Orr's Operations of GENERAL SURGERY

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Preface to the Third Edition

PREPARATION of a third edition of this book had just begun when Dr. Orr, Sr., was suddenly taken by coronary thrombosis. We, his students, have humbly assumed the task of completing the revision.

The continued trend toward specialization has further narrowed the field of general surgery since the first edition was prepared. However, the usefulness of a general reference on operations in general surgery remains. Although comprised chiefly of surgical techniques, a volume such as this should be useful to medical students, interns and residents as well as to the practicing surgeon. Indeed, it is our hope that general practitioners, internists and other members of the medical profession who do little or no operative surgery will find this a valuable aid in understanding the nature, scope, and limitations of surgical procedures recommended for their patients.

As in the previous edition, an effort has been made to include only well established and time-proved operative techniques. In certain fields, such as thoracic and cardiovascular surgery, progress has been so great that chapters on these subjects have been rewritten completely. The chapters on congenital anomalies and the lymphatic system have been deleted and the material incorporated into other areas. A chapter on head and neck surgery has been added. Dr. Harry A. Knauff has done much of the work in preparing this chapter.

The information contained in a volume such as this represents the cumulative knowledge and efforts of our surgical forebears through the centuries. Wherever possible, we have attempted to give credit to authors past and present from whose works we have borrowed. To the countless unnamed who have taught us and our teachers and our teachers' teachers, we acknowledge gratitude.

We have been fortunate in obtaining numerous new illustrations by Mrs. Kay Bell Wahl, who also did many of the drawings in the previous editions. Mrs. Lorene Cunningham and Mrs. Mary Reddish have been of great help in the preparation of the manuscript.

And lastly we hope that our efforts have not missed by too much the mark aimed at by the late Dr. Orr.

G. A. H.

May, 1958

T. G. O., JR.

Contents

CHAPTER 1

Wound Healing

Factors influencing the healing of surgical wounds may be divided into two general groups: first, those affected by the general condition of the patient, and, second, those concerned with the local condition of the wound.

Since good wound healing is essential for the success of surgical operations, a knowledge of these factors is fundamental. The more one studies wound healing, the more respect he has for tissues, and an improvement in technique inevitably results. The making and reconstruction of a surgical wound should never be considered a secondary part of an operation.

GENERAL FACTORS

Surgeons have long recognized the fact that patients in poor physical condition at the time of operation most frequently have disruption of wounds. The state of the patient's *general nutrition* must therefore be considered an important factor in wound healing. The *age* of the patient, *emaciation*, *anemia*, *prolonged infection*, *tuberculosis*, *nephritis*, *diabetes* or *cancer* may be responsible for delay in wound healing. Changes in the body chemistry also have their influence upon healing. As an example of such influence, Thompson, Ravdin and Frank demonstrated a delay in wound healing by experimentally produced hypoproteinemia. By using lyophilized serum, healing was restored to normal. Such hypoproteinemia results from starvation. Dehydration and excessive hydration also change the body chemistry and may delay wound healing.

Vitamin deficiency tends to retard wound healing. This is particularly true of vitamin C (ascorbic acid) deficiency. In a study of clinical cases Lund and Crandon found a higher percentage of postoperative hernias in patients having low vitamin C levels in the plasma. In an experimental study Lanman and Ingalls observed that wound healing in partially scorbutic animals was definitely delayed. These authors believe that

a partial vitamin C deficiency definitely influences the healing of surgical wounds in patients. Wolfer and his associates made some carefully conducted experimental studies of wound healing in vitamin C-depleted human subjects and concluded that prolonged ascorbic acid depletion caused approximately 50 per cent decrease in the tensile strength of healing wounds, and suggested the need of vitamin C in the tissues for maximum resistance to infection. Schilling and associates, from their own experiments and the work of previous investigators, concluded that vitamin C is essential for wound healing because of its effect upon fibroplasia and collagen formation.

Such complications as *coughing*, *sneezing*, *hiccuping*, *vomiting*, *crying* of children, passage of stomach tube, bronchoscopy, *excessive restlessness* during recovery from anesthesia, and *abdominal distention* may produce unusual strain upon a sutured wound, predisposing to necrosis of tissues, infection, delayed healing or wound disruption.

Cortisone and ACTH. The influence which cortisone and ACTH may have upon wound healing, if any, has not been decided. Howes and associates found that fibroplasia and granulations were delayed by cortisone in experimental animals. Alrich and his co-workers also concluded that ACTH and cortisone caused delayed wound healing in animals. They stated that clinical observations indicated a delay in wound repair in patients and advised caution before planning elective surgical procedures upon patients who have received either ACTH or cortisone. Creditor and associates reported histologic evidence of delayed formation of granulation tissue in biopsies of wounds in two patients who had received ACTH. As opposed to these findings, Schilling and his co-workers did not observe any effect of ACTH and cortisone upon wound healing. Savlov and Dunphy (1954), in their animal experiments, found that large doses of cortisone started before wounding retard healing, but, if started at the time of disruption of a primary wound, did not delay healing of a resutured disrupted wound. Hanlon did not observe any delay in wound healing in a patient with severe peritonitis treated with ACTH. Tweedie and Long (1954) stated that healing appears to progress normally except in those patients who have been on therapy for a long time before operation.

To control the general factors which influence wound healing, careful preoperative preparation and postoperative treatment are essential. Correction of nutritional deficiencies by proper and adequate diet, treatment of anemia, elimination of respiratory infections, and restoration of water and chemical balance are important in the preparation of a patient for operation and as part of the postoperative therapy. Modern methods used to decompress the stomach and small intestine should reduce the percentage of wound disruptions by preventing vomiting and distention.

LOCAL FACTORS

Type of incision, operative trauma, infection, hemostasis, drainage material, suture material, foreign bodies, lack of rest, disturbed blood supply, tension, edema, inaccurate approximation, and devitalized tissue all influence wound healing.

Incision and Wound Closure

The type of incision may definitely influence the rate of wound healing. Clean-cut wounds heal smoothly. The work of Ellis showed that wounds produced by electro-

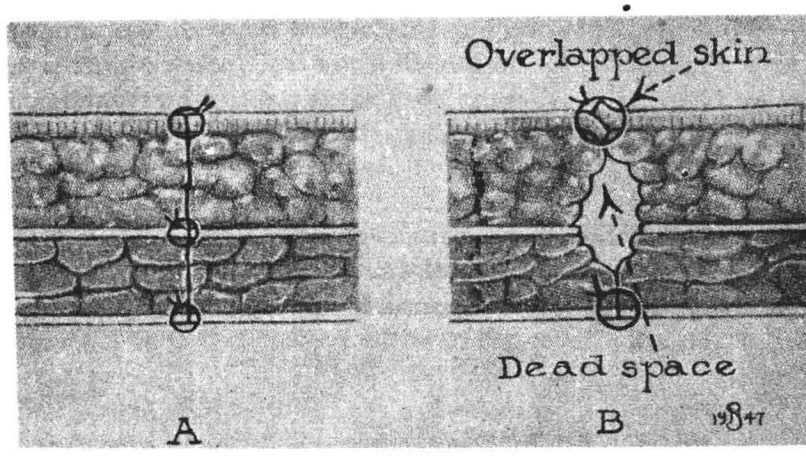

FIGURE 1. Method of wound closure in layers. *A*, Correct method of closing a wound. *B*, Incorrect method of closing a wound, leaving a dead space and overlapping the skin edges. (Redrawn from Cole and Elman: Textbook of Surgery, Appleton-Century Company.)

surgical units do not heal as rapidly and do not gain tensile strength as rapidly as similar wounds made with a knife. Separation of tissue layers beyond the necessity of structure identification and adequate suturing should be avoided. The rough handling of wound margins, careless clamping for traction, or tearing of structures unnecessarily devitalizes tissue. Roentgen irradiation may produce fibrotic changes in tissues which will jeopardize wound healing.

Accurate approximation of sutured structures deserves special attention. When closing the peritoneum, fascia or skin, portions of fat, muscle or other tissue should not be permitted to protrude between the sutures. Dead spaces should not be left in wounds to fill with blood and serum (Fig. 1).

In the mechanics of a good wound closure, tension on the tissues is of prime importance. In closing a wound the wound margins should be accurately approximated without any more tension than is necessary. A suture that is too tight squeezes out the blood supply, causing necrosis, which not only weakens the wound, but also predisposes to infection and adds an unnecessary load by compelling the body to remove dead material before normal cicatrization can take place (Fig. 2).

Infection

It is probable that no wound is absolutely free from bacteria and must, therefore, be considered contaminated. From a clinical standpoint, however, it hardly seems justifiable to say that a wound is infected until clinical or laboratory evidence of infection exists. Infections in clean surgical wounds may be reduced to a minimum by proper aseptic technique. More recently soap or a detergent with the addition of hexachlorophene has been found superior. *Proper sterilization and handling of all instruments and supplies used at the operating table* are emphasized. This is necessary in all hospitals, and particularly in those in which medical students, house officers and student nurses are receiving their training. Perhaps more errors in technique are made in handling surgical dressings and draping patients than by any other means in the operating department. Constant vigilance is necessary to train the novice properly in aseptic surgical technique. A surgeon who has permitted himself to become habituated

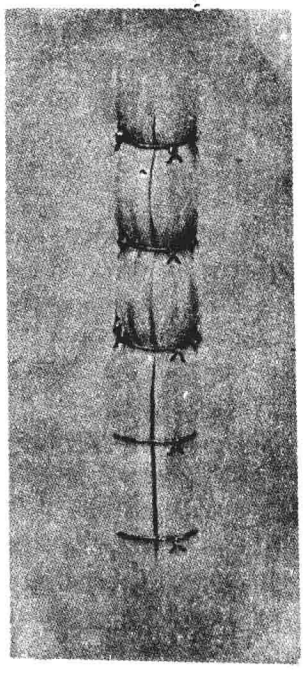

FIGURE 2. The effect of tight and loose skin sutures is shown here. Note necrosis where sutures are too tight (Reid.)

to careless methods is hopeless. Operating room technique must be properly learned and practiced from the beginning.

Careful *masking* of the nose and mouth is important because air-borne infections from the mouth and upper air passages are likely to be virulent.

Another important source of infection is the skin of the patient. When this possibility of infection is reduced to a minimum by proper *cleanliness*, grossly infected wounds rarely result from operation. Sharp dissection with a knife minimizes tissue damage. Exposed skin and wound edges should be protected with sterile towels during the operation. Wound surfaces exposed for long periods of time should be covered with gauze packs soaked in saline solution to prevent the devitalizing effect of the drying of tissues. Before closing a clean wound, irrigation with physiologic sodium chloride solution will remove bacteria, blood and serum, and aid in the identification of loose tags of tissue that should be removed.

After a wound has become infected the use of *antiseptics* adds little to the rapidity with which it heals. Anderson concluded from his experimental observations that the majority of infected wounds, adequately drained and not containing sloughing tissue, in normal patients will heal according to a regular geometric curve, the rate being proportional to the size of the wound and decreasing with the age of the patient regardless of the type of local treatment. Smelo expressed the opinion that antiseptics have more deleterious effect upon tissues than upon bacteria. He was unable to note any beneficial effect of antiseptics upon the processes of repair, and concluded that factors other than local dressings appear to play the dominant role in determining the rate of wound healing. David obtained just as rapid healing of wounds by cleansing them with sterile soap and sterile water as by more elaborate antiseptic treatment. He remarks that granulation tissue contains most of the fighting forces of the body against infection. Left to its own devices and protected from constant recontamination,

it soon demonstrates its ability to combat infection upon it. Strong antiseptic solutions applied to granulation tissue have not sufficient power of penetration to reach and destroy infecting bacteria without at the same time injuring or destroying granulations.

Hemostasis

Hemostasis is essential to primary wound healing. The formation of a hematoma within a wound prevents coaptation of the wound margins, prolongs cicatrization, and predisposes to infection. If large clots develop in wounds, evacuation may be necessary; but opening a wound to remove blood or serum invites infection.

Foreign Bodies

Foreign bodies in a wound, if not removed, must be absorbed or encysted. They may delay healing or form foci for infection. The observation of W. S. Halsted that peritonitis in a dog is much more readily produced in the presence of a foreign body or a portion of ligated strangulated omentum emphasizes this point. When considering foreign bodies in surgical wounds, *suture material* holds first place, since most wounds must be closed with sutures, and bleeding vessels are usually ligated with suture material. Every time a bleeding vessel in a wound is ligated, two foreign bodies are introduced: the ligature and the strangulated tissue distal to the ligature. Strangulation causes necrosis of tissue which must be extruded or absorbed. The ligature likewise must be absorbed, extruded or encysted. It is then obvious that the minimum quantity of ligature material should be used in a wound, and the minimum of tissue should be included in the grasp of a ligature to control bleeding. Ligature and suture material must be carefully selected to avoid unnecessary interference with wound healing.

Choice of Suture Material

Catgut. Howes and Harvey, in their study of the holding strength of the catgut suture, concluded that "the greater the amount of suture material embedded within a given area, the greater the degree of tissue reaction. Therefore, the least quantity of gut necessary to sustain the approximation of the tissues until requisite strength obtains in the wound should be employed." These authors found that no. 0 twenty-day chromicized catgut satisfies all requirements of the stitch in fascial and connective tissue layers. The finer sizes, no. 00 and no. 000 twenty-day chromicized gut, maintain sufficient tensile strength for the suturing of other structures and for ligation of all but the largest vessels. Very fine chromicized catgut may be satisfactorily used in intestinal surgery. Bower and his co-workers have used as small as no. 5–0 chromicized gut both experimentally and clinically in intestinal surgery and find that its holding power is efficient and that trauma and tissue reaction are less than when larger sizes are used. If there is much strain on a wound or if infection or delayed healing is anticipated, through-and-through tension sutures should be added.

The holding power of a sutured wound decreases during the first two or three days, and more rapidly than the tensile strength of chromicized catgut. This holding power increases after three or four days, when fibroblasts begin to form, and the tensile strength of the wound increases. In the healing of a clean wound there is a lag

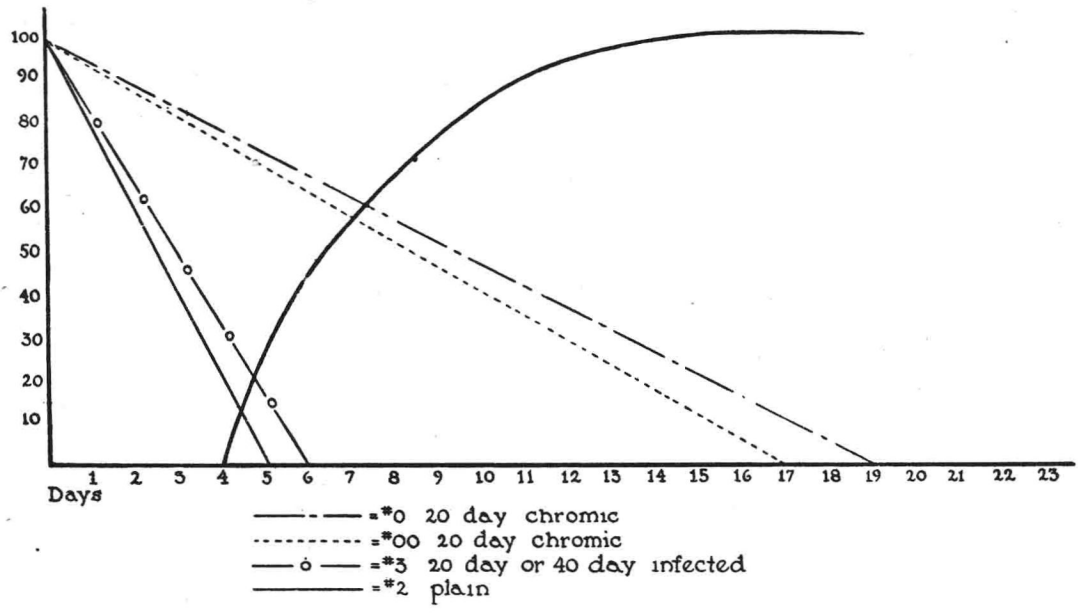

FIGURE 3. The curved line shows the healing of a wound as expressed by its tensile strength. The other lines show the decreasing tensile strength of catgut in comparison with the increasing tensile strength of the wound. (Howes and Harvey.)

period of four or five days when the strength of the wound is that of the early fibrinous adhesions. During this lag period the wound margins are held together entirely by the mechanical means used by the surgeon to close the wound. After this initial lag the maximum immediate strength of the wound is reached in ten to twelve days (Fig. 3). The experimental work of Localio, Casale and Hinton shows the the lag period is longer in wounds sutured with catgut than in wounds closed with non-absorbable sutures of silk, cotton, steel wire or nylon.

Howes emphasized that surgical catgut in wounds healing by first intention retains its tensile strength to the degree that is customarily expected (Fig. 4). In the presence of excessive blood, blood serum or inflammatory exudate, both plain and chromicized catgut rapidly lose tensile strength. It is then obvious that the best results with the use of catgut are obtained when strict hemostasis, minimum trauma and absolute surgical asepsis are observed. Jenkins and Hrdina found that plain catgut, with few exceptions, completely lost its tensile strength in about five or six days. Catgut, which usually loses its tensile strength in less than ten days, is completely absorbed within one to three weeks. If its tensile strength is retained longer than ten days, it is slowly absorbed in three to six months.

By increasing the number of sutures the holding power of the tissues is increased, and less strain is thrown on each suture. Interrupted sutures are recommended by Howes to preserve the strength of each unit as the sutures are absorbed or the holding power of the tissues is lost. The disadvantage of using a continuous chromic catgut suture for closing fascia when a drain is used is emphasized by Jenkins and Hrdina. The end of a continuous suture tied near a drain may be rapidly digested and permit

relaxation of the suture line. When a drain is used, a few interrupted sutures should be inserted on each side of the drain, or a stab wound should be used for drainage.

Catgut Allergy. Kraissl and associates suggested that some patients may be allergic to catgut. To support this suggestion they were able to sensitize guinea pigs to catgut, which resulted in a high percentage of disrupted wounds. Patients were found sensitive to catgut, especially if they gave a history of allergy or a previous operation. There is doubt whether this work can be completely substantiated. Pickrell and Clay were unable to produce any evidence to hypersensitivity to catgut experimentally or to observe any clinical evidence that sensitivity developed in patients after the use of catgut. They conclude that "although catgut, just as any other suture material, acts as a foreign body and causes a leukocytic response, it does not act as an antigen, nor is it capable of producing antigenic irritative phenomena." On the other hand, Hopps declares that hypersensitivity to catgut can be produced in experimental animals, but sensitization does not delay healing of laparotomy wounds repaired with catgut. Howes states that the myth of catgut allergy needs to be exploded once and for all, and that the truth should be admitted that a poor technique undoubtedly often accounts for the wound healing complications too glibly attributed to catgut allergy. In the present state of our knowledge the statement of Howes seems sufficient.

Comparative Value of Silk and Catgut. The comparative value of silk and catgut as buried sutures in clean wounds is still somewhat controversial. Jenkins and his associates conclude that "there do not appear to be any major clinical problems in wound closure which cannot be solved reasonably well by absorbable suture material." Meleney has observed less wound reaction when silk is used. His experiments have shown

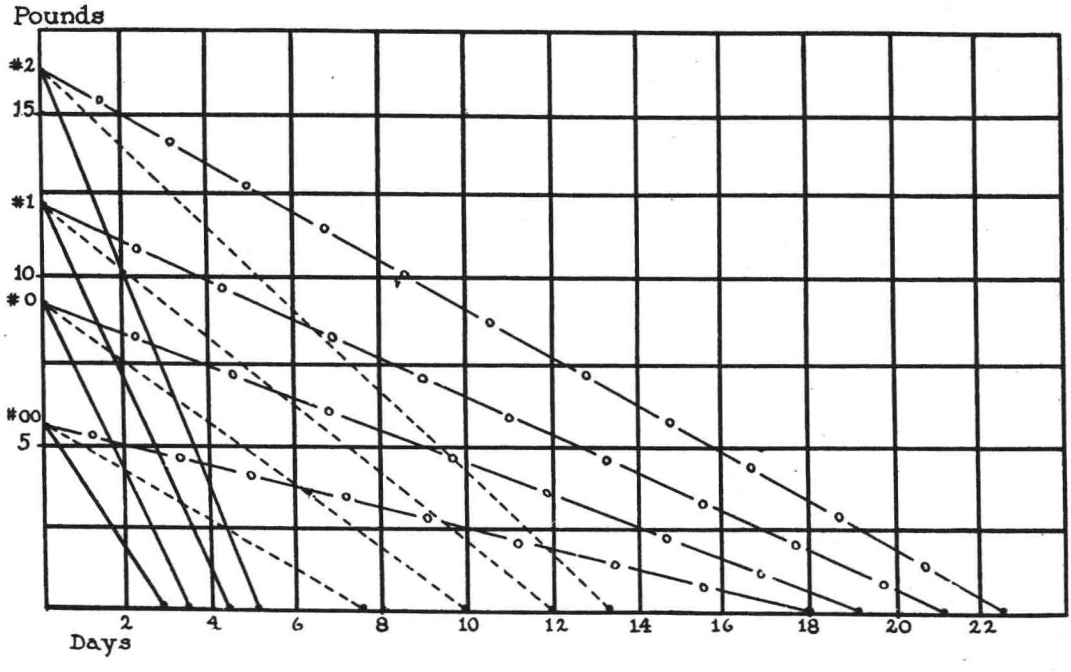

FIGURE 4. Decrease in the tensile strength of catgut in an uninfected wound: Solid lines, plain catgut; broken lines, 10-day chromic; lines with circles, 20-day chromic. (Howes and Harvey.)

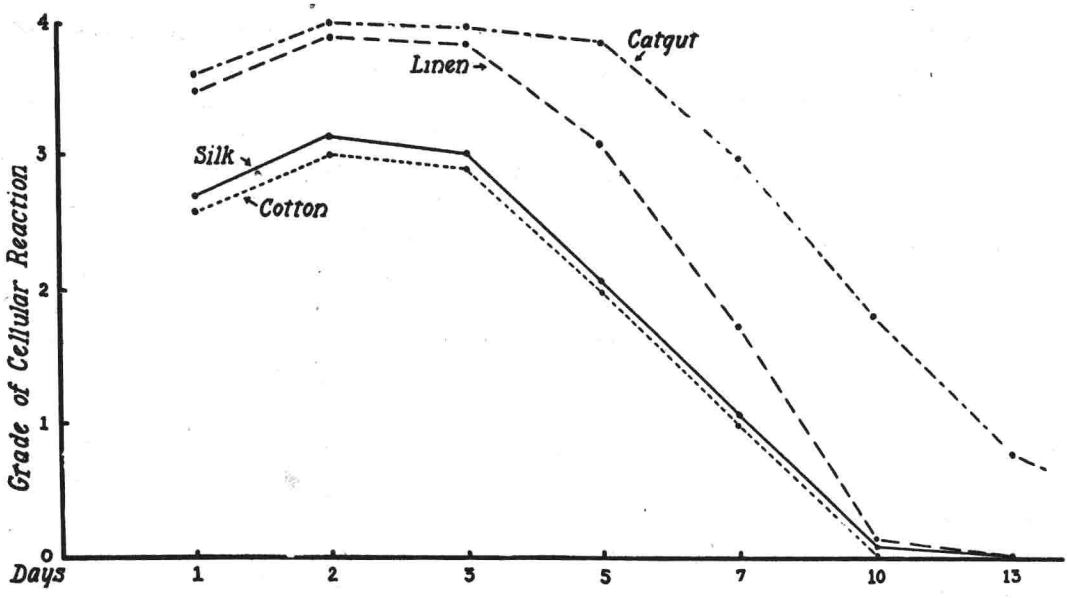

FIGURE 5. Graph illustrating the differential in cellular reaction of various suture materials. Tissue reaction continued much longer when catgut was used. (Meade and Ochsner.)

that wounds contain more bacteria and more cellular and fluid exudation around catgut than around silk sutures. Catgut sutures imbibe fluid, which increases their size and in time increases the tension on surrounding tissues. As the pressure on tissues is increased, the blood supply is diminished. Bates, in his animal experiments, made the observation that plain catgut causes much more irritation in the tissues than chromicized catgut. Wounds healed best when fine chromicized gut was used. Chromicized catgut was associated with a retarded and lessened exudative foreign body reaction and with the early appearance of fibroblasts and early healing. Bates concluded that if catgut is used for sutures and ligatures, the finer sizes of the chromicized product are the choice. Experimental studies by Jenkins and Dunham indicate that the irritation produced in tissues by catgut may be explained, in part, by the water-insoluble hydrocarbons and the alcohol used in the catgut tubing fluids.

Shambaugh and Dunphy, from their experiments with infected wounds in dogs, found that operative wounds repaired with silk tolerate bacterial contamination better than similar wounds repaired with catgut, and that healing of suppurating wounds is not appreciably delayed by buried silk sutures of a fine grade if cut close to the knot and not used as continuous sutures. Experimental suppurating wounds repaired with fine silk may heal completely without the removal or discharge of the silk sutures. In a clinical study Elkin recorded that 9.4 per cent of wounds in which catgut was used were infected compared to 2.1 per cent of infected wounds when silk was used. Localio and his associates found that aerobic cultures taken from experimental wounds sutured with catgut were positive approximately three times as frequently as cultures from wounds sutured with silk, cotton, steel wire or nylon. From experiments made upon rabbits and man Madsen concluded that silk, cotton, linen and stainless steel wire are preferable to catgut for closure of clean fascial wounds.

Silk. There is much recent evidence to support the belief by many that silk is

the most desirable suture material to use in clean surgical wounds. Economy and reliability of sterilization are, according to Shambaugh, obvious advantages of silk. This author also adds that silk is not weakened by sterilization, but loses about one fourth of its strength when wet. Size no. 000 silk for fascial sutures and no. 0000 silk for ligatures usually are advised. Heavier silk may be used for tension sutures. An increase in strength of the suture line may be obtained by increasing the number of individual stitches in a given area. Buried silk sutures should always be interrupted. Shambaugh finds that single interrupted stitches are stronger than mattress stitches.

Cotton. Meade and Ochsner have made both clinical and experimental studies of the use of cotton as suture material. They find that cotton produces less tissue reaction than catgut, linen or silk (Fig. 5). However, no great difference was noted between silk and cotton. "Commercial sewing" cotton, size for size, is two thirds as strong as catgut and three fourths as strong as silk. Mercerized cotton is 15 per cent stronger than plain cotton. Cotton maintains its tensile strength in tissues longer than catgut, linen or silk (Fig. 6). The sizes of cotton recommended are: no. 60 for plain ligatures on small vessels; no. 30 plain or mercerized for approximation of the peritoneum and fascia; no. 10 mercerized crochet cotton for through-and-through sutures of the abdominal wall. Long fiber cotton prepared for surgical use is now available in standard U.S.P. sizes. It has the advantage of greater uniformity and greater tensile strength. Cotton is being used by an increasing number of surgeons. The technique of the use of cotton should be the same as that of silk.

Alloy Steel Wire. Buried sutures of alloy steel wire are used by many surgeons

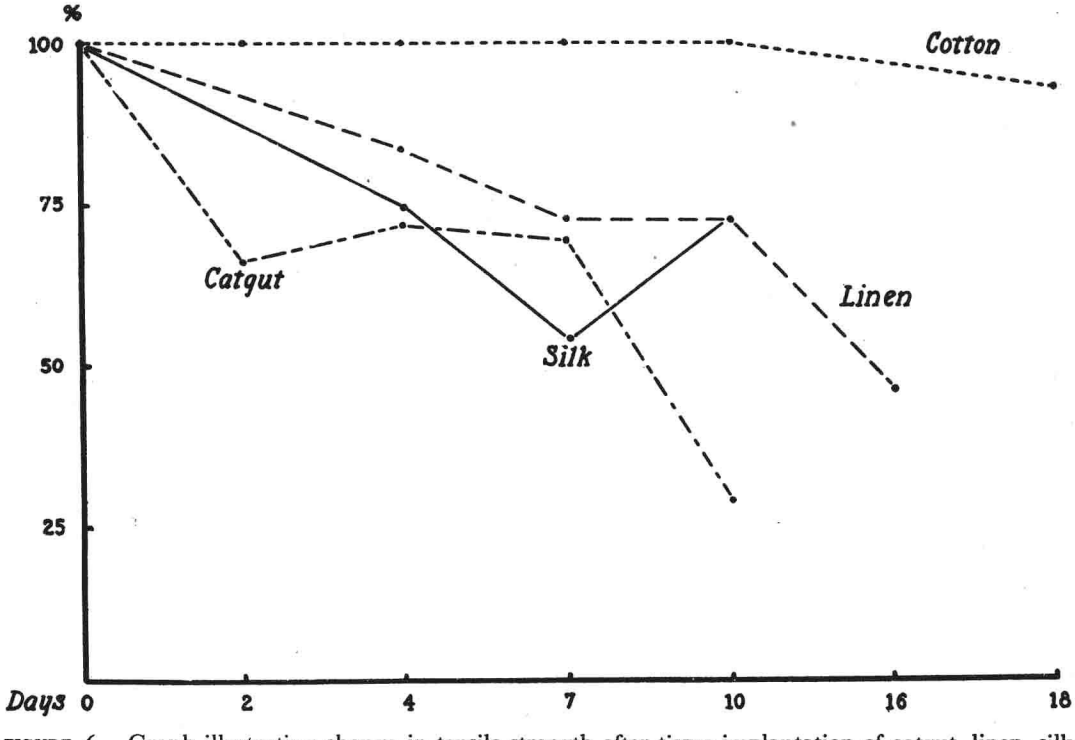

FIGURE 6. Graph illustrating change in tensile strength after tissue implantation of catgut, linen, silk and cotton. (Meade and Ochsner.)

with excellent results. It is Preston's opinion that wounds closed with wire have greater tensile strength than those closed with catgut or silk. By using alloy steel wire for the closure of abdominal incisions Jones has been able to reduce the incidence of both wound infections and wound disruptions. Whipple recommends the use of removable steel wire sutures through all layers of the abdominal wall. (See chapter on Abdominal Incisions.)

Errors to Be Avoided. There is much recent evidence to support the belief by many that silk is the most desirable suture material to use in clean surgical wounds, with the result that an increasing number of surgeons are using silk for both ligatures and sutures. Errors to be avoided as are follows: (1) tight sutures; (2) mass ligatures; (3) blunt scissors dissection; (4) careless hemostasis with heavy hemostats; (5) use of any but the smallest sizes of suture material (silk that will not break should not be used); (6) use of nonabsorbable sutures in any but a sterile field; (7) continuous sutures of nonabsorbable material; (8) placing of nonabsorbable buried sutures in the dermal layer of skin.

Drains

Drainage material in a wound is a foreign body which produces a typical reaction of the tissues against such material. In clean wounds it is better judgment to control all bleeding carefully, obliterate all dead space and close without drainage than to insert a drain and depend upon it to cleanse the wound of excess blood and serum. When drains are considered necessary in clean wounds, they should be removed in twenty-four to forty-eight hours. Infected wounds must frequently be drained. Here the removal of drains as early as is consistent with evacuation of exudate will prevent delay in healing by the presence of a foreign body.

Rest

Rest is an essential factor in the treatment of wounds. This is true of both clean and infected wounds. Motion of wound tissues disturbs delicate granulations, prevents the proper development of fibroblasts and may cause oozing of blood or serum which delays healing. The practice of splinting extremities, bed rest and limitation of activity are recognized parts of efficient management. The generally good results of early ambulation after operation seem to contradict the principle of rest as a major factor in wound healing which has been taught since the days of John Hunter. Early rising and the change of posture of a patient do not significantly exercise the wound area and interfere with wound healing if sudden and repeated strains are avoided.

Blood Supply

Without sufficient blood supply wounds will not heal. One of the best of media for bacterial growth is tissue deprived of its blood supply. Old age, general debility, strangulation of tissues by ligatures, devitalization of tissues by tension of sutures, excessive local trauma, edema, arteriosclerosis and other blood vessel diseases influence the blood supply to wounds. Reid emphasized the importance of closing infected or disrupted wounds with through-and-through silver wire, thus avoiding any introduction of foreign material within the wound proper or the strangulation of already damaged wound surfaces (Fig. 7).

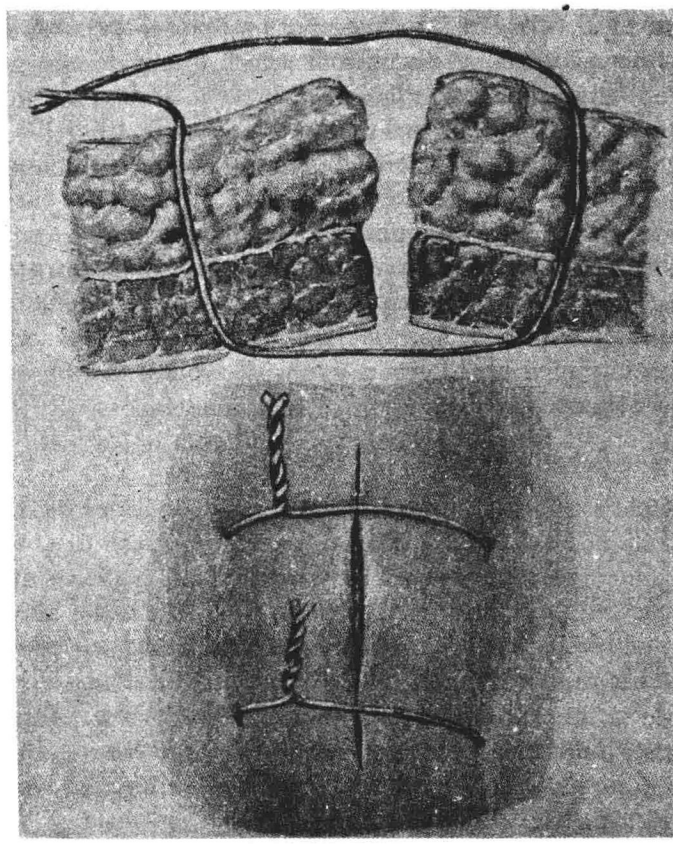

FIGURE 7. Through-and-through sutures of silver wire, useful in closing infected or disrupted wounds. (Reid.)

The position of the wound will often influence its blood supply. Reid mentioned that the relation of the wound to the heart level may be important in securing the best circulation. For example, a foot with disturbed circulation has better blood supply when somewhat below the level of the heart. The placing of sutures so that a warm, moist dressing will promote oozing of blood and serum during the period of edema is a practical point in maintaining good blood supply. Pressure dressings, which are useful for protection and approximation of wound surfaces, may, if improperly applied, compress small vessels or capillaries and vitiate blood supply. The release of all pressure and tension is possible in some cases, such as amputation stumps, by applying skin traction with weight and pulley. Heat applied to wounds increases the blood flow and promotes healing.

WOUND DISRUPTION

Incidence

It is probable that the incidence of disruption of abdominal wounds rarely exceeds 3 per cent. Wolff (1950) reported a 2.6 per cent incidence of wound disruption in a series of 1700 laparotomies. In 8319 major abdominal operations upon chil-