CARDIAC IMAGE UPDATED

Vol. 1, No. 3, July-September 2019

doi: 10.35366/91808
https://dx.doi.org/10.35366/91808

Original Research

Positron emission computed tomography. A new technique for the assessment of left ventricular volumes and ejection fraction

Tomografía por emisión de positrones. Una nueva técnica para medición de volúmenes y fracción de expulsión del ventrículo izquierdo

Oscar A Pérez-Orpinel,* Maximiliano Flores-Flamand,* Jessy Steve Masso-Bueso,* Carlo A Sánchez-Montaño,* Rodrigo Escalante-Armenta,‡ Alondra Flores-García,* Nilda Espínola-Zavaleta,* Erick Alexánderson-Rosas*,§

* Nuclear Cardiology Department, Instituto Nacional de Cardiología «Ignacio Chávez», Mexico City.
‡ Facultad Mexicana de Medicina, Universidad La Salle.
§ Phisiology Department, Facultad de Medicina, Universidad Nacional Autónoma de México, Mexico City.

Corresponding author:
Dr. Erick Alexánderson-Rosas
Juan Badiano Núm. 1, Colonia Sección XVI, 14080, Alcaldía Tlalpan, Ciudad de México, México
E-mail: alexandersonerick@gmail.com

ABSTRACT. Introduction: The left ventricular ejection fraction (LVEF) is a parameter that reflects the myocardial systolic function. Its measurement is of great importance to establish the diagnosis, treatment and prognosis of different cardiovascular diseases. There are several non-invasive methods such as echocardiography, magnetic resonance imaging, Gated-SPECT for the measurement of ventricular volumetric and the ejection fraction of the left ventricle. **Objective:** The objective of this study was to determine the normal values of left ventricular volumes and LVEF using Gated-PET-13N-Amonia in Mexican population. **Material and methods:** We included patients with normal Gated-PET^{13}N-Ammonium myocardial perfusion study. Left ventricular volumes and ejection fraction were obtained. Images were analyzed in QPS-QGS ®Cedars Sinai®. The variables were expressed in mean and standard deviation. **Results:** A total of 78 patients were included. The end-diastolic volume (EDV) at rest was of 84.9±28.2 mL, the end-systolic volume (ESV) 28.2±20.1, the stroke volume (SV) 56.8±12.8 mL and the LVEF 68.7±9.1%. The stress EDV was of 96.3±31.7 mL, the stress ESV 32.1±21.7 mL, the SV 64±13.9 mL and the LVEF 68.3±8.75%. **Conclusion:** The measurement of left ventricular volumes and ejection fraction obtained by the PET ^{13}N-Ammonium perfusion study is feasible and should be considered as an additional diagnostic tool.
Keywords: Ejection fraction, ventricular volumes, positron emission tomography.

RESUMEN. Introducción: *La fracción de expulsión del ventrículo izquierdo (FEVI) es un parámetro que refleja la función sistólica del miocardio. Su medición es de gran importancia para establecer el diagnóstico, tratamiento y pronóstico de distintas enfermedades cardiovasculares. Existen diversos métodos no invasivos como la ecocardiografía, la resonancia magnética, el Gated-SPECT para la medición de los volúmenes ventriculares y la fracción de eyección del ventrículo izquierdo.* ***Objetivo:*** *Determinar los valores normales de los volúmenes ventriculares y de la FEVI mediante Gated-PET-13N-Amonio, en población mexicana.* ***Material y métodos:*** *Se incluyeron pacientes a quienes se les realizó un estudio de perfusión miocárdica por PET 13N-Amonio para descartar cardiopatía isquémica, la cual resultó normal. Se obtuvieron los volúmenes ventriculares y la fracción de expulsión mediante reconstrucciones hechas por un software de PET cardiaco QpS-QGS Cedars Sinai®. Las variables se expresaron en medias y desviación estándar.* ***Resultados:*** *Se incluyeron 78 pacientes con estudio de PET 13N-Amonio normal. El volumen telediastólico (VTD) en fase de reposo es 84.9±28.2 mL, el volumen telediastólico (VTS) de 28.2±20.1 mL, el volumen latido (VL) de 56.89 ± 12.8 mL y la FEVI de 68.7± 9.1%. El VTD en fase de*

estrés fue de 96.35±31.7 mL, el VTS de 32.1±21.7 mL, el VL de 64±13.9 mL y la FEVI de 68.3±8.7%. ***Conclusión.*** *La medición de volúmenes ventriculares y de la fracción de expulsión del ventrículo izquierdo obtenida por el estudio de perfusión con PET 13N-Amonio es factible y debe ser considerada como una herramienta diagnóstica adicional.*
Palabras clave: *Fracción de expulsión; volúmenes ventriculares; tomografía con emisión de positrones.*

INTRODUCTION

Ventricular function parameters such as the left ventricular ejection fraction (LVEF) and ventricular volumes have been studied extensively by different invasive and non-invasive methods.[1-5] The best known are two-dimensional and three-dimensional echocardiography[1,2,6] and magnetic resonance imaging (MRI) which is considered the gold standard.[2-4]

The evaluation of LVEF and ventricular volumes has a significant clinical impact on the treatment and prognosis of patients with cardiovascular diseases.

2D echocardiography: two-dimensional echocardiography using the modified Simpson method is the most commonly used technique for measuring LVEF, due to its high availability. Although LVEF is a robust predictor of cardiac events in the general population, it has low sensitivity for the detection of small changes in left ventricular function. The LVEF calculated by two-dimensional echocardiography does not detect the subtle alterations in the contractility of the left ventricle, due to several factors that include the geometric presumption of left ventricle, inadequate visualization of the true apex and the intra and interobserver variability. It is also important to remember that the LVEF depends on the loading conditions, which can be modified frequently and affect the real value.[1,2]

3D echocardiography: with the advent of real-time 3D echocardiography, the analysis of ventricular volumes and ejection fraction is more reliable and reproducible. This technique allows to quantify beat by beat the volumes and LVEF, without any geometric presumption, with excellent correlation with the volumes determined by magnetic resonance (r = 0.96, 0.97 and 0.93 for end-diastolic volume [EDV], end-sistolic volume [ESV] and LVEF, respectively).[3,6]

Computed tomography (CT) scan: this technique uses contrast dye that allows

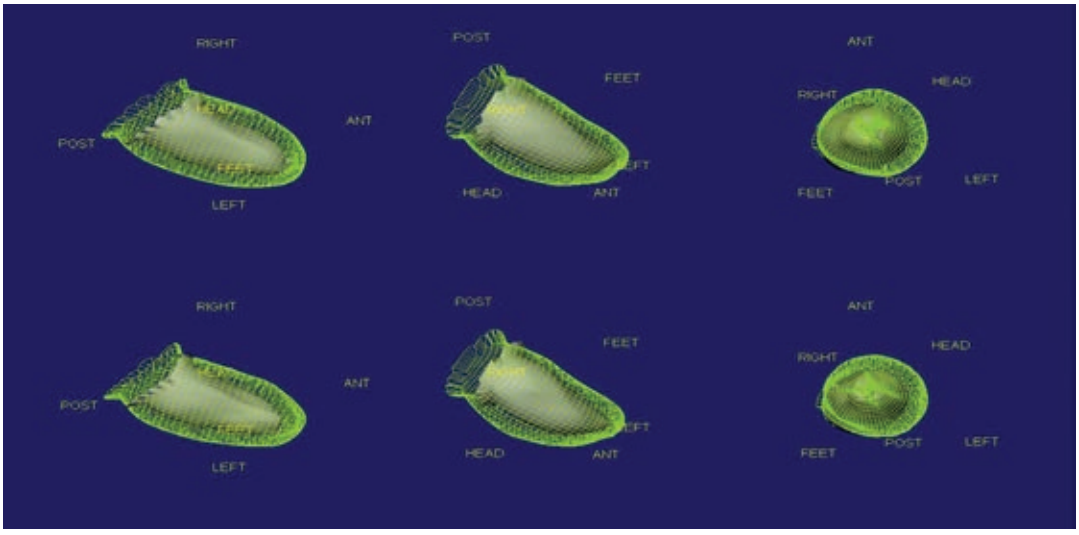

Figure 1:

Reconstruction of a cardiac positron emission tomography study, with spatial visualization of ventricular volumes.

Table 1: Demographic variables of the population studied.

Variable	Value (n=78)
Male sex	44 (56.4%)
Age (years)	63.2±10.7
Weigth (kg)	73.8±11.9
Heigth (mt)	1.63±0.09
Body mass index	27.4±3.5

clearly differentiation of ventricular pool and myocardium, eliminating errors on the geometric perception of the left ventricle. The weaknesses of CT include a low temporal resolution and a slight overestimation of the EDV, probably due to the administration of beta blockers during procedure.[3] On the other hand, radiation exposure is a factor that should be taken into consideration.

Cardiac magnetic resonance: is the study with the highest spatial and temporal resolution, to evaluate ventricular volumes and LVEF. This technique is considered the gold standard for volumetric measurements in cardiology. However, it's a high cost and poor available test.[4]

Nuclear cardiology: there are several nuclear medicine methods that can be used in the evaluation of ventricular volumes and LVEF. The most commonly used are Gated-SPECT (single photon emission computed tomography) and PET (positron emission tomography). PET has several advantages over Gated-SPECT, which include a considerable decrease in attenuation and greater temporal and spatial resolution. The limitations of nuclear studies are radiation exposure and the inability to obtain adequate triggering in patients with irregular rhythm. Although there are multiple programs for image processing, sometimes a manual adjustment is required to delimit the ventricle, generating variations in the reproducibility of the study.[5]

The objective of this study was to determine the normal values of ventricular volumes and LVEF using Gated-PET-13N-Ammonia in Mexican population without cardiovascular disease.

MATERIAL AND METHODS

This is a descriptive, retrospective and retrolective study, which included patients who attended the PET-Cyclotron unit of the Faculty of Medicine of the Autonomous University of Mexico (Mexico City). All patients underwent a myocardial perfusion study with 13N-Ammonium PET that ruled out the presence of ischemic heart disease.

The myocardial perfusion study was performed at rest with the administration of a dose of 20 mCi of 13N-Ammonium and during the pharmacological effort with the administration of 140 μg/kg /min of adenosine in continuous infusion for 6 minutes. In the 3rd minute of the infusion, the second dose of 20 mCi of 13N-Ammonium was administered and in the 5th minute the images of the stress phase began to be acquired *(Figure 1)*.

In addition to the perfusion variables, ventricular volumes and LVEF were recorded both at rest and in stress.

The reconstruction of the perfusion images, as well as the calculation of the volumes, was performed with a cardiac PET software from the Cedars-Sinai® Medical Center *(Figure 2)*.

Table 2: Ventricular volumes and left ventricule ejection fraction during rest and stress.

Rest	Mean	SD
EDV (mL)	84.97	28.2
ESV (mL)	28.2	20.1
SV (mL)	56.89	12.8
LVEF (%)	68.78	9.13
Stress	Mean	SD
EDV (mL)	96.35	31.7
ESV (mL)	32.12	21.7
SV (mL)	64.07	13.9
LVEF (%)	68.3	8.75

EDV = end-diastolic volume; ESV = end-systolic volume; SV = stroke volume; LVEF = left ventricule ejection fraction

Study	PET^PETCT_Cardiac_LM_DYN (Adulto)
Dataset	G_Ammonia_Stress (AC)
Date	2018-04-18 16:19:26
Status	QC=1.98, IR=0.32
Volume	45 mL[3]
EDV	124 mL[8]
ESV	45 mL[3]
SV	79 mL
EF	68%
Shape	0.68 [SI ED], 0.59 [SI ES], 0.88 [Ecc 3]
Study	PET^PETCT_Cardiac_LM_DYN (Adulto)
Dataset	G_Ammonia_Stress (AC)
Date	2018-04-18 15:58:33
Status	QC=1.51, IR=0.29
Volume	39 mL[3]
EDV	109 mL[8]
ESV	39 mL[3]
SV	70 mL
EF	65%
Shape	0.65 [SI ED], 0.48 [SI ES], 0.88 [Ecc 3]

Figure 2: Measurement of volumes and left ventricule ejection fraction using cardiac positron emission tomography software.

RESULTS

A total of 78 patients with an average age of 63±10.7 years were included. Forty-four (56%) were men and 34 women (44%). The demographic variables of the population studied are in *Table 1*.

In resting phase, the EDV was 84.9±28.2 mL, the ESV was 28.2±20.1 mL, the stroke volume (SV) was 56.8±12.8 mL and the LVEF was 68.7±9.1% *(Table 2)*.

In stress phase, the EDV was 96.3±31.7 mL, the ESV was 32.1±21.7 mL, the SV was 64±13.9 mL and the LVEF of 68.3±8.7% *(Table 2)*.

DISCUSSION

The results obtained in this population are correlated with ventricular volumes and the ejection fraction corresponds to that reported by other non-invasive imaging methods in the healthy population. In the guidelines published in 2015, normal values of volumes and LVEF in men were for EDV of 106±22 mL, ESV of 41±10 ml and LVEF of 62±5%. In women, the reference values were 76±15 mL, 28±7 mL and 64±5% for EDV, ESV and LVEF, respectively. The values reported correlate with the results obtained in the present study at rest.[6]

One of the main advantages in obtaining ventricular volumes by PET is the practically null interobserver variability, because the measurements are made with specialized software. This is a point in favor of PET 13N-Ammonium compared to more frequently used methods such as echocardiography, which despite being a very useful method, has a lot of intra and interobserver variability.

The 13N-Ammonium PET myocardial perfusion study has an advantage in relation to the Gated-SPECT perfusion study, since its high spatial resolution allows the calculation of volumes in a more exact way. This places PET 13N-Ammonium, at a level of accuracy similar to that of tomography or cardiac magnetic resonance.

Myocardial perfusion studies such as PET 13N-Ammonium are not used first for the measurement of ventricular volumes, but their usefulness is mainly used in the detection of perfusion defects. However, ventricular volumes and LVEF calculated by PET 13N-Ammonium are considered feasible and with a very good concordance, so they can be of great help to the clinician in making diagnostic and therapeutic decisions.

CONCLUSION

The measurement of ventricular volumes and the ejection fraction of the left ventricle obtained by the PET 13N-Ammonium perfusion study is feasible and should be considered as an additional diagnostic tool.

REFERENCES

1. Malm S, Frigstad S, Sagberg E, et al. Accurate and reproducible measurement of left ventricular volume and ejection fraction by contrast echocardiography: a comparison with magnetic resonance imaging. J Am Coll Cardiol. 2004; 44 (5): 1030-1035.
2. Chukwu EO, Barasch E, Mihalatos DG, et al. Relative importance of errors in left ventricular quantitation by two-dimensional echocardiography: insights from three-dimensional echocardiography and cardiac magnetic resonance imaging. J Am Soc Echocardiogr. 2008; 21: 990-997.

3. Asferg C, Usinger L, Kristensen TS, et al. Accuracy of multi-slice computed tomography for measurement of left ventricular ejection fraction compared with cardiac magnetic resonance imaging and two-dimensional transthoracic echocardiography A systematic review and meta-analysis. Eur J Radiol. 2012; 81: e757-e762.
4. Alfakih K, Reid S, Jones T, et al. Assessment of ventricular function and mass by cardiac magnetic resonance imaging. Eur Radiol. 2004; 14: 1813-1822.
5. Mudrick DW, Velazquez E, Borges-Nieto S. Does myocardial perfusion imaging provide incremental prognostic information to left ventricular ejection fraction? Curr Cardiol Rep. 2010; 12: 155-161.
6. Lang RM, Badano LP, Mor-Avi V, 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.