Detection of Left Main Coronary Artery Stenosis by Transesophageal Color Doppler and Two-Dimensional Echocardiography

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Although transthoracic two-dimensional echocardiography can detect dilation of the coronary arteries, the reliability of this technique in the detection of coronary artery stenosis is still doubtful. The purpose of this study was to test the ability of newly developed biplane transesophageal color Doppler and two-dimensional echocardiography in the detection of left main coronary artery stenosis. Blood flow in the left main coronary artery was detected in 57 of 67 (85%) patients by transesophageal color Doppler flow imaging. Using transesophageal two-dimensional echocardiography, adequate images of the full length of the left main coronary artery and identification of the bifurcation were obtained in 60 of 67 (90%) patients. Transesophageal echocardiography clearly showed significant (≥50%) narrowing of the coronary lumen in 10 of 11 patients (sensitivity, 91%) and insignificant narrowing or no abnormalities of the coronary lumen in the other 49 patients (specificity, 100%). The positive predictive accuracy for left main coronary artery disease was 100%, and the negative predictive accuracy was 98%. This preliminary study suggests that biplane transesophageal color Doppler and two-dimensional echocardiography appears to be a feasible noninvasive technique for imaging the left main coronary artery and detecting hemodynamically significant luminal obstruction. (Circulation 1990;81:1271–1276)

Two-dimensional echocardiography provides a noninvasive means of imaging cardiovascular anatomy and has been used to assess coronary artery lesions in several conditions.1–11 Two-dimensional echocardiography is especially useful in the detection of coronary artery aneurysms in patients with mucocutaneous lymph node syndrome.7 Although transthoracic two-dimensional echocardiography can detect dilation of the coronary arteries, the reliability of this technique in the detection of coronary artery stenosis is still doubtful. The recent advances of transesophageal color Doppler and two-dimensional echocardiography12–23 offer a promising means to circumventing the problems of conventional transthoracic approach. Without the chest wall intervening between transducer and heart, the transesophageal two-dimensional images are generally of high quality. This allows the use of higher frequency transducers and results in much better definition of cardiac structures. The purpose of this study was to test the ability of biplane transesophageal color Doppler and two-dimensional echocardiography to detect left main coronary artery stenosis.

Methods

The study group consisted of 67 consecutive patients referred to our medical center for coronary arteriography for suspected coronary artery disease. Only patients with clinically apparent significant aortic stenosis and those with previous aortic valve replacement were excluded because of the difficulty in clearly imaging the aortic root in these patients. There were 52 men and 15 women, aged 38–72 years (mean, 52 years).

Transesophageal Echocardiography

All patients gave informed consent for transesophageal echocardiography according to a protocol approved by the Human Studies Committee of the Kobe General Hospital. Transesophageal echocardiographic studies were performed with an Aloka SSD-870 system (Tokyo, Japan) with a newly developed transesophageal Doppler probe, which included two 5-MHz transducers (one is used for horizontal planes, and the other is used for longitudinal planes) mounted on the end of a flexible endoscope from which the...
fiberoptics have been removed (Figure 1). Empirically, this system has a 0.6-mm axial resolution. Patients were conscious at the time of the study, and the endoscope was introduced into the esophagus with the patient in the left decubitus position. After the orientational landmark of the aortic valve had been demonstrated at a distance of 30 cm from the patient's teeth, the left main coronary artery was identified as two parallel echoes by counterclockwise rotation of the endoscope. A complete scan of the left main coronary artery was performed by tilting and alternately withdrawing and advancing the tip of the endoscope. On the transesophageal two-dimensional image, coronary arteries were searched under the guidance of color-coded Doppler echocardiography (Figure 2); subsequent magnification of the area of interest provided high resolution of anatomical details. Adequate visualization of the left main coronary artery was considered accomplished if two parallel echoes were seen from the left coronary ostium to bifurcation of the left anterior descending and circumflex coronary arteries. Real-time images were stored in cine loop memory, permitting frame-by-frame review. Imaging and recording time averaged 10–15
minutes per patient. Stop-frame images were analyzed by two independent observers who were unaware of other patient data. Stenosis of the left main coronary artery was evaluated by using the horizontal plane transducer, and we used the longitudinal plane transducer to confirm that the structure was the left main coronary artery. The diameter of the left main coronary artery was digitized manually. For measurements of the diameter of the left main coronary artery, the values of five measurements were averaged. The degree of echocardiographic stenosis was expressed as a percentage of the original lumen and designated as 1) normal, 2) less than 50%, or 3) equal to or greater than 50%. Diameter of the original lumen was calculated as the average from the diameters of proximal and distal normal coronary lumen. If the stenosis existed at the ostium or just proximal to the bifurcation, the diameter of the middle part of the left main coronary artery was defined as the diameter of the original lumen.

**Coronary Arteriography**

Coronary arteriography was performed by standard catheterization techniques using the Judkins femoral artery approach. Coronary angiograms were interpreted with consensus of opinion by two independent observers without knowledge of the patient’s identity or clinical course. Significant stenosis of the left main coronary artery was defined as a 50% or greater luminal diameter narrowing, corresponding to an approximate 70% narrowing of the luminal cross-sectional area.

**Statistical Analysis**

Standard methods were used for calculation of sensitivity, specificity, positive predictive accuracy, and negative predictive accuracy. Observer variability for measurements of the diameter of left main coronary artery in our laboratory has been determined in 20 randomly selected patients. The average intraobserver variability for measurements of the diameter of left main coronary artery was 2.7% of the mean value, and the average interobserver variability was 3.8% of the mean value.

**Results**

There was no complication during and after transesophageal examination in any of the 67 patients. With the horizontal plane transducer, the long-axis image (Figure 3) of the left main coronary artery was obtained. With the longitudinal plane transducer, the cross-sectional image (Figure 4) of the left main coronary artery could be visualized from the ostium to bifurcation by counterclockwise rotation of the endoscope. Blood flow (Figure 2) from the left main coronary artery to the left anterior descending coronary artery was demonstrated in 57 of 67 (85%) patients by transesophageal color Doppler echocardiogram (short-axis view of aortic root) from subject with normal left main coronary artery. Left main coronary artery, left anterior descending artery, and left circumflex coronary arteries can be clearly seen. Ao, aorta; LA, left atrium; LMCA, left main coronary artery; LAD, left anterior descending coronary artery; CX, circumflex coronary artery.
Angiography. Satisfactory images of the full length of the left main coronary artery and identification of bifurcation were obtained in 60 of 67 (90%) patients studied. In patients with more than 50% stenosis, the success rate was 92% (11 of 12 patients), and it was 89% (49 of 55 patients) in patients with less than 50% stenosis or a normal left main coronary artery. Transesophageal echocardiography showed insignificant (<50% stenosis) narrowing or no abnormalities (Figures 3 and 4, and Table 1) of the coronary lumen in 49 patients with normal or insignificant angiographic lesions (specificity, 100%) and significant (≥50%) narrowing (Figure 5) of the coronary lumen clearly in 10 of the 11 patients (sensitivity, 91%). The positive predictive accuracy of the echocardiogram for left main coronary artery disease was 100%, and the negative predictive accuracy was 98%.

**Discussion**

This study demonstrates that high-quality images of the left main coronary artery and measurement of luminal diameter and percentage of stenosis could be obtained by using transesophageal echocardiography. Satisfactory examinations of the full length of the left main coronary artery were obtained in 89–92% of the patients; the sensitivity of transesophageal echocardiography in the detection of significant left main coronary artery stenosis was 91%, and specificity was 100%.

The diagnosis of left main coronary artery disease is important in the management of patients with symptomatic coronary artery disease. The prediction of left main coronary artery obstruction before coronary arteriography is important, considering the potential for sudden death or, at least, greater morbidity during arteriography in patients with such obstruction.24–26 Several studies1–6 have reported the usefulness of imaging the left main coronary artery and assessing the presence of significant stenosis by using transthoracic two-dimensional echocardiography. Weyman et al1 first described a technique for visualizing the left main coronary artery with two-dimensional echocardiography. They emphasized the need to visualize the lumen of the vessel both proximal and distal to the lesion. Rogers et al6 used a standard two-dimensional echocardiographic system with signal processing to detect proximal coronary arterial calcifications primarily in the left coronary artery, proximal left anterior descending artery, and left circumflex coronary artery in closed-chest patients.

The yield of adequate images of the left main coronary artery by transthoracic two-dimensional

![Figure 4. Transesophageal two-dimensional echocardiogram (longitudinal view) from subject with normal left main coronary artery. Cross-sectional image of left main coronary artery is clearly demonstrated. PA, pulmonary artery; LA, left atrium; LMCA, left main coronary artery.](image-url)
echoangiography is in the range of 57–99%, and Rogers imaged this vessel in its entirety in only 70% of cases in vitro. Imaging of just the origins of the left anterior descending and circumflex arteries has been more difficult, being reported in 53% and 34% of the patients, respectively. Despite the optimism generated by these studies, the technique never became popular. In many instances, the imaging quality is too poor to allow an anatomical evaluation. Some of the difficulties encountered in obtaining adequate coronary artery images with transthoracic echocardiography are those inherent in any echocardiographic study and include obesity, unfavorable chest wall configuration, long-term obstructive lung disease, and advancing age.

During the last several years, transesophageal echocardiography has been shown to provide optimal imaging quality in virtually all patients and of all cardiac structures including the coronary arteries. Imaging from the esophagus overcomes difficulties that are encountered in obese patients and those with emphysema, when attempting to obtain good image quality from the chest wall. The advantages of the transesophageal over the transthoracic approach in the evaluation of left main coronary artery disease are 1) absence of anatomical obstacles between the ultrasound transducer and the left main coronary artery, 2) nearly perpendicular alignment of ultrasound beam with the left main coronary artery, and 3) better resolution characteristics using higher-frequency (5 MHz) transducers. These advantages result in a superior recording quality and greater sensitivity in demonstrating the left main coronary artery anatomy. Furthermore, under the guidance of color-coded flow pattern, the coronary arteries can be easily identified. In the present study, we used a biplane transesophageal probe, which enabled us to visualize both long-axis and cross-sectional images of the left main coronary artery. Although we assessed percentage of stenosis of the left main coronary artery by using the horizontal plane transducer, the longitudinal scans offer additional qualitative information about the anatomy.

Because echocardiographic imaging is tomographic by nature and epicardial vessels follow the curving surface of the heart, description of a long portion of a single vessel can be accomplished only by use of multiple views, each with a slightly different transducer angulation. Further, the vessels move continuously in and out of the imaging plane in concert with normal cardiac motion, and might be visible only briefly during the cardiac cycle. For any given cardiac cycle, the coronary arteries are probably in view less than one third of the time. Under these circumstances, it is difficult to try to analyze echocardiograms of the coronary arteries in real time. The viewer is distracted by the noncoronary artery information that dominates the recording.
Thus, the examiner has to locate those few frames in which the coronary arteries are visible, in a tedious frame-by-frame scan of the videotape. With the transesophageal approach, longer examination time is more invasive for the patients. Our present study overcomes these problems with digital imaging processing and cine loop review. Digitizing the ultrasonic examination has simplified the situation dramatically. Those frames that contain the coronary artery images can be isolated more easily once the examination is recorded digitally, and the examiner is not distracted by noncoronary artery images. Playing these frames over in a repetitive manner gives the examiner an overview of the coronary artery anatomy.

Limitations

Our present study has some important limitations. Although we successfully obtained at least a part of the left main coronary artery image, views were sometimes limited, and complete examination of the full length of the left main coronary artery was not possible in 7 of 67 (10%) patients. Because only a part of the left main coronary artery is visible in any single view, evaluation of long sections of the left main coronary artery requires piecing together successive views of adjacent segments. Furthermore, transesophageal echocardiography is limited in scanning planes (horizontal and longitudinal images). Variability in the scanning plane inclination might be required to further improve the capability of the transesophageal approach.

References


Key Words:  • left main coronary artery stenosis  • transesophageal echocardiography
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