when the closure of the wound will not diminish the intestinal calibre more than one-third; either of the latter methods, when the gut is extensively injured. In certain wounds when direct closure will narrow the calibre more than one-third, additional room may be gained by closing the wound transversely. To do this it may be necessary to increase the size of the wound by making longitudinal incisions of suitable and equal lengths at either end of it. The intestinal wall is then grasped at corresponding points on opposite sides and drawn upon; the longitudinal wound is thus converted into a transverse one, and in this position its borders are united. By this means a certain amount of "elbowing" is produced. While, as a rule, it is unwise to trim the borders of intestinal wounds, yet care should be taken to examine the border of a wound contiguous to an important vessel, to ascertain if the integrity of the vessel has been endangered; otherwise the closure without this precaution may be followed by secondary hemorrhage.

The wound may then be closed by either the Lembert or continuous sutures. A double row of the Lembert or continuous suture may be made, or a single row of each, or the Czerny-Lembert. Of the continuous varieties, the right-angle continuous suture of Cushing is advisable. (See article on *Sutures*.)

The sutures, to be reliable, should go down to and embrace a thread or two of the submucosa, and not be more than three lines apart. Sutures limited to the serous coat alone are insecure and dangerous, and those entering the lumen, although less seriously considered than formerly, are yet to be regarded with wise distrust. The best material for suturing the intestine is the loose-textured carbolized iron-dyed silk.

If the mesenteric border only of the intestine is wounded, the injured portion of the gut should be excised, because gangrene is liable to follow from injury to the vessels of the part.

When the intestine is completely severed, either by the original injury or by the knife of the surgeon, the difficulty of adjusting the cut borders is much increased. The portion to be repaired must be drawn well out of the abdominal wound and carefully isolated by sponges and pads that completely prevent blood, fæces, etc., from entering the abdominal cavity. The uppermost extremity of the divided intestine will be known by the greater amount of fæcal matter seen at its open end. The intestinal contents must be pushed aside for some distance from the part to be operated on, and the bowel occluded above and below. This occlusion may be effected by using the clamps already referred to, or by making a hole in the mesentery and ligating the intestine with either a cord of iodoform gauze or a flat india-rubber band. The fingers of an assistant serve better than anything else. The clamps may cause sloughing if carelessly or continuously applied. The excision is made with sharp, straight-bladed scissors usually at a right angle to the long axis of the intestine. The length of the portion removed will depend on the extent of the injury; it should always be sufficient to include the seat of injury, even though it may be six or eight inches in extent, and when multiple perforations exist near each other, it is advisable to include them all in one resection, even if the portion of intestine removed must be three or more feet in length.

The vascular supply of the intestine at the seat of injury should be carefully examined, and all that portion of gut excised that has an impaired supply of blood, else gangrene of the bowel may ensue. In fact, it is a wise precaution in excision always to divide the gut at a point which will afford the best vascular supply to the extremities to be united—that is, close to the entrance of a mesenteric vessel into the uninjured portion. The mesentery corresponding to the portion of gut removed can be cut away in the form of an isosceles triangle, the base of which shall correspond to its intestinal attachment, or it may be ligated *en masse* or in sections at its point of attachment, and allowed to remain free in the abdominal cavity. The latter plan is unsafe, since, owing to the feeble vitality of its tissue, gangrene of the distal extremities of the mesenteric stumps frequently ensues. Parkes advised that the entire mass be included in one ligature drawn tight enough to check the bleeding, and that then, after the intestine has been united, the stump be stitched to the seat of operation, thereby forming again as nearly as possible a continuous mesentery. Another method is to make two incisions, one on each side of the mesenteric attachment and at a distance of about half an inch from it, through the wall of the intestine in its long axis corresponding in length to the portion of the intestine to be removed. The mucous lining of this mesenteric strip should then be torn away and its peritoneal borders united by a continuous suture of fine catgut. After the excision is completed and the ends of the intestine have been united, the mesenteric strip will present a looped appearance due to the approximation of the intestinal extremities. The opening of this loop should be united by sutures, and the opposed surfaces of mesentery should also be transfixed, to prevent the formation of a pocket there. When the ligature *en masse* is employed, it is not considered safe to use catgut.

As soon as all hemorrhage has been checked, the divided ends of the intestine are approximated by an assistant and some form of suture is introduced. The suturing is begun at the mesenteric border, care being taken to close tightly the triangular space at this point caused by the reflexion of the peritoneum from the walls of the intestine. After this, the protruding mucous membrane is pushed into the intestine and a suture is introduced at each of the three remaining aspects of the bowel, and then the intervening spaces are properly sewed. This is a better plan than to begin to sew at any given point and go directly around. If a Lembert is used, at least three or four lines of peritoneum should be included in the grasp of the suture at each extremity of the intestine. A suture should be drawn only sufficiently tight to bring the severed borders in close apposition, for if drawn too tightly the tissue grasped by it will slough. If a single row of sutures is to be made, they should be placed about 5 mm. apart. If a double row is to be employed, those of the first can be deposited within 6 or 7 mm. of each other, and those of the second at intervals between the former. After the bowel is united, it is well to return to the mesenteric border. This is the weakest portion of the wound. It should be covered by stitching the two peritoneal layers of the mesentery over it, or by an omental graft.

Omental Grafting.—In certain experiments on dogs, Senn fixed a flap of omentum over the seam of an enterorrhaphy, the free or distal end being attached over the seam, the proximal remaining continuous with the omentum. These soon grew in place and thus reinforced the bowel. To avoid the danger of strangulation occurring through the loop thus formed, isolated grafts were employed and fixed round the suture. In every instance they retained their vitality. In performing the operation, the intestinal peritoneum is lightly scarified before the flap is put in position, and in a few hours it is adherent. Intestinal end-to-end or lateral approximation, by means of Senn's plates, Murphy's button, and various analogous procedures, and also by the different methods of suture, is elsewhere fully described.

Cleansing the Peritoneal Cavity and Closing the Abdominal Wound.—All the bleeding points must be closed by ligature if possible, if not, then by cautery. It must not be forgotten that the tendency of intra-abdominal vessels to bleed when not exposed to the air is very great; therefore a simple oozing before the closure of the abdominal walls is likely to become a formidable hemorrhage afterward; and even though the secondary oozing be not sufficient to imperil life by loss of blood, it is liable to do so by causing inflammatory or septic processes. The blood and other fluids, fæcal matters, and all other foreign agents must be removed from the abdominal cavity, and the surface of the peritoneum with its cul-de-sac thoroughly mopped with soft aseptic sponges soaked in hot decinormal saline solution. Too great care cannot be taken in sponging away the foreign matters, and, as already stated, the same portion of the sponge should be applied to a serous surface but once, since to apply it repeatedly causes quite as surely the dissemination as the removal of the irritating agents, and the friction impairs and destroys the epithelial surface.

Malcolm, of London, advises flushing out the abdominal cavity for the purpose of adjusting naturally the intestinal folds. The saline solution at the temperature of 110° F. is poured into the cavity from a pitcher until the intestinal folds float up, subsiding later into their normal positions. The fluid is poured in until it returns clear. Flushing with hot fluid cleanses the peritoneal cavity, and, besides, acts as a stimulant. The leaving in the peritoneal cavity of a quart or so of hot saline solution, to dilute infecting agents and facilitate their removal, has the sanction of common practice, supported by favorable results. Whether the normal upward absorption flow should be facilitated by raising the foot of the bed (Kelly) or hindered by lowering it (Fowler) in instances of peritoneal infection, requires further study before a final conclusion can be reached. In this connection it is proper to recall that G. Wegner determined that the hourly absorption capacity of the peritoneum for fluids equalled from three to eight per cent. of the weight of the animal subjected to the experiment.

The abdominal wound should be closed by three rows of sutures. One should be continuous of fine, strong silk, perhaps chromatized catgut, and should include the serous and subserous tissues and the transversalis fascia. The practice of making a deep row of interrupted sutures widely separated, or of including the whole thickness of the abdominal wall in one such row, is to be condemned. The pockets or dimples of peritoneum which are thereby formed between the stitches invite the occurrence of hernia, and often beget dead spaces. The second row may be of silk or catgut, interrupted or continuous, including the aponeurotic and muscular tissues. The third row should be of interrupted silkworm gut or fine silver wire, and should effect the closure of the integument and subcutaneous part of the wound. Retaining sutures introduced outside of the preceding may be employed if undue tension be present or anticipated. If necessary, the wound may be drained. And last of all, an antiseptic or aseptic dressing is to be applied. The patient should be quieted by small doses of an opiate; the diet should be light at first and of a nature to leave little or no residue. The bowel contents ought to be maintained in a soluble state by means of saline medication when septic intraperitoneal processes are present. The bladder should be evacuated with a catheter.

PROGNOSIS.—Ruptured or lacerated wounds have thus far proved exceedingly fatal. Of five cases reported during the late Civil War all were fatal. Curtis reports eight cases which were operated on, and death occurred in all. Since then several others, in which laparotomy was performed, have been reported, only one of which, that of Crofts, was successful.

The prognosis in cases of gunshot wounds of the intestines, when treated by laparotomy, has of late years vastly improved. In 1887, Morton published a series of 22 cases with a little less than 23 per cent. of recoveries. About the same time MacCormac collected 30 cases in which laparotomy had been performed (Morton's were included), and gave the recoveries at a little over 23 per cent. Since then a collection of 35 cases shows 18 recoveries, or a little over 51 per cent.

In cases of laparotomy for contusions, Gachon (1895) found a mortality of 20 per cent. in early operations, while if the intervention was after the twentieth hour the mortality was 73 per cent. Petry (1896) found that after 42 first-day operations there were 33 per cent. recoveries; and that in 24 cases operated on after the first day there were 25 per cent. recoveries.

Adler (1892) found that in 154 cases of projectile wounds of the abdomen, in only 11 was serious visceral injury absent. Lühe (1890 and 1892) found that in 191 cases, 21 escaped intestinal injury and 6 escaped all visceral injury. Duroselle (1894) found that but 5 escaped visceral injury in 155 cases. Vulliet (1897) found that 12 escaped out of 83.

Vulliet mentions a series of 27 cases of lacerated and punctured wounds collected since 1890 which were treated expectantly. The percentage of recoveries was 57. In a series of 43 cases of projectile wounds treated expectantly, the percentage of deaths was 46.5. The same author speaks of the expectancy mortality of lacerated wounds as 37 per cent.; of projectile wounds as 50 per cent., referring probably to all cases since 1890. Reclus and Noguet claim that by the let-alone plan in 88 cases the mortality was but 25 per cent (this report appears to refer to wounds irrespective of causes).

In Coley's second series (1891) of laparotomies for penetrating wounds of the abdomen, amounting to 165 cases, the mortality was 67.2 per cent. Reclus and Noguet found the same mortality rate, 78 per cent. in 73 cases. Vulliet states that in 40 cases of laparotomy for projectile wounds performed during the first twelve hours, the mortality was 44 per cent.; after the first twelve hours, 50 per cent. Adler's figures correspond closely to those of Vulliet's.

Dörfler, the most recent writer (1897), states that the mortality from laparotomy in cases of projectile wounds performed in the first five hours is 50 per cent.; before twelve hours, 55 per cent.; after twelve hours, 70.5 per cent.

Laparotomy for instrumental wounds in the first five hours has the low mortality of 16 per cent. Fenner reports the following outcome of laparotomy in Charity Hospital, New Orleans, from January, 1892, to January, 1901: Gunshot wound of the abdomen 113 cases with 78 deaths; stab wounds of the abdomen 39 cases with 9 deaths.

Of stab wounds which were operated on, Morton reported 19 cases with 63 per cent. recoveries; MacCormac 18 cases with over 55 per cent. of recoveries. A collection of 19 cases made since then gives over 79 per cent. of recoveries.

Joseph D. Bryant.

INTRAVENOUS INJECTIONS.—This method of introducing substances into the body may be said to have a very limited field of usefulness in practical medicine, though it is the common method with animals in the laboratory. The mouth and rectum will always be the readiest ports of entry to the body. When these cannot be used, or when rapidity and certainty of action are needed, the hypodermic needle will usually meet the needs of the case. Rarely will the advantages of the intravenous route overweigh its dangers and difficulties.

The advantages of the intravenous method are: 1. Greater rapidity of absorption. This is certainly a just claim and constitutes the chief indication for the use of the method. 2. Greater certainty of absorption. Ordinarily the absorption of substances introduced under the skin may be reckoned as certain, but sometimes when a patient is *in extremis*, as in severe surgical shock, fluids placed under the skin are taken up but very slowly. 3. It is painless. Some irritating substances, such as mercurials, cause considerable pain when introduced hypodermically, but when injected into a vein they are so rapidly swept away into the general circulation that no local pain can occur. 4. Abscesses are less apt to occur for the same reason. One should not on this account, however, be less careful in regard to asepsis.

The disadvantages as compared to the subcutaneous method are: 1. Greater danger. This arises rather from failure to observe proper precautions than from any faults inherent in the method. When carefully and judiciously used the method is safe enough to be employed in the emergencies in which it is needed. The chief danger is probably from embolism. The substances introduced cause the formation of a clot which is carried to the right heart and thence to the lungs. If only agents known to be harmless when thus used are employed, if they are sufficiently diluted and are introduced slowly, there is little danger from this source. Thrombosis with ulceration has resulted from injections into a vessel in the foot

of a patient with varicose veins. The introduction of air is a danger that may be avoided by care. 2. The action of a drug when put directly into the blood may be different, qualitatively and quantitatively, from its action when it is given by the mouth or by the skin, because it reaches the blood and is carried to the heart and other organs in such concentrated form—an objection which may be partly overcome by using dilute solutions and giving them slowly. 3. The more difficult technique is often spoken of as the greatest objection. It is sometimes hard, especially in women, to put a needle through the skin directly into a vein. Even after the vein is exposed it may be an exasperatingly delicate operation to get a cannula into it.

The amount of care and skill needed to avoid the dangers and difficulties, then, is so great as to forbid the use of intravenous injections as a routine measure. The procedure is to be reserved for those cases in which other methods have failed, or in which an emergency demands great haste.

The following are some of the special instances in which intravenous injections have been used:

In syphilis the intravenous use of mercurials has been especially advocated by Baccelli. The solution used is as follows:

Corrosive sublimate	1
Sodium chloride	3
Distilled water	1,000

One cubic centimetre of this (1 mgm. of mercury) is the usual dose, but in urgent cases it may be increased. The cyanide has also been used. This procedure may be of value in those few cases in which mercury does not appear to produce its usual good effect when given in the ordinary ways or in which rapid advance of the disease makes it essential to get the patient mercurialized at the earliest possible moment. Besides the dangers already mentioned, the intravenous use of mercury has been followed by severe ptyalism even after small doses. For ordinary cases the method has no advantages over the simpler ones in common use.

Baccelli has also urged the intravenous administration of quinine in pernicious malaria. The following solution is used, acid solutions not being permissible:

Quinine hydrochlorate	gr. xv.
Sodium chloride	gr. xij.
Distilled water	ʒ iiss.

This is to be boiled and filtered. Symptoms of cinchonism, ephemeral in duration, may appear soon after the use of gr. xv. of quinine in this way. As in the case of mercury this method is to be reserved for the treatment of pernicious cases when quinine given in the ordinary ways has proved of no avail, or when great haste is demanded.

For the purpose of introducing into the circulation large quantities of artificial serum in surgical shock or hemorrhage or for "washing the blood" in uræmia, septicæmia or other toxæmic states, and in collapse from cholera—for these purposes intravenous injections are of the greatest value. In such cases only will the average practitioner ever be called upon to use them. In general we may say that the indications for the intravenous injection of salt solution are the same as for hypodermoclysis, and the reader is referred to the article with that title. And the hypodermic method, by reason of superior convenience and safety, will almost always be chosen. But in certain cases of extreme shock, absorption from the subcutaneous tissue is slow and uncertain. Thus Jones reports two cases in which, owing to failure of absorption from the skin, hypodermoclysis was ineffectual; on using the veins, however, both patients speedily improved. Again, when hemorrhage has been profuse and every moment is of value, the intravenous route is the best. Ringer's solution (see *Hypodermoclysis*) or 0.6-per-cent. salt solution may be employed. Milk or distilled water—both of which have been employed with fatal results—are mentioned only to be condemned.

Intravenous injections have been recently used in diabetes mellitus, especially in coma, and in accordance with the theory that the coma is due to an acid intoxication, large quantities of sodium bicarbonate are given in this manner. Three per cent. of sodium bicarbonate is added to decinormal salt solution and upward of a quart given. A discussion of the value of this procedure would be out of place here. It need only be said that the improvement is often striking, but if coma is well developed it is usually temporary. The intravenous route is the one usually selected in urgent cases—*i.e.*, in cases in which time is of importance.

Gelatin solutions have been used intravenously in aneurism, internal hemorrhages, hæmophilia, and other hemorrhagic conditions. The subcutaneous route is the one ordinarily chosen, the mouth and rectum being used at the same time. The intravenous route is hardly justifiable, and indeed the whole matter is still *sub judice*.

Intravenous feeding has been tried but is too dangerous to be of practical value.

Technique.—This varies with the substance to be introduced or, more properly, with the amount of fluid used. Small quantities, as in the case of mercury or of quinine, are best inserted directly into the vein. The arm is constricted by a bandage above the elbow so as to shut off the return of blood and distend the veins. The largest vein near the bend of the elbow is selected, and the field is rendered sterile by scrubbing with soap and then with corrosive sublimate solution. The sterilized needle is then introduced directly into the vein through the skin. It must point upward in the direction of the circulation. The bandage is then removed and the injection is slowly made. If the needle has not entered the vessel a small tumor will be formed and the attempt must be repeated. The solution should always be warm when introduced. Any syringe may be used which has a capacity of several drachms and which may be sterilized by boiling. The ordinary antitoxin syringe, made wholly of glass and packed with string, is as good as any. The only difficulty is in getting the needle into the vein. This is much lessened if care be taken to use a new and very sharp needle. The writer has easily inserted a needle into one of the comparatively small veins of the wrist. The vein is not injured and many injections may be made at the same point without producing any appreciable change in the walls of the vessel.

For the introduction of large quantities of fluid it is probably better to insert a cannula. After applying a bandage and rendering the field of operation sterile, as before, the vein is exposed by an incision and a double ligature is passed. The lower ligature is tied and the vein is partly opened by snipping with scissors. Into the opening thus made a glass cannula is inserted, or if this be not at hand a dulled hollow needle. The other ligature is now tightened about the cannula and the fluid is allowed to flow in from a height of one or two feet. Before starting the flow every precaution must be taken to see that the fluid contains no air. The injection is to be made slowly, at least fifteen minutes being taken for the introduction of a quart. The best temperature is about 110° F. After the operation is over the cannula is removed and the incision is closed and dressed. Every precaution should be taken to have the fluid and its container, all instruments and tubes, and the hands of the operator sterile. A glass irrigating apparatus with rubber tubing may be used, or in an emergency a rubber fountain syringe, sterilized by boiling. But the best apparatus consists of a large flask with a rubber stopper arranged like a wash bottle. Through two holes in the stopper glass tubes are passed. One, for the purpose of admitting air when the flask is inverted, leads to the bottom, and the other to which the rubber tube is attached leads just through the stopper. The whole apparatus filled with fluid may be sterilized in the steam sterilizer, or if an ordinary chemical flask is used it may be boiled over a tripod.

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INTUBATION.—In 1856 Bouchut suggested and actually practised a crude method of intubation, which, however, the ridicule of his confrères soon forced him to abandon. Before this time, catheterization of the larynx had been practised to a certain extent for the temporary relief of urgent symptoms of stenosis, but with little success. In 1880 Dr. Joseph O'Dwyer, of New York, with no previous knowledge of the experiments of Bouchut, began to study the subject of intubation. This work extended over a period of three years and was performed at the New York Foundling Hospital, where the operation of tracheotomy had given such fatal results that it had long since been abandoned. After many failures and a few partial successes, Dr. O'Dwyer gave to the world the perfected instruments as they are made to-day.

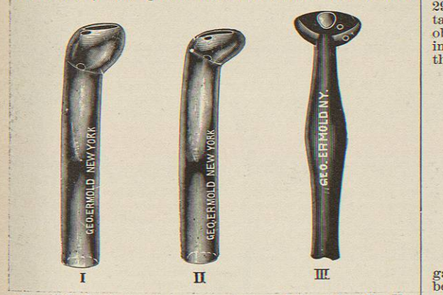

FIG. 2940.—Intubation Tubes. No. I., Granulation tube; No. II., lateral view of ordinary tube; No. III., anterior view of the same.

Intubation Instruments.—The tubes are made of hard rubber (the older metal tubes were found to promote the deposit of lime salts about the lumen and caused damage to the larynx if worn for more than a few days), in seven or more sizes suited to the various ages of childhood. A metal scale for determining the proper tube for a given age accompanies each set of instruments. The tubes (Fig. 2940, Nos. II. and III.) are long enough to reach nearly to the bifurcation of the trachea, thus lessening the chance of obstruction by loose membrane. The retaining swell is sufficiently full to keep the tube in place and yet small enough to allow of ready expulsion when the lumen is blocked. The neck is narrow and adapted to the grip of the vocal cords.

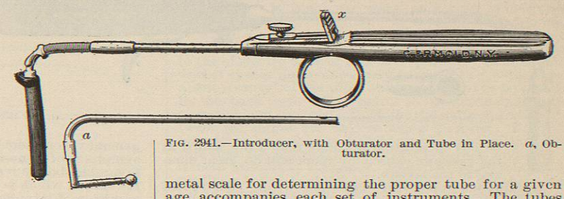

FIG. 2941.—Introducer, with Obturator and Tube in Place. *a*, Obturator.

Ulcerations were found to be caused by the earlier tubes at three points: 1. In the cricoid division of the larynx (the narrowest part); this is obviated by using the smallest possible tube for a given age. 2. At the base of the epiglottis; this is avoided in the modern tubes by giving the head a backward sweep and leaving a good deal of material at its anterior part, thus distributing the pressure at this point. 3. At the end of the tube and caused by the movement of the trachea against it; this is avoided by making the end bulging and well rounded off.

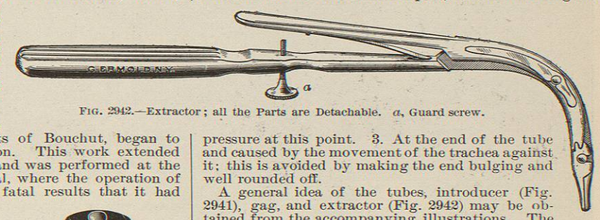

FIG. 2942.—Extractor; all the Parts are Detachable. *a*, Guard screw.

A general idea of the tubes, introducer (Fig. 2941), gag, and extractor (Fig. 2942) may be obtained from the accompanying illustrations. The obturator (Fig. 2941, *a*), one for each tube, fits into the introducer and is released from the tube by the thumb of the operator pushing forward the button at *x*. The mouth gag (Fig. 2943) is a powerful instrument and need not be used in young infants as it has the undesirable property of lacerating toothless gums.

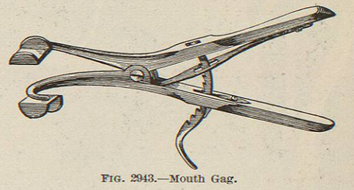

FIG. 2943.—Mouth Gag.

In addition to the regular tubes there are tubes especially adapted to getting rid of loose pseudo-membrane. These are hollow cylinders of different sizes and of large calibre (Fig. 2944), short enough not to push down the membrane and long enough to reach below the cricoid