Frequency and Clinical Significance of Failure to Visualize the Conus Artery During Coronary Arteriography

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SUMMARY In patients with occlusion of the left anterior descending coronary artery (LAD) or right coronary artery (RCA), the conus artery, which arises at or near the origin of the RCA, often serves as a principal source of collateral circulation. Coronary arteriograms in 508 adult patients revealed that in 80.5% the conus artery was well visualized on the RCA angiogram, but that in 19.5% it was not adequately visualized due to injection of contrast distal to its origin. In the latter patients, the presence of conus-LAD or conus-RCA collaterals might therefore go undetected. Because the degree of distal filling via collateral circulation affects medical and surgical decisions, it is important to attempt to visualize the conus artery adequately whenever the LAD or RCA is obstructed.

THE CONUS ARTERY supplies coronary blood flow to the conus, or outflow tract, of the right ventricle and is generally considered to be the first branch of the right coronary artery (RCA). On coronary arteriograms, the conus artery is generally viewed in the left anterior oblique (LAO) and right anterior oblique (RAO) projections (figs. 1-5). In the LAO projection it initially passes cephalad, then turns caudally and slightly laterally after reaching the apex of the right ventricular outflow tract. In the RAO projection, its initial upward course is again seen as it passes toward the anterior aspect of the heart. It terminates by ramifying near the anterior interventricular groove, which contains the left anterior descending artery (LAD).

The principal importance of the conus artery in adult patients with coronary artery disease (CAD) is to serve as a major source of collateral circulation when the LAD becomes obstructed. To a lesser extent, the conus artery can also collateralize the distal segment of an obstructed RCA (figs. 1 and 2).

Careful anatomic studies have shown that in approximately 50% of human hearts, the conus artery is actually not a branch of the RCA but arises instead from a discrete ostium in the right sinus of Valsalva close to, but separate from, the RCA ostium. When such patients undergo coronary arteriography, selective catheterization and contrast injection into the RCA might fail to opacify the conus artery. Serious underestimation of the extent of collateral circulation in patients with LAD or RCA disease could result under these circumstances. The purpose of this study was to determine how often this anatomic variation results in failure to visualize the conus artery adequately during selective coronary arteriography.

Methods

We prospectively analyzed coronary cinearteriograms performed in 508 adult patients with suspected CAD. Two-thirds of the studies were performed using the Judkins percutaneous femoral technique, and the rest were performed using the Sones brachial arteriotomy technique. Cases were included in the study only if both LAO and RAO views of the RCA were obtained. The arteriograms were classified according to whether they visualized the conus artery adequately, inadequately, or not at all. Visualization of the vessel was considered adequate if it was completely filled and seen along its entire length in at least one projection. Visualization was considered present but inadequate if the vessel was only partially filled, thereby rendering it difficult to ascertain the presence or extent of collateral circulation.

Results

Among the 508 cases, the conus artery was adequately visualized in either the LAO or RAO projection or both in 404 (80.5%). Inadequate visualization occurred in 22 cases (4.3%) and nonvisualization occurred in 77 cases (15.2%). Thus, in 19.5% of studies, the conus artery could not be properly evaluated. This problem was encountered with both the Judkins and the Sones techniques.

When the conus artery originated from the RCA, it invariably arose from the first 2 cm of that artery (figs. 3 and 4). Figure 5 is an example of a patient whose conus artery appears to arise from a separate ostium in the right sinus of Valsalva near the RCA ostium. In this patient and many other patients with similar anatomy, the conus artery is opacified as a result of reflux of contrast medium from the selectively catheterized RCA into the sinus, with subsequent filling of the nearby conus ostium.

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Discussion

This study indicates that the conus artery is not adequately seen in approximately 20% of adult patients undergoing coronary arteriography for suspected CAD. Presumably, these cases are part of the larger group of 50% in which the conus ostium is separate from the RCA ostium. In the 30% making up the remainder of this group, the conus artery is opacified during selective RCA arteriography despite

![Figure 1](image1.png)

**Figure 1.** Right coronary arteriogram in the right anterior oblique projection in a patient with obstruction of the left anterior descending artery (LAD). The conus artery supplies collateral circulation (arrowhead) to the distal segment of the LAD.

![Figure 2](image2.png)

**Figure 2.** Right coronary arteriogram in the right anterior oblique projection in a patient with obstruction of the midportion of the right coronary artery (RC). Collateral circulation emanates from the conus artery and a high acute marginal (AM) branch and anastomoses with a more distal AM branch through connections over the free wall of the right ventricle (arrowheads). This collateral pathway provides reconstitution of the distal RC.

![Figure 3](image3.png)

**Figure 3.** Right coronary arteriogram in the left anterior oblique projection. In this patient, the conus artery (arrow) originates from the right coronary artery 1 cm distal to its origin. The angiographic anatomy is typical: the vessel initially courses cephalad, then turns caudally and slightly laterally as it passes over the right ventricular outflow tract (toward the viewer in this projection).

![Figure 4](image4.png)

**Figure 4.** Right coronary arteriogram in the left anterior oblique projection. The conus artery (arrow) originates at the origin of the right coronary artery.
its separate origin (fig. 5). This results from reflux of contrast medium into the right sinus of Valsalva during selective RCA injection.

The crucial role that the conus artery may assume in CAD patients is illustrated in figure 6. In this case, the LAD and RCA were totally occluded, but the distal segments of both were supplied by collaterals emanating exclusively from an enlarged conus artery. If the latter vessel had not been seen during coronary arteriography, the existence of this extensive collateral circulation would not have been recognized. The presence or absence of collateral circulation is an important factor in determining the clinical status of the patient; recent studies have shown that collaterals may preserve myocardial function and ameliorate some of the effects of myocardial ischemia.\textsuperscript{1,5-11}

Decisions regarding medical or surgical treatment for CAD are often significantly influenced by the degree to which collateral circulation has developed. Once it has been decided that bypass surgery is indicated, the surgeon must know the anatomy of the distal segment of any coronary artery he plans to bypass. If arteriography shows the distal segment to be widely patent with smooth walls, a bypass can generally be attached anywhere along its course with few technical problems. If, however, the distal segment is diffusely diseased or has multiple additional stenoses (fig. 6), proper placement of the bypass becomes much more critical. As much information as possible regarding collateral circulation and the caliber of the distal segment of the recipient vessel needs to be obtained during coronary arteriography, and nonvisualization of a potential source of collaterals in 20\% of patients undergoing study represents a significant problem.

In patients with LAD or RCA disease, if the conus artery is not initially visualized during selective RCA arteriography, one should attempt to do so. We do not, however, recommend trying to catheterize the conus artery selectively. This can be both time-consuming and somewhat dangerous, because the os-
FIGURE 7. Right coronary arteriograms. (A) Left anterior oblique and (B) right anterior oblique projections. A large pre-infundibular branch (curved white arrow) supplies both the outflow tract and anterior free wall of the right ventricle. This vessel also supplies collateral circulation to the distal segment of an obstructed left anterior descending coronary artery (straight white arrow).

tium is small and is usually totally occluded by the entry of the catheter tip. The catheter should instead be withdrawn somewhat from its selective position in the RCA so that the tip no longer extends as far into the vessel. Then, a repeat injection performed forcefully enough to replace blood flow may cause enough contrast reflux into the right sinus of Valsalva to fill the nearby conus ostium satisfactorily. If necessary, the

FIGURE 8. (A) Right coronary arteriogram in the left anterior oblique (LAO) projection. No conus artery is seen. (B) Left coronary arteriogram in the LAO projection. A small conus branch (arrow) arises from the left anterior descending coronary artery and supplies the area of the right ventricular outflow tract.
catheter may have to be withdrawn entirely from the RCA and carefully repositioned nonselectively in the sinus with its tip pointing anteriorly to direct the contrast stream toward the conus ostium.

In this study, we found two other anatomic variations of the conus artery, each in seven cases (1.3%). The first is the presence of a large pre-infundibular branch, a term suggested by Paulin. This vessel (fig. 7) arises from the proximal RCA and supplies not only the right ventricular outflow tract, but also a large portion of the anterior free wall of the right ventricle. The latter territory is usually supplied by right ventricular and marginal branches of the RCA, so that a pre-infundibular branch may be considered a combination of conus, right ventricular and marginal arteries. The second variation is origin of a conus branch from the LAD instead of the RCA (fig. 8). In these instances, the RCA may or may not give off an additional conus branch of its own.

References
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