



Anatomical Assessment using 3D Heart for a whole heart study of a patient with Congenital Anomaly

By Juan Manuel Bonelli, MD, Instituto Gamma, Rosario, Argentina

"3D Heart, a free breathing 3D Fiesta (SSFP) sequence with ECG gating, enables non-contrast whole heart study and characterization of small vessels, not possible with other conventional techniques. It allows us the evaluation of the coronary arteries, the thoracic aorta and pulmonary arteries in young patients with congenital heart disease"

About the Author:



Juan Manuel Bonelli

Juan Manuel Bonelli, MD, Cardiologist at Instituto Gamma, Fellowship in Non-invasive cardiovascular Imaging, Professor in cardiovascular imaging at Universidad Nacional de Rosario and specialized in MRI and Cardiovascular CT.
E-mail: jmbonelli@gmail.com

About the Institution:

At Grupo Gamma we are committed to constantly seeking the best quality in everything we do. Our Integrated Health Network is the sum of the efforts of a passionate, demanding and visionary human team that seeks to create the best health experience for our patients who choose us every day.
Instituto Gamma



GE Healthcare Latam Collaborators:

Cristian Allard, Clinical Leader MR,
Tiago Giacometti, Educational Advisor
MR, Eduardo Figueiredo BSc, Clinical
Marketing Leader & Research MR,
Thomas Martin Doring, PhD, GROE



Introduction

The three-dimensional (3D) whole heart approach with respiratory navigator gating has been developed as an alternative to enable coronary imaging. This free-breathing and radiation-free approach is well established for the detection of coronary artery anomalies in infants and young children with congenital heart disease (CHD). The comprehensive evaluation of thoracic vasculature is uniquely suited to give detailed morphological information in CHD.

Previous techniques as Spiral 2D requires individual planes acquisition and are not suitable for curved reformatting to better access coronaries arteries.

Gated 3D FSPGR requires contrast injection and lacks resolution.

For this reason, 3D Heart was developed, permitting an assessment of proximal coronary arteries and anomalies in the Aorta. 3D Heart is a non-contrast, 3D Fiesta (SSFP), high spatial resolution sequence, respiratory navigated or breath hold and ECG gating, being able for reformatting in any plane, MIP reconstruction, providing anatomical details of small and big vessels.

We would like to demonstrate in this clinical case the benefits of 3D Heart Sequence in the anatomical assessment of small vessels in a patient with congenital anomaly.



Clinical Case Report

Patient History

A 29 years old, male, diagnosed at birth with single ventricle (SV), transposition of the great arteries (TGA), hypoplasia of RV, with 3 subsequent cardiac surgeries.

MR technique

The patient underwent cardiac MRI (Signa Artist, GE Healthcare, Milwaukee, USA) using a body array. The acquisition protocol included routine cardiac sequences and in addition the 3D Heart sequence. Images were post processed on an Advanced Workstation using Volume Illumination (AW Tennessee, Volume Viewer, GE Healthcare, Milwaukee, USA). The 3D acquisition protocol is listed in Table 1.

3D Heart technique

- 3D heart is a SSFP-based sequence with FatSat SPECIAL and T2 preparation pulse to reduce myocardium/stationary tissue signal, enhancing vessel conspicuity. A new steady state preparation reduces off-resonance artifacts and improves the robustness of 3D FIESTA image quality.
- The multislab approach increases inflow effects and therefore contrast, allowing extended coverage. Single Slab is also available in case of faster flow or post contrast cases.
- Includes 1 NEX Center-out k-space filling for motion freezing and contrast robustness.
- Key parameters are:
 - Number of RR interval for freezing cardiac motion as it define temporal resolution
 - Trigger delay: Critical in capturing diastolic period for coronaries visualization. Always manually select Trigger Delay, by observing 2ch or 4ch CINE, and select start of quiet period (Table 2). Systolic can be used for high heart rates and arrhythmic patients, with increased segmentation using increased number of RR and reducing phase encoding steps with ASSET.
 - Volume illumination, a AW tool, provides a richer, improved 'human like' visualization of the anatomy using volumetric lighting. It allows also a more real view of the anatomy of the great vessels and at the same time a fusion with 3D Heart sequence to give a more realistic visualization of the vessel anatomy.



| | |
|-----------------------|---------------------|
| Sequence | 3D Heart Nav |
| TR [ms] | 4.2 |
| TE [ms] | Min full |
| Chem SAT | Special-49 (Auto) |
| Flip Angle | 60 |
| Field of View [cmxcm] | 36x28 |
| Acquisition Matrix | 224*224 |
| Slice thickness [mm] | 2 |
| Overlap Loc | 3 |
| Acquisition plane | Axial |
| #Slab | 3 |
| Acceleration (Asset) | 2 |
| T2 prep | on |
| NEX | 1 |
| Loc per Slab | 3 |
| Scan time [min:sec] | 4:12 |
| Navigator | On (Cylindric) |
| Option Image | Gat-EDR-ZIP2-ZIP512 |

Table 1.
Acquisition protocol

| Heart Rate | T _{del} | #RR |
|------------|------------------|--------------------|
| <75bpm | Diastolic | 2 |
| >75bpm | Systolic | 3 (or 2RR + ASSET) |
| Arrhythmic | Systolic | 3 (or 2RR + ASSET) |

Table 2.
Patient Heart Rate Specific Parameters. T_{del} = delay time.



MR findings

TGA + KDS technique + stenotic conduits RV – PA. Aberrant right subclavian artery. Common origins for right coronary artery and anterior descending coronary in the right coronary sinus. AD has trajectory between the pulmonary artery and RV conduit, the latter stenotic. Circumflex artery is anomalous and has independent origin.

The 3D Heart sequence shows great three plane anatomy of great vessels and coronary origins in the heart

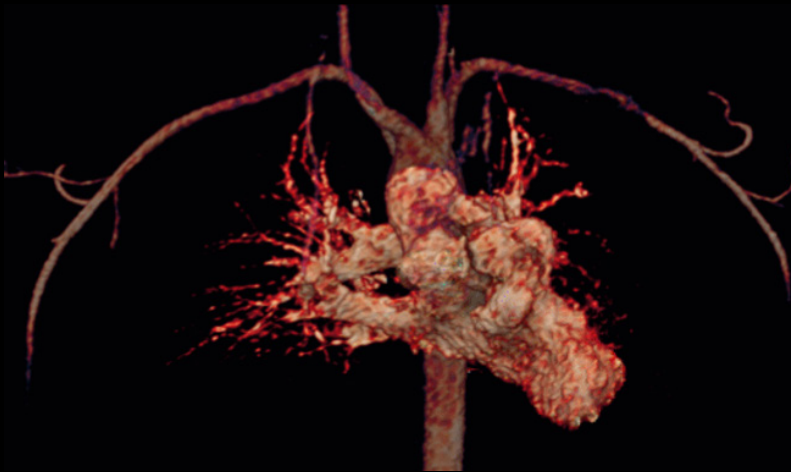


Figure 1. 3D Heart multiplane reformat: Reconstruction of large vessels

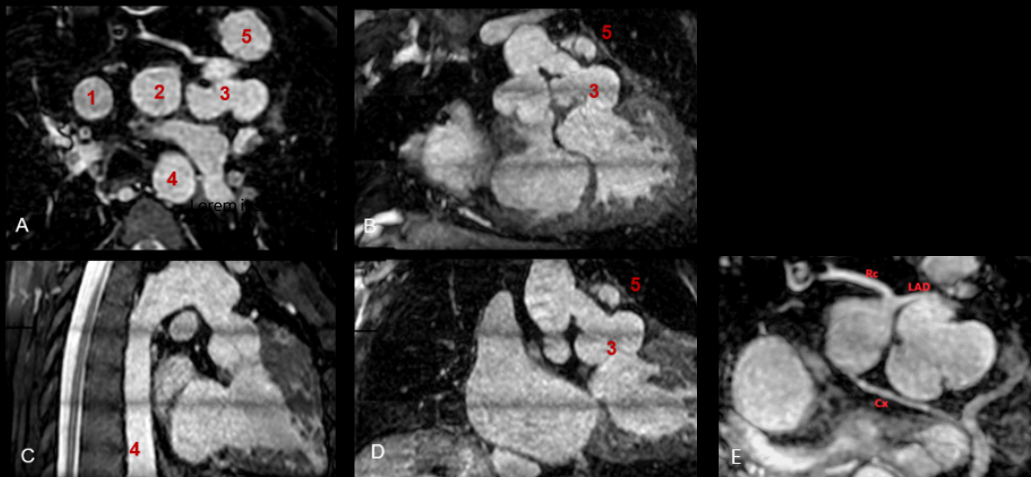


Figure 2. 3D Heart: Reconstruction of large vessels

A-D: Superior vena cava (SVC), 2 Ascending aorta (Ao ASC), 3 Pulmonary artery (PA), 4 Descending aorta (Ao Dsc), 5 RV – PA conduit. Please note: the stripe artefact can be avoided by choosing the higher slice overlap but this increases the acquisition time for the same FOV. In this case, we tried to balanced acquisition time to the specific patient condition, by accepting this minimal artifact. E: Coronary origins, Right Coronary (RC), Anterior Descending Artery (LAD), Circumflex Artery (Cx). The image in folder have the name picture 22.

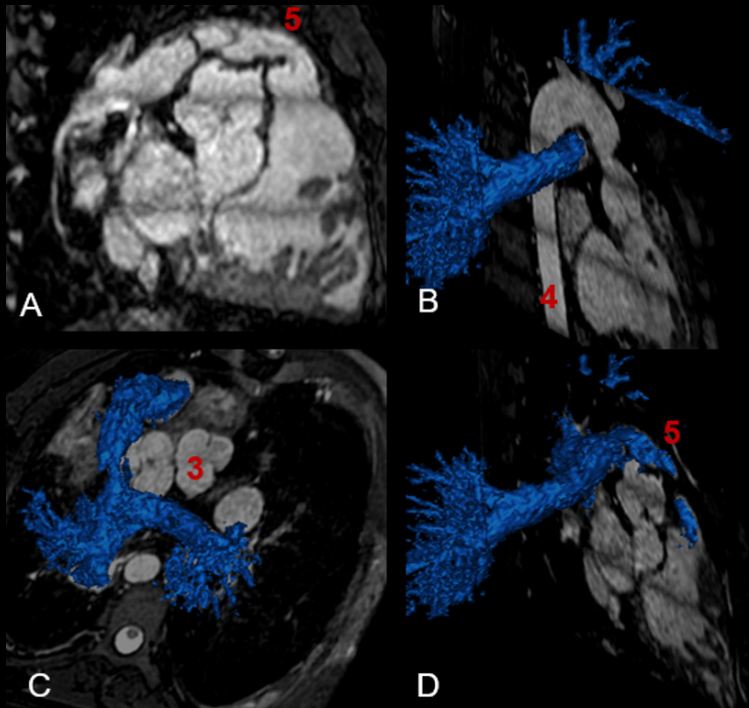


Figure 3. 3D Heart: Reconstruction of large vessels

sequence with Multiplane Reformating of pulmonary artery with VR technic in Volume illumination of AWS.

3: Pulmonary artery 4: Descending aorta 5: RV-PA Conduit.

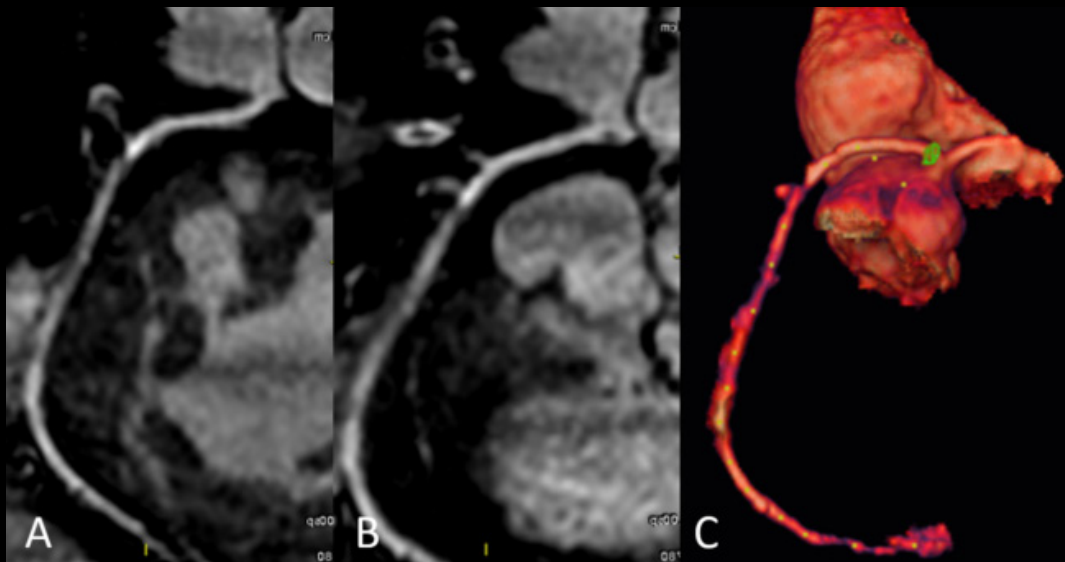


Figure 4. 3D Heart Reformating of small vessels
with Volume Viewer and VR Illumination.



Discussion and Conclusions

The three-dimensional (3D) whole heart technique, 3D Heart, is an excellent diagnosis tool in cardiovascular magnetic resonance imaging of congenital heart diseases. It offers significant advantages over other CHD imaging modalities and techniques: its free-breathing ability, high SNR with isotropic voxel resolution for multiplanar reformatting assessment and no usage of ionization radiation. One limitation that appears mainly in non-cooperative patients, are longer acquisition times with associated image quality degradation. Also, image quality might be reduced in the more distal coronary segments.

Isotropic 3D whole heart datasets are particularly useful in CHD for interventional planning. MR angiography has already been shown to be accurate for planning cardiac catheterization procedures, with the 3D nature of the dataset being critical.

3D whole heart datasets, with the added advantage of gating, are well-suited to the production of 3D printed models to aid surgical planning. This approach can be used to minimize radiation for fluoroscopic imaging and reduce the required dose of iodinated contrast.

Overall, 3D heart sequence shows promising results for coronary MR imaging.



Key points/Conclusions

- 3D heart, a SSPF based ECG gated, free breathing technique is an excellent and unique CMRI tool for the evaluation of young patients with congenital heart diseases.
- Its 3D high spatial resolution capabilities enables the examination of small vessels, essential in the evaluation of young patients, and not being possible with other conventional MR techniques.

References

Bluemke DA, Achenbach S, Budoff M, et al. Noninvasive coronary artery imaging: magnetic resonance angiography and multidetector computed tomography angiography: a scientific statement from the American Heart Association Committee on Cardiovascular Imaging and Intervention of the Council on Cardiovascular Radiology and Intervention, and the Councils on Clinical Cardiology and Cardiovascular Disease in the Young. *Circulation* 2008; 118:586-606.

Hamdy A, Ishida M, Sakura H. Cardiac MR assessment of coronary arteries. *CVIA* 2017; 1:49-59.

Sakuma H, Ichikawa Y, Suzawa N, et al. Assessment of coronary arteries with total study time of less than 30 minutes by using whole-heart coronary MR angiography. *Radiology* 2005; 237:316-321.

Stuber M, Weiss RG. Coronary magnetic resonance angiography. *J Magn Reson Imaging* 2007; 26:219-234.

The products / technologies mentioned in this material may be subject to the regulation of the government. Your shipment and effective commercialization only may occur after regulatory approval.

The products/technologies could be described with their market names, different from what is approved in the regulator. The commercialization of it will occur with the product name registered in the regulator.

JB00147BR