

BRACHIAL VEIN SUPERFICIALIZATION: A SPECIAL METHOD OF VASCULAR ACCESS FOR HEMODIALYSIS

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REZUMAT

Scopul lucrării: De a prezenta tehnica realizării accesului vascular prin superficializare de venă brahială și rezultatele acestei metode. **Material și metode:** În perioada 1984-2007 au fost efectuate 47 de superficializări de venă brahială la 42 pacienți, media de vârstă fiind de 41,7 ani cu limite 24-60, raportul femeii/bărbați este de 2,5/1. Superficializarea a fost realizată într-un singur timp operator. **Rezultate:** Complicațiile au fost împărțite în 2 mari categorii și anume precoce și tardive. Complicațiile precoce au fost grupate în complicații majore care au dus la compromiterea accesului vascular și minore care nu au dus la compromiterea accesului vascular. Complicațiile majore au fost în număr de 5: 3 cazuri de tromboză (10,63%) și 2 nematurări de fistulă (4,25%) în intervalul de timp până la 6 săptămâni. Complicațiile minore au fost edemul brațului în 12 cazuri (25,53%), în 3 cazuri dehiscentă parțială de plagă însoțită de necroză marginală (6,38%) și 5 infecții de plagă (10,63%). Complicații tardive au fost considerate cele care au apărut după prima dializă și sunt reprezentate de 7 cazuri de tromboze (15,9%), 2 cazuri de traumatisme ale venei superficializate (4,54%) și 2 cazuri de supraîncărcare a cordului și hiperpresiunii venoase (4,54%). Funcționalitatea imediată este de 89,36% (42 fistule), cea tardivă este de 65,62% (21 fistule); 15 cazuri s-au pierdut din evidență. Mortalitatea operatorie este nula. **Concluzii:** Superficializarea de venă brahială poate reprezenta o alternativă în condițiile epuizării capitalului venos superficial.

Cuvinte cheie: fistulă arterio-venoasă, superficializarea venei brahiale

ABSTRACT

Aim of the study: To present the technique and the results of the vascular access by brachial vein superficialization. **Material and methods:** 47 superficializations of the brachial vein were conducted between 1984 and 2007 in 42 patients; the average age was 41.7 years (24-60 years, male to female ratio = 2.5/1). The superficialization was performed each time in a single surgical intervention. **Results:** Complications were divided into 2 large categories: early and late and complications. Early complications were grouped in major complications, resulting in compromise of the vascular access and minor complications, which did not cause vascular access failure. Five major complications were reported within 6 weeks: 3 cases of thrombosis (10.63%) and 2 cases of fistula non-maturation (4.25%). Minor complications were arm edema in 12 cases (25.53%), 3 cases of partial wound dehiscence with marginal necrosis (6.38%) and 5 wound infections cases (10.63%). Complications appearing after the first dialysis were considered late complications. Thrombosis developed in 7 cases (15.9%), trauma of the superficialized vein in 2 cases (4.54%) and 2 cases (4.54%) of cardiac overload and venous hypertension were found. Immediate functionality rate was 89.36% (42 fistulas), the late one was 65.62% (21 fistulas); 15 cases could not be followed-up. Surgical mortality was 0. **Conclusions:** The brachial vein superficialization represents a useful alternative for vascular access in case of superficial venous capital depletion.

Key Words: arterio-venous fistula, brachial vein superficialization

INTRODUCTION

Intravenous treatment and repeated punctures of arterio-venous fistulae are compromising the superficial venous system, in which case the only viable solution for vascular access implies using synthetic grafts or a deep venous segment.

The superficialization technique of the profound venous segment (the basilic vein) was first described by Dagher in 1976.¹ The first reference in the literature regarding brachial vein superficialization belongs to Paul G. Koontz and Thomas S. Helling from the surgical department of St. Luke's Hospital in Kansas City, from 1983.² On October 10th 1984, for the first time in Romania, Doru Bordos performed the brachial vein superficialization for vascular access.

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Aim of this study is to present the details involving this technique and to assess the results of the vascular access by means of brachial vein superficialization.

MATERIAL AND METHODS

Surgical Technique

Patient set-up. The patient is placed in dorsal decubitus, with the upper limb in abduction and external rotation. The patient's arm has to be prepared carefully, with shaved armpits.

Anesthesia. Local anesthesia (Xylazine 1% or derivatives), local regional, general or oro-tracheal intubation may be chosen. Lately, local regional anesthesia was preferred over local anesthesia due to the possibility to exceed allowed Xylazine dosage.

The skin is incised longitudinally along the bicipital groove from the axilla to the ante-cubital fossa. The subcutaneous cell tissue is sectioned on the entire length of the incision, followed by rigorous hemostasis. The brachial fascia is sectioned on its entire length and one of the brachial veins is carefully dissected cranially and all collaterals are tied. Placement of either Prolene 6-0, 7-0 thread or a 4-0 Silk thread, by direct ligation or by suture (the latter being preferred by the authors) can greatly reduce the risk of venous stenosis or of ligation side-slipping. The medial ante-brachial cutaneous and the brachial cutaneous nerves have to be protected, due to their close vicinity to the vein. (Figure 1)

Having dissected the vein and mobilized on its entire length, the exact place of the future arterio-venous anastomosis has to be determined, allowing for a mobilization of the vein in the superficial plane without tension in the anastomosis.

Afterwards, the brachial artery is dissected circumferentially for about 3-4 cm, anticoagulated and clamped with fine vascular loops or clamps (bulldogs). Minimal longitudinal arteriotomy of about 0.5 cm is performed. This length was exceeded only in case of patients with small caliber arteries, where the arteriotomy length was of 0.7 cm. We appreciate that this is the maximum advisable length and exceeding this may lead to complications. The brachial vein is ligated distally and prepared for latero-terminal anastomosis. A very thin catheter was placed intravenously for about 1 cm and used to inject saline in order to check vein patency (both brachial and axillary vein that provides the venous outflow) and for vein dilatation, allowing for an easier anastomosis. We performed these operating steps sequentially, allowing for simple and fast adventicectomy and eliminating

the risk of stenosis through adventitia bridges. All these described maneuvers have reduced complication rates and allowed to double the vein caliber, which is normally 4-5 mm. The arterio-venous anastomosis between the brachial artery and the mobilized brachial vein (terminal on the vein) was performed using Prolene 6-0 or 7-0 running suture. (Figure 2)

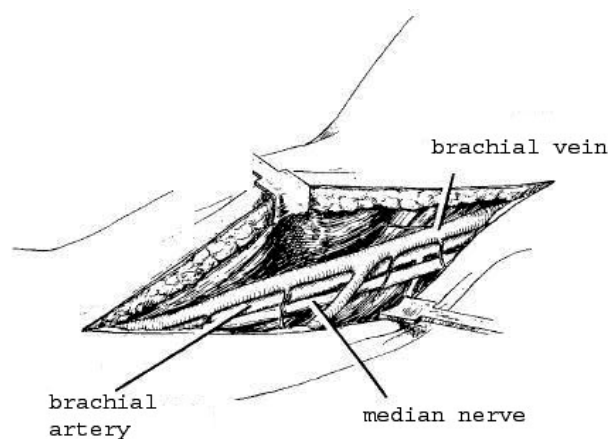


Figure 1. Longitudinal incision from the elbow fold to the axillary fold and the brachial vasculo-nervous package: brachial vein, superior brachial artery, inferior median brachial nerve. (P. G. Koontz and T. S. Helling, World J Surg)²

Special attention has to be paid to the two anastomosis corners, in order to prevent reduction of arterial caliber. The proximal end of the anastomosis was always performed first, placing the suture thread with 2 needles. At this point, there are 2 options to continue the anastomosis:

- Using one of the needles, to suture the posterior wall towards the position of the surgeon, exceeding the distal end of the arteriotomy overlapping with the anterior suture on 2 mm, after which using the second needle the suture from the proximal end on the anterior wall is performed progressing towards the distal end of the arteriotomy, so that the two suture threads meet approximately at the middle of the previous suture segment.

- Placing of 2 double-armed threads (each having 2 needles) at the 2 ends of the arteriotomy, with anastomosis operating steps similar to the one previously described.

These technical details are important to understand and master, allowing for a correct anastomosis while avoiding to end the suture at either end of the anastomosis and thus greatly reducing the risk of stenosis and back-wall suturing. They also allow to visualize the suture points and the close contact between the two intimae layers.

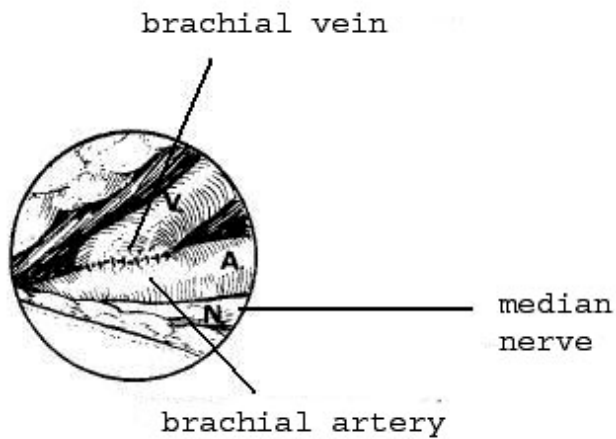


Figure 2. Latero-terminal brachio-brachial arterio-venous anastomosis (laterally on the artery).²

Artery declamping is performed first distal while checking for anastomosis leakage, after which the proximal end is declamped. A fistula performed technically correct will present pulsations and thrill in the venous segment. The superior skin flap is fixed with two or three clamps and the subcutaneous tunnel is shaped, in which the brachial vein will be placed. (Fig. 3, 4)

After embedding the vein, the subcutaneous cell tissue is sutured at the upper pedicled graft of the brachial fascia, in order not to allow the vein migration from this tunnel and to restore the brachial fascia. (Fig. 5)

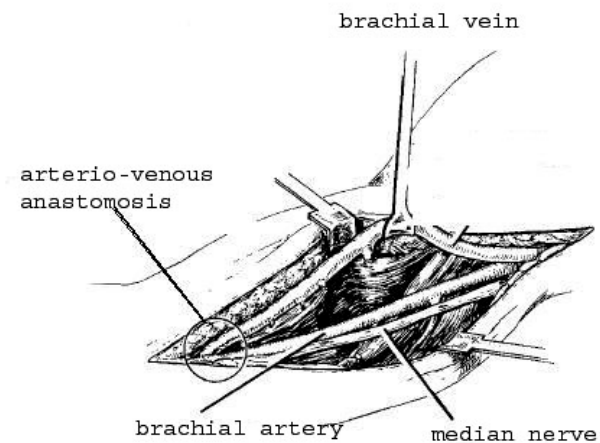


Figure 3. Anastomosed and superficialized brachial vein.²

A special instrument is described in the literature, which can be used to create this tunnel (tunnelizer), but this maneuver is “blind” and may lead to diffuse bleedings, difficult to control and rendering it thus invalid for us as an option. The surgical wound is sutured on anatomical planes and closed.

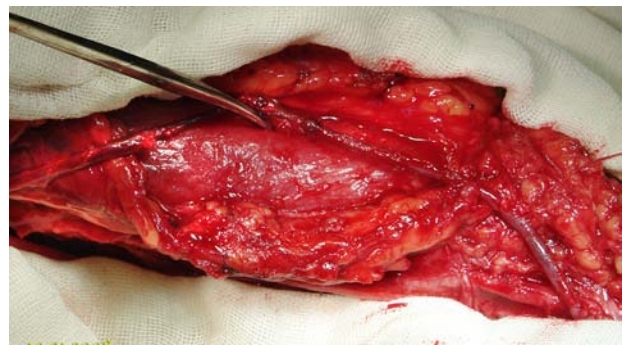


Figure 4. Intraoperative view of anastomosed and superficialized brachial vein.

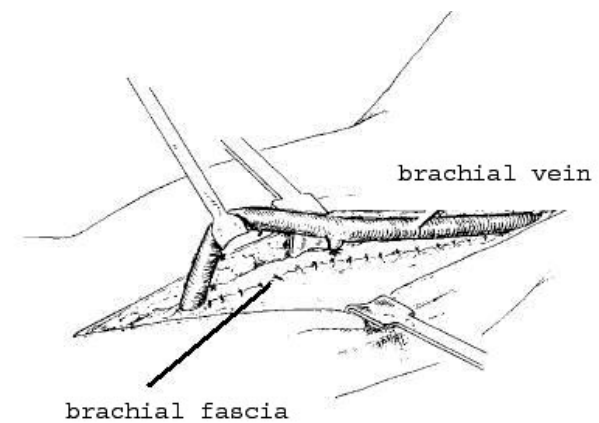


Figure 5. Final appearance with sutured brachial fascia.²

RETROSPECTIVE STUDY

During 1984-2007 we performed 47 brachial vein superficializations in 42 patients, the average age being of 41.7 years, with limits of 24-60, and the ratio females/males 2.5/1.

All patients have been clinically assessed pre-operative, assessment which has shown a compromised superficial venous system, as result of other attempts to create the vascular access or by repeated venous punctures or veins of inadequate sizes used for the arterio-venous fistula. Lacking imagistic assessment tools, the final decision regarding the feasibility of the brachial vein segment had to be taken intra-operatory, being considered usable for a-v fistula if the diameter of the vein was at least of 2mm. As result of these observations, 17 superficializations (36.17%) have been performed as first intent. These patients did not benefit from other attempts to perform the vascular access in our clinic, the brachial vein superficialization being the first surgical intervention performed by us. The rest of 30 fistulas (63.82%) were re-interventions, the initial vascular access being performed in our

clinic. All these superficializations were technically performed by termino-lateral anastomosis (laterally on the artery), in a single intervention.

RESULTS

The method proved useful but also presented complications that lead to a non-functional fistula. Due to the given circumstances we cannot report salvage procedures for the vascular access, because the complications have obliged us to perform another a-v fistula. The complications were divided into 2 major categories: early and late.

We grouped the **early complications** into:

- Major complications, that led to the compromising of the vascular access
- Minor complications, that did not led to the compromising of the vascular access.

There have been 5 major complications: 3 cases of thrombosis (10.63%) and 2 cases of fistula non-maturations (4.25%) within 6 weeks. In these cases we performed another vascular access. In 2 cases we performed another superficialization, and in the other 3 cases a standard vascular access in the contra-lateral limb.

Early complications were composed mainly of minor complications, dominated by the arm edema in 12 of the cases (25.53%) and complications which we considered as arising from this edema, namely in 3 situations of partial wound dehiscence, accompanied by marginal necrosis (6.38%). These wound problems have been either solved conservatively in the initial phase or by excision of the marginal necrosis and a secondary suture. We have also encountered 5 cases of wound infection (10.63%).

Late complications have been considered the ones that appeared after the first dialysis. They included thrombosis, developed in 7 cases (15.9%) and 2 traumas (4.54%) of the superficialized vein. An interesting issue to be emphasized is that one of the injuries was iatrogenic and occurred by puncture of the superficialized vein in another medical unit. Both kinds of complications induced the failure of the vascular access, which imposed for another fistula to be performed. In 3 cases we performed a new superficialization in the controlateral superior limb. There were 2 cases (4.54%), in which closing of the fistula was necessary, due to venous hyper-pressure.

The morbidity in this type of vascular access was in this case series 65.95%. Fortunately, the complications that lead to the loss of the vascular access were not numerous - 16 fistulas (34.04%).

The immediate functionality rate was 89.36% (42 fistulas). Late functionality at 3 years was 65.62% (21 fistulas), in 15 cases we had no follow-up. The surgical mortality is 0. Unfortunately, there were 3 cases in this group who died due to the lack of vascular access.

DISCUSSIONS

This superficialization technique has few very distinct elements which have to be considered:

- The vein should be dissected over a great length, because it will be mobilized and placed in a superficial median plane. This mobilization can caused the shortening of the useful venous segment. In this context, we preferred to mobilize the vein as much as possible, from about 1-2 cm under the elbow to the axilla. Thus, the brachial artery can be used at the most at 2 cm proximal from its bifurcation and we have performed the arterio-venous anastomosis without tension, which is essential for any vascular or non-vascular anastomosis. Placing the anastomosis at 2 cm proximal from emergence of the 2 terminal branches of the brachial artery facilitates preserving the epicondilian arterial arch, a very important element in case of the appearance of a blood steal phenomenon.
- The high pressure in the superficialized vein may lead to ligatures slipping. This is why we strongly advise for ligatures being performed with transfixing threads.

One of the greatest problem generated by this type of intervention is the very long incision from the elbow to the axilla, incision which is prone to wound problems – infections, necrosis and dehiscence – which may as well lead to compromising the vascular access.

Vein placement in the subcutaneous tunnel and the arterio-venous anastomosis have to be performed only after the vein is checked for twisting; the subcutaneous tunnel must be thin enough in order to allow for easy puncturing of the vein. Attention must be paid to the thickness of the subcutaneous cell tissue layer, which has to be great enough; otherwise skin erosions or even necrosis may appear. The superficialized vein has to be placed at distance from the surgical wound, because the post-surgical scar may hinder puncturing the superficialized vein. Even more, post-operative complication may appear such as wound dehiscence, which would lead to vein exposure. In this context, we preferred the longitudinal skin incision in the cutaneous projection of the bicipital groove, or even 1 cm below this projection. The surgical technique has to be extremely rigorous with a carefully performed

anastomosis, in order to avoid hematoma development with subsequent compressions of the superficialized venous segment.

In the studied group, complication incidence is relative high - 17% (8 cases). The problems with this kind of incision may be solved using the technique proposed by David Shemesh, consisting in a series of longitudinal incisions placed on the antero-medial side of the arm, avoiding thus that very long incision.⁹ Another way to avoid this approach can be the minimal invasive approach.¹⁰ Secondly, this technique can potentially produce iatrogenic lesions of the brachial vein during the dissection. We have not encountered such situations due to the extremely rigorous dissection technique of the brachial vein. The iatrogenic lesions of the vein can be avoided if we choose the two-step superficialization technique, in which the arterio-venous anastomosis is performed initially, after which the fistula is left to mature for 4-6 weeks, followed by the actual superficialization. This technique variant is used by Niren Angle and Dorobantu, who have adopted the two stage technique variant from its original author, Koontz.^{11,12} N. Angle has improved the original technique with an artifice: he performs the termino-lateral arterio-venous anastomosis (laterally on the artery) with one of the brachial veins, but maintains the first link branch between the 2 veins placed over the anastomosis, so that during the maturation period, both brachial veins will develop.

The advantage of performing the superficialization far apart from the a-v fistula completion is given by the occurring venous alterations. The vein expands and the walls arterialize, which makes dissecting the vein easier, diminishing the risk of iatrogenic venous lesion. Even more, K. Tomoteru assessed the functionality of the two different techniques and concludes that the fistulae performed in two stage procedures have longer patency (mean patency 15.2 months) compared to the ones performed in a single intervention (mean patency 2.8 months).¹³ A similar conclusion was also drawn by El-Mallah, who reports 60% patency in single stage interventions and 90% patency in two stage procedures, mentioning that this study concerned superficialization of the basilic vein.¹⁴

This kind of vascular access is accompanied by increased morbidity, especially in case of the single stage superficialization technique. The studied group had a morbidity of 65.95%, but fortunately the complications leading to loss of vascular access were only 34.04% (16 fistulae). Similar values are encountered in the literature. M. Atsushi reports a

35.71% rate of major complications due to thrombosis and stenosis, with a total morbidity of 60.71%.¹⁵ A great morbidity (54.54%) is also reported by L.F. Dorobantu, who encountered 12 edemas of the arm and 6 occlusions of the fistula in his case series. Towards these data, K. Tomoteru reports only major complications as ruptured arteries, steal syndrome, aneurism, and venous high pressure in 26.66% of the cases, all these complications leading to the failure of vascular access.¹³

A very high flow may appear in the vein, which could lead to a vascular steal phenomenon. It is of major importance that the 2 arterial branches should be very well assessed before the surgery. During the surgery, it is recommended that the upper limb should be entirely isolated, so that the pulse may be periodically checked at the radial and ulnar artery. In order to avoid the steal phenomenon, the length of the arteriotomy must not exceed 75% of the artery diameter, and the maximum allowed length is 0.7 cm. In our case series where we used this superficialization technique of the brachial vein, the maximum length of the arteriotomy was 0.5 cm.

In our case series, we encountered no symptomatic arterial steal syndrome, which would have led to the closing of the fistula. This observation is in some contradiction with literature data that reports an incidence of the ischemic phenomena due to the vascular steal, ranging from 1.6% to 6.3%.¹⁶⁻¹⁹ This complication we reported in just 1 case (2.12%). In our series, we also noticed the case of one superficialization that developed venous hypertension with enlarging of the brachial vein. Probably this case presented a central venous stenosis after a catheter placed previously at that level. Such situations are hard to assess without imagistic exploration. The existence of these technical possibilities facilitates an eventual revision procedure similar to the one presented by N. Angle, namely placing a stent in the subclavian vein.¹¹ These interventions associated with a clinical examination and an extremely rigorous anamnesis may establish a global pre-operative vascular profile. Lacking these investigations but insisting on preserving the venous capital, forced us to perform all standard and special methods available in the same upper limb before approaching the other limb. This explains the previously mentioned situations, in which we decided to perform an autologous fistula in the standard technique at the counter-lateral limb after a failed superficialization.

The functionality of these fistulas with their described pathology is maintained within reasonable

limits, ranging from 42% to 95%.^{4,11} The immediate functionality (after the first dialysis) in our case series is of 85.12%, and 65.62% at 3 years. We must emphasize that it is very difficult to compare our results with literature data, due to the fact that Angle, Dorobantu and the Japanese authors report an extremely recent experience, in a decade when the technical equipment is clearly superior and guidelines are clearly established. These authors published patency rates of 95%, 85.2%, and 72.72% respectively, superior to the patency rate reported by us.¹¹⁻¹³

CONCLUSIONS

This type of vascular access has very promising results. The brachial vein superficialization may represent an alternative solution in situations where the superficial venous capital has been depleted. State-of-the-art equipment and correctly implemented guidelines will further improve the results with this type of vascular access.

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