

# FREE FLOW CAPACITY OF INTERNAL THORACIC ARTERY GRAFTS AFTER SODIUM NITROPRUSSIDE INJECTION TO THE PEDICLE

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## ABSTRACT

**Objective:** The internal thoracic artery (ITA) is currently the preferred conduit for myocardial revascularization; however, perioperative vasospasm of the ITA may cause morbidity. Pedicle preparation and pharmacological vasodilatory treatment vary greatly. This clinical study was performed in order to define the effectiveness of two different applications of sodium nitroprusside as vasodilating agent.

**Methods:** Eighty-six consecutive patients whose left ITA was mobilized only by one surgeon for elective coronary artery bypass graft operations were randomly divided into two groups. The ITA was allowed to bleed freely, and the flow was determined (flow 1) in group I (n=42) 3 mg sodium nitroprusside in 10 ml of 5% dextrose solution was sprayed with pressure on the pedicle with a thin 25 gauge needle. In group II (n=44) half of the solution was sprayed in the same manner, and the other half of the solution was injected into the pedicle in the periarterial tissue along the length of the pedicle. Free flows of the ITA were registered before cardiopulmonary bypass (flow 2) and also just prior to performing ITA anastomosis to the left anterior descending artery (flow 3). With each

measurement hemodynamic parameters and the time between measurements were recorded.

**Results:** No statistically significant differences were found between the groups in respect to sex ratio, age, body surface area, heart rate 1 and 2, mean arterial pressure 1 and 3. There was no significant difference in the initial flow among groups. Significant differences were noted in the second flow measurement ( $p<0.05$ ) and in the third flow measurement ( $p<0.01$ ) between two groups. For each group there was a significant increase in flow from flow 1 to flow 2 and from flow 2 to flow 3 ( $p<0.02$ ).

**Conclusion:** Sodium nitroprusside injection to the pedicle provides a better flow than simple spraying of the same agent.

**Key Words:** Sodium nitroprusside, Internal thoracic artery, Vasospasm, Vasodilatation.

## INTRODUCTION

Internal thoracic artery (ITA) has become the conduit of choice for bypass grafting of the left anterior descending artery (LAD). The use of an ITA graft to the LAD has been associated with

longer survival and better quality of life (1,2). Nevertheless, perioperative spasm of the ITA graft has been reported to cause perioperative morbidity (3-5). To avoid spasm of the artery, and increases in its diameter and flow, various methods and vasodilators have been used either intraluminally or by topical application by different surgeons (6-11). Sodium nitroprusside is one of these agents and has been routinely used in our clinic since 1997. This study was designed to determine the effectiveness of two different applications of sodium nitroprusside on the flow of the ITA pedicle.

## **MATERIALS AND METHODS**

We studied 86 consecutive patients whose left ITA was mobilized for elective coronary artery bypass graft operations in a three month period following July 1999. Patients who were in hemodynamically unstable condition or showed evidence of ischemia during the operation, before cardiopulmonary bypass, were excluded from the study. Also systemic vasopressors or vasodilators were not used. The ITA was harvested by low energy electrocautery and ligaclips with a wide pedicle (at least 2 cm) from the subclavian vein proximally, to the bifurcation distally only by the same surgeon. The patient was full dose heparinized and activated clotting time (ACT) was over 300 seconds before transection of the ITA. The ITA was transected about 1 cm prior to the bifurcation and the first flow measurement was taken. Following transection the ITA was allowed to bleed freely for 60 seconds, then the blood volume was collected for one minute in a scaled container (flow 1). At the same time the heart rate (HR1), mean arterial pressure (MAP1) and the time of the measurement were also recorded. Then the tip of the artery was occluded with a ligaclip, and the artery was laid on a moist swab without twists and the nonfacial surface anteriorly.

The vasodilatory solution was prepared as 3 mg sodium nitroprusside in 10 ml of 5% dextrose solution and kept between the folds of a sterile dressing to avoid light. After the first measurement the patients were randomly allocated in one of the groups. In group I (n=42) all of the vasodilatory solution was sprayed with pressure on the pedicle from approximately 10

cm with a thin 25 gauge needle. In group II (n=44) half of the solution was sprayed in the same manner, and the other half of the solution was injected into the pedicle in the periarterial tissue along the length of the pedicle. Then the pedicle was wrapped with the soaked swab and positioned beneath the left sternal edge, and was left undisturbed until the second measurement time just before the establishment of cardiopulmonary bypass. Any clinical evidence of hypovolemia after the application of vasodilatory solution was noted. Before the second measurement the end of the ITA was trimmed to remove the part that was occluded by the ligaclip. Before cardiopulmonary bypass the flows were remeasured (flow 2). The time between the two flow measurements (time 1), and hemodynamic parameters (HR 2, MAP 2) were also recorded. Following the measurement, the tip of the ITA was again occluded with a ligaclip until the third measurement. The third flow measurement (flow 3) was also determined just before the LAD anastomosis during the cardiopulmonary bypass in the same fashion as flow 1 and 2. The time between the two flow measurements (time 2), and hemodynamic parameters (HR 3, MAP 2) were also recorded.

Grouped data are expressed as mean and standard deviation. Comparison of the parameters between groups was performed using unpaired t-test, and within each group by paired t-test,  $p < 0.05$  was expressed as significant.

## **RESULTS**

The demographic and hemodynamic data of the each group are shown in Table I. There were no significant changes with respect to sex ratio, age, body surface area, heart rate 1 and 2, mean arterial pressure 1 and 3 between the two groups (Table I). Group 2 had significantly lower mean arterial pressure (MAP 2) than group 1 ( $p < 0.02$ ) during the second flow measurement. But none of the patients developed clinical hypotension after the injection of vasodilatory solution. There were significant differences between the first and second heart rates in each group ( $p < 0.02$ ).

Flow measurements of the two groups are shown in Table II. The time 1 and 2, among three

**Table I.** Patients' clinical characteristics and hemodynamic data

	Group I (Sodium nitroprusside sprayed)	Group II (Sodium nitroprusside injection)
Male/female	37/7	36/6
Age (year)	55.2 ± 8.25	58.8 ± 8.6
BSA (m <sup>2</sup> )	1.85 ± 0.15	1.85 ± 0.13
Time 1 (min)	18.5 ± 4.1	18.8 ± 3.9
Time 2 (min)	24.4 ± 13.8	25.6 ± 12.9
HR 1	63.9 ± 18.2	69.2 ± 11.5
HR 2	80.9 ± 22.4	84.0 ± 17.5
MAP 1	73.1 ± 10.8	70.9 ± 9.9
MAP 2	68.2 ± 13.6	61.9 ± 10.1
MAP 3	68.6 ± 15.5	69.5 ± 13.3

BSA: Body surface area; HR: Heart rate; MAP: Mean arterial pressure  
Time 1: between the first and second flows  
Time 2: between second and third flows

measurements did not display significant differences within each group. Also there was no significant difference in the initial flow among groups. Significant differences were noted in the second flow measurement ( $p < 0.05$ ) and in the third flow measurement ( $p < 0.01$ ) between the two groups. For each group there was a significant increase in flow from flow 1 to flow 2 and from flow 2 to flow 3 ( $p < 0.02$ ). During the study, no episodes of clinically apparent ITA spasm were noted.

**Table II.** Flow rates before and after application of topical vasodilators.

	Group I (Sodium nitroprusside sprayed)	Group II (Sodium nitroprusside injection)
Flow 1 (ml/min)	21.6 ± 18.0	19.6 ± 17.2
Flow 2 (ml/min)	56.3 ± 31.3	71.7 ± 37.6
Flow 3 (ml/min)	70.4 ± 36.1	107.6 ± 60.1

## DISCUSSION

Anatomic studies of the ITA show that the proximal part of the ITA is a musculoelastic artery, the middle portion an elastic artery, and the distal segment a musculoelastic artery again (12). Physiologic studies of the ITA show the distal segment of the artery to have a highly sensitive vasoconstrictive response (13). If the

distal third of the ITA could be resected, there would be less tendency for the ITA spasm, but of course this is not possible in most of the cases. Previous observations show that the ITA spasm occurs during preparation, especially on the last third of the ITA (9,10,13). Various topical vasodilators have been studied to avoid the spasm of the ITA, and sodium nitroprusside is one of these agents.

Following a clinical study, we have been using sodium nitroprusside as described in group I for topical vasodilator since 1997 (11). Cooper and colleagues have shown that sodium nitroprusside is the most potent vasodilator among nifedipine, glyceryl trinitrate and papaverine (8). The concentration used in this study was then criticized by Sasson and associates (9) and also by Tatar and associates (14) in that clinically important bouts of hypotension were encountered. Before using routinely, we also tried different concentrations of sodium nitroprusside and at last agreed on 3 mg in 10 cc, which did not cause clinically important hypotension but provided a better result than papaverine.

In the preparation period of our study, we noted bouts of hypotension when we injected all of the vasodilatory solution (3 mg sodium nitroprusside in 10 cc 5% dextrose) into the pedicle. We then decided to inject half of the solution into the pedicle and spray the other half over the pedicle, in this manner there was a slight decrease in systemic pressure but no clinically important bout of hypotension was noted. In the study, second mean arterial pressure measurements (MAP 2) of the two groups showed significant difference, and an insignificant increase in the heart rate accompanied at the same time, but the lowest mean arterial pressure was 49 mm Hg in group 2. This was a tolerable result, so none of the patients were excluded from the study.

In a recent paper, Nili and associates (15) report that there is no statistically significant difference between papaverine, nitroglycerin, verapamil, nitroprusside and normal saline on ITA flow, but the free flow of the ITA increased significantly with time. A similar result was also noted by Sasson and associates (9), the distal segment of the ITA was resected, no influence of topical vasodilators on the ITA flow was noted. Perhaps



the ITA spasm spontaneously abates after a period of time, but the effect of topical vasodilators on the last third of the ITA cannot be excluded. Often however, it is not possible to resect this much of the ITA, and it seems prudent to use some technique to maximize the free flow which will not jeopardize the artery.

Several other procedures to improve the flow of the ITA have been suggested. Probing (16) or hydrostatic dilatation with intraluminal diluted papaverine injection (6) are methods used to maximize the flow of the ITA. Although adequate blood flow can be obtained with each of these methods, even a relatively low force can cause considerable damage to the intima and the internal elastic lamina, primarily in the muscular segment of the artery (17). Endothelial and medial damage is known to be associated with increased platelet and leukocyte adhesion and with increased early graft thrombosis (18). Probing of the ITA causes endothelial cell loss and impairs vasodilatation resulting from prostacyclin and endothelium derived relaxing factor besides high incidence of intimal dissection (19).

Usage of a topical vasodilator for the ITA pedicle is in our opinion an appropriate technique rather than probing or hydrostatic dilatation with intraluminal injection to increase ITA flow. In the present study, we tried an alternative application of sodium nitroprusside which is our drug of choice for topical vasodilatation. The results show that, there are significant differences between the two groups for the second (flow 2) and third (flow 3) flow measurements. Sodium nitroprusside injection to the pedicle in group 1 provided a better result with a 549% increase from flow 1 to flow 3, versus 325% increase in classical topical spraying of the same agent in group 2. There are also significant differences between flow 1, flow 2 and flow 3 in each group separately. The differences between flow 2 and flow 3 note the importance of time on the ITA spasm, but the dramatic changes from flow 1 to flow 2 note the need of topical vasodilators.

In conclusion, sodium nitroprusside injection to the pedicle provides a better flow than simple spraying of the same agent. Especially for the patients in whom the distal ITA cannot be resected, the need for a method to maximize the

free flow of the ITA seems reasonable. In patients undergoing coronary artery bypass grafting with an ITA graft, we recommend careful dissection and minimal direct handling of the ITA, followed by sodium nitroprusside injection to the pedicle to achieve maximal flow in the ITA graft.

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