# NECKLACE GRAFT ARTERIO-VENOUS FISTULA BAILOUT IN PATIENTS WITH EXHAUSTED HEMODIALYSIS ACCESSES IN UPPER LIMBS: A PROSPECTIVE SINGLE-CENTER EXPERIENCE

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## Abstract

Background:

**Objective:** This study aims to evaluate the Prosthetic axillo-axillary necklace graft as a potential option for difficult dialysis access when there are no other upper limb options available. The assessment will focus on the patency durability and efficacy of this graft.

**Methods:** We reviewed all cases of patients who came for creation an axillo-axillary arteriovenous necklace graft operation at our unit. The calculation of primary and secondary patency was performed.

**Main findings**: During the study period, 20 patients were included. the primary patency rate was 70% at the 3 months, 45% at 6 months, and 30% at 1 year. The overall secondary patency rate was 100% at the 3 months and 6 months and was 50% at 1 year.

**Principle conclusion:** The selection of arterio-venous access for hemodialysis should be customized based on the condition of the patient's vascular. The utilization of axillo-axillary arteriovenous access has emerged as a viable approach for patients who present with intricate access issues resulting from the depletion of upper limb accesses.

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## Introduction

As the expected life for the renal patients has been increased recently and with presence of complications of the vascular accesses many types of accesses have been appeared.

Numerous intricate locations have been utilized for challenging entry points. These categories can be classified into three distinct groups that exhibit escalating levels of danger and complexity. Consequently, it is advisable to approach them in a sequential manner. [(1)]

The first group consists of patients who underwent chest wall reconstruction using autogenous vein grafts harvested from the lower limb and subsequently translocated to the chest wall, group two: lower limb while group three: unusual vascular access procedures including upper and lower limb arterio-arterial loops. [(2)]

However, the installation of lower extremity access has been prohibited in numerous medical facilities due to the increased susceptibility to infection and the elevated likelihood of lower limb amputation. The axillary-axillary arterio-venous route, which involved the extension of a graft across the chest, gained recognition as the "necklace graft" due to its intricate nature. The initial instances of anterior chest wall arteriovenous grafts (AVGs) were documented during the 1970s. [(3)]

These procedures entailed the utilization of bovine grafts in individuals who had experienced numerous unsuccessful arteriovenous (AV) accesses in the past. [(4)]

Axillary-axillary arteriovenous bypass grafts may be considered as a final resort prior to utilizing a thigh autogenous access, even in instances of unilateral central venous stenosis or occlusion. According to the available evidence, it seems that accessing the chest wall is linked to a reduced infection rate compared to accessing prosthetics in the lower extremity. [(5)]

The utilization of Expanded PTFE as a conduit for vascular access was initially implemented during the latter part of the 1970s. [(6)]

Various modifications have been made to polytetrafluoroethylene (PTFE) in order to enhance its properties. One such alteration is the diastat graft, which is a self-sealing graft made of PTFE and silicone. Another modification is plasma-TFE, which has been created to enable early cannulation and eliminate the requirement for temporary dialysis catheters. [(7)]

### Aim of the work

This study aims to evaluate the efficacy of utilizing necklace grafts as a means of access for

hemodialysis, specifically focusing on the aspects of durability, patency rate, and complications.

## Methods

The study objective was elucidated to all participants.The utilization of laboratory and radiological procedures is commonly seen as standard practice within healthcare settings, hence not typically giving rise to significant ethical concerns. Written informed consents were obtained from all participants, and the study protocol was approved by the ethics committee of the Faculty of Medicine, Minia University, with approval number 422:6/2022 on June 17, 2022.

A comprehensive analysis was conducted on the entirety of patient cases seeking axillo-axillary arteriovenous necklace graft procedures at our medical facility throughout the time frame spanning from July 2021 to March 2023.

The data were gathered in a prospective manner. The preoperative evaluation encompassed a meeting with a nephrologist, and it is possible that a cardiological consultation may be required according to the condition of the patient. The patients had bilateral arterial and venous duplex scans of both upper limbs, as well as venogram procedures of both upper limbs, in order to confirm the patency of their central veins.

**Procedure:**

The treatment was performed utilizing general anesthesia, with patients positioned in a supine posture and their shoulders supported by a shoulder cushion.

Following the sensitivity test, a dosage of a broad spectrum antibiotic was administered. The head was then extended, and sterilization was performed using betadine from the angle of the jaw up to the umbilicus. Incisions were performed bilaterally on the anterior chest wall, namely 1 cm below the lateral third of each clavicle.

The dissection of the pectoralis major muscle was performed, followed by the dissection and division of the pectoralis minor muscle. Subsequently, the clavi-pectoro-axillary fascia was incised, allowing access to the axillary artery and the vein on the other side.

A concave subcutaneous passage located anteriorly to the top third of the sternum was created to facilitate the implantation of a 6*50mm polytetrafluoroethylene (PTFE) graft.

The procedure involved performing venotomy on the vein after heparinization, followed by creating the venous end of the graft in alignment with the direction of the vein parallel to the central venous system. The venous anastomosis was then established as the first step, utilizing a 5-0 polypropylene running suture at an acute angle, and subsequent heparinization (2500 IU) was administered intravenously. Subsequently, the arterial end of the graft was created in alignment with the center, and the arterial anastomosis was performed using a 5-0 polypropylene running suture at an acute angle.

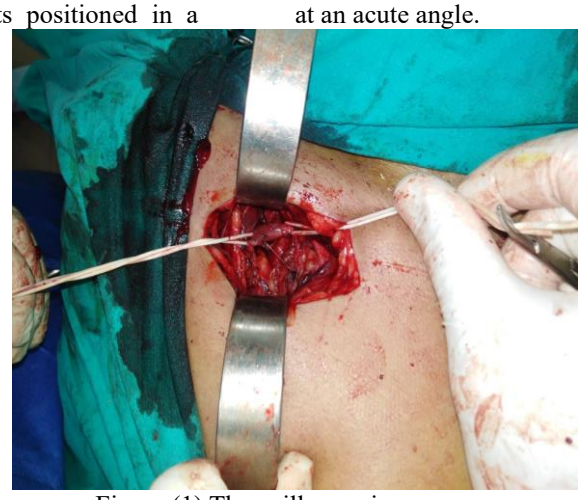

Figure (1) The axillary vein exposure

Figure (2) The venous anstomosis between axillary vein and PTFE graft.

Figure (3) The axillary artery exposure.

Figure (4) The arterial anstomosis between the axillary artery and PTFE graft

To mitigate the occurrence of steal syndrome and minimize the likelihood of intimal hyperplasia, the arteriotomy was modified to a size that is less than 80% of the artery diameter, while also ensuring an anastomotic angle of 15°.

The graft was irrigated, hemostasis was achieved, and the wounds were sutured with the placement of two suction drains. The implanted grafts had a diameter of 6 mm and were composed of internally reinforced expanded polytetrafluoroethylene.


**Figure (5): The final picture after closure anatomically with 2 suction drains**

**Procedural outcome:**

The success of the procedure is contingent upon clinical indicators of success, such as the presence of a palpable thrill, an audible bruit, and the absence of palpable hematomas or aberrant swellings.

**Post-procedural follow up:**

Postoperative assessments were conducted on all patients, with a focus on monitoring the patient's general state following anesthesia. Follow-up was performed to ensure ongoing evaluation and observation.

In the local context, it is important to assess the presence of thrill and bruit related to the graft, as well as any observable hematoma. Additionally, the status of the suction drain, any discharge observed during dressing changes, and the state of the skin should be evaluated.

The individual is administered antibiotics for 10 days.

The suction drain is often removed within a few days if there is no presence of discharge.

If the aforementioned parameters are satisfactory, it may be possible to discharge the patient after a duration of one week, with subsequent follow-up care being provided on an outpatient basis.

The removal of stitches typically occurs within a postoperative timeframe of 10 to 14 days, following which the initiation of dialysis from the graft can commence.

Following this, the participants underwent clinical evaluations at the one-month, three-month, and six-month intervals. These evaluations encompassed assessments of the thrill, bruit, skin condition, cannulation sites, and dialysis adequacy. Additionally, duplex measurements were conducted to determine the peak systolic velocity (PSV) in the graft, assess graft patency, and identify any hematomas associated with the cannulation site.

In cases where the flow rate was below 600 mL/min or had experienced a decrease of 20% compared to the last transonic examination, a fistula-gram was conducted to identify potential early problems and the need for intervention.

The achievement of primary patency and secondary patency will be attained.

This paper will discuss the various complications that may arise in a given situation, and will also explore the corresponding interventions required for each complication. Additionally, the paper will examine the prevailing mood associated with each intervention.

**Results**

During the period of study 20 patients underwent prosthetic axillary-axillary arteriovenous access necklace graft creation for patients who had exhausted all upper limb options bilaterally or who had exhausted all upper limb options unilaterally with a central venous obstruction on the contralateral side

Their age ranged between 22 – 64 years with mean value of 44.150 ± 13.303. Thirty percent of our patients were females and seventy present were males.

As shown in table (1)

**Table (1):** Demographic data of the studied patients

| | | **N= 20** |
|---|---|---|
| **Sex** | Male | 14 (70%) |
| | Female | 6 (30%) |
| **Age (years)** | Range | 22 – 64 |

| | | |
|---|---|---|
| | Median [IQR] | 41 [25.25] |
| | Mean ± SD | 44.150 ± 13.303 |

Hypertension was the most frequent associated comorbidity in the studied patients (80%), which was followed by diabetes mellitus (20%), while cardiac disease was present in 15% of the studied patients, other comorbidities including paraplegia, autoimmune diseases and hepatic diseases were found in 5% of our patient.

Three of our patients were smokers as showing in table (2), and figure (3).

**Table (2):** Associated comorbidities of the studied patients

| | | N= 20 | |
|---|---|---|---|
| | | **N** | **%** |
| **Associated comorbidities** | HTN | 16 | 80% |
| | DM | 4 | 20% |
| | Cardiac | 3 | 15% |
| | Paraplegia | 1 | 5% |
| | Hepatic | 1 | 5% |
| | Autoimmune disease | 1 | 5% |
| **Smoking** | Yes | 3 | 15% |
| | No | 17 | 85% |

NB: the same patient may have more than 1 comorbidities.

The arterial side of the graft was determined by preoperative venography to check for the patency of the central draining veins.

The table below determine the distribution of the arterial side of the graft in the studied patients right arterial side in 60% while the left arterial side in 40 % 0f the studied patients. As shown in table (3)

**Table (3):** Graft characteristics of the studied patients

| | | N= 20 | |
|---|---|---|---|
| | | **N** | **%** |
| **Arterial side of graft** | Right | 12 | 60% |
| | Left | 8 | 40% |

The follow up was illustrates in the following table:

**Table (4):** follow up of the studied patients over 1 year

| | | N= 20 | |
|---|---|---|---|
| | | **N** | **%** |
| **Follow up after 1 months** | Successful outcome (palpable thrill, audible bruit, adequacy of hemodialysis) | 20 | 100% |
| | Complications | 0 | 0% |
| | 1ry patency rate | 20 | 100% |
| | 2ry patency rate | 0 | 0% |
| **Follow up after 3 months** | Successful outcome (without intervention) | 15 | 75% |
| | Complications<br>Thrombosis with successful thrombectomy<br>thrombosis & rupture and terminated<br>thrombosis & infected access and terminated | 5<br>2<br>1<br>2 | 25%<br>10%<br>5%<br>10% |
| | 1ry patency rate | 15 | 70% |
| | 2ry patency rate | 2 | 100% |
| | Failure rate | 3 | 15% |
| **Follow up after 6 months** | Successful outcome<br>without intervention<br>after previous intervention at 3 months | <br>9<br>2 | <br>45%<br>10% |
| | New complications<br>venous hypertension passed conservative | 6<br>3 | 30%<br>15% |

| | | | |
|---|---|---|---|
| | Thrombosis with successful thrombectomy<br>Thrombosis & failed thrombectomy and terminated | 2<br>1 | 10%<br>5% |
| | 1ry patency rate | 9 | 45% |
| | 2ry patency rate | 4 | 100% |
| | Failure rate | 4 | 20% |
| **Follow up after 9 months** | Successful outcome<br>without intervention<br>after previous intervention at 3 months<br>after conservative ttt for venous hypertension | <br>8<br>2<br>3 | <br>40%<br>10%<br>15% |
| | New complications<br>re- thrombosis after previous thrombectomy and successful thrombectomy<br>Re-thrombosis of previous successful thrombectomy & failed thrombectomy and terminated<br>1 case died by non-access related complication | 3<br>1<br>1<br>1 | 15%<br>5%<br>5%<br>5% |
| | 1ry patency rate | 8 | 40% |
| | 2ry patency rate | 3 | 75% |
| | Failure rate | 6 | 30% |
| **Follow up after 12 months** | Successful outcome<br>without intervention<br>after previous intervention at 3 months and 9 months<br>after conservative ttt for venous hypertension | <br>6<br>3<br>3 | <br>30%<br>15%<br>15% |
| | New complications<br>Thrombosis &infection, failed thrombectomy and terminated<br>Pseudoaneurysm and ruptured | 2<br>1<br>1 | 10%<br>5%<br>5% |
| | 1ry patency rate | 6 | 30% |
| | 2ry patency rate | 3 | 50% |
| | Failure rate | 8 | 40% |

Regarding complications, 12 out of the involved 20 patient developed complications (60%) that were thrombosis of access and get infected with failed intervention and terminated in 3 cases (15%), rupture pseudoaneurysm and infection in 1 case (5%), thrombosis and failed intervention and terminated in 1 case (5%) and infected access that was terminated in 1 case (5%). Another 1 case (5%) was died due to non-access related complication. Another 6 cases develop complications but successfully managed; venous hypertension of upper limb that was managed conservative in 3 cases (15%) and Thrombosis and need thrombectomy that was successful in 3 cases (15%) as shown in table (5)

**Table (5):** Complications that were detected in the studied patients during the period of the study

| | | **N= 20** | |
|---|---|---|---|
| | | **N** | **%** |
| **Complications** | Died due to non-access related complication | 1 | 5% |
| | Venous hypertension on conservative ttt | 3 | 15% |
| | Rupture pseudoaneurysm and infection and terminated | 1 | 5% |
| | Thrombosed access and infection and failed intervention | 3 | 15% |
| | Thrombosis and need thrombectomy that was successful | 3 | 15% |
| | Re thrombosis after previous thrombectomy and failed | 1 | 5% |

Figure (6) thrombectomy of thrombosed axillo axillary necklace graft


Figure (7) completion venography post thrombectomy

**Discussion**

The selection of arterio-venous access for hemodialysis should be customized based on the vascular condition of the patients. The axillo-axillary necklace graft, a secondary access method utilized as an alternative to primary vascular access procedures, is typically considered when other upper limb options are not viable. Specifically, axillo-axillary necklace access may be the final upper body option, particularly in instances of severe central venous stenosis, obstruction, or unilateral upper limb arterial insufficiency, particularly in cases involving occlusion of the iliac veins [(8)].

The axillo-axillary necklace graft offers a distinct advantage in comparison to the loop graft due to its enhanced ease of rescue for a straight graft as opposed to a looped graft. Performing a surgical thrombectomy or a radiological intervention, such as balloon angioplasty, in a graft with a loop design has inherent challenges [(9)].

The axillo-axillary necklace graft presents a complex bypass procedure with complications that demand the expertise of skilled vascular surgeons for effective management. Consequently, many medical centers regard this bypass as a treatment option of last resort for patients. As a result, limited research has been conducted on this particular bypass technique [(10)].

A prospective, randomized trial was conducted at the Vascular Surgery Unit at Minia University Hospital. The study included a total of 20 patients who were diagnosed with chronic kidney disease (CKD) and were undergoing regular dialysis. These patients had exhausted all available upper limb accesses. The study was conducted between July 2021 and March 2023 [(11)].

The study revealed that the average age of all participants was 44.150 ± 13.303. Out of the total sample, 6 individuals identified as female while 14 individuals identified as male. Out of the total sample size of 20 patients, 3 individuals were identified as smokers while the remaining 17 patients were non-smokers. Specifically, 12 patients underwent right axillary artery inflow, whereas 8 patients underwent left axillary artery inflow [(12)].

The findings of our investigation were corroborated by the research conducted by Morsy et al. (2008), who reported the enrollment of a total of 18 patients in their study. The average age of the group was 55.1 years, consisting of 10 males and 8 females. In a sample of 11 individuals, right axillary artery inflow was conducted, whereas left axillary artery inflow was performed in 7 patients [(13)].

In the study conducted by O Gale-Grant et al. (2016), it was observed that a group of 35 patients underwent a prosthetic axillary-axillary arteriovenous access graft. The average age of the

participants was 63 years. Of the whole sample, 17 patients were female and 18 were male. In this study, the procedure of right axillary artery inflow was conducted in 18 patients, while the procedure of left axillary artery inflow was performed in 17 patients [(14)].

In a separate study conducted by RL McCann et al in 1996, a cohort of 26 patients underwent a surgical procedure involving the placement of a prosthetic axillary-axillary arteriovenous access graft. The average age of the individuals was 53 years. A total of 26 grafts were surgically implanted, with 22 being placed in females and 2 in males. Two patients necessitated the insertion of a secondary device.

The current investigation revealed that in terms of co-morbidities, four patients exhibited type 2 diabetes, while 16 patients presented with hypertension. Additionally, three patients had heart disorders, and one patient had a hepatic condition.

In the study conducted by Morsy et al. (2008), it was observed that all participants exhibited hypertension, with an additional nine individuals also presenting with type 2 diabetes. Moreover, in the research conducted by RL McCann et al. (1996), it was shown that 10% of the patients had Diabetes, 6% had hypertension, and 8% had other co-morbidities.

The study revealed that the primary patency rate exhibited a pattern of decline with time, with rates of 100% at one month, 70% at three months, 45% at six months, 40% at nine months, and 30% at one year. The secondary patency rate demonstrated complete success at both the 3-month and 6-month follow-up intervals, with a rate of 100%. However, at the 9-month and 1-year mark, the secondary patency rate decreased to 50%.

In contrast to a prospective study conducted by Morsy et al., our investigation revealed primary patency rates of 83% and 72.2% after six months and one year, respectively. Additionally, secondary patency rates were seen to be 94.4% and 88.9% at six months and one year, respectively. In the research conducted by O Gale-Grant et al. (2016), it was seen that the Primary patency rate was 88% upon creation, which decreased to 82% after 6 months and further declined to 42% after 48 months. On the other hand, the Secondary patency rate was found to be 100% during the original revision operation, and it decreased to 85% after 6 months following the revision.

Regarding the complications, our study revealed that 12 out of the 20 patients involved (60%) experienced various complications. These complications included thrombosis of access and infection with failed intervention, resulting in termination in 3 cases (15%); rupture of pseudoaneurysm and infection in 1 case (5%); thrombosis and failed intervention, leading to termination in 1 case (5%); and infected access, which was terminated in 1 case (5%). An further instance, accounting for 5% of the total, resulted in mortality due to complications unrelated to access. Complications were observed in an additional six cases, all of which were effectively controlled. Among these cases, three (15%) presented with venous hypertension of the upper limb, which was successfully managed by conservative measures. The other three cases (15%) exhibited thrombosis, which was effectively treated with thrombectomy procedures that yielded positive outcomes.

The findings of our study were corroborated by the research conducted by Morsy et al. (2008), which documented that two patients (11%) experienced postoperative problems, specifically wound infection. The patients received conservative treatment involving the application of active antiseptic dressings on a daily basis. Two individuals (11%) exhibited transient arm edema on the side of the venous anastomosis. A total of five surgical revisions were successfully performed. The interventions encompassed thrombectomy in four patients, constituting 22% of the sample, as well as the salvage of a ruptured graft subsequent to dialysis, which occurred as a result of repeated needle insertions at the same site. A single coagulated graft was not suitable for surgical modification. A single graft became contaminated in the local area, but it remained in use while undergoing daily cleaning and dressing. Eventually, with the occurrence of confirmed thrombosis, the graft was surgically extracted. During the study period, three patients expired due to circumstances that were not directly associated with their vascular access.

In the study conducted by O Gale-Grant et al. (2016), it was shown that complications arose in five patients subsequent to the original procedure. Two patients experienced infections at the location of their wounds, and both cases were effectively managed using oral medicines. A single patient encountered postoperative weakness in their hand on the artery side, which was subsequently alleviated with the implementation of physiotherapy throughout their hospital stay. Following the surgical procedure, a patient presented with symptoms of arm numbness and weakness on the artery side. Subsequently, a neurologist conducted an evaluation and determined that the patient had incurred a peripheral nerve injury. Out of the total number of 35 modifications conducted, 25 were identified as thrombectomy surgeries, while 5 were categorized as segmental replacements, and the other 5 were classified as conversions to alternative grafts. The stated cause of death for a particular patient was attributed to an infection in the arteriovenous graft wound.

We endorse the utilization of this demanding bypass procedure in individuals who possess a patent superior vena cava, subclavian and axillary vein, and an obstructed contralateral side.

**Conclusion**

Necklace chest wall fistula is considered complex tertiary access for hemodialysis as it has technical challenges in its creation and treatment of its serious complications.

Complications of such access make a lot of nightmares so it should be saved for a special group of patients who had exhausted upper limb accesses.

Complication of necklace fistula may need further challenging surgical techniques and may reach up to upper limb loss and death.

Our short term study recorded complications and follow up within one year of access creation and noticed that there were few previous researches and studies discussing this challenging access.

It is recommended for more futural studies and researches in this access in a trial to overcome technical challenges such as using saphenous conduit to decrease complications and improve quality of life for these patients.

It is recommended for the futural study to record complications and follow up patency rates for longer period.

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