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The Banding Method for the Reduction of Blood Flow in Hyperfunctioning Arteriovenous Fistula

Hiperfonksiyonel Arteriovenöz Fistülde Kan Akışını Azaltmak İçin Bantlama Yöntemi

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ÖZET

AMAÇ: İskemik çalma fenomeni, hemodiyaliz girişi için arteriovenöz (AV) fistülün uzuv kaybı ile sonuçlanabilen kritik bir komplikasyonudur. Uzamış dijital veya distal iskemi, cerrahi revaskülarizasyon ile önlenmelidir. Bu çalışmada, bu tür hastalar için VenocuffTM bantlama yönteminin sonuçlarını araştırmayı amaçladık

GEREÇ VE YÖNTEM: Hemodiyaliz girişine bağlı iskemi şikâyeti olan 22 hasta çalışmaya dahil edildi. Hiperfonksiyonel AV fistülde kan akımını azaltmak için Venoocuff bantlama yöntemi uygulandı. Demografik bulgular ve postoperatif bulgular operasyonun 1. haftası başında ve 6. aydan sonra kaydedildi.

BULGULAR: Yaş ortalaması 64.6 ± 27.3 yıl olan 16 (% 73) erkek hasta vardı. En sık eşlik eden hastalıklar DM (n: 20 /% 90) ve hipertansiyon (n: 22 /% 100) olarak bulundu. 12 (% 54) radyosefalik AV fistül vardı. Preoperatif ve postoperatif Vmax değerleri sırasıyla -21,3 ± -9,1 cm / s ve 24,64 ± 10,45 cm / s olarak bulundu (p = 0,000). Tüm hastalarda postoperatif erken dönemde iskemik yakınmalar ve bulgular geriledi.

SONUÇ: Venocuff kullanılan bantlama yöntemi, hiperfonksiyonel AV fistülde kan akışını azaltmada ve iskemik şikayetleri iyileştirmede etkili görünmektedir.

Anahtar Kelimeler: hiperfonksiyonel av fistül, iskemik çalma sendromu, venocuff, bantlanma

ABSTRACT

OBJECTIVE: Ischemic steal syndrome is a critical complication of arteriovenous (AV) fistula for haemodialysis access that can result in limb loss. Prolonged digital or distal ischemia should be prevented with surgical revascularization. In the current study, we sought to determine outcomes of the Venocuff banding method for hemodialysis access-induced distal ischemia.

MATERIALS AND METHODS: Twenty-two patients with haemodialysis access related ischemia complaints were included in this study. The Venocuff banding method was applied to reduce blood flow in the hyperfunctioning AV fistula. Demographical and postoperative findings were recorded early in the first week and six months after the operation.

RESULTS: There were 16 (73%) male patients and an average age of 64.6 ± 27.3 years. The most commonly accompanying diseases were found to be diabetes mellitus (n:20/90%) and hypertension (n:22/100%). There were 12 (54%) radiocephalic AV fistulas. Preoperative and postoperative Vmax values were found to be -21.3 ± -9.1 cm/s and 24.64 ± 10.45 cm/s, respectively (p = 0.000). Ischemic complaints and findings regressed in the early postoperative period for all patients.

CONCLUSION: The banding method using Venocuff seems to be effective for reducing blood flow in hyperfunctioning AV fistula and ameliorating ischemic complaints.

Keywords: hyperfunctioning AV fistula, ischemic steal syndrome, venocuff, banding

INTRODUCTION

The best treatment method for end-stage renal disease is kidney transplantation. However, because of donor insufficiency, these patients must continue with haemodialysis until transplantation is possible. The most sustainable and safest method for prolonged dialysis access is by arteriovenous (AV) fistula creation (1,2). However, anatomically, the available zones for AV fistula creation are limited and these areas must be used for many years, maybe even for a lifetime. Therefore, AV fistula continuity should be preserved as long as possible. Naturally, acceptable physiological blood steal from artery to vein always occurs in AV fistula (1,3). However, ischemic steal syndrome (ISS) is a rare complication of AV fistula that can result in fistula loss due to the need to cancel the flow from the artery to the vein to prevent ischemia. The occurrence rate of ISS for radiocephalic fistulas is 1 to 2%, and for brachiocephalic fistulas, it is 5 to 15% (4,5). Optionally, the fistula tract can be closed surgically or by endovascular methods, but this results in AV fistula loss.

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Alternatively, steal can be reduced to physiological levels via surgical reconstruction or wrapping methods using external banding techniques (6-8).

Venocuff TM is a medical device produced for venous banding in the treatment of venous insufficiency in chronic venous insufficiency (9). This device has reportedly been successfully applied in the prevention of venous reflux in venous insufficiency. In the current study, we sought to investigate the results of venous banding with Venocuff TM in AV fistula steal syndrome.

MATERIAL & METHODS

After the determination of study protocols, clinical approval was received from the Ministry of Health of the Republic of Turkey with approval number kaya-2020-08-11T21_48_03. The demographical (age, gender, tobacco use, comorbidities) and operational findings and preoperative and postoperative status were recorded retrospectively.

Patient selection criteria: Patients with ISS due to haemodialysis access were included in this study. Patients who did not accept having an operation for fistula revision or had contraindications against the intervention (such as an infection, advanced gangrenous lesion, etc.) were excluded from the study. In total, 22 individuals were included in this study. Preoperative and postoperative hand circulation was evaluated using the snuffbox technique (the technique was demonstrated at picture 1), and maximal systolic flow velocity (Vmax) values were recorded as described previously (10).

Operation method: The AV fistula tract was opened under local anaesthesia. The vein was dissected and fixed just at the anastomosed site of artery. The surrounding adhesions of the vein were removed and the vein was skeletonized. Then, the Venocuff TM (produced by Vaso Products Pty Ltd., Artarmon, New South Wales, Australia) was wrapped to surround the skeletonized site of the vein. Banding was controlled by simultaneous Doppler evaluation during the procedure and size was adjusted. The operational technique was demonstrated at picture 2 A, B. After confirmation of the thrill of the AV fistula, the surgical excision was sutured.

After the operation, patients were followed by outpatient clinic consultations. AV fistula persistence and complaints were noted. Anticoagulation was not utilized due to the periodical heparinization during haemodialysis access in all patients.

Statistical Analyses

The statistical evaluation was made using the SPSS software statistical program (Version 15.0, SPSS Inc., Chicago, Illinois, United States). Results were expressed as mean ± standard deviation (SD), and the categorical variables were expressed with percentages. Mann-Whitney U tests were performed for the comparison of preoperative and postoperative Vmax values.

RESULTS

There were 16 (73%) male patients and an average age of 64.6 ± 27.3 years. The most commonly accompanying diseases were found to be DM (n:20/90%) and hypertension (n:22/100%). There were 12 (54%) radiocephalic AV fistulas. The demographical and clinical findings are summarized in Table 1.

Banding was applied to all patients and the disrupted reversal flow was found to have been fixed after the operation. Preoperative and postoperative Vmax values were found to be -21.3 ± -9.1 cm/s and 24.64 ± 10.45 cm/s, respectively (p = 0.000).

Table 1. *Demographical and comorbid conditions*

Clinical Characteristics	Age (years) (mean±SD)	Male Gender (n/%)	Tobacco usage (n/%)	Diabetes mellitus (n/%)	Hypertension (n/%)	Hyperlipidemia (n/%)	Peripheral vascular disease (n/%)	Coronary artery disease (n/%)
	62.8±12.25	16/73%	9/%40	20/90%	22/100%	10/45%	7/31%	3/15%
Fistula Related Characteristics	Previous AV fistula operation (n/%)		Radiocephalic AV Fistula (n/%)			Brachiocephalic AV Fistula (n/%)		
	14/64%		12/54%			10/46%		

The cyanotic and ischemic findings and ischemia related complaints recovered after a few hours and almost all lesions recovered in within few weeks. Picture 3 A, B presents the remission of cyanosis. Postoperatively, patients directly underwent haemodialysis, and patency was found to be 100% for all reconstructed AV fistulas using the banding method. Thrombosis or additional postoperative problems were not observed.

Picture 1. *The illustration of the snuffbox technique: Measurement of the maximal systolic flow velocity (Vmax)*

DISCUSSION

Our results indicate that ISS can be prevented by the bandingmethod. The Venocuff TM seems to be an effective and easy alternative material for AV fistula wrapping. The early recovery from ischemic complaints, no disruption in the haemodialysis process and acceptable midterm patency rates are all good points to this method.

End-stage renal disease is a significant health problem that can occur at an early age. Every year, more than 100,000 new patients who require treatment are reported. Kidney transplantation is the best treatment method for this disorder (11,12). However, one of the most challenging points is insufficient donors for transplantation. Therefore, these patients must continue to live with dialysis until an appropriate new kidney is found (1-3,11,12). The continuous dialysis can be provided by peritoneal dialysis or direct haemodialysis with central venous catheters and AV fistula (13). Studies have reported that vascular access type haemodialysis is more effective and more beneficial for long-term survival. In this context, dialysis should be continued as the vascular access type if possible. Central venous catheters are one option for vascular access type haemodialysis; however, they are uncomfortable due to the external parts located outside the body, and precisely for this reason, they have a greater risk for infections. AV fistulas are a comfortable, safe and sustainable method for continuous haemodialysis. All these reasons increase the importance of AV fistulas in end-stage renal disease patients (11,13,14).

Picture 2 A. *The imaging of hyperfunctioning AV fistula before the Venocuff Banding. B. The imaging of hyperfunctioning AV fistula after the Venocuff Banding*

Many factors have been reported that affect patency rates in AV fistula. Gender, the characteristics of the artery and vein (such as diameter), surgical technique, accompanying diseases (DM, atherosclerosis, etc.), smoking and blood pressure alterations are all main factors that affect the long-term patency of AV fistulas (16,17). Another problem is excessively increased AV blood flow. This condition causes the steal of more oxygenated blood to the venous bed than is necessary for supplying the distal bed, and this is called AV fistula steal syndrome. This process leads to ischemic manifestations such as pain, pallor, gangrene or necrosis in the extremities. The steal phenomenon may be related to atherosclerosis, the size of the AV anastomosis, thrombotic distal occlusion or other factors. It can also result in

extremity loss if it is not diagnosed and treated in a timely manner (4,8). Treatment strategies are based on stopping or reducing the excess flow from the artery to the vein. Direct ligation procedures can applied, but then patients need new alternatives for haemodialysis access. Thus, ligation is applied with new revascularization strategies (7,19).

Picture 3 A. *Preoperative imaging of hand; extensive cyanosis. B. Postoperative imaging of hand: regressing of cyanosis in hours*

The distal revascularization-interval ligation (DRIL) method includes the ligation of the native artery just distal to the anastomosis and makes a bypass from the proximal to distal site with protection of the AV anastomosis (7,19). The revascularization using distal inflow (RUDI) method involves the ligation of the native vein just distal to the anastomosis and makes a new bypass to the distal artery to the ligated vein (7,19). Other options include increasing the blood supply of the arterial bed proximal to the distal bypass via synthetic grafts or autologous vein grafts (7,19). Coil embolisation is also an option for stopping the venous steal in AV steal syndrome; however, it can result in disrupted blood flow in the AV fistula (20). Minimally invasive strategies that can be applied are side branch ligation or partial ligation of the vein to reduce arterial blood flow to the vein (19,21). Plication or open surgical banding methods have been reported as a less invasive option for treating AV fistula steal syndrome. Banding methods can provide control of the blood flow in AV fistula and balanced decrement on the vein bed and increment on the distal arterial bed. The literature discusses different banding and wrapping methods for AV fistula reconstruction (7,19). Schneider et al. described a technique that covers the arterial and venous sides of AV fistula. They reported that the T banding technique successfully reduced the blood flow of a hyperfunctioning AV fistula, but could not prevent steal phenomena that were not caused by high shunt flow (22). However, Babakhani et al. presented a brief report on five cases in which they applied a tube banding method to correct steal syndrome. They claimed that steal phenomenon-related ischemic symptoms quickly resolved after the application of this method with no postoperative thrombosis observed in their series (23). There are several conflicting results about this kind of plication or banding technique. This situation may be related to a lack of a consensus on the rate of throttling for the AV fistula anastomosis. One small series reported that more successful outcomes can be obtained by evaluating blood flow with Doppler signal subjectively during the plication or banding procedure (24). Scheltinga et al. reported that the banding method can be successful if the access flow is monitored during the banding procedure and clinical outcomes improved with close intraoperative follow up. Moreover, they added that, although the results of blind banding did not have successful outcomes, the success rate can be quite improved with intraoperative monitoring methods (25). In our series, we did a simultaneous Doppler evaluation during the operation and calculated the Vmax values pre-throttling and post-throttling of the native vein just on the distal side to the anastomosis, and the Vmax values were noted in the assessment of banding efficacy. The ischemia related complaints regressed in all patients and operation related complications were not observed during the six-month follow-up. Venocuff TM is a tissue-compatible, Dacron-reinforced silicone cuff or band that is wrapped around the incompetent venous valve externally

and adjusted with tightening until reaching normal functional valve capacity (26). We used this material for banding the hyperfunctioning AV fistula in treating the steal phenomenon. In our series, the Venocuff TM was tightened (it is easily adjustable due to its belt-like design) over the vein just to the distal side of the anastomosis to maintain the continuous thrill of the AV fistula at its minimum diameter.

In conclusion, the banding of a hyperfunctioning AV fistula under monitoring by Doppler evaluation seems to be effective in preventing AV fistula steal syndrome. The technique is less invasive and allows for the protection of the previous AV fistula tract. Moreover, Venocuff TM seems to be an effective alternative as a banding material, allowing adjustable throttling.

Limitations of this study: The main limitation of the study is related to its design. This study includes the data of a single center and is not a comparative study. The second limitation is related to the lack of long-term data.

Etik: Bu çalışmanın etik kurulu alınmıştır.

Ethics committee approval had been taken.

Yazar katkı durumu; Çalışmanın konsepti; İK, dizaynı; İK, Literatür taraması; İK, verilerin toplanması ve işlenmesi; İK, istatistik; İK, yazım aşaması; İK,

Author contribution status; The concept of the study; İK, design; İK, literature review; İK, and processing data; İK, statistics; İK, writing phase; İK,

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