IMPORTANCE OF TRANSIT TIME FLOW MEASUREMENT IN CORONARY ARTERY BYPASS GRAFTING

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ABSTRACT

Objective: The aim of this study is to determine the effect and ability of detection of graft patency by intraoperative transit time flow measurement in coronary artery bypass grafting. **Methods**: A prospective study of Five hundred and seventy five patients underwent on-pump isolate coronary artery bypass grafting performed by the author between January 2009 till July 2010. transit time flow measurement was routinely performed for assessment of graft patency during operation. Interpretation of the values obtained using the transit time flow measurement determined whether or not to revise a graft. **Results**: Patency of 1868 grafts using transit time flow measurement were assessed. Revision was required for 8 grafts (0.4%) in eight patients based on unsatisfactory transit time flow measurement findings. **Conclusions**: Transit time flow measurement seems to be important in deciding whether a graft is patent or not, and it allows for improvement of surgical outcome.

Key Words: CABG • Transit time flow measurement • Graft patency

INTRODUCTION

Coronary artery bypass surgery (CABG) prolongs survival, improves quality of patients undergoing the procedure(1). Patency of the grafts directly associated with both early and late clinical results after CABG. Graft occlusion can lead to refractory angina, myocardial infarction, arrhythmias, and even mortality(2). Although it is a rare occurrence, the incidence of perioperative graft failure has been estimated to be from 5 to 10%(3).In the past intraoperative graft patency was examined by palpitation of graft pulsation, assessing hemodynamic stability and electrocardiographic changes. But this method is not accurate and objective. To directly verify the patency of anastomosis in CABG several methods have been tried among which transit time flow measurement (TTFM) has been found to be a suitable method for easy and effective intraoperative direct assessment of bypass grafts(4-7)

PATIENTS AND METHOD

Five hundred and seventy five patients undergoing on-pump isolate coronary artery bypass grafting performed by the same surgeon between January 2009 and July 2010 were included in study CABG was completed in the usual manner under general anesthesia ,through midsternotomy incision using partial cardiopulmonary bypass. The grafting material (left internal mammary artery (LIMA), saphenous vein grafts (SVG) and/or radial artery) was harvested simultaneously. Heparin was given at 3 mg/kg and the activated clotting time was kept above 450 s. All operations were performed with mildly hypothermic cardiopulmonary bypass and cross clamping. Cardiac arrest was established initially with antegrade crystalloid cardioplegia, then cooled ante-or retrograde blood cardioplegia containing potassium and finally warm blood cardioplegia were administered for myocardial protection. The distal anastomoses were performed with 7-0 polypropylene running suture. The proximal anastomoses were performed with 5-0 polypropylene running suture on a partially excluded ascending aorta. After decannulation heparin was totally reversed.

In postoperative period, fractionated heparin was administrated subcutaneously at the first postoperative day and continued until the

patient was mobilized. Low-dose aspirin treatment was started the day after surgery and continued thereafter.

Intraoperative coronary graft flow measurement:

Coronary graft flowmetry measurement started after patient came off bypass, we use inotropic agents to maintain the systolic pressure at 90–100 mmHg in patients with lower pressure. TTFM was performed for assessment of every graft after completion of anastomosis during operation by using a transit time flow meter (MediStim VQ-1101, MediStim ASA, Oslo, Norway), and all measurements were repeated before the closure of the sternum. The TTFM probe was perfectly fitted around the graft. When necessary, different probes, which fit the actual size of the vessel were used to avoid distortion or compression of the graft. The 4 -mm probe was most commonly used for vein grafts. Skeletonization of a small segment of the mammary artery was necessary to reduce the quantity of the tissue interposed between the vessel and the 2- mm probe. Flow through the whole sequential bypass and flows through the both proximal and distal segment of graft were examined. The device displays a flow curve and calculates the mean flow (ml/min), pulsatile index (PI) and diastolic filling percentage (DF%). In case of the DF < 50% and/or PI > 5 it was accepted as an indicator of poor flow. The mean flow was not solely used as an indicator of poor flow, and it was evaluated together with the other two parameters. Interpretation of the values obtained has allowed us to reach a decision whether or not to revise a graft. In case of unsatisfactory TTFM findings, the length and property of the graft was checked. It was also checked for twisting, kinking, air bubbles or spasm. If one of them was detected it was corrected. If no obvious cause was found then the graft was opened by a small incision approximately 1 cm away from the anastomosis. The patency of the anastomotic site and the distal coronary artery was checked by using a small coronary probe. In patients with a second severe lesion in distal coronary artery, a new anastomosis with another graft was performed. In patients with LIMA–LAD grafts in whom TTFM findings were unsatisfactory, patency of the LIMA was also checked by a coronary probe, and evaluation of antegrade blood flow. If a severe stenosis in the proximal segment of LIMA was detected, the LIMA was transected and then anastomosed to the aorta. All measurements were repeated before the closure of the sternum to confirm graft patency and to detect any possible new graft kinking or compression even if satisfactory TTFM findings were obtained in the last measurement.

RESULTS

The mean age of the studied group was 56(range:26-82)years, male to female ratio of 5:1 .The mean EuroScore value of patients was 4(range: 1-16). The average number of grafts per patient was 3.25(range:2-6). The most common target vessel was left anterior descending artery (LAD).

TTFM measurements were done on 1868 grafts of study group .Mean values of the PI was 2(range 1-15), the mean DF% 60(range:30-70) and mean flows in different anastomoses was 35(range :10-120) ml/min in study group before sternal closure and were documented for each case. In a total of eight grafts of eight patients in whom unsatisfactory TTFM findings were detected, revision of the anastomosis or the bypass graft was performed, and the operation was ended when a good flow was achieved. The defined reasons of the poor flow and the technical data for these eight grafts were as follows:2 due to kink in vein grafts,1 too long and another 1 too short vein grafts,1 proximal LIMA lesion,1 distal LIMA to

LAD anastomotic stenosis, and 2 distal vein graft stenosis.

The grafts were transected and shortened in the case of the graft that was too long and lengthened by a piece of vein in case of the short one, and repositioned in the correct orientation in the two that were found twisted. In two patients with LIMA–LAD grafts that were unsatisfactory TTFM findings, stenosis in proximal segment of LIMA was detected in one patient. Proximal IMAs were transected and then anastomosed to the aorta as an end-to-side fashion. In the remaining patient, the defect was in the distal anastomosis which was revised and good flow achieved. In the remaining 2 patients with disdal vein graft anastomotic stenosis ,revisin was done and excelled flow achieved. After revision, all flow values and flow patterns improved. No electrocardiographic changes were noted in those patients in whom unsatisfactory TTFM findings were noticed and the anastomoses were corrected.

The major postoperative complications, overall morbidity and mortality rates are shown in Table 4. Patients were discharged after a mean ICU stay of 1 day (range 12hrs-4days)with a mean total hospital stay of 6 days (range 5-12 days).

DISCUSSION

Coronary artery bypass surgery prolongs survival and improves quality of life (1). Despite substantial improvement in surgical technique the operative treatment of the ischemic heart disease is still only palliative. Early closure of 10–15% of saphenous vein grafts in first month, followed by another 5–10% in the next 11 months is mostly secondary to a defect in surgical technique. This could be caused by kinking of graft, linear tension due to insufficient graft length but most frequently because of failure in construction of the anastomosis itself(8).The anastomotic quality in CABG is directly associated with both early and late outcome. Graft occlusion can lead to refractory angina, myocardial infarction, arrhythmias, and even death(1-3). For this reason intraoperative verification of graft patency is of great importance.

Many techniques have been used in the past to determine graft patency intraoperatively: electromagnetic flowmeters, initially adopted in coronary surgery, have been recently replaced by ultrasonic technology (Doppler and TTFM). Using TTFM technique several groups have reported excellent results in diagnosing technical failures during CABG and resolving the problem during the same operation(9-11).D'Ancona (12) has reported that in 6–8% of all patients a technical failure can be diagnosed with TTFM and resolved during the same operation. This is of great benefit for the patient avoiding unnecessary perioperative complication.

Three important flow parameters in TTFM are flow, DF% and PI. Flow is expressed through 1-a flow curve that displays the systolic and diastolic filling of the graft through color coding (systolic: light red, diastolic: light blue), and 2- a mean flow value (ml/min). The curves should always be coupled with the electrocardiography (ECG) tracing to correctly differentiate the systolic from the diastolic flow. Mean flow is dependent on many variables including blood viscosity, the size and quality of the graft, resistance in the graft, the quality of the outflow bed, the size of the native coronary artery and spasms in arterial grafts. Absolute blood flow value is not a good indicator of the quality of the anastomosis, and must be considered together with the two other indicators and clinical findings (ECG, hemodynamic values). DF% indicates the percentage of coronary filling in diastole. By using ECG synchronization, the DF% is defined as the blood volume filling in diastole divided by the total blood volume in one heart cycle. DF% is especially important in low flow situations where the mean flow

value is less than 10 ml/min. This is because the DF% is the metabolic part of the flow, i.e., what is useful for the heart. The systolic flow on the other hand is useful for the compliance. Recent studies suggest that DF% is the most important indicator for intraoperative graft patency verification. PI, expressed as an absolute number, is a good indicator of the flow pattern and, consequently, of the quality of the anastomosis. This number is obtained by dividing the difference between the maximum and the minimum flow by the value of the mean flow. The PI is proportional to the vascular resistance. Therefore, a high PI is an indicator of poor quality of a graft or anastomosis. Clinical studies have shown that a PI < 5 indicates a well-functioning graft. D'Ancona (12) evaluated the TTFM in a large series and underlined that a meticulous and controlled method of assessing the results of intraoperative flow measurements can improve the quality of information and increase the accuracy of diagnosing technical problems with newly constructed bypass grafts. They have developed a standard algorithm for using and interpreting intraoperative TTFM. Measurements should always be done with and without proximal occlusion of the revascularized coronary artery to detect any stenosis localized at the toe of the anastomosis and to exclude flow competition from the native vessel. High level of retrograde blood flow from graft before proximal anastomosis was performed may exist in spite of stenosis at the toe of the anastomosis; in this case drastic reduction in absolute flow is observed after proximal snaring of the coronary artery. On the contrary, low flow status may be detected in perfectly patent anastomosis, whenever competition is present from less than critically stenosed coronary arteries. In these cases, after placement of proximal snare, an increase in absolute graft flow will be observed. Graft patency evaluation on the only basis of absolute flow value should be discouraged. Blood flow is directly proportional to blood pressure and inversely proportional to vascular resistance. For this reason, absolute blood flow is not a good predictor of anastomotic quality because high vascular resistances may exist in spite of fully patent anastomosis. In conclusion they agree that mean graft flow, being very dependent on the quality of the revascularized coronary artery, is not per se a good indicator of the quality of the anastomosis. On the contrary, TTFM technology may be very useful if mean flow values are interpreted together with TTFM curves, DF% and PI values .

A protocol suggested by D'Ancona et al. (12)was used to detect graft dysfunction in present study. TTFMs performed immediately after the anastomosis is completed during cardiopulmonary bypass and then several more times thereafter to detect spasm resulting from manipulation and any possible graft kinking or compression before closure of the sternum. Close monitoring of the systemic pressure is also necessary especially when arterial grafts are used. Low systemic pressure and manipulation can cause spasm of the graft resulting in decreased absolute flow. We use inotropic agents to maintain the systolic pressure at 90–100 mmHg in patients with lower pressure. The size of probe used to measure flow is important. Only good contact with flow probe can guarantee an accurate measurement. For this reason, selection of correct probe size is mandatory. The importance of TTFM for evaluating coronary artery bypass grafts lies in the interpretation of the data. Therefore, we measured simultaneously flow curves, PI, DF % and mean flow values to correctly interpret TTFM findings in our study, which is crucial to reduce the number of undetected technical errors.

Transit time flow measurement given important and accurate intraoperative information about the status and patency of coronary grafts. It enables technical problems such as kinked, twisted, or stenotic grafts to be diagnosed accurately, thereby allowing prompt revision of the constructed grafts before the patient leaves the operating theater.

In conclusion we strongly believe that a meticulous operative technique should be supported with intraoperative TTFM in completed bypass grafts. Detection of graft dysfunction intraoperatively by TTFM improves the surgical results.

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