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Original Research Article

Cardiovascular CT in the diagnosis of pericardial constriction: Predictive value of inferior vena cava cross-sectional area

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ABSTRACT

Background: The diagnosis of pericardial constriction remains challenging.

Purpose: We sought to evaluate the predictive value of cardiovascular CT-based measurements of inferior vena cava (IVC) parameters in the diagnosis of pericardial constriction.

Methods: Forty-two consecutive patients referred for assessment of pericardial constriction by 64-slice CT were evaluated. The diagnosis of pericardial constriction was confirmed by clinical history, echocardiography, cardiac catheterization, intraoperative findings, histopathology, or a combination. Diameter and cross-sectional area of the suprahepatic IVC and cross-sectional area of the aorta were measured on a single-axial CT image at the level of the esophageal hiatus. Maximum pericardial thickness was measured. Logistic regression and receiver operating curve analyses were performed.

Results: Twenty-two patients had pericardial constriction. Mean age of the 42 patients was 57.1 ± 16.4 years, 57.1% were men. IVC diameter, IVC area, the ratio of IVC to aortic area, and pericardial thickness were all significantly greater in patients with constriction than in patients without ($P < .05$ for all). IVC-to-aortic area ratio had the highest odds ratio (51; 95% CI, 2.8–922) for the prediction of constriction and remained a significant predictor in multivariable analysis. In nested models, IVC-to-aortic area ratio had incremental value over pericardial thickness for the diagnosis of constriction. IVC-to-aortic area ratio discriminated between patients with and without constriction with an area under the curve of 0.88 on receiver operating curve analysis, with a value ≥1.6 having a sensitivity and specificity of 95% and 76%, respectively. Interobserver agreement for IVC-to-aortic area ratio was excellent (intraclass correlation coefficient, 0.98).

Conclusion: Assessment of IVC-to-aortic area ratio on CT aids with the diagnosis of pericardial constriction and has independent and incremental value over pericardial thickness alone.

Conflict of interest: The authors report no conflict of interest.

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1. Introduction

Pericardial constriction is an important cause of heart failure characterized by impedance to diastolic filling because of a noncompliant or thickened pericardium.[1] Constriction usually manifests clinically years after the initial pathologic trigger. Despite advances in imaging techniques, including transthoracic echocardiography (TTE), CT, and cardiac magnetic resonance imaging (MRI), the diagnosis of pericardial constriction remains challenging and may be delayed.[2–4]

Cardiovascular CT allows for high-resolution assessment of the pericardium with short examination times.[5] Morphologic evaluation of the pericardium, including evaluation of pericardial thickness and calcification, has been the predominant focus of CT evaluation of suspected pericardial constriction to date.[6,7] However, a significant proportion of patients with pericardial constriction may not have pericardial thickening or calcification detectable on CT, and additional imaging parameters may be useful in establishing the diagnosis.[6,8–12]

In clinical practice, the hemodynamic consequences of pericardial constriction may be assessed with echocardiography, invasive cardiac catheterization, or cardiac MRI.[6,13] The inferior vena cava (IVC) is commonly used to estimate right atrial (RA) pressures during echocardiography.[14] Normally, the IVC is similar in size to the descending aorta at the same level.[15] In patients with pericardial constriction, however, the IVC may be dilated, reflecting increased RA pressures.[15–17]

We hypothesized that morphologic assessment of the suprahepatic IVC on cardiovascular CT would be a useful adjunct in the assessment of pericardial constriction and would allow for evaluation of the functional and hemo dynamic consequences of constriction. The aim of the present study was therefore to assess indexed IVC dimensions in patients with clinically suspected pericardial constriction referred for cardiovascular CT evaluation and to determine the predictive value of these measurements in the diagnosis of pericardial constriction.

2. Methods

2.1. Patients and protocol

The institutional research ethics board approved this retrospective cohort study. The requirement for patients' signed informed consent was waived. Consecutive patients (2005–2012) with clinically suspected pericardial constriction who had undergone cardiovascular CT at a single center were identified. Data were abstracted on demographic characteristics, clinical history, diagnostic imaging, surgical outcomes, and histopathology from the electronic patient record. In patients who underwent surgical pericardiectomy, operative reports were reviewed to confirm a surgical description of pericardial constriction, including obliteration of the pericardial space and the presence of abnormal pericardium (thickening or calcification or both). Exclusion criteria consisted of clinical follow-up of $>$12 months, follow-up at an outside institution, greater than moderate tricuspid or pulmonic regurgitation, any tricuspid or pulmonic stenosis, greater than moderate pulmonary hypertension (pulmonary arterial systolic pressure $\geq$ 60 mm Hg), known restrictive cardiomyopathy, and known aortopathy or aortic dilation (given that the descending aorta was used as an internal reference).

The reference standard used for the diagnosis of constriction consisted of (1) noninvasive imaging findings on echocardiography, including early diastolic septal bounce, respiro-phasic septal shift, respiro-phasic variability in Doppler flow velocities across the mitral value of $>$25% or across the tricuspid valve of $>$40%, and hepatic vein diastolic flow reversal in expiration[3]; (2) findings from invasive cardiac catheterization which included left ventricular end-diastolic pressure minus right ventricular (RV) end-diastolic pressure difference of $\leq$5 mm Hg, pulmonary arterial systolic pressure $<$55 mm Hg, RV end-diastolic pressure/RV end-systolic pressure $>$1/3, inspiratory decrease in RA pressure $<$5 mm Hg, dynamic discordant respiratory variation between left ventricular and RV pressure tracings, and systolic area index $>$ 1.1[18]; or (3) intraoperative and histopathology findings, with a history that was consistent with constriction.[17–19]

The diagnosis of pericardial constriction was considered established if cardiac catheterization findings were diagnostic for constriction, along with a consistent clinical history. The diagnosis was then also confirmed on the basis of histopathology findings, which included pericardial fibrosis, thickening, inflammation, or a combination. If cardiac catheterization was unavailable or equivocal, then other imaging findings, including echocardiography, were used to establish the diagnosis. For exclusion of constriction, hemodynamic changes and typical imaging features must have been absent on cardiac catheterization or TTE or both, as well as lack of subsequent surgical pericardiectomy over the period of follow-up of at least 1 year.

2.2. Cardiovascular CT imaging

Cardiovascular CT studies were performed with a 64-slice CT scanner (Toshiba Medical Systems, Tokyo, Japan) and images were acquired during a single inspiratory breathhold with 0.5 mm of collimation, 0.5 to 5 mm of reconstructed slice thickness, 100 to 120 kVp of tube potential, and tube current modulation adapted to body habitus.

All CT studies were analyzed offline by an experienced observer who was blinded to clinical and patient information. Cross-sectional areas of the suprahepatic IVC and descending aorta were measured by manual contouring on a single-axial image at the level of the esophageal hiatus (Figs. 1A, 2A, and 3A). Measurements were made in end systole on studies for which multiple cardiac phases were available for review. On these studies, measurements were repeated in diastole at the same slice level for the purpose of comparison between cardiac phases (however, systolic measurements were used in all other calculations). Maximum IVC diameter was measured on the same slice (Figs. 1B, 2B, and 3B). IVC cross-sectional area was indexed to aortic cross-sectional area to account for potential differences in size of the IVC, depending on the size of the patient. The presence of pericardial calcification, pericardial effusion, pleural effusion, and ascites was assessed (Fig. 1C). Maximum pericardial thickness was measured