Journal of Cardiology 67 (2016) 92–97

Contents lists available at ScienceDirect

Journal of Cardiology

journal homepage: www.elsevier.com/locate/jjcc

Original article

Simultaneous fat and bone assessment in hospitalized heart failure patients using non-contrast-enhanced computed tomography

Masaaki Konishi (MD, PhD)[a,*], Eiichi Akiyama (MD)[a], Hiroyuki Suzuki (MD)[a], Noriaki Iwahashi (MD)[a], Nobuhiko Maejima (MD)[a], Kengo Tsukahara (MD)[a], Kiyoshi Hibi (MD, FJCC)[a], Masami Kosuge (MD)[a], Toshiaki Ebina (MD)[a], Yasushi Matsuzawa (MD)[b], Satoshi Umemura (MD, FJCC)[c], Kazuo Kimura (MD, FJCC)[a]

[a] Division of Cardiology, Yokohama City University Medical Center, Yokohama, Japan
[b] Division of Cardiovascular Diseases, Mayo College of Medicine, Rochester, MN, USA
[c] Department of Medical Science and Cardiorenal Medicine, Yokohama City University Graduate School of Medicine, Yokohama, Japan

ARTICLE INFO

Article history:
Received 2 December 2014
Received in revised form 18 March 2015
Accepted 30 March 2015
Available online 5 May 2015

Keywords:
Pericardium
Fat
Heart failure
Bone

ABSTRACT

Background: Heart failure (HF) is associated with adverse metabolic influences and provokes fat loss as well as bone and muscle loss at the terminal stages. Pericardial fat is an ectopic fat depot that can potentially affect the myocardium, but the role of pericardial fat in HF is unclear. We sought to characterize pericardial fat in HF, particularly in association with bone tissue using cardiac computed tomography (CT).

Methods: In 61 consecutive hospitalized HF patients with left ventricular ejection fraction ≤50%, pericardial fat volume (PFV), CT density in the thoracic vertebrae, and ectopic calcification in the aortic valve were assessed simultaneously using electrocardiogram-gated non-contrast-enhanced CT.

Results: The mean PFV was $93.5 \pm 50.6\ cm^3$, which might reflect the total body fat measured with dual energy X-ray absorptiometry (Pearson's $r = 0.48$, $p = 0.01$). The PFV index, defined as the PFV/body surface area, was significantly higher among older patients (>65 years; $63.5 \pm 30.6\ cm^3/m^2$ vs. $42.7 \pm 17.1\ cm^3/m^2$, $p < 0.01$) and among patients with atrial fibrillation (AF; $70.9 \pm 36.4\ cm^3/m^2$ vs. $48.8 \pm 21.2\ cm^3/m^2$, $p < 0.01$) and hypertension ($60.7 \pm 29.3\ cm^3/m^2$ vs. $41.5 \pm 18.2\ cm^3/m^2$, $p < 0.01$) compared to patients without these conditions. The PFV indices were comparable between the patients with and without ischemic etiology, diabetes, and renal dysfunction. Patients with increased PFV indices (above the median) exhibited lower CT density in the thoracic vertebrae (134 ± 41 Hounsfield units vs. 161 ± 57 Hounsfield units, $p = 0.04$), and were more likely to have aortic valve calcification (48% vs. 18%, $p = 0.02$) and N-telopeptide (bone resorption marker; 20.7 ± 5.2 nmol BCE/mmol Cr vs. 25.5 ± 5.9 nmol BCE/mmol Cr, $p = 0.03$) levels than those without increased PFV indices.

Conclusions: We simultaneously assessed the pericardial fat and bone tissue of HF patients with CT and successfully characterized AF, hypertension, and advanced age as factors that are associated with increased PFV. PFV was correlated with bone tissues and alterations in bone turnover.

Introduction

Heart failure (HF) is currently a worldwide clinical problem because of the associated high mortality, morbidity, and readmission rates with the aging of the population [1]. Although HF at the terminal stages, i.e. cardiac cachexia, is associated with adverse metabolic influences and provokes fat loss as well as muscle and bone loss, the role of fat in HF remains poorly understood [2]. Fat tissue is now considered not only a site of the storage of excess energy but also as an active endocrine organ that generates adipokines, which influence both systemic metabolism and the cardiovascular system [3,4]. Pericardial fat is recognized as an ectopic visceral fat depot in close proximity to the myocardium and coronary arteries, and it is possible that pericardial fat affects these structures. Although the investigators of the Framingham Heart Study could not describe an independent association of

* Corresponding author at: Division of Cardiology, Yokohama City University Medical Center, 4-57 Urafune-cho, Minami-ku, Yokohama 232-0024, Japan. Tel.: +81 45 261 5656; fax: +81 45 261 9162.
E-mail address: m_koni@yokohama-cu.ac.jp (M. Konishi).

http://dx.doi.org/10.1016/j.jjcc.2015.03.016
0914-5087/

pericardial fat volume (PFV) and left ventricular function in people without known cardiovascular diseases [5], the characteristics of PFV in HF patients have not been elucidated.

In addition, fat tissue has recently been reported to exhibit cross-talk with bone tissue through neurohormonal interactions [6,7]. In clinical practice, HF patients are considered to be a high-risk population for osteoporotic fractures [8,9], and fracture is one of the prognostic risk factors in HF patients [10]. However, the association between the measured fat volume and bone density in HF patients has not been reported.

Non-contrast-enhanced cardiac computed tomography (CT) can quantify both calcified tissue and fat tissue, but data in HF are lacking because cardiac CT is not typically indicated for HF patients. We hypothesized that PFV would correlate with some clinical backgrounds of HF and sought to characterize PFV in HF patients, particularly in the association with bone tissue via cardiac CT.

Methods

Study patients

From March 2012 to June 2013, we screened 245 consecutive patients of Yokohama City University Medical Center. These patients were admitted with diagnoses of HF as defined by the Framingham criteria [11]. We prospectively enrolled 71 consecutive patients who provided written consent after excluding those requiring hemodialysis, those with an implanted device, and those for whom CT could not be planned during hospitalization. There were 10 patients with HF with preserved ejection fraction (>50%) in this cohort and we analyzed the remaining 61 patients with left ventricular ejection fraction ≤50%. The study was approved by the ethics review committee of our institution, and written informed consent was obtained from each patient before participation. This study is registered in the UMIN protocol registration system with the identification number UMIN000010161.

Measurements

Data regarding the medical histories, symptoms, and treatments of each patient were collected. Hematology and biochemistry tests were performed on blood drawn on the day prior to discharge following an overnight fast. Markers of bone turnover were assessed in 29 patients who were admitted after December 2012. Bone resorption was assessed via serum N-telopeptide. Bone formation was assessed via serum bone-specific alkaline phosphatase, osteocalcin, and procollagen type I N-terminal propeptide. The estimated glomerular filtration rate was calculated by the modified formula described in the Modification of Diet in Renal Disease study, which was proposed by the Japanese Society of Nephrology [12]. Echocardiography was performed in standard parasternal and apical views upon admission. Dual energy X-ray absorptiometry (QDR4500A, Hologic, Bedford, MA, USA) was used to evaluate the body compositions of unselected 26 patients. Underlying diseases were diagnosed at discharge according to the American College of Cardiology/American Heart Association clinical data standards [13].

Cardiac CT scan protocol and image analysis

A CT scanner (Aquillion, Tohshiba Medical Systems, Otawara, Japan) was used with the following parameters: detector collimation 160 row × 0.5 mm (non-helical scan), rotation time 350 ms, tube current 200 mA, and voltage 120 kVp. Reconstructions were set at 75% or 40% of the cardiac cycle as appropriate. The reconstructed CT image data were transferred to a workstation for post-processing (Synapse Vincent, Fujifilm, Tokyo, Japan). PFV was measured three-dimensionally in all patients using non-contrast-enhanced images, as reported previously [14] (Fig. 1A). A predefined image display setting was used [window width = 150 Hounsfield units (HU) and window center = −120 HU] to identify the pixels that corresponded to fat tissue [5,14]. Pericardial fat was defined to be any adipose tissue located within the pericardial sac [15–17]. We measured vertebral CT density by placing a region of interest over an area of vertebral body trabecular bone (Fig. 1B). We avoided placing the region of interest near any area that would distort the measurement (i.e. any area with focal heterogeneity or imaging-related artifacts) [18]. We measured the CT densities of 2–3 thoracic vertebrae and averaged the results. Abnormal CT densities were defined as <130 HU [18]. Coronary and aortic valve calcification was quantified using the Agatston method, which accounts for both lesion area and calcium density [14,19]. Among the patients with coronary stents, we substituted the maximum Agatston score among the four major coronary arteries without a stent for the stented artery and summed the four scores, as there were no patients in which all four arteries were stented. The presence of aortic valve calcification was defined by an Agatston score >0.

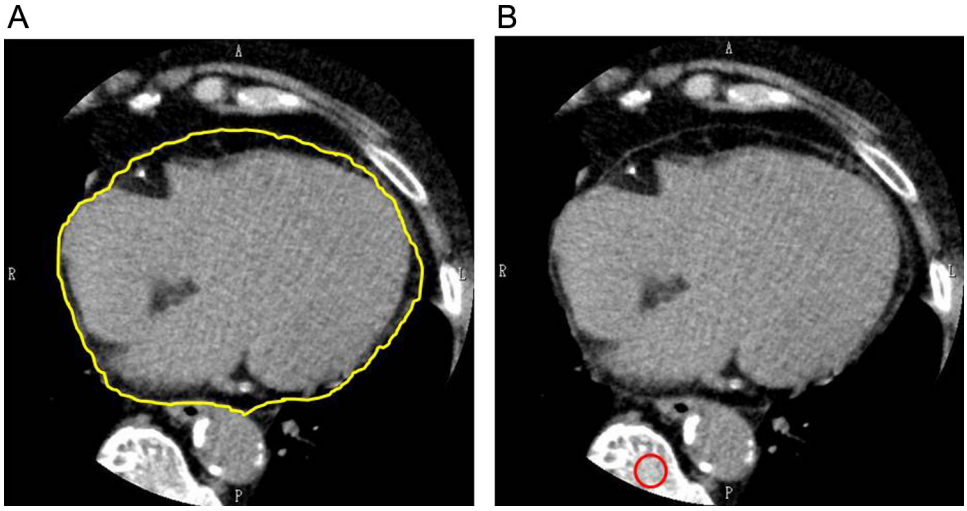

Fig. 1. Measurement of PFV and CT densities in the thoracic vertebrae. (A) PFV measurement. Pericardial fat was defined as any adipose tissue located within the pericardial sac (yellow line). (B) We measured vertebral CT density by placing a region of interest over an area of vertebral body trabecular bone (red circle). CT, computed tomography; PFV, pericardial fat volume. (For interpretation of the references to color in this figure legend, the reader is referred to the web version of the article.)