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Use of Cardiac Magnetic Resonance Imaging Based Measurements of Inferior Vena Cava Cross-Sectional Area in the Diagnosis of Pericardial Constriction

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Abstract

Purpose: To evaluate the value of cardiac magnetic resonance imaging (MRI)–based measurements of inferior vena cava (IVC) cross-sectional area in the diagnosis of pericardial constriction.

Methods: Patients who had undergone cardiac MRI for evaluation of clinically suspected pericardial constriction were identified retrospectively. The diagnosis of pericardial constriction was established by clinical history, echocardiography, cardiac catheterization, intraoperative findings, and/or histopathology. Cross-sectional areas of the suprahepatic IVC and descending aorta were measured on a single axial steady-state free-precession (SSFP) image at the level of the esophageal hiatus in end-systole. Logistic regression and receiver-operating curve (ROC) analyses were performed.

Results: Thirty-six patients were included; 50% (n = 18) had pericardial constriction. Mean age was 53.9 ± 15.3 years, and 72% (n = 26) were male. IVC area, ratio of IVC to aortic area, pericardial thickness, and presence of respirophasic septal shift were all significantly different between patients with constriction and those without ($P < .001$ for all). IVC to aortic area ratio had the highest odds ratio for the prediction of constriction (1070, 95% confidence interval [8.0-143051], $P = .005$). ROC analysis illustrated that IVC to aortic area ratio discriminated between those with and without constriction with an area under the curve of 0.96 (95% confidence interval [0.91-1.00]).

Conclusions: In patients referred for cardiac MRI assessment of suspected pericardial constriction, measurement of suprahepatic IVC cross-sectional area may be useful in confirming the diagnosis of constriction when used in combination with other imaging findings, including pericardial thickness and respirophasic septal shift.

Résumé

Objectif : Déterminer s'il est utile de mesurer la superficie de la section transversale de la veine cave inférieure (VCI) lors de l'examen d'imagerie par résonance magnétique (IRM) cardiaque pour établir le diagnostic de constriction péricardique.

Méthodes : Des patients ayant subi une IRM cardiaque en raison d'une suspicion clinique de constriction péricardique ont été identifiés de façon rétrospective. Le diagnostic de constriction péricardique a été posé par les antécédents cliniques, une échocardiographie, un cathétérisme cardiaque, des observations peropératoires ou une étude histopathologique. La superficie des sections transversales de la VCI suprahépatique et de l'aorte descendante ont été mesurées sur une image axiale unique tirée d'une séquence de précession libre d'état stationnaire (SSFP) réalisée en coupe axiale à l'échelle de l'hiatus œsophagien lors de la télésystole. Des analyses de régression logistique et de la fonction d'efficacité de l'observateur ont été réalisées.

Résultats : Trente-six patients ont été inclus; 50 % (n = 18) présentaient une constriction péricardique. L'âge moyen des patients était de 53,9 ± 15,3 ans et 72 % d'entre eux (n = 26) étaient de sexe masculin. Les valeurs associées à la VCI, le rapport entre la superficie de la section de la VCI et la superficie de la section de l'aorte, l'épaisseur du péricarde et la présence de mouvement septal lors de la respiration ont

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grandement différé selon que le patient présentait une constriction ou non ($P < 0{,}001$ pour l'ensemble). Le rapport entre la superficie de la section de la VCI et la superficie de la section de l'aorte présentait le rapport de cotes le plus élevé pour prédire la constriction (1070, intervalle de confiance de 95 % [8,0-143051], $P = 0{,}005$). L'analyse de la fonction d'efficacité de l'observateur a révélé que le rapport de la superficie de la section de la VCI et de la superficie de la section de l'aorte permettait de distinguer ceux qui présentaient une constriction de ceux qui n'en présentaient pas en raison d'une aire sous la courbe de 0,96 (intervalle de confiance de 95 % [0,91-1,00]).

Conclusions : Chez les patients dirigés en IRM pour évaluer une éventuelle constriction péricardique, la mesure de la superficie de la section transversale de la VCI suprahépatique peut permettre de confirmer le diagnostic de constriction si elle est jumelée à d'autres aspects d'imagerie, notamment l'épaisseur du péricarde et le mouvement septal lors de la respiration.

Key Words: Pericardium; Pericardial constriction; Inferior vena cava; Cardiac imaging techniques; Magnetic resonance imaging

Pericardial constriction is a relatively rare condition characterized by impedance to diastolic filling caused by a fibrotic, calcified, or thickened pericardium [1]. Although several diagnostic criteria have been proposed, the diagnosis of pericardial constriction remains challenging and is often delayed [2,3].

Cardiac magnetic resonance imaging (MRI) is increasingly used as a diagnostic tool in the evaluation of patients with suspected constriction [4,5]. Increased pericardial thickness (>4 mm) has been the predominant imaging criteria used to establish the diagnosis, however, approximately 18% of patients with constriction may have normal pericardial thickness [6−8]. The hemodynamic consequences of constriction can be assessed by cardiac MRI with the use of real time imaging to identify respirophasic septal shift and phase contrast imaging to detect discordant respirophasic variations in transmitral and tricuspid flow [9−11].

Measurement of inferior vena cava (IVC) size is an indirect method to assess the hemodynamic consequence of constriction and is readily measured from standard MRI sequences [12]. The suprahepatic IVC is normally similar in size to the descending aorta at the same level [13]. However, in patients with constriction the IVC may be dilated, suggestive of increased right atrial (RA) pressures and impaired diastolic filling of the right ventricle (RV) [12−15].

We hypothesized that an enlarged IVC cross-sectional area and increased IVC to aortic cross-sectional area ratio as assessed on cardiac MRI would be useful in establishing the diagnosis of pericardial constriction. The aim of the present study was to evaluate IVC dimensions in patients referred for cardiac MRI with clinically suspected pericardial constriction, and to determine the predictive value of these measurements in the diagnosis of constriction.

Materials and Methods

Patients and Protocol

This retrospective cohort study was approved by our institutional research ethics board. The requirement for patients' signed informed consent was waived. A consecutive sample of patients who had undergone cardiac MRI for evaluation of clinically suspected pericardial constriction at a single center between 2005 and 2012 were identified retrospectively from an institutional database. Patients were excluded if they had clinical follow-up of less than 1 year after cardiac MRI, greater than moderate tricuspid or pulmonic regurgitation, any tricuspid or pulmonic stenosis, greater than mild pulmonary hypertension (pulmonary arterial systolic pressure ≥45 mm Hg), known restrictive cardiomyopathy, and known aortopathy or aortic dilation.

Data were abstracted on demographic characteristics, imaging findings, and clinical and surgical outcomes from the electronic patient record. The standard for establishing the diagnosis of pericardial constriction has been published previously [15], and included: 1) noninvasive imaging findings on transthoracic echocardiography (TTE) or cardiac MRI; 2) findings from invasive cardiac catheterization; and 3) intraoperative and histopathology findings along with a concordant clinical history. TTE criteria included early diastolic septal bounce, respirophasic septal shift, respirophasic 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 [16]. Hemodynamic evaluation on cardiac catheterization included left ventricular (LV) end-diastolic pressure − RV end-diastolic pressure difference of ≤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 LV and RV pressure tracings, and systolic area index >1.1 [17]. Surgical findings included obliteration of the pericardial space and the presence of abnormal pericardial thickening and/or calcification. Histopathology findings included pericardial fibrosis, thickening, calcification, and/or inflammation.

A diagnosis of pericardial constriction was established if hemodynamic findings on cardiac catheterization were consistent with constrictive physiology, along with a concordant clinical presentation. If cardiac catheterization was unavailable, then other imaging findings including respirophasic septal shift on cardiac MRI or TTE, and/or other TTE criteria outlined above were used to establish the diagnosis. The diagnosis was then also confirmed based on surgical and histopathology findings when available.