Journal of Cardiology 72 (2018) 395–402

Contents lists available at ScienceDirect

Journal of Cardiology

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

Original article

Potential benefit of a simultaneous, side-by-side display of contrast MDCT and echocardiography over routine sequential imaging for assessment of adult congenital heart disease: A preliminary study☆

Hiroki Oe (MD, PhD)[a,*], Nobuhisa Watanabe (RDCS)[b], Toru Miyoshi (MD, PhD, FJCC)[c], Kazuhiro Osawa (MD, PhD)[c], Teiji Akagi (MD, PhD, FJCC)[c], Susumu Kanazawa (MD, PhD)[d], Hiroshi Ito (MD, PhD, FJCC)[c]

[a] Division of Cardiovascular Medicine, Sakurabashi Watanabe Hospital, Osaka, Japan
[b] Center of Ultrasonic Diagnostics, Okayama University Hospital, Okayama, Japan
[c] Department of Cardiovascular Medicine, Okayama University Graduate School of Medicine, Dentistry and Pharmaceutical Science, Okayama, Japan
[d] Department of Radiology, Okayama University Graduate School of Medicine, Dentistry and Pharmaceutical Science, Okayama, Japan

ARTICLE INFO

Article history:
Received 16 February 2018
Received in revised form 20 April 2018
Accepted 26 April 2018

Keywords:
Adult congenital heart disease
Doppler echocardiography
Multi-detector computed tomography

ABSTRACT

Background: Management of adult congenital heart disease (ACHD) patients requires understanding of its complex morphology and functional features. An innovative imaging technique has been developed to display a virtual multi-planar reconstruction obtained from contrast-enhanced multidetector-computed tomography (MDCT) corresponding to the same cross-sectional image from transthoracic echocardiography (TTE). The aim of this study is to assess the usefulness of this imaging technology in ACHD patients.
Methods: This study consisted of 46 consecutive patients (30 women; mean age, 52 ± 18 years old) with ACHD who had undergone contrast MDCT. All patients underwent TTE within a week of MDCT. An experienced sonographer who did not know the results of MDCT conducted a diagnosis using TTE and, then, using the new imaging technology. We studied whether this imaging technology provided additional or unexpected findings or makes more accurate diagnosis.
Results: In this imaging technology, MDCT cross-section provides higher-resolution image to the deep compared to corresponding TTE image. Depending on the MDCT section which can be arbitrarily set under the echo guide, we can diagnose unexpected or incremental lesions or more accurately assess the severity of the lesion in 27 patients (59%) compared to TTE study alone. This imaging technology was useful in the following situations:

1. For anatomical guidance for Doppler flow assessment.
2. Assessment of morphology of obstruction in outflow tracts or conduit.
3. To clarify the etiology of unordinary severe valvular disease.
4. Assessment of the patient with diseased prosthetic valves.

Conclusions: This integrated imaging technology provides incremental role over TTE in complex anatomy, and allows functional information in ACHD patients.

Introduction

Proper management of adult congenital heart disease (ACHD) requires understanding the complex anatomy and physiology of the heart and vessels [1–3]. Transthoracic echocardiography (TTE) together with color Doppler has allowed comprehensive assessment of cardiac morphology, function and hemodynamics in most patients with ACHD. However, TTE study has several limitations associated with the poor image quality especially in patients who underwent frequent surgery or with abnormal position of cardiovascular system [1–5]. If the initial TTE findings are inconclusive, repeated examinations are often required. Transesophageal echocardiography is an alternative approach but also

DOI of commentary article: https://doi.org/10.1016/j.jjcc.2018.05.013.
* Corresponding author at: Division of Cardiovascular Medicine, Sakurabashi Watanabe Hospital, 2-4-32 Umeda, Kita-ku, Osaka 530-0001, Japan.
E-mail address: hirokioe@gmail.com (H. Oe).

https://doi.org/10.1016/j.jjcc.2018.04.015
0914-5087/

has limitations associated with the operator's skill, limited echo view, and/or artifacts produced by prosthetic valves [6–8].

Contrast-enhanced multi-detector computed tomography (MDCT) has excellent spatial resolution and allows comprehensive analysis of its complex anatomy even in patients with complex malformation. It plays an increasing role in the assessment of ACHD patients. However, it is hard to provide information on regional wall motion, blood flow velocity, or hemodynamics, and has been difficult to render any cross-section quickly [1–3,8]. A recently developed imaging modality can display a virtual multiplanar reconstruction obtained from contrast MDCT and corresponding to the real time TTE image side by side (Canon Medical Systems Corporation, Otawara, Japan) [9–11]. This simultaneous display technology of MDCT and echocardiography currently available for echo examination of static organs [12–17]. Several studies have proven its feasibility, especially for guidance of biopsy and percutaneous interventional procedures involving poorly visible or unidentifiable focal tumors of the liver, kidney, breast, and prostate. This simultaneous two-screen display of MDCT and real-time echogram (STDME) technology is expected to be useful for accurate evaluation of anatomy and hemodynamics in patients with complicated cardiovascular lesions, but it has not been used in clinical cardiology to date.

In this study, we applied the STDME technology that simultaneously displays cross-sections of MDCT and TTE to patients with ACHD. We aimed to study whether this STDME technology can complement the shortcomings of TTE and improve its diagnostic potential compared to TTE depending on the severity of baseline ACHD.

Materials and methods

Study population

This study involved patients with ACHD who underwent both TTE and contrast MDCT. All patients who underwent clinically indicated MDCT study within a week were offered to undergo TTE study including the simultaneous image display technology. Expert echocardiographers performed routine TTE and Doppler examination with commercially available TTE systems in all patients. All patients who underwent clinically indicated MDCT were offered to undergo TTE with the new imaging technology within 1 week of the MDCT examination. Patients with implantable cardiac devices (pacemakers, implantable cardioverter defibrillators, and cardiac resynchronization therapy devices) were excluded because of concern that the switching noise possibly induced by the magnetic sensor of this imaging technology.

This study complies with the Declaration of Helsinki. This study was conducted from January 2014 to October 2015, in Okayama University Hospital. The study protocol was approved by the Ethics Committee of Okayama University Graduate School of Medicine, Dentistry, and Pharmaceutical Sciences. Written informed consent was obtained from all patients before any study procedures were performed (No. 1509-010).

Application of the simultaneous display system

Contrast MDCT study

After an appropriate interval following injection of a radiocontrast agent, CT scans were performed using a 128-slice CT scanner (SOMATOM Definition Flash; Siemens Medical Solutions, Erlangen, Germany). MDCT images were acquired in the supine position, with the upper extremities extended over the head. Reference CT volume datasets were acquired using retrospective electrocardiogram-triggered spiral acquisition [18].

STDME technique

The STDME technology is incorporated to echocardiography apparatus (Aplio 500; Canon Medical Systems Corporation) (Fig. 1). We exported the datasets of contrast MDCT volume to this echocardiography apparatus. The combination of the magnetic sensor on the echocardiography apparatus and the position sensor attached to the transducer (PST-25BT/30BT) allowed the precise identification of the position, angle, and motion of the transducer relative to the patient's chest. To display the precise MDCT cross-sectional image corresponding to the real-time TTE image, we aligned both images in advance. After MDCT image registration, we defined the common plane and designated one anatomic landmark as the reference point on both MDCT and TTE images. In this study, the landmark was the origin of the anterior leaflet of the mitral valve in the apical four-chamber view. The STDME technology recognizes the position and angle of the transducer and simultaneously displays the cross-sectional CT image corresponding to real-time TTE image [10,11]. Thus, the cross section of MDCT and TTE perfectly match and are displayed side by side on the same screen. The MDCT image then acted in synchronization with the TTE image using the simultaneous image display technology (Fig. 1; Video 1; Patient # 41).

Study protocol

A level-3 trained [19] echocardiographer (W.N.), who was blinded to the results of the contrast MDCT, performed routine TTE examination in each patient. Patients rested in left decubitus position. We asked him to diagnose lesions as much as possible and to evaluate the severity of the lesion as accurately as possible. He evaluated the quality of the TTE image. After the routine examination, the same echocardiographer used the STDME technology to assess whether any additional findings and an improvement in diagnosis were found (Video 1). Final diagnosis was established with transesophageal echocardiography or catheter examination.

We assessed whether the STDME technology adds incremental or unexpected findings and/or improves the diagnostic accuracy on the previous TTE findings. Initially, we classified the patients into three groups based on the extent to which the diagnosis by TTE was judged to be complete and accurate, named as TTE diagnostic ability.

A: All pathological lesions and their severity are considered to be fully evaluated with TTE.
B: TTE can only diagnose incompletely or may underestimate the severity.
C: We cannot speculate the lesions at all with TTE.

Then, we assessed whether the STDME technology adds incremental or unexpected findings and/or improves the diagnostic accuracy on the previous TTE findings. We assessed the magnitude of improvement in diagnostic potential with the STDME technology compared to TTE study alone, named as improvement score. This judgment was performed by an experienced physician who did not know clinical data.

Point 0: Additional diagnosis or more accurate evaluation is not provided with the STDME technology.
Point 1: Additional diagnosis or more accurate evaluation is provided with the STDME technology in class A patient.