Tomographic Visualization of Coronary Bypass Grafts: the New Diagnostic Frontier in Clinical Cardiology

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In the 16th century, the astronomer Nicolas Copernicus created a new paradigm when he described the rotation of the earth on its axis and its orbit of the sun. In *De Revolutionibus*, he described this new concept as "A fundamental change in the way of thinking or looking at a work or concept."[1]

Revolutionary concepts do not often arise in medicine. However, they are fundamental to its progress. In 1958, Mason Sones performed the first coronary angiogram and opened a new frontier in modern cardiology.[2] Soon after, coronary angiography opened the way for the development of cardiovascular surgery and, eventually, percutaneous revascularization.

Nowadays, noninvasive diagnosis of coronary artery disease by computed tomography (CT) represents a new frontier. Current technological advances allow 3-dimensional image acquisition of coronary artery anatomy with a temporal resolution of 100-220 ms and a spatial resolution of 0.6 mm. Various studies to assess the efficacy of CT for detecting coronary obstructions of greater than 50% have reported a high diagnostic sensitivity (72%-95%) and specificity (85%-100%).[3-7] In addition, recent studies indicate that, similar to intravascular ultrasound, CT can offer information regarding the composition of atherosclerotic plaques.[8] Adopting this technology into clinical practice could have various significant implications. The possibility of being able to use CT to obtain information on coronary artery anatomy noninvasively and inexpensively provides us with an opportunity to assess a larger number of patients at risk from coronary artery disease. At the same time, the implementation of CT as a diagnostic technique could limit the inappropriate use of invasive catheterization and restrict its application to patients with a high probability of requiring intervention.

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In this issue of REVISTA ESPAÑOLA DE CARDIOLOGÍA, Trigo Bautista et al[9] evaluate the usefulness of CT in the assessment of coronary artery bypass grafts. In 38 patients who had undergone surgical revascularization, the authors demonstrate a sensitivity of 92% and a specificity of 97% for the detection of more than 50% stenosis of the bypass grafts. The results of this study are similar to other recently published results using 16-detector CT.[10] One of the advantages of the new generation of 16-detector CT scanners is the capacity to acquire images within a total time period of 25-35 seconds. This reduced acquisition time limits the number of artifacts caused by respiratory movement and improves image quality by allowing the injection rate for the contrast agent to be increased. Currently, 32 to 64-detector scanners allow the acquisition time to be reduced to less than 15 seconds and the dose of contrast agent to be reduced to less than 100 mL.

It is of particular interest to note that in the study of Trigo Bautista et al[9] it was possible to visualize 109 (93%) of the 117 reported bypass grafts by CT. In contrast, invasive coronary angiography was only able to detect 89 (86%). It is sometimes difficult to locate the origin of coronary artery bypass grafts and explore them selectively in the catheterization laboratory. In patients with various bypass grafts, the duration of the procedure, the use of a contrast agent, and the risk of vascular complications can increase considerably. CT offers a number of advantages over angiography for the assessment of coronary artery bypass grafts. Firstly, in theory, CT eliminates embolic complications, which are more common in these patients. Secondly, CT allows the ascending aorta and the proximity of the right ventricle to the chest wall to be assessed along with the condition of the

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thoracic arteries in patients in who repeat revascularization is considered. Thirdly, CT can be used to establish the presence of thrombi and the extent of calcification in the wall of the bypass graft. This information can be useful in determining the risk of an intervention.

Nevertheless, we should recognize that there are certain limitations and disadvantages associated with the use of CT to assess coronary artery bypass grafts. The diagnostic accuracy of the technique depends upon the quality of the images. This could be a limitation in patients who are obese, have a high heart rate or arrhythmias, present extensive calcification of the coronary arteries, or who are unable to sustain a prolonged single-breath hold. In fact, few studies have reported results obtained from consecutive patients, suggesting a bias in patient selection. In patients who are symptomatic or show evidence of ischemia, CT allows an assessment to be made of whether the bypass grafts are obstructed. However, in many cases it is impossible to accurately assess the distal anastomosis[10] or the condition of the native coronary arteries, since these normally have a smaller diameter and a high degree of calcification. In patients with acute symptoms and bypass graft obstruction, the use of CT prior to percutaneous revascularization could increase the risk of acute renal failure due to the double dose of contrast agent. In the series of Trigo Bautista et al,[9] 1 patient developed acute renal failure. Given these limitations, it would be prudent to restrict the use of CT for the assessment of bypass grafts to patients with normal kidney function, who are in sinus rhythm, do not have a history of allergy to contrast agents, and who present stable symptoms.

It is also important to recognize that, as with invasive coronary angiography, the anatomic information provided by CT does not substitute the value of ergometry and imaging during exercise. Despite the fact that these techniques have a low sensitivity for the detection of bypass graft obstruction, they remain useful to establish the presence or absence of ischemia. A significant number of patients who have undergone revascularization develop obstruction of the bypass graft following surgery but establish collateral flow. We should remember that there is no evidence that repeat revascularization in these patients is beneficial in the absence of ischemia. Other patients develop diffuse disease in multiple bypass grafts and in the native coronary arteries. In these cases, imaging techniques allow areas of ischemia to be identified and guide revascularization. Finally, various studies have shown that the results of ergometry and imaging of perfusion and contractility under stress have a greater prognostic value than the results of coronary angiography. Consequently, the use of CT is not justified in asymptomatic patients who do not present evidence of ischemia.

Finally, we should bear in mind that although CT is a noninvasive technique, there are risks associated with its use. In addition to the risk of anaphylactic reaction and renal failure associated with the use of iodinated contrast agents, CT requires relatively high doses of ionizing radiation. A typical study of the native coronary arteries exposes patients to a dose of 6-12 mSv. It has been estimated that this exposure could increase the risk of cancer by 1:2000. The exposure is even higher in studies of coronary artery bypass grafts since they require a larger coverage. Therefore, it is important to compare the potential benefit with the risk and avoid indiscriminate use of this technique.

There are clear situations in which CT is preferable to invasive coronary angiography. For instance, in patients with acute aortic dissection, CT can be used to define that anatomy of the coronary arteries, removing the need for catheterization prior to surgery. In patients with peripheral vascular disease or with a prior history of embolism, the use of CT can prevent vascular complications. Scanners with 32-64 detectors offer the possibility of simultaneously assessing the coronary arteries, the aorta, and the carotid arteries; this could be extremely useful in patients with vascular disease in whom repeat revascularization is considered.

Without doubt, multislice CT has opened a new frontier in the diagnosis of coronary artery disease. The technology continues to advance rapidly, and it is anticipated that current limitations will gradually be overcome. Future studies should assess the optimal way in which to incorporate this new technology into clinical practice. We anxiously await the results.

REFERENCES

1. Merriam-Webster Online Dictionary. Available from: www.m-w.com/cgi-bin/dictionary?book=Dictionary&va=revolution&x=17&y=15
2. Sones FM, Shirey EK. Cine coronary arteriography. Mod Concepts Cardiovasc Dis. 1962;31:735-8.
3. Nieman K, Cademartiri F, Lemos PA, Raaijmakers R, Pattynama PM, de Feyter PJ. Reliable noninvasive coronary angiography with fast submillimeter multislice spiral computed tomography. Circulation. 2002;106:2051-4.
4. Ropers D, Baum U, Pohle K, Anders K, Ulzheimer S, Ohnesorge B, et al. Detection of coronary artery stenoses with thin-slice multi-detector row spiral computed tomography and multiplanar reconstruction. Circulation. 2003;107:664-6.
5. Kuettner A, Beck T, Drosch T, Kettering K, Heuschmid M, Burgstahler C, et al. Diagnostic accuracy of noninvasive coronary imaging using 16-detector slice spiral computed tomography with 188 ms temporal resolution. J Am Coll Cardiol. 2005;45:123-7.
6. Mollet NR, Cademartiri F, Krestin GP, McFadden EP, Arampatzis CA, Serruys PW, et al. Improved diagnostic accuracy with 16-row multi-slice computed tomography coronary angiography. J Am Coll Cardiol. 2005;45:128-32.
7. Martuscelli E, Romagnoli A, d'Eliseo A, Razzini C, Tomassini M, Sperandio M, et al. Accuracy of thin-slice computed tomo-

graphy in the detection of coronary stenoses. Eur Heart J. 2004; 25:1043-8.
8. Achenbach S, Moselewski F, Ropers D, Ferencik M, Hoffmann U, MacNeill B, et al. Detection of calcified and noncalcified coronary atherosclerotic plaque by contrast-enhanced, submillimeter multidetector spiral computed tomography: a segment-based comparison with intravascular ultrasound. Circulation. 2004; 109:14-7.
9. Trigo Bautista A, Estornell J, Ridocci F, Soriano CJ, Gudín M, Vilar JV, et al. Valoración no invasiva de injertos coronarios con tomografía computarizada: comparación con la angiografía convencional. Rev Esp Cardiol. 2005;58:807-14.
10. Schlosser T, Konorza T, Hunold P, Kuhl H, Schmermund A, Barkhausen J. Noninvasive visualization of coronary artery bypass grafts using 16-detector row computed tomography. J Am Coll Cardiol. 2004;44:1224-9.