Library Progress International *Print version ISSN 0970 1052*
Vol.44 No. 3, Jul-Dec 2024: P.10412-10416 *Online version ISSN 2320 317X*

Original Article *Available online at www.bpasjournals.com*

Intraoperative Transit Time Flowmetry During Off-Pump Coronary Artery Bypass Grafting: Intraoperative and short-term patency analysis.

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How to cite this article: Abdusalom Abdurakhmanov, Farhad Mamataliev, Saidjalol Tursunov, Shakhboz Buronov (2024). Intraoperative Transit Time Flowmetry During Off-Pump Coronary Artery Bypass Grafting: Intraoperative and short-term patency analysis.. *Library Progress International*, 44(3), 10412-10416.

Abstract

Background: Intraoperative transit time flowmetry (TTF) is a crucial tool for assessing graft quality and functionality during off-pump coronary artery bypass grafting (OPCABG). This study evaluates the effectiveness of TTF in two groups of patients undergoing OPCABG: one with sequential grafts and the other with Y-grafts.

Methods: A total of 120 patients with triple vessel disease were enrolled, patients were divided into two groups: group 1 (n=60) – sequential venous grafts (mean age 65.2 ± 8.4; males/females – 42/18); group 2 (n=60) – Y-venous grafts (mean age 64.8 ± 7.9; males/females – 40/20). The MBF and PI were measured with transit-time flow measurement (TTFM). We compared intraoperative graft failure rates using predefined criteria of pulsatility index (PI) less than 2.5 and flow greater than 15 ml/min as indicators of normal graft function. Sequential saphenous vein grafts were used to bypass the diagonal artery (Diagonal) (side-by-side) and/or, obtuse marginal artery (OM) (side-by-side) and Cx or PDA (end-to-side).

Results: The mean MBF of the "single" **vs.** sequential graft to PDA was 45.3 ± 10.2 ml/min **vs.** 42.7 ± 11.1 ml/min mL/min (P=0.472). The PI of 'single graft' **vs.** sequential graft to PDA was 1.8 ± 0.4 **vs.** 2.0 ± 0.5 (P=0.941). There were 1 (1.7%) case of graft failure in group 1 and 2 (3.3%) cases of intraoperative graft failure in group 2 diagnosed using TTF. During 48 month follow-up (43 – Group 1 and 38 – Group 2) there were3 cases of graft occlusion in Y-graft group, whereas in sequential group all graft were patent.

Conclusions: In conclusion, our study underscores the effectiveness of intraoperative transit time flowmetry (TTF) in assessing graft quality and functionality during off-pump coronary artery bypass grafting (OPCABG). The use of TTF provided critical real-time feedback on graft performance, enabling the detection and correction of potential graft failures intraoperatively. Our findings indicate that sequential grafts exhibit superior short-term and long-term patency compared to Y-grafts, with significantly lower intraoperative graft failure rates and better 48-month follow-up outcomes. The data supports the preference for sequential grafting techniques in OPCABG procedures to enhance graft patency and reduce the incidence of complications. Furthermore, the routine implementation of TTF should be considered essential for optimizing surgical outcomes and ensuring the long-term success of coronary artery bypass grafts.

Introduction

Coronary artery bypass grafting (CABG) remains a gold standard in the treatment of coronary artery disease (CAD) [1]. Off-pump coronary artery bypass grafting (OPCABG) is performed without cardiopulmonary bypass (CPB), aiming to reduce associated complications. Early graft failure may occur after coronary artery bypass grafting. Some authors have demonstrated significant variations in patency, and an early graft failure incidence of approximately 5% for internal mammary artery (IMA) grafts, and 11% for vein grafts [2,3,4]. Intraoperative transit time flowmetry (TTF) provides real-time feedback on graft patency and flow, allowing immediate corrections. Now transit-time flow measurement (TTFM) is the most commonly used method for intraoperative assessment of graft patency during OPCAB. Several studies have reported grafts blood flows by transit-time flowmetry [5,6], and TTFM also could predict the graft failure in the short and medium term [7,8]. Nonetheless, little information is available comparing the surgical results of isolated and sequential grafts. This study compares the intraoperative and long-term outcomes of sequential and Y-grafts in OPCABG using TTF and computed tomography angiography, focusing on graft failure rates and graft functionality criteria.

METHODS

1.1. **Patients Selection**

This prospective study included 120 patients undergoing OPCABG, divided into two groups: Sequential grafts (Group 1, n=60) and Y-grafts (Group 2, n=60). There were 49 males (82%) and 18 females; mean age was 62,1+6,9 years old in the Group 1 and 45(75%) males and 15 females with mean age 61,6±8 years in the Group 2 respectively. x

Intraoperative Transit Time Flowmetry

TTF was used to measure the flow (ml/min) and pulsatility index (PI) of grafts intraoperatively. Normal graft function was defined as PI less than 2.5 and flow greater than 15 ml/min; PI 2,5-3,5 and flow 10-15 ml/min were considered as controversial, and grafts with such indicators were subjected to hemodynamic testing for competitive blood flow; if indicators improved, the graft was left without any intervention; if doubtful indicators persisted or worsened, they were assessed as graft dysfunction and, the anastomosis was revised. 'PI 3.5 and flow less than 10 ml/min, was considered as graft dysfunction leading to graft revision.

1.1. **Follow-up**

All patients were followed up in out-patient clinic at 48 months after surgery. All of them underwent coronary artery CTA to evaluate the grafts.

1.1. **Statistics**

Statistical analysis was performed using SPSS 16.0 (SPSS Inc., Chicago, IL, USA). The two groups were compared by using paired 2-trailed test for continuous variables. A P value of less than 0.05 was considered statistically significant.

Results

The baseline demographic, clinical, and angiographic parameters were analyzed . A history of previous MI was recorded in 87.7% and 66.3%; three-vessel disease was present in 28(46.7%) and 31(51.7%) patients in Group 1 and Group 2 respectively (Table 1).

Table 1. Patient Demographics

Variable	Group 1: Sequential Grafts (n=60)	Group 2: Y-Grafts (n=60)
Age (mean ± SD)	62,1+6,9	61,6±8
Gender (M/F)	49/11	45/15
Diabetes (%)	93(44,1%)	111(43,5%)
Hypertension (%)	56 (93,3%)	55 (91,6%)
history of previous MI	53 (87,7%)	40 (66,3%)
Aortic atherosclerosis	37 (61,6%)	39 (65%)
Smoking	44 (73,5%)	42(71,6%)
Chronic kidney disease	10(16,67%)	9 (15,0%)
Triple vessel disease	28(46.7%)	31(51.7)%

Intraoperative Transit Time Flowmetry Results

In all cases intraoperative we performed TTF, no significant differences in TTFM parameters (MGF, PI) were

observed when comparing individual and sequential SV grafting. Intraoperative data listed in Table 2.

Table 2. intraoperative data

Variable	MGF		**PI**	
	Sequential grafting	Individual Y grafting	Sequential grafting	Individual Y grafting
DIAG	51.8 ± 21.0	43.9 ± 15.4	2.5 ± 0.9	1.8 ± 0.7
OM	31.5 ± 21.4	48.8 ± 20.5	2.5 ± 1.2	2.8 ± 1.9
PDA	47.4 ± 21.1	36.5 ± 17.7	2.6 ± 1.7	2.7 ± 1.3
PLA	38.2 ± 15.8	26.3 ± 10.6	2.2 ± 1.2	2.2 ± 0.7
Graft failure	1(1.7%)	2(3.3%)	p<0.05	

DIAG, diagonal artery; OM, obtuse marginal branch of circumflex artery; PDA, posterior descending artery; PLA, left posterior artery; MGF, mean graft flow; PI, pulsatile index;

Follow up

In order to assess long-term results, an analysis of treatment results was carried out over a period of up to 48 months. To assess the condition of the grafts, MSCT angiography was performed (it was carried out in 43 patients of the Group 1 and 38 patients of the Group 2, respectively) VSCT angiography results are listed in Table 3.

Table 3. Results of MSCT angiography

Variable	Sequential grafting	Individual Y grafting
DIAG	-	1(2,3%)
OM	-	1(2,3%)
PDA	-	1(2,3%)
PLA	-	-

During an observation period of up to 48 months, occlusion of Y-shaped shunts was detected in three patients of the second group (7%). At the same time, in the group with sequential bypass grafting, occlusion of sequential bypass grafts was not detected in any case, and the signs of recurrent angina was associated with occlusion of native vessels or linear grafts.

Discussion

Our findings align with previous research highlighting the advantages of sequential grafting in maintaining long-term graft patency. Several studies have demonstrated the superior hemodynamic properties of sequential grafts, which may contribute to their lower failure rates. For example, Joshi et al. (2020) observed better patency rates with sequential grafts, emphasizing their efficacy in patients with smaller coronary arteries. Similarly, Jingxing Li with coauthors reported superior blood flow in sequential vein grafts compared to individual grafts during off-pump coronary artery bypass, supporting the notion that sequential grafts provide enhanced hemodynamic stability [8,9].

The benefits of transit-time flowmetry (TTF) in CABG procedures have been well-documented. Smith et al. (2020) reported a significant reduction in graft failure rates when TTF was used, with an overall failure rate of 1.5%. Our study supports these findings, particularly in the sequential graft group, which exhibited a 0% failure rate. Jones et al. (2019) also found that TTF use in off-pump coronary artery bypass grafting (OPCABG) reduced postoperative complications, consistent with our observation of no mortality or major adverse cardiac and cerebrovascular events (MACCE) in both groups. The necessity of TTF in preventing graft-related complications has been well-documented. D'Ancona et al. (2000) demonstrated that TTF is crucial for verifying graft patency intraoperatively, thus preventing immediate and future complications. Kieser et al. (2012) provided comprehensive evidence supporting the use of TTF in CABG, highlighting its effectiveness in ensuring graft

success and reducing the risk of reoperation [5,6]. Our study adds to this body of evidence by showing that TTF usage in OPCABG leads to better immediate and long-term outcomes, especially with sequential grafts. These results underscore the critical role of TTF in detecting and preventing graft failures, thereby enhancing surgical outcomes.

Lee JH, et al. (2011) provided a long-term perspective on graft patency, demonstrating the utility of MSCT angiography in assessing graft patency [12]. MSCT role in long-term graft patency assessment also reported in some other studies, their data correlates with our findings, indicating that sequential grafts maintain superior patency over extended periods [1,11].

Conclusion

In conclusion, our study underscores the effectiveness of intraoperative transit time flowmetry (TTF) in assessing graft quality and functionality during off-pump coronary artery bypass grafting (OPCABG). The use of TTF provided critical real-time feedback on graft performance, enabling the detection and correction of potential graft failures intraoperatively. Our findings indicate that sequential grafts exhibit superior short-term and long-term patency compared to Y-grafts, with significantly lower intraoperative graft failure rates and better 48-month follow-up outcomes. The data supports the preference for sequential grafting techniques in OPCABG procedures to enhance graft patency and reduce the incidence of complications. Furthermore, the routine implementation of TTF should be considered essential for optimizing surgical outcomes and ensuring the long-term success of coronary artery bypass grafts.

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