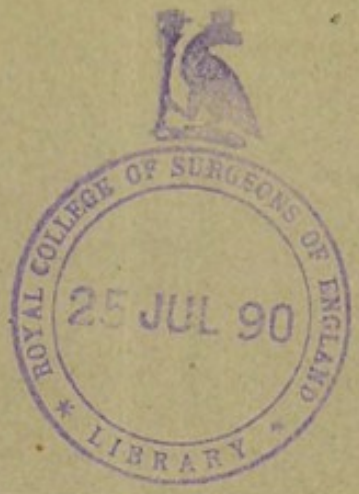
On penetrating gunshot wounds of the abdomen : an experimental study and clinical review / by Aug. Schachner.



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GUNSHOT WOUNDS

OF THE ABDOMEN.

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Reprint from ANNALS OF SURGERY, June, 1890.

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ON PENETRATING GUNSHOT WOUNDS OF THE ABDOMEN. AN EXPERIMENTAL STUDY AND CLINICAL REVIEW.

By AUG. SCHACHNER, M.D.,

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NOW that the propriety of operative interference in the treatment of penetrating gunshot wounds of the abdomen is fairly settled, a natural demand addresses itself to the surgeon for the early establishment of such rules as offer the best success in the treatment of these injuries.

While the indications upon a whole may seem very plain, there are yet many questions and processes to be understood and decided, which time, research and experimentation can alone supply. An analysis of such cases and discussions as the current literature affords bears strong evidence in this direction, and until a more intimate knowledge of the details of the subject is at hand, our success must necessarily be limited. In view of this, a series of experimental operations were instituted by Dr. Ap Morgan Vance, and the author, with the hope of throwing additional light upon the subject, and although the desired end may not be found within the scope of this paper, it is hoped that it may be of some value as an additional contribution to that already at hand from Parkes, Senn, Bull, Stimson and others. Before entrance upon the subject proper, we take this occasion to extend our thanks to the hospital committee, Dr. J. L. Long, Mr. B. H. Lammers, now Dr. Lammers, and others, for valuable assistance rendered upon different occasions. The earlier and major portion of this work was done near the suburbs of the city, but upon the approach of winter was transferred to the Louisville City Hospital. The facilities afforded at either place were only ordinary, and especially at the latter, where several dogs that had been

operated upon and recovered, as well as one that was shot, and upon which no operation was performed, through a defective means of keeping, made their escape. The dogs were selected, regardless of their surroundings or conditions, and in several instances their deaths were apparently traceable to the undersize of the subject.

Shaving the field of operation and anæsthetizing constituted the only preliminary steps to which they were submitted previous to the shooting. In nearly every instance ether was the anæsthetic employed, five deaths occurring from the effects of the anæsthetic which are not hereafter mentioned in the experiments. Of these, with the exception of one or two, chloroform was employed, death occurring either before or during the earlier part of the operation. The shots were fired at a close range, and only such care exercised as to avoid the production of some irreparable injury, while they should still fairly present such cases as ordinarily fall into the hands of the surgeon.

The wounds were inflicted by a .22 and .32 calibre Smith & Wesson pistol and a .22 calibre Remington rifle, the projectiles used being floberts, .22 "shorts" and "longs" and .32. Comparing in size the abdominal viscera of an average full-grown dog with those of an adult human, about the same effect is obtained from the use of a .22 in a dog as that of a .32 or larger in a man.

The work was done as antiseptically as permissable. After shaving, the field was scrubbed with potash soap, followed by a 1:2000 sublimate solution, or a 5% solution of carbolic acid, and lastly bathed in a 10% ethereal solution of iodoform. During the progress of the operation the surrounding site was covered with towels, wrung out of a hot 1:2000 sublimate solution. Likewise upon the part of the operator suitable antiseptic precautions were employed. Successive baths of permanganate of potash, oxalic acid and hyposulphite of soda served for the preparation of the sponges. In those cases where cleansing of the abdominal cavity was indicated, flushing with warm Thiersch's solution or warm sterilized water was resorted to; otherwise the irrigator charged with Thiersch's solution answered the purpose. Catgut prepared

after the method of Kocher, and silk after that of Czerny, represented the materials used for sutures.

The dressings in common use did not prove to be of practical value here. After closure of the abdominal wound, which was done by the combined "mattress suture" and "glover's stitch," it was dusted with iodoform and a liberal application of liq. gutta percha used as the only dressing. The liq. gutta percha when made by reinforcing the U. S. P. preparation, with an additional one-third of its official amount of gutta percha furnished an admirable dressing, sealing the wound in a most thorough manner. As to the food, this in the beginning, for about a week subsequent to the operation, was restricted to that of a liquid character, but later such care was less and less observed, until finally almost ignored, and in one instance where a resection was done, by a mistake a large piece of raw meat was given but a few hours after the operation without any evil resulting. Such briefly represents the manner in which the experiments were carried on. Neither time nor space would permit here of even a brief review of the opinions and progress of the work done upon this subject.

Some General Considerations of the Nature of These Injuries.

Nowhere within the domain of surgery are the effects attending gunshot wounds more multiple and uncertain in their nature than those penetrating the abdominal cavity.

Even where some definite knowledge of the character of weapon and missile used and the circumstances under which the injuries were received are at hand, no safe conclusions can be reached as to the extent and course of the ball or the amount and character of damage it creates, since it is a well-known fact that even where projectiles are discharged under conditions as like as practicable, they will often differ widely in their energy and velocity. While it may be safely said that as a rule the extent of danger is more or less in direct ratio to the size of the ball, such a rule is by no means absolute. Numerous conditions, some of which apparently trivial in their

nature, have a marked influence upon the effect of the missiles. To a certain extent this was descernable in these experiments where floberts, .22 "shorts" and "longs" were differently employed. Notwithstanding the latter and regardless of the weapon, there was apparently no difference in the number of perforations whether the one or the other was employed. Such however was not the case as regards the nature of the injury. Here a certain relation was traceable between the character of the missle and weapon upon one hand and that of the injury upon the other. Especially was such the case

FIG. 1.—SHOWING A PERFORATION CREATED BY A .22 CALIBRE BALL FIRED FROM A REMINGTON RIFLE.

where the rifle was employed, the effect of which was in nearly every perforation markedly out of proportion to the size of the ball. Figs. 1 and 2, each of which measured more than an inch in length and nearly the same in width. The diverse effects of missiles are generally explained upon the differences in their energy and velocity, together with a rotatory motion which they acquire after a certain part of their course. Where the disproportion between the effect and the size of the missile is

very great the difference seems to point largely to the latter as the cause. With the exception of two, every ball fairly entered the abdominal cavity and many passed through making their exit upon the opposite side. Of the two that failed to enter one became arrested immediately under the parietal peritoneum while the other fell harmlessly aside without even producing a lesion in the skin.

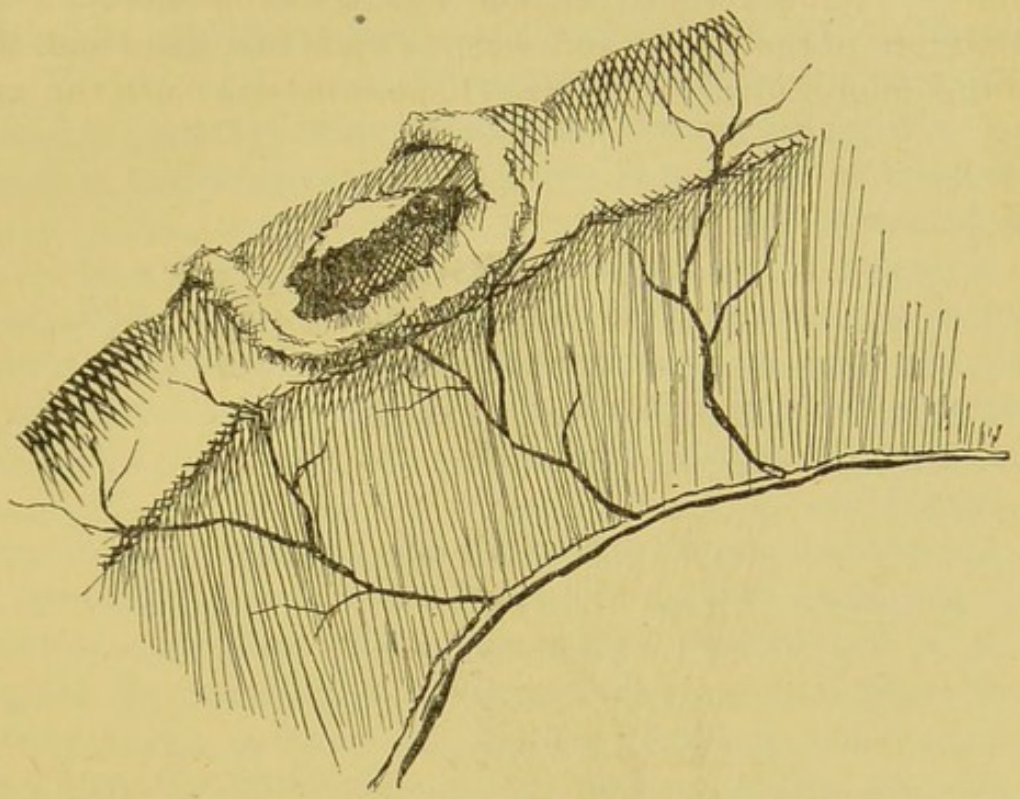

FIG 2.—SHOWING ANOTHER PERFORATION CREATED BY A .22 CALIBRE BALL FIRED FROM A REMINGTON RIFLE.

In forty experiments upon thirty-six alive and four just dead from the effects of the anæsthetic, where it was positively known that the ball had entered the abdominal cavity, one escaped without receiving any injury whatever to the contained viscera, in another the damage amounted to a non-perforating wound of the intestine and a wound of the mesocolon involving a large vessel, in a third to that of a non-perforating wound of the intestine and in a fourth to a wound of the spleen without any intestinal lesion. That balls may pass through the abdominal cavity in the human, without producing an in-

jury to any of the contained viscera, is mentioned by different authors; and while there remains no doubt of the possibility of such, experience has abundantly proven that it is by far the exception and we may safely conclude that when a ball has entered the abdominal cavity that injury to one or more viscera has occurred. And when we consider the anatomical arrangement of the contained viscera it is not difficult to see why such should almost inevitably be the case and only where the path of the ball is superficial or tangent to the abdominal wall does escape at all seem possible.

Following the perforation of the intestine generally occurs an ectropion of the mucosa which as a rule corresponds in degree to the size of the opening.

Notwithstanding the great uncertainty of the wound of entrance as a guide to the injury within, a study of the same should not be overlooked, since it not only furnishes inferences of the probable injury but is often of value to the surgeon as an aid in more readily determining the source of the severe hæmorrhage.

The opinion among surgeons seems to differ upon the relative frequency with which extravasation complicates perforations of the stomach and intestines. By many it is held that such is the rule, while the experiments differently made upon lower animals decidedly point to the contrary, and also in the human subject the cases are not sparing where not only large as well as multiple openings existed without any extravasation occurring and in spite of the fact that the bowel contained much feculent matter. It is the opinion of Sir William MacCormac[1] that experience teaches that fæcal extravasation follows in ninety-nine out of every one hundred intra abdominal injuries, but no mention is made of the time that passes before the escape, and Otis, in the "Medical and Surgical History of the Rebellion," expresses a like opinion that in the vast majority of cases extravasation follows. It is to be regretted that in the cases so far reported very little is mentioned of this as a complication to the injury, since it is only by a study of a large number of cases that this question can

[1]Klin. Zeit. und Streitfragen, p. 357, bd. 2, hft. 10.

be satisfactorily answered. In thirty-two of the containing experiments nineteen were attended with extravasation and of this number it was the exception for such to occur before handling of the intestine was commenced. Erichsen assigns three principal causes that tend to prevent extravasation: (*a*) Ectropion of the mucosa. (*b*) Closure of the opening by the contiguous coils of intestines. (*c*) Arrest of the peristalsis from the shock of the injury.

In the experimental work it was not an uncommon occurrence to notice a perceptible impression upon the animal immediately after the reception of the injury. Occasionally the intestines were found almost throughout in a state of contraction or in portions alternately contracted and dilated and where this contraction existed it never failed to undergo relaxation upon exposure and handling. In the absence of interference, that extravasation should be the ultimate outcome of perforations of the intestines is not difficult to see, yet there is no doubt that a large number of the cases that fall into the hands of the surgeon during the first twelve hours are devoid of this complication and the chances of immunity increases with the promptness of the interference and the enjoining of absolute quiet on the part of the patient.

Based upon an analysis of 253,142 cases of shot injuries occurring in the late war, Otis[1] placed the frequency of those occurring in the abdominal region at 3.3%, or one in twenty-nine. The following aggregate of 1,072 cases of known injury to the abdominal viscera represents the relative frequency with which the different viscera were injured.

Wounds.	*Cases.*	*Ratio of Mortality of Determined Cases.*
Intestines,	653	80.3
Liver,	173	63.5
Stomach,	79	75.9
Kidney,	78	66.2
Blood Vessels, Omentum and Mesentery,	54	87.
Spleen,	29	93.1
Suprarenal Capsule,	1	100.
Pancreas,	5	80.
Total,	1,082	

[1] Med. and Surg. History of War of Rebellion, 2d Surg. Vol.

While the table prepared by Otis from which the above is an extract may in certain particulars be doubtful, it gives at least an approximative idea of the relative frequency with which the different organs are injured and from the above it is apparent that the chances of injury to any certain organ increases with its size and superficial location.

Intestinal injuries involving the mesenteric border are often attended with profuse hæmorrhage, the same is true of wounds of the stomach near the curvature.

Wounds of the spleen and liver are always attended with hæmorrhage and where the injuries are severe there is danger from this source of death primarily, and in addition to this in the latter organ authors lay great stress upon the irritating effects of the bile upon the peritoneum. Such, however, was not the experience in these experiments and it is mentioned in the history of the civil war that the experiments upon lower animals by Höring, Herlin and Campaignac indicate that the irritating action of bile upon the peritoneum is overrated, and that some of the facts observed during the war point in the same direction.

Wounds of the pancreas are generally above the others in gravity because of its deep location and the close relation to important vessels. Injuries of the omentum and mesentery are regarded as serious only when they are attended with hæmorrhage. Of the solid viscera mentioned in the experiments the spleen was wounded in nearly half. This was partly due to the transverse direction of the balls, but principally to a very much enlarged condition of this organ that was not uncommonly met with in these animals.

In a series of five experiments the "do-nothing" plan was carried out with a view of studying nature's method of repairing these injuries. Of these four resulted in death, and the fifth made his escape in a week's time in a condition which left no doubt of his recovery. However, in this case the course of the ball was so superficial, and the resulting effects so slight, that it is believed that the ball either failed to enter the abdominal cavity, or if it did so, its course was such a superficial one as to pass above the contents.

Observations, experimental and otherwise, lead to the belief that where unaided repair results, nature effects this in some of the following ways: (*a*) Closure of the perforation by an adhesion to a neighboring coil. (*b*) An omental adhesion. (*c*) By an adhesion to the abdominal wall. (*d*) Only where the opening is minute by an exudate of plastic lymph. In the experiments terminating in recovery, subsequent examination showed that peritonitis had occurred in nearly all. Generally this was circumscribed, but in a few it extended over the whole peritoneum, and in one the adhesions were so extensive that the whole of the intestines were adherent in one solid mass, and were so removed. Notwithstanding the recent deformity that followed the closure of intestinal wounds, permanent coarctation was rarely observed, and then only in a slight degree.

Symptoms, Diagnosis and Prognosis.

As for the symptoms, they may be conveniently divided into the primary, or those referable to the injury itself, and the secondary, or those referable to the complications consecutive to the injury. The symptoms of the first class can be mentioned as those relative to the constitution at large and those of a local nature.

The constitutional symptoms here are the well known symptoms of shock, the same as the symptoms of severe injuries elsewhere. Although shock, in a more or less degree, is a common attendant upon these injuries, its absence, even in severe cases, is not infrequent, and it has been noted that in many cases there exists a marked disproportion between the injury and the shock. Even when attended with severe hæmorrhage, there may be a comparative absence of the symptoms relative to the same, an example of which occurred under the observation of the writer during a service as interne at the Louisville City Hospital.

An athletic negro, of apparently 20 years, was found reclining upon a porch, talking to his friends in a very rational manner, with little or no evidence of severe injury. Subsequently upon arrival at the hos-

pital it was found that a ball of a .32 calibre had entered the left hypochondriac region, passing downward, backward and inward, lodging itself against the body of a lumbar vertebra, and in its transit half severing the descending colon and a lumbar artery near its origin, completely filling the cavity with blood. Notwitstanding an operation upon entrance by the visiting surgeon, the man sank 12 hours thereafter from hæmorrhage.

Prominent among the local symptoms are vomiting, pain, abdominal distension, with or without loss of the area of hepatic dulness, the escape of blood, bile or fæces from the external wound, and in wounds of the kidney or bladder, bloody urine. The vomit may or may not contain blood, and if the latter, it generally indicates a perforation of the stomach, but the same may also result from a non-penetrating wound of this organ. The pain is variable, and often severe, and localized in character. Abdominal distension with loss of the area of hepatic dulness indicates the escape of gases into the peritoneal cavity. Tympanitis without such indicates an accumulation within the intestinal cavity, and may occur in the absence of a lesion. When unmistakable escape of bile or fæces occurs externally, it is a positive proof of a wound of the liver or intestines. With the exception of a few drops, hæmorrhage from the external wound seldom occurs. Bloody stools, or hæmorrhage within the rectum, may also occur in perforations as well as partial divisions and contusions of the intestines, and when its occurrence is rapid it points to injury of the large intestines.

Unless the case be one that tends to an uneventful recovery, the secondary symptoms worthy of note are generally those of peritonitis, septicæmia, or pyæmia, the symptoms of which are already too common to require repetition here. Occasionally, however, an intoxication is met with to which Vechére has given the name of intestino-peritoneal septicæmia, and for a review of the latter I refer to the article by Stimson[1] on the same subject. The author's language of the review is borrowed here at length.

[1]New York Medical Journal, 1889. Vol. II.

"This intoxication, which has variously been termed peritonism, latent peritonitis, or the asthenic form of acute peritonitis, is supposed to have its origin in an infection of the peritoneal cavity by intestinal gases or microbes that have escaped, either through an opening or by transudation through the unbroken intestinal wall, and by this is set up a fermentation which produces ptomaines whose absorption is the immediate cause of the poisoning. The autopsy reveals but slight redness of the peritoneum, or possibly one or more points of distinct inflammation, and sometimes a brown fœtid effusion. The intestines are distended and decomposition advances rapidly. The clinical features are a prompt and marked meteorism, painlessness of the abdomen, both spontaneous and on pressure, except for that which is due to the wound of the parietes when present; a normal, subnormal or but slightly elevated temperature until shortly before death, when it rises rapidly; a small rapid pulse, anorexia, thirst, nausea and even vomiting of a fæcal like matter, and a marked alteration of expression. Its course may be marked during the first three or four days only by constipation, anorexia and meteorism. Then the severe symptoms and death follow in from five to twelve days from the beginning."

Owing to the uncertainty which surrounds the symptoms it is plainly evident that a correct diagnosis of the exact nature and extent of the injury is impossible. In those cases attended with hæmatemesis, bloody urine or the indubitable escape of bile or fæces from the external wound it is safe to infer that the ball has entered the cavity and with more or less injury to the organs to which the symptoms point. However, the first two only occur in injuries of the corresponding viscera and their absence is no positive sign of the escape of these organs, and, as to the escape of bile or feces from the external wound, unless such is very large, this rarely occurs.

In view of this uncertainty, Dr. Senn has devised a so-called "Infallible Test," for the diagnosis of an injury of the gastro-intestinal canal and as a guide to the surgeon in determining his course in these cases.

The test in question is already too well known to require more than a passing introduction here, and consisting, as it does, of a rectal insufflation of hydrogen with its escape and

ignition at the external wound. Besides the functions of diagnosing a gastro-intestinal perforation, it is also used at the completion of the operation to determine whether or not the gastro-intestinal canal is again intact.

The test is yet of a comparatively recent origin and since the recorded cases of its use are but few, its precise merits, or demerits, are yet unknown. So far the following objections have already been urged against it. First, that it is unreliable. Second, in the absence of gastro-intestinal injury there may be serious damage elsewhere which the test does not indicate. Third, that it may be the source of infection. Fourth, by the distension of the abdominal cavity it materially increases the danger of the anæsthesia. As for the first objection, the case of Dr. Dalton[1] clearly proves that the test is not infallible and the records abound in a number of cases where the damage was confined to the mesentery or some of the solid viscera, producing a condition beyond the reach of the test.

Dr. Senn has remarked that the gas is innocuous and does not tend to increase extravasation, but this is questionable. It does seem that where the perforated large intestine, especially the cæcum, is well filled with liquid or semi-solid fæces that extravasation would almost inevitably follow the use of the gas, since the ileo-cæcal valve offers a certain amount of resistance before it gives away, which pressure it appears would be sufficient to drive out some of the contents. This exact condition was met with in experiment 17, and, although the apparatus was not at hand for its trial, it was interesting to note the amount and ease with which extravasation occured. Moreover, some have even objected on the ground that the gas when it enters the peritoneal cavity is hardly aseptic after passing through many feet of intestines, although in the event of a perforation the insufflation is followed by an immediate laparotomy, which would allow but a momentary residence of the gas in the peritoneal cavity. That the abdominal distension with its corresponding pressure upon the diaphragm materially

[1]Western Medical Reporter, October, 1889. P. 218.

increases the danger of the anæsthesia is also proven in the case reported by Dr. Dalton. The test was experimentally employed here six times; in five, hydrogen was used and in the sixth it was replaced by air. In three of the five it was a success, noting in one the absence of any perforation, while in the other two it escaped and burned in a jet.

The remaining two could not be insufflated, owing to a perfect occlusion of the intestinal lumen with fæcal matter. Several attempts were made to overcome the obstruction with different tubes and rectal plugs, but without success, and it became evident that nothing short of its removal would suffice. The one in which there was an absence of a gastro-intestinal perforation, was corroborated by an abdominal section, and when the search was finished it became somewhat troublesome to reduce the distended intestines.

The danger of an explosion, as well as poisoning from arseniuretted hydrogen, have also been hinted, but these cannot be fairly urged against it, since, of the first sufficient evidence is at hand to allay any fears in this direction and if the reagents are chemically pure, as recommended, the second is impossible. But further on more can be seen upon this subject.

Reflection bespeaks a serious condition even in the most favorable cases, and, naturally, the prognosis increases in gravity with the extent of the injury. Although there is recorded a successful case[1] in which laparotomy was not undertaken until the fifth day, the importance of an early operation cannot be too strongly urged.

Procrastination in these injuries is usually repaid with a liberal share of harmful consequences.

Death very soon after the injury is generally either from hæmorrhage or shock and not infrequently the latter is very much dependent upon the hæmorrhage. When death occurs later it may be due to peritonitis or more generally from some of the septic processes already named.

Treatment.

The treatment divides itself into three indications. First, to

[1]Klin. Zeit. und Streifragen, bd. ii., heft. 10., s. 355

determine the penetration of the ball, together with the presence or absence of any intra-abdominal injury. Second, to correct the intra-abdominal injury, and third, the treatment of the complication secondary to the injury. For the fulfillment of the first indication we have at hand two procedures, Senn's rectal insufflation of hydrogen and laparotomy. As for the choice between these two, laparotomy, boldly but carefully performed, seems decidedly the most preferable, for when the *ensemble* of objections urged against the test are considered the advantages of its use are not sufficient to outweight the harm that may result. According to Trélat,[1] intra-abdominal injury follows in 97 out of 100 perforations, and drawing a more liberal margin of 95 in 100 would leave but 5 out of 100 in which the operation was purely exploratory.

Although the dangers of a simple laparotomy, even in a subject otherwise healthy, are not to be denied, yet where the precautions against infection are scrupulously observed the mortality will be exceedingly low and the operation certainly seems a justifiable step in the face of what was reasonably supposed to be a very serious condition. Nor does the medico-legal aspect appear to suffer any improvement by the general adoption of the test since in consideration of the objections already offered the test in the event of an unfavorable termination where intra-abdominal injury is present, may possibly give rise to the same debatable questions that attend an unfavorable exploratory operation without intra-abdominal injury.

In every case that laparotomy is undertaken it should be with the preparation and expectation of finding intra-abdominal injury. By most surgeons the laparotomy in the linea alba is given the preference over that of one performed in the course of the ball since occasionally the course of the latter is such that its following is inadmissable and often it necessitates the making of very large and undesirable incisions, while a laparotomy in the linea alba not only furnishes the easiest access to all the organs but also its making is attended with less hæmorrhage, and is generally a more desirable wound for closure and subsequent treatment.

[1]The Medical and Surgical Reporter, May 12, 1888.

However where it is highly probable that the ball has become arrested in the abdominal parietes, or where infection of its track is suspected either from the use of the probe or fragments of clothing carried in with the ball, incision and drainage should always be employed, not only for diagnostic purposes but also for the proper treatment of the bullet wound under such circumstances. But only where the ball is very small and given at a long range with a transit through several layers of clothing or a very thick abdominal wall can its arrest without penetration be hoped.

Ordinarily probing of the bullet wound should be carefully avoided, for the cases of non-penetration when the abdominal wall is fairly wounded are extremely few, and the experiences of Esmarch and others have conclusively proven this a source of infection in all gun-shot wounds. In all of the experiments the abstention of interference with the bullet wound was followed by an absence of suppuration from this source.

Following the opening of the abdominal cavity comes the search for and repair of the intra-abdominal injury. The search for the wounds of the gastro-intestinal tract may either be made through a large incision with "eventration" or through a small one hooking up a coil of the intestine and carefully tracing the whole tract from end to end. The apparent advantages of the former are, that it affords an easier access and better command over the whole of the intestines and their attachment. Both have been employed in the experiments and each seems to have its advantage. Where there is profuse hæmorrhage or extensive damage of the intestines with danger of extravasation "eventration" would be the shortest way of locating the hæmorrhage, and the best control over extravasation, but where upon opening the cavity it is apparent that little or no hæmorrhage has occurred a loop of intestine can be carefully hooked up through a small opening, and the whole intestinal tract examined without exposing more than about six inches at one time. In those cases where from the wound of entrance and exit the other organs can be safely excluded from the path of the ball such an examination will suffice; otherwise if necessary the incision can be enlarged till a

satisfactory ocular or digital examination will prove the absence of injury to any or all of the other viscera.

My co-worker, Dr. Vance, ingeniously unbent and covered the ordinary safety pin with rubber tubing or fine catheter and by piercing the mesentery on each side of the wound where it is devoid of vessels has succeeded in sealing the wound against extravasation during the examination or closure of any intestinal injury. The principle has been found to be advan-

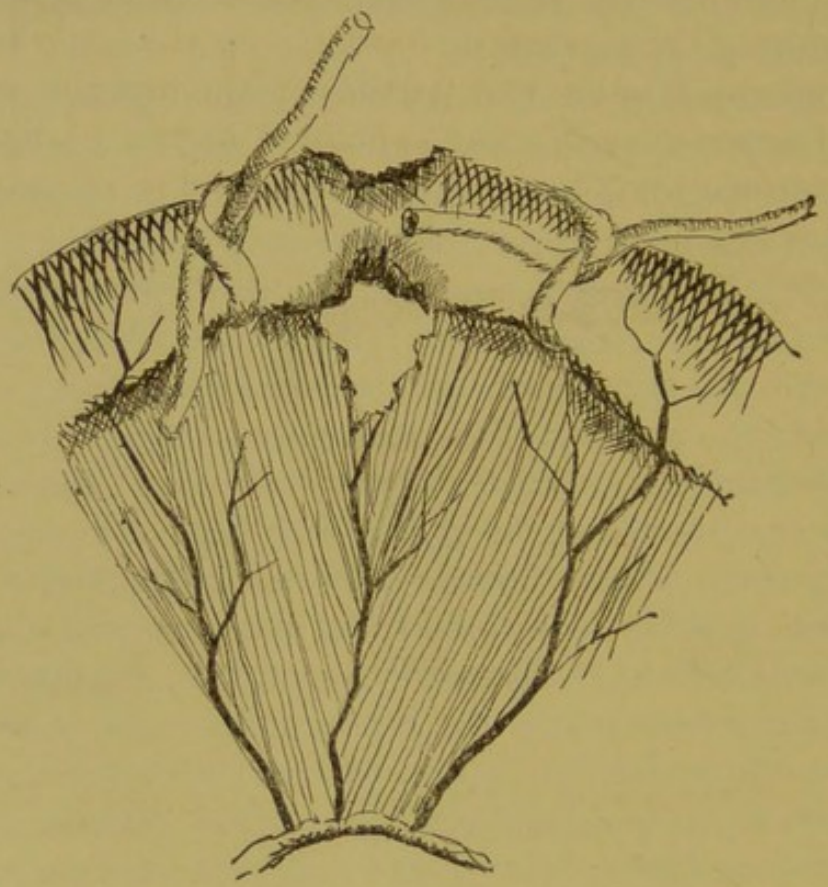

FIG 3.—SHOWING THE APPLICATION OF THE RUBBER TUBING FOR CONTROLLING FÆCAL EXTRAVASATION.

tageous, but owing to the projecting points of the pins which frequently caught and damaged the omental folds and mesentery the latter was found somewhat impracticable and in lieu of which, the writer substituted ordinary small rubber tubing as shown in Fig. 3, which can not only be used for the purpose already named, but from its simplicity and cheapness will afford an admirable substitute for the many clamps already suggested for the control of extravasation during re-

section and other intestinal operations. In its application a single knot will suffice and too much traction should be avoided.

The injuries of the intestinal tract may be variable in character. For clinical and prognostic purposes they can be arranged as contusions, penetrating and non-penetrating wounds. The contusions are often quite large and attended with corresponding hæmatomas. The penetrating wounds for the purpose of treatment admit of the division into those isolated from and those involving the mesenteric border. By the latter is meant such as encroach upon that portion of the intestine which is devoid of serous covering, and contained in the triangular interspace formed by the union of the two folds of mesentery

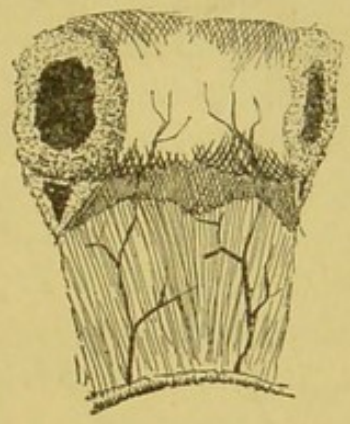

FIG. 4.—SHOWING THE ABSENCE OF THE SEROUS COVERING AT THE MESENTERIC BORDER OF THE INTESTINE.

see Fig. 4. Because of this absence of the serosa, which precludes the possibility of obtaining "plastic adhesion" in a few hours, which is so indispensible in intestinal suturing, as well as the interference with the blood supply of the intestine which attends wounds in this location, they are justly to be regarded as the most serious of intestinal wounds. Space will not permit a review of the various mechanical measures already recommended, for the care of intestinal injuries and the remarks in this direction will be confined to such as by the present opinions are deemed most efficient and advantageous. Hæmatomas were frequently met with at the intestinal border

of the mesentery and sometimes about the intestine proper. When unattended with a wound they were left untouched without any harm resulting, but in the reverse for additional security, they are best treated as a perforating wound.

For the closure of intestinal wounds various stitches have been recommended, prominent among which are the Lembert, Gely, Gussenbauer, Czerny and the continued suture. Of these nearly all have been experimentally employed, and as for safety, simplicity and efficiency none recommends itself as strongly as the Lembert stitch. The latter when applied, should not be too far apart (3 or 4 lines), and to insure security should not include too narrow a strip of the serous surfaces. Unless the wound be linear in character the stitches are best introduced parallel with the long axis of the intestine, since by such its lumen suffers least from coarctation.

In tying the sutures only sufficient traction should be employed to bring the opposite sides in contact. This apposition is soon followed by a slight œdema and the commencement of exudation which adds to the safety of the closure. The secure closure of the wound, particularly at the angles, is sometimes misleading. In at least two experiments death was due to an infection traceable apparently to this source. Unless the edges of the wound are so ragged and everted as to interfere with their closure trimming is unnecessary and superfluous. It has been noted in several of the experiments that were followed by early deaths that these edges level themselves into rounded ridges on each side of the wound during the first 24 hours after their closure, Fig. 5 (*a*). According to Lembert the stitches ulcerate their way into the intestinal cavity by the seventh or eighth day, and are discharged. It was repeatedly noticed that in 36 or 48 hours sufficient exudate was thrown out to cover the entire suture externally. In gunshot perforations the mucosa was frequently observed in those cases where death followed during the first 24 hours to be denuded of its epithelial layer for four or five lines beyond the opening, with a slightly congested zone for its boundary. Where the stitches were introduced entirely through the muscularis "or deeper," they were generally visible internally

within 24 hours thereafter, but in those introduced merely through the serosa, or the serosa and partly through the muscularis, they were nearly always to be found encysted beneath a layer of fibrin a month or more subsequently, with hardly any change in their condition. Possibly later on, through a process of maceration and absorption, they disappear.

The needle found most suitable was that known as (Milward & Son) the milliners' needle, which is a long narrow needle, devoid of cutting edges. The earliest, and perhaps secondin choice, of the intestinal sutures is the continuous or glov-

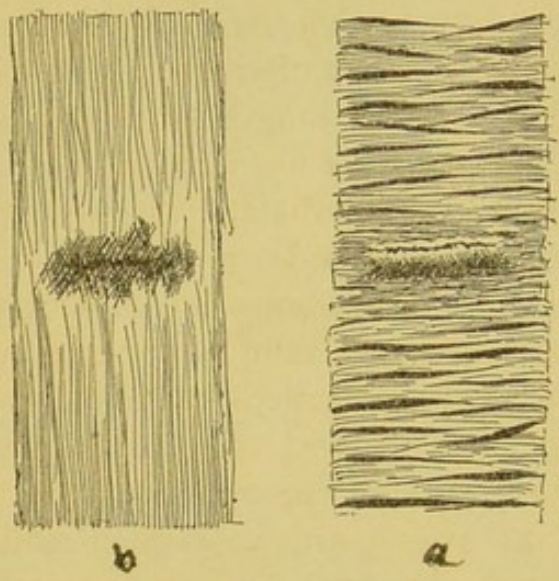

FIG. 5.—*a*. SHOWING THE INTERNAL APPEARANCE OF A SUTURED WOUND AT THE CLOSE OF 24 HOURS. *b*. SHOWING THE EXTERNAL APPEARANCE OF THE SAME.

ers' stitch, which, in view of its simplicity and the rapidity of its application, is even preferred by some to that of the Lembert, but the main objection against it as a substitute for the latter is that tearing of a single stitch results in the loosening of the entire suture, and since the purchase generally obtained is not very strong, this can very easily occur. However, in those cases where the wound does not penetrate all the coats of the intestines, or from some reason it becomes necessary to bring the operation to a rapid completion, Nussbaum recommends the preference of this suture. Such wounds as are isolated from the mesenteric border, and of an ordinary size, are easily closed without any further preparation of their condition, but

where they are of such a nature as in Fig. 2, a triangular excision leaving the mesenteric attachment intact was followed by the best results, Fig. 6.

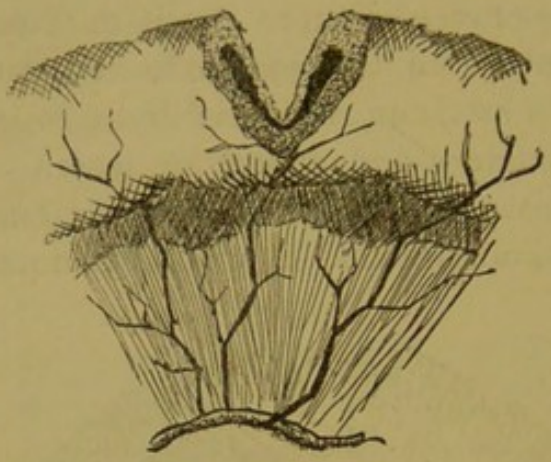

FIG. 6.—TRIANGULAR EXCISION OF THE WOUND.

Wounds upon the mesenteric border are always troublesome, and since excision upon the concave border is inadmis-

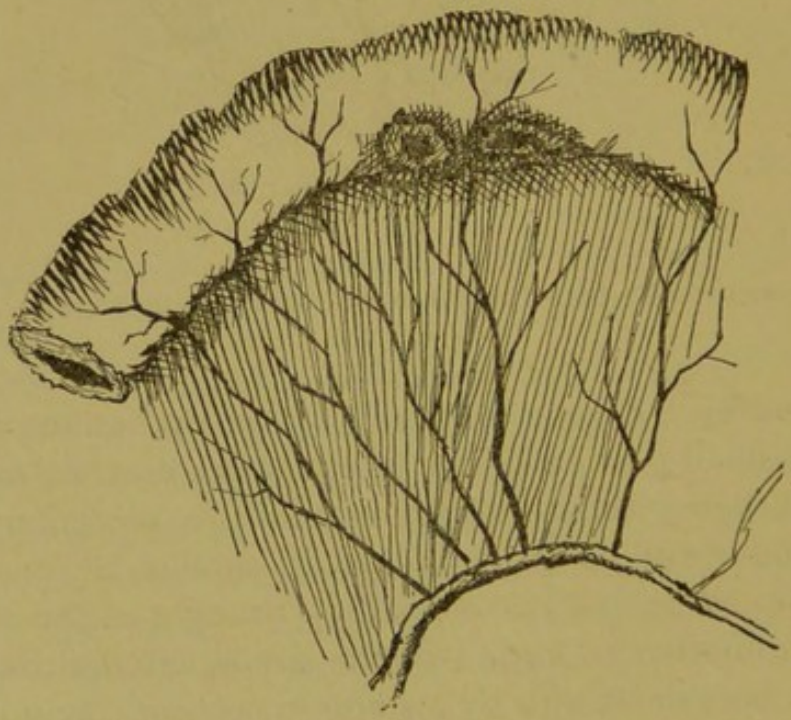

FIG. 7.—WOUNDS CREATED BY A FLOBERT. ONE OF WHICH SLIGHTLY INVOLVES THE MESENTERIC BORDER.

sible they frequently require complete resection. Those of a small size are conveniently closed by drawing together a fold

of the mesentery upon one side and the border of the intestine upon the other, but in those of a complete division of the mesenteric border, as in Fig. 3 and 8, resection is the only alternative. In re-uniting the divided ends of the intestine the operator has the choice of three methods, circular enterorrhaphy by the Lembert or Czerny-Lembert suture, invagination as recommended by Senn, which is but a modification of the same step by Baudens and Jobert, or lateral anastomosis by absorbable plates. Although experience has hardly established the comparative value of these, the lateral anastomosis

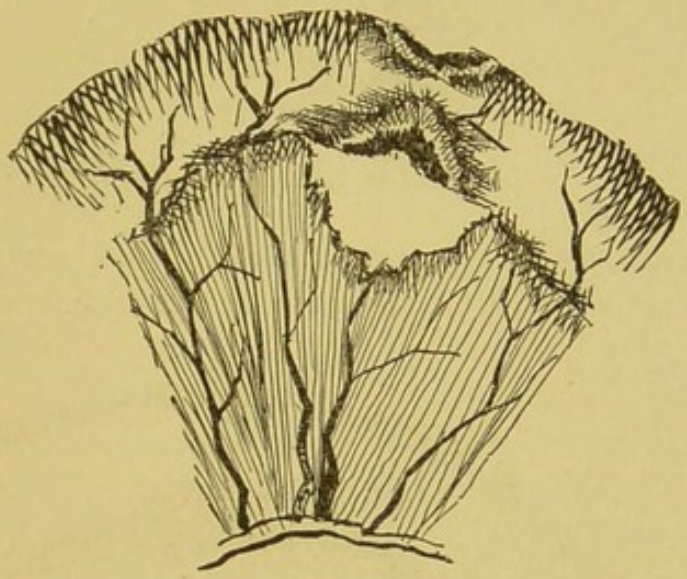

FIG. 8.—SHOWING TYPICAL INJURY OF THE MESENTERIC BORDER, REQUIRING A COMPLETE RESECTION.

as revived by Dr. Senn seems to be the operation of the day. When a small portion of the intestine is resected this can be accomplished without interfering with the mesentery, but in resections of two or more inches it should be accompanied with an excision of a corresponding triangle of the mesentery. Where a number of large wounds are situated close together, they are best dealt with by a single resection, including them all.

Non-penetrating wounds of various sizes and depths were repeatedly left untouched for a test of their security, and while no harm was traceable to them, still the safest method of their

treatment consists of their closure just as in penetrating wounds. In eventration the intestines during manipulation are best protected from shock by covering with disinfected towels which are kept warm by continuous irrigation of warm sterilized water, or, as was practiced in the experiments, by pouring from time to time warm sterilized water over the mass from a suitable vessel.

After all the discovered wounds are closed, a diligent and painstaking search of the entire gastro-intestinal tract should be made for any additional injury that possibly has escaped, and for the detection of such, as well as to prove the security of the intestinal closure, Senn's test is again recommended. The objections urged against the test as a diagnostic means of determining the necessity of a laparotomy cannot, at least in the same degree, be urged against it for this purpose.

So far there has been, to my knowledge, one case reported by Dr. Senn in which the test, in addition to eleven perforations, detected a twelfth, low down in the pelvis, which otherwise would have escaped, the patient recovering. Against this is the case reported by Dr. Dalton, in which this method of testing the gastro-intestinal tract occasioned serious damage by so distending the intestines that their return was exceedingly difficult, and even provoked a rupture of the sutured parts, seriously crippling the chance of recovery, the case terminating in death. In addition to the latter is another, occurring under the observation of Dr. Fenger,[1] in which, notwithstanding the use of the test, at the close of the operation an opening at the pyloric end of the stomach escaped. The following extract forom the writer's language explains itself:

> After all the apertures found were closed and the vessels tied, the intestines were replaced and gas again insufflated. The sutures proved to be absolutely air-tight. Some bubbles, however, escaped from the upper extremity of the incision, but Dr. Fenger thought that it came from the peritoneal cavity. The abdomen was flushed "et cætera." Autopsy one hour after death. On removing the intestinal tract the following appeared: (After reciting in detail the appearance the writer

[1] J. L. Hillmantel, Jour. Am. Med. Ass'n, July 21, 1888.

closes the autopsy as follows:) The second lateral apposition was found 11 inches below pylorus, where 2½ inches of gut, with four perforations, had been resected. Finally, a perforation was found in the pyloric end of the stomach which was not sutured.

In the face of these two cases, the value of this method, as it now stands, is certainly questionable, since, in the first, it clearly points to a serious possible danger which has not only already occurred with Dr. Dalton, but Dr. Senn himself alludes to it as having been annoyed by the same thing, and in the second case its absolute certainty is very strongly shaken. Although apart from its not being absolutely infallible, if some means were at hand to rapidly relieve the distension, the test might prove itself a valuable adjunct to a careful research in detecting any additional perforation that might possibly have escaped. In a single experiment for the purpose, an incision was made into the large intestine with the hope of relieving the distention, but owing to acute flexures caused by the distention, this end was not reached till another was made into the small intestines, and a third into the stomach, the latter organ being partly filled with large pieces of meat, which prevented the exit of the gas through the pylorus, upon pressure. Judging from this, a simple incision which can be made under the control of the surgeon will hardly overcome the difficulty.

Wounds of the mesentery, when they are but perforations, can be passed without any additional interference, unless attended with hæmorrhage, in which case deligation of the injured vessel is required. Large lacerations should be closed with a running suture to avoid the future possibility of an incarceration and obstruction of a loop of the intestine in the opening. On account of the extreme delicacy of the membrane, its closure is often attended with some difficulty, which can be frequently overcome by introducing the sutures near the edge of a vessel, as this region affords the strongest grasp for the suture.

Wounds of stomach are treated according to the same rules as apply to injuries of the intestines.

Wounds of the liver. The recent advances in hepatic surgery by Tait, Langenbuch, Burkhardt and others show that the fear

from hæmorrhage, sepsis and the deleterious effects of bile upon the peritoneum are very much exaggerated. Lawson Tait[1] has a number of times successfully performed hepatotomy, removing from the liver substance immense quantities of hydatids. Burkhardt[2] succeeded in arresting a furious hæmorrhage from a stab wound of the liver by a tampon of iodoform gauze, and Dr. L. MacLane Tiffany[3], in two operative cases, resorted primarily to the step of isolating an area of liver substance by uniting the edge of the parietal peritoneum with the surface of the liver, and through this extra-peritoneal area in one case he incised an abscess, and in another removed gall stones from the gall bladder, directly through the liver substance.

The wounds of the liver proper may either be simple abrasions, such as are produced by the ball glancing over its surface; clean cut perforations, or perforations attended with the loss of more or less liver substance. In abrasions of the liver the sear of the Paquelin will suffice, but generally the hæmorrhage ceases of its own accord. Such perforations as are hardly any larger than the ball itself are best controlled by closure of both openings with a continued catgut suture, introduced to the depth of two or three lines, and repeated two or more times after the weaving of a net work over its orifice. In the event of its failure to arrest the flow, or in perforations attended with the loss of hepatic substance, a tamponade of iodoformized gauze is the last resort. In perforations or lacerations at the free border of the liver, a V-shaped excision of the whole, uniting the surface with a running suture upon both sides, and if necessary doubly applied, recommends itself.

In wounds of the gall bladder, the closure of the apertures is best effected by either the Czerny or Rydygier's modification of the latter, using the continued suture in the first row, and the Lembert in the second. Before closure, unless already empty, evacuation and disinfection of the gall bladder should be observed.

[1]Diseases of the Ovaries. Tait.

[2]Jour. Amer. Med. Ass'n, Vol. VIII, p. 323. Vol. IX, p. 62.

[3]Loc Cit. Jour. Amer. Med Ass'n, Vol. X, p. 785.

Cholecystenterostomy and cholecystectomy are operations to which the surgeon may be forced in the exigency of the case.

The experiments by Dr. Nicholas Senn[1] upon the pancreas have markedly advanced the surgery of this organ. They have shown that the tail or a portion of the body can be unhesitatingly removed, but operations upon the head should be of a conservative nature, not only for the purpose of sparing the common duct, but also as much of this portion of the organ as the conditions which necessitate the operation will permit. The complete extirpation of the pancreas was invariably followed by death, produced either by traumatism or gangrene of the duodenum. In transverse visceral wounds the arrest of hæmorrhage is the most important indication, and the suturing of the divided organ is advised with a view to preserving as nearly as possible the integrity of the blood supply rather than to secure the continuity of the pancreatic duct which, in division, uniformly results in an occlusion from a cicatrix. In case of extreme crushing, the indication is to remove the crushed portions after preliminary ligation of the organ on each side of the comminuted region. In using the double ligature the experiments show the safest plan to consist in the removal of such portions as are not supplied by blood vessels, rather than to trust to their absorption with the risk of proving a nidus for infection. In partial resections for injury or disease, ligaturing the peripheral portion and allowing it to remain is recommended as the most preferable step, since it lessens the danger by the infliction of less traumatism, and its removal in a short time, by absorption, can be confidently expected. It has also been demonstrated that no fear need be entertained of a retention cyst forming in the peripheral portion, even though some of the parenchyma of the organ remains,

Wounds of the spleen. In superficial abrasions, such as are produced by the glancing of the ball over its surface, the sear of the Paquelin, just as in lacerations of the liver, will usually

[1]The Surgery of the Pancreas as Based upon Experiments and Clinical Researches. Transactions of Amer. Surg. Ass'n, 1886.

answer, but where the injury is of a severer nature, there are several procedures open. Should it consist simply of a perforation without much laceration of splenic structure, closure of both openings of the track with a continuous suture was uniformly successful when applied. In a perforation or laceration very near or involving the edge of the spleen, its excision in the shape of a triangle, uniting the edges with a running suture, is the most advisable step. Where the perforation involves a large vessel which precludes the closure of the track, or where the laceration is such that excision is unfeasible, the complete removal of the organ is required. It was observed that in partial resection or where the closure of the perforation with the suture was practiced, that the spleen rapidly increased in its size below the point of interference, as well as suffered a change in its color.

The changes which were apparently due to an interference with the venous circulation in the organ never gave rise to any trouble, and with the exception of one or two cases, upon subsequent examination, no traces of them were left. The changes which were apparent in the exceptional cases consisted of a slight atrophy, with a darkening in the color.

Wounds of the kidney and bladder. Unless the injury consists of a superficial laceration nephrectomy is as yet the only procedure in the treatment of these wounds. The superficial lesions are treated just as the similar injuries of the spleen and liver. The steps recommended for the repair of the gall bladder are also applicable to perforations of the urinary bladder.

General precautions. The last of the three leading indications is the treatment of the suppurative peritonitis that may follow consecutive to the injury. The treatment of this embraces prophylactic as well as curative measures. It is almost superfluous to repeat here that the strictest observance of the rules of antisepsis is of the utmost importance. Whether or not it is positively known that extravasation has occurred the cavity at the close of the operation should be carefully washed out with warm Thiersch's or some other suitable solution, and after drying close with the introduction of a glass or non-collapsible drain which is so arranged that without disturbing the

dressing access can be had to the abdominal cavity and if necessary the removal of any secretions affected. If the removal of such in this manner is insufficient, "febrile symptoms, tenderness, and tympanitis developing on the first few days after the operation," Gerster[1] favors the use of salines as advised by Tait. The track of the ball, which is another and not uncommon source of infection, can nearly always be sealed from within by its closure with two or more stitches applied after the manner of Lembert and where infection is probable should be treated externally by incision and drainage.

In the event of suppurative peritonitis having made its appearance, early opening and disinfection of the peretonial cavity is indicated and for this purpose Mikulicz[2] and others have divided the peritonitis into two types. "*Diffuse, septic* and *progressive fibro purulent* peritonitis," both distinct but capable of merging into one another, the former being an acute or per acute peritonitis dependent upon the infection of a large portion of the peritoneal surface, which, unless it runs a per acute course with the symptoms of intoxication, is marked by the attendance of a variable amount of sanguino-serous or purulent putrid thin fluid exudation. The peritoneum is injected and at times covered by a thin fibrinous, deposit but firm and extensive adhesious are absent. The latter runs an acute or subacute course with infection limited to the vicinity of the perforation by the adhesions formed from the fibro-purulent exudation.

The process successively spreading with the encapsulation of more or less pus between the glued viscera.

For the first Mikulicz advises that of freely opening the abdomen with the finding and closure of the opening (if there be one) and the disinfection of the peritoneum.

In the second each intra-peritoneal pus cavity is opened separately by the free incision of the abdominal wall where it appears most prominent, and, following the incision, carefully washed out avoiding the rupture of the adhesions and in lieu of closure by sutures loosely packed with iodoform gauze

[1]Loc. Cit, Annals Surgery, Jan. 1887, page 27.
[2]Gerster's Aseptic and Antiseptic Surgery.

with the possible introduction of a drain. Upon this principle Mikulicz has operated with some success, using as diagnostic indications the increased resistance, pressure sensitiveness, dullness and an increase of the previously lowered bodily temperature using in doubtful cases the exploratory puncture.

Dr. Wylie[1] in a recent and advanced paper upon this subject assumes a similar position as Mikulicz, strongly favoring early interference in the treatment of peritonitis. The succeeding lines represent an abstract from this writer's conclusion after an experience of several successful cases.

When there are symptoms of local peritonitis, intense pain and tenderness followed by tympanitis and vomiting with chilly sensation and rise of temperature, search should be made for the cause. If signs of a tumor or exudation can be definitely made out and the general symptoms indicate the formation of pus then the patient should be etherized and the pus reached by incision, the pus evacuated, the cavity washed out and drained. If the general symptoms are severe and no localized center of pus is made out then an incision should be made in the median line and the peritoneal cavity explored with the index finger. If then a pus sac is found, if it be so situated that it can be reached by another lateral incision and the pus evacuated without allowing it to escape into the free peritoneal cavity, it should be made and the median incision closed. If it cannot be reached by a lateral incision where the wall of the sac is adherent to the abdominal wall then the pus should be drawn off by an aspirator or trocar and the cavity washed out clean with an antiseptic solution before it is freely opened and a drainage tube inserted.

If signs of general peritonitis show themselves, that is by vomiting, obstinate constipation, tympanitis etc, then a free incision should be at once made into the median line and the starting point of the peritonitis found if possible. If it is over the cæcum an incision should be made and the pus washed out by means of hot water of a temperature of 110° to 115° from a large fountain syringe with a large glass drainage tutbe atached to the rubber. After the free pus about the cæcum is washed out several fingers or the whole hand should be put into the abdominal cavity and the intestinal adhesions broken up and

[1]The Surgical Ttreatment of Local and General Peritonitis by W. Gill. Wylie, M.D. The Am. Jour. of Obstet and Diseases of Women and Children, March, 1890.

all puddles of pus completely washed out. Then a drainage tube should be introduced into the opening and the wounds closed around them.

In all cases of general peritonitis an exploratory incision should be made as early as possible after trying to lessen the tympanitis. If an exploratory incision does no good it is not likely to add much to the danger. There may be cases of idiopathic peritonitis but I have never seen one proved by anything to be relied upon. Certainly in septic peritonitis where shock is not too great free opening, washing out and drainage will cure some cases. It helps if it does not cure tubercular peritonitis and exploratory incision has proven to be in the hands of experts almost entirely free from danger and it must become the practice in almost all cases of general and local peritonitis where there are marked symptoms of the formation of pus, an extension "into septic peritonitis or intestinal obstruction."

In closing Dr. Wylie remarks: "What I wish to especially advocate, is early operation in cases of general peritonitis, both those starting from a local peritonitis and those due to the escape of septic matter into the peritoneum, and to make it plain that to succeed in such cases it will not do to merely open the belly, allow pus to escape, put in a drain tube or gauze and leave intestinal adhesious causing obstruction to remain, to kill even more certainly than septic poison or fail to empty and wash out all puddles of septic fluid encysted among the coils of intestines, but we must make free incisions large enough to introduce the hand and break up all adherent intestines and freely wash the whole cavity of the peritoneum and put in two or more drainage tubes."

From a study of the foregoing abstracts it does seem that the indications in the treatment are plain and reviewing the successes achieved by Mikulicz,[1] Krœnlein,[2] Tait,[3] Wylie,[4] Korniloff,[5] and others, this certainly appears the most feasible and justifiable step.

[1]Samml. klin. Vortræge von Volkmann, No. 262.
[2]Krœnlein, Langenbeck's Archiv, Bd. 23, S 522.
[3]Brit. Med. Jour., 1883, Vol. 304.
[4]The Amer. Jour. Obst. and Dis. of Women and Children.
[5]Medizinskoje obosrenje, 1887, No. 12.

Description of Experimental Operations upon Gunshot Wounds of the Abdomen.

Experiment 1.

Aug. 8. Full grown English bull. Weight, 43 lbs. Shot with a S. & W. pistol, .32 calibre. Ball entered at lumbar region, passing obliquely through, coming out on opposite side and burying itself in the table. Laparotomy revealed one non-penetrating and three penetrating wounds of the intestines, and a wound of the kidney. Abdominal cavity filled with blood, which came from the renal wound, but no evidence of fæcal extravasation. The penetrating wounds were closed with Lembert stitches, and nephrectomy practiced for the wounded kidney, the ball having passed through its central portion and completely shattered the organ. The ligature, which was a single one, was hardly applied before it slipped and although it was almost immediately seized there occurred a considerable loss of blood with a telling effect. Clots were removed and the cavity repeatedly flushed with warm Thiersch's solution and closed. Hypodermics of whisky, ammonia and digitalis were given, and, in a condition of profound shock, removed to a warm place. Operation lasted one hour. The animal died in six hours without rallying from shock.

Post-mortem. Eight hours after death. Abdominal cavity clean. Intestines distended with gas. Intestinal wounds sealed with inflammatory exudate. Ligations of renal stump unchanged. Death from shock.

Experiment 2.

Aug. 15. Medium size mongrel. Weight, 27 lbs. Shot with a flobert, from a Remington rifle. Laparotomy revealed one perforating wound and a wound of the mesenteric artery near its origin from the abdominal aorta, which was not found till after death, the animal dying, just as the abdominal cavity was opened, from hæmorrhage, it being really an unsurgical case.

Experiment 3.

Aug. 15. Medium size dog. Weight, 28 lbs. Shot with a flobert from a Remington rifle. Laparotomy revealed very slight hæmorrhage and one perforating intestinal wound which was closed with a continuous stitch. No fæcal extravasation. Cavity closed. No shock. Time, 30 minutes.

Aug. 16. Dog escaped from kennel during the night. Drinks freely of milk.

Aug. 28. Dog lively. Stitches removed. Abdominal wound almost entirely healed.

Sept. 3. Perfect recovery. Animal sacrificed to obtain specimen.

Post-mortem. The site of injury was found with difficulty, and showed no scar or infringement upon the intestinal lumen. It was only recognizable from the thread that was hanging from the surface.

Experiment 4.

Aug. 22. Full-grown mongrel. Weight, 39 lbs. Shot with a .22 long from a Remington rifle, the ball entering 2 inches to the left and below umbilicus, passing straight through coming out on opposite side. Laparotomy revealed a moderate amount of hæmorrhage and fæcal extravasation coming from the intestinal wounds,

which numbered 12 perforating and 1 non-perforating. Resection was performed beginning just below the ileocæcal valve and removing over 4 feet of the small intestine including all but three of the intestinal wounds. Of these three, two were perforating and were closed with a continuous suture; the other was non-perforating and left alone. The resection was performed by ligaturing the mesentery *en masse* at its vertebral border. The ends of the intestines were united after the method of Wölfler. The *toilet de peritone* was carefully done and the other layers closed with a continuous suture. Given six minims of Magendie's solution and several hypodermics of whisky and removed to a warm place in a condition of shock. External heat was applied but the animal only partly rallied.

Time, $1^1/_2$ hours. Was seen again at midnight. Extremities warm, respiration rapid and shallow, pulse feeble and rapid.

Aug. 23. Found dead.

Post-mortem. Cavity contained about 2 ounces of bloody fluid and a few clots. The mesenteric stump was covered with a blood clot. The resection as well as the other wounds were sealed with exudate and retained air sufficiently to resist some pressure and float when ligated and thrown upon water. Rectum filled with hardened fæces. Death from shock.

Experiment 5.

Aug. 28. Small mongrel. Weight, 18 lbs. Shot with a S. & W. pistol, .22 calibre. Laparotomy revealed the abdominal cavity filled with blood and fæcal extravasation. Five perforating and two non-perforating intestinal wounds and a nick in the free border of spleen. Two of intestinal wounds were large and required the resection of one inch of intestine. The others were closed with Lembert stitches. The non-perforating wounds were broad and shallow and were left untouched. Splenic wound being small was disregarded. The principle source of the hæmorrhage was from two of the intestinal wounds that were situated on the mesenteric edge and involved the vessels in that region. The clots were removed, cavity flushed and closed. Was given $^1/_4$ grain morphia and alcohol hypodermically and removed to a warm place. The animal being undersize its intestines were small and fragile, all of which served to prolong the operation to $1^1/_2$ hours. Died 1 hour after removal from table of shock.

Post-mortem. Soon after death. Cavity contained about 1 ounce of bloody fluid and a few clots in the omental folds. Intestinal wounds apparently unchanged.

Experiment 6.

Aug. 31. Full-grown dog. Weight, 38 lbs. Shot with a S. & W. pistol, .22 calibre. Ball entered 1 inch to the right, and on a level with the umbilicus, passing in an antero-posterior direction causing her to wince, and corrugate the abdominal walls. Laparotomy revealed one non-penetrating and four penetrating wounds of the intestine and a wound of the upper edge of the kidney. The abdominal cavity contained but a few ounces of blood but posteriorly was a very large subserous hæmatoma, which communicated with the abdominal cavity by the track of the ball. Fæcal extravasation into the peritoneal cavity. Two of the perforating wounds which were in the ileum and required a resection of one inch of intestine which was done after the method of Wölfler, the others were in the cæcum and were closed with the Lembert stitch. The non-penetrating wound being unattended with hæmorrhage was left alone. Nephrectomy was practiced for the wound of the kidney. The

hæmatoma was incised and removed. The cavity flushed with warm Thiersch's solution and closed. The animal was given 1/4 grain morphia hypodermically and 1 ounce of whisky per rectum and removed to a warm place, bearing evidences of considerable shock, from which she reacted sufficiently in a half hour to be crawling about. Time, 1 hour and20 minutes.

Sept. 1. Drank a few ounces milk in the morning, but died at noon after living 20 hours.

Post mortem. Few hours after death. External wound in good condition. Abdominal cavity free from bloody fluid, but contained a few clots. Intestines somewhat matted together and wounds sealed. Renal stump unchanged. Death from an acute septic peritonitis.

Experiment 7.

Sept. 7. Full-grown mangy dog. Weight, 32 lbs. Shot with a S. & W. pistol, .22 calibre. Ball entered 1 inch to the right and a little below the umbilicus. Laparotomy revealed a moderate amount of hæmorrhage, and an oozing of liquid fæces. Intestines showed six perforating wounds, one wound to the spleen, and a nick in the free border of the liver. The intestinal wounds were closed with Lembert stitches. The wound of the liver being slight, with the hæmorrhage arrested, was allowed to go untouched. Splenectomy was practiced for the wound of the spleen using a double catgut ligature for its ligation. The cavity was flushed with warm sterilized water and closed. Given 1/4 grain of morphia and several hypodermics of whisky and removed to a warm place bearing evidences of considerable shock from which he rallied sufficiently in a few hours time to be crawling about. Seen at 11 P.M., too weak to stand. Operation lasted 1 hour.

Sept. 9. Drank a few ounces of milk, but still too weak to stand.

Sept. 10. Drinks freely of milk, and appears livelier.

Sept. 11. Runs about, and takes liquid food freely.

Sept. 15. Refuses food and appears sick. Removed from the kennel, which afterwards proved to be infected.

Oct. 6. Animal perfectly recovered Sacrificed to obtain specimen.

Post-mortem. All appearances gave evidence that a general peritonitis had ensued. The lobes of the liver were adherent to each other with a cicatrix at the site of the wound. The intestines were adherent to the abdominal wall and to one another at different places. Splenic stump was not found. All the organs were covered with a perceptible layer of fibrine.

Experiment 8.

Sept. 15. Full-grown part bull. Weight, 37 lbs. Shot with a S. & W. pistol, .22 calibre. Ball entered 1 inch to left and below the umbilicus and was subsequently found on the opposite side, having made a hole in the opposite wall, but fell back into the abdominal cavity. Laparotomy revealed considerable hæmorrhage but apparently no fæcal extravasation. Intestines received six large and two small perforations. There were two perforations unaccompanied with hæmorrhage in the mesentery and a small nick of the spleen which was left untouched in the treatment on account of its size and the absence of hæmorrhage. The intestinal wounds were closed with Lembert stitches. Of the mesenteric wounds one was closed with a single stitch. The blood was removed, and cavity flushed with warm Thiersch's solution. Cavity closed and given a hypodermic of morphia and a warm rectal injection of

saline solution and whisky. Removed to a warm place in a condition of considerable shock from which he slowly reacted with the aid of external heat. Operation lasted 1 hour and 20 minutes. Seen at 11 P.M., reacting slowly.

Sept. 16. Unable to stand, but otherwise lively, and drinks freely of milk.

Sept. 17. Gait slow and unsteady. Takes considerable milk.

Oct. 18. Perfectly recovered. Sacrificed to obtain specimen.

Post-mortem. A most extensive peritonitis had ensued in which all of the intestines were firmly bound together in one mass and were so removed. There were likewise adhesions to the liver and the abdominal wall at the seat of the abdominal section.

EXPERIMENT 9.

Sept. 21. Small sized terrier. Weight, 17 lbs. Shot with a flobert from a S. & W. pistol, the ball entering one inch to the left and one inch and a half below the umbilicus. Laparotomy revealed seven wounds of the intestine and two of the mesentery. The mesenteric wounds were very much lacerated, one of which being in connection with an intestinal wound and attended with hæmorrhage. Considerable hæmorrhage and fæcal extravasation had occurred. The intestinal wounds were closed with Lembert stitches. The wound in the mesentery, which was attended with hæmorrhage, was treated with a ligature; the other was left untouched. The intestines were in sections alternately contracted and dilated, and very fragile. The cavity was flushed with sterilized water, mopped out and closed. Ten minims of Magendie's solution and two drams of whisky were given hypodermically and removed to a warm place in a condition of severe shock. External heat applied, but reaction was very slow and only partial. Because of his small size and old age, he was a very unfit subject. Operation lasted one hour. Death followed in six hours from shock.

Post-mortem. Few hours after death cavity contained a few ounces of bloody fluid. Intestinal wounds agglutinated, excepting the one on the mesenteric border, from which was oozing thick liquid fæces.

EXPERIMENT 10.

Sept. 22. Full grown mongrel. Weight, 29 lbs. Shot with a flobert from a S. & W. pistol, the ball entering 1 inch to the left and on a level with the umbilicus. Laparotomy revealed a moderate amount of hæmorrhage, and, apparently, no fæcal extravasation. The spleen was perforated near its center and the intestines in five places. The splenic wound was treated with a continuous suture on both sides, including upon the inner surface the omentum in the stitch. The intestinal wounds were all small, and closed by Lembert stitches excepting one, which was linear in character, and closed with a running suture in the direction of the long axis of the intestine. Abdominal cavity was flushed, mopped out and closed. Given two drams of whisky hypodermically, and placed aside in slight shock, from which he rallied in an hour's time. Operation lasted half hour.

Sept. 23. Broke from kennel and was found in some high grass some distance away. Refused food.

Sept. 24. Drank a few ounces of milk only.

Sept. 25. Improved. Takes milk freely.

Sept. 30. Apparently recovered.

Oct. 15. Recovered. Killed to obtain specimen.

Post-mortem. Circumscribed peritonitis, extending some distance beyond the original injury. Intestines adherent to the site of the abdominal section, as well as a few adhesions to one another. The injured spots were found with difficulty. Intestinal lumen suffered no infringement, and when split open the sutures were found hanging from the inner surface, ready to be cast off.

Experiment 11.

Sept. 22. Medium size black spitz. Weight, 26 lbs. Shot with a flobert from a S. & W. pistol. The ball entered 1 inch to the left and a little below the umbilicus. Laparotomy revealed three perforating wounds of the intestine, and only a small amount of hæmorrhage. No fæcal extravasation. Intestinal wounds closed with Lembert stitches. The abdomen closed without flushing. Given ten minims of Magendie's solution and whisky hypodermically. Removed to the kennel without shock. Operation lasted 40 minutes.

Sept. 23. Escaped from kennel with his companion during the night. Refused food in the morning, but drank freely of milk at noon.

Sept. 24. Appears lively and takes considerable milk.

Oct. 15. Recovery. Killed to obtain specimen.

Post-mortem. The only observation of any note was a circumscribed peritonitis at the seat of injury.

Experiment 12.

Sept. 29. Medium sized mongrel. Weight, 20½ lbs. Shot with a S. & W. pistol of .22 calibre, the ball entering on a level with and to the left of the umbilicus. Laparotomy revealed a moderate amount of hæmorrhage and fæcal extravasation; six perforating and one non-perforating intestinal wounds. The intestinal wounds were closed with Lembert stitches. Clots were removed, and the cavity carefully flushed and mopped out. Removed to kennel with evidences of shock. Operation lasted 1 hour.

Sept. 30. Refuses food and appears weak, lying around in a listless manner.

Oct. 1. Improving; takes a small amount of milk; gait unsteady.

Oct. 2. Appears stronger and drinks freely of milk.

Oct, 24. Recovery. Killed to obtain specimen.

Post-mortem. Seat of injury found with difficulty, showing evidence of slight circumscribed peritonitis.

Experiment 13.

Oct. 5. Liver colored dog. Weight, 41 lbs. Shot with a S. & W. pistol of .22 calibre; the ball entered two inches above and to left of umbilicus. Laparotomy revealed considerable hæmorrhage in the abdominal cavity, and a broad non-perforating wound of the intestine, the ball severing the serosa and muscularis. The spleen presented an oblique perforation, passing upward from the external to the internal surface. The intestinal wound was treated with five Lembert stitches. The splenic wound was closed with a continuous suture on the external surface. The inner surface was treated in a like manner, only including the omentum in the suture. This successfully arrested the hæmorrhage, but the spleen below the suture rapidly increased in size and became cyanosed in appearance. The appearance was so unfavorable that extirpation was resorted to. Splenic stump dusted with iodoform and dropped back; cavity flushed with warm sterilized water and closed; given

a hypodermic of ¼ grain morphia and 1/120 grain atropine, together with a rectal injection of saline solution, and removed to a warm place in a condition of shock. Operation lasted nearly one hour.

Oct. 6. Walks about and takes food, apparently suffering very little, if any, inconvenience.

Oct. 7. Same.

Nov. 10. Recovered and turned over to the pound keeper, under whose care he was poisoned. In a post-mortem made by himself the bullet was found encysted in the abdominal wall.

EXPERIMENT 14.

Oct. 5. Full grown mongrel. Weight, 40 lbs. Shot with a S. & W. pistol of .22 calibre. The ball entered 1 inch above and to left of umbilicus. Laparotomy revealed two perforating and one non-perforating wound of intestine and a wound of the mesentery. Abdominal cavity contained only a slight amount of blood. Intestinal wounds closed with Lembert stitches. Abdominal cavity closed without flushing. Hypodermic of a ¼ grain morphia and 1/150 grain atropine, and removed to his kennel in an excellent condition. No shock; up and walking about in less than an hour. Operation lasted a half hour.

Oct. 6. Lively. Takes milk freely.

Oct. 11. Same.

Oct. 20. Recovered, but disappeared.

EXPERIMENT 15.

Oct. 6. Full grown dog. Weight, 38 lbs. Shot with a Remington rifle, .22 calibre, using a long shell. Ball entered on a level with the umbilicus, passing in an oblique course downward toward the right, coming out on the opposite side. The abdominal cavity was filled with blood, which principally came from a wound in the border of the spleen. The intestinal wounds found ante-mortem were seven in number, and of such size and character that it was plainly evident that the animal was beyond redemption. The splenic wound received the first attention, in the excision of a triangular piece, including the perforation, the edges being united by a running catgut suture, beginning upon the external surface and passing over the free border down the internal surface, which completely arrested the hæmorrhage. In addition there was a perforation through the mesentery, which was treated with a catgut ligature for the same purpose. The first intestinal wound measured fully an inch in length, removing more than two-thirds of the circumference of the gut, leaving only a narrow strip upon the mesenteric border. For this, complete resection was performed, reuniting the ends, after the manner of Wölfler. The next were two large wounds which were treated by a single partial resection. Beyond, some distance, were two more which received a similar treatment, and, lastly, two more very large wounds close together, which were treated by a single resection. The animal being already 1½ hours under operation, and in a condition of shock, no further search was made for additional injury. The clots were removed, and the cavity flushed and closed. Given ½ grain morphia, together with 1/60 of a grain atropine, and several hypodermics of whisky, and removed to a warm place, suffering severely from shock. Operation lasted nearly 2 hours. Fæcal extravasation and entozoa. Partly reacted, but after the lapse of three hours began to fail steadily till midnight, when death occurred, after living 6 hours.

Post-mortem, eight hours after death. Cavity contained about one and a half ounces bloody fluid; intestines distended with gas. Intestinal wounds closed and filled with plastic exudate. In addition there were two more perforations in the large intestine at the commencement of the rectum, which was filled with hardened fæces, and notwithstanding this, none escaped. Splenic wound covered with exudate.

Experiment 16.

Oct. 12. Medium-sized dog. Weight, 22 lbs. Shot with a S. & W. pistol, .22 calibre. The ball entered to the right and above the umbilicus, passing through the abdominal cavity. Laparotomy revealed slight hæmorrhage, fæcal extravasation, and entozoa. One non-penetrating and six penetrating wounds of the intestine, which were of moderate size and principally closed by the continued suture. Abdominal cavity flushed and mopped out. Cavity closed and removed with very little shock, from which he soon rallied. Time, a little over $^1/_2$ hour.

Oct. 13. Somewhat weak but took a few ounces milk toward noon.

Oct. 14. Able to walk about and takes milk.

Acs. 31. Recovered. Killed to obtain the specimen.

Post-mortem. Abdominal wound healed with the sutures encysted. Intestines adherent and bands of lymph thrown across. Slight encroachment upon the intestinal lumen. A loop of silk was found hanging from the interior ready to be cast off. Spontaneous omental grafting occurred in another.

Experiment 17.

Oct. 17. Medium-sized half bull. Weight, 26 lbs. Shot with a flobert from a Remington rifle, .22 calibre. The first shot, as was shown by a laparotomy, failed to produce an injury to the abdominal viscera. The second shot produced five perforating wounds in the small intestines and three in the cæcum, together with a perforation in the mesentery. The perforating wounds were closed with Lembert stitches and the non-perforating wounds were small and left untouched. The cavity repeatedly flushed and mopped out. Given hypodermics of morphia and atropia. Closed and removed to kennel with very little evidence of shock. Operation lasted nearly an hour, during which there was extensive fæcal extravasation and entozoa.

Oct. 18. Lies about in a drowsy manner, refusing food this morning, but took a few ounces of milk at noon.

Oct. 19. Refuses all food and very apathetic.

Oct. 20. Found dead.

Post-mortem. Few hours after death. Abdominal cavity contained a thick purulent fluid. Intestines matted together. Wounds of the ileocæcal region in an ulcerated condition, some of which were patulous. Death from septic peritonitis.

Experiment 18.

Oct. 17. Full-grown black mongrel. Weight, 35 lbs. Shot with a Remington rifle, using a .22 short. Ball entered one inch to left and below umbilicus, passing through the abdominal cavity, making its exit on the opposite side. Laparotomy revealed considerable hæmorrhage and fæcal extravasation. Intestine received three large wounds together with a perforation of the spleen. The wounded intestines were drawn out of the abdominal cavity to control the fæcal extravasation. Splenec-

tomy was practiced for the splenic wound. The intestinal wounds were large, one requiring a triangular excision. The others were closed with Lembert stitches. Cavity was repeatedly flushed, mopped out and closed. Removed in a condition of shock to a warm place. Operation lasted 1 hour.

Oct. 18. Drank a few ounces milk in the morning, which he soon vomited. Later in the day he refused all food and appears drowsy.

Oct. 19. Refuses food and appears apathetic.

Oct. 20. Very weak. Refuses food, and appears apathetic. Temperature, 102.2°.

Oct. 21. Temperature, $103^{2}/_{5}°$; otherwise the same. Died late this afternoon.

Post-mortem. Soon after death. Abdominal wound upon pressure discharged a few drops of pus. Abdominal cavity contained about six ounces of reddish yellow pus. Splenic stump adherent to omentum forming a pocket for the accumulation of pus. Intestinal wounds in contact but upon pressure allowed the escape of the contents. Died of septic peritonitis.

Note.—This as well as the one used in the previous experiment was obtained from the dog pound which really is nothing more than a fertilizing works where they are fed upon the bodies of dead animals. From the amount and condition of the contents I believe insufflation would have unquestionably very much increased the quantity of extravasation in both of these.

Experiment 19.

Oct. 18. Full-grown half bull. Weight, 40 lbs. Shot with a S. & W. pistol, .22 calibre. Senn's test was employed and indicated the absence of a perforation of the gastro-intestinal tract. This was corroborated by a laparotomy which revealed a slight hæmorrhage and a non-penetrating wound. The cavity was flushed, mopped out and closed. The intestines remained distended throughout the operation, and were returned with difficulty. In applying the test the wound of entrance was so small that it was only rendered patulous after mutilation. There was no shock, and the animal made an uninterrupted recovery. Soon after recovery he made his escape from the hospital.

Experiment 20.

Oct. 18. Full-grown black bitch. Weight, 50 lbs. Shot with a S. & W. pistol, .22 calibre. Laparotomy revealed the cavity filled with blood. Intestines received three small perforating wounds and a contusion. The animal, which was found to be pregnant with six pups, also received three perforating wounds of the uterus and tubes. The intestinal wounds were closed with Lembert stitches. The pregnant tubes and uterus were ligated in sections and cut away. The cavity was flushed, mopped out, and closed. Given a hypodermic of morphia and whisky and removed. No fæcal extravasation. Operation lasted $1^{1}/_{4}$ hours.

Oct. 19. Appears lively, and drinks freely of milk.

Oct. 20. Same.

Oct. 21. Made his escape but was again found Oct. 26 in a recovered condition.

Experiment 21.

Oct. 29. Medium-sized brindle bull. Weight, 28 lbs. Shot with a S. & W. pistol, .22 calibre. Ball entered one and a half inch above and to the right of the umbilicus. Laparotomy revealed considerable hæmorrhage and fæcal extravasation. Five perforating wounds of the intestines and a wound of the spleen. Splenectomy

was practiced for the wound of the spleen, ligating its root in three portions. Intestinal wounds closed with Lembert stitches. Cavity flushed with warm sterilized water and closed. Given a hypodermic of whisky and morphia and removed in a good condition. Operation lasted 1 hour.

Oct. 30. Died at noon, living only 18 hours after the operation.

Post-mortem. Abdominal cavity contained about a pint of bloody fluid and clots. Intestinal wounds sealed and in good condition.

Experiment 22.

Oct. 29. Full-grown black spitz. Weight, 30 lbs. Shot with a S. & W. pistol, .22 calibre. Ball entered two inches to the right and above umbilicus. Laparotomy revealed slight hæmorrhage, five perforating and two non-perforating intestinal wounds. A wound of the mesentery. The perforating wounds were closed with Lembert stitches. The others were left untouched. Cavity flushed with warm sterilized water, mopped out and closed. Given a half grain morphia and two hypodermics of whisky. Slight fæcal extravasation. Operation lasted 1 hour. In this case Senn's test was attempted, but it was impossible to force the gas beyond the fæcal accumulation. The bag was a five gallon one, and well filled, and such compression used as almost to cause a rupture. Also the exchange of different tubes was practiced but without success.

Oct. 30. Very weak. Refuses food.

Oct. 31. Improved. Took several ounces milk.

Nov. 2. Appears lively and takes food freely.

Nov. 4. Same.

Nov. 8. Recovered, but made his escape from the hospital.

Experiment 23.

Nov. 2. Medium-sized white dog. Weight, 21 lbs. Shot with a S. & W. pistol, 22 calibre. Ball entered obliquely to left of umbilicus. Laparotomy revealed considerable hæmorrhage, six intestinal, one mesenteric and a wound of the spleen. The mesenteric wound was treated with a ligature to arrest the hæmorrhage. The intestinal wounds were closed with Lembert stitches and splenectomy practiced for the wound of the spleen. Cavity flushed, mopped out and closed. Fæcal extravasation. Operation lasted 1 hour. In this experiment Senn's test was used with the same difficulty and result as in the preceding. The rectum being completely filled with fæcal matter in a soft condition.

Nov. 3. Took a few ounces of milk in the morning but died at noon. Seemed very much annoyed with tenesmus.

Post-mortem. Three hours after death. Abdominal cavity contained a few ounces of bloody fluid. Small intestines alternately contracted. Large intestines completely filled with fæcal matter. Intestinal wounds in fair condition. In addition to those closed, another was found that had passed unobserved. Died of an acute septic intoxication.

Experiment 24.

Nov. 2. Mongrel. Weight, 32 lbs. Shot with a S. & W. pistol, .22 calibre. Ball entering two inches to the right and on a level with the umbilicus ranging obliquely upward. Laparotomy revealed slight hæmorrhage a broad non-perforating

wound of the intestine and a wound of the mesocolon involving a large vessel. The vessel was ligated and the intestinal wound treated with Lembert stitches, which arrested the hæmorrhage from its edges. The cavity was flushed, mopped out, and closed. Given an injection of morphia and atropia, and removed in an excellent condition. Operation lasted $^1/_2$ hour.

Nov. 3. Lively, and takes food freely. Will again be referred to in another experiment.

Experiment 25.

Nov. 5. Full-grown dog. Weight, 49 lbs. Shot with a S. & W. pistol, .22 calibre. The ball entered to the right and above umbilicus, passing in a slanting manner downward toward the flanks. Cavity filled with blood. No intestinal wound. The spleen was of a very large size and lying in front of the intestines protected them from injury. The external surface of spleen received a grazing wound for which splenectomy was performed. The splenic root was ligated with a double ligature, but additional ligatures were required to arrest the hæmorrhage. Cavity was flushed, mopped out and closed. Given fifteen minims Magendie's solution and whisky hypodermically and in a condition of shock removed to a warm place. Operation lasted 1 hour. Reaction very slowly ensued.

Nov. 6. Drank a few ounces milk, but very weak.

Nov. 7. Found dead this morning.

Post-mortem. Abdominal cavity contained about a pint of bloody fluid and clots. Ligatures apparently intact. Splenic stump covered with clots.

Death from recurring hæmorrhage.

Experiment 26.

Nov. 12. Full grown mongrel. Weight, 44 lbs. Shot with a S. & W. pistol, .22 calibre. Ball entered to the right and below the umbilicus, passing obliquely downward. Laparotomy revealed considerable hæmorrhage and fæcal extravasation, four perforating wounds of the intestines and a grazing wound of the spleen. Intestinal wounds closed with Lembert stitches. Splenic wound treated with a running suture; clots removed, cavity flushed, mopped out, and closed. Given fifteen minims Magendie's solution and whisky hypodermically, and removed, in a condition of shock, to a warm place, and external heat applied. Operation lasted nearly 1 hour. Reaction in 2 hours.

Nov. 13. Refuses food, and lies in a quiet manner with retracted belly and an occasional groan. Temperature, 101°, respiration 20. Given twenty minums Magendie's solution.

Nov. 14. Died this morning.

Post-mortem, several hours after death. Cavity contained about a half pint of bloody fluid. Intestines distended with gas and adherent. Intestinal wounds all sealed, excepting one which allowed the escape of fæces; splenic wound covered with lymph. The mesocolon contained a large rent which involved several small vessels. The dog was very old, which accounted for the ease with which the tissues tore. Death from an acute septic peritonitis.

Experiment 27.

Nov. 12. Full grown black dog. Weight, 41 lbs. Shot with a S. & W. pistol,

.22 calibre. Ball entered below and to the right of umbilicus. Laparotomy revealed the ball lodged immediately under the peritoneum, having failed to enter the peritoneal cavity. Shot a second time, the ball entering at about the same place. Cavity soon filled with blood, which was found to come from a mesenteric artery. The vessel ligated and the examination continued. Eight perforations were found in the intestines. Intestinal wounds closed with Lembert stitches. Cavity flooded and mopped out. The operation lasted nearly 1 hour. Extravasation of liquid fæces occurred. Given ten minims of Magendie's solution and whisky, hypodermically, and removed in an excellent condition.

Nov. 13. Lively and took several ounces of milk.

Nov. 14. Same.

Nov. 22. Continued in good condition up to his escape from the hospital. Recovered.

Experiment 28.

Nov. 16. Full growu black mongrel. Weight, 40 lbs. Shot with a S. & W. pistol, .22 calibre. Ball entered on a level with and to the left of umbilicus. Laparotomy revealed considerable hæmorrhage, eight perforating intestinal wounds, two of which involved the mesenteric border, a wound of the spleen and one of the mesentery, involving a vessel. The mesenteric wound was treated with a ligature. Wound of the spleen closed by a running suture upon both sides. Lembert sutures were used to close the intestinal wounds, excepting those on the mesenteric edge, which were closed by the continued suture, drawing up a loose fold of the mesentery near the intestinal border to assist in the closure. Cavity flushed and closed. Given ten minims of Magendie's solution and whisky, hypodermically. Removed to the kennel in a good condition. Operation lasted 1 hour.

Nov. 17. Refuses food and lays about in a drowsy manner. Evening temperature, 101.5°.

Nov. 18. Same.

Nov. 19. Temperature, 102°; still refusing food and indifferent to everything. Late in the evening, the dog in a very much depressed condition was again placed upon the table, and after stimulation with whisky and digitalis, again opened. The cavity contained about a half pint of purulent fluid, which was carefully mopped out; intestines highly inflamed and fragile. Several small non-perforating rents near the mesenteric border had ulcerated through. These were closed by the Czerny Lembert suture; the cavity flushed with a hot 1:10000 solution of bichloride, and mopped out. This was repeated with hot sterilized water, and again mopped out and closed. Operation lasted 1 hour.

Nov. 20. Found dead.

Post-mortem. Abdominal cavity contained about three ounces of purulent fluid. Intestines matted together with adherent omentum. Spleen marked with a dark spot beneath the suture. In the left hypochondriac region was found a small sponge, enclosed in a pocket formed by the adherent intestines and omentum which was overlooked in the first operation. The end was largely determined by the cold room during the night. Death from septic peritonitis.

Experiment 29.

Nov. 23. Medium sized mongrel. Weight, 36 lbs. Shot with a S. & W. pistol, .22 calibre. Ball entered one inch below and three inches to the left of umbilicus.

Laparotomy revealed a moderate amount of hæmorrhage, two perforating wounds of the uterus, and one of a ligament of the uterus, seven perforating intestinal wounds and one of the spleen. The uterine wounds were closed with a continuous suture. The splenic wound was sewed upon both sides with the continued stitch The intestinal wounds were close together and were all removed in a resection of 12 inches, the ends being united after the manner of Wölfler. The site of the resection was reinforced by an omental graft, cavity flushed, mopped out and closed. Fæcal extravasation occurred. Operation lasted 1½ hours, and when completed the dog was suffering severely from shock. Given ten minims of Magendie's solution and whisky hypodermically, and removed to a warm place and external heat applied. Reaction followed in about 2 hours.

Nov. 24. Refuses food, but appears lively otherwise.

Nov. 25. Improving; took several ounces milk.

Nov. 26. Improving; fed upon milk and finely chopped meat.

Nov. 27. Refuses food and appears drowsy, vomiting at intervals; takes water freely, which he soon vomits. After stimulation abdominal section was again performed. The resection was again brought to view, and found to be in an obstructed condition from an enterolith. The proximal end of the united gut was very much distended, and the gut in the vicinity in an inflamed condition. The pressure within being sufficient to cause partial separation, another resection of six inches was performed, the cavity washed out and closed. Given whisky hypodermically and removed to a warm place in a condition of shock, from which he died. Like in the other, the end was largely determined by the cold room.

Post-mortem. Cavity clean, and resection unchanged.

Experiment 30.

Nov. 23. Very large black mongrel. Weight, 60 lbs. Shot with a S. & W. pistol, .32 calibre. Laparotomy revealed a slight hæmorrhage and three large perforating intestinal wounds, which were closed with Lembert stitches. Cavity mopped out and closed. No fæcal extravasation. Operation lasted nearly an hour. Given five minims of Magendie's solution and two hypodermics of whisky, and removed in an excellent condition. Reaction prompt.

Nov. 24. Appears sleepy. Vomited a half pint greenish fluid. Refused milk.

Nov. 25. Very much improved. Eats well and appears lively.

Nov. 26. As lively as before the operation.

Nov. 27. Same.

Dec. 14. Recovered. Killed to obtain specimen.

Post-mortem. An extensive peritonitis had occurred with adhesions to the omentum and the neighboring coils.

Experiment 31.

Nov. 23. English bulldog. Weight, 34 lbs. Shot with a S. & W. pistol, .22 calibre. Ball entered one inch to the left and below the umbilicus. Laparotomy revealed considerable hæmorrhage, nine perforating wounds of intestine and a wound of spleen. Several of the intestinal wounds were on the mesenteric border, and closed with a continuous suture. The remaining wounds were closed with Lembert stitches. Splenic wound closed on both sides with a continuous suture. Cavity sponged out, flushed and closed. Operation lasted over an hour. Extravasation of

liquid fæces. Hypodermic of Magendie's solution and whisky, and removed to a warm place in a condition of shock. Reaction occurred in 2 hours.

Nov. 24. Very weak and refuses food.

Nov. 25. Took several ounces milk.

Nov. 26. Improving. Fed upon meat and milk.

Dec. 9. Same.

Dec. 19. Recovered and reclaimed.

Experiment 32.

Nov. 23. Full grown black mongrel. Weigbt, 40 lbs. Shot with a S. & W. pistol, .22 calibre. Ball entered three inches below and to the left of umbilicus. Laparotomy revealed six perforating and two non-perforating intestinal wounds, two wounds of the mesentery involving mesenteric vessels. The vessels were ligated in the mesenteric wounds and the perforating intestinal wounds closed with Lembert stitches. The non-perforating wounds were left untouched. Cavity was flushed and closed. Operation lasted about 1 hour. Fæcal extravasation. Given ten minims Magendie's solution and whisky hypodermically, and removed to a warm place.

Nov. 24. Very weak and refuses food.

Nov. 25. Gait unsteady; took a few ounces milk.

Nov. 26. Refuses food and appears listless.

Nov. 27. Very weak and refuses food. Appears suffering from septic poisoning. Stiches were cut, which allowed the wound to gap, and the escape of thick creamy pus.

Nov. 28. Very weak and emaciated. Refused milk but took some finely chopped meat.

Nov. 29. Improving; takes meat.

Nov. 30. Same.

Dec. 2. Lively and eats well.

Dec. 14. Perfect recovery. Killed to obtain specimen.

Post-mortem. The abdominal wound closed by granulation partly, and partly by the coils of intestines, which were covered externally by a layer of granulation tissue leaving in the abdominal wall a broad and depressed scar. The intestines were firmly and closely bound together, and to the abdominal parietes.

Experiments Upon Gunshot Wounds Without Operative Interference.

Experiment 33.

Sept. 30. Medium-sized English bull. Weight, 30 lbs. Shot with a S. & W. pistol, .22 calibre. Given ten minims Magendie's solution and allowed to come from under the anæsthetic.

Oct. 1. Refuses food and lies huddled together as if too weak to stand.

Oct. 2. Found dead some distance from his house.

Post-mortem. Abdominal cavity contained a small amount of thick fluid. Intestines matted together with the omentum adherent. There were two perforating wounds in the small and two in the large intestines, each of which were discharging a thick yellowish-red creamy fluid. In addition there were two more perforating wounds of the intestines. Death from septic peritonitis.

EXPERIMENT 34.

Oct. 20. Medium-sized mongrel. Weight, 31 lbs. Shot with a Remington rifle, using a .22 short shell. Ball entered on a level with, and one and a half inches to the right of the umbilicus. Dog was allowed to come from under the anæsthetic and remain so for an hour. Again placed under the anæsthetic and Senn's test applied. Gas soon made its appearance at the wound of entrance and burned in a jet. Animal again returned to the kennel.

Oct. 21. Found dead.

Post-mortem. Abdominal cavity contained about eight ounces of bloody fluid and a large number of clots. Considerable extravasation of fæces and entozoa. Five large wounds of the intestines and one of the mesentery involving a vessel. Wound of the splenic border. Death from hæmorrhage.

EXPERIMENT 35.

Oct. 20. Medium-sized mongrel. Weight, 20 lbs. Shot with a flobert from a Remington rifle. Ball entered on a level with and two inches below the umbilicus. Senn's test was applied indicating an intestinal perforation. The gas did not burn in a jet but only now and then the bubbles ignited. Removed, but died in an hour's time.

Post-mortem. Abdominal cavity filled with bloody fluid and clots. There were seven perforating wounds of the intestine and four of the mesentery. Two of the latter involved mesenteric vessels. Death from hæmorrhage.

EXPERIMENT 36.

Nov. 5. Medium-sized mongrel. Weight, 20 lbs. Shot with a S. & W. pistol, .22 calibre. Ball entered on a level with and to the right of the umbilicus, passing in a very shallow course. Given 12 minims Magendie's solution and removed. No shock, the dog rallying at once.

Nov. 6. Up and takes milk.

Nov. 7. Lively and eats freely.

Nov. 8. Same.

Nov. 12. Apparently recovered and made his escape from the hospital. In this experiment the ball apparently did not enter the abdominal cavity, or if it did so, it failed to create any serious damage.

EXPERIMENT 37.

Nov. 12. Small mongrel. Weight, 17 lbs. Shot with a S. & W. pistol, .22 calibre. Given 15 minims Magendie's solution and removed.

Nov. 13. Found dead.

Post-mortem. Cavity contained some blood and nine perforating wounds of the intestines. Death from shock.

EXPERIMENTS UPON SEPARATE ORGANS—RESECTIONS.

EXPERIMENT 38.

Aug. 28. Full-grown bull dog. Weight, 34 lbs. Abdominal cavity opened and a loop of intestine withdrawn. The vessels at the mesenteric border ligated and one

inch resected. The ends were united after the method of Wölfler (uniting the posterior third from within). Uneventful recovery followed.

Experiment 39.

Aug. 31. Small mongrel. Weight, 14 lbs. Abdominal cavity opened and a loop of intestine withdrawn, resecting four inches as in the previous experiment. Recovery.

Experiment 40.

Oct. 2. Same dog used that served in the foregoing experiment. Abdomen opened just above the scar from the former operation. The resection was found in a perfect condition with a spontaneous omental graft at the seat of union. The sutures all encysted excepting those introduced posteriorly. Eighteen inches including the former resection were now removed. The vessels were ligated at the vertebral border of the mesentery and a V-shaped piece excised uniting the edges with a running catgut suture. The intestines were united as in the preceding experiments only reinforcing the resection by an "omental graft." The ends were united not far from the ileocæcal valve, and the blood supply very much interfered with; however no harm resulted. Recovery followed without any inconvenience to the animal after the removal of 22 inches of intestine.

Nov. 28. Killed to obtain the specimen.

Post-mortem. Several adhesions at the seat of resection. No narrowing of the calibre. Sutures encysted. The web of the mesentery between the vessels at the resection absent.

Experiment 41.

Oct. 12. The same subject that served in Experiment 38 was used here. Abdomen opened and the site of the former resection withdrawn and found marked by an omental adhesion and a slight narrowing of the intestine internally and externally. The sutures all encysted and plainly visible. Four inches were resected including the site of the former operation. Very shortly after the operation the dog by mistake was fed upon a large piece of meat, but no harm resulted.

Nov. 5. Killed to obtain the specimen.

Post-Mortem. Omentum adherent. Lumen slightly narrowed. Sutures encysted.

Experiment 42.

Nov. 19. In this experiment the same dog was used that served in Experiment 24. Laparotomy above the former site. The spleen withdrawn and a triangle excised measuring one inch at its base and a fraction more from base to apex. The edges were united by a continuous suture commencing on its external surface, passing over the free border and down upon its internal surface. This completely arrested the hæmorrhage. Following this the spleen increased to almost double its size and became cyanosed in appearance, in which state it was returned and the cavity closed.

Dec. 28. Recovered. Killed to obtain specimen. Complete union marked by a white line which represented the united edges. Omentum adherent. Sutures encysted and somewhat softened. Part below the suture slightly atrophied and darker color, but otherwise unchanged.

EXPERIMENT 43.

Jan. 2. Full-grown mongrel. Weight, 40 lbs. Curvilinear incision under the right border of the ribs, and afterward joined by one in the linea alba. Liver exposed and perforated by a blunt aseptic instrument as well as the excision of a narrow but long triangle. The puncture was sewed upon both sides which arrested the hæmorrhage completely. The excision was united by a running cat-gut suture applied as in the previous experiment, which likewise arrested the flow from the surfaces. In drawing the liver into view rupture of its capsule occurred in several places. Cavity washed out and closed.

Jan. 3. Walking about. Took several ounces of milk in the morning but refused food at noon and evening. Urine loaded with bile.

Feb. 18. Killed to obtain specimen.

Post-mortem Liver marked by white lines at the points of rupture. Slight scars at the punctures. The excision was marked by an omental adhesion but otherwise unchanged. No evidence of peritonitis.

EXPERIMENT 44.

Jan. 2. Small white mongrel. Weight, 19 lbs. A hypodermic syringeful of bile was obtained from another dog and injected into the peritoneal cavity without the introduction of air. This was repeated a second time and each time followed by an exhibition of pain from the dog. The syringe was cautiously introduced, care being observed to try and insure the arrival of the bile in the peritoneal cavity, and from the impression it was apparently successful.

Jan. 3. Refuses all food and lies quiet in one place.

Jan. 4. Same.

Jan. 15. Recovered, and killed for further examination.

Post-mortem. Absolutely no signs were visible of any change having occurred within the peritoneal cavity.

EXPERIMENT 45.

Jan. 29. Liver-colored mongrel. Weight, 32 lbs. Abdomen opened and the intestines exposed. The intestines were insufflated with air until they were distended. The respirations became short and slow. Puncture was made into the large intestine, which was followed by an escape of air and the collapse of the intestine, but only for a short distance beyond. This was repeated in the small intestines with the same result. The stomach, which was likewise distended, was compressed, but no gas escaped till a puncture was made into it. The intestines were largely distended, and the occurrence of acute flexures prevented the ready escape of the air.

SYNOPSIS OF EXPERIMENTAL WORK AND RESULTS.

Experiment.	*Projectile*	*Weapon.* *S. & W. §Remington Rifle.	*Perforating Intestinal Wounds.*	*Non-Perforating Intestinal Wounds.*	*Wounds of Mesentery ‡Mesocolon.*	*Wounds of other Organs.*	*Total Wounds.*	*Hæmorrhage.* *Large. ‡Slight. §Moderate.	*Fecal Extrav.* †None. §Moderate. ‖Lig. fecal *Large. ‡Slight.	*Shock.* —*Ext. †None. ‡Slight. §Moderate.	*Time.*—*Hours.*	*Result.* *D. †R.	*Remarks.*
1	32	*	3	1	0	Kidney.	5	*	†	*	1	*	Death from shock in 6 hours. Wounds covered with thin layer of exudate.
2	Flo.	§	1	0	1	None.	2	*	†	†	....	*	Unsurgical. Death almost immediately from hæmorrhage.
3	Flo.	§	1	0	0	None.	1	‡	†	†	½	†	Continued suture subsequently found hanging from the site.
4	22 l.	§	12	1	0	None.	13	§	§	*	1½	*	Death in 10 hours from shock. Resected 4 feet intestines.
5	22	*	5	2	0	Spleen.	8	*	‡	*	1½	*	Death from shock. Resected 1 inch.
6	22	*	4	1	0	Kidney	6	*	‡	*	1⅜	*	Death from acute septic peritonitis.
7	22	*	6	0	0	Spleen & Liver.	8	*	‡	*	1	†	Wounds of the intestines, liver and spleen.
8	22	*	8	0	2	Spleen.	11	*	†	*	1⅜	†	Extensive adhesions of all the intestines in one mass.
9	Flo.	*	7	0	2	None.	9	*	‡	*	1	*	Intestines during operations were in portions contracted and dilated.
10	Flo.	*	5	0	0	Spleen.	6	§	‡	‡	½	†	Splenic wound treated with a suture on both sides.
11	Flo	*	3	0	0	None.	3	‡	†	†	¾	†	Subsequent examination revealed circumscribed peritonitus.
12	22	*	6	1	0	None.	7	§	‖	§	1	†	Same.
13	22	*	0	1	0	Spleen.	2	*	†	§	1	†	No intestinal perforation.
14	22	*	2	1	1	None.	4	‡	†	†	½	†	No remarks.
15	22	§	9	0	1	Spleen.	11	*	*	*	2	*	Extreme trauma in this experiment.
16	22	*	6	1	0	None.	7	‡	‡	‡	½	†	Spontaneous omental grafting.
17	Flo.	§	8	2	1	None.	11	‡	*	§	1	*	Death from perforative peritonitis.
18	22	§	3	0	0	Spleen.	4	§	*	*	1	*	Same.
19	22	*	0	1	0	None.	1	‡	†	†	½	†	No perforation. Senn's test applied.
20	22	*	3	0	0	Uterus.	6	*	†	§	1¼	†	Hysterectomy of pregnant tubes and uterus.
21	22	*	5	0	0	Spleen.	6	*	‡	‡	1	*	Death from recurring hæmorrhage.
22	22	*	5	2	1	None.	8	‡	‡	‡	1	†	Senn's test impossible from occlusions.
23	22	*	6	0	1	Spleen.	9	*	‡	§	1	*	Death from undetected wound.
24	22	*	0	1	‡	None.	2	§	†	†	½	†	Wound of mesocolon involving large vessel.
25	22	*	0	0	0	Spleen.	1	*	†	*	1	*	Death from hæmorrhage.
26	22	*	4	0	1	Spleen.	6	*	‡	*	1	*	Tissues very fragile, tearing readily.
27	22	*	8	0	1	None.	9	*	§	‡	1	†	No remarks.
28	22	*	8	0	1	Spleen.	10	*	*	‡	1	*	Second laparotomy for purulent peritonitis.
29	22	*	7	0	0	Spleen, Uterus.	11	§	‡	*	1½	*	Death from obstruction dependent upon an entero-lith.
30	32	*	3	0	0	None.	3	‡	†	†	1	†	No remarks.
31	22	*	9	0	0	Spleen.	10	*	‡	*	1¼	†	No remarks.
32	22	*	6	2	2	None.	10	§	§	*	1¼	†	Secondary drainage for purulent peritonitis.

Résumé.

The following represents a résumé of the whole.

The experiments were divided into three classes. Experiments upon gunshot wounds with interference, experiments upon gunshot wounds without interference, and experiments upon separate organs.

Of the thirty-two experiments represented in the first class, seventeen ended in recovery and, omitting the second experiment, in which death followed almost immediately, the mortality amounts to 45.1%.

In all except four of the recognized fourteen that ended fatally death occurred either at the end of or during the first twenty-four hours following the operation.

In the excepted four the deaths occurred in one and a half, three, three and a half and four and a half days respectively after the operation. The mortality of the whole being dependent upon, two from hæmorrhage, 14.2%; five from shock primarily, 35.7%; six from sepsis, 42.8% (and one from shock consecutive to an operation for obstruction).

Although the end in view was not that of securing recoveries, but rather that of an inquiry into the treatment of these injuries, yet with different subjects and better surroundings it might also have been different.

The second class consisted of five that were shot and allowed to go without operative interference. Of these one recovered, one died of shock, two of hæmorrhage, and one of sepsis. In the one that escaped there is a strong probability that very slight if any injury occurred.

The third class consists of four resections after Wölfler's method, a partial resection of the liver, a partial resection of the spleen and one experiment upon the peritoneum, all ending in recovery. Lastly a final experiment with Senn's test.

Resulting from the foregoing paper, I beg leave to submit for further consideration, the following deductions:

1. In view of the uncertainty which attends these injuries exploratory laparotomy should in every case be boldly but carefully performed. The operator being in readiness to meet

any indication that the exigency of the case may demand.

2. Laparotomy in the linea alba is preferable to one performed in the course of the ball unless there are reasons to believe that the ball became arrested short of the peritoneum or its track infected, in which case incision and drainage should be employed.

3. Considering the objections against Senn's test as a diagnostic means of determining the necessity of a laparotomy the possible harm outweighs to such an extent the possible benefit that its general adoption is hardly justifiable.

4. The value of Senn's method in determining at the close of the operation the security of the intestinal tract is questionable, and still *sub judice.*

5. Large intestinal wounds not involving the mesenteric border are best treated by partial resections.

6. Intestinal wounds upon the mesenteric border unless very small require a complete resection.

7. Where several large wounds are situated very close together a single resection including them all should be considered.

8. Partial resections of the liver, spleen or pancreas are feasible steps and may be required.

9. Suturing of both openings in wounds of the liver and spleen for the arrest of hæmorrhage is advisable.

10. Excepting superficial lesions nephrectomy is the only procedure in wounds of the kidney.

11. Should obscure symptoms arise pointing to an early peritonitis the use of salines are indicated.

12. If suppurative peritonitis is established, early exploratory incision, drainage and disinfection of the peritoneum should be undertaken.