Chapter 47

INTRODUCTION TO MICROSURGERY

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There are many procedures in the author's private practice of plastic surgery, specifically hand surgery, that can be adapted to surgical repair of birds. The observations and conclusions described below are drawn from an extensive experience with repair, rehabilitation, and return to the wild of sick and injured birds of prey. The size of the patient and critical nature of many of the repairs make microsurgery and the use of the operating microscope natural adjuncts for avian surgery.

Specific to this area is the use of the operating microscope. The dexterity and manipulation of a surgeon's fingers and hands are far greater than unaided vision will permit. Enhancing these capabilities with the microscope allows the surgeon to use his fingers and hands with a greater degree of precision and care than otherwise attainable. Moreover, magnification in soft tissue procedures affords a closer scrutiny of vessels that may hemorrhage, hemorrhage being one of the major causes of surgical failure in pet birds, particularly with intracavitary procedures (intracranial, intrathoracic, and intra-abdominal).

The impetus for this new work began in the early 1970's with the advent of microvascular surgery, which allowed anastomosis of vessels as small as 0.4 mm to provide a patent antegrade flow. This opened the door to replantation of divided or sectioned digits and limbs and the removal and replacement of large sections of osseous and composite soft tissues from remote distances in a single stage, such as the replacement of a missing thumb with a big toe. All of this is significant in the repair and restoration of wild birds and in the operative therapy of all avian species.

In the past with wild bird rehabilitation, adequate treatment was simply to pin or otherwise stabilize fractures and follow this by the immediate repair of overlying soft tissue. If one considers for a minute the impact required to fracture an avian bone, itself a marvel of light and strong construction, it does not take much imagination to suppose that other more deeply situated, finer, and more delicate structures are similarly injured.

We have reached the point in the surgery, care, and rehabilitation of these injured limbs that simply pinning the fracture and closing the skin will have to give way to more thoughtful investigation, exploration, and repair of injured soft tissues as well, specifically blood vessels, nerves, and musculotendinous units. Repair and restoration of joints will ultimately become a specialized discipline in its own right, but at the present time the engineering tolerances of the joints are so critical that they are relatively intolerant of even the healing process, which itself compromises the ultimate functional range of motion.

Understanding and committing to memory the anatomic relations in a *regional* manner rather than in the usual textbook *systemic* fashion cannot be overemphasized. The author is unaware of any detailed avian surgical text currently available which presents the detailed regional anatomy required by the microsurgeon. The responsibility, then, for acquiring this information lies squarely with the surgeon himself who must do his own dissections and sketches. Careful attention must be paid to fascial and muscular planes and to identifying which vessels and nerve branches lie in each. The surgical principle involved when facing a large hemorrhagic wound that is stained with blood, feathers, and dirt is to proceed proximally and distally, identify the undisturbed structures, and follow them back into the wound. This identification and orientation of structures will prevent the twisting and abnormal rerouting of bones, tendons, vessels, and nerves that commonly occurs.

MICROSURGICAL TECHNIQUES

In order to accomplish some of the microsurgical procedures, including microvascular repairs, one must become familiar with the technical knowledge and instrumentation and develop some expertise in this area. Essential to microsurgical performance is the avoidance by the surgeon of alcohol, stimulants such as caffeine or nicotine, heavy exercise, and of course, fatigue.

Most macroscopic surgical techniques are applicable to microsurgery; however, a few are replaced or modified. Because the field is magnified, movements that are taking place at a normal pace seem very rapid under the microscope. The velocity increases in direct proportion to the increase in magnification. Normally undetectable hand motions may appear as tremors under the microscope. Therefore, it is necessary that all actions be carried out in a slow, deliberate manner. Particularly when drawing suture through a small vessel, one must progress at a very slow pace in order to avoid tearing the tissue or pulling the suture all the way through the vessel.

Because microscopic fields are so small, it is necessary for the surgeon to keep his instruments, needles, and suture material in an area close around the visible field so that they can be easily retrieved. This may require that the needle be placed in a bit of muscle close to the anastomosis site or on a microscopic clip. When working at some of the higher magnifications, the operator will even find some difficulty in placing his instrument into the microscopic field. This can sometimes be facilitated by sliding the instrument to be placed in the field down the shaft of one that is already located in the field.

It is also essential that the surgeon's wrists be anchored close to the operative site. In contrast to techniques taught in macrosurgery, flicking or snapping the suture through the tissue is not possible in microsurgery because of the great vibration and tissue tearing that may occur during this type of maneuver. Rather, it is necessary to hold the heel of the hand flat against a surface and *roll* the instrument between the fingers. The wrists must rest securely on something near the patient that will provide a sound base: a rolled towel, a special post device, or the edge of the animal board. Resting it on the patient itself is discouraged because the respiration of the patient combined with the surgeon's own respiration will exaggerate the tremor and vibrations that are normally visible through the microscope.

It is necessary for the surgeon to "control" his own respirations by breathing slowly and regularly. Breath holding is almost a reflex for any fine intricate movement but should be avoided to minimize vibrations.

If a hand tremor becomes uncontrollable during the surgery, there are many things that might be suspected, but three are most common. First, the surgeon may find that his wrists are no longer resting on the support. It is very difficult to do microscopic surgery with the wrists in the air. The very large muscles of the shoulder simply cannot hold the hands still enough to operate under the microscope. Additional support is gained with the placement of the feet securely on the floor. Second, again because the field is so small, it is very possible that either the gloves, the suture, or the gown has become entangled in something that is outside the visual field of the microscope and the resulting tether, unrecognized by the surgeon, is preventing him from accomplishing his objective. Finally, when a severe tremor develops, the surgeon may find that he has been holding his breath for the last few minutes and is watching his own hypoxia at work.

It is advantageous in microsurgery to be able to use all instruments in either hand. As the techniques in using these instruments are being developed for the first time, it is worthwhile to acquire ambidextrous skills.

INSTRUMENTATION

Only the tips and the boxes of microsurgical instruments are required to be microsized. Most of the instruments should have handles of normal length, that is, at least the length of a pencil, so that the handles may extend and rest over the back of the hand (Fig. 47–1). This is to help provide stability to the tips of the instruments and to accommodate the rolling action of the instruments necessary in microsurgery. Because of the required rolling action, nearly all microsurgical instruments, with the exception of scissors, come with round handles. Damage and everyday wear and tear make it useful for the surgeon to acquire some skill in the sharpening and repair of these small instruments. Care is usually done under the microscope.

The needle holder, from an engineering standpoint, needs a given strength and size at the box and proximal part of the point; however, more distally toward the suture and needle-handling end, it is ground down to a dolphin-nosed point.

For vascular repair, an irrigation device is needed to instill heparinized solution into the lumen of the vessel. This step washes out any clots and debris from intravascular blood that remains after clamping. A blunt 30-gauge

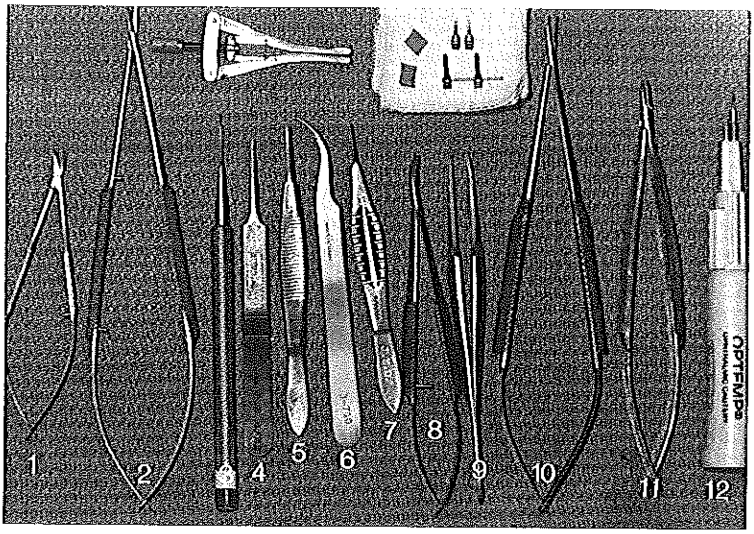


Figure 47–1. Microsurgical instruments include (from left) microscissors (1,2), intra-arterial loop (3), micro pickups (4–7), micro needleholders (8–11), disposable ophthalmic cautery (12); (top) self-retaining retractors; microvascular clips with balloon patches.

needle is adequate. A regular 30-gauge hypodermic needle can be used; however, the tip must be amputated and polished under the microscope to prevent snagging the intima of the vessel. The needle is attached to a 30-cc syringe of heparinized lactated Ringer's solution with a plastic connector. This solution may also be used to keep the vessels and surrounding tissues moist throughout the procedure.

The suture material most often used for microvascular repair is a 10–0 nylon with a 75-micron needle. A 6–0 to 9–0 size suture is normally satisfactory for other, less delicate avian repairs.

A microvascular clip is actually two clips on a sliding bar; one clip is placed on the distal and the other on the proximal segment of the vessel when carrying out the repair. A small piece of colored rubber balloon is placed behind the clip and serves as a color backdrop to afford better reference and distinction.

A number of different electrocauteries can be used in microvascular work. The normal bipolar electrocautery is most common. However, for experimental work and for many avian procedures, the ophthalmic battery-operated, nonresterilizable electrocautery is beneficial and has the advantage of having no cords or other connections. (See Chapter 48, Selected Surgical Procedures, for cautions in use.)

The most expensive item, of course, is the microscope itself (Fig. 47–2). Many used models are available through medical schools when the schools update their equipment to include motorized zoom and focus features. These features are not necessary for bird surgery and require additional foot work in order to operate them.

The objective lens of the microscope should be approximately 150 mm for bird surgery; the ocular lens is 12.5 mm. Longer focal lengths may require the surgeon either to sit a great deal higher or to stretch his head and neck in order to reach the oculars, resulting in inability to set his feet flat on the floor with a possible increase in tremor. Nearly all operating microscopes have their own intrinsic light source; however, some may use a reflective light source requiring a mirror.

Some less expensive substitutes for commer-

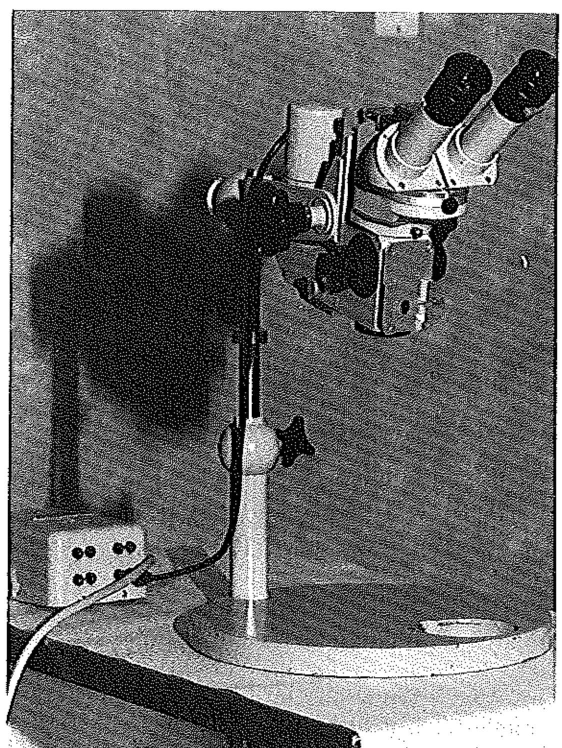


Figure 47–2. Tabletop model operating microscope.

cially available microvascular instruments work well in the early stages of experience while the clinician is evaluating the merits of this surgical mode for his practice.

The usual Castroviejo microvascular needle holder may cost from $250 to $450. No. 4 or No. 3 jewelry forceps from a jewelry supply store, with vulcanized silicone (Silastic) applied to the outside of the handles to make them round can replace this instrument. Modification of an ordinary Castroviejo ophthalmology needle holder requires grinding of the tip and application of Silastic to the handles. In addition, the normal clasp or lock on this instrument must be removed because the jar of the click or lock in setting or releasing is enough to tear tissue or fine vessels. These substitute instruments roll well, are strong enough to hold the micro needles and sutures, and are approximately one tenth the cost of an instrument designed specifically for microsurgery.

For general dissection, No. 2 or No. 3 jewelry forceps can be used. The No. 5 jewelry forceps, which is the finest of those available, is used for the very finest dissection, specifically dilating vessels from the inside and stripping the adventitia. Generally two of these are used simultaneously, one in each hand, for the final preparation of the vessel for repair.

A section of latex tubing approximately 1/4- to 5/16-inch in diameter is an adequate replacement for the vascular clip for use in developing initial skills. The top is cut off the tubing, and the tubing itself is then slit in a miter box fashion (Fig. 47–3).

LABORATORY EXERCISE TO PRACTICE MICROVASCULAR REPAIR

The following is an introductory procedure that can be practiced to develop microsurgical skills. It is advisable to practice microvascular techniques (e.g., suturing of vessels) on laboratory rats to acquire the skill necessary for avian repair. An end-to-end repair is described; however, end-to-side repairs and side-to-side repairs are also possible. Vein grafts may have some potential in replacing arteries lost in gun blast injuries.

In the laboratory specimen rat, the femoral artery and vein are the most accessible and allow refinement of surgical techniques under magnification. Birds will differ in that they have a large network of veins that surrounds most of the major arteries. Accurate repair of an avian artery cannot be accomplished until this network of veins is cleared away.

Four strips of autoclave tape on the extremities and one across the tail are usually sufficient

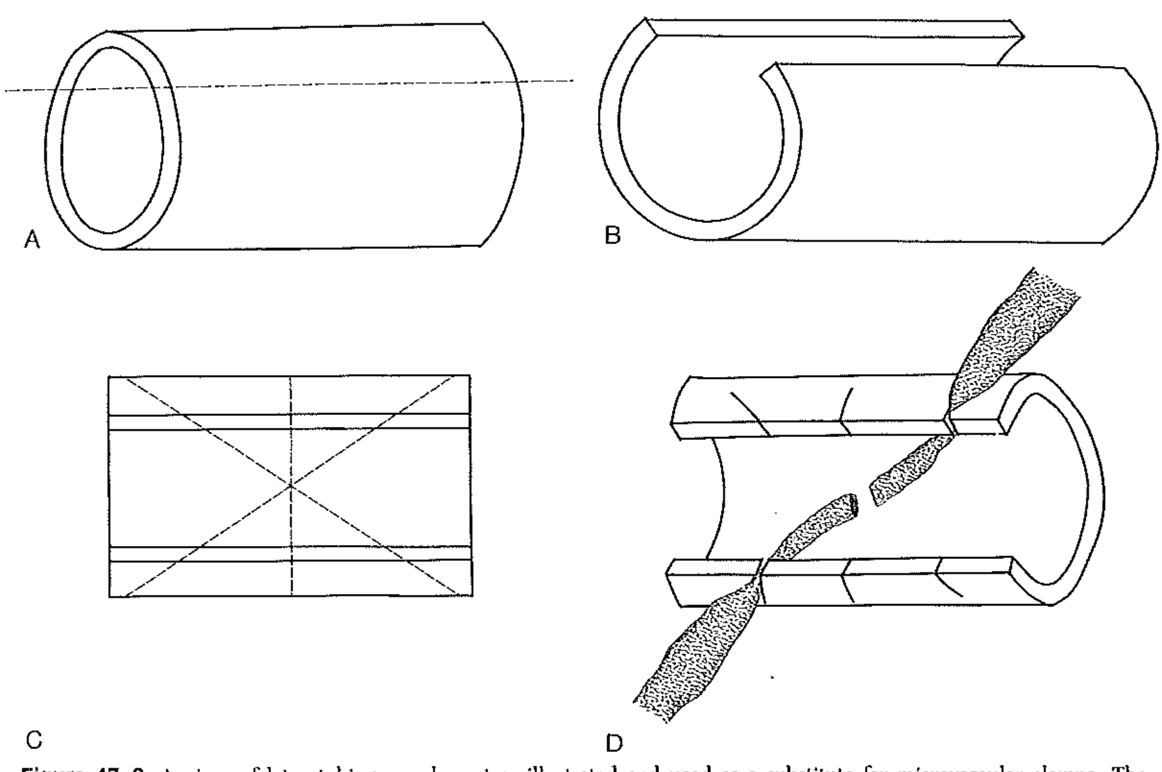


Figure 47–3. A piece of latex tubing may be cut as illustrated and used as a substitute for microvascular clamps. The vessel is threaded through the slits prior to dissection.

to position the anesthetized rat on an animal board. The groin area is clipped and surgically prepared. A long incision, usually the entire length of the groin, is recommended, especially in the early stages of practice. This allows the microvascular clip to lie flat instead of in a caudal position, which it will usually assume if a small or keyhole incision is made. The skin and the underlying muscular layer can be opened macroscopically.

At approximately the midsection of the vessel across the groin, a perforating muscular branch will be encountered. This branch must be electrocoagulated and sectioned in order to get adequate length for the anastomosis of the femoral artery. Later, as skill develops, this branch can be anastomosed and rerouted in practicing end-to-side and side-to-side repairs.

As the vessels are isolated, the vein will be found on top and superficial to the artery. Two lymphatic vessels are on the surface of the vein, one superficial and another deep. If these are not stripped free of the vein, subsequent tearing of them may result in lymphorrhea after a vascular repair and provide an avenue for the entrance of infection.

For color contrast, a 1 sq cm section of balloon is then placed beneath the artery, which has been cleaned of the surrounding areolar material (Fig. 47–4). As a comparison, the vessel to be approached for dissection and repair is smaller than the lumen of a 23-gauge needle.

At this point, if it is clear that a considerable amount of vasoconstriction has taken place because of the manipulations, a bath of 0.5 per cent xylocaine without epinephrine will help relax the muscular wall of the artery. A little stroking of the portion of the vessel in the operative field will enhance the vasodilation and the xylocaine effect.

The distal clamp is placed first to get hydrostatic dilation of the vessel before the proximal clamp is situated; the two bar clamps are slid together before sectioning. Try to avoid placing the anastomosis site close to the stump of the muscular branch that was previously electrocoagulated. Transect the vessel between the clamps with sharp scissors.

After sectioning, gentle irrigation of the vessels is critical. The cannula must be inosculated directly into each section of the cut vessel to wash out the blood and fiber. With the No. 5 forceps in one hand and the irrigation device in the other, grasp only the adventitia with the tip of the forceps (Fig. 47–5). Gently flush one side, switch the instruments to the opposite hands, and repeat in the other direction. Any particles of fiber left in the lumen will become the nidus for thrombus formation that will occlude the lumen postsurgically.

After having hydrodilated and irrigated the lumen of the vessel, one of the most delicate maneuvers that is required for this repair is introduction of the No. 5 forceps into the lumen of the vessel and gentle manual dilation of the lumen (Fig. 47–6). This is done both proximally and distally.

The next step involves the stripping back and actual circumcision of the adventitia from the outside of the vessel wall (Fig. 47–7). This is important because even a small bit or fiber of the adventitia projecting into the lumen of the repaired vessel will collect thrombocytes and promote thrombus formation.

The first suture is placed at the superior pole of the interface of the two vessel edges to be

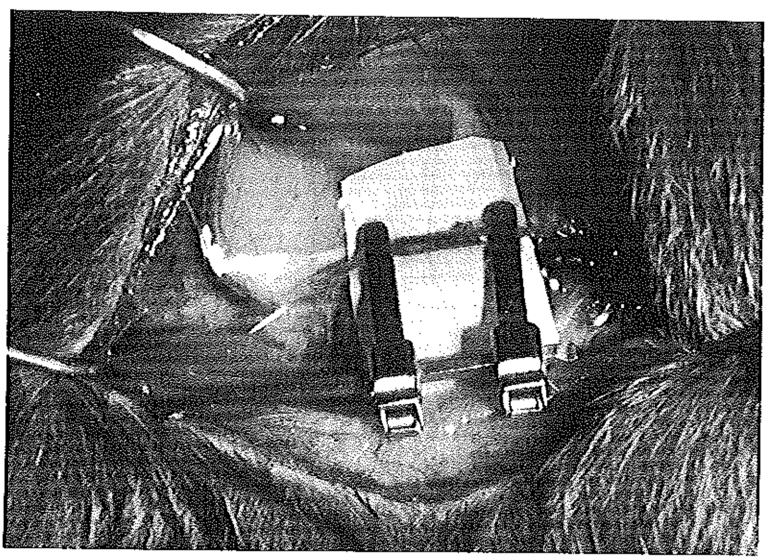


Figure 47–4. With low power field, the artery is prepared for sectioning. Microvascular clips and a 1 sq cm piece of colored balloon are in place.

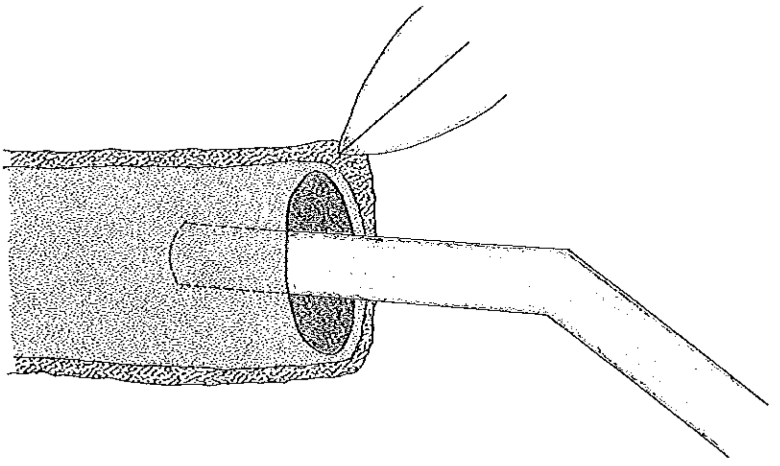


Figure 47–5. The tip of the 30-gauge irrigating cannula is placed inside the vessel lumen for relatively forceful irrigation with heparinized lactated Ringer's solution.

anastomosed; the No. 2 suture is placed at the inferior pole and the number three is placed between the two on the first side to be repaired. The whole clip is then rolled over to get to the underside to place sutures 4, 5, and 6 (Fig. 47–8).

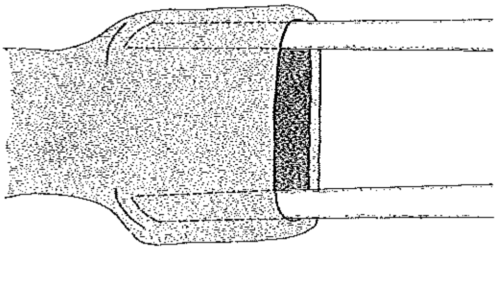
The first suture is the most difficult to place because the vessels are floppy and not joined in any manner. Normally the entry is made approximately two wall thicknesses away from the cut margin of the vessel. The most critical suture for the final success of the anastomosis is the second (Fig. 47–9*A*). If the No. 2 suture is not correctly aligned, i.e., not placed exactly the same distance from the No. 1 suture on the distal as it is on the proximal end of the vessel, the resulting deformity in the vessel greatly compromises the cross-sectional area of the repair (Fig. 47–9*B*). This abrupt change in lumen area causes a turbulent pattern in blood flow which will also enhance thrombus formation.

For all sutures, the forceps have to be introduced into the lumen of the vessel to receive the needle (Fig. 47–10*A*). The needle is driven in between the two blades of the forceps, grasped, and retrieved. The forceps protect the needle tip from picking up the rear side of the intima.

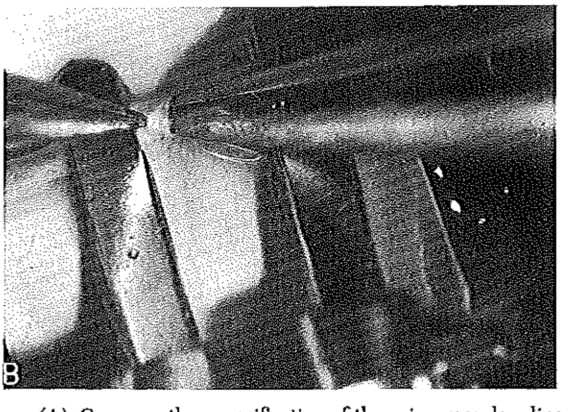
On the opposite edge, the forceps will pick up the adventitia, which opens the mouth of the vessel (Fig. 47–10*B*). As the needle is introduced into the mouth, the forceps support the superficial wall of the vessel and hold the vessel steady while the needle is guided out through its exit. The needle is then drawn through with the forceps. It is necessary to use the forceps to steady the distal segment so as to avoid damaging the proximal segment by pulling with the needle.

The suture is then slowly drawn through the two segments of the vessel. If an assistant is available, he can inform the surgeon when the tail of the suture is getting close to the entrance into the vessel. With the limited field it is easy to pull the suture through both sides of the vessel before it is noticed.

Tie the knot square and lay it square. Two throws are enough in 10–0 and 11–0 nylon; a third, unnecessary knot will only increase the



A



B

Figure 47–6. The vessel is manually dilated with jewelry forceps *(A)*. Compare the magnification of the microvascular clips and balloon piece *(B)* with Figures 47–4 and 47–2.

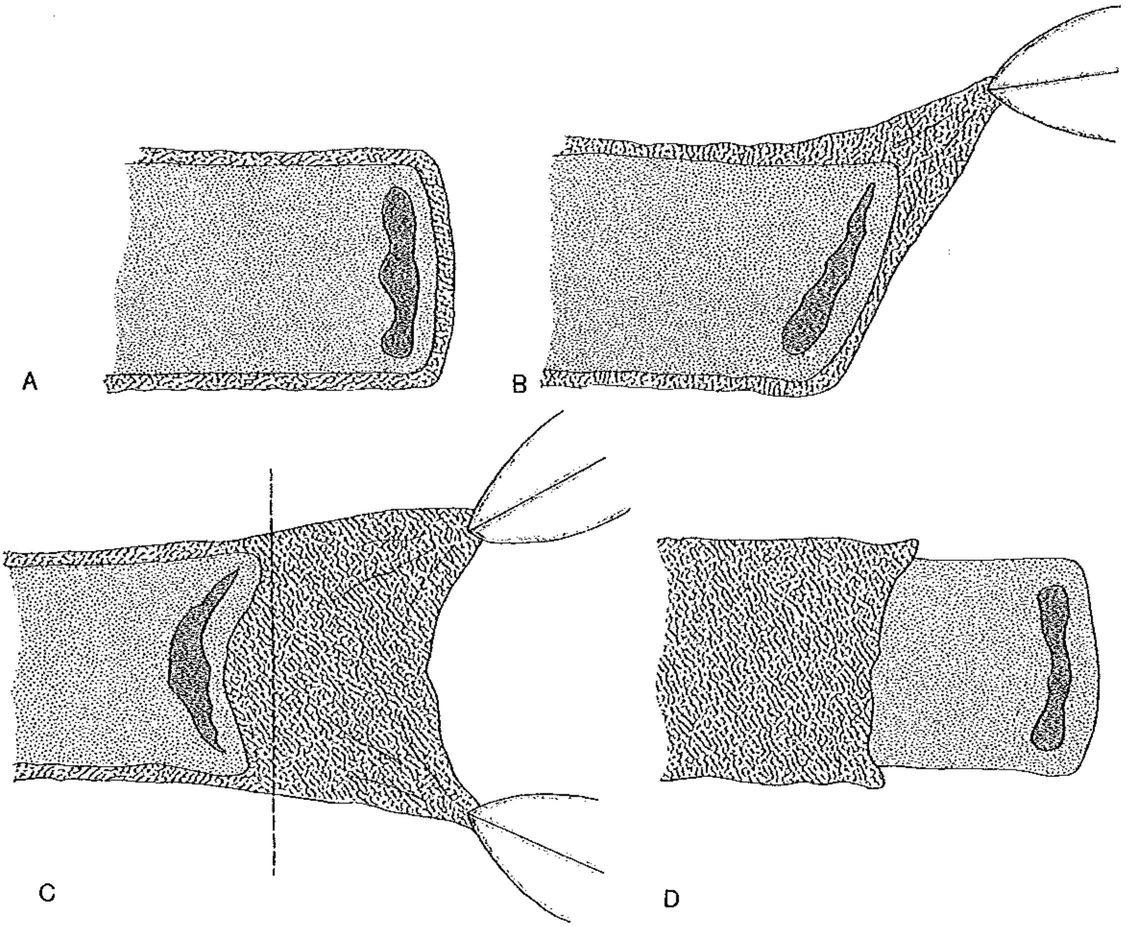


Figure 47–7. The adventitia around the vessel *(A)* is first teased over the end *(B)* and prepared for cutting *(C)*. The "circumcision" is complete after retraction of adventitia *(D)*.

risk of tearing the vessel. A surgeon may spend about half his time with a microvascular repair simply in tying the knots.

At this point, the vessel is lying in approximately the same attitude it had when it was sectioned.

In picking up suture material, the surgeon may inadvertently pick up the adventitia and produce a tear. To prevent this, it is helpful to introduce the first blade of the forceps under the distal tail of the suture and either lift it or pick it off the vessel itself before clamping down the second blade.

If a loop occurs while tying, simply tie it down snugly, pull the loop out, and tighten it one more time.

After the third suture is placed, the microvascular clip is turned completely over and again situated flat. Sutures on the reverse side are easier to place, since the first side is already in position. It is also easier to avoid picking up the deep side inadvertently. One may choose to sound both the proximal and distal vessel segments prior to starting this side to make sure none of the first three sutures has violated the deep side of the vessel. Again, tie the knot square and lay it square.

If things are not going smoothly at any

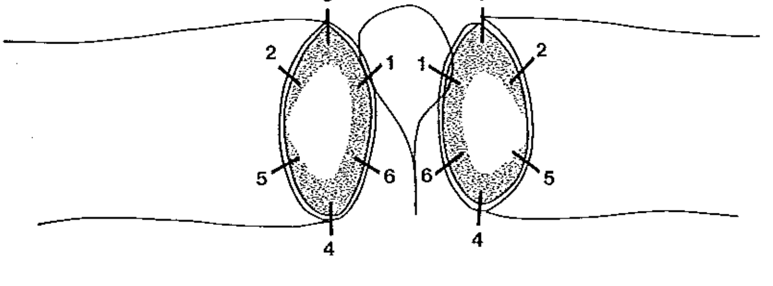
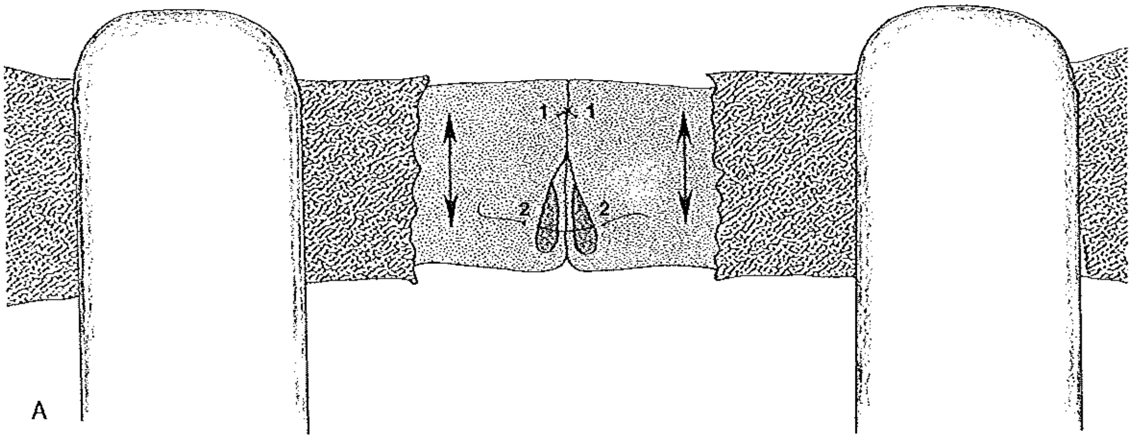


Figure 47–8. A diagram of the placement of the six sutures from a side view.



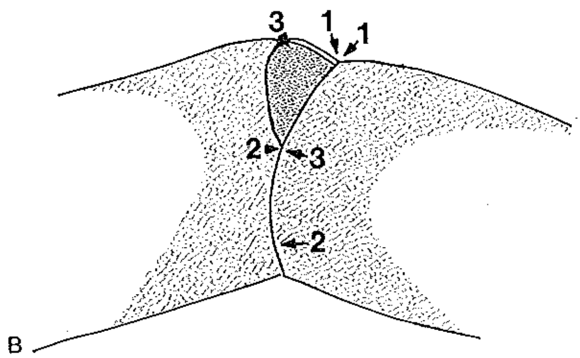


Figure 47–9. *A*, The distance between the first and second suture entries on the right and left sides must be exactly equal. *B*, Not placing the first and second suture entries at equal distance on each side will result in a deformity of the vessel. This "mis-suture" will reduce the anastomotic cross-section by 31 per cent, resulting in turbulence at this site and possible thrombus formation.

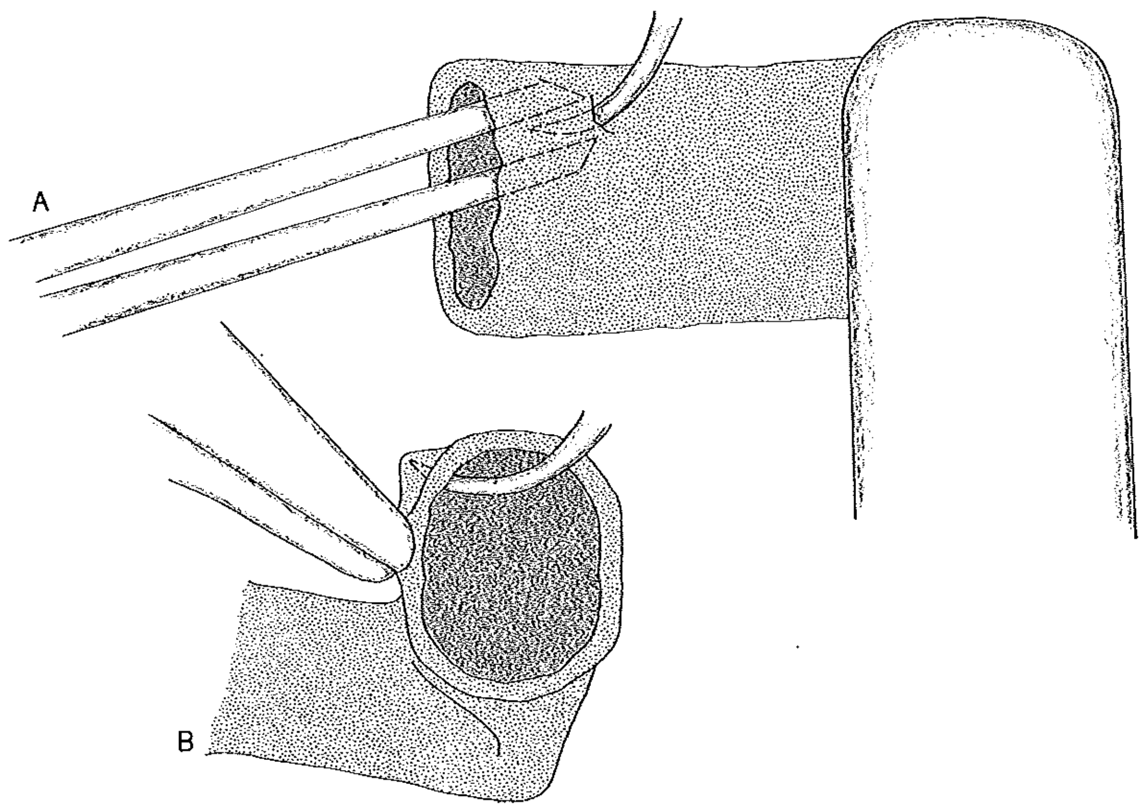


Figure 47–10. *A*, In making a suture, the jeweler's forceps must be introduced inside the vessel to prevent picking up the opposite side. *B*, On the second side the mouth of the vessel is turned up so that the inside of the vessel is in full view.

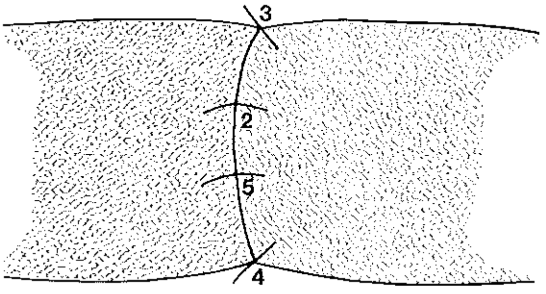


Figure 47–11. The completed anastomosis is inspected for possible gaps prior to releasing the clamps.

point—the vessel, needle, or forceps not cooperating—it is better to stop and begin again before the vessel is torn.

Leaving the tails of No. 4 and No. 3 sutures long after tying will help in rotating the vessel for the upper and lower margins. Once the three sutures have been placed on the reverse side, the clip is turned back for the final inspection for holes or gaps that might need to be closed with a final suture before the clamps are removed (Fig. 47–11).

A small piece of Saran or similar plastic wrap may be placed around the anastomosis prior to the release of the clamps. This helps to prevent blood loss while the clotting at the interface is taking place. The distal clamp is removed in order to allow backflow into the repaired site; then the proximal clamp is removed.

A little watchful "negligence" is in order at this point. Avoid getting overly anxious about throwing extra sutures into a bleeding anastomosis. Allow the blood to accumulate around the vessel, snug up the plastic wrap a bit, and wait. Additional xylocaine may be added around the repaired vessel in order to help dilate the lumen and increase the flow. A patent lumen is suggested by expansive pulsations of the vessel in a circumferential manner.

If there is an obstruction of the lumen, the pulsatile motion will be linear, along the long axis of the vessel, rather than circumferential. The linear pulsation indicates that the flow of blood is impacting against the obstruction at the anastomosis site. When the oozing at the anastomosis site has stopped, remove and discard the balloon and the plastic wrap.

A final test of the repair may be performed. The surgeon may use proximal forceps to gently grasp and hold the vessel to prevent flow toward the anastomosis. The blood is then stripped out distally across the anastomosis and into the distal segment of the vessel and held with a second forceps. The proximal forceps is then released, and immediate flow across the anastomosis indicates a patent antegrade flow.

While microvascular repair itself may not be the interest of all avian practitioners, the use of an operating microscope is strongly indicated for avian surgery, and the described procedure offers the clinician the opportunity to develop skills with this equipment. Simple pinning of fractures and tissue closure over damaged limbs or trunk portions is no longer going to be acceptable surgical care. Exploration and identification, if not repair and treatment, of other damaged and diseased areas is vital to current state of the art of surgical therapy.

ACKNOWLEDGMENT

The author wishes to thank Jody Sayle for the illustrations for this chapter.