Tailor-made right ventricular imaging

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Right ventricular (RV) performance has a major role in the clinical status and prognosis of patients with congenital heart disease, especially in patients with a systemic right ventricle such as patients with congenitally corrected transposition of the great arteries (TGA) or with TGA corrected by a Mustard or Senning operation.

Quantification of RV function is challenging for several reasons. Especially in echocardiography, the anterior position of the right ventricle in the chest causes near-field artifacts, which may preclude visualisation of the RV apex. Also, the complex morphology of the right ventricle makes an estimation of volumes based on two-dimensional (2D) measurements unreliable. Thirdly, exact delineation of the thin and highly trabecularised RV wall is difficult.

Several modalities are available to assess RV function, of which cardiac magnetic resonance imaging (CMR) and echocardiography are most frequently used in clinical practice. CMR is considered the standard of reference, yet CMR is more costly and less widely available than echocardiography. RV volume measurements by 2D echocardiography correlate poorly with CMR [1]. Strain and strain-rate imaging provides an accurate, yet indirect, assessment of RV myocardial performance [2]. Three-dimensional echocardiography provides more accurate RV volume measurements than 2D echocardiography, yet compared with CMR it consistently underestimates RV volume [3–5]. This is probably due to incomplete depiction of the right ventricle. Also, in 3D echocardiography image quality was insufficient in approximately one fourth of patients [3–5].

CMR, on the other hand, is contraindicated in patients with a defibrillator or an MRI-unsafe pacemaker. Therefore, in the present issue, Winter and colleagues studied whether CT may be an alternative to CMR for the determination of RV volumes and function in TGA patients with a contraindication to CMR

[6]. They studied 35 TGA patients; of these patients 20 underwent CMR to measure RV volumes and ejection fraction. In the remaining 15 patients, in whom CMR was contraindicated due to the presence of a pacemaker or defibrillator, RV volumes and ejection fraction were determined by CT. The authors found that the intra- and interobserver variability of RV volumes and ejection fraction measured with CT were higher compared with those with CMR. However, except for RV stroke volume these differences in variability were not statistically significant. Although the current study provides no direct intra-patient comparison between CMR and CT, previous studies demonstrated adequate correlation of RV volumes and function measured with 64-slice CT and those with CMR [7]. However, the more limited temporal resolution of 16-slice CT resulted in a systemic over-estimation of RV end-systolic volume [8].

As also addressed by Winters et al., CT is associated with radiation and iodine contrast material. The radiation dose of 14 mSv in the current study is substantial, especially for relatively young patients who are likely to receive additional examinations and treatments associated with radiation. In a 20-year-old subject, a radiation dose of 14 mSv confers an approximately 0.2 % (men) to 0.5 % (women) lifetime attributable risk of cancer [9]. The risk of cancer associated with a radiation dose of 14 mSv is 1.8 (men) to 3.2 (women) times higher for a 20-year-old subject compared with a 60-year-old subject of the same sex [9].

As discussed in more detail by Winters et al., presumed pacemaker- and defibrillator-related contraindications are predominantly theoretical and further research addressing CMR compatibility is warranted. MRI-safe pacemakers may prove valuable in patients with congenital heart disease. However, leads in the right ventricle may yield substantial artifacts in both CT and MRI, although current studies do not report preclusion of accurate RV measurements with CT in patients with a pacemaker.

Obviously, for those patients depending on CT for RV imaging, strategies to reduce radiation dose are warranted. Dose-modulation protocols, in which tube current is reduced

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during less essential phases of the cardiac cycle, may reduce the radiation dose as has been demonstrated for retrospectively gated CT coronary angiography. Also, technical advances in newer generation CT scanners, such as more detector rows to enable scanning of the entire heart within one gantry rotation and improved detector sensitivity, may lead to a further reduction in radiation dose. Also, the amount of iodine contrast may be reduced with dual-energy scanners, as was recently shown for CT pulmonary angiography [10].

On the positive side, CT angiography can visualise the pulmonary arteries and aorta more accurately than CMR, which may prove valuable in clinical decision making in TGA patients.

As supported by the study by Winters et al., a tailor-made approach for the individual patient is essential. Currently, in our opinion, CMR and 3D echocardiography remain the modalities of choice for RV imaging. However, in patients with contraindications to CMR and poor echocardiographic image quality, CT seems a valid alternative. Future technological advances may reduce the health risks associated with CT, while CT angiography provides potentially valuable additional information.

Conflict of interest None.

References

1. Lai WW, Gauvreau K, Rivera ES, et al. Accuracy of guideline recommendations for two-dimensional quantification of the right ventricle by echocardiography. *Int J Cardiovasc Imaging*. 2008;24:691–8.
2. Teske AJ, De Boeck BW, Melman PG, et al. Echocardiographic quantification of myocardial function using tissue deformation imaging, a guide to image acquisition and analysis using tissue doppler and speckle tracking. *Cardiovasc Ultrasound*. 2007;5:27.
3. Khoo NS, Young A, Occleshaw C, et al. Assessments of right ventricular volume and function using three-dimensional echocardiography in older children and adults with congenital heart disease: comparison with cardiac magnetic resonance imaging. *J Am Soc Echocardiogr*. 2009;22:1279–88.
4. Leibundgut G, Rohner A, Grize L, et al. Dynamic assessment of right ventricular volumes and function by real-time three-dimensional echocardiography: a comparison study with magnetic resonance imaging in 100 adult patients. *J Am Soc Echocardiogr*. 2010;23:116–26.
5. van der Zwaan HB, Helbing WA, McGhie JS, et al. Clinical value of real-time three-dimensional echocardiography for right ventricular quantification in congenital heart disease: validation with cardiac magnetic resonance imaging. *J Am Soc Echocardiogr*. 2010;23:134–40.
6. Winter MM, Romeih S, Bouma BJ, et al. Is cardiac CT a reproducible alternative for cardiac MR in adult patients with a systemic right ventricle? *Neth Heart J*. 2012. doi:10.1007/s12471-012-0310-x.
7. Guo YK, Gao HL, Zhang XC, et al. Accuracy and reproducibility of assessing right ventricular function with 64-section multi-detector row CT: comparison with magnetic resonance imaging. *Int J Cardiol*. 2010;139:254–62.
8. Koch K, Oellig F, Oberholzer K, et al. Assessment of right ventricular function by 16-detector-row CT: comparison with magnetic resonance imaging. *Eur Radiol*. 2005;15:312–8.
9. Einstein AJ, Henzlova MJ, Rajagopalan S. Estimating risk of cancer associated with radiation exposure from 64-slice computed tomography coronary angiography. *JAMA*. 2007;298:317–23.
10. Yuan R, Shuman WP, Earls JP, et al. Reduced iodine load at CT pulmonary angiography with dual-energy monochromatic imaging: comparison with standard CT pulmonary angiography—a prospective randomized trial. *Radiology*. 2012;262:290–7.