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Effect of Internal Thoracic Artery Side Branches On Distal Flow

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Objective: Internal thoracic artery (ITA) is routinely used as an arterial greft for coronary artery bypass grafting (CABG). Steal phenomenon is described as a culprit causing myocardial low perfusion due to ITA side branch patency. Steal phenomenon due to limited dissection of ITA side branches in minimally invasive CABG method resulting in patency of ITA side branches has gained popularity. There is no definite evidence in the literature regarding the side branches of the ITA as the only cause of myocardial ischemia in CABG.
Material and Methods: In order to document the effects of ITA side branches on the flow pattern, 22 patients applying for CABG were randomly involved in the study. ITA was dissected with pedicle until the subclavian artery proximally and the bifurcation distally, protecting first intercostal and thymic side branches. ITA flow measurements were done from the distal part and after resecting the 1/3 distal part, clamping and unclamping the side branches for each part.
Results: There was no significant difference in flow measurements for clamped and unclamped side branches in neither the distal (20.7±10.1 mL/min vs. 20.3±11.1 mL/min) nor the proximal (55.6±26.0 mL/min vs. 55.1±29.0 mL/min) parts of ITA ($p>0.05$). On the other hand, flow measurements were higher at the proximal part than the distal part regardless of the side branches being clamped or not ($p<0.01$).
Conclusion: In this report we found that ITA side branches have no significant effect on distal flow. Therefore, patent side branches of ITA do not cause myocardial ischemia unless accompanying lesions such as stenosis of anastomosis, inadequate caliber of ITA and inadequate distal run off of the coronary vessels are present. Flow measurments were higher when ITA was resected more proximally, suggesting that ITA must be used as proximally as possible in anastomosis.

Key Words: Internal thoracic artery, Side branches

İnternal Torasik Arterin Yan Dallarnn Distal Akıma Etkisi

Amaç: İnternal torasik arter (İTA) koroner bypass cerrahisinde rutin olarak kullanılan arteryel grefttir. Açık olan ITA yan dallarına olan akım nedeni ile çalma fenomeni tanımlanmış ve myokardiyal perfüzyon bozukluğunun nedeni olarak gösterilmiştir. Minimal invaziv koroner cerrahisinde kullanılan sınırlı İTA diseksiyonunun yan dalların açık kalmasına neden olması sonucu çalma fenomeni önem kazanmıştır. Literatürde ise açık kalan İTA yan dallarının koroner bypass sonrası myokardiyal iskeminin tek nedeni olduğunu gösteren kesin bulgu yoktur.
Yöntem: İTA yan dallarının akım patternine olan etkisini ortaya koymak amacıyla, koroner bypass cerrahisi için başvuran 22 hasta randomize olarak çalışmaya alındı. İTA, birinci interkostal ve timik dalları korunarak, proksimalde subklavian artere, distalinde de bifurkasyona kadar pediküllü olarak serbestleştirildi. İTA'nın önce distal kısmından yan dallar klempli ve klempsiz, sonra 1/3 distal kısım kesilerek yan dallar klempli ve klempsiz akım ölçümleri yapıldı.
Bulgular: İTA yan dallarının klempli ve klempsiz akım ölçümlerinde, distal (20.7±10.1 mL/dk - 20.3±11.1 mL/dk) veya proksimal (55.6±26.0 mL/dk - 55.1±29.0 mL/dk) akımlarında anlamlı fark bulunmamıştır ($p>0.05$). Ancak proksimal kısımda akım distale göre yan dallar klempli veya klempsiz ölçümlerde daha yüksek bulunmuştur ($p<0.01$).

Sonuç: Bu çalışmada İTA yan dallarının distal akıma anlamlı etkisinin olmadığı gösterilmiştir. Açık kalan yan dallar anastamoz stenozu, yetersiz kalibrasyonda İTA ve yeterli distal yatak olmaması gibi nedenler olmadıkça myokardiyal iskemiye neden olmamaktadır. İTA akımlarının proksimale çıkıldıkça artması, İTA'in anastamoz sırasında mümkün olduğunca proksimalden kullanılması gerektiğini göstermiştir.

Anahtar Kelimeler: İnternal torasik arter, Yan dallar

Internal thoracic artery (ITA) is routinely used as a graft in coronary artery bypass grafting operations. Following utilization of ITA as a graft, low clinical success due to inadequate flow has been reported.[1] Usual causes of clinical failure are technical errors of anastomosis, stenosis and utilization of an ITA with small caliber. In a group of patients, steal phenomenon due to incomplete division of all branches has been defined as the cause of low myocardial perfusion.[1] Stenosis of left subclavian artery at a level proximal to ITA and congenital abnormalities of brachiocephalic vessels may also cause insufficient perfusion. A recently established minimally invasive method is increasingly being used in coronary revascularizations.[2] In this method, restricted dissection of internal thoracic artery leaves side branches open (particularly proximal side branches with high caliber), therefore, steal phenomenon is becoming a current issue again and this situation is giving rise to investigations on this subject.

In the present study, we aimed to investigate and demonstrate the effect of side branches on flow of ITA with high (distal ITA) and low (relatively more proximal ITA) distal resistance, in a prospective clinical design.

MATERIAL AND METHODS

Following the approval of the ethical committee, 22 patients who did not require emergency revascularization, who did not have history of any previous coronary revascularizations and any distal LAD (left anterior descending) lesions (angiographically) and who had systolic pressure 90 mmHg or higher were randomly selected among patients referred to our clinic for coronary revascularization, were included in the study.

Age, weight, height and body surface area of all patients were recorded. The internal thoracic artery was dissected with its pedicle, protecting the first intercostal and thymic branches. Dissection was advanced proximally until the take-off of subclavian artery and distally until ITA bifurcation. Following heparinization, the ITA was resected below the bifurcation level. A "bulldog" clamp (Fogarty soft jaw 6-mm clamp, model 614-06, Baxter-Edwards, Santa Ana, Calif.) was applied to the internal thoracic artery and a previously prepared 1/10 papaverine HCl solution was sprayed over the ITA pedicle. After ten minutes, while side branches were patent, the ITA was cut just above distal bifurcation and performed flow (D) measurements from the distal part with high resistance. The same procedure was repeated after clamping side branches (Dc). The distal 2 cm. of the ITA was resected and with the same method, flow measurements from the proximal part with low resistance were performed when side branches were clamped (Pc) and not clamped (P). During all measurements mean blood pressure and heart rate values of patients were stabilized, when necessary, by volume replacement or by changing inhalation anesthesia and these values were recorded. For most of the cases, ITA was shortened 2-3 cm more proximally, and used afterwards; the flow was seen to further increase at this level. Six patients were excluded due to various reasons. Five patients were excluded as the first intercostal branch was so poor in quality and one case was excluded because there was a proximal injury of ITA so that distal measurement was impossible.

Statistical Method

Statistical evaluation of study data was performed with Wilcoxon T test and two way analysis variance using commercial software package "SPSS for Windows 8.0".

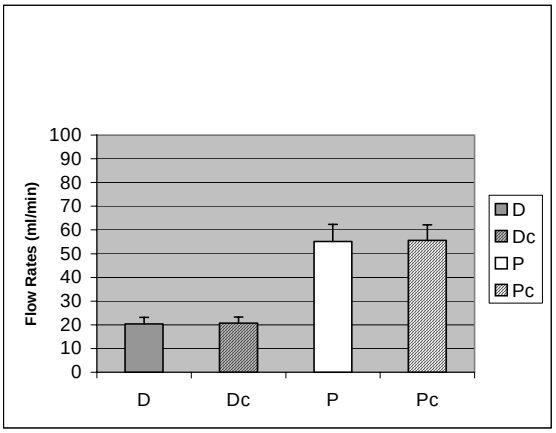
RESULTS

Mean age of cases was 57.4 ± 11.6 years (38-73). Mean weight was 59.1 ± 3.3 kg and mean body surface area was 1.63 ± 0.03 m^2. Mean blood pressure values were D: 85.6 ± 10.0 mmHg, Dc: 86.0 ± 10.8 mmHg, Pc: 87.2± 9.0 mmHg and P: 87.4 ± 9.4 mmHg, respectively. There were no statistically significant differences between blood pressure values measured at 4 different occasions. Mean heart rates were D: 72,6 ± 15.1/ min., Dc: 71.2 ± 14.9 / min, Pc: 71.6 ± 14.5 / min, and P: 72.0 ± 14.2 / min on four different occasions,

respectively. There was not any statistically significant difference between four measurements of heart rate.

Mean distal flow with clamp was 20.7 ± 10.1 ml/min, mean distal flow without clamp was 20.3 ± 11.1 ml/min, mean proximal flow without clamp was 55.1 ± 29.0 ml/min and mean proximal flow with clamp was 55.6 ± 26.0 ml/min. When distal flow values with and without clamp were compared and when proximal flow values with and without clamp were compared, a statistically significant difference was not found. However, a statistically significant difference was found when distal and proximal flow values with side branches clamped were compared (mean distal flow with clamp 20.7±10.1/min, mean proximal flow with clamp 55.6±26.0/min) ($p<0,01$). There was also a statistically significant difference when distal flow value without clamp and proximal flow value without clamp were compared, (distal flow without clamp 20.3±11.1/min, proximal flow without clamp 55.1±29.0) ($p<0.01$) (Figure 1)

Figure 1. Comparison of distal and proximal flow rates with and without side branches clamped
D=distal flow without clamp, Dc=distal flow with clamp, p=proximal flow without clamp, Pc=proximal flow with clamp



DISCUSSION

Recently minimally invasive coronary artery bypass surgery operations are gaining popularity. In this method anastomosis of ITA and LAD is performed via left thoracotomy.[1, 2] When ITA is approached via left thoracotomy, heart remains just beside the sternum in its native position. With this method, the limited dissection of prepared graft can be sufficient for LAD anastomosis. For this anastomosis usually 4-6 cm (occasionally 8-10 cm) of graft is required. ITA is prepared directly or via thoracoscopy in minimally invasive surgery.[1, 3, 4] Some of the side branches of proximal internal thoracic artery can not be exposed with this method; therefore these branches may be left patent. There are different opinions on whether this situation leads to insufficient perfusion of LAD or not. Internal thoracic artery anastomosis with the side branches left patent leads to myocardial ischemia in some patients, but not in others. Real ITA steal phenomenon occurs when pressure in the proximal part of ITA decreases and flow on this artery reverses direction (similar to what happens in proximal subclavian artery stenosis).

Physiologically ITA perfuses its target tissue during systole. In contrast, following anastomosis, ITA-coronary artery flow occurs mainly during diastole. Coronary and muscular branches do not share the same flow, as their hemodynamic phases are different. Development of angina has been demonstrated in some patients with patent internal thoracic artery side branches (pericardiophrenic or intercostals).[1, 3] In the reported cases, surgical or percutaneous closure of side branches eliminated clinically manifested angina. These findings support the hypothesis that there is significant flow towards the side branches of ITA. On the other hand, in two series of postoperative angiographic study, patent side branches of ITA was frequently found, however its association with decreased coronary perfusion could not be demonstrated.[5, 6] Abhyankar et al. demonstrated with intraarterial Doppler ultrasonography that occlusion of a major side branch of ITA does not increase the flow to the coronary artery significantly.[7, 8] Guadino et al. compared blood flow rates on ITA at rest and by inducing coronary vasodilation with dipiridamole, using transthoracic echo-doppler and they demonstrated that patency of side branches does not lead to any change in flow rate.[9]

When internal thoracic artery and coronary artery anastomosis is performed adequately and caliber of coronary artery is sufficient, there may be a weak flow from coronary artery towards the side branches of ITA, but it does not have a significant hemodynamic effect on LAD blood flow. However technical reasons

(stenosis of anastomosis) or anatomical reasons (caliber and quality of ITA or target vessel may be poor or ITA may be anastomosed too distally) may lead to a flow towards side branches of low resistance. In two studies supporting this theory, there was a steal phenomenon associated with patent side branches, however percutaneous dilatation of anastomosis provided clinical improvement and increase in ITA caliber in all cases, therefore occlusion of side branches was not required.[10, 11] In these patients, the relief of anastomosis increased distal flow of the graft and flow towards side branches was minimal.

In the present study, there was no significant difference in ITA flow due to clamping of the side branches. We measured flow at bifurcation level of internal thoracic artery (site with highest resistance) and at a more proximal level and we found that patency of the side branches does not effect flow rate. One drawback of this study is the lack of a flow characteristic (more in diastole and less in systole) and distal resistance similar to ITA-LAD anastomosis. The free flow pattern of ITA is not similar to the flow pattern of ITA-LAD anastomosis. The distal resistance at the time of our flow measurements was low than the resistance of ITA-LAD anastomosis. Differences in resistance of internal thoracic artery effects flow in the patent side branches. As this factor was considered at the beginning of the study, ITA was cut just below (just above the bifurcation) the part with maximum spasm (distal 1/3) and two measurements were done under relatively high resistance and a difference was not found. Presence of bleeding during proximal measurements demonstrated that resistance of ITA during measurement was significantly low. If side branches have an effect under low resistance, there would be a retrograde flow in these side branches and there would be an increase flow when the side branches were not clamped. Following shortening distal 1/3 of internal thoracic artery (2 cm), flow rates were significantly higher compared to bifurcation level. Therefore, for the anastomosis, proximal part with high flow should be preferred whenever possible.

When an ischemic symptom is considered to be due to the side branches of internal thoracic artery, the presence of an anastomotic stenosis and sufficiency of ITA caliber should be evaluated. We found that insufficient dissection of ITA side branches does not affect the flow on ITA to a great extent. We suggest that flow towards patent side branches of ITA alone does not cause myocardial ischemia in the absence of associated anatomical pathologies and technical failures.

REFERENCES

1. Luise R., Teodori G., Di Giammarco G, D'Annunzio E, Paloscia L, Barsotti A, Gallina S, Contini M, Vitolla G, Calafiore AM. Persistence of mammary artery branches and blood supply to the left anterior descending artery. Ann Thorac Surg 1997;63:1759-64
2. Robinson MC, Gross DR, Zeman W, Stedje-Larsen E. Minimally invasive coronary artery bypass grafting. A new method using an anterior mediastinotomy. J Card Surg 1995;10:529-36
3. Benetti FJ, Ballester C, Sani G, Doonstra P, Grandjean J. Video assisted coronary bypass surgery. J Card Surg 1995;10:620-5
4. Acuff TE, Landreneau RJ, Griffith BP, Mack MJ. Minimally invasive coronary artery bypass grafting. Ann Thorac Surg 1996;61:135-7
5. Ivert T, Huttunen K, Landou C, Bjork VO. Angiographic studies of internal mammary artery grafts after coronary bypass grafting. J Thorac Cardiovasc Surg 1988;96:1-12
6. Kuttler H, Hauenstein KH, Kameda T, Wenz W, Schlosser V. Significance of early angiographic follow-up after internal thoracic artery anastomosis in coronary surgery. Thorac Cardiovasc Surg 1988;36:96-9
7. Kern M.J. Editorial: Mammary Side Branch Steal: Is this a real or even clinically important phenomenon? Ann Thorac Surg 1998;66:1873-5
8. Abhyankar AD, Mitchell AS, Bernstein L. Lack of evidence for improvement in internal mammary artery graft flow by occlusion of side branch. Cathet Cardiovasc Diagn 1997;42:291-3
9. Guadino M, Serricchio M., Glieca F, Bruno P, Tondi P, Giordano A, Trani C, Calcagni ML, Pola P, Possati G. Steal phenomenon from mammary side branches: when does it occur? Ann Thorac Surg 1998;66:2056-62
10. Palac RT, Meadows WR, Hwang MH, Loeb HS, Pifarre R, Gunnar RM. Risk factors related to progressive narrowing in aortocoronary vein grafts studied 1 and 5 years after surgery. Circulation 1982;66(suppl I):1-40. Circulation. 1982 Aug;66(2 Pt 2):I40-4.
11. Singh RN, Sosa JA. Internal mammary artery-coronary artery anastomosis: influence of the side branches on surgical result. J Thorac Cardiovasc Surg 1981;82:909-14.

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