in the urine. The urine in the epileptic patient was at first thought to contain indigo blue, because the chemical differentiation of methylene blue from indigo blue is a matter of some difficulty when the two bodies are only present in very small amounts in dilute solution. The spectrums are practically identical, and reducing agents have the same bleaching effect on both bodies. Both bodies were readily extracted by chloroform. The following tests, which appear most reliable, were carried out by one of us (F. L. G.). The methylene blue of the urine was first separated by shaking with CHCl_3 , evaporated and taken up in water.

Distinguishing Tests.	Methylene Blue.	Indigo Sulphate.	Pills.	Urine.
I. Evaporate aqueous solution to dryness and heat gently	Readily clears and gives a faint greenish sublimate	Characteristic purple sublimate	Same as methylene blue	Faint methylene blue reaction.
II. To solution add solution of KOH	No effect	Colour discharged reappears on adding acid	No effect	? Pink on one occasion.
III. To solution add strong nitric acid	Not altered	Decolourized	Not altered	? Not altered.
IV. Tested for zinc	Found in the commercial variety	Absent	Faint	Faint.

The first and last tests were the most definite. The action of KOH in HNO_3 gave indefinite results with the urinary solution. Possibly the methylene blue had been affected by bacterial changes.

REFERENCES.

- ¹ Kowalewsky, *Centralbl. f. d. med. Wissensch.*, Berlin, 1898, xxxvi.
² F. J. Smith, *Lancet*, London, 1894, i, 89. ³ Emerson, *Clinical Diagnosis*, p. 272, 1906. ⁴ W. M. Ord, *Trans. Path. Soc.*, London, 1878, xxix.
⁵ F. P. Weber, *Lancet*, London, 1901, ii. ⁶ Max Kaufmann, *Zeitschrift f. physiologische Chemie*, 1911, Bd. 71, p. 48.

The Arris and Gale Lectures

ON

THE MECHANISM AND TREATMENT OF SHOCK.

DELIVERED AT THE ROYAL COLLEGE OF SURGEONS,
MARCH 20TH, 1912.

BY

H. TYRRELL GRAY, M.A., M.C.CANTAB.,
F.R.C.S.ENG.,

SURGEON TO OUT-PATIENTS, HOSPITAL FOR SICK CHILDREN, GREAT ORMOND STREET, AND TO THE NORTH-WEST LONDON HOSPITAL, ETC.,

AND

LEONARD PARSONS, M.D.LOND., M.R.C.P.LOND.,
ASSISTANT PHYSICIAN, GENERAL HOSPITAL, BIRMINGHAM, AND TO THE CHILDREN'S HOSPITAL, BIRMINGHAM; ASSISTANT LECTURER IN PATHOLOGY AT THE UNIVERSITY.

(Continued from page 1008.)

LECTURE II.—PART I.

THE ABDOMEN AND GENITO-URINARY SYSTEM.

1. The Abdomen.

The variations in blood pressure associated with surgical interference with the viscera are so varied, and open to such different interpretations, that this branch of our study is quite as complex and difficult as in any region of the body.

In the first place, all manipulations must be carried out carefully, so that pressure on the abdominal wall is eliminated; otherwise false interpretations may result. Pressure on the abdominal wall is well shown, in animals under spinal anaesthesia, to cause a proportionate and mechanical rise of blood pressure, and a prolonged mechanical inspiration from the compression of the viscera against the diaphragm and lower thoracic wall.

Chart 36 also illustrates this phenomenon to some degree. It represents exploration in the region of the appendix in a case of abdominal tubercle in a child of 10 years. A to B represents the blood-pressure variations accompanying the induction of chloroform anaesthesia, the constant depth of which is evidenced by the extreme regularity of the respiratory tracings throughout. The rise c c' d' d occurred during the preparation of the patient and the cleansing of the operation area; some considerable pressure on the abdominal wall results when soap and water are employed for this purpose, and the curve c c' d' d must be attributed to this agency.

Chart 36.— CHCl_3 . Exploration of caecum and appendix.

The curve from e to f represents the incision and separation of muscle; the peritoneum is reached at f. At f the peritoneum was opened under deep anaesthesia, and the separation of tough tuberculous adhesions commenced. These manœuvres are signalized by a marked excursion of the blood pressure lever, but the most startling change is noticed at f'. At this point the finger was introduced deeply, and adhesions in the neighbourhood of the posterior wall of the abdominal cavity were freed, in order to present the caecum and examine the appendix.

It is worthy of note that the most marked rise in pressure (to f'') was induced from manipulations of the posterior peritoneal wall; and that directly these ceased, on presentation of the bowel (f'''), the blood pressure rapidly sank to g, only to rise again in step-ladder fashion on the continuation of similar manipulations nearer the surface. The outstanding features here are: (1) The marked pressor effect induced by a stimulus to the parietal peritoneum; and (2) the similar more pronounced effect from manipulations of the posterior wall of the peritoneal sac. Corresponding to this rise of pressure, the chart shows a definite acceleration of the pulse-rate during the deeper manœuvres within the abdomen, and also on opening the peritoneal sac. The constant depth of anaesthesia accounts for an absence of variation on the respiratory curve. The markedly pressor type of curve obtained in this operation, particularly during the invasion of the posterior wall of the peritoneum, would seem to suggest a low shock value to surgical interference in these regions. This, however, is clinically incorrect,

hence the degree to which such variations are attributable to centripetal impulses, or to other agencies, must be investigated.

Chart 37 represents the closure of a faecal fistula into the upper part of the sigmoid in a child of about 3 years. The child's condition was not good, and the

Chart 37.—Ether. Faecal fistula.

operation was performed under ether anaesthesia administered by the open method. No tracing was obtained in the early stages of the operation. A small rise of pressure, at A,

accompanies the separation of the intestine with scissors from its adhesion to the peritoneum at the site of the fistula. The rest of the operation consisted of the suture of the opening in the intestine in two layers. This manoeuvre was one of considerable difficulty, owing to the depth at which these manipulations had to be carried out. For the gut could not be brought to the surface, and consequently traction on its mesentery and manipulation of the deep peritoneum were entailed. The chart shows that a very considerable disturbance of the blood pressure accompanies this part of the operation; while the conclusion of the intra-abdominal manipulations, after the removal of the gauze packing and the introduction of a drainage tube (B), are followed by a gradual fall of pressure.

It is probable that the wide excursions of the manometer are due to the stimulus of the steps of the operation alone, since, in the first place, there is a complete absence of relationship between the high and low pressure readings and the respirations, in the original tracing; in the second place the cessation of intra-abdominal manipulations is accompanied by a regular fall in blood pressure, which contrasts vividly with the type of chart preceding it. This chart seems to illustrate again the increased disturbance induced by manipulations in the neighbourhood of the posterior peritoneal wall and its mesentery. Charts 36 and 37 represent operations in very similar regions of the abdomen; operations of a different degree of severity it is true, but nevertheless involving only a more violent stimulus to similar structures. It could reasonably be expected, therefore, that Chart 37 would show a more pronounced reproduction of Chart 36; but this is far from being the case. For, whereas in Chart 36 the intra-abdominal manoeuvres induced a marked pressor type of variation, Chart 37 shows a very evident depressor type of curve. It might, therefore, be concluded, on the basis of previous reasoning, that interference in the region of the sigmoid was accompanied by a greater degree of shock than in the right iliac fossa. While it is perfectly true on all grounds, that the operation shown in Chart 37 was accompanied by much more shock than was the case in Chart 36, it does not follow that the shock connected with these two regions differs appreciably. Evidence to the contrary is found in the following:

1. Assuming that shock depends on the nature and extent of the peripheral centripetal impulses, it remains to be shown how far the variations observed are the result of these.

2. No consideration has yet been given to the effect of toxæmia, general health, etc., on the mechanism of the production of shock.

Now, in Chart 36 the child was in excellent condition,

Chart 38.—Acute appendicitis.

better illustrated than in Chart 38, though this operation in itself was short and is not one of a high shock value. Toxaemia may, apparently, produce a condition analogous to, but in reality different from, the second or

depressor stage of shock; and a surgeon performing an operation, undertaken under these conditions, may have to reckon with this very formidable antagonist from the commencement. It must not be supposed, however, that these conditions are the same; for, in shock, we are dealing with pure pressor fatigue; while in toxæmia a somewhat similar effect is produced through the agency of a virulent poison, which also affects the centres themselves. (We shall show that, in their effects, general anaesthetics are to be classed with toxæmias.) In order to investigate the extent to which the variations thus described are attributable to centripetal impulses, it is necessary to study similar operations when all the centripetal impulses (with the exception of the vagus) have been cut off by means of a spinal anaesthetic, administered by the method described elsewhere by one of us. Chart 39 represents appendicectomy in a remarkably

Chart 39.—Spinal anaesthesia. Appendicectomy.

placid child of 11 years, under spinal anaesthesia with dextrin-stovaine (5 c.cm). Evidence of mental disturbance is completely lacking in the original tracing. The constant type of curve accompanying spinal anaesthesia to a high level, independent of the nature of operation, has been studied by us elsewhere. In this case it is evident that the usual fall of blood pressure is interrupted after A, which signalizes the attack on the deep peritoneum. From B to C, while the child was retching, the manipulations were stopped as usual and a pad put over the wound. At C the blood pressure is seen to have fallen to a lower level. Though the operation data are rather inadequate in this case, experience enables us to say that at C the manipulations in the deep peritoneum recommenced, and the child went to sleep. The rising blood pressure, therefore, on recommencing the deep peritoneal manoeuvres, lasts until the removal of the appendix, and then falls a little, only to be again raised on the renewal of traction involved in the ligation of the meso-appendix.

This and similar charts show that, whereas under spinal anaesthesia surgery of the abdominal wall induces no mean rise in the blood pressure curve, a definite rise accompanies intra-abdominal manipulation. Again, this rise seems most marked when the posterior peritoneal wall is interfered with, and when the mesentery is dragged upon. It is least marked with the manipulation of intestine and visceral peritoneum. The increased extent

Chart 42.—Spinal anaesthesia. Appendicectomy.

of this phenomenon, accompanying an increase of the extent and violence of the operation, is illustrated in Chart 42. This represents appendicectomy, with widespread septic peritonitis. In this operation far more

extensive interference with the abdominal contents was necessitated by a prolonged search for several pockets of pus. Interrupted readings only were taken, but the degree of rise in pressure, accompanying the manipulations of the deep peritoneum, is far more definitely marked than in the case we have just shown. In comparing these features, which are traceable in all our charts of operations performed under these conditions, variations are to be expected, due to the rapidity with which thoracic paralysis is initiated, and with the time of commencement of the operation relative to this rapidity. A tracing of an operation for the relief of acute strangulation of the jejunum, in a collapsed child of 2½ years, shows that these phenomena are also evident in operations in the upper part of the abdomen.

The disturbance of the blood-pressure line in operations in the abdomen under spinal anaesthesia is capable of two explanations: (1) That the anaesthetic does not induce a complete block to the centripetal impulses we are considering; (2) that it is due to some local mechanism.

(1) Against this explanation is the fact that no conscious child would quietly submit to such operations unless all centripetal impulses were cut off. Further, the variations observed in the blood-pressure line are unaccompanied by the corresponding alteration in the pulse-rate, which we have before remarked when these variations are due to central afferent impulses. Further evidence as to the completeness of the nerve block will shortly be apparent. In confirmation of the truth of these observations in the case of

localized peritoneal trauma under spinal anaesthesia, we have found that hot saline solution poured into the abdominal cavity under spinal anaesthesia induces a marked rise of blood pressure (in Chart 43 the rise was 32 mm. Hg). The saline solution initiates a far more widespread stimulus than the steps of the operations we have studied, and, assuming the complete block to centripetal impulses in spinal anaesthesia, this rise must be attributed to a local mechanism. It is not due to direct action on the blood vessels, for this should induce vaso-dilatation and a corresponding fall of blood pressure. If hot water (125° F.) be poured into the abdominal cavity of a cat which has been subjected to an overdose of chloroform, it is seen that the blood pressure immediately rises to a marked degree, and that the pulse becomes slower and more forcible at first, later smaller and more rapid. In a shocked dog, where the pressor paths are fatigued and the vasomotor centre appears inactive to pressor stimuli from the periphery, the rise of blood pressure accompanying the introduction of hot saline into the peritoneal cavity is less marked, but it is accompanied by a more marked slowing and increase in force of the heart. The same manoeuvre repeated in a shocked dog, whose semilunar ganglia have been poisoned by painting them with pure nicotine, no rise of blood pressure is observed, but a fall, which is accompanied by acceleration and diminution in size of the cardiac impulse.

That the slowing of the pulse is not due to vagus stimulation is shown by the rise of blood pressure; for we shall produce tracings which show that surgical stimulation of the abdominal vagus is usually followed by a marked fall, and never by a rise, in blood pressure. The explanation appears to be that the hot saline solution stimulates the semilunar ganglia or their efferent fibres, inducing a vaso-constriction of the abdominal vessels.

This local rise of blood pressure increases the work of the heart, slows the rhythm, and increases its force at first. Later, as the immediate local effect of this stimulus wears off, the domination of the centripetal impulses causes stimulation of the vasomotor centre and cardio-acceleration, which we have repeatedly laid stress on. When this central pressor effect is almost eliminated in extreme shock, the slowing of rhythm and increase of force of the cardiac impulse is more pronounced and lasts longer. For, under these conditions, the variations are attributable to a mixture of the local vaso-constriction, with efferent depressor stimuli to the vasomotor centre, such as exist in this stage of shock. In accordance with this, when the pressor effect has been eliminated by shock and the semilunar ganglia have also been thrown out of action by the application of nicotine, these depressor afferent impulses (possibly with local vaso-dilatation) existing alone, lower the blood pressure.

In order to study more fully this local abdominal vasomotor mechanism in abdominal surgery, such operations as are performed in human subjects have been repeated in animals (in whom a greater detail of observation is possible) under precisely analogous conditions. In this connexion, however, we wish to remark that, in all probability, the vasomotor mechanism in the human subject is more highly organized than in quadrupeds, in compensation for the erect position. It is to be expected, therefore, that variations should be less marked and shock induced quicker in animals. As a matter of fact,

this seems to be the case.

(In all operations upon animals one of us operated, while the other anaesthetized and marked the signal on the indicator line. In some places the signals are not always absolutely synchronous with the various manipulations carried out. Too much attention must not be paid to slight inaccuracies of this nature, and

Chart 43.—Spinal anaesthesia. Strangulation of jejunum. Hot saline in abdomen.

discrepancies will, in most instances, be indicated on the tracing or in the text.)

The operation of splenectomy in the dog, under chloroform anaesthesia administered on a towel, is one of a large number demonstrating the accuracy of our observations in the human subject. Thus, the incision of the abdominal wall is followed by a marked rise of pressure, which persists as long as these structures are being manipulated, and falls during the application of the skin clips which fasten the towels to the edges of the wound. Splitting the fascia and muscle fibres of the rectus abdominis again repeat the rise of pressure, which is further increased on opening the peritoneum, and, still further, with traction on this structure and enlargement of the wound. Ligature of the pedicle of the spleen by isolated ligatures, as well as one round the whole structure, involves traction on the mesentery, and this, combined with the manipulations within the abdomen essential to its performance, maintains the blood pressure at fairly high level, while a rapid fall occurs with the release of traction consequent on the completion of the ligatures. At the same time the respiratory trace shows that the attack on the abdominal wall stimulates the respirations, while the manipulation of the viscera gradually inhibits them. The conclusion of the tracing (which is not shown) only repeats in the main the points to which attention has been drawn. One further point, however, was well shown—that is, the cessation of interference with the viscera was accompanied by an increase in the amplitude of respirations to approximately their original level. This inhibition of respirations is well illustrated in all intestinal manipulations on animals,

Trace 16a.—CHCl₃. Puppy shocked by visceral manipulations.

where a respiratory tracing is shown. We shall show shortly tracings which illustrate vagus stimulation in certain manipulations within the abdominal cavity. Many experiments, however, demonstrate that this vagus inhibitory action on respiration is practically absent in the lower abdomen, and increases as the upper region of the abdomen is approached. It is more marked when the mesentery is manipulated than when intestine only is handled, and especially with traction. The higher up the manipulations of the mesentery, the more marked is this phenomenon. Finally, traction on the stomach and oesophagus practically inhibit inspiration completely.

As regards the heart, this vagus action is entirely subordinate to (1) vasomotor influences excited in the centre, as the direct result of the centripetal impulses of the operation; and (2) to the indirect stimulation of the heart by the raised blood pressure, which is the result of the direct stimulus of the operative manoeuvres to the efferent splanchnic system and the resulting vaso-constriction of the mesenteric vessels.

Manipulation of the mesentery, therefore, shows the inhibitory action of the vagus on the heart entirely masked by the sympathetic phenomena.

Trace 16a, however, shows well that the traction on the stomach and the oesophagus alone does not stimulate any (or at least very few) of the splanchnic fibres (*j j'*); this manoeuvre excites an almost pure vagus inhibition both on respirations and heart, so that the blood pressure falls from inhibitory slowing of the cardiac rhythm; firm traction stopping the heart almost completely, as will be seen in a subsequent tracing. In the human subject this respiratory inhibition is particularly well shown in an operation

Chart 44.—Ether. Abdominal manipulations. Respiratory inhibition.

on the abdomen under ether anaesthesia. A tracing was taken from a little girl whose intestines had prolapsed through a recent laparotomy wound. These were returned to the abdomen, and the wound resutured with some difficulty owing to their distended condition. (Chart 44.) The stimulus of the ether is well shown in the respiratory-amplitude, while the commencement of the manipulations raised the blood pressure and markedly inhibited inspiration. As the intestines were reduced, and the suture of the abdominal wall was commenced, the respiratory amplitude began to return, and, at the same time, the blood pressure fell

from the cessation of the stimulus. The pulse-rate increased in rapidity as usual, masking any vagus action on the heart.

In order to investigate the variations in blood pressure contributing towards the final collapse so commonly seen in splanchnic shock, we present tracings 16a and 16b. These represent the indicator line and blood pressure

tracing from a young puppy which was profoundly shocked by various manipulations in the abdomen. Chloroform anaesthesia was administered through a tracheotomy tube in a constant self-regulated quantity by a mechanical pump. The incision of the abdominal wall at *a* is accompanied by the usual rise in blood pressure, which falls from traction on the stomach (*b* to *b'*), and also sinks gradually on compression of the stomach, which was distended. Manipulations in the upper abdomen and firm pressure on the posterior wall of the peritoneum produce a moderate rise of pressure which is maintained some time after the cessation of the stimulus, *c d d'*; the pressure line finally rises to *e* before sinking to *f* in the interval between the manipulations. At *f* the right semilunar ganglion was searched for and stimulated by firm scratching, which manoeuvre was discontinued at *f'*; it will be noticed that the rise *f f'* is immediately followed by a rapid fall when the stimulus ceases; but that the blood pressure subsequently begins to rise again in the interval (soon after *f'*). Traction on the small intestine at *g* (near its commencement) induced a very marked rise in blood pressure, with definite improvement of the heart, and this was followed by a gradual fall to *h*, which is hardly broken by traction on the lower abdominal or pelvic viscera (bladder and rectum). These latter manoeuvres usually induce a well-recognized increase of blood pressure and respiratory stimulation; here, however, the mesenteric vessels are doubtless contracted from the excessive splanchnic stimulus, and are little affected by the additional reflex from the vasomotor centre. At *h*, however, traction on the right kidney pedicle is accompanied by an exact repetition of the phenomenon at *ff'*—that is, the rise *h h'* is followed by the fall (as the traction is released), the latter being immediately superseded by a further marked rise in blood pressure after the cessation of the stimulus. Even at this height a further rise in blood pressure accompanies traction on the transverse mesocolon.

It should be noted that, after all these manoeuvres (as far as *j*), which induce a considerable degree of shock in a small puppy, the blood pressure is not greatly lower than at the commencement; it is even higher than at the beginning of the intestinal manipulations at *c*. At *j* traction on the lesser curvature of the stomach and oesophagus illustrates the vagus cardiac inhibition, with its fall of pressure, mentioned above (*j* to *j'*). It must be remembered that we are concerned with centripetal impulses, as well as local vascular phenomena, in the reading of these tracings, and that up to the present no evidence of any depressor stage of shock has been noticeable.

Continuing with Trace 16b (in the same animal): At *a* the whole mesentery of the small intestine was dragged on and pinched from *a* to *a'*. At *a'* the usual fall in pressure is followed by the very marked rise, which we have already observed in connexion with the stimulation of the semilunar ganglion. A repetition of this manoeuvre at *b b'*, however, is only accompanied by a short rise, and then by a fall, during the traction.

Trace 16b.—Continuation of 16a. Depressor stage.

Stimulation of the semilunar ganglion, by scratching at *c*, repeats the phenomena, already observed, with this exception—that, after *c*, the fall is very much more pronounced (below *c b'*); and, unlike the former instances, the subsequent rise to *c''* does not reach a higher level than *c'*. The gradual fall, as far as *d*, is interrupted to a slight degree by the manipulation of the intestines, and pouring hot saline into the abdominal cavity; while, at *d*, the usual semilunar stimulus is only followed by a very moderate variation of the usual type. Traube-Hering curves are becoming apparent, and it is to be noticed that, whereas each manœuvre reproduces in type the earlier blood pressure variations, the blood pressure reaches a lower level after each stimulus. The vagus inhibitory fall of pressure is well shown at *c c'*. That this period of the tracing represents the depressor stage of shock is evident. Thus, a semilunar stimulus at *f f'*, again hardly induces any rise compared with the earlier ones; but is followed by a fall to a definitely lower point. If *f'* to *g'* be compared with *g* to *h* in the previous tracing, it will be seen that in the latter a cessation of stimulus is followed by a gradual fall after the secondary rise. In the former, *f'* to *g* (16b), no fall is observed; but rather, the blood pressure swings up to an intermediate level in the interval, a feature of the second, or depressor stage of shock. At *g* manipulations of the liver and diaphragm show the same phenomena exhibited by the stomach, that is, domination of vagus inhibition and a fall of blood pressure. While further evidence of the depressor stage of shock is seen when traction on the rectum, which usually induces a pressor type of rise in blood pressure, is accompanied by a small rise and then a fall to a lower level; the blood pressure afterwards swinging back to an intermediate level. The animal was now in a state of profound shock. From these two tracings we learn that, in harmony with the results in the human subject, a pressor rise accompanies the attack on the abdominal wall and parietal peritonæum; manipulation of the intestines being also accompanied by a definite rise in pressure. Manipulation of the gut itself hardly induces any vasomotor disturbance; but traction on the mesentery induces a marked rise in blood pressure, which is more and more accentuated as the stimulus approaches the upper end of the mesentery in the neighbourhood of the semilunar ganglia. The nearer these ganglia traction is applied (especially on the kidney pedicle) the more in degree and type do the variations simulate those exhibited by stimulation of the semilunes themselves; this manœuvre induces a marked rise in blood pressure. Traction on the transverse mesocolon resembles the small intestine in its result; but traction on the stomach and oesophagus, and manipulations of the liver and diaphragm, establish the domination of the vagus phenomenon—namely, a fall in blood pressure from cardiac inhibition.

That these changes in blood pressure are due to the vaso-constriction of the abdominal viscera is shown by a tracing from a dog, of similar manipulations within the abdomen, combined with stimulation of the right semilunar ganglion by scratching. If in such a manœuvre synchronous tracings of the blood pressure, respirations, and oncometer are taken, a definite contraction of the kidney on the left side accompanies a simultaneous rise in blood pressure from the stimulation of the right semilunar ganglion and the mesentery. The contraction of the kidney is relieved immediately the stimulus to the opposite semilunar ganglion ceases. At the same time these manipulations in the upper region of the abdomen inhibit very definitely the excursions of the respiratory lever. It is further noteworthy that the excursion of the blood pressure is accompanied by a definite slowing in rhythm and increase in force of the heart, and that, after the fall, on the cessation of the stimulus, the pressure again rises, and the rapidity of the heart gradually increases, while its force is diminished. In order to confirm the bearing of isolated experiments on a surgical operation, we operated upon a dog under ether anaesthesia to expose the kidney (right) transperitoneally. Blood pressure, respiratory and oncometer tracings (from the left kidney) were taken simultaneously. The ether anaesthesia masks to a considerable degree those changes in blood pressure which we have observed to take place under chloroform. This point has been previously referred to. Before the beginning of the trace the left kidney had been exposed through

a transverse incision from the loin to the abdomen. And the absence of variations in the oncometer trace, accompanying the early steps of the operation in the neighbourhood of this wound, are to be attributed to the previous existence of a Lowén's reflex—that is, the previous manipulations in arranging the oncometer, and interfering with the abdominal wall for this purpose, had induced a reflex vaso-dilatation in this (the left) kidney. Accordingly, as the stimulus of these manoeuvres became less and the experiment was continued, gradual contraction of the kidney to the normal is indicated by a fall in the oncometer trace, until the point when the peritoneum is reached. The first definite active fall in the oncometer trace accompanies the slight temporary rise in blood pressure on dragging the parietal peritoneum. Subsequently, manipulations of the small gut and its mesentery are accompanied by the usual blood pressure variations, and, at the same time, by a steady fall of the kidney volume as far as the point where these manipulations cease. During the introduction of the hand into the abdominal cavity, the blood pressure shows a steady fall while the oncometer trace gradually rises. For the stimulus to the peritoneum is relaxed and the blood pressure falls; while, at the same time, the hand in the abdomen increases the pressure on the mesenteric vessels, and blood is forced into the abdominal viscera, whose volume is increased by passive engorgement. Thus a marked rise in the kidney volume is accompanied by a diminution of the pulse wave in the oncometer tracing, and is not due to arterial dilatation (which would render the pulsations more prominent) but to venous engorgement. This rise in volume is broken simultaneously with the fall in blood pressure by moderate manipulation near the under surface of the liver. Again, traction on the right kidney pedicle illustrates well that the rise in blood pressure is accompanied by marked vaso-constriction of the abdominal viscera, for the opposite (left) kidney volume shows a very precipitate diminution, while at the same time the oncometer pulsations almost vanish. Release of this traction is at once followed by a relaxation of the left renal arteries and an increase in the kidney volume, while the pulsations return rapidly to about their former distinctness.

After this point, the application of crushing clamps to close the abdominal wound showed very marked variations indeed. Thus, as the blood pressure continuously and markedly rises, an enormous contraction of the kidney volume (as evidenced by a rapid fall in the oncometer tracing) shows that this rise in blood pressure is accompanied by a marked contraction of the vessels of the abdominal viscera. This feature is particularly well illustrated as the operation of laparotomy is performed again; and the fact that pressure on the abdomen causes a rise of blood pressure of mechanical origin is illustrated very well by a simultaneous rise in the oncometer tracing with the practical disappearance of the pulse wave. The latter is restored directly pressure on the abdomen is relaxed. The remainder of our tracing showed that a continued rise of blood pressure accompanied the surgery of the abdominal walls, with a simultaneous gradual but marked fall in the kidney volume. We wish to call attention to the fact that here, again, the respirations showed marked variation in accordance with our previous statements. Thus, manipulations within the abdomen were always charac-

terized by a simultaneous inhibition of respiration; while a rise of blood pressure, accompanying manipulations of the abdominal wall, was synchronous with a very marked increase in rate, amplitude, and regularity of the respiratory tracing. Finally, similar tracings under chloroform show that the rise of pressure following manipulations in the upper abdomen, pressure on the posterior peritoneal wall, manipulation and traction of the small intestine, traction on the kidney, and stimulation of the semilunar ganglia, etc., are one and all due to the vaso-constriction of the vessels whose nerve fibres, at some part of their course, lie in the stimulated area.

There are three possible mechanisms by which these variations may be brought about: (1) Deep reflex vaso-constriction in the segment stimulated; (2) centripetal impulses to the vasomotor centre inducing efferent general vaso-constrictor impulses; (3) direct stimulus of the efferent nerves to the visceral vessels. In order to ascertain the degree to which one of these factors is responsible for such variations as has been observed, the first two were eliminated by means of the administration of a spinal anaesthetic (dextrin-stovaine $\frac{2}{3}$ c.cm.) to a dog, paralysis being induced to about the mid-dorsal region. It must be remembered that in order to do this a lamina had to be removed in a chloroformed animal and the injection given

directly under the dura. Some shock naturally accompanies this procedure, but it does not greatly affect the result. We therefore produce part of a tracing taken from this dog under spinal anaesthesia, which compares the blood pressure variations accompanying interference in the lower abdomen and pelvis (lower tracings) with manipulations in the upper abdomen (upper tracings) near the semilunar ganglia (Trace 20). It is clear that manipulations in the former do not break to any extent at all the perfect regularity of the blood

Trace 20.—CHCl₃ and spinal anaesthesia. Dog. Comparison of manipulations in upper and lower abdomen. Two upper tracings and lower indicator line=respirations and blood pressure in upper abdomen. Two lower tracings and upper indicator line=respirations and blood pressure in pelvis (cystectomy).

pressure line. In Lecture I we showed that the vasomotor disturbances accompanying manipulations in other regions than the abdomen were due entirely to centripetal impulses reaching the vasomotor centre. It was shown that these variations were a clear indication of the nature and extent of the centripetal stimuli to the vasomotor centre; and can, therefore, be accepted as an indication of the shock value of these parts. The complete elimination of such variations under spinal anaesthesia in operations on the pelvic viscera (which normally induce a pressor type of curve) shows that these deductions are equally true for this region. In this tracing, contrasted with this regular blood pressure line, we find very definite variations in blood pressure as the upper abdomen is attacked. These variations (accompanied by the usual inhibition of respiration) become more and more marked the nearer the stimulus approaches the semilunar ganglia. Thus, during the opening of the abdomen, an almost unbroken line in blood pressure and respiration is present; while manipulations in the upper abdomen are seen to induce a rise in blood pressure, in spite of the fact that centripetal stimuli are blocked. Traction on the kidney and pressure on the posterior peritoneal wall induce the characteristic rises in pressure respectively which we have noted before under general anaesthesia; even if these are not very accentuated. (It should be noted that, by this time, chloroform anaesthesia had been maintained for a con-

Trace 22.—Semilunar phenomenon after excision of spinal cord in the splanchnic area.

siderable period.) Small rises of pressure accompany traction on the lower end of the large bowel. Manipulation high up in the abdomen induces marked deviations of pressure; while traction on the stomach induces an almost complete inhibition of respiration on each occasion, but only a slight fall in blood pressure (the slight effect on the blood-pressure of dragging on the stomach is probably explained by the marked degree of collapse existing). Manipulations in the region of the semilunar ganglia induce the typical rise and variability in the blood pressure (*q, r*) which has been observed to accompany similar manoeuvres in animals when centripetal paths are not blocked; this shows that these variations in abdominal operations are almost entirely local in origin. Thus not only does each separate manipulation induce its own characteristic rise in pressure, but the high pressure is maintained as long as the stimulus continues.

It might be argued that either the spinal anaesthetic did not produce a complete block to centripetal impulses, or that its effect had worn off when these phenomena were observed. In order to show that neither of these views is correct we repeated the same manoeuvres, after division of the spinal cord above the splanchnic area, in a dog under chloroform anaesthesia. The resulting collapse was to some extent controlled by a subcutaneous infusion of physiological saline. As a result, manipulations in the upper abdomen, similar to those we have already studied, induced the typical "semilunar phenomenon" which has been repeatedly observed and controlled. At the same time a very noticeable feature is that the slowing and improvement of the pulse, before noted as being an accompaniment of this semilunar phenomenon, was infinitely better marked. Indeed, at the end of these manipulations, the action of the heart very markedly improved. It is possible that these variations might be attributable to a reflex vaso-constriction through the segments of the cord below the level of transection. In order to exclude this, the same manipulations were repeated after excision of the cord over the splanchnic area. (Shock was so profound at this time that no chloroform was necessary for the remainder of the experiment—unconsciousness being complete.) Trace 22 shows the results on these phenomena of excision of this part of the cord. In the first place attention is called to the condition of the blood pressure and the pulse at the commencement, as showing that the animal was nearly dead. Stimulation of the semilunar ganglion (right) is, in each instance, followed by the usual phenomenon in an extraordinarily marked degree. If this tracing be compared with similar manoeuvres in Traces 16a and 16b (where the centripetal depressor impulses are not blocked) the extraordinary improvement in blood pressure and cardiac action are only attributable to the combination of the local splanchnic stimulus with the elimination of central depression. We took a further tracing on this same animal to show that manipulations of the mesentery immediately below the semilunar ganglia induced the same effects to an even more marked degree. (After paralysing the semilunar ganglia with nicotine, this "semilunar phenomenon" is practically absent.) When the animal was practically dead, and the heart had ceased to beat, the semilunar phenomenon could be reproduced and the cardiac action definitely improved. In a shocked animal (where ordinary centripetal impulses from the shocked area do not materially affect the blood pressure), if the semilunars be paralysed with nicotine, ordinary manoeuvres are accompanied by a blood pressure line almost as steady as with a spinal

anaesthetic. Dragging on the stomach, however, induces a slight fall of blood pressure and complete stoppage of the heart. The contrast between this phenomenon and the results of similar manoeuvres in Trace 16a shows that, in the latter, the mechanism was the double one referred to; and that, in this case, elimination of the sympathetic permits an unmixed vagus inhibition. In the human subject this vagal inhibition is particularly well illustrated during enucleation of the tonsils by the method of Mr. G. E. Waugh. We can produce a tracing to show that the blood pressure falls, the pulse rate is under half, and respiration is inhibited. (The chart of this case was shown in Lecture I, end of Chart 24.)

The following conclusions may be drawn. Vasomotor variations in abdominal surgery are due to:

1. *Local vascular changes*, from the direct stimulus to those nerve fibres proceeding from the semilunar ganglia to the arteries of the intestine and mesentery. We shall show that fatigue of these may occur experimentally, but does not, in all probability, occur surgically. This may be termed "local visceral shock."

2. Blood pressure variations due to centripetal impulses are symptomatic of central or "systemic shock."

Local Visceral Shock.—The degree of vasomotor disturbance of local origin depends on mechanical causes, relative to the number of efferent fibres stimulated and the degree of their stimulation, in accordance with Diagram 2. (See Lecture II, Part II.)

From these observations we may deduce that the fall of blood pressure due to prolonged operations in the abdomen are due to afferent pressor fatigue and the domination of active central depressor impulses—that is, *second stage of shock*.

But that this fall is actively broken by the local splanchnic stimulation referred to, in accordance with the diagram, we have shown. The beneficial effect of blocking these centripetal depressor impulses (such as we have shown in spinal anaesthesia, transection, and excision of the cord) cannot be overestimated. Further, according to the duration and extent of dragging or manipulation of mesentery and peritoneum, will depend not only the degree of local vaso-constriction, but also the degree of centripetal stimulus initiated, from the varying number of nerve fibres (afferent and efferent) excited.

The shock value of the intestines and mesentery cannot be estimated at all by blood-pressure readings, which may be absolutely useless and fallacious in estimating the degree of shock. A combined detailed study of all these tracings demonstrates that, as regards centripetal impulses, the shock value of the intestines is a very high one, the blood pressure completely masking these facts. Concurrently with the effect of splanchnic stimulation on the blood vessels we find inhibition of the intestinal wall. Thus, experimentally, the intestines become distended as the manipulations increase. Similarly intestinal inhibition has been noted by Meltzer, and observed by all surgeons, during the incision of the abdominal wall in cases of intestinal obstruction. Meltzer aptly illustrates this inhibition on opening the abdomen by comparison with the inhibition of conversation induced by the opening of the door and the introduction of a stranger into a crowded room.

Finally, in operations on the stomach and under the diaphragm the splanchnic system hardly plays any part. Vagus inhibition here predominates both in respect to the heart and blood pressure, and also to the respiration. This vagus inhibition in these operations has a distinct bearing both on technique and on choice of anaesthetics, etc.

The condition of the arteries in shock requires a word. To state that these are either contracted or dilated is incorrect, for either statement needs qualification. In the pressor stage of shock they are contracted; in the depressor stage (when the stimulus is relaxed) they are neither contracted nor actively, nor passively, dilated. They preserve their normal tone independent of central control, unless in the last stages of experimental local visceral shock. In this case only the abdominal vessels are directly fatigued, so that a splanchnic stimulus reverses the phenomena we have noted; but we would point out that this condition does not obtain in surgery, with the possible exception of the kidney.

Memoranda:

MEDICAL, SURGICAL, OBSTETRICAL.

MELAENA NEONATORUM.

I NOTE in the JOURNAL of February 17th a case of malaena neonatorum, reported by Mr. James Dunlop, M.B., of Shettleston, N.B.

In March, 1911, I attended a primipara, a young healthy woman, who under chloroform was delivered with forceps of a female child. On the evening of the second day I was hastily summoned by the nurse. The baby had passed per rectum three large clots, followed by a large quantity of bright blood. This continued with varying severity several times daily for three days. The infant was extremely blanched, and it was difficult to keep it warm. On the fifth day the motions became normal and recovery took place. I gave mild astringents and small doses of liq. opii sed.

I could find no reports of similar cases, and during thirty years' general practice at home and abroad had never seen a similar condition.

W. MORRISON, M.A., M.D.,
Senior Honorary Physician, Ballarat Hospital,
Australia.

THREADWORMS IN THE VERMIFORM APPENDIX. WITH regard to threadworms and other *vermes* in the vermiform appendix, it may interest Drs. Claude Wilson and Hamilton to know that recently I found a very fine specimen of *Trichocephalus dispar*—the whipworm—in the appendix of an adult male, but no ova were detected. There was no very clear history of acute attacks, but the patient was subject to much dyspepsia and distinct tenderness in the region of the appendix, which was very long and tightly kinked, and bound down.

WALLINGTON. WALTER GRIPPER, M.A., M.B. Cantab.

ABDOMINAL ANGINA.

THE interesting description of this condition given in the joint paper contributed to the Royal Society of Medicine by Sir Lauder Brunton and Dr. W. E. Williams is very similar to that which applies to a case I have had under observation for the last two years. The patient, a man of 80, who is wonderfully active for his age, has for two years been subject at intervals of some months to severe attacks of pain situated in the umbilical region, on each occasion coming on after extra exertion, such as taking a longer walk than usual. During the first attack the pain was of a very severe character, and when I arrived at the patient's home he appeared to be in *extremis*, his body being covered with perspiration and his whole appearance such as to suggest that he had not many minutes to live. On examination, however, it was found that the pulse was not appreciably affected, and after the administration of morphine the pain subsided. This attack I at first considered to be due to indigestion brought on by over-exertion soon after a heavy meal, but subsequent attacks led me to suspect that the pain was very similar to that of angina pectoris, and suggested the treatment by nitrites, which has proved successful in giving relief. During the attacks there is a desire to defaecate, but no expulsion of faecal matter. I may add that there is evidence of arterial degeneration, but not more than advanced age would account for, and the urine is normal. There is no history of gout or plumbism.

Selby,

ARTHUR SOMERS, M.B. B.Ch.

Reports

ON

MEDICAL AND SURGICAL PRACTICE IN THE HOSPITALS AND ASYLUMS OF THE BRITISH EMPIRE.

BRISTOL ROYAL INFIRMARY.

A CASE OF TRAUMATIC PNEUMOTHORAX.

(By RICHARD C. CLARKE, M.B., Ch.B. Bristol, M.R.C.S., L.R.C.P., House-Surgeon.)

DORIS M., a well-nourished child of 2, was brought into the casualty room at 3 p.m. on February 24th, 1912. The child had been playing in the road, and was run over by a baker's cart. She was brought straight up, and I saw her some ten minutes after the accident.

She was then very blue in the face, and was suffering from marked dyspnoea. Respirations about 80. On examination of the chest, except for marked retraction with inspiration, nothing abnormal was seen, neither did palpation reveal any evidence of fractured ribs. The apex beat of the heart was in the fifth space in the mid-axillary line. The chest was resonant all over, but the breath sounds differed considerably on the two sides. On the left side they were loud and harsh; on the right side, though by no means inaudible, the sounds were not half so loud. I failed to get the bell sound.

During the examination the child was becoming more and more dyspnoeic, so I sent for an exploring needle, and fitting a rubber tube on to it I pushed it into the chest on the right side in about the fifth space in the anterior axillary line. The end of the rubber tube was placed in a bowl of water. There was a continuous gush of air lasting about five minutes, with quite a miraculous effect on the condition of the child. The colour immediately became good and the respirations dropped to 50. The apex beat at the same time came back to the nipple line. When the continuous stream of air from the tube had stopped, with each expiration there was a gush with no intake of water from the tube at inspiration. After watching this for about half an hour I squeezed the rubber tube. This had the effect of causing dyspnoea with migration of the apex beat towards the axilla. On letting go, the rush of air was continuous and at high pressure. I then substituted for the exploring needle an ordinary intravenous cannula, on account of its larger calibre and blunt end, and the child was admitted under the care of Mr. Walters.

During the afternoon and evening some 2 oz. of blood was blown out of the tube and the child suffered considerably from shock. The respirations remained at 50. On the next day there was still a large amount of air coming out of the tube with each expiration, so it was decided to leave the tube in. The condition of the child had improved considerably.

On the next evening, as there was very little air coming out, the tube was removed. This was exactly fifty hours after the accident. The child seemed distressed at first but soon settled down. There was now some bronchitis on the left side with distant breath sounds on the right side.

From this time the recovery was uninterrupted and, when the child left the hospital three weeks after, there were no abnormal physical signs in the chest. I have lately seen her, and she is now quite healthy and getting stronger every day.

The point of interest in this case is the large amount of air which leaked out of the lung at each inspiration. This, I think, shows that the tear was most probably in one of the larger bronchi, as there was so little haemorrhage. Had the tear been in the substance of the lung, it would have to be so large to let out so much air, that death would have been caused by haemorrhage. Another point of interest is the extraordinary immediate improvement after letting the imprisoned air out of the chest.

I am indebted to Mr. Walters, assistant surgeon to the infirmary, for permission to publish this case.