Right Ventricular Function
Imaging Techniques

Lance C. Visser, DVM, MS

KEYWORDS

• Echocardiography • Tricuspid annular plane systolic excursion
• Fractional area change • Tissue Doppler • Myocardial performance index • Strain
• Canine • Feline

KEY POINTS

- The right ventricle is challenging to image and its function may be affected by numerous cardiovascular diseases, including those traditionally viewed as left heart specific.
- Echocardiographic assessment of right ventricular function is warranted in dogs and cats with known or suspected cardiovascular disease.
- Tricuspid annular plane systolic excursion, fractional area change, and right ventricular systolic myocardial velocity are appealing for routine clinical assessment of right ventricular function.
- Myocardial performance index, strain-based imaging, and three-dimensional imaging are more time consuming but may be helpful in specific situations.
- Further study of right ventricular function indices is warranted, particularly in animals with cardiovascular disease.

INTRODUCTION

Little attention has been given to the study of the quantitative assessment of right ventricle (RV) function, and it is likely to be ignored during the routine clinical echocardiographic assessment of dogs and cats. The RV may seem to be less frequently or obviously involved in diseases that commonly affect small animal patients (eg, degenerative mitral valve disease or cardiomyopathies). Right ventricular function is notoriously difficult to quantify, especially compared with the left ventricle (LV). Challenges of RV performance assessment include its complex three-dimensional (3-D) shape, which is less amenable to geometric assumptions; separate inflow and outflow regions; prominent endocardial trabeculations; and marked load-dependence. However, in humans, a rapidly growing body of literature has revealed that quantitative RV function assessment plays a pivotal role in predicting clinical status, morbidity,

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Department of Medicine & Epidemiology, School of Veterinary Medicine, University of California, Davis, One Shields Avenue, Davis, CA 95616, USA
E-mail address: lcvisser@ucdavis.edu

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and mortality in a variety of cardiovascular diseases that similarly affect small animal patients, including those traditionally regarded as left heart specific.[1–5] The documented value of assessing RV function in diseases that more directly affect the left heart is perhaps a reminder that the ventricles function as a single unit intimately linked by superficial myofibers, the interventricular septum, and the pericardium. Viewing LV function and RV function separately should be considered flawed.[6] Thus, functional assessment of both ventricles is encouraged during routine clinical assessment regardless of the underlying disease process. Studies evaluating echocardiographic indices of RV function in dogs and cats are beginning to emerge. This article highlights recent advances in RV function assessment for small animals. In addition to highlighting relevant aspects of RV anatomy and physiology, several quantitative indices of RV function are discussed, including imaging techniques, advantages and disadvantages, and clinical impact.

RIGHT VENTRICULAR ANATOMY AND PHYSIOLOGY

The RV can be anatomically divided into 3 components: (1) the inlet, consisting of the tricuspid valve, chordae tendineae, and papillary muscles; (2) the trabeculated apical myocardium; and (3) the infundibulum, or conus, consisting of the RV outflow tract. Compared with the ellipsoid shape of the LV, the RV 3D shape is more complex. In the longitudinal plane it appears triangular and in the cross-sectional plane it is crescentic. Right ventricular mass is approximately one-sixth that of the LV, despite the 2 chambers pumping equal volumes.[7]

The myofiber orientation of the RV consists of superficial layers that are arranged circumferentially and parallel to the atrioventricular groove. These fibers are arranged in an oblique manner as they advance toward the apex and the LV.[8] In contrast, the deep RV myofiber layers are arranged longitudinally from base to apex. The myofiber orientation and contractile motion of the LV is more complex. The LV contains superficial myofiber layers that are arranged obliquely, subendocardial layers that are arranged longitudinally, and circumferentially oriented fibers in between. This arrangement results in the more complex LV movement consisting of torsion, rotation, and thickening.[8] The interventricular septum is generally considered part of the LV, but it does contain longitudinal fibers that belong to the RV.[9] Right and left ventricular myofiber continuity, along with the interventricular septum and pericardium, contribute to the interaction between the two ventricles throughout the cardiac cycle; the so-called ventricular interdependence.

The RV's primary function is to receive systemic venous return and pump it into the low-resistance pulmonary arteries. It does so by contracting in a sequential pattern starting with the inlet and trabeculated myocardium and ending with the infundibulum.[8] Contraction of the RV occurs by 3 separate motions: (1) movement of the free wall toward the septum, producing a bellows effect; (2) contraction of the longitudinal fibers, thus pulling the tricuspid valve annulus toward the apex; and (3) traction of the free wall at the points of attachment secondary to LV contraction.[3,8] An experimental study in dogs has shown that the major contributor of RV contraction is longitudinal displacement of the base toward the apex.[10] This finding has also been shown in humans using tagged cardiac MRI.[11] Greater shortening of the RV in the longitudinal plane versus the radial plane is likely caused by the high surface area-to-volume ratio of RVs. Hence, compared with the LV, less inward (radial) motion is required to eject the same stroke volume. Characteristics of RV contraction are highly dependent on its loading conditions, as is readily apparent in nontachypneic hyperpneic patients with a pronounced respiratory sinus arrhythmia where acute alterations in RV preload overtly affect RV function.