Please see page 15 for the article by Kovalova et al. (doi:10.1016/j.euje.2004.04.009) to which this editorial pertains.

Analyzing right ventricular (RV) volumes, mass and function has remained a challenge in clinical practice, while the relevance for obtaining accurate, reproducible data has augmented with increased numbers of patients with Grown Up Congenital Heart (GUCH) disease and acute and chronic pulmonary abnormalities. In comparison to the left ventricle, the right ventricle has a complex shape with different anatomical portions which contribute to the stroke volume (SV) to a variable extent.

Invasively, angiography, thermodilution and conductance catheter techniques can provide absolute volumes and stroke volume, but they are inappropriate for repeated follow-up. The non-invasive modalities that are available today are echocardiography, nuclear (SPECT and PET), magnetic resonance and multi-slice CT (MSCT). While the general advantages and disadvantages of these modalities are very well known to the readers of the Journal, it might be worthwhile to recall the ones that are specific for the right ventricle. 2D echocardiography has difficulties to image all the different portions of the right ventricle in perpendicular views, making it difficult to adopt a simple geometric model like for the left ventricle; 3D echocardiography makes it possible to visualize the entire right ventricle and to reslice it in short axis cuts but resolution and wall delineation of these reconstructed images has only recently become acceptable; nuclear techniques suffer from lack of spatial resolution and overlap with left ventricular structures, but adequate results have been obtained; MR and CT provide full coverage with good wall delineation which makes it possible to use Simpson’s slice addition scheme. All techniques, however, struggle with the heavy trabeculation of the right ventricle and with the demarcation of the valvular structures; it is impossible to ”catch” the large tricuspid valve in 3D, making a linear/planar separation at the valve plane necessary which introduces an inevitable error: the shape of the tricuspid valve differs significantly between end diastole and end systole. It is extremely difficult to delineate the trabeculations, either by hand or automatically, so one cannot include them for mass calculations and exclude them for volumetric measurements, as it is done for the left ventricle. Since the thickness of the wall is only 2–3 mm in normal hearts, measuring RV mass is beyond the spatial resolution of current techniques and can only be accomplished reliably in RV hypertrophy. Finally, one could challenge the entire concept of defining RV function by volumetric measurements since both tricuspid insufficiency and pulmonary leaks are common in RV pathology and confuse the interpretation of a simple ejection fraction: effective ejection fraction, i.e. the effective SV (SV minus pulmonary insufficiency volume) divided by end-diastolic volume could be a better parameter but this requires the measurement of flow across the pulmonary valve during both systole and diastole.

In this issue of the Journal Kovalova et al. report on the use of a geometric ellipsoidal shell model of the right ventricle in comparison to SV of the right ventricle by thermodilution and SV of the left ventricle as defined by Doppler and Teichholz; they obtained good correlations for patients...
without tricuspid regurgite or intracardiac shunt. About 5% of patients were excluded from the study due to poor image quality which is quite low for any echocardiographic study and could be related to patient selection. Although the technique used by the authors seems logical, it still accounts for only part of the complex shape of the right ventricle as they acknowledge themselves. Furthermore, the method uses a modified 4-chamber view which probably requires some skill and experience from the operator and a learning curve must certainly be present. The very good results should therefore be interpreted with caution and confirmed by other groups. It would also be nice if the Bland–Altman analysis was reported and if the method could be validated against a more solid 3D reference technique like MR of MSCT. Finally, inter- and intra-observer variability as well as inter-study differences should be examined, since the main application will be in serial examinations of the same patient. Notwithstanding these limitations any improvement in the echocardiographic examination of the right ventricle is welcome since echocardiography is and remains the most important tool for cardiac imaging. The recent improvements in 3D or 4D echocardiography could also present an opportunity for improvements in RV measurements and the results are very encouraging both for the left and right ventricle; as usual the right heart is lagging a bit behind but the gain could actually be bigger for the right than for the left ventricle.

With increasing complexity and larger data sets the need for computer-aided techniques of segmentation becomes more evident and the right ventricle or 3D imaging is no exception. Although improvements have been made over the years, fully automated segmentation or contouring is not yet available, not even for the modalities with fairly optimal contrast between cavity and wall like MR, MSCT or contrast enhanced echocardiography. This slow progression hints at the underlying difficulties in translating the methods used by the human eye and brain into computer algorithms. Theoretically the best approach should involve the use of predefined finite element models of the structures under study but also this approach has not yet gained wide acceptance or validation.

This brings us to the question if we really need these volumes which need to be acquired and analyzed in such a painstakingly difficult way to address the clinical problems we face. The answer is neither yes nor no but rather sometimes and not always. Ejection fraction as a parameter of systolic performance has the advantage of wide acceptance and validations but remains extremely load dependent and this holds certainly for the right ventricle. So other parameters of ventricular performance could also be envisioned like M-mode of the tricuspid ring, myocardial velocity imaging (MVI) of the ring or the free wall, flow measurements at the pulmonary valve (in combination with EDV as outlined above) and last but not least, the myocardial performance index $I_{MV}$ using isovolumic and ejection time intervals. These measurements also present technical difficulties and need further validation for their prognostic implications but are relatively simple to obtain in routine clinical practice. Some claim load independence but practice has taught that load independence remains the holy grail of non-invasive imaging and that some parameters might be less load dependent but none are independent. For most relevant clinical questions load independence of a parameter would be important but not indispensable as long as one realizes this limitation and takes it into account.

Further studies should therefore try to combine different modalities in the same patient population to define which parameters best represent the underlying patho-physiology and allow to make the necessary decisions for the management of the patients. It is doubtful that one parameter, be it ejection fraction or another, will fulfill all needs, so that we will have to learn which one to use for a specific question and pathology. Whichever this parameter, however, it will have to be non-invasive, accurate and reproducible to be relevant.

References


8. Aepfelbacher FC, Yeon SB, Ho KK, Parker JA, Danias PG. ECG-gated 99mTc single-photon emission CT for assessment of right ventricular structure and function: is the information provided similar to echocardiography? *Chest* 2003;124(1):227–32.


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