Flow-based intraoperative bypass graft patency assessment during coronary artery bypass grafting (CABG) verifies a bypass graft’s patency and prevents early graft failure. It also establishes a bypass graft’s flow carrying capacity.

Competitive Flow

However, when a bypass graft is sewn to a distal coronary but the proximal native coronary artery is not fully stenosed, flow from both the bypass graft and the native coronary feed the distal coronary and myocardial bed. Blood from a partially stenosed native coronary artery “competes” with bypass graft flow to perfuse the distal myocardium (Fig. 1). Bypass graft flow is lowered. When a native coronary artery is fully stenosed, no competitive flow occurs (Fig. 2). Therefore, when bypass graft flow is lower than expected, an assessment of competitive flow will inform surgeons’ subsequent surgical decisions.

When Is Competitive Flow Important?

Questionable bypass graft flows (between 5 mL/min and 20 mL/min) can be attributed to a number of causes: competitive flow; physiological factors (vasospasm, soft pressure, poor vessel runoff) or technical problems (anastomotic quality, twists or kinks along the graft). By first evaluating and eliminating competitive flow as the cause of a questionable bypass flow, surgeons can determine another cause and proceed, if necessary, with corrective action.

How Is Competitive Flow Assessed?

(Refer to flow chart on page 2)

Competitive flow is assessed by simply occluding the native coronary artery with finger pressure while measuring flow through the bypass graft. If graft flow increases with this occlusion, competitive flow is indicated. A negative flow pulse on the graft waveform profile is also indicative of competitive flow.

When Is Competitive Flow Assessed?

Although it is optimal to assess competitive flow immediately after each bypass graft flow is measured, one may, from a practical standpoint, assess competitive flow only

(1) If mean graft flow is less than expected given the physiology of the patient, or

(2) If mean flow is in the questionable range from 5 mL/min - 20 mL/min.
Two flow measurements are recommended:
- One without occluding the native coronary artery;
- One with the native coronary artery occluded (finger pressure, forceps etc.).

If native coronary artery occlusion fails to increase graft flow, a 100% stenosis in the native coronary is indicated. If occlusion of the native coronary produces a higher graft flow, competitive flow from the native coronary is present. In such instances, the analysis of graft patency should be based only on flow observations taken with full coronary occlusion.

A negative pulse in the flow waveform (retrograde flow) always identifies the presence of competitive flow. Such a negative flow pulse will occur, typically, at the start of systole, but may occur at the end of systole as well.

The absence of a negative pulse does not rule out the possibility of competitive flow.

Competitive flow reduces or reverses graft flow. It, therefore, lowers the predictive value of graft flow as a useful measure of graft patency.
Patent Grafts that Exhibit Competitive Flow

The retrograde flows (below 0 mL/min) in the two LIMA - LAD grafts below indicate competitive flow even though their mean flows are in the acceptable range. In the upper graft, mean flow was 36 mL/min; in the lower graft, mean flow was 25 mL/min. Both grafts have diastolic dominant profiles, characteristic of grafts that feed the left heart myocardium. (Courtesy of B. Mindich, MD)

Technical Problem & Competitive Flow

A 72-year-old male patient underwent off-pump CABG of the left internal mammary artery (LIMA) to the left coronary artery (LAD). When flow was measured on the LIMA-LAD graft, mean flow was 22 mL/min. The 1.5 mm LAD was of good quality. When the LAD proximal to the anastomosis was fully occluded with a snare, graft flow increased to 48 mL/min indicating competitive flow from the native LAD. The surgeons concluded that the anastomosis was good and the graft was patent.

A second case reported a 64-year-old male patient who underwent off-pump CABG with a LIMA bypass graft to the LAD and a SVG bypass graft to the OM. The 1 mm LAD was of poor quality with multiple non-critical lesions. The LIMA graft had low flow when it was measured following anastomosis. When the native coronary was occluded, the subsequent graft flow increased to 15 mL/min. The surgeons, therefore, decided to augment distal LAD perfusion with a second SVG graft to the distal LAD. SVG graft flow, with the LIMA graft occluded, was 20 mL/min which the surgeons concluded was adequate.

Conclusion

The goal of CABG surgery is to deliver sufficient blood flow to the myocardium by augmenting blood flow through the coronary arteries with bypass grafts. When a bypass graft exhibits inferior flow characteristics, competitive flow should be examined first as a cause for reduced graft flow. Knowing if competitive flow is present both informs the surgeon and allows the surgery to proceed without attempting to identify and correct other causes for graft flows that are less than expected.

REFERENCES


Hamada Y et al, “Effect of Coronary Artery Bypass Grafting on Native Coronary Artery Stenosis. Comparison of Internal Thoracic Artery and Saphenous vein grafts,” J Cardiovascular Surg (Torino) 2001 42(2): 159-64.


Appendix

Alternative Competitive Flow Description

Competitive flow can also be understood with a highway traffic analogy. The highway is the native coronary vessel. The ramp is the bypass graft. If the highway before the on-ramp is completely blocked by a rock slide (full stenosis), the cars can enter the highway from the on-ramp undeterred by any highway traffic. Ramp traffic comprises all no competition, maximum bypass flow.

However, if the highway is only partially blocked by the rock slide (partial stenosis)(Fig. B), some of the highway traffic will continue to drive by the rock pile obstruction. The on-ramp traffic must then slow down to yield and merge with the highway traffic. Due to the competitive flow of highway traffic, fewer cars will be able to enter the highway from the ramp in the same time frame as when the highway was totally blocked (Fig. A) and there was no competitive flow from highway traffic.

REFERENCES


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