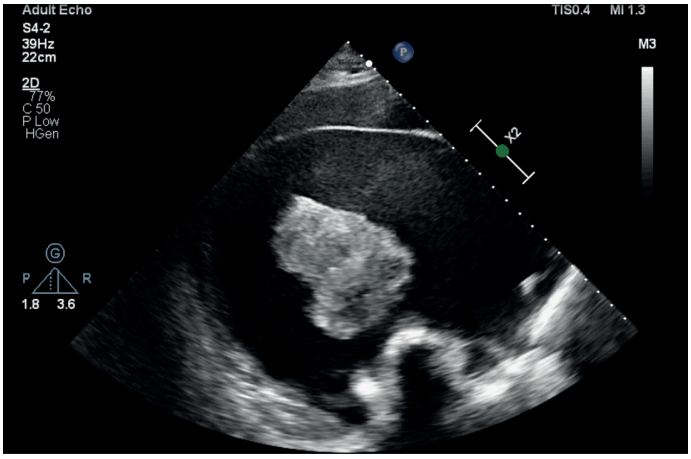


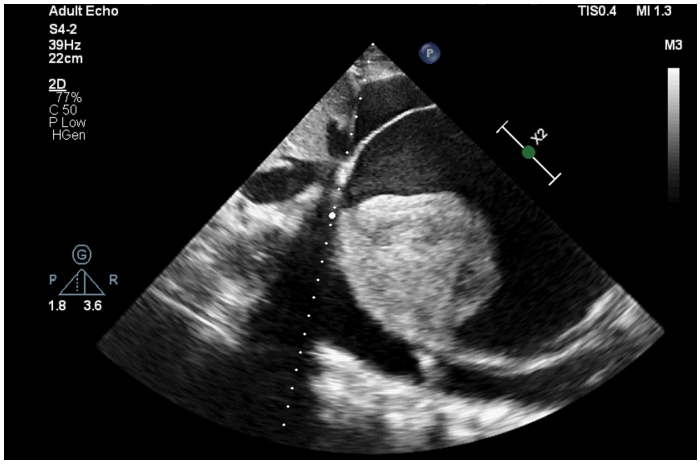
Figure 1 – *Giant left atrium with the massive thrombus adhered to its lateral wall. LA, left atrium; RA, right atrium; LV, left ventricle; RV, right ventricle.*



Video 1 – *Giant left atrium with massive thrombus adhered to its lateral wall. Short-axis view.*
Watch the video here: http://departamentos.cardiol.br/dic/publicacoes/revistadic/2019/v32_2/video_v32_2_atrio_esquerdo_ingles.asp



Video 2 – *Giant left atrium with massive thrombus. Subcostal view.*
Watch the video here: http://departamentos.cardiol.br/dic/publicacoes/revistadic/2019/v32_2/video_v32_2_atrio_esquerdo_ingles.asp



Video 3 – *Giant left atrium with massive thrombus adhered to its lateral wall. Subcostal view.*
Watch the video here: http://departamentos.cardiol.br/dic/publicacoes/revistadic/2019/v32_2/video_v32_2_atrio_esquerdo_ingles.asp

Authors' contributions

Conception and design of the study: Oliveira MDP, Sá GA. Acquisition of data: Oliveira MDP, Moleta DB, Miranda RS, Souza GCS, Sá GA. Analysis and interpretation of the data: Oliveira MDP, Sá GA. Writing the manuscript: Oliveira MDP, Sá GA. Critical revision of the manuscript for important intellectual content: Oliveira MDP, Sá GA.

Potential conflict of interest

The authors declare that there is no relevant conflict of interest.

References

1. hurst W. Memories of patients with a giant left atrium. Circulation. 2011;104:2630-1.
2. Ntalas I, Niederer S, Aziz W, Chambers JB, Rajani R. Giant left atrium: Adaptive or maladaptive? Hellenic Journal of Cardiology. Hellenic J Cardiol. 2018 Jul 7. pii: S1109-9666(18)30228-8.

An Unusual Case of Acute Myocardial Infarction

Hugo Antunes, Inês Almeida, Júlio Gil, Luisa Gonçalves Gonçalves, Miguel Correia
Centro Hospitalar Tondela-Viseu, Viseu - Portugal

A 42-year-old female with irrelevant medical history, medicated with oral contraceptives. Admitted by precordial pain of anginal characteristics, with electrocardiography in sinus rhythm with transient inferolateral ST-segment elevation and elevation of troponin I (28ng/mL). Despite recent emotional stress, transthoracic echocardiography showed no abnormalities, excluding Takotsubo's cardiomyopathy.

Electrocardiography with no dynamic abnormalities. Coronary angiography with no epicardial coronary lesions. For a better characterization of the condition, cardiac magnetic resonance was performed, showing small area akinesia at the transition between the lower and lateral distal segments, with hypersignal in the T2-weighted sequences and transmural enhancement in the late enhancement sequences — findings suggestive of a small area of infarction in the circumflex/right coronary artery, potentially from embolic causes (Figures 1A to 1C).

No detection of atrial fibrillation at monitoring. Transesophageal echocardiography evidenced Patent Foramen Ovale (PFO) with discrete basal left-right shunt. After injection of agitated saline serum associated with cough/Valsalva maneuver, significant passage of blisters to the left atrium was seen through the oval fossa (Figures 1D to 1F). Acute myocardial infarction (AMI) was assumed to derive from paradoxical embolism, with suspension of oral contraception. PFO closure was performed. The thrombophilia study revealed homozygosity of the Methylenetetrahydrofolate Reductase Gene (MTHFR).

In the absence of atherosclerotic disease, AMI in a young patient with no cardiovascular risk factors should alert to the possibility of embolic etiology. Paradoxical embolism manifested as AMI is rare and requires a high level of clinical suspicion. Treatment is still a matter of debate, but PFO closure should be considered to avoid recurrence of events.

Keywords

Embolism, Paradoxical; Foramen Ovale, Patent; Myocardial Infarction.

Correspondência: Hugo Antunes •
Rua Bouça da Lage. Guimarães, Portugal. 4805-603
E-mail: hugo.ads.antunes@gmail.com

DOI: 10.5935/2318-8219.20190031

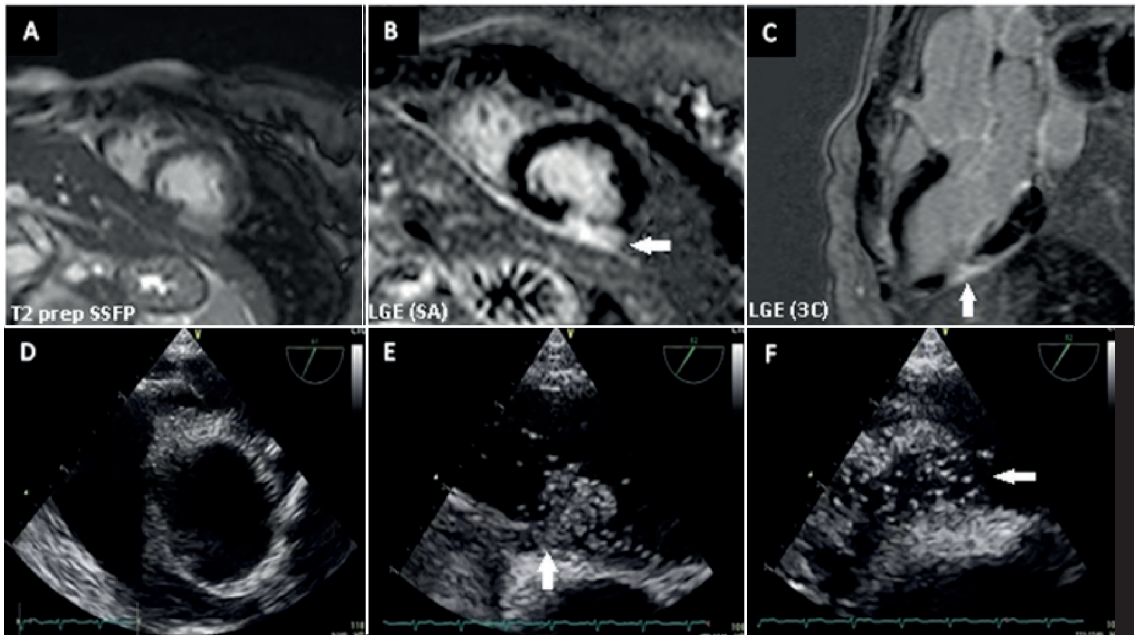


Figure 1 – *(A-C) A small area of transmural enhancement on the inferolateral wall, in the transition between a middle and an apical third, an area with evidence of hypersignal in the T2-weighted sequences (in this case, a T2 prep SSFP). (D-F) TEE with stretched patent foramen ovale.*