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Different Techniques of Microvascular Anastomosis

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Abstract: Background: Several new techniques have been developed for microvascular repair to reduce the procedure time, such as laser, glue, intravascular stent and precise microvascular anastomotic system. The major reasons for developing these alternative techniques are to reduce the time required to perform an anastomosis, an operation that takes up most of the time in a reconstructive microsurgical procedure, as well as the amount of suture material used, the trauma inflicted, and the likelihood of thrombosis; additionally, the elimination of size discrepancy, the reduction of costs, and the development of a technique that is relatively easy to learn and perform are other factors contributing to the development of these alternative techniques

Introduction

Several new techniques have been developed for microvascular repair to reduce the procedure time, such as laser, glue, intravascular stent and precise microvascular anastomotic system. The major reasons for developing these alternative techniques are to reduce the time required to perform an anastomosis, an operation that takes up most of the time in a reconstructive microsurgical procedure, as well as the amount of suture material used, the trauma inflicted, and the likelihood of thrombosis; additionally, the elimination of size discrepancy, the reduction of costs, and the development of a technique that is relatively easy to learn and perform are other factors contributing to the development of these alternative techniques **(1) .**

However, the classic suture techniques have the better patency rate and results than these new technologies. The success of microvascular anastomosis and minimization of postoperative complications are related to exposition of adventitia and media; choice of suture material and needle; number of sutures; suturing technique; elimination of luminal occlusion linked to inversion, eversion, stenosis, thrombosis, and intimal thickening; and freeing the lumen from foreign material as well as a traumatic meticulous handling **(2).**

End-to-end anastomosis

By far, the most frequently used technique is the end-to end anastomosis. Because of its simplicity in less experienced hands, it has one of the lowest failure rates**. (3)**

1) Conventional Interrupted Sutures Technique

The suture is passed full thickness from the outside-in direction of one vessel end into the lumen and then from the inside out through the other vessel end. Preferably, the knot is tied on the outside.An average of eight sutures is needed to achieve an anastomotic strength comparable with the native vessel wall **(4).**

Although, the classical interrupted anastomosis technique, has already some disadvantages including leakage on clamp release which requires additional stitches, prolonged oozing duration and the longer time it requires for a successful anastomosis, which can be a compromising factor in prolonged cases of replantation or free tissue transfers **(5).**

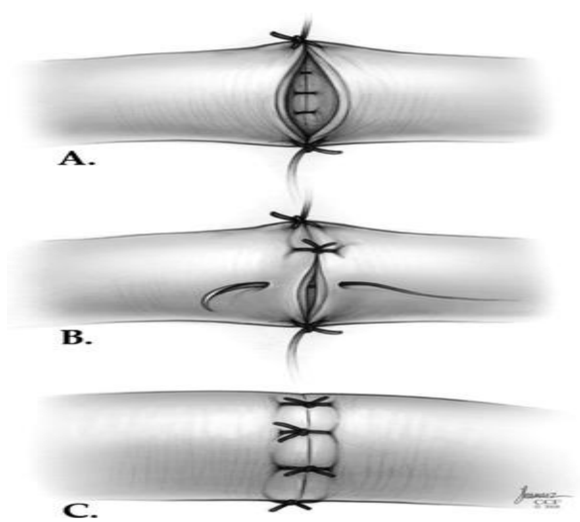

Fig .1. Schematic illustration of the simple interrupted technique. The vessel ends are bisected with two stay sutures placed at 180 (the posterior wall is finished) (A). The suture is passed full thickness from the outside-in direction of one vessel end into the lumen and then from the inside-out through the other vessel end (B). The knot is tied on the outside and step B is repeated finishing the anterior wall (C). **(5).**

2) Continuous Suture Technique

The continuous suture technique can save anastomosis time over interrupted technique, and it has the advantage rapidly reperfusing the involved tissues under conditions in which time is a factor **(6)**

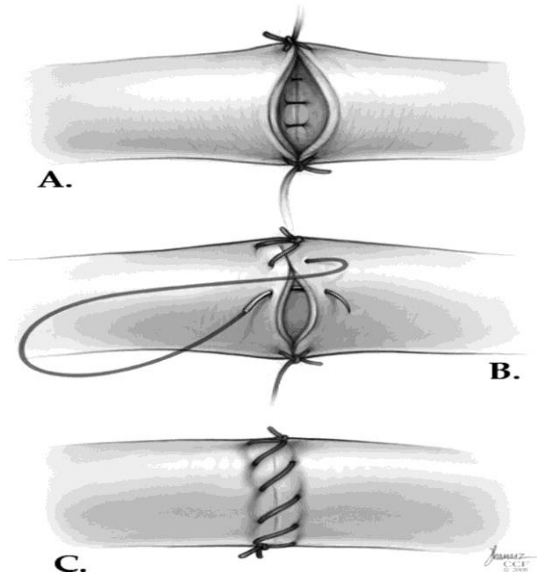

Fig.2. Schematic illustration of the continuous suture technique. The vessel ends are bisected with two stay sutures and one end is used to finish the posterior wall after flipping the clamps (A). Each suture is passed from the outside of the donor vessel to the inside of the recipient vessel (B). A total of two knots are tied at the end of the procedure: one at the apex and one at the base (C) **(5).**

3) Sleeve Anastomosis Technique

The sleeve anastomosis technique begins with meticulous adventitial trimming and sufficient gentle dilatation of the proximal (feeding) vessel end. This is followed by partial thickness bites (without entering the vessel lumen) placed at a distance approximately one and half times the vessel diameter from the vessel end **(5).**

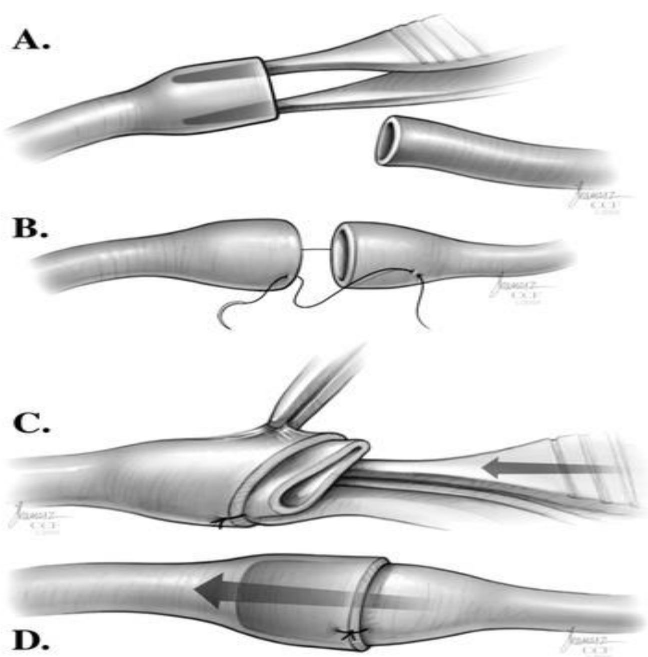

Fig.3. Sleeve anastmosis technique steps **(5).**

4) Spiral-Interrupted Technique

The spiral-interrupted technique is a unique modification that involves placing a loose running suture to form a decrescendo spiral (loops) on the surface of the anastomosis. This suture then becomes interrupted following tangential cuts made through the loops. All suture segments are then tied individually as similar to the common interrupted technique **(5).**

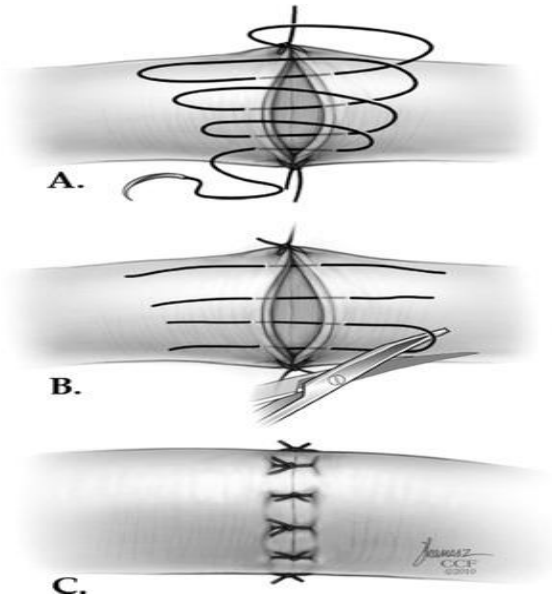

Fig.4.Schematic illustration of the spiral anastomosis. A loose running suture is placed to form a decrescendo spiral (loops) on the surface of the anastomosis (A). This suture then becomes interrupted following tangential cuts made through the loops (B). All suture segments are then tied individually as similar to the common interrupted technique (C) **(5).**

5) One Way Up Technique

This is a useful technique of end-to-end anastomosis in tightly confined spaces, and when we cannot properly manipulate both the vessels of the microvascular anastomosis, we cannot manage to rotate it in order to carry out the suture of the posterior wall. **(3)**

When performing the one-way-up technique, we begin suturing the posterior side. The needle is introduced from the deep side of the vessel to the intima of the posterior wall and returns through the intima in the lumen of the posterior wall of the opposite vessel. The knots are the same as in simple stitches. After placing three or four stitches in the posterior wall in an inverted fashion, it is easy to perform the remaining stitches in a conventional way. It is important to place the posterior wall stitches close enough to prevent any leakages, as revising the posterior wall is bothering. Lastly, the anterior face is sutured **(7).**

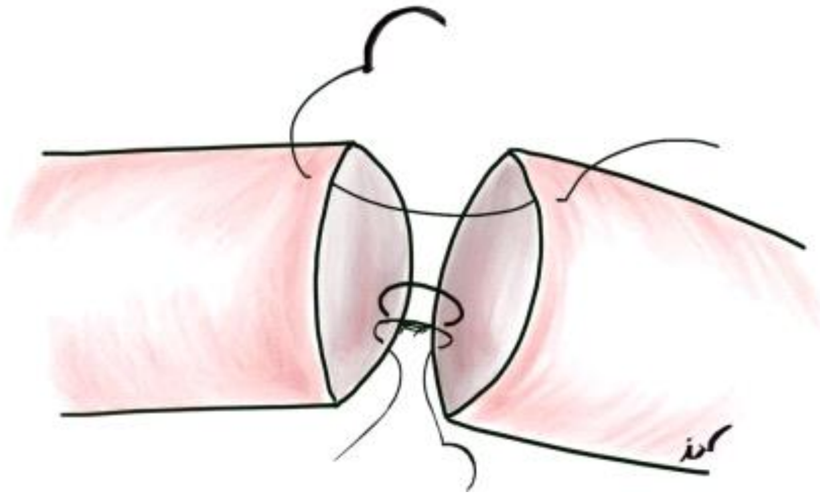

Fig.5. Illustration of One Way Up Technique **(3)**

6) Eversion with Four sutures technique

This technique requires two require two fish- mouth incisions and four stitches for an anastmosis , and it can reduce the anastmosis time and the surgical trauma to the vessel without compromising the patency rate , bleeding time or anastmotic healing .In addition this technique significantly reduce the amount of forign body exposed to the lumen **(8).**

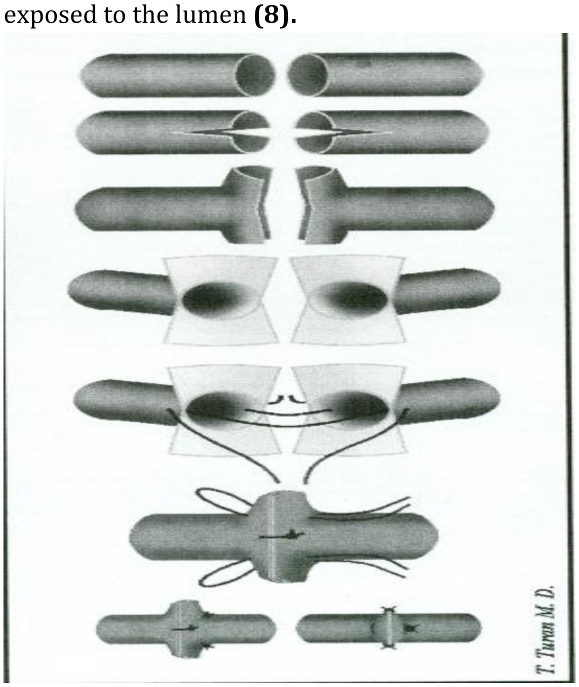

Fig.6.A step-by step schematic view of eversion with four sutures technique **(8).**

7) Multiple U Technique

The Multiple U technique is our technique of choice. It combines the safety of simple sutures with the comfort and speed of the continuous ones. It allows to constantly maintain a perfect visualization of the vascular lumen and at the same time minimizes the necessary maneuvers, to ensure that the opposite vessel wall is not inadvertently caught with the needle. **(3)**

The multiple-U technique for microvascular anastomosis starts by making two orientation sutures at the 12- and 6-o'clock positions, which define the anterior and posterior walls, respectively Then, running sutures are placed over the anterior wall in a continuous and horizontal mattress fashion. We then tie knots with the first two limbs on the same side, forming interrupted horizontal mattress sutures . Repeat this process and continue to tie knots with the following limbs on the same side, which will eventually allow the formation of multiple interrupted horizontal mattress sutures over the anterior wall . After the anastomosis is complete on one side, we can flip the vessels over and repeat the same process on the other side to finish the anastomosis **(9)**

End-to-side anastomosis

The reason for placing running horizontal mattress sutures first and then tying knots interruptedly later is that it allows a clear visualization of the back wall and prevent damage during the anastomosis. Additional simple interrupted sutures can be made for reinforcement if leakage is found after releasing the vessel clamps. **(9)**

End-to-side anastomosis

The multiple-U technique is a widely available technique that guarantees everted anastomosis sites and solid intima-to-intima contact. This technique can be performed on both arterial and venous anastomoses regardless of vessel size and wall thickness.

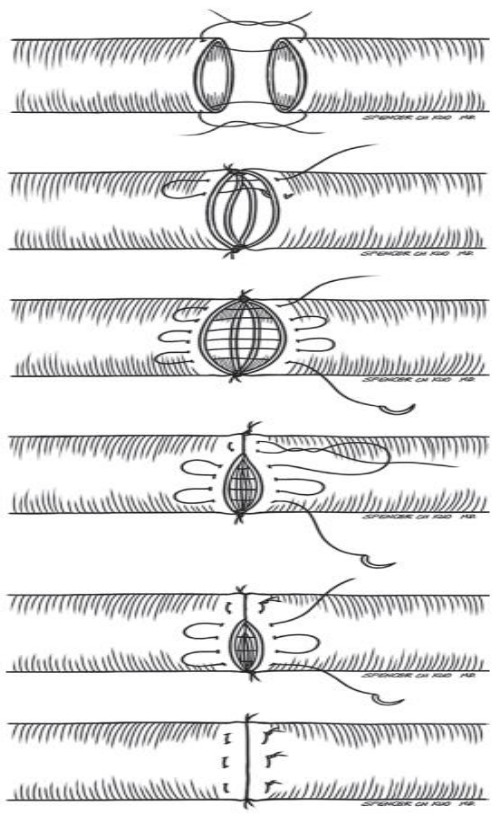

Fig. 7. (Above) Make two orientation sutures at the 12- and 6-o'clock positions, which define the anterior wall and the posterior wall. (Second and third rows) Place running sutures over the anterior wall in a continuous, horizontal mattress fashion. (Fourth and fifth rows) Tie knots with the first two limbs on the same side interruptedly, forming an interrupted horizontal mattress suture. (Sixth row) Form multiple interrupted horizontal mattress sutures over the vessel wall **(9)**

End-to-side anastomosis

This type of suture is very useful when there is a great discrepancy between vascular lumens, or when the flow through a vascular axis must be preserved. Therefore, it is very useful in lower limb reconstructions, when one of the vascular axes is damaged or we want to preserve the integrity of all**. (10)**

For example, in head and neck surgery, after a cervical dissection, the high rate of venous thrombosis makes it advisable to choose the internal jugular as recipient vein**. (11**)

In view of the discrepancy between the internal jugular and the vein of any flap, as well as the pertinence of maintaining the flow through the internal jugular, an end-to-side anastomosis is frequently chosen**. (3)**

To perform this end-to-side anastomosis, we must occlude the flow through the larger vessel that will remain in continuity. Next, by putting traction on the wall of the vessel with a transmural suture, we elongate the wall and make a section with the straight adventitectomy scissors or with a scalpel. **(10)**

The diameter of the hole created must not be greater than the one on the recipient vessel present in the free flap. If possible, the flap is tilted over the anastomosis to suture the posterior face; otherwise, we will use a one-way-up suture technique **(12)**

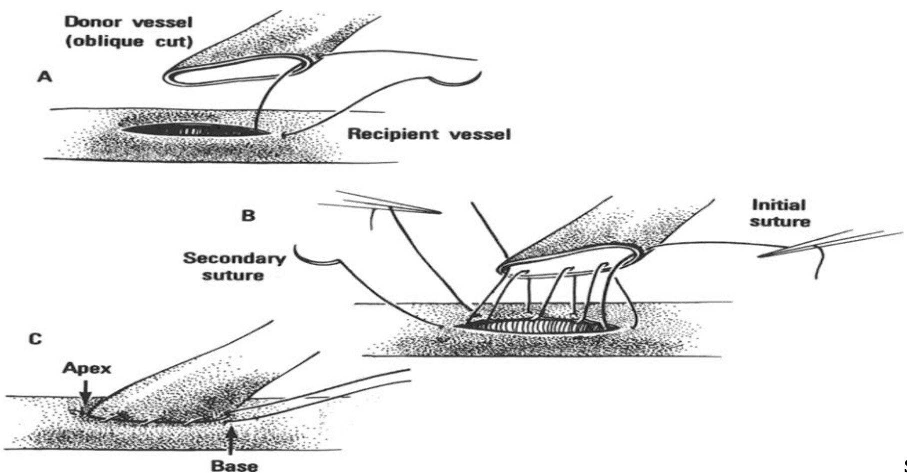

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Fig.8. End to side Microvascular anastmosis **(12)**

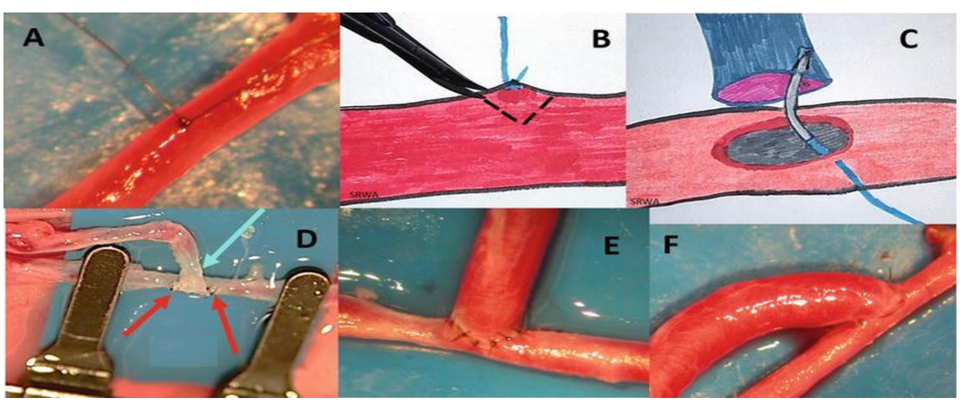

Fig.9. Performing and end-to-side anastomosis. (A) A suture is tied to the arterial wall (media). (B) A "v"-shaped cut is made. (C) The needle is pushed from the artery to the donor vessel, starting from the right side. (D) Two stay sutures at 180° (red arrows) stabilize the donor vessel; one more is put mid-way at the back (light blue arrow). (E) The sutures are placed radially and evenly. (F) Completed **(12).**

Recent innovations in microsurgery

As Microvascular anastomosis is a critical aspect of reconstructive surgery, it has witnessed significant advancements in recent years. These innovations aim to improve surgical outcomes, reduce operative time, and enhance the overall success rate of microvascular procedures. This chapter explores some of the most recent innovations in microvascular anastomosis techniques and technologies.

1. Supermicrosurgery

Supermicrosurgery represents a groundbreaking innovation in microvascular anastomosis, allowing surgeons to perform intricate procedures with enhanced precision. This technique involves the use of specialized microsurgical instruments and high-power magnification systems, enabling the repair of vessels with diameters as small as 0.3 to 0.8 millimeters **(13).**

Supermicrosurgery has revolutionized the field by expanding the scope of reconstructive procedures to include free tissue transfer in areas with limited vascularity, such as lymphaticovenous anastomosis for lymphedema treatment **(14).**

2. Robotic-Assisted Microvascular Anastomosis

Robotic-assisted microvascular anastomosis offers several advantages over traditional manual techniques, including enhanced dexterity, stability, and precision. Robotic systems, such as the da Vinci Surgical System, enable surgeons to perform microvascular anastomosis with improved ergonomics and reduced tremor, thereby minimizing the risk of technical errors. Recent studies have demonstrated the feasibility and safety of robotic-assisted microvascular anastomosis in various reconstructive procedures, highlighting its potential to improve surgical outcomes and expand the capabilities of microsurgery **(15).**

3. Microvascular Coupling Devices

Microvascular coupling devices represent a promising innovation in microvascular anastomosis, offering an alternative to traditional suturing techniques. These devices utilize mechanical or magnetic coupling mechanisms to achieve vascular approximation and secure anastomotic connections **(16**).

Recent advancements in microvascular coupling technology have resulted in the development of miniaturized, biocompatible devices that facilitate rapid and reliable vascular anastomosis. Clinical studies have demonstrated the efficacy of microvascular coupling devices in various reconstructive procedures, with comparable outcomes to conventional suturing methods **(17).**

4. Indocyanine Green Fluorescence Imaging

Indocyanine green (ICG) fluorescence imaging has emerged as a valuable tool for intraoperative assessment of microvascular perfusion and patency. By intravenously administering ICG dye and visualizing its fluorescence using near-infrared imaging systems, surgeons can evaluate blood flow in real time during microvascular anastomosis **(15).**

Recent advancements in ICG fluorescence imaging technology have led to the development of high-resolution, real-time imaging systems that provide detailed visualization of microvascular anatomy and perfusion dynamics. This technology has been shown to improve intraoperative decision-making and reduce the risk of postoperative complications in microsurgical procedures **(18).**

In conclusion ,Supermicrosurgery, robotic-assisted microvascular anastomosis, microvascular coupling devices, and indocyanine green fluorescence imaging represent just a few examples of the advancements driving progress in microsurgical practice. Continued research and development in this area hold promise for further improving the safety and efficacy of microvascular procedures in the future.

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