On Resistance to Peritoneal Bacterial Infections; an Experimental Study with Special Reference to Agglutination,

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C O N T E N T S.

Introductory and historical resumé.

In former times, infection of the Peritoneal Sac was regarded with dread, introduction of pathogenic organisms led in many instances to a fatal issue, such cases with general toxaemia resulting from an inflammatory process in the abdomen were regarded as catastrophies, happening so often to arise suddenly in a patient of previous sound health. And with recent prophylaxis and treatment, prompt recognition of symptoms, and a competent knowledge of pathology there still remain many sad reminders of the seriousness of abdominal toxaemia.

But, as it has been clearly shewn in pulmonary phthisis that patients may suffer frpm the disease and recover from it without marked physical signs and later reveal traces of old scars and cretaceous areas in advanced life on post mortem examination, so it is with many infective abdominal diseases. Peritonitis of

an active type is extremely common, abdominal adhesions resulting from such are similarly commonly seen at operations and post mortem examinations. At a recent symposium on Alimentary Toxaemia at the Royal Society of Medicine, (1) experience of clinicians and pathologists is united on the frequency of abdominal adhesions, which, though natural results in the reaction of the tissues, sometimes produce later noxious effects. Mollison and Cameron (2) have found that in routine examinations of the intestines and enveloping folds of peritoneum in situ, adhesions were found in 50 consecutive cases.

Without minimising the risk of dangerous inflammation following peritonitis, therefore it seems clear that it is not safe to assume that organisms in the peritoneal cavity are kept warm, moist, and supplied with

pabulum in such a way that they may develop even more suitably than in an incubating chamber. Rather is it that in spite of these advantages there are physical and physiological means of defence against offenders.

The omentum, with also coils of gut, is conveyed to an inflamed part and if allowed, may adequately shut off a septic focus from the general cavity, or plug a ruptured viscus. In some cases even a kind of prescience seems to be possessed by the omentum, which envelops a dangerous zone ~~even~~ before infection has reached the peritoneum. Experiments (3) with lead shot embedded in its structure, followed by radiograms taken at intervals, would seem to indicate that the omentum is moved from place to place largely by peristalsis, it possesses no muscles for independent movements, while any chemiotactic attraction between it and an inflamed surface

causing attraction of an organ possessing mass such as the omentum has, would seem to be impossible. Other factors aiding peritoneal resistance are the helpful paralysis of the gut, and the readiness of formation of limiting adhesions or membranes.

The whole of the bio-chemistry of immunity is also at work, important vascular structures in or near the peritoneum have their stores of blood altered, protective substances are being exuded into the peritoneum, other bodies are being removed, phagocytosis is active, and, in recovering cases, offensive particulate bodies are removed. Durham has shewn how, after intra peritoneal injections of carmine or soot, in a few hours transference from the peritoneal cavity has taken place, and the peritoneal fluid is clear, while the omentum and the retro peritoneal lymph glands are deeply

pigmented. In the same fashion too, there are many cases of acute peritonitis in which the peritoneal exudate is found to be sterile, while the neighbouring structures contain living bacilli. Mechanically and chemically great activity is found in peritoneal infections. Inflamed foci are barred off, phagocytosis is active, deleterious organisms are removed, anti microbic and antitoxic substances are poured into the affected part, toxic substances are carried away, and probably many other changes take place in the stir of tissue reaction.

Do the peritoneal folds, the mesentery, the viscera, and the omentum remain merely passive in their energy, transferring to, or removing from, the coelom various substances, or are they actively engaged as productive agents? Either theory is compatible with the great vascularity of the

omentum particularly, which surely has some other function to perform than that of merely storing blood, acting as a protective apron to delicate viscera, or guiding loops of bowel into hernial traps. It is the object of the present enquiry to study some of the points of a wider significance in peritoneal invasion, particularly in relation to agglutinin formation, and its help in minimising the effects of inflammation.

That many other protective factors exist is quite beyond doubt, but the agglutination itself of the invading microbes is of interest and of use, while the disputed question as to the precise locality of formation of agglutinins is an attractive subject.

The phenoma occurring in agglutination generally and in the reaction of "Widal" in particular, are well known, and have been studied

and described in detail in the works of Gruber and Durham, Kraus, Widal and Sicard, Duclaux, Nicolle, and many others.

That there is some substance in the blood of an immunised animal which agglutinates the organisms towards which the immunity has been produced is the simple statement of a fact, while speculation has been reserved for the consideration of the nature of the substance, the reasons for the change and the actual sequence of events in the change, and the place of production or secretion of the substance.

A brief historical sketch is here necessary à propos the facts recognised up to the present time.

Bordet (4) first of all described the main phenomena occurring in the agglutination of the Bacillus cholerae "in vitro" The current hypothesis in explanation of the change

was that one bacillus in some way lost its movement and acted as an attractive centre for those around, forming an agglutination nucleus, probably from an adhesive property of its capsule.

Duclaux (5) recognised the difficulty of this explanation, as why one particular organism should take on this function was obscure. Duclaux advanced as a theory that there might be a coagulation of some kind, with retraction of the clot to its centre, causing at the same time the approachment of the bacilli entangled in the meshes of the clot, much in the same way as in the clotting of milk or in the coagulation of the blood with formation of corpuscular rouleaux.

Also, the idea that motility or vitality had any active part in the process was banished by the results of Widal and Sicard (6)

who shewed that the process obtains in all details with cultures of organisms killed by various chemical substances. It is therefore, purely a chemical reaction.

Meanwhile, Gruber and Durham (7) had demonstrated that the action is specific, that the serum which agglutinates one organism will not do so for another of a different species. Kraus (8) then realised the idea of Duclaux in the cases of plague, cholera, and enteric fever, shewing that the active serum actually produces a coagulation in the culture fluid of the corresponding organism, from which the bacilli themselves have been filtered.

That this "coagulum of Kraus" is essentially related to the phenomenon was demonstrated in a very effective manner by Ch. Nicolle (9) who introduced other organisms

or fine powder (powdered talc) into the filtered cultures, when, after addition of the agglutinating serum, typical clumpings of the added foreign bodies were got. Also, he established that the "agglutinable" substance in the culture is a chemical body soluble in alcohol and ether, and thermostabile, resisting temperatures of over 80 C., while the "agglutinating" substance (agglutinin) is thermolabile and destroyed by heating. Further light on the chemico-physical properties of the substances actively concerned has been given by the work of Scheller (10) Bilz, Arrhenium, Eisenberg and Volk, and others. An important point in the change has been noted by Salimbeni (11) who shews that the reaction is much favoured by the presence of air.
He goes further, however, and states that the reaction cannot take place "in vivo" from the absence of the oxygen, but that such an action

does occur, there is, in my opinion, no doubt, as the change, truly not in an advanced stage, as that got "in vitro" with the aid of oxygen, can be seen unmistakably and recognised in exudates taken from the tissues and immediately fixed. Such a change occurring in the fresh tissues is noted in the present observations and argument and the accentuation of the action in the presence of air shewn by Salimbeni may be described as a helpful, though not an essential, factor.

Having thus considered those properties and methods of action of agglutinins which are essential to further details, one turns now to the main question of discussion, the locality of their formation. From the frequent presence of these substances in the blood, observers have been induced to attribute their formation to elements in the blood.

Ruffer and Crendiropoulo (12) have

endeavoured to locate their origin in the polymorphonuclear leucocytes. From their experiments they find that "the polynuclear leucocytes of non-immunised animals always possess an agglutinative power greater than, or more rarely equal to, that of the serum".

From this they conclude that "they may therefore be rightly considered as the producers, or at any rate, the carriers of the agglutinins".

In immunised animals again they find that "the specific agglutinins appear in the polynuclear leucocytes and are therefore probably formed in them."

Thus the sum of their experiences is that the leucocytes act as carriers or more probably as centres of formation.

Their technique is not above criticism.

The method employed consists in the centrifugalisation of the blood samples, followed by washings of the corpuscular elements in various saline solutions. Possibly such treatment alters the distribution of the agglutinins, but whatever may be the explanation, we find that if the reaction is produced with freshly drawn blood from immunised animals, there is no clumping of the bacilli noted in the vicinity of the leucocytes such as one would expect if they contained more agglutinin than the serum, so that evidences in the normal untreated condition of a carrying or a producing function of the leucocytes are absent.

So too, in contrast with these results, Gengou (13) in his observations found that in the blood, leucocytic extracts were less potent than the oedematous fluid or the blood itself. Gengou also states that the blood is

richer in agglutinins than the organs, but in his experiments the animals were killed only when the blood had well marked agglutinating properties, at a time, as Metchnikoff (14) shews, when the agglutinins might have passed from any of the tissue elements into the blood.

Metchnikoff has observed the occurrence of agglutinins in the peritoneal fluid previous to their appearance in the blood stream, hence he concludes that the greater part in formation is done by the cells of the exudate. These experiences of Metchnikoff were made very early in the agglutinin production, and from this may be considered of greater value than any made at a later stage, when transference to, or fixation in, other parts might have occurred.

Regarding the direct evidence as to the locality of formation, a most interesting point is observed in the cases of normal patients

or animals which have suffered from or succumbed to peritoneal bacterial infection, while inferences may also be based on the histological structure of the omentum in normal and pathological conditions, its comparative histology, and from experiences in animals in which the omentum has been previously excised.

The normal appearanee of the omentum must be studied first in some detail before instituting comparisons with the arrangements got in immune animals, and also to gain some knowledge of the disposition and form of its contained cells, whose relation to the process will be discussed later from an experimental point of view.

2. Normal Histology of the Omentum.

In the guineapig the omentum is fairly well developed and descends in front of the intestinal coils from an attachment on the greater curvature of the stomach. It differs from the human omentum in containing the pancreas enclosed within its folds.

Sections were made as follows:- fixation by sublimate - inclusion in paraffin - followed by staining of the prepared sections with Haemalum and Eosin, Eosin and Methylene blue or Thionine blue, or Magenta red and Picro-indigo-carmine.

On examination of sections with a medium power (200 diams.) perhaps the most apparent feature is the large amount of fat enclosed within the connective tissue framework, which is highly vascular.

This is well recognised, but in addition to fat and vascular channels there are other constant tissue elements in abundance whose position in the omentum has not been so clearly emphasised. These are areas of richly cellular tissue, which generally occur just under, or close to, the endothelial covering, though smaller masses of this type are found in the deeper parts, and throughout the whole omental tissue in the interstices between the fat globules. This relationship is shewn in figure 1. which gives the general shheme of distribution of the constituent elements in the omentum.

On further examination of the cellular masses with a high power the characteristics of the individual cells may be seen. The most common of these are cells of the form shewn in figure 2 (a) and figure 3 (a) and

these possess medium sized, round, darkly staining nuclei, with a fair amount of surrounding protoplasm.

Not so common as these, but still abundant in the areas, are cells with larger nuclei and a good supply of protoplasm. The nuclei of these cells are quite three or four times greater in diameter than the nuclei of the cells described before, while another characteristic is that the nucleus is distinctly more difficult to stain, and thus presents a pallid appearance. In form the nucleus is oval or rounded, more rarely quite spherical (fig 2 (b) and fig. 3 (b))

Cells with these characters exactly described are considered by Branca (15) to be the endothelial cells forming the covering of the omentum, but in sections it will be seen that they occur independently in the dpeper

localities especially at the gaps or angles left between the rounded fat globules, though not so abundantly as near the surface, thus their separate existence apart from the continuous endothelial coat is demonstrated, however close their histogenetic affinities may be. (These masses, it may be remarked, are not due to folding of the section or tangential cutting.) It is to these characteristic forms that attention will be directed later.

In addition, another form of cell is seen, possibly a modification of the first described.

These resemble the first in nuclear form, size, and staining affinities, but the protoplasm is distinctly less abundant, presenting the appearance of a narrow ring or halo surrounding the nucleus. Also it takes up

the nuclear stain to some degree, being polychromatophyll. (fig 2 (c) and fig 3 (c))

In addition ordinary connective tissue cells are seen with their typical fusiform nuclei. Leucocytes of the ordinary variety are abundant.

To sum up then, in the omentum the arrangements are:-

1. An endothelial covering layer.
2. Fat globules enclosed in a connective tissue envelope.
3. Vessels, lymphatics, ets.
4. Cellular areas, in sub-endothelial or in inter-adipose situation, containing various types of cells, these being;

   Cells with medium sized, round, well stained nuclei.
   Larger cells with larger, oval, pale nuclei, identical in form with endothelial cells, but found in the deep parts.
   Cells with round, medium sized, well stained nuclei, and polychromatophyll protoplasm

disposed in a ring round the nucleus.

Connective tissue cells.

Leucocytes.

The human omentum is essentially similar in its structure; that in the horse and in the cat is later alluded to. In some species there are modifications of form, and fenestrae normally occur.

It would be interesting from the point of view of Comparative Anatomy and Pathology to investigate the frequency and severity of peritoneal inflammations in the natural state, also the powers of resistance when the condition is developed, in those species of animals in which the omentum is very small or very large. In one case of a fish (Pleuronectes Solea) studied at the Marine Biological Station, Millport (1900) rapid and fatal peritonitis

followed a small penetrating wound of the coelom.

Do birds also, who possess no diaphragm, suffer in any peculiar way from peri-visceral sepsis?

3. Evidences as to the locality of agglutinin formation from experiences on animals and man not possessing naturally the property of agglutination.

In a series of observations, based on the study of the effect of inoculation of cultures into the peritoneal cavity of guineapigs, the changes are striking.

Intraperitoneal injections were given, of 2 minims diluted to greater bulk in sterile saline solution, of a 24 hours culture in bouillon of Bacillus coli of a suitable virulence. Films were prepared post-mortem but just after death, and were fixed by the "dry" method, or by immersion in absolute alcohol and ether (equal parts), followed by staining in eosine and methylene blue, or eosine and thionin blue. The blood was chosen in films from the portal vein, so that it

would be within the abdomen, as near as possible to the locus of investigation of the peritoneal fluid itself, and exposed therefore to similar experimental conditions.

I have used the term peritoneal fluid, effusion, or exudate, though I believe in some cases such fluid is not necessarily derived from true peritoneal cells, but arises more particylarly from vascular areas near the peritoneum.

In film preparations of the peritoneal exudate and of the blood (taken from the portal vein just before entering the liver) a marked contrast is got.

In the peritoneal effusion organisms were very abundant, but distributed, in many instances, in an irregular manner in the field forming distinct clumps.

In the blood, on the contrary,

organisms were present in numbers, but with a uniform distribution, shewing ø no tendency to agglutination. This would seem to shew that some structure in or about the peritoneal cavity had produced the agglutination, at anyrate one may conclude that the fluid of the peritoneal cavity contained agglutinative substances, quite absent in the blood stream.

Again, on further examination of the agglutinated masses in the exudate, in the centre of each in many instances was seen a large cell with an oval pale nucleus, histologically identical with the form described in the omentum as lying in the cellular areas commonly near the endothelial surface.

Round these cells the bacilli were aggregated in such numbers as to partly conceal the cells, while in the vicinity of the clump the numbers gradually diminished the

greater their distance from the clump. In addition, in a few examples, clumps were seen without the presence of a large central cell, but these independent clumps were noted only at a more or less short distance from a clump surrounding a cell. An idea of the distribution is seen in fig 5, contrasting with fig. 4, which shews the uniformity of disposition of the organisms in a non-agglutinated culture.

In the films also were noted variations in the form, size, and staining affinities of the bacilli near the points of agglutination. (Pfeiffer's phenomenon ?)

From the number of organisms in the masses the cell in the centre is to an extent overshadowed, thus whether or not it contains engulfed organisms cannot be made out, but in other parts of the field phagocytosis is

evident and bacilli are seen ingested within the protoplasm of leucocytes and round other cells of the omentum, while these cells, though aiding resistance in this manner by phagocytosis have not any relation to the localities of agglutination. They act as Microphages and Macrophages.

Capillary force might be adduced as an explanation of the presence of attraction of the bacteria towards the cells, but that this is not so is clear from the special affinity of the organisms for certain cells only. Also the diluted bouillon culture was examined by itself and a uniform disposition noted, to eliminate any fallacy due to inequalities of grouping in the field.

This much, then, seems clear, that the large nucleated omental cells present in the effusion have an attractive influence on

the organisms, or in other words, that they alone in the cells of the effusion (at this early stage) produce the agglutinin, while the clumping without an attractive cell might be explained by the exudation into the fluid of a primarily intra-cellular agglutinin.

The process is really delicate, gross reaction of agglutination is not seen in these early cases.

In the blood films, where such an agglutinative reaction is absent, these attractive cells also are absent, and the red blood corpuscles, leucocytes, (increased in number to some degree), and bacilli, are uniformly distributed, which fact gives us negative evidence pointing to the omental cells as the causal agents in agglutination, and positive evidence against the idea that the reaction is got ffom a leucocytic secretion.

In the human subject I have made many preparations and have frequently remarked and been puzzled by, the presence of certain "macrophages" in films of peritoneal exudate taken fresh and fixed in the operating theatre, direct from the living patient at abdominal operations for peritoneal sepsis following intestinal obstruction or strangulation. The peculiarity lies in their relation as centres of bacillary attraction, which can be explained on the present basis of argument - they are in the initial stage of secretion of agglutinating substance. These large oval necleated cells are found in the human omentum.

It is well known that an agglutination from serum alone can be produced without the presence of cellular elements of any kind, but such an action is only produced where a

diffused agglutinin is got in solution.

This process of diffusion is indeed noted in its commencement in the films described, in relation to the secreting omental cells, and by an extension of the process of diffusion of the agglutinin the appearance of the reaction in the blood serum can well be explained as following absorption of the soluble substance into the circulation. In the present method of observation, such an absorption is noted, with induction of agglutinative properties in the serum, when the animals lived long enough.

A point in favor of this view as to the importance of the special large omental cells is got from the tissue arrangements in the omentum, as the readiness of egress of these cells preparatory to their distribution of the agglutinin is hastened by their position

close under the endothelial layer, the only condition required for their liberation being the shedding of the endothelium, which does take place (at least in the peritoneal infections) the endothelial cells then serving their function as phagocytes. After that, proliferation of the large cells and their irruption directly into the peritoneal cavity might go on without barrier. Without actual irruption of cells the soluble agglutinin might be passed by osmosis to other parts.

Induction of immunity, or rather, induction of the agglutinative reaction, according to this view would be produced generally only after a local formation of the agglutinin in the peritoneal fluid or omentum. Before dogmatising on the results above described, the statements must be brought into accordance with other observations of a different nature.

From a general standpoint, the destructive and absorptive powers of the peritoneal surfaces on pathogenic organisms are established and abundant proof has been given of this action in the works of numerous observers (Durham (16), Flexner (17), Wegner (18).)

Might we not say that this power of destruction is aided to some extent by the situation of the bacilli in the midst of the region of agglutinin production?

This view might be taken as at least helpful, though from the action of so many other varying factors in peritoneal destruction of organisms, its relative importance is beyond estimation.

Is it not even possible that the mural infiltration of leucocytes, or "pavementing" of the walls of ~~a~~ capillary vessels

in inflammation generally, might be due to a chemical change in the capillary endothelial cells with a kind of agglutinating or adhesive effect on the leucocytes contained in the vessel during stasis?

Yet apart from these general speculations, there are more exact data at hand as to the rôle of the omentum.

4. Evidences from the study of animals and man possessing that power of agglutination.

The process of immunisation does not necessarily mean that of development of an agglutinative property, yet in many instances the two are found together.

In those species in which the serum possesses a certain amount of natural agglutinative power, or in others where such a reaction has been conferred experimentally it is interesting to note, among other conditions, the relations of the omental structure in connection with this agglutinative property of the blood serum.

Take first those animals where the power exists normally.

In the horse, for example, the serum possesses the property of being able to

agglutinate Cholera vibrio, Bacillus coli, Bacillus typhosus, and Bacillus tetani very distinctly, (Bordet, (19)) and from this circumstance it has been used intra peritoneally at abdominal operations with satisfactory results, (Borchardt (20), Schmidt, (21)) since in laboratory experiments a reinforcement of peritoneal destructive action is noted after its injection.

Again, the normal serum of rabbits has agglutinative powers. (Rodet. (22))

If, following up our line of argument, we consider the substance in the blood to be derived chiefly from the omental cells, then in these instances we should expect a hyperdevelopment of agglutinative function of the special cells, either physiological without increase in numbers, or anatomical with excess in numbers. This latter

anatomical or gross increase expected and deduced from other facts is actually found; in both the horse and the rabbit cellular areas are well represented, including the cells of specific form described before.

These observations, striking in their confirmation of the previous ones, might be explained as individual peculiarities, the agglutinative power being merely coincident with the cellular development, and independent of it.

In cases in man, after enteric fever resulting in death, and where agglutination reaction was marked, I have examined sections of the omentum, with a negative result as to anatomical increase in cellularity. There may be a physiological hyperplasia.

So the results must be taken only as evidence not conclusive in itself, but of

support when coupled with the other evidence.

To obviate entirely this difficulty, observations have been made on guineapigs with an artificially induced power of agglutination, where the omental structure may be definitely compared with the normal condition.

The agglutinative reaction in the serum was induced by injections of 2 minims diluted to a greater bulk by sterile saline solution, of a 24 hours bouillon culture of B. coli of a non-lethal virulence. These injections were repeated every second day for two to three weeks.

After induction of the reaction, organisms of high virulence were used to kill the animals, now partly immunised by the previous injections.

Post mortem the changes described before were found, only in a more marked

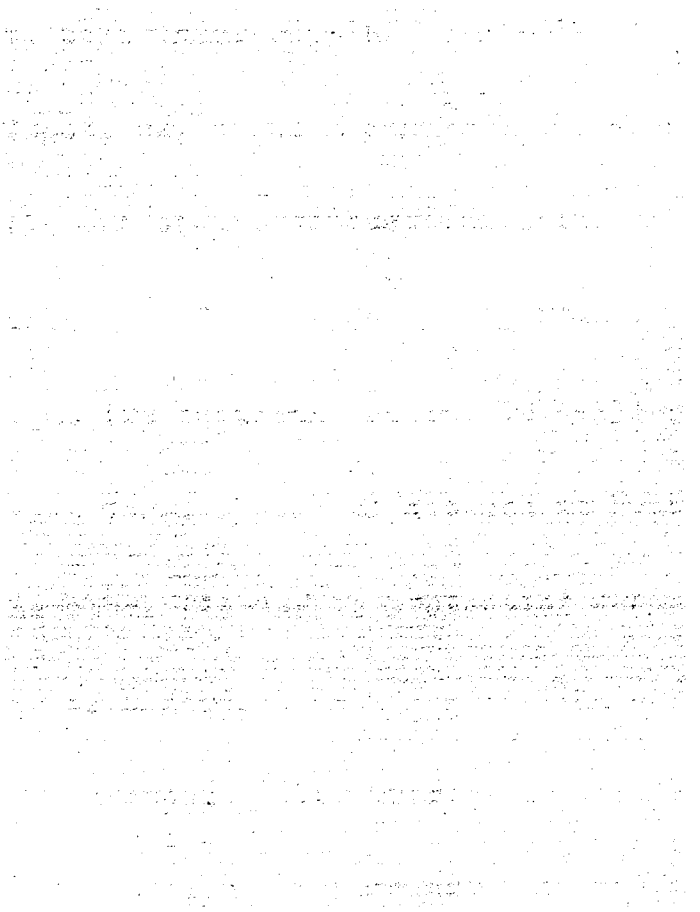
degree. In the peritoneal fluid was noted agglutination in relation to omental cells, with also agglutination apart from them, shewing that the soluble agglutinin existed in a free state in the fluid to a greater extent than in the non-immunised examples.

In the blood agglutination also was seen, apart from cellular elements. The interesting point, however, was in the omental condition. The cellular areas were increased in extent, the vessels also being abundant. In the areas the large nucleated cells were develpped in greater number than in the normal condition. An experimental error here creeps in. It is possible that the increased cellularity is due to a hyperplasia directly induced by a local stimulating effect of irritation.

5. Evidences in animals after previous excision of the Omentum.

The relation of these experiments to the subject is important. The omentum was ligatured and excised in two guineapigs, and after a 4 weeks recovery, intraperitoneal injections of B. coli were made.
Thus, the animals were deprived of the cellular islets in the omentum. Resistance to infection seemed to be weakened.
After injection films of the exudates were made and these did not shew any tendency to agglutination of the organisms. This again gives us evidence that the omentum, if not alone, at any rate in great part, is influential in producing agglutinins, from the absence of reaction with the other tissues functionally intact. This contrasts well with the experiments last mentioned, shewing that

defective omental development is associated with defective agglutinative reaction, while increased omental development (increased cellular development) is concurrent with increased development of the agglutinative reaction.



6. Conclusions.

The results of observations as developed in this communication may be stated thus:-

1. The omentum with its great vascularity and specialised cellular structure is not simply a blood storing adipose appendage, a protecting apron, or a mere mechanical wall limiting peritoneal sepsis. In addition to other functions, it is a centre of bio-chemical activity, one of its productions being agglutinins. It is a secreting organ. As well as its important action in helping to counteract local abdominal disease it helps also the other tissues in protecting against diseases of a general nature affecting any other part of the body. Its unnecessary removal at operations is not a harmless proceeding.

2. Agglutinin bodies are produced

almost entirely from the omentum, while the leucocytes or other elements of the blood must take only a minor part, in their formation.

3. The agglutinins are evolved from characteristic cells in the omentum lying in masses under the endothelial covering in a position favourable for migration into the peritoneal fluid.

4. When the agglutinative reaction is developed in the blood, the sequence of events has been;

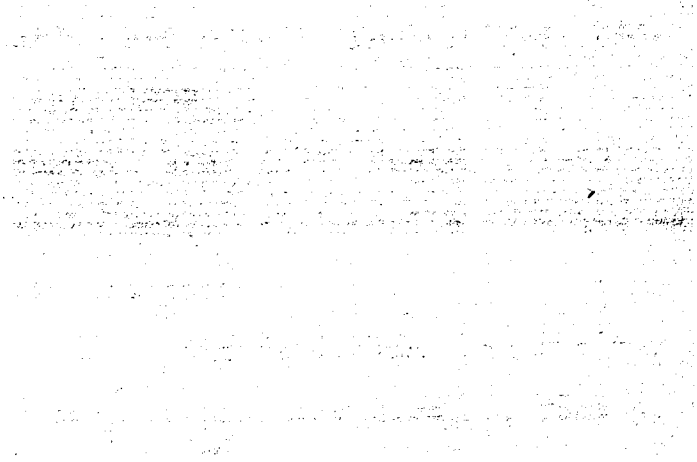
Increased activity of omental cells with or without migration of these cells into the peritoneal fluid.

Extracellular diffusion of their agglutinin into the peritoneal fluid.

Absorption of the agglutinin from the peritoneal fluid into the general circulation.

5. It has been shewn that agglutinins are 'specific' towards each agglutinable organism.

Are the cells developing them for each organism different? It seems unlikely, and more reasonable to suppose that in cases apart from those of peritoneal sepsis, other cells besides those of the omentum may take part in their formation, with aid from increased activity of secretion from the omentum.



Appendix (a)

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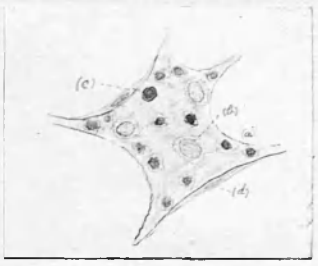
Appendix (b).

Figures.

Figure 1. Low power view of omentum of guineapig, shewing cellular masses, fat spaces, and a bloodvessel. This portion shewn does not contain pancreas.



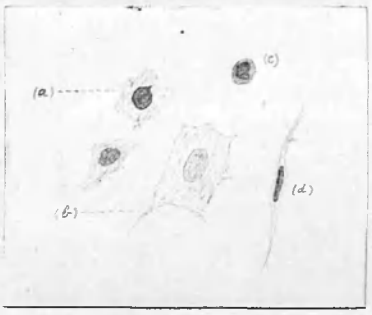


Figure 2. High power view of same, shewing the composition of a cellular islet at the intersection of the fat spaces.

Figure 3. Constituent cells of the cellular masses.

(a) Small round cells.

(b) Large cells with pale nuclei.

(c) Small polychromatophyll cells.

(d) Connective tissue cells.

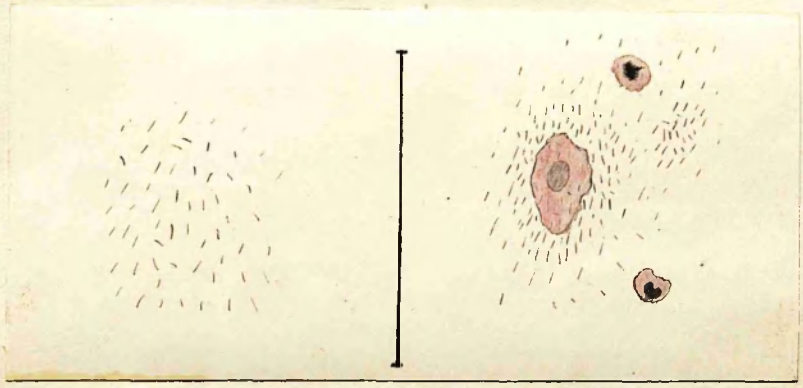


Figure 4. 24 hours bouillon culture of bacillus coli. Film shews uniformity of distribution.

Figure 5. Film from peritoneal effusion of guineapig killed by intraperitoneal injection of bacillus coli. Agglutination is seen round large omental cell, none in relation to the leucocytes. An area of agglutination is also seen apart from the omental tissue cell, but close to it.

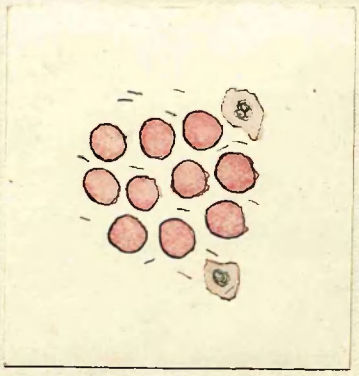
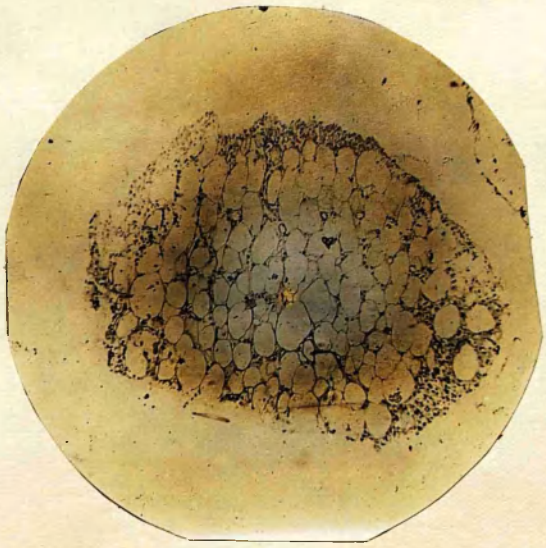
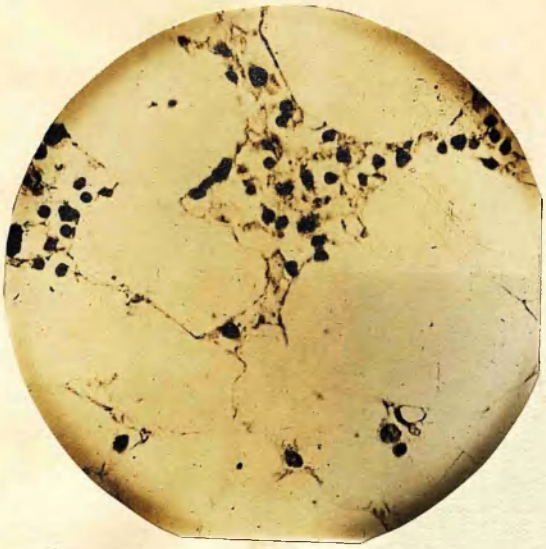
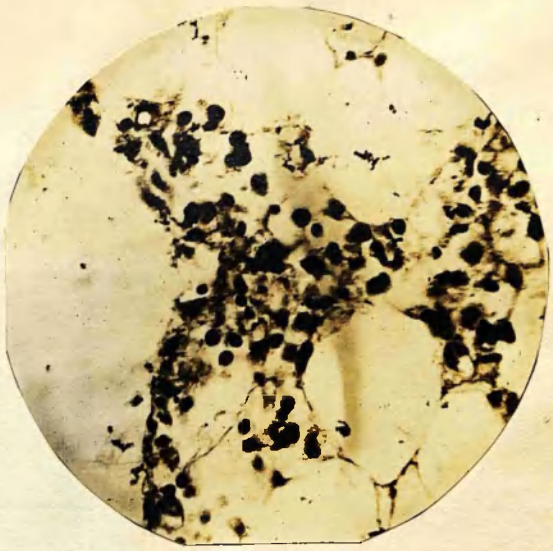


Figure 6. Blood film from same case as the preceeding. The bacilli are distributed uniformly in the field irrespective of the blood cells.



Low power photograph of omentum, shewing cellular masses.





High power photographs of omentum

shewing characters of cells.

The genesis of agglutination of bacilli.

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