EDITORIAL ARTICLES.

SENN ON THE DIAGNOSIS OF GASTRO-INTESTINAL PERFORATION BY THE RECTAL INSUFFLATION OF HYDROGEN GAS.

The fertile mind of Professor Senn is notable for the originality of its conceptions. Our readers have been favored during the last half year with an account of his remarkable work in the treatment of intestinal obstruction, as presented to the Ninth International Medical Congress a year ago. Dr. Senn has not been satisfied to rest content with the laurels won by his previous labors in abdominal surgery, but has continued his vivisection experiments into the diagnosis of intestinal perforation.¹

The fact that intestinal perforation can be treated by suture with success is now fully established. And it may also be considered as demonstrated that a traumatic perforation of any portion of the gastro-intestinal canal is inevitably fatal unless it be treated by suture.

The fact that a small number of cases are on record in which undoubted perforation of the gut recovered without other than expectant treatment can not be regarded as militating against the truth of this general rule, since they form so small a portion of the total that they may be ignored in the consideration of the subject.

In opposition to this condition may be placed simple perforating wounds of the abdominal parieties without lesion of the viscera, a condition amenable to simple closure of the external wound and comparatively innocuous.

But the great difficulty that presents itself to the surgeon in the ab-

sence of positive symptoms is the differential diagnosis between a simple penetrating wound and a penetrating wound complicated by injury of the gastro-intestinal canal. While the existence of serious intra-abdominal haemorrhage can usually be readily recognized by well-marked physical signs and a complexus of symptoms which points to sudden diminution of intra-arterial pressure, and thus furnishes one of the positive indications for treatment by laparotomy, the well-known fact remains that a visceral injury of the stomach or intestines seldom gives rise to symptoms upon which the surgeon could rely in making a positive diagnosis.

In the treatment of penetrating wounds of the abdomen laparotomy is resorted to either for the purpose of (1) arresting dangerous haemorrhage, or (2) the detection and treatment of a wound or wounds of its hollow viscera. The first indication is readily recognized, and the diagnosis not only justifies the operation, but imposes it as a stern duty upon the surgeon from which he should never shrink. The recognition of the second indication offers greater difficulties, and the uncertainty of diagnosis which surrounds such cases is used as a sufficient argument by many in opposing the adoption of timely and efficient surgical treatment, and is responsible for the loss of many lives which otherwise might have been saved. The uncertainty of diagnosis must remain in the way of a more general adoption of laparotomy in the treatment of penetrating wounds of the abdomen in the case of timid surgeons, and the same cause may lead to most unpleasant medico-legal complications in the practice of bolder and more aggressive operators. Clinical experience and statistics have demonstrated the importance of making a distinction between punctured and gunshot wounds in the abdomen, both in reference to diagnosis and treatment. It is well known that penetrating stab-wounds are less likely to be complicated by visceral injury than bullet wounds, consequently this class of injuries offers a more favorable prognosis and does not call so uniformly for treatment by abdominal section. That penetrating gunshot wounds of the abdomen do not always implicate the gastro-intestinal canal has been well demonstrated by experiment and clinical observation. During the last two years three cases of bullet wounds of
the abdomen came under the observation of Dr. Senn where no doubt could be entertained that penetration had taken place, and yet all the patients recovered without operation. In all three cases the bullet had taken an antero-posterior direction.

As in private practice the treatment of penetrating wounds of the abdomen usually involves great medico-legal responsibilities, it becomes of the greatest importance to arrive at positive conclusions in reference to the character of the injury before the patient is subjected to the additional risks to life incident to an abdominal section. A death from acute inflammation of the peritoneum consequent to an explorative section after an abdominal lesion in which no visceral complication was discovered, may involve the surgeon in the gravest consequences, since the fatal result may be attributed directly to the operation rather than to the original wound. If some infallible diagnostic test could be applied in cases of penetrating wounds of the abdomen, which would indicate to the surgeon the presence or absence of visceral lesions of the gastro-intestinal canal, the indication for aggressive treatment would become clear, and the medico-legal responsibility of the operator would be reduced to a minimum.

As neither the symptoms nor ordinary physical examination could offer satisfactory evidence of the condition of the viscera in case of a wound of this kind, Dr. Senn was induced to search for some reliable test which in such cases should prove that the penetrating bullet or instrument had injured the gastro-intestinal canal. It occurred to him that a wound in the stomach or intestine should be sought for in some such way as a plumber locates a leak in a gas pipe. The first object to be accomplished was to prove the permeability of the entire gastro-intestinal canal to inflation of air, and the next step was to find some innocuous gas which, when inflated, would escape from the intestinal wound into the peritoneal cavity, and from there through the external wound where its presence could be proved by some infallible test.

The literature of the permeability of the ileo-cæcal valve to rectal inflation of air or gas is quite abundant, and the conclusions reached by various authors are diametrically opposite. While the majority
positively assert that the valve is perfectly competent and effectually guards the ileum against the entrance of both fluids and gases forced into the rectum, a considerable minority insist that it is permeable only in exceptional cases, and only a few claim that its resistance can be overcome by a moderate degree of pressure. Experiments by Heschl, Bull, Cantani, Behrens, Debierre, Lucas, Dawson and Battey are quoted upon this point, and the twenty-third, twenty-fourth and twenty-fifth experiments related in his paper on Intestinal Obstruction. These three experiments combined with clinical experience leave no further doubt that, practically, the ileo-caecal valve is not permeable to fluids from below, and that for diagnostic and therapeutic uses it is unsafe and unjustifiable to attempt to force fluids beyond the ileo-caecal valve.

It would be expected a priori that air and gases on account of their less weight and greater elasticity than water, could be forced along the intestinal canal with less force, and for that reason alone, if for no other, should be preferred to water in cases where it appears desirable to distend the intestines above the ileo-caecal valve. The results obtained by experimental research in the past speak in favor of rectal inflation by air or gas in all cases where for diagnostic or therapeutic purposes it becomes necessary to dilate the entire or a portion of the gastro-intestinal canal.

By six experiments Dr. Senn showed that both in the human subject and in animals by a moderate degree of force, short of producing any injury of the tunics of the intestines, air can be forced along the entire alimentary tract, and that this procedure can be resorted to with perfect safety for diagnostic and therapeutic purposes in all cases where the tissues of the intestinal wall have not suffered too much loss of resistance from antecedent pathological changes. In these experiments the air was injected through the anus with an ordinary elastic syringe, the inflation being traceable by percussion and manipulation.

By eight experiments he demonstrated conclusively that it is more difficult to inflate the alimentary canal from above downwards than from below upwards, as in the living animal he succeeded only in one in-

stance in forcing hydrogen gas from mouth to anus, while in others a de-
sufficient to rupture the peritoneal coat of the stomach only
effected distention of the stomach and upper portion of, the intestinal
canal. It is evident that great distention of the stomach constitutes
an important factor in causing or aggravating intestinal obstruction, as
it effects compression which causes impermeability of the intestines,
or aggravates conditions arising from an antecedent partial permea-
bility by producing sharp flexions among the distended coils of the in-
testines. For diagnostic and surgical purposes the stomach can be
readily inflated almost to any extent through a stomach tube, and
when it becomes necessary to ascertain the presence of a visceral
wound or perforation of this organ, this method of inflation may be re-
sorted to with advantage.

Accurate experiments to determine the force required to render the
ileo-caecal valve incompetent had not previously been made, and re-
cognizing the great importance of obtaining accurate information on
this subject, Dr. Senn made three experiments on dogs and two on
healthy young men. In all experiments air or hydrogen gas was used.
The inflation was made with a rubber balloon. The pressure was es-
timated either with a mercury gauge, or with a manometer used by gas
fitters and plumbers. The manometer or mercury gauge was con-
ected by means of rubber tubing with the rectal tube on one side and
the rubber balloon on the other. The rubber balloon in which the hy-
drogen gas was collected held 4 gallons, and numerous experiments
showed that when the gas was forced through the opening of a stop-
cock, the lumen of which was about the size of a knitting needle, a
compression equal to 200 lbs. (90 kilograms) would never register
more than 3 lbs. (1.3 kilograms) of pressure.

In the living subject the escape of air or gas from the rectum was
prevented by an assistant pressing the margins of the anus firmly
against the rectal tube.

In a normal condition the ileo-caecal valve in a healthy adult person
was found to be overcome by rectal inflation under a pressure of 14 to
24 lbs. (.6 to 1.2 kilogram). This amount of pressure is not suffi-
cient to injure the tunics of a healthy intestine, and in both instances
the subjects of the experiments complained but little of the immediate or remote effects of the experiment. As the result of numerous observations, it is shown that when the inflation is made slowly and continuously there is less danger of injuring the intestines than when the inflation is made rapidly, or without interruptions. Slow and gradual distention of the caecum is best adapted to overcome the competency of the ileo-caecal valve, by effecting diastasis of the margins of the valve. The rubber balloon holding from 2 to 4 gallons (10 to 20 litres) recommends itself as the most efficient and safest instrument for making rectal insufflation for therapeutic or diagnostic purposes.

The pressure necessary to rupture a healthy intestine was found to be greatly in excess of that required to force air through the ileo-caecal valve, or even the whole length of the alimentary canal, as showned by a large number of experiments upon dogs and upon the human cadaver. It only requires from one-quarter of a pound and a half (.1 to .7 kilograms) of pressure to force air through the ileo-caecal valve, and from half a pound to two pounds and a half (.2 to .7 kilograms) to force it from anus to mouth, while even the weakest portion of the gastro intestinal canal effectually resisted a distending force of from eight to ten pounds (3.6 to 4.5 kilograms). The experiments on the human cadaver, where the resisting power of the gastro-intestinal canal to diastalic force was greatly reduced by ante-mortem pathological changes, show that under such circumstances it would have been safe to resort to inflation, as the pressure required to rupture the colon, or small intestines exceeded that which has been found adequate to force air or gas beyond the ileo-caecal valve, or even the entire length of the alimentary canal. When an intestine is distended to its utmost capacity slowly by inflation of air or gas, and the pressure is maintained uninterruptedly, rupture occurs at one of two points, either a longitudinal laceration of the peritoneal coat takes place on the convex surface of the bowel opposite the mesenteric attachment, or minute ruptures on the mesenteric side give rise to extravasation of air or gas between the two serous layers of the mesentery, in either case, if the pressure is increased, complete rupture takes place at the point where the laceration first commenced.
He also presents five experiments upon dogs, and eleven upon human beings in illustration of the distention of the gastro-intestinal canal by rectal insufflation of hydrogen gas. They furnish only so many more demonstrations of the permeability of the ileo-caecal valve and the entire alimentary canal by the gas insufflated through the rectum. In one of those cases the author was himself the subject, and he relates his experience as follow:

"Under a pressure of $\frac{1}{2}$ pound (.4 kilogram), nearly 6 litres of gas were insufflated per rectum. The distention of the colon caused simply a feeling of distention along its course, but as soon as the gas escaped into the ileum colicky pains were experienced, which increased as insufflation advanced, and only ceased after all the gas had escaped, which was the case only after an hour and a half. When the intestines and the stomach had become fully distended the feeling of distention was distressing, and was attended by a sensation of faintness which caused a profuse clammy perspiration. A great deal of the gas escaped by eructation, which was followed by great relief. The colicky pains attending the inflation of the small intestines by air or gas are evidently caused by increased peristaltic action of the bowels in their attempt to expel their contents, as it always assumed an intermittent type and subsided promptly after the escape of the gas."

In none of these experiments did the pressure exceed 1 pound (.4 kilogram) in overcoming the resistance offered by the ileo-caecal valve, and often a steady long continued pressure of $\frac{1}{4}$ or $\frac{1}{3}$ pounds (.1 to .15 kilogram) sufficed. Every time the ileo-caecal valve was rendered incompetent by distention of the caecum the pressure was promptly diminished owing to the escape of gas from the colon into the ileum. In the experiment where the inflation was made in a case of typhilitis the ileo-caecal valve offered no resistance, and the gas escaped freely into the ileum; the valve in all probability had been rendered partially or completely incompetent during the course of the local inflammation, or the indurated, thickened walls of the caecum, when distended during the inflation, were better adapted in effecting incompetency of the valve. These experiments also furnish strong proof of the fact that inflation, to be safe and effective, should be done very slowly under a
low, steady pressure, continued only for a short time, and is attended by no risks whatever of rupturing a healthy intestine and, when cautiously practiced, can be resorted to even in cases where the resisting power of the intestinal wall has been diminished by antecedent pathological processes.

The experiments, to which reference has already been made, on man and dogs, have fully demonstrated the safety of pure hydrogen gas when employed in this manner, as not in a single instance were any immediate or remote toxic symptoms observed which could be referred to absorption of the gas; hence we have the assurance that the inflation of a large quantity of hydrogen gas is unattended by any risk whatever, as far as intoxication is concerned.

As it was necessary however, that the gas should not only be harmless when injected into the uninjured alimentary canal, but that it should also be innocuous and non-irritating when brought into contact with other tissues, several experiments have been made. By these it was shown that the gas was innocuous, and free from irritation when brought into contact with the tissues most susceptible to inflammatory reaction in the living body—the peritoneum, the pleura, and the subcutaneous cellular tissue. They also show that hydrogen gas is removed by absorption in a comparatively short time when injected into serous cavities or into the subcutaneous connective tissue.

His experimental work closed with nine experiments upon dogs to show the value of his procedure in the diagnosis of penetrating gunshot wounds of the abdomen. In these experiments the animals were strapped on one of Pasteur’s operating tables. The abdomen was shaved, and after complete etherization the shooting was done at short range with a 32 calibre revolver. Inflation of hydrogen gas was practiced immediately after the shot was fired, and its escape from the wound was shown by igniting it at the mouth of the injury. It burned with a steady blue flame as long as the gas continued to escape. After this the abdomen was opened and its contents examined for visceral injuries. In all cases where the colon was perforated inflation could be done under very slight pressure, as the gas readily escaped into the peritoneal cavity, and from there through the bullet wound in the abdominal wall, where it was ignited as it escaped.
In all of these experiments, the bullet was fired through the abdomen from side to side transversely or somewhat obliquely, directions which invariably brought into the track of the bullet a number of intestinal coils and often the colon likewise. In the two experiments where the track of the bullet was a little higher up the intestines escaped, but the stomach showed two perforations; one near the pyloric, and the other near the cardiac extremity. Rectal insufflation of hydrogen gas proved an infallible test in every instance, except in the case where it failed on account of the inflation apparatus being out of order. Contrary to the experience of other experimenters, it was found that fecal extravasation does not uniformly take place soon after gunshot wounds of the intestines, and in the cases where it was observed some part of the colon had been wounded. Intestinal inflation does, therefore, not tend to increase the frequency of this occurrence, and must therefore be looked upon as a harmless measure in this direction.

Inflation, as a preliminary measure, greatly expedites the first step in the operation of abdominal section in cases where the intestine has been perforated or injured, as the gas which escapes into the peritoneal cavity separates the intestine from the anterior abdominal wall, and the incision can be made safely and rapidly without fear of wounding the intestines. Penetrating wounds of the abdomen, where the course of the bullet is in an opposite direction to that which has been described in the preceding experiments, that is in an anterior direction, may not implicate the intestines at all, or if visceral injury is inflicted, it is more likely that only a single perforation exists, and never does the surgeon meet with such a multiplicity of lesions as has been cited above. Unless the surgeon can ascertain beforehand that in a case of penetrating wound of the abdomen an injury to some portion of the gastro-intestinal canal exists, the very means which he resorts to in making an anatomical diagnosis is often an imminent source of danger, as only too often he may have to examine every inch of the gastro-intestinal canal for this purpose, a procedure which is always attended by great risk to life. If by such a simple and harmless procedure as insufflation of hydrogen gas he can satisfy himself that the gastro-intes-
tinal canal is perforated, the course to pursue becomes clear—to open the abdomen, *seek for the perforation until he finds it*, and to adopt the proper treatment for the visceral injury.

Cases have also happened in which the operator opened the abdomen, sought for, found and treated one or more perforations, and on making the autopsy a day or two later found to his great chagrin and sorrow, a perforation which he had overlooked at the time of operation. The author thinks that in cases in which any doubt exists as to the integrity of the remaining portion of the intestinal canal, after closing one or more perforations, it would be advisable to search for additional perforations by resorting again to slow and careful inflation before the abdominal wound is closed. If no other perforation exists the gas will be confined to the interior of the gastro-intestinal canal, and if the stomach or intestines, at some point difficult of access, are injured, the leakage of gas through the perforations will lead the surgeon to the wound.

In the practical application of rectal insufflation of hydrogen gas, as a means of diagnosis in penetrating wounds of the abdomen, the field of possible operation should be carefully prepared by shaving and disinfection before inflation. After thorough disinfection of the external wound or wounds, and the field of operation, the patient should be placed thoroughly under the influence of an anaesthetic for the purpose of relaxing the abdominal muscles, which greatly facilitates the inflation. In the absence of a Wolf's bottle hydrogen gas can be readily generated in a large wide-mouthed bottle into which a small handful of chips of pure zinc is placed. The mouth of the bottle is closed with a cork with two perforations, through which two glass tubes are inserted, one for the purpose of pouring in water and sulphuric acid, and the other, which should be bent nearly at right angles, for leading away the gas. This glass tube and the rubber balloon with a capacity of 16 litres of gas are connected by means of a rubber tube. In from five to ten minutes the requisite amount of gas can be generated and every thing is ready for the inflation. The rubber tube connecting the balloon with the rectal tip of an ordinary syringe should be interrupted by a stop-cock, so that the escape of the gas can be prevented when-
ever inflation is temporarily suspended. The return of gas along the sides of the rectal tip can be readily prevented by an assistant pressing the anal margins firmly against it. The inflation must always be made slowly, as long continued, uninterrupted pressure accomplishes most effectually lateral and longitudinal dilatation of the cæcum, conditions which render the ileo-caecal valve incompetent, and which must be secured before inflation of the small intestines is possible. The entrance of gas from colon into ileum is always attended by a diminution of pressure, and its occurrence can invariably be recognized by a gurgling or blowing sound over the ileo-caecal valve, and sometimes the sounds are sufficiently loud to be heard at some distance.

If, after inflation, abdominal distention and tympanites be from the very first diffuse, and liver dulness has disappeared, it is a certain indication that it is due to the presence of gas in the peritoneal cavity and not to distention of the gastro-intestinal canal. If, on the other hand, the distention and tympanites follow the course of the colon, and after the entrance of the gas through the ileo-caecal valve is circumscribed and limited to the umbilical and hypogastric regions, and gradually extends to the upper portion of the abdomen, and the liver dulness is displaced upwards, it is in all probability caused by a gradual and successive inflation of the intact bowel in an upward direction. In some penetrating wounds of the abdomen it is difficult, if not impossible, to follow the course of the bullet through the abdominal wall with a probe or finger on account of the relative change of position of the different layers of tissues in the track of the bullet obliterating the canal, but even in these cases a moderate distention of the peritoneal cavity by an accumulation of gas outside of the intestines will force bubbles of gas through the tortuous canal, and by this sign the surgeon may know positively that some portion of the gastro-intestinal canal has been perforated, and in order to prove that the bubbles which escape are part of the hydrogen gas which has been inflated he applies a lighted match or taper, and if it is hydrogen gas it will ignite with a slight explosive report, and burn with a characteristic blue flame. The burning of the escaping hydrogen gas on the surface of the external wound is a most effective means in securing for the wound
an aseptic condition, and on that account the escaping gas should be lighted both for diagnostic and therapeutic purposes in all cases in which rectal insufflation of hydrogen gas reveals the presence of visceral injuries of the gastro-intestinal canal.

As the hydrogen gas from its low specific gravity will always occupy the highest space in a cavity partially filled with fluids, it is necessary to place the external abdominal wound in such a position that blood or any other fluid that may be present in the abdominal cavity will not interfere with its ready escape. If the wound is anterior the patient must be placed in dorsal position; if lateral, on the opposite side during inflation. If during inflation early and diffuse tympanites takes place, it speaks in favor of perforation of the colon.

Should the external wound prevent the escape of the gas from the peritoneal cavity by sliding of the different layers of tissue of the wound in the abdominal wall, or by the presence of a coagulum in the track made by the bullet, it becomes necessary to secure a sufficient degree of patency of the wound for the escape of the gas by careful probing or the removal of coagulated blood. The finding of perforations is also greatly facilitated by inflation, as the bowel below the lowest perforation will always be found at least slightly dilated by gas. If this perforation is now closed and additional perforations are suspected to exist the inflation can be repeated, and the bowel will again become distended as far as the next perforation, and this process can be repeated until the entire intestinal canal has been examined by this method. By searching for leaking points in this manner but little manipulation of the intestines becomes necessary, and thus one of the great sources of danger in the operative treatment of wounds or perforations of the gastro-intestinal canal is avoided. The moderate distention of the intestines left after treating the visceral wounds never interfered with the return of the intestines into the abdominal cavity or the closure of the external wound in any of the experiments, and the numerous observations made in reference to the disappearance of the gas by absorption, or escape through the natural outlets, are conclusive in showing that the distention due to the presence of gas disappears in a remarkably short time, and it can, therefore, be safely
stated that rectal insufflation of hydrogen gas in the diagnosis and
treatment of penetrating wounds of the abdomen does not interfere
with an ideal healing of the visceral and laparotomy wounds.

Dr. Mackie, of Milwaukee, is the first to have reported the use of
this method upon the human being. A colored man, æt. 27 years,
had received a 38 calibre pistol shot wound two inches to the left of
the linea alba, and one inch below the costal arch, passing out in the
left lumbar region close to the spine and one inch above the iliac crest.
Rectal sufflation according to the method of Senn was practiced
and the escape of gas was demonstrated only upon pressure after the
abdomen was greatly distended. The ignition test was not employed.
Upon abdominal section two perforations were found in the stomach
and at the junction of the duodenum and jejunum two perforations
were found together with one perforation of the transverse meso-colon
and two of the mesentery. These were all sutured, but the patient
died of septic peritonitis thirty-six hours after the receipt of the injury.
This case presented a test of the diagnostic method of the severest
kind, owing to the lack of symptoms of perforation.

This method has found another field in the service of Dr. W. W.
Keen at St. Agnes Hospital in Philadelphia. The patient had a faecal
fistula on the left side of the abdomen. The question as to whether a
lateral or a median incision should be made depended upon whether
the proximal opening was in the large or small intestine; the distal
opening threw no light upon this point. In order to determine the
question, inflation of the bowel by hydrogen gas was used by Dr.
Keen, since, if the gas escaped by the faecal fistula before any gurgling
occurred in the ileo-caecal valve, it would prove that the opening
was in the large intestine; if however the gurgling sound was
heard as the gas passed through the ileo-caecal valve prior to its escape from the fistulous opening, it would be proof that the


opening was in the small intestine. The gas injected into the rectum escaped from the faecal opening before any gurgling at the ileo-caecal valve, and was identified by the flame, and it was clear that its proximal extremity was in the large bowel. Upon incision this was found to be the case, the canal originating in a carcinomatous growth at that point.

It seems clear that Prof. Senn has added to the surgeon's armamentarium a procedure of the greatest diagnostic value. It is a question, however, whether the hydrogen injected might not combine with certain of the gases produced in the gut, and form an explosive compound which might precipitate the death of the patient. A demonstration of the innocuity of the method from this stand point would still further define its value.

Dr. Senn closes his paper with the following propositions:

1. The entire alimentary canal is permeable to rectal insufflation of air or gas.

2. Inflation of the entire alimentary canal from above downwards through a stomach tube seldom succeeds, and should therefore only be resorted to in demonstrating the presence of a perforation or wound of the stomach, and for locating other lesions in the organ or its immediate vicinity.

3. The ileo-caecal valve is rendered incompetent, and permeable by rectal insufflation of air or gas under a pressure varying from one-fourth of a pound to two pounds.

4. Air or gas can be forced through the whole alimentary canal from anus to mouth under a pressure varying from one-third of a pound to two pounds and a half.

5. Rectal insufflation of air or gas, to be both safe and effective, must be done very slowly and without interruptions.

6. The safest and most effective rectal insufflator is a rubber balloon large enough to hold 16 litres of air or gas.

7. Hydrogen gas should be preferred to atmospheric air or other gases for purposes of inflation in all cases where this procedure is indicated.

8. The resisting power of the intestinal wall is nearly the same
throughout the entire length of the canal, and in a normal condition yields to diastaltic force of from eight to twelve pounds of pressure. When rupture takes place it either occurs as a longitudinal laceration of the peritoneum on the convex surface of the bowel, or as multiple ruptured from within outward at the mesenteric attachment. The former result follows rapid, and the latter slow inflation.

9. Hydrogen gas is devoid of toxic properties, non irritating when brought in contact with living tissues, and is rapidly absorbed from the connective tissue spaces and all of the large serous cavities.

10. The escape of air or gas through the ileo-cæcal valve from below upwards is always attended by a blowing or gurgling sound, heard most distinctly over the ileo-cæcal region and by a sudden diminution of pressure.

11. The incompetency of the ileo-cæcal valve is caused by a lateral and longitudinal distention of the cæcum which mechanically separates the margins of the valve.

12. In gunshot or punctured wounds of the gastro-intestinal canal insufflation of hydrogen gas enables the surgeon to demonstrate positively the existence of the visceral injury without incurring the risks and medico-legal responsibilities incident to an exploratory laparotomy.

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