New Cardiac Magnetic Resonance Reference Ranges for Right Ventricular Volumes and Systolic Function

What Is New and Why Should We Care?

Graham Fent, MBChB, BSc; Sven Plein, MD, PhD

Accurate quantitation of right ventricular (RV) volumes and systolic function provides important diagnostic and prognostic information in a wide range of conditions. In the case of heart failure, a preserved RV ejection fraction (RVEF) is associated with improved long-term survival. The most recent task force criteria for the diagnosis of arrhythmogenic RV cardiomyopathy require the presence of abnormal measurements of RV end-diastolic volume or RVEF to fulfill the major imaging criterion for diagnosis of the condition. In pulmonary arterial hypertension, increased RV end-diastolic volume and decreased RV stroke volume independently predict mortality and after myocardial infarction, RV function is an independent prognostic marker of clinical outcome.

See Article by Foppa et al

Cardiac magnetic resonance (CMR) is considered the current reference standard for quantitation of RV volumes and systolic function because of its accuracy and reproducibility, and several previous studies have reported normal values for this method. So why then do we need new normal reference values?

CMR methods have undergone considerable evolution and standardization during the past 2 decades. Today, balanced steady-state free precession (SSFP) is the standard for acquisition of cine CMR images because it provides much better endocardial border delimitation, shorter scan times, and higher signal:noise ratios than the formerly used spoiled gradient echo methods. The overall better image quality of balanced SSFP acquisition and the ability to more clearly differentiate trabeculation from the endocardial border leads to different estimates of left ventricular and RV chamber size, with typically larger volumes and lower mass.

Many older studies reporting normal values are, therefore, largely obsolete, and it is important that normal values for contemporary CMR methods are available. The largest study of those using older acquisition methods was the Multi-Ethnic Study of Atherosclerosis (MESA), which included a cohort of 4204 participants for whom CMR measurements of RV volumes were available. The authors reported increased RVEF with advancing age, increased RV end-diastolic volume but lower RVEF in men versus women, lower RVEF in black versus white individuals as well as higher right ventricular end-diastolic volume and lower RVEF in obese individuals.

Several other studies have provided normal reference ranges for RV volumes and systolic function using contemporaneous SSFP acquisition, but these are on a much smaller scale than the study by Foppa et al in this issue of Circulation: Cardiovascular Imaging.

Foppa et al report sex-specific normative values for RV measurement from a cross-sectional study of members of the Framingham Heart Study Offspring cohort. The reported normal values are derived from the 1336 participants remaining after exclusion of those with a history of either respiratory disease, previous venous thromboembolic disease, or significant left ventricular systolic impairment, ensuring a well-characterized sample. In addition to providing a normal range, the study makes several important observations. RVEF was greater in women, RV volumes were higher in males, and RV volumes increased with body size while there were smaller RV volumes in older subjects. Indexation of values according to body surface area adjusted appropriately for body size and obesity and out-performed indexation by height only, though had a tendency toward overcorrection for RV volumes.

We commend the authors on providing updated, sex-specific normal reference ranges for measurements of RV volumes and systolic function using current SSFP CMR in such a large, real-world community-based cohort. The cohort studied represents a wide range of middle-aged to elderly subjects (mean age, 64±9 years; 576 men) and includes subjects with a wide spectrum of body mass index. The authors’ findings broadly correlate with previous studies in terms of smaller RV volumes with aging, increased RV volumes, and lower RVEF in men versus women and increased RV volumes with obesity. Reproducibility between readers was good and on par with previous studies.

Some limitations of the study have been cited by the authors and are worth expanding on, including the fact that the study cohort only included white participants. In the MESA population, differences in RV volumes and RVEF were described in ethnic groups, but that study did not use SSFP acquisition. An additional limitation of the study is the age range of 37 to 89 years and lack of inclusion of younger...
participants. Although the normal RV values reported by the authors represent the most robust currently available using SSFP CMR for middle aged to elderly subjects, they do not apply to younger patients. Indeed, quoted reference ranges for younger subjects in other studies fall outside the 95% confidence intervals reported by Foppa et al.\textsuperscript{11} As such, the use of alternative reference ranges\textsuperscript{12,13} for RV volumes and systolic function in younger adult patients is advised.

It should be noted that the authors acquired cine RV images using left ventricular short-axis imaging planes and did not acquire additional axial imaging planes to allow comparison of the obtained values. Although this is common clinical practice, analysis of a stack of RV cine loops in the axial imaging plane reduces intra and interuser reproducibility\textsuperscript{14} and is widely considered the optimal method by which to measure RV volumes. Measurement of RV volumes from LV short-axis imaging planes can result in difficulty in distinguishing the right atrium from the basal RV at the level of the tricuspid valve, as well as in accurate segmentation of the RV indibulum.\textsuperscript{15} The transposition of contours onto orthogonal imaging planes can aid the positioning of RV contours, in particular at the base of the heart. The use of the orthogonal imaging planes can aid the positioning of RV contours, in particular at the base of the heart. The use of the orthogonal imaging planes can facilitate these decisions (Figure), but it is unclear whether this was done in this study. A more detailed description of the analysis strategy and inclusion of a figure illustrating contour placement would have been important to ensure that the values reported in this article can be reproduced by others.

In addition, the authors considered papillary muscles and trabeculations as part of the intracavitary volume. Although this was certainly not incorrect and is in line with previous studies, modern postprocessing software allows exclusion of both papillary muscle and RV trabeculation. The inclusion of reference values where the contribution of papillary muscle and RV trabeculation to RV volumes was accounted for would have been a welcome addition to the study.

In summary, the study by Foppa et al\textsuperscript{11} provides normal reference values for RV volumes and systolic function using SSFP CMR. These are the most robust and comprehensive contemporary reference values for middle-aged and elderly patients; however, the use of values specific to younger patients and non-white patients is advised where these are required.

Disclosures

None.

References


**Key Words:** Editorials ■ body surface area ■ heart failure ■ obesity ■ right ventricular function
New Cardiac Magnetic Resonance Reference Ranges for Right Ventricular Volumes and Systolic Function: What Is New and Why Should We Care?

Graham Fent and Sven Plein

doi: 10.1161/CIRCIMAGING.116.004589

*Circulation: Cardiovascular Imaging* is published by the American Heart Association, 7272 Greenville Avenue, Dallas, TX 75231

Copyright © 2016 American Heart Association, Inc. All rights reserved.
Print ISSN: 1941-9651. Online ISSN: 1942-0080

The online version of this article, along with updated information and services, is located on the World Wide Web at:

http://circimaging.ahajournals.org/content/9/3/e004589

Permissions: Requests for permissions to reproduce figures, tables, or portions of articles originally published in *Circulation: Cardiovascular Imaging* can be obtained via RightsLink, a service of the Copyright Clearance Center, not the Editorial Office. Once the online version of the published article for which permission is being requested is located, click Request Permissions in the middle column of the Web page under Services. Further information about this process is available in the Permissions and Rights Question and Answer document.

Reprints: Information about reprints can be found online at:
http://www.lww.com/reprints

Subscriptions: Information about subscribing to *Circulation: Cardiovascular Imaging* is online at:
http://circimaging.ahajournals.org//subscriptions/