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Off-Pump Coronary Artery Bypass Grafts Assessment by Multislice Computed Tomography


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ABSTRACT

Background: Selective coronary angiography is the standard but invasive procedure for postoperative assessment of coronary artery bypass graft patency. The aim of this prospective study is to evaluate the multislice computed tomography (CT) as a means of postoperative patency assessment and anastomotic site control of arterial and venous coronary bypass grafts performed with off-pump coronary artery bypass techniques.

Methods: Over a 6-month period, 20 patients underwent isolated coronary artery bypass (beating heart technique) and benefited, 7 days later, from a patency and anastomotic site control by multidetector angio multislice CT with cardiac gating.

Results: Whole internal thoracic artery bypasses and venous grafts were visualized perfectly on their entire length, including the anastomotic site, and 3-dimensional reconstruction was possible. The relationship between cardiac cavities and the bypasses were well visualized, allowing quantification of bypass stenosis ensured by software analysis.

Conclusions: Postoperative control of coronary bypasses is possible by multislice CT with a very satisfactory resolution, thus making it possible to check the patency of coronary bypasses and the quality of anastomosis with a noninvasive method. Three-dimensional reconstructions are very useful in the event of redo surgery.

INTRODUCTION

With the development of off-pump coronary artery bypass (OPCAB) surgery, a useful technique for some groups of patients [Benetti 1991; Pfister 1997], surgeons are confronted with technical difficulties when performing coronary anastomoses (cardiac movements, bleeding on the anastomotic site), which may deteriorate the long-term result, and riskier reinterventions may be required [Gundry 1998]. It appeared useful to perform perioperative and early postoperative controls of such bypasses. The methods used for postoperative direct control of coronary bypasses are primarily Doppler, allowing only assessment of the internal thoracic artery (ITA), and selective coronary angiography, the "gold standard," which nevertheless requires an arterial puncture with all its consequences (morbi-mortality, discomfort).

For many years, a third method of direct exploration of coronary bypasses has been developed, using by the multislice computed tomography angioscanner (MCTscan), which makes it possible to control the patency of arterial and venous coronary bypasses and the native coronary network [Daniel 1980; Albrechtsson 1981; Bateman 1986; Nieman 2001; Nieman 2002]. MCTscan has been used in our department of cardiovascular surgery for a feasibility study since 2002 [Demaria 2003] with excellent initial results. The aim of this preliminary prospective study is to evaluate the MCTscan as a means of postoperative patency assessment and anastomotic site control of arterial and venous coronary bypass grafts performed with OPCAB technique.

MATERIAL AND METHODS

Patients

Over a 6-month period, 20 patients who had undergone isolated coronary artery bypass with beating heart technique benefited after information, approximately 7 days after surgery, from a patency and anastomotic site control with a MCTscan associated with cardiac gating (Light Speed; General Electric, Waukesha, WI, USA). The MCTscan was carried out after control of the renal function. All patients with renal insufficiency and/or iodine allergy were excluded. The heart rate of the patients had to be lower than 60 beats/minute, possibly with oral beta-blocking medication when necessary, to ensure optimal image acquisition.

Technique of CT Scan

After positioning of the patient, 120 to 140 mL of iodized contrast product were injected in a peripheral vein. After a few seconds, when the contrast agent reached the ascending aorta (measured then at 100 UH), it was requested that the

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Figure 1. A Y connection using both internal thoracic arteries, the right one connected to the left.

patient provide a 25-second apnea, during which time the acquisition of cardiac volume was carried out. A retrospective cardiac "gating" allowed, while the software adapted to the heart rate of the patient, the rebuilding of the 0.6-mm-thick slices every 0.6 mm, from the data gathered during 250 milliseconds at the end of the diastole, when the heart is well filled and relatively immobile and the coronary arteries well perfused. The software then rebuilt the images either in multiplanar mode or curvilinear 2-dimensional (2D), or in voluminal mode surface 3-dimensional (3D).

RESULTS

The procedure was performed without any particular complication for all 20 patients. The duration of the procedure was about 15 minutes. The images obtained, after software reconstruction, allowed a very good visualization of the native coronary network and of the bypasses. The delivered irradiation was about 2 to10 mSv per procedure.

The ITA and venous grafts were well visualized all along their path even on the anastomotic site, and 3D reconstruction was possible. Even sequential bypasses and the Y connections using both ITAs were well explored (Figure 1). The site of the distal anastomosis was also well identified, and the anastomosis itself could sometimes also be visualized perfectly, in plane mode as well as in 3D mode (Figures 2, 3). The same results occurred for bypasses toward the posterior interventricular artery and the left marginal arteries (Figure 4). The anatomic relationship between cardiac cavities and bypasses was also well demonstrated by 3D reconstructions. The software could also rebuild a virtual bypass over all its length, thus allowing evaluation and quantification of its diameter and possible rectilinear image of the stenosis.

Results of the MCTscan identified 2 bypass occlusions and one stenosis confirmed by angiography (Table). However, in one case, an anastomotic stenosis was found by conventional angiography but was not previously identified by MCTscan. The clips sometimes created localized artifacts. In 2 cases, it was not possible to analyze the images because of tachyarrhythmia and motion artifacts.

DISCUSSION

The advent of the beating heart coronary surgery, more difficult technically, emphasizes the need for a direct control of bypasses in the perioperative and postoperative periods. Doppler remains the method of choice for perioperative and postoperative control, in particular for ITA [Haaverstad 2002], and selective coronary angiography is the "gold standard" in the postoperative period. However, this invasive

Figure 2. The site of the left internal thoracic artery distal anastomosis on the left anterior descending artery well identified in plane mode.

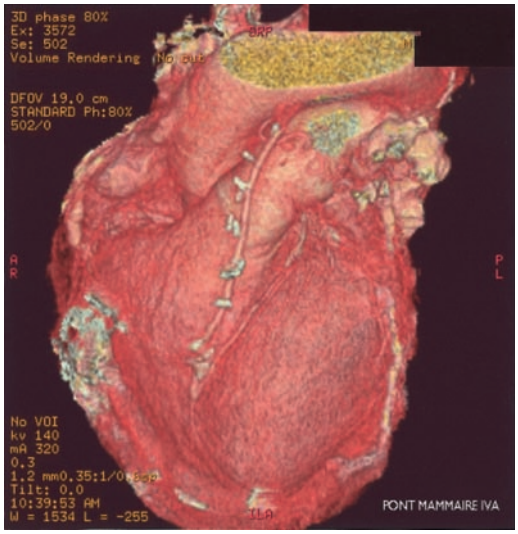

Figure 3. The site of the left internal thoracic artery distal anastomosis on the left anterior descending artery well identified in 3D mode. The surgical clips are also visualized.

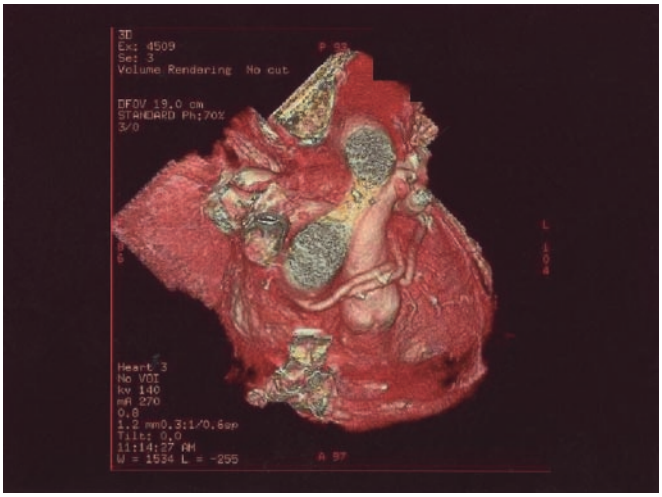

Figure 4. Venous bypass connected in Y in front of the pulmonary artery.

procedure presents a significant risk of morbi-mortality [Christiaens 1998]. There is thus a place of choice for a noninvasive examination allowing the control of coronary bypasses during the early postoperative period. The angioscanner initially successfully evaluated the native coronary network [Achenbach 1996]. Then, after the preliminary work of Achenbach [1997], the MCTscan showed that it could precisely evaluate the patency of an arterial or venous coronary bypass [Engelmann 1997; Jara 2002], in 2D and 3D. Our preliminary results confirm these data with precise images demonstrating the patency of coronary bypasses and detecting stenosis or occlusion. Concerning the interval between surgery and MCTscan, an immediately postoperative MCTscan could be deleterious for the patients. Seven days after surgery appears to be a satisfactory option because it is before the discharge, but patients are well recovered from the operation. Furthermore, eventually, reoperation is still possible without major risks.

Results of Multislice Computed Tomography Angioscan (MCTscan)*

Patient	Grafts	MCTscan
1	LITA-LAD	Well visualized
2	LITA-LAD, RITA-RCA	Well visualized
3	LITA-LAD	Well visualized
4	LITA-LAD	Well visualized (except anastomosis)
5	LITA-LAD, RITA-LMA, SVG-MA	Well visualized
6	LITA-LAD, RA-LMA, SVG-LMA	SVG-LMA occluded
7	LITA-LAD	Well visualized
8	LITA-LAD	Well visualized
9	LITA-LAD, SVR-RCA, SVG-LMA	Well visualized
10	LITA-LAD	Well visualized
11	LITA-LAD, RITA-RCA	RITA occluded
12	LITA-LAD	Well visualized
13	LITA-LAD	Anastomotic stenosis
14	LITA-LAD	Well visualized
15	LITA-LAD	Well visualized
16	LITA-LAD	Well visualized
17	LITA-LAD (sequential)	Well visualized
18	LITA-LAD	Well visualized

*LITA indicates left internal thoracic artery; LAD, left anterior descending artery; RITA, right internal thoracic artery; RCA, right coronary artery (or posterior inter ventricular artery); SVG, saphenous vein graft; MA, marginal artery; RA, radial artery; LMA, left marginal artery.

The advantages of this method are multiple. The duration of an MCTscan is short and therefore very well tolerated by the patient. It requires only one peripheral venous puncture. The images show the lumen of the vessels clearly and explore the anastomotic sites correctly. The anatomical relationships of bypasses with the cardiac structures are well defined, providing very useful information in the event of redo surgery with permeable bypasses, more easily located, and preserved by the dissection of the cicatricial fibrosis. The disadvantages are those of any iodized examination (eg, impairment of renal function, allergic reaction). The angioscanner is less irradiant than a selective coronary angiography but requires the injection of a quantity of iodine slightly higher than an isolated opacification of bypass without ventriculography. In the event of associated ventriculography, the quantity of iodine necessary is then more important than for selective coronary angiography.

The current limits of the method include inappropriateness for patients with atrial fibrillation or with tachycardia, because these conditions result in difficulties of images rebuilding at the same time at the end of the diastole. Also, coronary arteries with diameter less than 1.5 mm are poorly explored, and stenoses located within a calcareous sleeve are more difficult to quantify. The surgical clips cause artifacts. Concerning types of bypasses, arterial grafts of internal mammary arteries are smaller (and usually have metal clips along their course), but this is not the case for venous grafts. Therefore, the accuracy for arterial grafts is not as good as for venous grafts. Further technological progress and the evolution of detectors (matrix detectors) would allow higher spatial and temporal resolution compatible with the reduction in the volume of the iodized contrast necessary.

In conclusion, this preliminary prospective study indicates that the postoperative control of coronary bypasses is possible by MCTscan with a very satisfactory resolution. It is possible to check the patency of coronary bypasses and sometimes the quality of anastomosis with a noninvasive method, especially in the case of OPCAB techniques. The 3D reconstructions are very useful in the event of redo surgery. The grade of stenosis can be quantified. This noninvasive method also explores the native coronary network and will most probably become the first intention diagnosis method for coronary lesions [Treede 2002]. This development is likely even more because of the availability of scanners of increasing performances. However, validation studies comparing MCTscan and selective coronary angiography will be essential before definitive definition of the place of the MCTscan in the coronary imaging.

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