Chapter 3. Microvascular anastomosis on rat living model

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The most common skill needed for microvascular surgery is the anastomosis of small (1-3mm) blood vessels. Once this is mastered you will be able to perform a whole range of surgical procedures, from replantation and revascularization to free flap transfer. Several exercises can simulate real life situations using different models (latex, chicken, rat femoral vessels). Practice is the key to develop microsurgical skills.

Equipment and instruments

Most surgeons use the surgical microscope for magnification. It offers several advantages: wide-field, adjustable range of magnifications with superior depth perception, incorporated lightning, allows simultaneous access for the surgeon and the assistant, it can be linked to an external monitor for training or monitoring purposes. The microscope should be fitted with 10× to 15× eyepieces and a 200 to 300 mm focal length objective lens. For most exercises, a maximum magnification of 25× should suffice. In the operating room setting it is useful to use the footswitch for the control of the zoom and focus of the microscope.

Another option is the use of surgical loupes (magnification from 2, 5 to 6×) which have a larger field of view, but their magnification is fixed, and do not have a lightning system.
They also require a still position of the head and neck, which can be tedious for longer procedures.

*Microsurgical instruments* are specially designed in terms of shape, weight and length in order to facilitate easy, precise movement. The minimal instrument tray should contain: a needle holder, two jeweler’s forceps, a vessel dilating forceps, two microscissors (a straight and a curved one), two individual clamps, a double vessel clamp, and a vessel irrigator.

In order to balance and rotate them with ease, the instruments should be held between fingertips, as a pencil. In microsurgery the fingers initiate the movements, with a small input from the wrist. The hands should be held stable, supported on the table, on their ulnar side. The needle holder and the microscissors are used with the right hand and the forceps with the left one (for the right handed surgeons). You need to establish an order for the instruments on the table within easy reach, to be able to grasp them without lifting the eyes from the microscope; thus eye fatigue is avoided.

The usual *suture material* is 9/0 or 10/0 monofilament (nylon or polypropylene). The needle has a non-cutting, tapered point and a flat body, and it is produced in a range of curvatures. The tapered point provokes minimal damage when passing through the vessel wall and the flat body allows a safe grip with the instruments. The needle curvature is chosen according to the confines of the surgical field. The needle should be positioned in the needle holder just distal to its middle, at an angle of 90 to 120 degrees.
Before starting make sure that you are in a comfortable position with both feet on the ground, neck straight, forearm and hands well supported, the table adjusted to the proper working height. A relaxed, comfortable position and a focused mind will reduce tremor.

1. Microvascular end to end anastomosis

Vessel exposure
Using the usual surgical instruments the soft tissues are dissected to identify the vessels. Place the small retractors in the muscle to properly expose the vessels. (Fig 1-3)
The microscope is brought in the operating field and it will be used for the rest of the surgical steps. It is set on medium magnification. From this stage forward the microsurgical instruments will be used.

Using two forceps, or a forceps and a microscissor, the pedicle sheath is opened and the vessels are liberated from the surrounding tissue. The collaterals are dissected, ligated and cut. All the manoeuvres are done under clear vision, in a bloodless field. The vessels are manipulated gently grasping them only by the adventitia. The vessels should be liberated on a sufficient length, such as the vessel can be turned and to allow for the placement of microclamps.

A blue or yellow **background** is placed under the vessel. It isolates it from the surrounding tissue and prevents injury to the other elements of the pedicle. (Fig 4)
Placing the microapproximator - For the beginner is easier to start with the microapproximator (two clamps sliding on a rail). Grasp the rail and separate maximally the 2 clamps. The vessel will be grasped by the adventitia and placed in distal 3rd of the clamps' jaws to achieve optimal occlusion pressure. The distal clamp is closed first, the artery is pulled gently towards it (to ensure maximal length between the clamps) and then the proximal one is closed. (Fig 5)

Fig. 4. Vessels exposure using magnification

Fig. 5. Placing the microapproximator
**The vessel is sectioned** using the straight microscissors, perpendicular on its long axis, at the middle of the distance between the two clamps. The ends retract slightly. The lumen is gently *dilated* using the vessel dilating forceps avoiding any trauma to the intima. (Fig 6)

![Image](image.png)

Fig. 6. The vessel is sectioned under the microscope

Using the fine *microirrigation* blunt cannula (30 gauge) the blood and the debris are washed away from the vessel ends. The irrigation fluid is heparinized saline or Ringer solution (1000 UI/dl). Only the irrigation liquid enters the lumen not the cannula tip, in order to prevent intima damage.

The next step is *adventicectomy*. The magnification is increased and the adventitia is gently pulled along and over the vessel end. The excess is trimmed with straight scissors, taking care not to injure the vessel end (which can be seen through the transparent adventitia). The rest of it will retract and the ends will be cleaned. Thus the edges are clear and the adventitia will not be pulled in the vessel with the sutures. The two clamps are brought closer, sliding them on the rail, reducing the distance
between the ends to 1-2 mm. This allows the tension free suture of the vessel wall.

**Placing the stay sutures**
The stay sutures are used to align the vessel ends and will facilitate their manipulation. In the majority of cases we use the triangulation method described by Carrel. The sutures are placed at $120^\circ$ to each other (at 10, 2 and 6 o’clock positions). Thus the posterior wall falls backward and catching it while suturing the anterior wall is avoided. For smaller vessels (under 1 mm) or vessels of different caliber, triangulation is difficult and the stay sutures are placed at $180^\circ$.

Zoom in the microscope and place the first 2 stay sutures (at 10 and 2 o’clock) (Fig 7)

![Fig. 7. Placing the first stay sutures](image)

Introduce the forceps gently in the vessel lumen, and use it as counter pressure when passing the needle. The needle is introduced perpendicularly, piercing the vessel wall at a
distance 2 times the thickness of the wall for the arteries and 3 times the thickness of the wall for the veins. By pronating the hand, slide the needle through the wall, and recuperate the needle with the forceps on the other side. Never grasp the vessel wall or the tip of the needle. Take the needle in the needle holder, open the other lumen by grasping the adventitia and pass through the other wall from the inside to outside, symmetrical to the first passage. Apply exterior counter pressure with the forceps. Decrease the magnification to tie the knot. Pull the suture leaving a shorter end of about 5 mm. Grasp the longer suture end (the one with the needle) with the needle holder and make a double loop around the forceps, grasp the shorter end with the forceps and tighten the knot. Tighten gradually with even pull, under direct vision, in a horizontal plane, in order to bring the walls together without excessive pressure. Make another simple loop around the forceps with the suture held in the needle holder and tighten the second throw in the opposite direction, thus obtaining a square knot. Add a third one for safety.

Place the second suture at 20’clock position. Flip the microapproximator 180 degrees. Verify that the back wall wasn’t caught in the first 2 stay sutures and place the third stay suture in the middle of the back wall at 6 o’clock position. Leave the ends of the stay sutures long to use them in vessel manipulation.

*Place the rest of the sutures* (two or three sutures between the stay sutures) at regular intervals, starting with the front wall first (Fig 8). After finishing check the anastomotic line for obvious gaps and restore the vessel to the original position. Remove the background.
For the last 2-3 sutures you can use the “stitch now tie later technique” to have enough space and access to the lumen to place them safely. Pass the sutures and leave the ends long, without tying them. After all the sutures are passed, tie them one by one.

*Remove the microapproximator*, starting with the distal clamp first (Fig. 9). In case there are major leaks place another suture.
Release the proximal clamp and apply gentle pressure with wet gauze.

Before final closure (Fig. 10), recheck the anastomosis after a few minutes performing permeability tests.

- Examine the anastomosis under medium power magnification, it should have transversal pulsations; if those are longitudinal they suggest a flow obstruction (the blood is hitting the anastomotic clot).
- The lift test is a more reliable – Use a closed forceps to lift the artery distal to the anastomosis until flow is obstructed. The artery will appear to blanch over the surface of the forceps. The forceps are then lowered and the lumen should appear to refill briskly both proximally and distally to the forceps.
- Acland’s “milking” test is more traumatic. Occlude the artery with a forceps immediately caudal to the anastomosis, and then occlude the artery again with a second forceps, immediately distal to the first one. Slide the second forceps over the artery in the direction of the blood flow, keeping it closed and release the first forceps. An almost instant filling of the emptied segment of the artery proves patency of the anastomosis. Any delay is a sign that the anastomosis is partially blocked (partial thrombosis or a through and through stitch). If there is no filling and the vessel remains collapsed the anastomosis is obstructed.
2. Microvascular end to side anastomosis

This is the suture of the stump of the donor vessels to the lateral wall of the recipient one. Although end-to-side microsurgical anastomosis is technically more challenging, it is useful for free flap transfers (Godina 1979). It accommodates the discrepancies in the vessel diameters and, additionally, it does not interrupt the distal blood flow. The vessel preparation is similar to the end-to-end anastomosis.

A delicate step is the arteriotomy. The adventitia is removed from the future arteriotomy site and the vessel is grasped. An ellipse of the wall is excised, with the scissors making two cuts that unite in a “V”. For small vessels only an incision in the wall is sufficient. The length of the arteriotomy should be one and half times that of the vessel. The donor vessel stump is cut obliquely in order to increase its diameter. The lumen of both

Fig. 10. The vascular anastomosis before final closure
vessels is flushed with heparinized saline. Remember: only the irrigation liquid enters the lumen, not the cannula tip. Two stay sutures are placed. Place your first stitch through the heel of the donor vessel and the proximal end of the arteriotomy site. The second stay suture is placed between the toes of the donor vessel to the distal aspect of the recipient arteriotomy. Next, place interrupted 10–0 monofilament sutures along each side, starting with the back wall. Place 3 to 5 separate sutures starting from the stay sutures and advancing towards the centre. Enter the donor vessel first and exit through the recipient vessels, using backhand. Apply the sutures radially, perpendicular to the anastomotic line. Take care to place the first stitches very close to the stay sutures in order to avoid anastomotic leaks. Turn over the graft to face the anterior wall. Inspect the interior of the anastomosis and make sure that the sutures were placed correctly. Then suture the anterior wall in the same manner. Before securing the final suture, the clamps are sequentially opened to flush air and debris from the lumen prior to restoration of flow.

Once the basic end to end technique is mastered, more advanced exercises can be tried: continuous suturing, back wall first suturing, and side to side arterial anastomosis. The skills that are developed in the laboratory will increase procedural confidence and proficiency in clinical practice.
Experimental models in rodents

References