

Increase in Graft Blood Flow in the Early Postoperative Period

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ABSTRACT

Flow has been suitably measured by transit-time flow measurement, but measurements in the early period after cardiopulmonary bypass do not reflect expected values because of several factors. We documented that flow measurements during immediate revision of bleeding increased 3 times for the left internal thoracic artery and 2 times for the saphenous vein graft over previous measurements made after cardiopulmonary bypass in a patient who underwent coronary artery bypass surgery.

INTRODUCTION

In recent years, several studies have been published about flow measurement in coronary artery bypass grafting (CABG). Transit-time flow measurement (TTFM) has been reported as a suitable method for quick and reproducible intraoperative assessment of graft function [D'Ancona 1999; Becit 2007; Tokuda 2007]. Although many studies have validated the usefulness of TTFM, exact flow values in grafts have not been well established because graft flow is measured early. Furthermore, graft flow cannot be evaluated later by flowmeter because the chest has been closed. Graft flow measurement, however, is affected by several factors that all interact with each other. These factors include arterial pressure, coronary artery resistance, residual antegrade coronary flow, the type of graft, microvascular tonus, the lengths and diameters of the graft and the grafted coronary artery, hematocrit, temperature, anastomosis quality, and kinking and twisting of the graft. Changes in any of these parameters will affect flow measurements.

CASE REPORT

After obtaining approval from our institutional research ethics board, we routinely measured graft flows for a year after weaning a patient from cardiopulmonary bypass. We describe a 55-year-old male patient who underwent 2-vessel CABG surgery and then underwent revision for bleeding in the early postoperative period. The target vessels were the

left anterior descending (LAD) and right coronary arteries. After median sternotomy, the left internal thoracic artery (ITA) was harvested as a pedicle. A dilute papaverine solution was applied to the ITA to prevent spasm, and the conduit was wrapped with papaverine-soaked gauze until use. The flow measured in the free ITA was 120 mL/min before cardiopulmonary bypass was commenced.

The patient was transported to the intensive care unit without inotropic agent support. During the early postoperative period, the patient was hemodynamically stable, and the

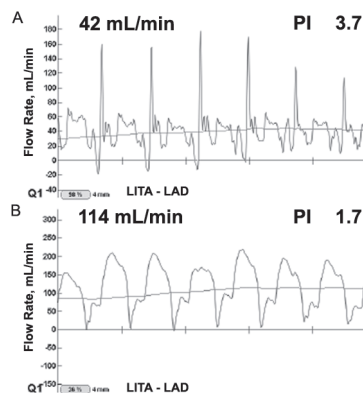


Figure 1. Flow measurements for the left internal thoracic artery (LITA) graft to the left anterior descending coronary artery (LAD). A, Early after cardiopulmonary bypass. B, During revision surgery for bleeding. PI indicates pulsatile index.

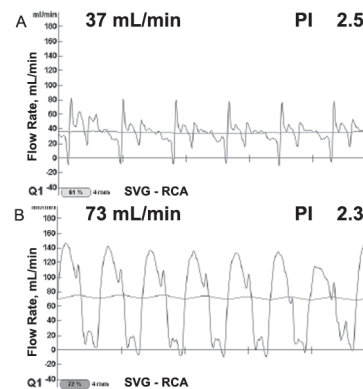


Figure 2. Flow measurements for the saphenous vein graft (SVG) to the right coronary artery (RCA). A, Early after cardiopulmonary bypass. B, During revision surgery for bleeding. PI indicates pulsatile index.

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results of a blood gas analysis were normal. After the volume of blood drainage reached 1200 mL on postoperative hour 4, we decided that the patient required reoperation for bleeding control. The patient was transported to the operation room. After preparation of the patient for surgery, the chest was reopened, and the bleeding from the chest wall from which the ITA was harvested was seen and controlled by electrocautery. The contractions of the heart muscle were excellent, and manual exploration revealed both grafts to be open. We decided to measure the flow of the grafts to determine whether their flow had changed from early after cardiopulmonary bypass to early in the postoperative period. The flows of the graft of the left ITA to the LAD artery early after cardiopulmonary bypass and in the early postoperative period were 42 mL/min (pulsatile index, 3.7) and 114 mL/min (pulsatile index, 1.7), respectively (Figure 1). The corresponding flows for the saphenous vein graft to the right coronary artery were 37 mL/min (pulsatile index, 2.5) and 73 mL/min (pulsatile index, 2.3) (Figure 2). After the patient was weaned from cardiopulmonary bypass and during the revision, a flowmeter (Medi-Stim Flowmeter; Medi-Stim, Oslo, Norway) was used for all measurements of graft flow. Arterial pressures measured early after cardiopulmonary bypass and during revision were not different. After the bleeding was controlled, the patient was taken to the intensive care unit. No problems occurred during the postoperative period, and the patient was discharged on sixth day of his hospital stay.

COMMENT

The goal of CABG is to increase perfusion pressure of the poststenotic coronary artery to increase the myocardial oxygen supply. Previous studies have reported mean perioperative flow measurements of approximately 40 mL/min [Becit 2007; Tokuda 2007]. Walpoth et al [2008] demonstrated an increase in graft flow during the postoperative period, but the methods of blood flow measurement differ intraoperatively and postoperatively, a difference that could be a source of methodologic bias. Furthermore, no studies have shown that blood flow increases in the immediate postoperative period. An increase in graft flow during the early postoperative period has not been demonstrated reliably by any measurement method. We have demonstrated that graft flow increased in the early postoperative period. Contrary to a previous study [Walpoth 2008], our findings revealed that the flow increase in the ITA graft was greater than in the saphenous vein graft. This finding may be related to changes in graft spasm as well as to coronary resistance, or it could be due to a larger myocardial perfusion territory; however, vasospasms of the ITA graft, competitive antegrade flow through the native coronary artery, and the rheology of the distal coronary artery perfusion bed could be other reasons for flow–perfusion mismatch. Vasospasms might be associated with harvesting of the ITA graft, increased neurohormonal change, or the surgery trauma itself. Because flows for both graft types increased in the immediate postoperative period, the increase in blood flow may be attributed in our case to changes in microvascular tonus and coronary resistance. Adaptation of the coronary

artery to blood flow is important, as is adaptation of the graft to the coronary artery.

Taniguchi et al [2007] recently reported that a significant pressure gradient exists through the ITA graft between early and late measurements. Therefore, a determination of whether perfusion of the LAD artery is maintained solely by the ITA graft or whether flow of the native vessel also contributes to the flow should be informative. Tokuda et al [2007] pointed out that abnormal TTFM values, because of their low predictive value, do not necessarily indicate immediate graft failure. These investigators recommended that measurements be repeated before a decision is made to revise an anastomosis. It is obvious that low flow rates will produce low perfusion pressures in the LAD artery. In our case, flow in the ITA graft increased approximately 3 times and flow in the saphenous vein graft increased 2 times over the previous measurement. This case is unique in that increases in graft flow were found fortuitously during a revision. Therefore, in the period after cardiopulmonary bypass, the lower rate of flow through the graft reflects the hydrodynamics of the graft itself, competitive antegrade flow through the proximal stenotic coronary segment, and the rheology of the perfusion bed of the distal coronary artery. Changing coronary resistance caused by changing patterns of retrograde flow and recovery from ischemia and cardioplegia may play a role in increasing graft flows. This case report reveals that blood flow through grafts increases quickly to catch up to the actual coronary blood flow.

In conclusion, we believe that measurements of graft flow have improved the knowledge of the physiological aspects of coronary surgery. Resistance seems to be the major determinant of flow alterations in vascular beds that lead to low flow values and lower perfusion pressures in the early period after cardiopulmonary bypass. Decrease in this resistance in the early postoperative period leads to increases in graft blood flow. If flow measurements are combined with measurements of coronary pressure, we believe that graft flow competition and anastomosis quality can be evaluated more precisely and reliably.

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