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Cardiac Angio-CT Scan for Planning MIDCAB

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ABSTRACT

Precise evaluation of the cardiac and thoracic anatomy of the patient is mandatory for planning safe minimally invasive direct coronary artery bypass (MIDCAB). Three-dimensional images obtained with a computed tomographic coronary angiography (angio-CT) scan make it possible to accurately visualize the intrathoracic surgical anatomy in order to check the feasibility of the direct exposure of the anatomical structures involved in the surgical procedure. Particular morphological parameters of coronary arteries such as diameter, wall calcification, and intramyocardial position as well as bypass grafts and internal thoracic artery (ITA) displacement can all be precisely defined with this method. We present our preliminary experience using cardiac angio-CT scan as a method for selecting patients for MIDCAB in order to avoid possible surgical complications to minimize the necessity for conversion to the standard surgical approach as well as for choosing the best surgical access.

INTRODUCTION

Minimally invasive direct coronary artery bypass (MIDCAB) procedures may present complications such as difficulty in locating the coronary artery, difficulty performing coronary anastomosis, and the need for conversion to sternotomy [Lytle 1996, Ullyot 1996]. The contraindications and exclusions for MIDCAB are mainly anatomical [Subramanian 1997].

New high-speed multislice computed tomography (CT) systems allow the accurate portrayal of the intrathoracic anatomy. Images are reconstructed using a retrospective electrocardiogram-gated protocol along with contrast analysis and 3-dimensional (3D) display algorithms. The 8 or 16 detectors and the reduced tube rotation time of last-generation scanners allow the coverage of the entire heart during a single breath-hold following an intravenous bolus of 120 mL of nonionic contrast material. Faster computer software offers submillimeter-resolution reconstructions and increased postprocessing capabilities, such as quantitative angiography, calcification score evaluation, stereo-specific assessments, and others.

In this phase of technical development, multislice CT's ability to enable visualization of coronary vessel branches that are less than 2 mm in diameter gives it an advantage over nuclear magnetic resonance imaging (MRI), which in addition does not allow calcification score evaluation. Computed tomographic coronary angiography (angio-CT) scan represents an important opportunity to check the feasibility of the direct exposure of the anatomical structures involved in the surgical procedure in order to avoid possible surgical complications.

We discuss here our early experience using cardiac angio-CT scan in the planning of MIDCAB.

MATERIAL AND METHODS

Through the use of cardiac angio-CT scan 3D images, we preoperatively evaluated 10 patients scheduled for MIDCAB, in order to obtain an accurate definition of their intrathoracic surgical anatomy (Table 1). Direct exposure of the anatomical structures and the feasibility of the surgical procedure were checked (Figures 1 through 6). Morphological parameters of the coronary arteries involved in the procedure, the internal thoracic artery (ITA), the aorta, and a stereo-specific assessment were precisely defined with this method (Table 2). The calcification score evaluation was performed by means of a four degrees "ad hoc" score (Table 3).

The following scanning protocol was used: 4 × 1–mm collimation (simultaneous acquisition of 4 1-mm–thick sections per rotation), pitch of 1.5-2.0, 500 millisecond rotation time, 120 kV, and 300 mA, which corresponds to an estimated effective radiation dose of 5 mSv.

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Table 1. Patient Preoperative Evaluation Results*

Patient No.	Sex	Age	Main Stenosis	Intramyocardial Position	Artery Diameter	Artery Calcification	Selected for MIDCAB	Conversion to Sternotomy
1	M	80	RCA vein graft	No	1.8	0	Yes	No
2	M	50	MB vein graft	No	1.5	4	No	—
3	M	66	LAD	No	1.6	4	No	—
4	F	69	LAD vein graft	No	2	0	Yes	No
5	M	76	LAD	No	1.8	0	Yes	No
6	M	78	MB vein graft	No	1.7	4	No	—
7	M	66	LAD	No	1.9	0	Yes	No
8	F	73	LAD	Yes	2.1	0	No	—
9	F	66	LAD	No	1.8	3	No	—
10	M	73	LAD	Yes	1.6	3	No	—

*MIDCAB indicates minimally invasive direct coronary artery bypass; RCA, right coronary artery; MB, marginal branch; LAD, left anterior descending artery.

Presence of any of the following criteria excluded patients from MIDCAB: intramyocardial position of the coronary artery involved in the MIDCAB, a coronary artery wall calcification score >2, or a coronary artery diameter <1.5 mm (Table 2).

RESULTS

After the angio-CT scan evaluation, only 4 of the 10 patients were selected for MIDCAB, according to the morphological criteria mentioned above. All selected patients underwent MIDCAB without complications, no patients required conversion to a standard surgical approach. Of the 6 patients excluded for MIDCAB, 2 presented with an intramyocardially positioned graftable coronary artery, 5 patients presented with a calcification score >2 (3 patients with 4 and 2 with 3), and no patients had an involved coronary artery diameter <1.5 mm (Table 1).

DISCUSSION

Wide acceptance of MIDCAB has been limited, particularly because of technical problems related to surgical exposure of the coronary arteries and the consequent risk of complications and conversion to sternotomy.

The contraindication and exclusion criteria for MIDCAB surgery are mainly anatomical and strictly related to the difficulty locating the left anterior descending artery (LAD) or performing the anastomosis. In some patients, unfavorable anatomy can be detected preoperatively; however, a great num-

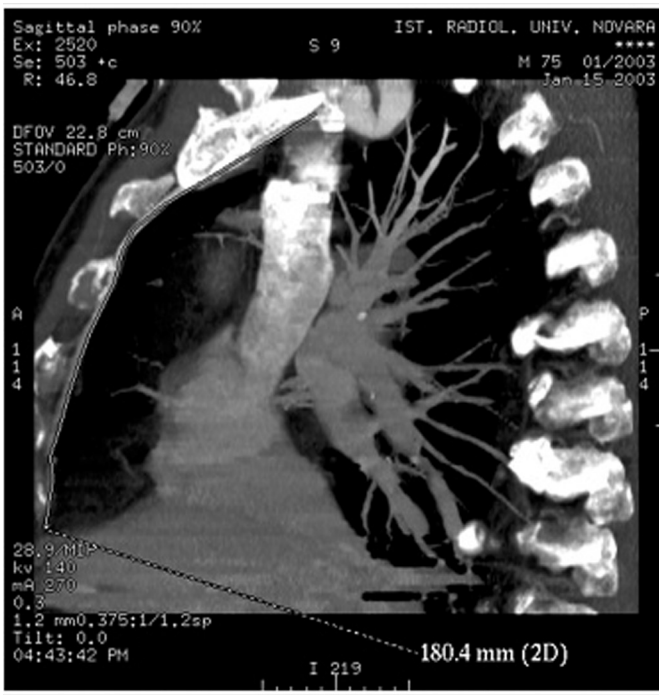

Figure 1. Right internal thoracic artery length.

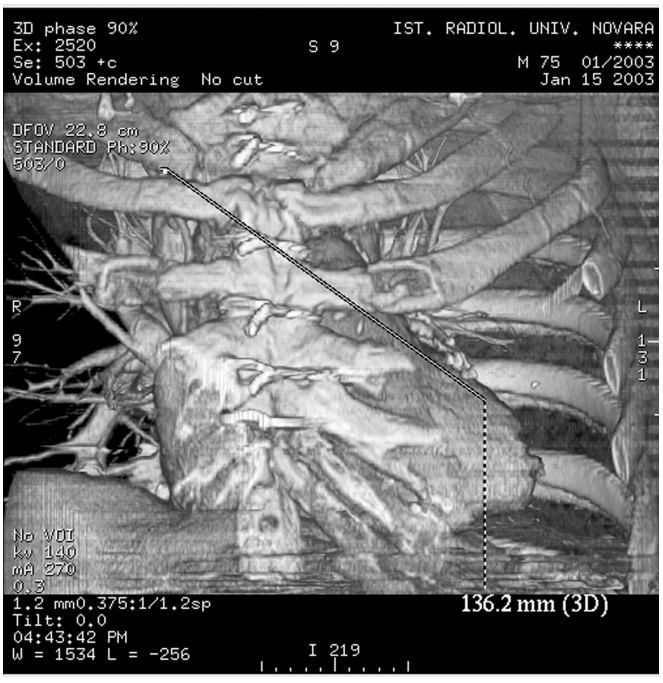

Figure 2. Virtual length of the right internal thoracic–left anterior descending artery bypass.

Figure 3. Three-dimensional image of the intercostal spaces.

ber of patients are excluded from the procedure only at the time of the operation and consequently contribute to a high rate of conversion to sternotomy [Calafiore 1996, Subramanian 1997].

Morphological parameters of coronary arteries as well as diameter, wall calcification, and intramyocardial position are important in developing a plan for an uncomplicated MIDCAB procedure. The preoperative cardiac angio-CT scan is very useful in assessing the feasibility of the anastomosis. Cardiac angio-CT scan provides precise information about coronary morphology that is particularly useful in avoiding conversion to the standard surgical approach and/or minimizing complications (Figures 1-6). Furthermore, very useful information about the ITA such as its location, length, diameter, and size of its collateral branches is obtained through cardiac angio-CT scan (Figures 1-3). These assessments allow the surgeon to minimize the invasiveness and improve the safety of MIDCAB procedures.

Figure 4. Two-dimensional image at the sixth intercostal space.

Figure 5. Two-dimensional image at the sixth intercostal space: left anterior descending artery–thoracic wall distance.

Cardiac angio-CT scan provides measures of ITA length, cardiac structures, and virtual length of the graft to be implanted for coronary artery bypass graft (CABG) (Figures 1-4). These data make it possible to plan for maximal use of arterial conduits (Figures 6 and 7).

Even though only the use of the left ITA (LITA) is compatible with MIDCAB, it is important to evaluate preoperatively to determine if the LAD is laterally placed (as in the case of a hypertrophic or dilated left ventricle) and if the right ITA (RITA) is long enough to be anastomosed to it (Figures 1-3).

Patient characteristics that influence access to the LAD and left internal mammary artery (IMA) may form the basis for preoperative contraindications. These characteristics include the degree of curvature of the chest wall, the length of the chest wall, chronic lung disease (the downward and medial displacement of the heart requires a lower entry level for the correct site of grafting and longer IMA dissection), cardiomegaly, and obesity. Cardiac angio-CT scan offers in these situations essential information for choosing the surgical access that provides optimal exposure of the involved coronary arteries (Figures 3-6).

In this series of patients, coronary calcification was the most frequent cause of exclusion from MIDCAB (5 of 6 patients excluded, see Table 1).

Figure 6. Three-dimensional image: stereo-specific assessment: sternum, left internal thoracic artery, and left anterior descending artery.

Table 2. Morphological Data Obtained with Cardiac Angio-CT Scan

Coronary artery
Diameter
Wall calcification
Intramyocardial position
Lateral position
Posterior position
Internal thoracic artery
Diameter
Length
Collateral branches
Aorta
Calcification
Distance: coronary-thoracic wall
Intercostal space

Table 3. Calcification Score

0 = absence
1 = light
2 = moderate
3 = severe
4 = heavy

Reoperative CABG for prior failed saphenous vein grafts represents an important indication for MIDCAB. Currently, approximately 10% of isolated revascularization operations in the developed countries are reoperations [Loop 1990]. Subramanian et al reported that 31% of their patients are reoperative candidates [Subramanian 1997]. In our little preliminary series, 2 of the 4 patients selected for MIDCAB were reoperative CABG patients.

Patients undergoing coronary reoperations are different from those having primary operations. Atherosclerotic vein grafts, the presence of patent arterial bypass grafts, and difficulty with sternal reentry are the most common problems related to reoperations. More common problems during reoperation include the unavailability of standard bypass graft conduits, diffuse cardiac and noncardiac atherosclerosis, and a difficult coronary artery exposure and identification. Many of these problems can be better assessed during preoperative evaluation by cardiac angio-CT scan.

The danger of sternal reentry is usually related to damage to patent bypass grafts and to the right ventricle. Patent left ITA grafts are a serious problem, particularly if they are adherent to the sternum. The presence of a patent right ITA graft that crosses the midline to left-sided coronary vessels increases the risk of damaging that graft. These problems may represent an indication for a MIDCAB procedure. Furthermore, the surgeon must be alert for situations in which the preoperative angiography does not completely delineate the entire coronary and graft anatomy.

If a graft that was performed during a previous operation is not visualized on postoperative angiography, there are 2 possible explanations. The first one is that the graft is occluded, and the second one is that the graft is not angiographically visible. Cardiac angio-CT scan may be very useful to discriminate between these situations. The position of previously performed bypass grafts can be exactly determined and their routes precisely studied by cardiac angio-CT scan. Precise localization of patent graft position is very useful in avoiding damaging the grafts during the surgical dissection for redo-CABG.

Because of epicardium scarring, it is usually more difficult to find the coronary arteries, and cardiac angio-CT scan can be very useful in determining preoperatively the optimal location of the new anastomosis.

When MIDCAB is performed on pump (port access), a preoperative cardiac angio-CT scan is also very useful for the evaluation of aortic calcifications. The precise evaluation of the status of the aortic wall prevents dissection and atherosclerotic embolisms during port-access procedures [Stevens 1996].

CONCLUSIONS

Cardiac angio-CT scan has been an effective procedure both in selecting patients and in choosing the best surgical approach for MIDCAB. The effectiveness of this methodology might change the actual selection criteria for MIDCAB. Furthermore, this kind of experience should be transferred to angio-MRI although at the moment the definition power of MRI is not satisfactory for vessels with diameter <2 mm and it does not enable determination of calcification score. A more extensive evaluation and study is mandatory in order to standardize this methodology.

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