JACC: CARDIOVASCULAR IMAGING VOL. 9, NO. 6, 2016
© 2016 BY THE AMERICAN COLLEGE OF CARDIOLOGY FOUNDATION ISSN 1936-878X/$36.00
PUBLISHED BY ELSEVIER http://dx.doi.org/10.1016/j.jcmg.2015.09.024

Diagnostic Performance of 3D Bull's Eye Display of SPECT and Coronary CTA Fusion

Tadaki Nakahara, MD, PhD, Yu Iwabuchi, MD, Koji Murakami, MD

ABSTRACT

OBJECTIVES The aim of this study was to develop a display method to describe the fusion data of myocardial perfusion single-photon emission computed tomography (SPECT) and coronary computed tomography angiography into a single image that we call fusion-based bull's eye (FBE). This study sought to show its generating process and evaluate its diagnostic performance.

BACKGROUND Three-dimensional (3D) display is mostly used when reviewing SPECT/coronary computed tomography angiography fusion images, although multidirection interpretation is required to sweep the entire heart. Bull's eye display of the fusion image will be useful in clinical practice.

METHODS FBE images were generated from the 3D fusion data by determining a cardiac axis, adding a cylindrical object around the aortic root, obtaining a panoramic image from circumferential data of the 3D images, and converting it into a polar coordinate display image. The diagnostic performances of SPECT, the conventional 3D fusion, and FBE as to the presence of hemodynamically relevant coronary vessels were compared in 39 patients with abnormal SPECT findings.

RESULTS The 3D fusion and FBE images were successfully obtained in all patients. Of an evaluated 105 coronary segments in 35 patients without coronary artery bypass grafting, SPECT showed 17 segments (16%) equivocal to determine hemodynamically relevant coronary vessels. FBE corrected the diagnoses of 5 segments, in which SPECT was false-negative in 2 or false-positive in 3, with only 2 equivocal segments ($p = 0.0017$). FBE also revealed 4 culprit lesions in all 4 patients with coronary artery bypass grafting. There were no discordances between FBE and the 3D fusion.

CONCLUSIONS FBE had the same capacity as the 3D fusion to solve equivocal SPECT findings or correct the diagnoses in 24 of 109 (22%) coronary segments for culprit lesion detection. Although FBE requires manual generation process at present, it facilitates evaluation of myocardial perfusion and coronary anatomy with only 1 image.
(J Am Coll Cardiol Img 2016;9:703–11) © 2016 by the American College of Cardiology Foundation.

Myocardial perfusion single-photon emission computed tomography (SPECT) and coronary computed tomography angiography (CTA) are distinct diagnostic imaging modalities providing functional and anatomic information, respectively. SPECT studies have shown solid evidence for prognostic assessment based on the extent and severity of myocardial perfusion abnormalities in patients with coronary artery disease (1-4). However, coronary CTA has high sensitivity and negative predictive value for detecting coronary artery stenoses, and coronary CTA gains wider acceptance of its daily use because of advanced technologies with which higher quality images can be obtained with less amount of radiation (5,6). However, according to a recent large-scale study, coronary CTA failed to demonstrate prognostic benefit for evaluation of symptomatic patients with suspected coronary

From the Department of Diagnostic Radiology, Keio University School of Medicine, Tokyo, Japan. All authors have reported that they have no relationships relevant to the contents of this paper to disclose.

Manuscript received May 13, 2015; revised manuscript received September 2, 2015, accepted September 3, 2015.

ABBREVIATIONS AND ACRONYMS

CABG = coronary artery bypass grafting

CTA = computed tomography angiography

FBE = fusion-based bull's eye

SPECT = single-photon emission computed tomography

3D = 3-dimensional

artery disease as compared with functional testing (7). The results are partly explained by the previous studies demonstrating that only structural information of coronary artery cannot predict hemodynamically significant stenoses that are linked to subsequent cardiac events (4,8-10).

SPECT-coronary CTA hybrid imaging may be one of the forms that routine myocardial perfusion imaging will take (11) because image fusion significantly improves detection of hemodynamically significant coronary lesions (11-13). Expanded availability of image fusion software facilitates the clinical use of SPECT-coronary CTA cardiac fusion using coronary CTA from external sources (14,15). Three-dimensional (3D) display is commonly used to exhibit this type of image fusion, although it sometimes requires image browsers supporting movie display for multidirection interpretation to avoid overlooking the potential disease. In this regard, under the circumstance of availability of both SPECT and coronary CTA, it would be better to display data on a single image like bull's eye for SPECT.

SEE PAGE 712

Here, we developed a display method to describe the SPECT-coronary CTA data into a single image that we call "fusion-based bull's eye" (FBE). As far as we searched the PubMed biomedical database (US National Library of Medicine, Bethesda, Maryland), no articles related to "bull's eye" and "SPECT" and "CT" or "CTA" or "coronary CTA" have been published through April 1, 2015. The aims of this study were to show the process of FBE generation and evaluate its diagnostic performance.

MATERIALS AND METHODS

PATIENTS AND IMAGING PROTOCOL. From January 2014 to August 2014, exercise (n = 344) or dipyridamole (n = 330) stress/rest SPECT was performed and 65 patients had abnormal SPECT findings. SPECT images were acquired 15 min after patients were injected with 111 MBq of thallium-201 chloride at the time of peak stress, followed by low-dose CT scanning for attenuation correction using SPECT/CT scanner (Discovery NM/CT 670pro, GE Healthcare, Waukesha, Wisconsin). SPECT data were collected in 60 views in steps of 6° with each detector rotating 180° (360° acquisition). Scan duration was 10 min, 12.5 min, and 15 min for patients weighing <60 kg, 60 to 70 kg, ≥70 kg, respectively. The matrix size for data acquisition and image reconstruction was 3.4 mm (128 × 128). Reconstructed SPECT images with 3.4-mm slice thickness were obtained with a Butterworth filter (order, 10; cutoff frequency, 0.33 cycles/cm). Unfortunately, the SPECT/CT scanner has an only 16-detector row CT, making it difficult to perform coronary CT angiography. Attenuation and scatter correction were applied.

Among 65 patients with abnormal SPECT findings, such as stress-induced ischemia and myocardial infarction, 39 underwent coronary CTA with the time interval of not more than 8 months. Patient demographics are shown in **Table 1**. Coronary CTA was performed using a 64-detector row CT (LightSpeed VCT, GE Healthcare) or a 320-detector row CT (Aquilion ONE, Toshiba Medical Systems, Otawara-shi, Japan). Dose of oral metoprolol, which was administered 1 h before CT scanning, was adjusted for patient's heart rate not to exceed 65 beats/min. Then, coronary CTA data with administration of glycerol trinitrate (0.3 mg) were obtained before and after intravenous injection of 0.7 ml/kg of iodine contrast material (Iopamiron 370, 370 mgI/ml Iopamidol; Bayer Healthcare, Tokyo, Japan). Data were reconstructed with 0.625-mm slice thickness and no overlap for the 64-detector and 0.5-mm slice thickness and 0.25-mm overlap for the 320-detector row CT. Both SPECT with low-dose CT for attenuation correction and coronary CTA data acquisitions were approved by the institutional review board and all subjects consented in writing.

TABLE 1 Patient Characteristics (n = 39)

Demographics	
Age, yrs	71 ± 8
Male	35 (90)
Body mass index, kg/m^2	23 ± 3
Medical history	
1-vessel coronary disease	11 (28)
2-vessel coronary disease	10 (26)
3-vessel coronary disease	12 (31)
Previous PCI	20 (51)
Previous CABG	4 (10)
Previous myocardial infarction	13 (33)
Typical/atypical chest pain	6 (15)
Dyspnea	5 (13)
Clinical risk factors	
Diabetes mellitus	19 (49)
Hypertension	23 (59)
Dyslipidemia	20 (51)
Chronic kidney disease	7 (18)
Tobacco (current or within 1 year of quitting)	4 (10)

Values are mean ± SD or n (%).

CABG = coronary artery bypass grafting; PCI = percutaneous coronary intervention.