Original Research

JCAM

# TYPES OF ANASTOMOSIS IN FEMOROFEMORAL BYPASS SURGERY

## FEMOROFEMORAL BYPASS CERRAHİSİNDE ANASTOMOZ TÜRLERİ



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**Öz**

Amaç: Bu çalışmanın amacı, femorofemoral anastomoz için farklı cerrahi tekniklerdeki enerji kayıplarını deneysel olarak değerlendirmektir. Gereç ve Yöntem: Femorofemoral anastomoz, S 450, S 900, ters U, U ve right-angled olmak üzere beş farklı konfigürasyonda yapıldı. Anastomoz konfigürasyonları aynı uzunlukta tüp setleri ve politetrafluoroetilen (PTFE) sentetik tüp greftler kullanılarak oluşturuldu. Flow sağlamak için Kardiyopulmoner bypass makinası kullanıldı. Basınç ölçümleri,anastomoz bölgesinin öncesi ve sonrasında sabit ve eş zamanlı basınç takibi ile sağlandı. Bulgular: Bu deneysel çalışmada S tipi anastomozun avantajlı olduğu belirlendi. S anastomoz tipinde, minimum enerji kaybı ve en düşük basınç gradient ölçümleri saptandı. Minimum enerji kaybı ve basınç gradient farkı S 450 anastomoz tipinde gözlenmiştir. Tartışma: S tipi femorofemoral anastomoz tipi hemodinamik olarak diğer anastomoz tiplerinden daha etkili bir seçenektir.

**Anahtar Kelimeler**

Femorofemoral Bypass; Greft Açısı; Akım Gradienti

**Abstract**

Aim: The aim of this study was to experimentally determine the energy loss in different techniques of femorofemoral anastomosis. Material and Method: Femorofemoral anastomoses were performed in five different configurations including the S 45°, S 90°, inverted - U, U, and right-angled. Femorofemoral anastomosis configurations were created by using tubing sets and polytetrafluoroethylene (PTFE) synthetic ringed grafts of the same length. The flow was provided by a cardiopulmonary bypass pump. The pressure measurements were taken with constant, real-time pressure monitoring of the lines before and after the femorofemoral anastomosis sites. Results: This experimental study revealed the advantage of type S anastomosis. In the S anastomosis type, minimum energy loss and the lowest gradient recordings were determined. The minimum energy loss and gradient difference were observed in the S 45°. Discussion: Type S femorofemoral anastomosis is a hemodynamically more effective choice than the other techniques.

**Keywords**

Femorofemoral Bypass; Graft Angulation; Flow Gradient.

DOI: 10.4328/JCAM.4950 Received: 15.02.2017 Accepted: 08.03.2017 Printed: 01.04.2017 J Clin Anal Med 2017;8(suppl 2): 102-4
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## Introduction

Femorofemoral crossover bypass is an extra-anatomical arterial bypass. It is usually performed on patients with unilateral iliac artery occlusion and endovascular abdominal aortic aneurysm repair (EVAR) using an aortouniiliac endoprosthesis. Femorofemoral bypass is a simple, safe, and acceptable alternative to aortobifemoral, aorto-unifemoral, and iliofemoral bypass in older patients and in patients with high-risk profiles, particularly those with limb-threatening ischemia [1].

In terms of performing bypasses and anastomoses, the hemodynamic effects of the geometrical configurations of the grafts are very important from a surgical point of view. Inadequate inflow is considered the most likely cause of poor femorofemoral bypass function [1].

Flow disturbances and loss of energy due to anastomosis models are important problems with regard to perfusion pressure. Therefore, the aim of this experimental study is to describe the pressure-energy loss in different techniques of femorofemoral anastomosis.

## Material and Method

Five different femorofemoral anastomosis models were studied (Fig. 1). Different types of femorofemoral anastomoses were created using the same length tubing sets and polytetrafluoroethylene (PTFE) synthetic ringed grafts. The bypass length and anatomical positions were standardized for every type of anastomosis. The proximal and distal ends of the PTFE graft were connected to a cardiopulmonary pump (COBE) for every anastomosis type. In each experiment, we used a set of normothermic cardiopulmonary bypass (CPB) circuits with a standard 3/8 inch tubing set, a reservoir, and a pump; the prime of the CPB circuit consisted of 800 mL blood (Hct 30%). We used the traditional method to set occlusion, and a drop speed of 2.5 cm/min to calibrate roller pumps for use in CPB. The blood flow was circulated in the circuit at a flow rate of 5 L/min. The experimental period was 30 minutes. The pressure sensors were placed at the femorofemoral anastomosis right inlet and left outlet point. The distances between the pressure lines were equal. The pressure on both sides of the femorofemoral anastomosis was monitored continuously with flow on throughout the experiments and the data were recorded separately for every experiment every 5 minutes over 30 minutes. Pressure monitoring was achieved with PETAS MKA 900. The pressure transducer was calibrated to accurately process the data after every experiment.

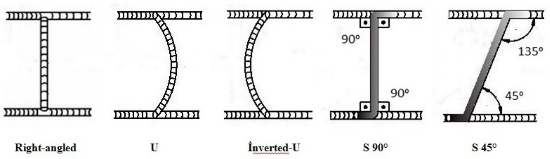


Figure 1. Femorofemoral anastomosis: Right-angled, U, inverted - U, S 90°, S 45°

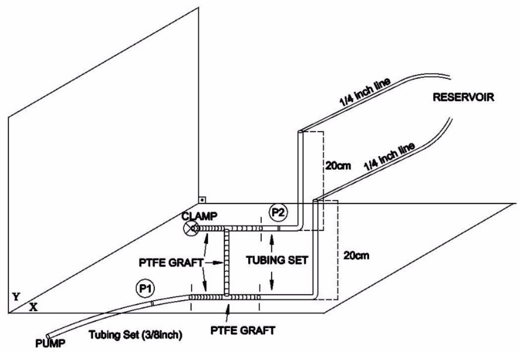


Figure 2. Experimental model of femorofemoral anastomosis.

To reproduce arterial resistance because the flow was nonpulsatile in our study, the free sides of the lines were raised 20 cm on the X-axis (perpendicularly to the Y-axis). These heights were bilaterally equalized. In addition, at a point distant from the pressure sensor, ¼ inch lines were used to reproduce arterial resistance after this 20th cm of these raised lines (Fig. 1).

A 5 L/min flow was chosen because the flow was continuous in our study. In normal subjects, volumetric mean arterial blood flow is, on average, 500-750 ml/min for one lower extremity and 1000-1500 ml/min for two lower extremities. In normal cardiac physiology, however, the diastolic component of the cardiac cycle is twice the systole. Therefore, when we divided the continuous 5 L/min cardiopulmonary pump flow by 3, this would match the normal cardiac systolic flow for lower extremities, which is 1.66 L/min.

The mean and median values "were equal" in all groups. The Kruskal-Wallis Test (post-hoc test using Mann-Whitney tests with Bonferroni correction) was used to compare the types of anastomosis. Statistical significance was defined as a p-value of 0.05 or less. SPSS for Windows (SPSS Version 15.0. SPSS Inc., Chicago, IL) was employed for statistical analyses.

## Results

Table 1 shows the distribution of the pressure gradient of five anastomosis models with five values and comparison of variances. The mean pressure values after anastomosis among the types of anastomosis were statistically significantly different ($p < 0.001$).

To determine the technique that causes the lowest loss of energy and pressure gradient is one of the most important components of surgical competency. In the present study, especially, inverted - U, U, and right - angled anastomosis models were found to cause greater flow disturbances and decreased energy. The median pressure gradient was significantly lower in S (S 45° and S 90°) anastomosis models than in the right - angled, U, and inverted - U anastomosis models (18, 29, 48, 53, and 58 mmHg respectively, Table 1). The lowest gradient (18 mmHg) was found in the S 45° anastomosis.

Table 1. Pressure gradients of femorofemoral anastomosis (mmHg).

| Type of anastomosis | Mean ± SD | Med (Min - Max) | p |
|---|---|---|---|
| Inverted-U | 58.4 ± 2.71 | 58 (55 - 62) | 0.001* |
| U | 53.8 ± 2.77 | 53 (51 - 58) | |
| Right-angled | 48 ± 2.12 | 48 (45 - 50) | |
| S 90o | 28.8 ± 2.59 | 29 (25 - 32) | |
| S 45o | 18.2 ± 2.39 | 18 (15 - 21) | |

* Kruskal-Wallis H-test; Med, median; Min, minimum; Max, maximum

## Discussion

The mode of graft failure appears to be closely related to the problems of inflow rather than the runoff. This relationship shows the importance of anatomically correct femorofemoral modeling. Vascular anastomosis is a complex task that has multiple requisite skills, which include manual dexterity and visual-spatial ability [2].

Although the type of anastomosis is one of the most important components of surgical competency, patency after femorofemoral bypass is affected by a variety of factors [3]. Factors affecting long-term patency include the amount of suture material used; the anatomic level of arterial disease and the outflow target artery; the degree of calcification of the vessels; more effective medication regimens consisting of a statin, an antiplatelet agent, and -blocker; and intraoperative care and postoperative management [3,4].

Improvements in preoperative medical optimization, vascular characteristics of patients, and postoperative medical therapy have all contributed to improvements in the patency rate of vascular grafts [4,5]. Even so, the type of anastomosis continues to play a significant role in the optimal strategy and long-term patency for revascularization.

In vitro fluid dynamic studies have revealed that geometry plays a key role in determining local flow fields [6]. According to in vitro fluid dynamic studies, the flow fields vary with the angle of anastomosis, and different types and degrees of flow disturbances are present at different locations within the same anastomosis [7-9]. To determine the technique with the lowest loss of energy and pressure gradient is one of the most important components of surgical competency. In particular, inverted - U, U, and right-angled anastomosis models were found to cause more flow disturbances and decreased energy.

It is widely accepted that local flow dynamics and mechanical conditions play a major role in the development of subsequent graft failure in vascular graft anastomosis [10]. Flow characteristics and vascular resistance are strongly influenced by the angulation of the graft in femorofemoral tunnel and the type of anastomosis. The postoperative perfusion pressure in lower extremities is important in the clinical application of femorofemoral bypass configurations. The pressure gradients and perfusion pressures are strongly influenced by the type of femorofemoral anastomosis in our experimental study.

The graft angulation and types of anastomosis can create significant differences in terms of graft patency regarding energy loss and turbulent flow. Accordingly, decrease of energy loss leads to increased distal perfusion pressures. Comparing these five anastomosis techniques, the S 90° and the S 45° femorofemoral anastomoses had better results than the other techniques. The 45-degree tilt in femorofemoral tunnel leads to the most significant minimum loss of energy in comparison with the other two S configurations.

In conclusion, femorofemoral bypass with S-type anastomosis is a hemodynamically more effective choice. The S 45° anastomosis is superior to the S 90° anastomosis. In this aspect, this experimental study concluded that the S 45° type of anastomosis is preferable from a hemodynamic perspective. In light of this data, we suggest it would be wise to reduce the use of the other techniques in femorofemoral crossover bypass procedures.

*Competing interests*

The authors declare that they have no competing interests.

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*How to cite this article:*
Akyuz M, Kestelli M, Cakir H, Karakas N, Isık O, Gurbuz A. Types of Anastomosis in Femorofemoral Bypass Surgery. J Clin Anal Med 2017;8(suppl 2): 102-4.