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Transit Time Flow Measurements in Coronary Surgery: The Experience From a New Center in Bosnia

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ABSTRACT

Background: A new cardiovascular center in Tuzla, Bosnia & Herzegovina was opened for cardiac procedures in September 1998. In the first three years of operation, a total of 440 coronary artery bypass grafting (CABG) procedures were performed there. Off-pump coronary artery bypass (OPCAB) was emphasized as the main tool for surgical revascularization. Transit time flow measurement (TTFM) was used routinely to check graft patency. The purpose of this paper is to report on flowmetry results in the Tuzla CABG population.

Methods: All patients were considered candidates for both on-pump (ONCAB) and off-pump (OPCAB) CABG procedures. Approximately 60% of the procedures were performed as ONCAB and the rest as OPCAB. For all patients, TTFM was performed on all grafts.

Results: Eighteen patients were converted from OPCAB to ONCAB. Revision was required for 1.8% of the grafts. All grafts were successfully revised and were patent at the time of wound closure.

Conclusion: We believe that TTFM is a crucial tool in CABG. It offers a reliable and inexpensive tool for quality assurance in coronary revascularization.

INTRODUCTION

The Cardiovascular Center in Tuzla was opened for cardiac surgery in September 1998. All members of the surgical team had been trained in cooperation with the Center for Minimally Invasive Cardiac Surgery of Kaleida Health, Buffalo, New York.

Off-pump coronary artery bypass (OPCAB) was emphasized as the main tool for surgical revascularization. As in Buffalo, transit time flow measurement (TTFM) was used routinely [D'Ancona 1999] to check graft patency and has been used in all coronary artery bypass grafting (CABG) cases done to date. The purpose of this paper is to report on flowmetry results in the Tuzla CABG population.

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MATERIALS AND METHODS

During the initial three months, all operations were performed under the supervision of surgeons from the United States; afterwards, the majority of operations were done by the independent Bosnian team. All patients were considered OPCAB candidates, but more than half of the operations were done as ONCAB. In a few cases, patients were converted from OPCAB to ONCAB due to hemodynamic instability [Soltoski 1998], but in the majority of cases ONCAB was chosen in order to provide perfusionist experience with cardiopulmonary bypass (CPB) and cardioplegia because the Center did not otherwise have a sufficient number of cases requiring CPB to provide this experience.

ONCAB was performed with normothermic or mildly hypothermic CPB. Cold antegrade and sometimes retrograde cardioplegia was used. Distal anastomoses were generally done first.

OPCAB was performed with median sternotomy except for a small number of MIDCAB procedures. Pressure stabilization was used for all OPCAB cases [Bergsland 1998]. For multivessel CABG, the so called "Lima" stitch (described by Dr. Ricardo Lima, Recife, Brazil) was used to expose all distal targets [Karamanoukian 1999]. The first graft was almost always the left internal mammary graft to the left anterior descending artery (LAD), followed by other vein grafts. In young patients, bilateral internal mammary artery grafts were frequently performed. Heparin was given to keep the activated clotting time above 300 seconds.

TTFM Procedure and Revision of Grafts

TTFM was performed as described below. The criteria established by the Buffalo group [Bergsland 2000] were used. Criteria for good grafts were: high mean flow, diastolic flow pattern, low pulsatile index, and absence of systolic spikes. Criteria for bad grafts were: low mean flow, systolic flow pattern, high pulsatile index, and systolic spikes. In cases of poor flow and unfavorable TTFM parameters, the graft was checked for proper length, twisting, and the presence of air bubbles or spasm, which are frequent reversible causes for

Table 1. Patient demographic data.

	ONCAB	OPCAB
No. of patients	271 (61.59%)	169 (38.40%)
Gender		
Male	236 (87.08%)	138 (81.65%)
Female	35 (12.91%)	31 (18.34%)
Age		
Average	55.30	55.98
Maximum	73	80
Minimum	34	37
Ejection fraction		
Average	52.46%	52.65%
Maximum	70%	70%
Minimum	20%	12%

poor TTFM parameters. When no reversible cause of poor TTFM results was identified, the graft was revised [D'Ancona 2000a]. The conduit was always amputated above the anastomosis, which was inspected to identify the cause of malfunction [Walpoth 1998].

ONCAB: All grafts were checked while the patient was still on CPB and after weaning from CPB prior to decannulation. In case of malfunctioning grafts, the patient was placed back on CPB and the grafts were revised with or without new cardioplegic arrest. TTFM was then performed again until satisfactory flows were obtained.

OPCAB: TTFM was performed after the completion of each graft. Grafts were revised if necessary before embarking on additional grafts. TTFM was again performed after administration of protamine. Measurements were generally performed with and without a proximal obstructive snare on the native vessel to test for distal patency. This technique was not generally used for ONCAB operations.

RESULTS

At our Center, 440 patients underwent CABG between September 1998 and September 2001. Basic demographic data and risk factors of patients are shown in Table 1 (◎).

Table 2. Preoperative risk factors.

Risk factors	ONCAB	OPCAB
Hypertension	152 (56.08%)	85 (50.29%)
Smoking	189 (69.74%)	125 (73.96%)
Diabetes	53 (19.55%)	19 (11.24%
Previous MI	152 (56.08%)	103 (60.94%)
COPD	10 (3.69%)	4 (2.36%)
Renal failure	8 (3.32%)	9 (5.32%)
Liver failure	8 (2.95%)	8 (4.73%)
Stroke	10(3.69%)	8 (4.73 %)
Previous heart surgery	1 (0.36 %)	8 (4.73%)

MI = myocardial infarction, COPD = chronic obstructive pulmonary disease

Table 3. Number of grafts.

No. of grafts	ONCAB	OPCAB
1	3	68
2	64	75
3	138	21
4	63	3
5	3	2
Grafts per patient	2.99	1.79

Preoperative risk factors are shown in Table 2 (◎). Hypertension, smoking, diabetes, and previous myocardial infarction were common and similar in incidence and extent in both groups.

The number of grafts per patient was higher in the ONCAB group (2.99) versus the OPCAB group (1.79) (see Table 3 ◎). This was obviously anticipated from the selection criteria.

CPB was used only three times in single bypass operations. In two of these, conversion to CPB was performed because of hemodynamic instability. In two cases, five bypass grafts were created without the use of CPB, confirming the feasibility of achieving complete revascularization without CPB.

The most common target vessel in both groups was the LAD. In the OPCAB group, the LAD bypass graft was performed in every case except one. See Table 4 (◎).

The major postoperative complications are shown in Table 5 (◎). The ONCAB patients had major complications more frequently (8.11%) than the OPCAB group (5.32%). The most common complication requiring reoperation was bleeding, which occurred in 3.69% of the ONCAB group and 2.95% of the OPCAB group. Postoperative stroke was seen in five ONCAB patients (1.84%) and in one OPCAB patient (0.59%).

Overall complications and mortality are summarized in Table 6 (◎). There were no deaths in the OPCAB group, while in the ONCAB group eight deaths (2.95%) were registered. There were no deaths among the 18 patients converted to CPB. Overall mortality was 1.81%.

The number of patients with revision and revised grafts is shown in Table 7 (◎). In both groups, grafts to the LAD and to the diagonal artery were the most often revised. There were no revisions in the OPCAB group for the Cx or RCA

Table 4. Coronary target vessel

Target vessel	ONCAB	OPCAB
LAD	259 (31.89%)	168 (55.44%)
Diagonal	112 (13.79%)	41 (13.53%)
Cx system	247 (30.41%)	27 (08.91%)
RCA system	194 (23.89%)	67 (22.11%)
Total distal anastomosis	812 (100%)	303 (100%)

LAD = left anterior descending artery, Cx system = circumflex system, RCA system = right coronary artery system

Table 5. Postoperative morbidity.

	ONCAB	OPCAB
Reoperation for bleeding	10 (3.69%)	5 (2.95%)
Stroke	5 (1.84%)	1 (0.59%)
Deep sternal infection	2 (0.72%)	1 (0.59%)
Thrombosis of graft	1 (0.36%)	1 (0.59%)
GI bleeding	0 (0.00%)	1 (0.59%)
IABP	4 (1.47%)	0 (0.00%)
Overall morbidity	22 (8.11%)	9 (5.32%)

IABP = intraaortic balloon pump

system. The percentage of revised grafts was higher in the OPCAB group (2.64% versus 1.60%), as shown in Table 8 (◎).

The most frequent surgeon-related cause of graft revision was a compression stitch (19.04%) (Table 9a, ◎). A compression stitch is a stitch with at least one large bite compressing the native vessel. Among other more frequent causes of graft revision were an intimal flap (23.80%) and a poor native vessel (14.23%). The number of other causes of graft revision was 14, which amounted to 66.66% of the total number of revised grafts (Table 9b, ◎).

DISCUSSION

When the Tuzla Cardiovascular Clinic opened for cardiac surgical procedures in 1998, it was our intention to perform OPCAB as much as possible for patients requiring CABG. We believed that OPCAB was preferable from a quality perspective and that cost-saving considerations were also important in a country emerging from war. OPCAB was considered a good alternative. The whole surgical team was therefore trained extensively in OPCAB techniques. It was considered essential, starting from the first case, to use TTFM as a graft verification tool. Previously developed criteria were used to establish indications for graft revision [Jaber 1998]. As reported in previous experiences, there were a significant number of graft revisions, although the percentage of grafts requiring revision was lower than that reported from the training institution in Buffalo. Approximately five percent of the Tuzla patients needed graft revision, while in the early experience from Buffalo the percentage of revised patients approached ten percent [D'Ancona 2000b]. We believe the lower percentage for the Tuzla team reflects the fact that they began the OPCAB procedure further along the learning curve because of their education in Buffalo. Also, OPCAB technology, particularly for stabilizers, has improved significantly in recent years. Finally, the protocol for OPCAB in Tuzla includes preoperative use of platelet active (CORRECT) drugs, which were not used in the early experience in Buffalo.

As expected, there were more grafts revised in the OPCAB group than the ONCAB group, probably reflecting the greater technical challenge of OPCAB surgery. The difference was not significant however, and it must be mentioned that OPCAB patients had a more stringent TTFM protocol, including the use of proximal snaring, a procedure that will detect problems at the toe of the anastomosis. Proximal snaring is not used in ONCAB, and the technical problems may therefore be underestimated in ONCAB patients.

All revisions in the OPCAB group occurred in anterior vessels. The posterior vessels, which are supposed to be technically more challenging in OPCAB, did not require revision. Even in the ONCAB group the revision rates were higher in the anterior vessels. This may be due in part to the surgeon's reluctance to avoid a very poor distal target anteriorly and the easier decision to avoid grafting off a poor Cx or RCA branch.

The mortality and morbidity rates in both ONCAB and OPCAB patients were acceptable, although the OPCAB results were significantly better perioperatively. The perioperative infarction rate was also low, which is one indicator of the absence of graft problems. We have had very few reinterventions in this group of patients, although no routine postoperative angiography has been possible.

CONCLUSION

Transit time flow measurement is a highly specific tool for the diagnosis of high grade or total graft occlusion. We

Table 6. Overall results.

	ONCAB	OPCAB
No complications	241 (88.92%)	160 (94.67%)
Morbidity	22 (8.11%)	9 (5.32%)
Mortality	8 (2.95%)	0 (0.00%)

Table 7. Total number of patients with revision and revised grafts.

	No.	%
Number of patients	440	
Total number of grafts	1115	2.53 per patient
Total number of patients with revision	19	4.31%
Total number of patients revised successfully	19	4.31%
Total number of revised grafts	21	1.88%
Total number successfully graft revision	21	1.88%

Table 8. Revised grafts.

Revised grafts	ONCAB	OPCAB
LAD	7 (2.70%)	7 (4.16%)
Diagonal	2 (1.78%)	1 (2.43%)
Cx system	2 (0.80%)	0 (0.00%)
RCA system	2 (1.03%)	0 (0.00%)
Total revised grafts	13 (1.60%)	8 (2.64%)

LAD = left anterior descending artery, Cx system = circumflex system, RCA system = right coronary artery system

Table 9a. Surgeon-related causes of graft revision.

Cause of revision	No. of revisions	%
Compression stitch	4	19.04
Graft twist	1	5.26
Graft kink	1	5.26
Graft too short	1	5.26
Total	7	33.33

Table 9b. Other causes of graft revision.

Cause of revision	No. of revisions	%
Graft flap	5	23.80
Poor native vessel	3	14.28
Graft dissection	2	9.52
Graft occlusion	2	9.52
Other	2	9.52
Total	14	66.66

believe that TTFM is essential for the comprehensive performance of CABG procedures.

REFERENCES

1. Bergsland J, Schmid S, Yanulevish J, et al. Coronary artery bypass grafting (CABG) without cardiopulmonary bypass (CPB): a strategy for improving results in surgical revascularization. Heart Surg Forum 1998-1593, 1(2):107-10, 1998.
2. Bergsland J, D'Ancona G, Karamanoukian H, et al. Technical tips and pitfalls in OPCAB surgery: the Buffalo experience. Heart Surg Forum 2000-7789, 3(3):189-93, 2000.
3. D'Ancona G, Karamanoukian HL, Salerno TA, et al. Flow measurement in coronary surgery. Heart Surg Forum 1999-03815, 2(2):121-4, 1999.
4. D'Ancona G, Karamanoukian HL, Ricci M, et al. Graft revision after transit time flow measurement in off-pump coronary artery bypass grafting. Eur J Cardiothorac Surg 17:287-93, 2000.
5. D'Ancona G, Karamanoukian HL, Ricci M, et al. Intraoperative graft verification: Should you trust your fingerprints? Heart Surg Forum 3(3):189-93, 2000.
6. Jaber SF, Koenig SC, BhaskerRao B, et al. Role of graft flow measurement technique in anastomotic quality assessment in minimally invasive CABG. Ann Thorac Surg 66:1087-92, 1998.
7. Karamanoukian H, Bergsland J, Salerno T. Single suture techniques to help expose the heart for complete revascularization without cardiopulmonary bypass. Ann Thorac Surg 68:1428-30, 1999.
8. Soltoski P, Salerno T, Levinski L, et al. Conversion to cardiopulmonary bypass in off-pump coronary artery bypass grafting: Its effect on outcome. J Card Surg 13(5):328-34, 1998.
9. Walpoth BH, Bosshard A, Genyk I, et al. Transit time flow measurement for detection of early graft failure during myocardial revascularization. Ann Thorac Surg 66:1097-1100, 1998.