Sine-Wave Technique to Superficialize a Deep Arteriovenous Fistula and Mini Review of the Techniques to Deal with Deep-Seated Arteriovenous Fistula

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Abstract

Context: Deep-seated arteriovenous fistula (AVF) poses a problem for cannulation. Sine-wave technique is described as a superficialization technique. A mini review of techniques of superficialization is presented. Aims: The aim of the study was to describe a technique of superficialization for deep-seated AVF. Settings and Design: This study was a descriptive study. Subjects and Methods: We describe “Sine-Wave” technique of superficializing the deep-seated AVF for easy cannulation. Statistical Analysis Used: Not applicable. Results: Sine-wave technique is an easily performed technique for superficializing the deep-seated AVF with good result. Conclusions: There are various techniques advocated to overcome the difficult cannulation in deep-seated AVF. However, all have certain potential shortcomings. Sine-wave technique of superficializing a deep-seated AVF easily overcomes these shortcomings.

Keywords: Brachiocephalic arteriovenous fistula, radiocephalic arteriovenous fistula, deep-seated arteriovenous fistula, sine-wave technique, superficialization

INTRODUCTION

Arteriovenous fistula (AVF) is the preferred access for hemodialysis for end-stage renal disease (ESRD).\(^1,2\) However, sometimes an otherwise mature AVF is too deep and presents difficulty in cannulation.\(^3\)

Superficialization of a deep-seated AVF is utilized to overcome this difficulty.\(^1,4\) There are many techniques described for superficialization of a deep-seated AVF to overcome the difficulty in cannulation.\(^5\)

We describe a new technique of superficialization as we felt there are potential shortcomings with the other described techniques in the literature. We have christened this technique as “sine-wave” technique to reflect the shape of the incision that is made. This technique was successfully utilized in two cases where the AVF was too deep and considered not fit for cannulation by the Nephrologist and dialysis technician.

I never lose. I either win or learn

Nelson Mandela.

SUBJECTS AND METHODS

Case 1
A 58 year old, diabetic, hypertensive, and obese female, with ESRD, stage five, was on maintenance hemodialysis through a tunneled catheter. She was referred to our center for the creation of AVF. The brachiocephalic fistula (BCF) AVF at elbow crease was created.

However, after about 10 weeks, only a small segment, near the elbow crease, had a thrill and the nephrologist and dialysis technician pronounced it too difficult for cannulation.

However, color Doppler flow imaging (CDFI) showed good caliber vein of 6 mm and good flow rate (800 ml/min) but was at a depth of (12–14 mm) from the skin. Because of deep

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How to cite this article: Chatterjee P, Dabas AK. Sine-wave technique to superficialize a deep arteriovenous fistula and mini review of the techniques to deal with deep-seated arteriovenous fistula. Indian J Vasc Endovasc Surg 2018;5:253-8.
location of AVF, the thrill was not palpable and it was not considered fit for safe cannulation.

She was taken up for superficialization under local anesthesia (2% lignocaine) using sine-wave technique. She had good recovery. There was no wound complication and sutures were removed on the 12th day.

The dialysis was started successfully through the fistula after 4 weeks and tunneled catheter was removed. After 6 months of follow-up, AVF was functioning well [Figures 1-6].

**Case 2**

A 58 year old lady with diabetes, hypertension, and ESRD was referred for the creation of AVF. The first attempt at wrist had failed. However, the second attempt at radiocephalic fistula (RCF) AVF at distal forearm was successful.

However, in follow-up, even after 12 weeks, AVF was deemed not suitable for cannulation by the dialysis technician. The CDFI showed a good caliber vein (7 mm) and good flow rate (650 ml/min), but the vein was deep (10–12 mm).

She underwent superficialization of the vein using the sine-wave technique under regional anesthesia. She had good recovery. There were no wound complications and sutures were removed on the 14th day. The fistula is functioning well after 6 months of follow-up [Figures 7-10].

**Description of the technique**

A curvilinear “sine wave” incision is given over the arm or the forearm. The incision is given so that underlying arterialized vein/AVF is at the center of the deflections of the amplitude, so-called “baseline” of the wave. Care is taken that the amplitude and half wavelength are equal as depicted in the diagram. It is based on the principles of raising random pattern skin flaps where the height: base ratio is kept at 1:1 or less, that is, height of the flap must not exceed the base of the flap [Figure 11], to ensure perfusion of the distal margin of the flap.[6]

Incision is made vertically downward without beveling down to the underlying veins. The skin flaps are raised using skin hooks along the markings to obtain wide exposure of the area of interest. The initial flaps are raised at the level of vein, which

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**Figure 1:** Preoperative marking of the deep-seated arteriovenous fistula

**Figure 2:** Sine-wave incision marked

**Figure 3:** Vein mobilized and side branch tied

**Figure 4:** Skin flaps approximated after removing fat
would mean the flaps will have sufficient (unwanted) thickness. The vein is also mobilized fully off its bed. Subsequently, the flaps are thinned out and made devoid of the unwanted fat with use of sharp scissors, and bipolar cautery is used for meticulous hemostasis. The aim is to obtain skin flaps with just enough layer of fat to preserve the deep-dermal and sub-dermal plexus of chain-linked vessels that ensure viability of the skin flap tips of random pattern skin flaps. This allows for the preservation of the deep-dermal and sub-dermal plexus of chain-linked vessels that ensure viability of the skin flap tips of random pattern skin flaps.
pattern skin flaps.⁷ Such thin flaps, overlying the fistula, make the cannulation easy due to improved palpability.

Moreover, tying off any draining side branch or any underlying stenosis can also be dealt in the same sitting. The flaps are sutured back to restore the sine wave continuity of the skin markings. We prefer closure in two layers with skin sutures in vertical mattress configuration to ensure eversion of skin edges. The thrill can be appreciated just after the closure. A light, nonadherent, noncompressive gauge dressing is done. The wound is inspected on the 3rd and 7th days after the procedure and the sutures are removed after 14 days.

The fistula can be utilized any time after 2 weeks.

**Discussion**

AVF remains the best possible means for the hemodialysis.¹² In some patients, especially obese, despite achieving good flow rates and good caliber of the vein, AVF is not easily accessible due to the excess depth of the vein. The thrill is not palpable and it presents difficulty in safe cannulation.³⁴

Early attempts of transposing the veins or AVF to superficial planes were made with basilic vein in arm⁹ and in forearm with cephalic veins⁹ with good results.

Since then, various methods have been described to overcome the difficulty of deep-seated fistula.

The procedures described in the current literature are have been termed differently such as fistula elevation procedure (FEP),⁸⁻¹¹ superficialization,¹¹ lipotomy,¹²⁻¹⁴ liposuction over the fistula,¹⁵⁻¹⁷ tunneling with transposition,¹⁸⁻⁰ and minimal incision superficialization technique (MIST).¹⁹

All the above techniques are testimony to human diligence, ingenuity, and perseverance to overcome an obstacle.

The efforts started with reporting of use of basilic vein for AVF by Dagher et al.⁹ By virtue of its deeper location along with proximity to brachial artery and nerves, it required transposition to the anterior location by tunneling. Since then good results have been reported,¹⁹ and it has been accepted as standard procedure now.⁵

Dagher et al. performed 23 brachio basilic AVF. All the procedures were done in a single stage. They had an average of 8 months of follow-up for fistula usage. They reported good results with only two failures.⁶

Silva et al. reported their results of tunneling and transposition of cephalic vein in forearm.⁹ Out of 89 AVF, with cephalic vein transposition in forearm, maturation rate was 91%. Cumulative patency rate (life table analysis) was 84% at 1 year and 69% at 2 years.

Cull et al. reported the technique of FEP in 20 cases of BCF and 7 cases of RCF.⁶ FEP involved placing a longitudinal incision over the fistula, mobilization of the vein along the incision, ligation of tributaries, and dealing with any stenotic segment, approximating the subcutaneous fat beneath the vein. Thus, the vein was elevated to a more superficial plane and the skin is closed over the vein. In BCF group, the cumulative patency was 71% at 1 year and 60% at 2 years. However, in RCF group, there were five early failures. They also used FEP in eight cases of brachio-basilic AVF where the vein length was inadequate for tunneling. In this group, 50% were considered success. For all the FEP procedures, the combined cumulative patency rates were 53% at 1 year and 47% at 2 years.

The same group reported their experience of 295 consecutive FEP done over a period of 7 years.¹¹ They reported functional primary functional patency of 73% at 6 months, 60% at 1 year, and 46% at 2 years. Mean duration of follow-up was 36 months. Sixteen percent of AVF were single stage and 84% were as two stage. Fifty-eight percent were BCF, 46% were RCF, and 24% were brachiobasilic fistula (BBF) and seven cases (2%) involved superficial femoral vein fistula.

In BCF group, primary patency rates were of 62% at 1 year and 47% at 2 years. In RCF group, primary patency rates were 66% at 1 year and 39% at 2 years. In patients with BBF, 52% were patent at 1 year and 45% at 2 years.

During the same period Weyde et al. reported their technique of “superficialization” to tackle the deep-seated veins.¹¹ This technique is quite similar to that of FEP. A longitudinal incision was made just lateral to the underlying vein, mobilization of the vein with division of the tributaries, and closure of the vein bed and fat, and the vein was placed in pocket created beneath the skin. They did 24 such procedures and reported only one failure due to hematoma in immediate postoperative period. Rest all were successfully cannulated. The actual survival percentage was 95.6% at 1 year. They advocated a two-stage procedure.

Lipotomy for dealing with deep-seated veins was described by Bourquelot et al.¹¹ Authors advocate use of tourniquet. Two transverse incisions made 8 cm apart are used to remove fat. The pad of fat removed, extends from peri-adventitial plane of the vein to beneath the skin leaving about 1 mm fat.
beneath the skin. Laterally, fat is removed up to 2 cm from
the vein. A drain is placed and skin incisions are closed. Out
of 49 patients, with RCF, immediate technical success was
reported in 47 patients (96%). In their series, primary patency
rates were 71% ± 7% at 1 year, 63% ± 7% at 2 years, and
63% ± 8% at 3 years.[13]

Another technique described for overcoming the difficulty
of cannulating the deep AVF is liposuction[16,17] Causey et al.
reported one case which was successful.[16] Krochmal et al.
reported a short series of three cases.[17] All were successfully
cannulated.

The technique involves ultrasound (USG)-guided tumescent
infiltration along the vein and later liposuction by standard
liposuction equipment under USG guidance till a thrill is
palpable.[16,17]

Evans et al. used the tunneling and transposition technique for
superficialization in 23 cases of deep-seated RCF and BCF.[4]
The cephalic vein was mobilized using a single long incision,
divided near the arterial end and was tunneled in a superficial
plane and anastomosed to restore the continuity. Out of 23
AVF, 21 were considered fit for cannulation.[4]

Inkollu et al. reported MIST and its results.[18] The technique
involves two small incisions at two ends of the segment to be
mobilized. The vein is mobilized with ligation of tributaries,
divided, and valves dealt with valvulotome. The vein is then
tunneled in a subdermal plane and anastomosed to reestablish
the continuity.

They reported results of 162 MIST procedures done over a
period of 6 years. The technical success was 100%. Fourteen
cases were excluded for valid reasons. The primary patency
rates for 148 procedures was 70.6% at 6 months, 62.1% at
1 year, 52% at 2 years, and 38.9% at 3 years.[18]

Another technique to overcome the deep-seated veins
described is, implantable titanium devices, called Venous
Window Needle Guide (VWING; Vital Access Corp, Salt Lake
City, Utah).[20-22] The technique involves exposing the segment
of the vein by a small incision and suturing the device to the
vein. The incision is sighted in a manner that the scar does
not interfere with identification of the device or cannulation.
A limited lipectomy is also done if deemed necessary.
Alignment of the device is kept longitudinally along the axis
of the vein and oriented perpendicularly to the skin surface. If
part of the vein is palpable and accessible for cannulation, then
only one device is required otherwise two devices are required.
The sizes of the device would vary with the patient habitus
and vein size. Use of USG is also recommended to select an
appropriate site of implantation. This device is suitable only
for buttonhole method of cannulation.

Jennings et al. reported the results of implantable titanium
devices, called Venous Window Needle Guide (VWING).[21] A
total of 82 devices were implanted with 100% technical success
rate. Three devices (3 cases) were excluded from the study. One
died before cannulation and the other two refused to participate
in the study. At the end of 6 months, out of the remaining 79
devices, three could not be cannulated due to depth and another
one was not properly oriented. At the end of 6 months, 66 of
the 82 devices implanted were successfully in use.

Forneris et al. also reported six cases of VWING device
implantation, with technical success in all cases.[22]

We believe that there are several advantages of sine-wave
technique over others.

First, it avoids an additional anastomosis, and possibly a
long-term additional site for intimal hyperplasia induced
stenosis as required in techniques of superficialization,[3]
MIST,[18] and tunneling and transposition.[9]

Second, the vein is not tunneled as described in tunneling and
transposition,[9] and MIST.[18] Hence, possibility of twisting and
damage to the vein is avoided.

Third, the scar tissue does not lie over the complete length of
the vein as in FEP.[10,11] The scar tissue will cross only the small
fraction of the vein. Moreover, possibility of the scar hypertrophy
and keloid formation will not hamper the use of the fistula.

Fourth, it is never a blind procedure. In MIST, two small
incisions are made and the vein is dissected free for almost a
length of 10–12 cm which leads to a possibility of dissecting
a portion of vein in a blind manner and in such case there may
be damage to vein or avulsion of the branches.

In the technique of lipectomy, a transverse incision of 8 cm
is made and fatty tissue is resected for about 4 cm on either
side of incision.[13,14] In lipectomy, one plane is certain that is
periadventitial plane. However, to exactly determine the
plane between the skin and fatty issue appears difficult with
a possibility of either creating a buttonhole or leaving behind
more than the desired tissue.

In the present (sine wave) technique, the skin flaps are raised
and the desired amount of fatty tissue can be resected under
direct vision.

Fifth, with MIST and lipectomy technique, the segment of
the vein mobilized is limited by the incision. However, with
the technique described any length of vein can be mobilized
between wrist and elbow in case of RCF and between elbow
and shoulder in case of BCF.

Sixth, it does not require any additional skill or equipment
such as in liposuction technique or VWing. Other drawbacks
of liposuction are that it is not advocated in tortuous vein.
Moreover, the cost and availability are the other potential
drawbacks in third world countries.

Seventh, there is no requirement of tourniquet application as
is done in lipectomy as hemostasis is easily achieved.

Eighth, after superficialization by this technique, any technique
of cannulation can be followed and not the “buttonhole”
technique alone as mandated by VWing implants.
**Drawback**
Only two cases have been done with this technique though were no complications. However, a more number of cases with long-term follow-up are required for establishing this as one of the available standard techniques of dealing with a deep-seated AVF.

**Conclusion and Results**
Deep-seated AVF is more likely to be encountered with rise in obesity. The technique described is not only intuitive but also based on a sound, time-tested scientific technique of random pattern flap. We do hope that it will establish itself as one of the versatile techniques in dealing with deep-seated AVF.

**Declaration of patient consent**
The authors certify that they have obtained all appropriate patient consent forms. In the form the patient(s) has/have given his/her/their consent for his/her/their images and other clinical information to be reported in the journal. The patients understand that their names and initials will not be published and due efforts will be made to conceal their identity, but anonymity cannot be guaranteed.

**Acknowledgment**
We acknowledge with all humility the help rendered by our revered teacher Mr RPS Gambhir MS, DNB, FRCS Ed, FRCS, FACS, Consultant Vascular Surgeon King’s College Hospital London, at all stages of preparation of this article. Also, we would like to put on record our gratitude to our Nephrologist colleagues, Col Jairam and Gp Capt Vishal Singh.

**Financial support and sponsorship**
Nil.

**Conflicts of interest**
There are no conflicts of interest.

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