Return showing Number and Value of Splints Made in Orthopaedic Workshops.

Week ending—			£	s.	d.
October 28th, 1916	...	36	...	5	3 0
November 4th	...	49	...	7	14 6
" 11th	...	75	...	17	3 9
" 18th	...	64	...	9	11 6
" 25th	...	86	...	12	9 0
December 2nd	...	21	...	11	2 6
" 9th	...	23	...	13	16 0
" 16th	...	67	...	14	18 0
" 23rd	...	26	...	14	11 6
" 30th	...	29	...	8	19 0
January 6th, 1917	...	43	...	12	8 0
" 13th	...	70	...	20	12 0
" 20th	...	55	...	19	1 0
" 27th	...	133	...	34	0 0
February 3rd	...	122	...	27	9 0
" 10th	...	91	...	30	0 0
" 17th	...	55	...	19	17 6
" 24th	...	81	...	17	16 6
March 3rd	...	106	...	31	4 6
" 10th	...	139	...	34	4 2
Totals	...	1,371	...	£362	1 5

Total number of splints made from October 28th to March 10th, 1917.

Cash value at pre-war prices, £362 ls. 5d.

Of the above returns 1,013 are stock pattern splints, namely, cock-up splints, gutters, club-foot shoes, crab (long and short), Turner's arm, whole hand-splints. The balance (358) are special splints designed in workshops, and made to surgeons' instructions.

Quantity of Orthopaedic Repairs by the Bootmaker.

The total number of cases requiring orthopaedic repairs by the bootmaker from October 21st, 1916, to March 4th, 1917, was 361. This was apart from ordinary repairs. The work consisted of inside and outside elevations, T-straps, cork soles, bars on soles, crooked heels, surgical boots and alterations according to medical orders.

Painting, Drawing, Photographic Department.

This department is under the control of Mr. Bird, the distinguished artist, who is assisted in photography by Mr. Lewis. Here not only photographs and drawings of cases during the various stages of treatment and splints used are made, but actual paintings in natural colour whenever the surgeon thinks it necessary. In this way can be kept complete records of operation cases, which are especially valuable in demonstration for teaching purposes.

X Rays.

This department is fully equipped with all the latest methods for x-ray photography under the supervision of Captain Keys-Wells, R.A.M.C., who attends the hospital daily.

Plaster Department.

This is under the charge of Sister Hurch, formerly of St. Bartholomew's Hospital, who has, as chief assistant, Private Wilde. Casts are made of all deformities admitted and permanent records can be kept of cases before and after operation. In addition to plaster jackets for support and plaster splints, casts are made of limbs and other parts on which splints, both leather and steel, are moulded so as to ensure accurate fitting when finished.

Artificial Limbs.

In association with the question of military orthopaedics it is important to remember that at Roehampton Hospital for Limbless Soldiers all cases of amputation are being provided with suitable artificial limbs at the expense of the State.

I am largely indebted for information relating to the Shepherd's Bush Hospital to the courtesy and assistance of Major Jenkins, R.A.M.C., Officer in Charge, Captain Hill, R.A.M.C., Registrar, and Mr. Poate, Director of Workshops.

The medical staff is to be congratulated in having converted within a week what was formerly an infirmary into a modern orthopaedic hospital.

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Observations

ON

THE PATHOLOGY OF CARDIAC DROPSY.

BEING THE OLIVER-SHARPEY LECTURES DELIVERED
BEFORE THE ROYAL COLLEGE OF PHYSICIANS
OF LONDON, MAY, 1917.

BY

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(Abridged.)

LECTURE II.

We have now to consider the question of the abnormal exchange of fluid between the blood capillaries and the tissue spaces, which leads to an excess of tissue fluid in the congested area, to a deficiency in other parts, and to an increase in the total blood volume.

Absorption in Area of Superior Vena Cava.

It has been shown that when the inferior vena cava is obstructed the venous pressure in the fore part of the body falls, owing to abstraction of blood from this region, and also that at all stages of the disease this pressure is still below normal. The circulatory conditions in this part are, therefore, such as to determine a continuous absorption of fluid by the capillaries from the tissue spaces. It is not to be supposed that absorption is the only process occurring in this region, but that a new balance has been struck between lymph production and absorption. Exactly how this condition is brought about is not known, except that the low capillary pressure is a factor in the process of absorption.

Starling was the first observer to show that proteins are able to exert a definite though small osmotic pressure. In the case of the proteins of the blood plasma he found this pressure to be about 30 mm. Hg as compared with isotonic salt solution. The protein concentration of the extravascular fluid is a quarter or a third of that of the blood plasma, so that the latter is able to exert a definite osmotic attraction for the extravascular fluid. The force of this attraction, as I have already mentioned, is about equal to the hydrostatic pressure in the capillaries, so that when the latter falls below the normal level water will be absorbed.

Absorption in Area of Inferior Vena Cava.

Turning now to the consideration of the exchange of fluid in the area drained by the inferior vena cava our task is not so simple. I have so far assumed that increased absorption is occurring at the periphery as in the fore part of the body.

This question of absorption at the periphery can be examined experimentally, because the parietal peritoneum, which is included in this region, is particularly suitable for such experiments.

With regard to the visceral peritoneum, it is quite clear that output has overbalanced absorption, so that in order to find out what is happening in the case of the parietal peritoneum, we must inquire into the relative parts played by these two processes in the peritoneum generally during the various stages at which the fluid is accumulating, remaining stationary, or disappearing.

Output into Peritoneal Cavity.

Our inquiry into the subject must first be directed to the relative rates of output of fluid into the peritoneum at the different periods of the disease. I shall show later that absorption from the peritoneum is occurring always at the same rate, so that a comparison of the rates at which the ascites reaccumulates after the abdomen has been thoroughly emptied should give us the required information. For this purpose the animal was anaesthetized and the abdomen opened under aseptic precautions. The fluid was then removed with a graduated pipette and the abdomen closed. I found that, however large or small the amount of fluid removed, and whatever the stage of the disease, the ascitic fluid had reaccumulated on the next day.

It may be stated generally that the rate of output is rapid from the beginning, that it increases to some extent as the blood increases in volume, and that it diminishes gradually as the dropsy disappears, although the blood volume is still high. In all stages of the disease, therefore, the dropsy is being actively produced, and it is not a question of the production up to a certain point, and then the gradual absorption of the accumulated fluid after the production has ceased. Absorption is constantly occurring at a certain definite rate, and the accumulation and disappearance of the fluid are entirely due to alterations in the rate of output of lymph. As the anastomoses are established this rate of output falls, and the ascites, therefore, disappears. The ascites is not a stagnant pool of fluid, which is rapidly put out and then slowly absorbed, but at all stages of the disease there is a rapid and continuous circulation of lymph from the blood into the peritoneum and thence back into the blood. The ascitic fluid is thus being constantly changed.

Absorption from Peritoneal Cavity.

We now turn to the question of absorption from the peritoneal cavity, and at the outset it appears self-evident that this process must be occurring at the normal rate at least; otherwise, judging by the amount of fluid which is put out during the day, the animal would soon become tightly distended with ascitic fluid. If the mechanisms whereby absorption is carried out are normal, it is clear that a check would be placed to such a rapid accumulation of fluid, because in the normal animal it is well known that blood serum and other protein solutions are readily absorbed.

In order to test the rate of absorption of a normal cat for the ascitic fluid of another cat I did three experiments, and found that the normal cat absorbs at the rate of at least 2 c.cm. per hour, so that in twenty-four hours it would take up from 40 to 50 c.cm. A further point to note is that the amount of solid matter in the residual fluid was precisely the same as that in the ascitic fluid introduced. Absorption occurs at a uniform rate, and the fluid is absorbed as a whole.

The points which have now to be determined are whether the absorptive mechanisms of the ascitic cat are in a normal condition, and whether they are as capable of fulfilling their functions as are those of a normal animal.

The normal animal absorbs fluid from its peritoneal cavity in two ways:

1. By its subperitoneal lymphatic plexus and thoracic duct, and
2. By its subperitoneal blood capillaries.

We have, therefore, to inquire into the condition of the lymph flow from the thoracic duct of the ascitic animal, and whether the blood vessels of its peritoneum are capable of absorbing fluid at the same rate as those of the normal animal.

I. Lymph Flow from the Thoracic Duct.

The effect upon the lymph flow of complete obstruction of the inferior vena cava above the diaphragm is well known. Experimenting on the dog, Heidenhain showed that the lymph flow is immediately increased. This increase may be moderate but sometimes it is enormous—ten to twenty fold. The total solids in the lymph are increased by 1 or 2 per cent. Ligature of the portal vein gives rise to a more moderate increase in the lymph flow, the increase being about five fold. The total solids in the lymph in this case are diminished by about 1 per cent. Starling has proved that the lymph after obstruction of the inferior vena cava comes entirely from the liver, that its increased quantity is due to the very high pressure of blood in the liver capillaries, and that its increased concentration is due to the great permeability of the walls of the liver capillaries as compared with those in other parts of the body. I have repeated these experiments on the cat and have obtained similar results. I have not, however, found such great increases of lymph flow as occur in the case of the dog. The increases which I have noted after ligature of the inferior vena cava have been much smaller, not more than two or three times the normal, and commonly less than this. In all, however small the increase in quantity, the total solids of the lymph were increased by about 1 or 2 per cent.

When the vein is partially obstructed above the

diaphragm, there is no immediate effect upon the lymph flow. The animals with ascites may be divided into two groups with respect to their lymph flow: The first group includes those during the first few days after the vein is constricted in which the venous pressures are normal or moderately raised, and in which the blood volume is normal or not materially increased; in this group the lymph flow is within normal limits. The second group includes all those at a later date in which the venous pressures are high, and in which the blood volume is increased; in this group the lymph flow is always increased. In both groups the rate of lymph flow does not depend upon the amount of ascites present.

Cause of Increased Lymph Flow.

We see, therefore, that when the disease is fully established there is a considerable increase in the lymph flow from the thoracic duct, and we have now to inquire whether this excessive flow is indicative of increased rate of absorption from the peritoneal cavity, or whether it is due to increased rate of lymph production.

If the increased flow of lymph were indicative of increased rate of absorption from the peritoneal cavity, the rate of flow should correspond with the amount of ascitic fluid present, because there is no other reason than the accumulation of peritoneal fluid which would give rise to the increased lymph flow. But I have shown that, although the thoracic duct is capable of carrying away fluid much more rapidly than normal, the lymph flow is not increased during the first few days when large amounts of ascitic fluid accumulate. Also, in the later stages the flow may be greatly exaggerated, although there are only small amounts of ascitic fluid present. It is quite true that the lymph flow increases at the period when there is an increase in the ascites, but that the two conditions depend upon some common factor and not the one upon the other is apparent from the comparative study of individual cases.

That injections of fluid into the peritoneum do not give rise to an increase in the lymph flow was shown first by Orlov, and later by other observers. Saline solutions are absorbed readily, but during the process there is no increase in the lymph flow. In the human being, however, the pressure of ascitic fluid not uncommonly reaches a considerable height. An abdominal pressure of 100 mm. Na_2SO_4 solution was recorded by Starling and myself in a case of ascites in a dog with heart failure. The abdomen contained 2,310 c.cm. of ascitic fluid and the lymph flow was greatly increased. During the first ten minutes 30 c.cm. of lymph (about ten times the normal) were obtained and when the flow settled down to a steady rate it remained about five or six times above the normal. After tapping the abdomen and emptying the cavity the lymph flow still remained at its high level, showing that the rapid flow was not due to draining away of the peritoneal fluid, but still it might have been due to drainage of distended lymph spaces. In order to determine whether fluid at high pressure was rapidly carried off by the thoracic duct from the peritoneal cavity I performed two experiments, which gave identical results, and showed that there was no increase in the lymph flow, although fairly large amounts of fluid were absorbed.

A distinction must be drawn between absorption by the lymphatics from the peritoneal cavity and from the tissue spaces. The peritoneal cavity is enclosed by a definite membrane, and is in intimate relation with a subperitoneal plexus of lymphatics, but there is probably no direct communication between them. It is regarded at the present time that the endothelial cells of the peritoneal membrane are everywhere in close contact with each other, and that there are no permanent openings between them. Fluids and solid particles, however, pass with ease through the interstices between the cells. The force causing the movement of such fluids and particles into the subperitoneal lymphatics from the abdominal cavity is derived from the movements of respiration, and more particularly of the diaphragm, owing to the arrangement of its lymphatics. Solid particles are no doubt chiefly carried through by leucocytes. The composition of the fluid on each side of the peritoneal membrane is practically the same, so that there is no force tending to osmosis or diffusion. Absorption from the peritoneum is thus a relatively slow process, and it is possible that if the respiratory movements are interfered with by an excessive accumulation of fluid the

process of absorption by the lymphatics will be correspondingly slow. The mere accumulation of fluid in the abdominal cavity would not, therefore, increase the outflow of fluid from it. A rapid output of lymph from the capillaries would, on the other hand, distend the lymph spaces, and materially raise the pressure in them, thus increasing the outflow of lymph. This is particularly true of the lymph spaces of an organ such as the liver, which is enclosed in a capsule, so that any increase of lymph production in it more easily raises the pressure in its lymph spaces, and increases the flow of lymph from its lymphatics. So long as the tissue fluid remains inside the abdominal organs it is absorbed comparatively quickly by the lymphatics, but when it drains out into the peritoneum it is lost to the lymphatics, and a certain time must elapse before it can be absorbed in the usual manner. The increased lymph flow of the ascitic animal is therefore not indicative of increased rate of absorption from the peritoneal cavity, but such absorption by the lymphatics takes place at the same rate at all stages of the disease, and also at the same rate as in the normal animal. There is no increase in the rapidity with which fluid is drained off during the period of subsidence of the ascites from the peritoneum or from the lymph spaces, which might be supposed to have been overfilled.

If the increased lymph flow of the ascitic animal is not dependent upon increased rate of absorption of the ascitic fluid, it must be an index of *increased lymph production*.

We have already seen that, at the period at which the lymph flow becomes increased, the ascites attains its maximum height both in quantity and rate of production. The latter depends upon the rate of production of lymph, so that the increased lymph flow coincides with increased lymph production. At this time, also, a general plethora is established, the pressures in the portal vein and inferior vena cava rise and the liver swells to an increased extent. It was first shown by W. Müller, and is now universally recognized, that in artificial plethora there is increased lymph production and increased lymph flow from the thoracic duct. This increased lymph production takes place chiefly in the abdominal organs, which are thus responsible for the increase in the flow of lymph. There is therefore no doubt that the increased lymph flow and the increase in the ascites are directly dependent upon the plethora, and that the lymph comes from the abdominal organs, particularly the liver.

The question which now requires an answer is why there is no increase in the lymph flow from the liver in incomplete obstruction of the inferior vena cava until the condition of plethora is established, whilst there is a considerable output of fluid into the peritoneum, giving rise to ascites. The explanation appears to lie in the different degrees of tension in the distended liver. The flow of lymph is constant from the lymphatic radicles to the thoracic duct and thence into the veins. There must, therefore, be a gradual rise of pressure as we follow the lymph stream up into the liver. The higher the pressure in the lymphatics of the liver the more rapid must be the flow of lymph. In the early stages of narrowing of the inferior vena cava the liver distends owing to the rise of venous pressure behind the obstruction, but we have seen that this rise, although enough to dilate the vessels of the liver and fill out that organ with blood, is really only trifling. The vessel walls are altered and lose their tone, so as to remain dilated under a pressure which is normal or only slightly raised. The lymph production is increased owing to nutritive changes in the capillary walls, but the pressure in the lymphatics does not rise high enough to materially increase the lymph flow from the thoracic duct. The nutrition of all the tissues of the liver suffer, and lymph drains out through the capsule into the peritoneum. When plethora is established the venous pressures rise to a high level, the liver enclosed in its capsule distends further, and the tension within it becomes considerable. There is a further increase in the lymph production, and the lymph finds an easier exit through the lymphatics than through the capsule. The condition now has become somewhat similar in many features to that immediately resulting from complete obstruction of the inferior vena cava, in which there occurs a rapid rise of pressure in the liver, a great increase in the lymph flow, and slight ascites. Ascites will accumulate without any material rise of pressure in the liver, but the rate of the lymph flow is directly dependent on the pressure in that organ. In the

case of complete obstruction the percentage of total solids in the lymph is increased, this being due to the fact that the lymph is entirely derived from the liver. In the ascitic animal there is no increase in the solids of the lymph although the flow is increased. This is what might be expected if the increased lymph flow resulted from plethora, because in this condition the lymph comes not only from the liver but also from the intestine, the lymph of which is of less protein concentration than normal lymph. The lymph is of no greater concentration than the normal because it is a mixture of intestinal and liver lymph. Before plethora is established, and when the lymph flow is normal, the percentage of total solids is also within the normal limits.

II. Absorption by the Subperitoneal Blood Capillaries.

For reasons which I have already stated, I assumed that increased absorption was taking place by the capillaries at the periphery of the body, and we have now to inquire whether this assumption is justified by experiment. The blood from the capillaries of the parietal peritoneum passes into the veins of the abdominal wall, so that these capillaries form part of the system of vessels which are situated at the periphery. If, therefore, it can be proved that an increased absorption is taking place from the peritoneum directly into the blood, we shall be justified in concluding that our assumption is correct, because it is obvious that the visceral peritoneum, which is putting out lymph at such a rapid rate, cannot be held responsible for increased absorption.

For many years it had been known to physiologists that the blood vessels were able to absorb fluids and dissolved substances, but due prominence was not given to this method of absorption until it was definitely proved by Starling and Tubby that absorption of colouring matters in solution from the serous cavities took place rapidly by the blood vessels. They found that the residue of the solution, which they had introduced into the serous cavity, on withdrawal contained protein, and concluded that the process at work was really one of interchange between the fluid in the cavity and the blood, each taking from the other that constituent which it did not possess.

Later researches by Leathes and Starling showed that this absorption was due to osmosis, and that there was no question of any active absorption by the endothelium because there was no material difference in the process when the endothelium was injured by sodium fluoride or by scalding. They proved that not only was water absorbed by osmosis, but also sodium chloride by diffusion.

Osmosis and diffusion will thus account for the absorption of saline solutions by the blood vessels up to a certain point—namely, that at which there is equalization of the amounts of the various salts on each side of the membrane when osmotic equilibrium is established. The osmotic pressure of the blood proteins, as Starling has pointed out, must also be taken into account, the force of attraction of which for extravascular fluid varies inversely as the concentration in protein of the latter. One would therefore expect absorption of fluid by the blood vessels to still continue until increasing protein concentration of the peritoneal saline solution reduced the absorbing force due to the difference of osmotic pressures on each side of the membrane to the level of the hydrostatic pressure in the capillaries. Further than this osmosis and diffusion will not account for the absorption of ascitic fluid by the capillaries.

Normal Cat.

Our first task is, therefore, to find out whether the ascitic animal is capable of absorbing salt solution by its subperitoneal blood capillaries, and, if so, what is the rate of this absorption as compared with the normal. In order to do this I have employed Starling's method of injecting a coloured solution into the peritoneum, and first, in order to obtain a standard of the normal rate of absorption in the cat, I repeated the experiments on the normal animal. As the urine is not uncommonly suppressed in these experiments, instead of noting the colour of this fluid as an index of the colour of the blood, small amounts of blood were withdrawn from the femoral artery at short intervals.

Three experiments were done, with the same results in each case. The blood serum was distinctly tinged blue in about six minutes after introducing the fluid into the peritoneum, and in a few minutes later it was fairly dark blue.

The lymph was tinged in from fifteen to twenty minutes, and was fairly dark blue in thirty to forty minutes. The urine was also coloured blue when it was excreted. In no case was the lymph flow increased, and it was never darker than the corresponding sample of blood.

These experiments are in entire agreement with those of Starling, and show that coloured saline solution is absorbed rapidly from the peritoneum of the cat by the blood vessels, being distinctly visible in the blood in about six minutes, and in the lymph in about fifteen to twenty minutes.

Ascitic Cat.

We now turn to a consideration of absorption by the blood vessels of the ascitic animal. I have done two experiments: the first animal had had its inferior vena cava narrowed twenty-four hours, and the second one twenty-seven days, previously. The experiments were conducted exactly as described above. In the case of the first cat the lymph flow, as is usual with animals on the day after operation, was normal. In four minutes after the indigo solution had been introduced the blood showed a distinct tint of blue which rapidly darkened, but the lymph was not stained until about sixteen minutes had elapsed after the first tint appeared in the blood. The second cat, which had been operated upon twenty-seven days previously, was well nourished and healthy. The lymph flow of this cat was increased, as is usual with animals at the end of a month when the blood volume is increased. The blood was tinged blue in four minutes, and the lymph in ten minutes, after the coloured fluid was introduced. The colours of the blood and lymph increased in intensity, the blood at first being the darker of the two.

It is quite evident from these two experiments that the ascitic animal is quite as capable of absorbing coloured saline solution by its subperitoneal capillaries as the normal animal, and that the absorption occurs more rapidly, because the blood was tinged in a shorter time in the ascitic than in the normal animal. The rate of osmosis is therefore greater than in the normal animal, and from this we are justified in drawing the conclusion that the capillaries of the abdominal wall are absorbing fluid from the tissue spaces more rapidly than normal. The same conclusion must be formed in regard to the hind limbs, so that in the whole periphery of the body increased absorption is taking place.

One further fact is noticeable. The lymph of the second animal was coloured in about half the normal time. This is due to the more rapid lymph flow of the animal. It is an additional fact in support of my statement earlier on that the increased lymph flow of the ascitic cat is an index of increased lymph production.

It will be remembered that a portion of the parietal peritoneum is drained by veins opening into the superior vena cava. It might, therefore, be objected to these experiments that the osmotic absorption of fluid really occurred into these vessels and not into those opening into the inferior vena cava, so that the experiments did not prove absorption by branches of that vessel. This question can easily be set at rest by ligaturing the superior vena cava before the coloured fluid is run into the peritoneal cavity, so that there can be no doubt that the fluid is absorbed by branches of the inferior vena cava. I therefore performed two experiments of this nature. In the first cat the inferior vena cava had been constricted three days. A cannula was connected with the thoracic duct, and the superior vena cava ligatured between the entrance of the azygos vein and the auricle. The lymph flow was normal. In two minutes the blood serum was tinged blue and in four minutes from the beginning its colour was markedly blue. The lymph was not tinged till twenty-one minutes after the fluid was introduced. The second cat was also a three days cat. The same procedure was adopted. The lymph flow of this animal was a little above the average. In two minutes the blood serum was tinged blue as in the first cat. The lymph was tinged in ten minutes.

These two experiments prove that the osmotic absorption of fluid occurs into the blood vessels of the parietal peritoneum when all anastomoses are cut off. It will be noticed that absorption occurs in a third of the normal time when the superior vena cava is ligatured. I have already shown that when this vein is ligatured there is a great rise of pressure in all its tributaries from the accumulation of blood in them, and that simultaneously the

pressure in all the tributaries of the inferior vena cava falls owing to abstraction of blood. This is the reason of the increased rate of absorption of the fluid. Ligature of the superior cava relieves the abdominal vessels of some of their blood, with the result that they take in fluid more rapidly. It is thus clear that, when both superior and inferior venae cavae are obstructed together, increased absorption takes place in the extremities and in the body wall, whilst increased output is occurring in the central parts of the body. This must also take place in uncompensated heart disease, which I have shown to be precisely similar in its results to the simultaneous obstruction of the superior and inferior venae cavae.

So far we have considered the rate of absorption by osmosis at an early stage of the process, and we have now to study the rate at which it occurs *during the later stages* until absorption is complete. This was investigated by removing all the ascitic fluid and replacing it by normal saline solution, which was withdrawn at different periods of time, and examined in regard to its amount and its concentration in dissolved solids as compared with the normal animal.

On comparing the rates of absorption of saline solution in the normal and the ascitic cat I have found that during the first hour almost the same amounts are absorbed, the ascitic cat absorbing rather more than the normal, but the residual fluid in the ascitic cat contained a percentage gain of solid matter which was six times as great as that of the normal cat. In the next experiment the absorption was allowed to go on for eight hours: 70 c.cm. of saline solution were introduced into a normal cat and at the end of eight hours only 3 c.cm. could be recovered from the peritoneum; the percentage of total solids in it amounted to 4.7; 45 c.cm. of ascitic fluid were removed from the peritoneal cavity of a dropsical cat and 70 c.cm. of saline solution introduced; at the end of eight hours 45 c.cm. were recovered from the peritoneum. The rate of absorption in this cat had fallen off two and a half times as quickly as in the normal animal. The percentage of total solids in the residual fluid was 6.6. The original ascitic fluid of the cat contained 7.9 per cent. of total solids, so that in eight hours the animal had almost made up its original percentage of solid matter in the peritoneal fluid, and the volume of the fluid was precisely the same as the original amount of ascitic fluid. In another ascitic cat of two weeks' standing 30 c.cm. of fluid were removed containing 6.5 per cent. total solids. The amount of saline solution introduced was 49 c.cm., and after twenty-four hours 22 c.cm. of fluid were removed containing 6.5 per cent. solids.

One may state generally that certainly within twelve hours the introduced fluid will have become about the same as that originally withdrawn both in amount and composition. We see, therefore, that in the ascitic cat the interchange of solids between the blood and the saline solution contained in the peritoneum is a much more rapid process than in the normal animal. The process of osmosis is more rapid in the ascitic than in the normal animal during the early stages, but it is interrupted much more quickly in the ascitic animal by the more rapid output of solid matter, so that in the later stages absorption of fluid becomes much slower, and osmotic equilibrium is established long before the fluid can possibly be absorbed.

We have now to inquire into the *origin of the protein* which accumulates in the peritoneal fluid. The presence of salts which collect in the fluid are quite easily accounted for by diffusion, so that the partial pressure of each saline constituent of the blood becomes equal on each side of the separating membrane. The presence of the protein cannot be thus easily explained, as protein is indiffusible. In the first place, I must point out that we are dealing with two sets of blood vessels—those of the viscera, in which output has overbalanced absorption, and from which the ascitic fluid originates, and those of the parietal peritoneum which are absorbing more quickly than normal—so that we must distinguish two separate processes: osmotic absorption of fluid and equalization of partial pressure of salts by diffusion in the case of the capillaries of the parietal peritoneum, and increased output of lymph from those of the viscera. It is the increased output of lymph into the saline solution which rapidly brings its concentration in protein and salts up to that of the original ascitic

fluid, and so arrests osmosis and diffusion in the case of the parietal peritoneal vessels. This arrest of osmosis occurs at a certain stage in each animal, depending entirely upon the rate of output of lymph.

The protein thus originates in the lymph which is being rapidly produced by the viscera, and for this reason the fluid becomes of the same composition as the original ascites.

When salt solution is introduced into the peritoneum of the normal animal protein appears in it for the same reason—namely, that there is normally a very slow output of lymph into the peritoneum, which is being as rapidly absorbed, so that this structure is kept slightly moist, and there is no accumulation of fluid in it. It is this normal lymph production which accounts for the appearance of protein in the peritoneal saline solution. In support of this hypothesis may be mentioned the fact, noted by Gray and myself, that sometimes in the normal hutch-fed rabbit, and commonly when it is pregnant and the muscles are flabby and the abdomen is full, ascitic fluid is present. We showed that there were no pressure changes in the circulation of these ascitic animals. The ascitic fluid of these rabbits appears to be normal tissue fluid, the rate of production of which is probably normal, but absorption by the lymphatics is impeded owing to the respiratory movements and action of the abdominal muscles being less effective in this direction than are those of a wild animal, in which the abdomen is taut and the movements active and vigorous.

Finally, we arrive at the question whether absorption entirely ceases by the blood vessels of the peritoneum when osmotic equilibrium is established between the ascitic fluid and the blood. This entirely depends upon whether protein is absorbed by the capillary wall or not.

An increased absorption of fluid may be occurring by the capillaries of the abdominal wall, although they do not take up the ascitic fluid from the peritoneum. The explanation of this is that the protein concentration of tissue fluid is kept low by the tissue cells using up the protein during their metabolic activities, whilst the ascitic fluid remains of the same protein concentration. Until proof is forthcoming that absorption of protein may occur by the capillary wall, we must assume that when the ascitic fluid attains osmotic equilibrium with the blood plasma the ascites is entirely absorbed by the lymphatics.

SUMMARY.

1. The accumulation of fluid in the peritoneal cavity following an incomplete obstruction of the inferior vena cava in the chest, or in uncompensated heart disease, is due to an increased output of lymph from the viscera, more especially the liver. This increased output is constantly occurring at all stages of the disease; an increase in the amount of fluid is due to an increase in the rate of output, and the disappearance of the fluid is due to a gradual falling off of the rate of output.

2. Absorption from the peritoneal cavity by the lymphatics is occurring at all stages at the normal rate, a check being thus placed to an excessive accumulation of the ascitic fluid. The fluid is therefore being continuously renewed, and there is a constant circulation of lymph from the blood into the peritoneal cavity and back again to the blood by the thoracic duct.

3. Increased absorption of tissue fluid is taking place in the abdominal wall and hind legs, as in the fore part of the body, but it has not been proved that the ascitic fluid is absorbed as such by the capillaries of the parietal peritoneum. There is no evidence to show that the endothelial cells of the peritoneum actively absorb the fluid.

4. The increased lymph flow from the thoracic duct observed at a certain stage in the course of the dropsy is an index of increased lymph production in the abdominal organs owing to the plethora.

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THE DISINFECTION OF DRINKING WATER

WITH A DESCRIPTION OF A NEW SUBSTANCE FOR THE
PREPARATION OF STABLE TABLETS FOR THE
STERILIZATION OF POLLUTED WATER.

BY

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THE sterilization of contaminated drinking water is a problem of special importance in war time. The use of bleaching powder, or similar hypochlorite or chlorine preparation, has been used with the greatest success for the sterilization of relatively large volumes of water. The use of water-carts containing water treated with a carefully regulated quantity of bleaching powder has given every satisfaction when the method could be satisfactorily carried out—as, for example, when troops are practically stationary. The problem of sterilizing small individual quantities of water, such as are needed by cavalry or rapidly moving troops, is much more difficult, and, up to the present, it has not been perfectly solved. The use of hypochlorites for such purposes is difficult, owing to the instability of small tablets containing the minute quantity of active disinfectant. In their place acid sulphates of the alkali metals have been extensively used in tablet form, but the superior potency of many chlorine compounds would indicate that a stable potable chlorine disinfectant suitable for the sterilization of small quantities of water is desirable. With this end in view, we have made a number of experiments with various types of substances, one of which we believe to be worth practical application.

Our first experiments were made with chloramine-T,* but it was found that when this substance was added to heavily contaminated waters it required a relatively high concentration to sterilize the water promptly, particularly in the case of hard alkaline waters. For example, 1 part of chloramine-T to 25,000 parts of water may be necessary, and such an amount is decidedly unpalatable. Subsequently it was found that much lower concentrations of chloramine-T were effective if the contaminated water was slightly acidified with any acid—for example, citric, tartaric, acetic, etc. Under these conditions 1 : 250,000 or less of chloramine-T was effective (see Table I), and the resulting water was not unpleasant to the taste. But

TABLE I.

Experiments with Chloramine-T, with and without Addition of Tartaric or Citric Acid.

No.	Water Treated.	Concentration of Disinfectant.	Acid Added. Grams per Litre.	Time of Action in Minutes.	Surviving Organisms per c.cm.
1	Hard water + B. coli ...	1 : 25,000 1 : 25,000	None None	10 30	2,508,800 35,200 14,880
2	Hard water + B. coli ...	1 : 300,000 1 : 300,000	— 0.4 0.4	— 10 30	1,120,000 180 0
3	Hard water + B. coli + 0.1 % faeces	1 : 200,000	0.8 0.8	— 10	3,232,000 0
4	Hard water + B. coli ...	1 : 250,000 1 : 250,000 1 : 250,000 1 : 250,000	— 0.2 0.2 0.8 0.8	— 10 30 10 30	520,000 27,200 7,200 130 50
5	Hard water + V. cholerae	1 : 250,000 1 : 500,000	— 0.8 0.8	— 10 10	744,000 0 0
6	Hard water + B. typhosus	1 : 250,000 1 : 500,000 1 : 500,000	— 0.8 0.8 0.8	— 10 10 30	345,000 0 1,760 0

* The abbreviated name for sodium toluene-p-sulphochloramide, (Cp. *BRITISH MEDICAL JOURNAL*, January 29th, 1916; *Proc. Roy. Soc.*, B, 89, p. 232, 1916.