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SOME POINTS  
*IN THE*  
ANATOMY, PATHOLOGY & SURGERY  
OF INTUSSUSCEPTION

WITH ILLUSTRATIONS BY THE AUTHOR.

D'ARCY POWER.

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BY

(S. 16)  
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Dedicated  
BY  
THE AUTHOR,  
WITH SINCERE RESPECT,  
TO  
ALFRED WILLETT, F.R.C.S. ENG.,  
AT WHOSE SUGGESTION  
THIS PIECE OF ORIGINAL WORK  
WAS FIRST UNDERTAKEN.

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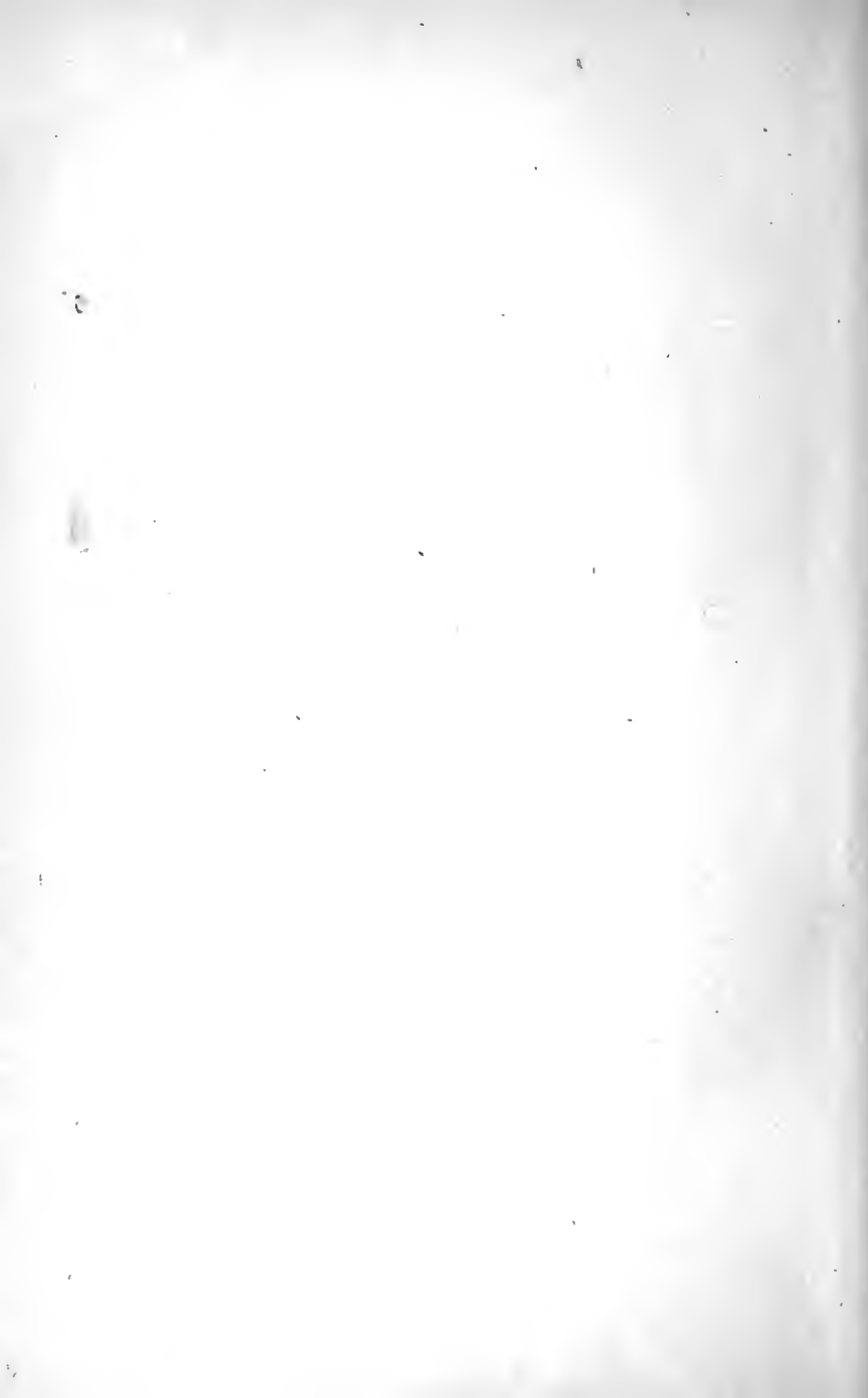
## P R E F A C E.

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THE substance of this work formed a series of lectures which I delivered as Hunterian Professor of Pathology and Surgery at the Royal College of Surgeons of England in February, 1897. The exigencies of time and the conditions under which the lectures were given required me to compress the material I had amassed. The Editors of the various medical journals were good enough to devote much of their space to report the lectures. I should not, therefore, have felt justified in attempting to gain further publicity unless I thought that the results obtained might perhaps be serviceable to those who are investigating the wider and more important subject of Rupture. The problems to be solved in Hernia are often identical with those occurring in the surgery and pathology of Intussusception.

My best thanks are due to Dr. Pickard, Dr. Hayne, and Dr. Muir, successively Resident Medical Officers at the Victoria Hospital for Children. Their help in collecting the statistics given in Chapter II. has been invaluable.

*October, 1897.*



## CHAPTER I.

### SOME POINTS IN THE MINUTE ANATOMY OF INTUSSUSCEPTION.

I CANNOT but feel that I am courting criticism by attempting to reconsider so well worn a subject as that of intussusception. It is an affection which has been known and treated ever since medicine has had a literature, for Hippocrates himself recommended enemata for its relief, and Paraxagoras of Cos is said to have been bold enough to open the belly for its cure. I have before me, however, the noble example of our great master of pathology and surgery. John Hunter did not scorn to employ his time, and his great talents upon such subjects as the natural history of the teeth, the inflammation of the internal coats of veins, the treatment of abscesses, and the cure of popliteal aneurysm—subjects which his contemporaries were accustomed to think of as threadbare, but from which his genius and his patience enabled him to evolve far-reaching conclusions which have withstood the test of time, bringing with it methods he could not even imagine. I cannot pretend to imitate him in any single point. It is only possible for me to follow humbly in his footsteps and to bring forward such facts as I have obtained by clinical observation and from pathological research in a subject to which he himself devoted both time and thought.

My clinical observations have been made at the Victoria Hospital for Children, and I am greatly indebted to my colleagues there for the readiness with which they have allowed me to use their cases. The pathological facts have been gleaned from an examination of the specimens preserved in the museums attached to the various medical schools in London and the provinces,

whilst my task has been greatly simplified by the liberality with which the Royal College of Physicians of England and its sister College of Surgeons have allowed me to work in the laboratories they maintain with such noble munificence.

Very little<sup>1</sup> is known of the minute anatomical changes in the intestine which take place in strangulated hernia; still less is known about those which occur in the rarer condition of intussusception, yet the Hunterian Museum and the museums attached to the medical school of every large hospital contain plenty of material for examination. The kindness of the conservator of the Hunterian Museum—Professor Stewart—and of the curators of the various museums has afforded me the opportunity to examine such specimens as seemed to be in a good state of preservation. I propose to describe the results I have obtained, with such conclusions as it seems lawful to draw from them. Verbal descriptions of unknown objects are wearisome, and convey but little knowledge when it is impossible to study the preparations at leisure. I have therefore obtained photomicrographs of many of the sections, to render my remarks somewhat more interesting. I may say at the outset that an obvious fallacy attends these observations. The work is new, and it has been carried out by a single observer upon a comparatively small number of specimens—thirty-one in all. These specimens have not always been preserved with the minute attention to details of a hardening process which marks the histology of our own time. Pathological histology is of such recent growth that the older surgeons were rarely anything more than morbid anatomists. Spirit, however, was cheap and strong at a time when its retailers offered their customers to be “drunk for a penny, dead drunk for twopence, and straw for nothing,” upon which to sleep off the inexpensive debauch. Some of the specimens preserved in these long bygone days are therefore better fitted for microscopical examination than are those obtained more recently. I cannot hope to have made more than a beginning, and I do not doubt that I have often fallen into grievous error in my interpretations, but others with better material will soon correct my mistakes, and will advance more quickly along the paths I indicate.

**Early Changes.**—Fig. 1 shows the earliest changes in an intussuscepted intestine which I have been able to obtain. The

<sup>1</sup> Nicaise, “Des Lésions de l’Intestin dans les Hernies,” Paris, 1866.

sections were taken from the intestine of a child 8 months old<sup>1</sup> who had suffered for thirteen and a half hours from the symptoms of an intussusception. I opened the abdomen and reduced the invaginated gut with such success that the baby digested his food and passed a perfectly natural motion. Symptoms of fresh obstruction appeared forty-five hours after the operation, and the child died six days after the abdominal section, and seven days after the onset of the illness. The post-mortem examination showed that there was neither peritonitis nor intussusception. The small intestines were distended with flatus, but the disten-

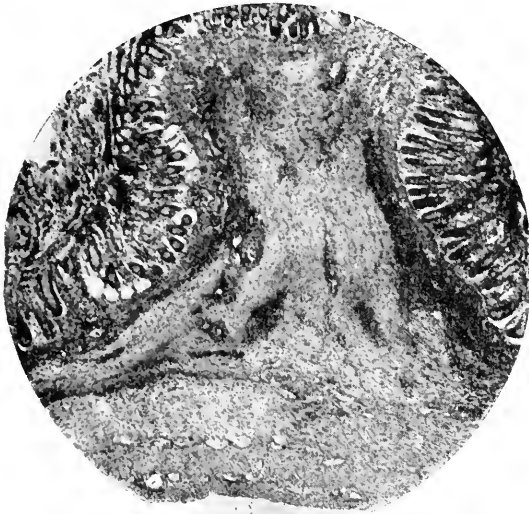


FIG. 1.—Section through a piece of colon which had been invaginated in a child. The submucous tissue is thickened by an extravasation of blood, whilst the bloodvessels and lymphatics supplying the muscle are enlarged (Leitz, Oc. 1, Obj. 4).

sion ceased suddenly, and without any visible cause, 12 inches from the ileo-cæcal valve. The colon, like the lower part of the ileum, was collapsed.

The collapsed intestine was at once hardened in Foà's solution (Müller's fluid saturated with corrosive sublimate), the process being completed by alcohol. Sections taken through the colon  $\frac{3}{4}$  of an inch from the ileo-cæcal valve show (Fig. 1) that the stress of the disease has fallen upon the submucous coat. In the

<sup>1</sup> *Brit. Med. Journ.*, London, 1895, vol. ii., p. 1356.

mucous coat the crypts of Lieberkühn are either single or double. Each is lined with a layer of columnar epithelium which in some parts is normal, but in others contains an increased number of goblet cells, showing that the glands have been subjected to irritation. The increase in the number of goblet cells accounts for the excessive secretion of mucus, which is often so marked a symptom of intussusception. Each crypt of Lieberkühn, as is usual in children, has its own sheath of adenoid tissue separating it from its neighbour upon either side. This tissue is a little



FIG. 2.—Section through a piece of colon which had been invaginated in a child, showing the thickened submucous tissue, the disarrangement of the muscularis mucosæ, and the enlargement of a solitary follicle.

swollen, for it is rather more distinct than it should be in a healthy intestine, whilst the masses of lymphadenoid tissue forming the solitary follicles are greatly increased in size (Fig. 2).

The muscularis mucosæ forms a thick, continuous, and well-defined layer, which in the hardened section is depressed at the solitary follicles (Fig. 2). Its cells are unaltered. The submucous tissue is abundant in quantity, and the presence of an increased number of small round cells shows that it is slightly inflamed. It contains numerous large and rather thick-walled arteries, but its veins are neither large nor conspicuous by their

congestion. The meshes of its connective tissue are widely open, and are filled with an extravasation of blood, which, though considerable in quantity, has not yet exerted any great pressure upon the walls of the vessels, for even the capillaries are patent and contain blood corpuscles. The extravasation of blood is not uniform, and the mucous membrane with its submucous tissue is thrown into ridges, which run transversely to the axis of the intestine, the ridges being due to the thickening caused by the extravasation. The effusion is most abundant just above the layer

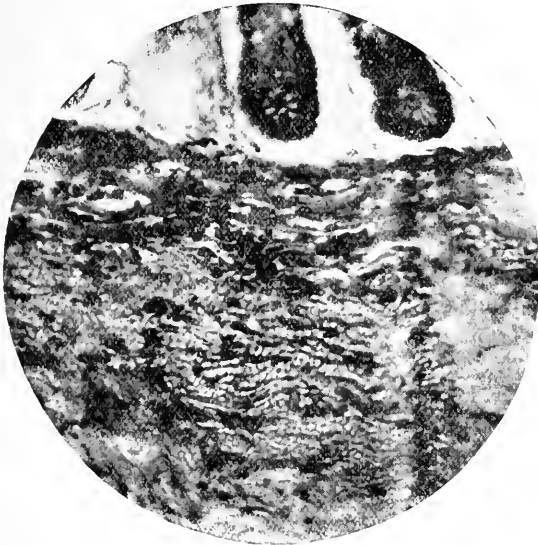


FIG. 3.—Section through a piece of colon which has been invaginated. The extravasated blood corpuscles are seen to lie in rows in the deeper parts of the submucous tissue.

of circular muscle, and it fades away (Fig. 3) towards the muscularis mucosæ, though it is easy to see how it might have tracked through this layer and along the inflamed and softened adenoid tissue lying between the crypts of Lieberkühn, until it had made its escape into the lumen of the intestine.

The circular layer of muscle (Fig. 1) has not undergone any visible change. It is separated from the longitudinal band of fibres by a large lymphatic vessel. This vessel and the plexus myentericus are normal histologically. The longitudinal muscle is very œdematous, for the fibres are separated one from another

by stellate spaces, though the individual fibres have undergone but little, if any, change. The serous coat is separated from the muscular layer by many large venous channels, but for the most part it is healthy, and it only contains patches of extravasated blood at long intervals.

The ileo-cæcal valve has undergone changes in every respect similar to those described as occurring in the colon. The general structure is thickened, and an extravasation of blood has taken place into its centre, while its lymphatics are blocked with leucocytes, showing how easily an inflammation might begin in the valve. The bloodvessels, however, are not enlarged, and the epithelium lining its crypts of Lieberkühn do not contain an undue proportion of goblet cells.

The changes in the ileum are similar to those which have taken place in the large intestine. The villi, however, are reduced to mere tags of connective tissue. The submucous layer is thickened by an extensive extravasation of blood, which has not yet undergone any change. The circular layer of muscle is comparatively healthy, though blood has been effused into its substance, but the longitudinal layer of muscle is completely disorganized. Its fibres are widely separated from each other by the effused corpuscles, and the protoplasm of the muscle cells is becoming degenerate. The serous coat is also greatly thickened by the effused blood.

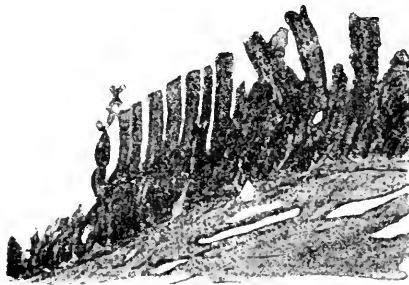


FIG. 4.—A portion of the ileum from a case of experimental invagination produced in a cat seven days previously. The villi are greatly congested. The submucous coat is congested and thickened, and its lymphatic vessels and veins are enlarged.

The next section (Fig. 4) is taken from an intussusception which was made experimentally in a cat by drawing the colon over the cæcum and the lower part of the ileum, and securing it with a few point-sutures at the neck of the invagination. The specimen was obtained by resecting the invaginated

intestine a week afterwards. The animal made an excellent recovery, and lived many months after the operation.

The minute anatomical changes are again more marked in the



mucous and submucous layers than in the muscular and serous coats, but this specimen differs from the previous one in the fact that the mucous membrane has suffered more severely than the submucous tissue.

The villi covering the mucous membrane are much congested (Fig. 5), and the blood corpuscles are escaping from them in many parts into the lumen of the intestine. The diapedesis of white corpuscles is only just beginning, and as there has not been any great multiplication of cells, it may be assumed that the inflam-



FIG. 5.—Two of the villi from the previous section, more highly magnified, to show the congestion of their bloodvessels and the invagination of their apices. Most of the columnar epithelium has been converted into goblet cells.

matory process has hardly advanced beyond the stage of congestion and stasis. The apices of many of the villi are often curiously invaginated, a change which is due, in all probability, to unequal shrinkage during the hardening process, though I do not remember to have seen it in any of the numerous sections I have examined when teaching classes of normal histology. The columnar epithelium of the villi is converted almost wholly into goblet cells. The crypts of Lieberkühn are quite healthy, their epithelium is normal, and they are not surrounded by any inflammatory zone of small round cells. The muscularis mucosæ is unaltered, and both its layers of muscular fibres are clearly seen.

The submucous coat is swollen; its bloodvessels—large and small—are filled with normal blood corpuscles, and its lymphatic channels are enormous. The swelling of the submucous coat is chiefly due to œdema, for it is not associated with any great infiltration of small round cells, nor has there been much extravasation of blood into the meshes of its connective tissue. The circular layer of muscle is greatly congested, and its individual fibres are separated one from another. Blood has been extravasated into it to a slight extent, but the œdema is much less



FIG. 6.—Section through the ileum of a dog which died of intussusception. The details of the structure of the mucous membrane are destroyed by an extensive extravasation of blood. The submucous tissue is greatly thickened by effused blood, and its bloodvessels are engorged. The circular layer of muscle is very œdematous and congested, but the longitudinal layer is unaffected.

marked than it was in the previous case. The longitudinal layer of muscle is scarcely altered, and the serous coat is continuous with the slightly congested mesentery.

The section from the experimental invagination in a cat may be compared very profitably with one<sup>1</sup> (Fig. 6) taken from the ileum of a dog killed by an intussusception which occurred spontaneously. An extensive extravasation of blood has done serious injury to the mucous membrane by surrounding and compressing the glands and the villi. It has separated the fibres of

<sup>1</sup> St. Barth. Hosp. Museum, No. 2192.

the muscularis mucosæ one from another, and it has caused great thickening of the submucous tissue. The circular layer of muscle is profoundly affected (Fig. 7). Its blood-supply is greatly increased, and its lymphatics are so much enlarged that the muscle has become œdematous. The œdema, in turn, has reacted upon the muscle fibres, so that hardly one in ten is healthy (Fig. 8), the remainder having undergone an inflammatory change which has led to a loss of all structural details in the transverse section



FIG. 7.—Section through the muscular layer of the intestine, from the same case as the preceding specimen. The circular muscle is œdematous and degenerate, whilst the longitudinal coat is healthy.

of its fibres. The longitudinal layer of muscle (Fig. 7) is hardly altered. The structure and outlines of the individual fibres are distinct, but there has been a slight extravasation of blood continuous with an extravasation which has occurred between the longitudinal layer of muscle and the serous coat of the intestine.

The changes shown by these specimens form an interesting series, and are typical of many others which I have examined. They show that the mucous membrane, the submucous tissue, and the circular layer of muscle suffer more severely in the early stages of an intussusception than the longitudinal layer of the muscle or the serous coat.

The changes in the submucous coat are the most extensive, but those occurring in the circular layer of muscle are the most important, for they militate against the recovery of the patient even after the intussusception has been reduced.

The series of changes taking place in a case of simple intestinal invagination appears to be as follows: The vessels in the mucous and submucous layers become congested in consequence of the obstruction to the free circulation of blood, which is caused by the bending of the intestine upon itself at the apex, and again at

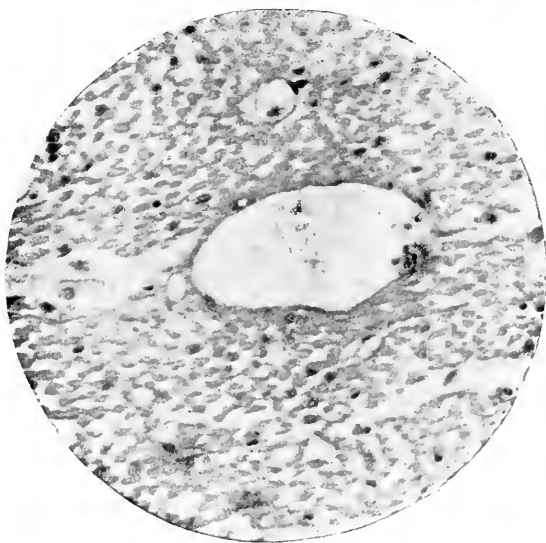


FIG. 8.—Section through the circular muscle from the same specimen, more highly magnified.

the neck of the intussusception. The congestion affects the veins and the capillaries more than the arteries, and after a varying length of time it is followed by an escape of blood from the congested vessels. This extravasation of blood is due to simple over-distension of the capillaries, resulting from the venous congestion. The over-distension makes them yield, for their endothelial walls are only surrounded by a delicate layer of connective tissue which affords but a minimum of support even in health, whilst in cases of intussusception it is so softened by œdema as to be still less capable of preventing or counteracting any undue dilatation of the vessels. In the most acute cases, however, where the pres-

sure at the neck of the intussusception has been so severe as to cut off the blood-supply, the capillaries may be empty. No bleeding occurs in these cases, and the surgeon is sometimes misled as to the nature of the affection he is called upon to treat. But after the intussusception has been reduced, when the blood again passes through the empty vessels, it either escapes or so much plasma exudes as to cause a fresh œdema, which may be sufficient to paralyze the bowel and kill the patient. Paralysis of the bowel from hæmorrhage is rare, and it is more often due to œdema of the circular muscle, for small extravasations of blood may be absorbed in simple cases, leaving the wall of the intestine thickened, but still capable of doing its duty.

**Later Changes.**—Some of the later stages in an intussusception are seen in a section<sup>1</sup> (Fig. 9) taken from the cæcum of a

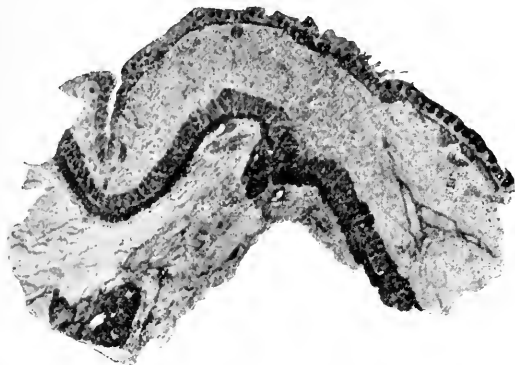


FIG. 9.—Section through the cæcum of a child, æt. 9 months, who died sixty hours after the onset of symptoms (John Hunter's specimen). The mucous membrane is almost unaffected, but it is covered with clotted blood. The muscularis mucosæ is normal. The submucous layer is thickened. The circular layer of muscle is more œdematous than the longitudinal layer. The meso-cæcum is thickened by threads of fibrin, and it contains a congested lymphatic gland.

boy, aged 9 months, who died sixty hours after the first symptoms of intestinal obstruction had been recognised. The specimen is of great interest. It was shown by John Hunter on August 18, 1789, at the Society for the Improvement of Medical and Chirurgical Knowledge, one of the most select medical societies which has existed, for it consisted of twelve members, who met once a month at Slaughter's Coffee-House in St. Martin's Lane. Persons

<sup>1</sup> Hunterian Museum, No. 2,703.

to be eligible for election were required to attend regularly, and to be physicians or surgeons of five years' standing on the staff of St. Bartholomew's, St. George's, Guy's, or St. Thomas's Hospitals. The society existed from 1783 to 1818, and during this time it admitted only eighteen members. John Hunter read some of his best papers at its meetings, and it is a proof of the importance he attached to the specimen that he brought it forward at this society rather than at any of the others to which he belonged. The specimen formed the text upon which he wrote his celebrated paper, "On Introsusception," and thanks to the interest which it excited in the mind of our master, as well as in that of his unworthy assistant (Sir) Everard Home, it has been so well preserved from the time it was removed from the child's body that I have no difficulty in describing its histological characters, though it is now 108 years since the patient, the Hon. Mr. Howard,<sup>1</sup> died.

The mucous membrane is very slightly if at all thickened, but it is covered in parts with a layer of coagulated blood. The muscularis mucosæ is normal, and beneath it is a considerable quantity of adenoid tissue. The whole of the submucous layer is thickened, partly by œdema, partly by the extravasation of blood, and partly by the infiltration of inflammatory products. The veins in the submucous layer are congested, and there are many huge capillaries from which a considerable diapedesis of white corpuscles has taken place. The circular and longitudinal layers of muscle are œdematous, but the circular layer is the more affected, and the meso-cæcum is thickened by threads of fibrin. It contains a lymphatic gland surrounded by healthy fat. The gland, seen in section, is itself inflamed, for its vessels are congested.

The later stages of intussusception are also seen in a section<sup>2</sup> (Fig. 10) taken through the ileum of a child, æt. 5 months, who had suffered for three weeks from intestinal disturbance, which had culminated in symptoms of acute intussusception six days before her death. The case is carefully recorded by Dr. Howship,<sup>3</sup> who says that gentle aperients were repeatedly given, and that there was great frequency in the passing of blood. The mucous membrane is congested, and much blood has been poured out into its substance. The submucous tissue is greatly thickened

<sup>1</sup> *Brit. Med. Journ.*, 1897, vol. ii., p. 300.

<sup>2</sup> *Mus. Roy. Coll. Surg. Eng.*, No. 2,711.

<sup>3</sup> *Edin. Med. Journ.*, 1812, vol. viii., p. 129.

and intensely congested. The thickening is due to an extravasation of blood, and to an infiltration of inflammatory cells, for the submucous tissue is in a state of diffuse suppuration. The circular and longitudinal layers of muscle are congested and œdematous, whilst many of their fibres are degenerating. The serous layer is thickened, congested, and suppurating.

The next section<sup>1</sup> (Fig. 11) shows a still later stage than the one just described. It was taken from a child, æt. 8 months, who had been ill for ten days, during the last three of which it suffered

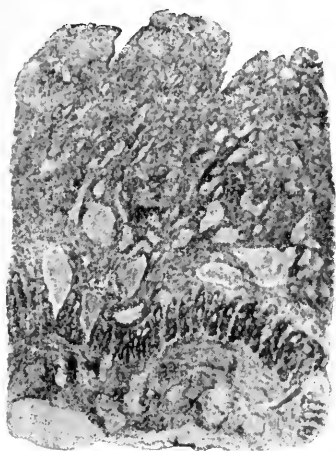


FIG. 10.—Section through the ileum of a child, æt. 5 months, to show the later changes occurring in intussusception. The mucous membrane is congested, and blood has been poured out into its substance, whilst the submucous tissue is beginning to suppurate. The muscular layers are œdematous, and the serous coat is thickened and suppurating.

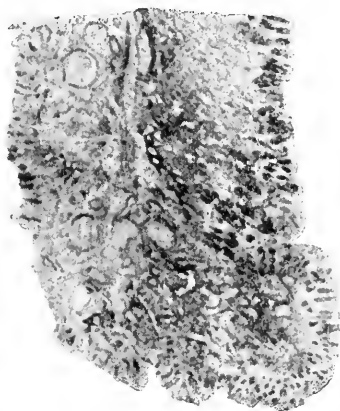


FIG. 11.—Section through the caecum of a child, æt. 8 months, who died of intussusception. The mucous membrane is intensely congested, the submucous, muscular and serous layers are suppurating. The serous coat of the entering layer is adherent to the serous layer of the returning layer of the intussusceptum. The submucous tissue of the returning layer is thickened by an extravasation of blood.†

from the symptoms of acute intussusception. Every part of the invaginated intestine is seriously injured, though the mucous membrane has undergone somewhat less change than the other tissues. The crypts of Lieberkühn, with their epithelial cells, are quite distinct, and, with the exception of some conversion into goblet cells, their lining epithelium has undergone but little

<sup>1</sup> Mus. Roy. Coll. Surg. Eng., No. 2,710.

change. The connective tissue between the crypts is intensely congested, and in some parts the walls of the vessels have given way, so that blood has been extravasated into the lumen of the intestine. The muscularis mucosæ is so infiltrated with inflammatory products that in many places it is no longer present as a uniform layer. The submucous and muscular coats are enormously congested, and are in a state of diffuse suppuration, for they are greatly thickened by a large number of small round cells mixed with extravasated red blood corpuscles. At the part where the section is made, the serous coat of the intussusceptum has



FIG. 12.—Section from the ileum of a woman who had an enteric intussusception associated with a polypus. The villi have become mere processes of connective tissue. The submucous layer is full of extravasated blood, but the mucous and muscular coats maintain their normal thickness.

formed dense adhesions to the serous coat of the middle layer of the invaginated intestine, whose submucous coat is itself thickened by an extravasation of blood.

**Changes in Adults.**—The changes which take place in the invaginated intestine of adults are in some points identical with those which occur in the more delicate tissues of children, but in others they are widely different. This section<sup>1</sup> (Fig. 12) was taken from the ileum of a married woman, æt. 30, who was seized

<sup>1</sup> *Trans. Path. Soc. Lond.*, 1892, vol. xliii., p. 74.



with a sudden abdominal pain on November 21. Her abdomen was opened on November 25, and the small intestine was found to be invaginated and irreducible for 5 inches at a point situated 2 feet above the ileo-cæcal valve. The intestine was cut away, and with it a small fibrous polypus undergoing calcareous degeneration, which was attached to the mucous and muscular coats of the ileum just above the beginning of the intussusception. The patient died of peritonitis on the day after the operation. The histological changes in the intussuscepted intestine<sup>1</sup>



FIG. 13.—Some of the villi from the same specimen as the preceding, to show the changes which have taken place in them.

are very great, and must have been in progress for some time, though the actual duration of the symptoms was short. The villi (Fig. 13) are mere shrivelled tags of connective tissue, from which the columnar epithelium has disappeared, whilst the adenoid tissue, the involuntary muscle, and the central lymphatic have been replaced by small round cells, the products of the chronic inflammatory change which has affected the walls of the intestine. Congested vessels are visible here and there, and in many places blood is extravasated into the connective tissue. The submucous layer (Fig. 12), too, is full of extravasated blood,

<sup>1</sup> St. Barth. Hosp. Mus., No. 2,191 (*a*).

which has pushed aside all the other structures except the greatly dilated veins filled with blood corpuscles, which still remain conspicuous objects in the section. The pigmented granules surrounding the margin of each bloodvessel show the chronic nature of the irritation, for the granules consist of altered blood pigment derived from the disintegration of red blood corpuscles. The extravasation of blood has involved the muscular coat of the intestine, so that the individual fibres of the circular and longitudinal layer of muscle are separated from each other by the red blood corpuscles which are lying free between them. The serous coat of the intestine also contains a few blood corpuscles in the meshes of its connective tissue.

The Museum of the Royal College of Surgeons of England contains (No. 2,704) an interesting preparation presented by Sir Stephen Hammick. It was taken from the body of a sailor, *æt.* 27, who had suffered from symptoms of chronic intestinal obstruction for six months before his death. A tumour was felt to the right of his navel for two months before he died of emaciation. The post-mortem examination of the body proved that this tumour was an intussusception of the ileum, *cæcum*, and colon, into the lower part of the large intestine. Microscopic examination of the ileum from this specimen shows that the submucous tissue beneath the muscularis mucosæ is congested, but that the chief change is a conversion of the submucous and muscular coats of the intestine into dense fibroid tissue, containing little, if any, cellular infiltration. The villi upon the mucous membrane are greatly congested, but they do not seem to have undergone the mummifying changes seen in Fig. 13.

**Exfoliation of Intestine.**—The next two cases are examples of chronic intussusception, which end either in the death of the patient (as in the last case, from exhaustion), or in exfoliation of the invaginated intestine. Recovery sometimes occurs after exfoliation, but in about 40 per cent. of these cases death results from the secondary accidents which attend the process of repair when the separated gut has been discharged. Such a separation of the bowel is more usual in adults than in children, but the Museum of the Middlesex Hospital contains (No. 1,537) 5 inches of ileum cast off from the intestine of a child, *æt.* 7 months. The gut is turned inside out.

Another specimen of exfoliated bowel was presented to the

Museum of the Royal College of Surgeons (No. 2,715) by Mr. Hacon of Hackney, who has very courteously given me details additional to those which he furnished to Dr. Peacock when he showed the preparation at the Pathological Society of London in 1864.<sup>1</sup> It consists of a piece of bowel measuring 40 inches in length, with a polypus attached to its upper end. The piece of bowel was passed by a lady, æt. 32, who was suddenly attacked with vomiting and abdominal pain on December 28, 1863. The symptoms recurred at intervals for two or three weeks, and at the end of this time she had complete intestinal obstruction,



FIG. 14.—A section from a part of the small intestine passed by a lady who survived for many years. The whole thickness of the section consists of dense fibroid tissue, except along the upper border, where the outline of the mucous membrane is still visible, though none of its details can be made out.

lasting for two or three days. The bowels then acted regularly, and without the passage of blood. The piece of intestine was passed by the anus, enveloped in faecal matter and without any blood, upon the eighteenth day after the supervention of the severe obstruction, and fifteen days after the resumption by the bowel of its normal habit. The patient died, unmarried, July 30, 1889, from some lung trouble. She became very thin before her death, and at times was subject to constipation, but she never

<sup>1</sup> *Trans. Path. Soc. Lond.*, vol. xv., p. 113.

again suffered from obstruction of the bowels. No post-mortem examination of the body was made.

The specimen consists of the whole thickness of the intestinal wall, for portions of the mesentery are still attached to it, and the mucous membrane is seen covering its inner side. The microscopic sections (Fig. 14) show that all the coats of the intestine have undergone sclerosis. The line of the mucous membrane is distinct, though none of the details of its structure can be seen, but the submucous coat is indistinguishable from the muscular, and the muscular layers from each other, or from the serous coat. The whole thickness of the section consists of dense fibroid tissue, like that found in an old scar. This tissue is a little more cellular, and rather more vascular just beneath the mucous membrane, and along its outer border; but otherwise it is a dense hyperplasia of the connective tissue, containing a few large vessels which appear black in the section, for they are filled with stained celloidin.

The Museum of Guy's Hospital contains a specimen<sup>1</sup> of equal interest to that just described. It consists of a piece of intestine exfoliated from a child, *æt.* 1 year, who recovered from an intussusception. The piece of intestine measures 12 inches in length, of which 1 inch is small intestine, the remainder being cæcum and ascending colon. It forms a single tube, which is turned inside out in such a manner that the vermiform appendix lying within its lumen opens directly upon its outer or mucous surface. The microscopical sections which I have examined show that the walls consist of fibrous tissue.

It is not necessary, however, that the intestine should undergo a process of sclerosis before it can be cast off with safety to the patient. The very next specimen at Guy's Hospital<sup>2</sup> consists of 18 inches of small intestine, passed by a woman, *æt.* 33, twelve days after she had been seized with symptoms of intussusception. The patient afterwards recovered. The bowel has not been turned inside out, for the mesentery is still visible upon its outer side. Microscopic sections show that the exfoliated piece of bowel contains each layer of a normal intestine, but merely as a skeleton of digested fibrous tissue or reticulin, for everything has disappeared except the connective tissue, some nuclei, and the débris of a few cells. All the coats of the bowel have been intensely

<sup>1</sup> Guy's Hosp. Mus., No. 1,105.

<sup>2</sup> *Ibid.*, No. 1,106.

congested; but the muscles, the bloodvessels, and the cells have been completely removed.

A similar specimen is in the Cambridge Museum, and Dr. Joseph Griffiths has kindly allowed me to take a section from it. It is a portion of the whole circumference of the bowel—measuring 26 inches in length—which was passed by a governess between 20 and 30 years of age, who is still alive. She had suffered for some time from an obscure intestinal affection. The bowel, as in the preceding case, was passed without being turned inside out,

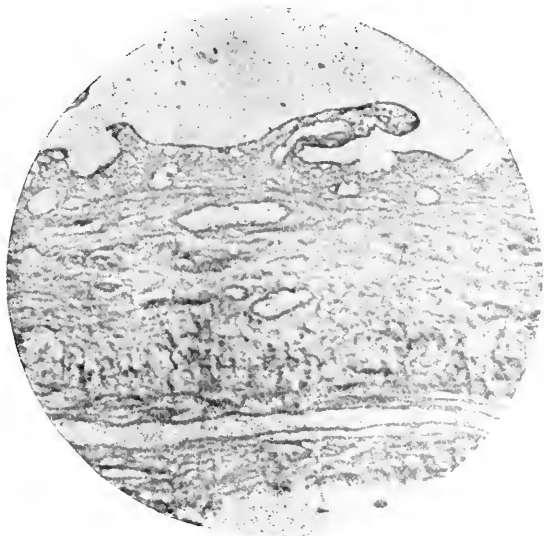


FIG. 15.—A section through a piece of bowel which was passed by a woman *æt.* 48. She died ten days later. The bowel has been reduced to its connective-tissue elements, which have become converted into reticulin by a process of tryptic digestion.

for the mesentery is seen on the outside of the specimen. The sections show that every layer of the intestine has been intensely congested, but that only its connective-tissue skeleton of reticulin remains.

Almost identical appearances are seen in a section<sup>1</sup> (Fig. 15) taken from a piece of intestine passed by a woman, *æt.* 48, who had been seized with signs of internal strangulation seventeen days previously. The symptoms of strangulation continued for six days and then abated, but the piece of intestine was not

<sup>1</sup> St. Barth. Hosp. Mus., No. 2,189.

passed until eleven days after the improvement began to show itself. There were faecal evacuations after the intestine had been passed, but the patient died exhausted ten days later. A section of the intestine examined under the microscope shows that the villi are mere ghosts of their former selves, that they have been intensely congested, and that their epithelial covering has completely disappeared. All the crypts of Lieberkühn have vanished, but there are still traces of solitary follicles, though their position is very often only indicated by empty spaces. The submucous tissue is moderately thickened, but its cellular elements have disappeared so completely that it also is reduced to a skeleton of reticulin riddled with holes, marking the position of the congested bloodvessels. The muscular fibres have entirely disappeared, and the outer margin of the intestine is represented by an irregular border of connective tissue.

The changes which have taken place in these three specimens are identical. All the elements of the intestinal wall have disappeared, with the exception of the connective tissue. The connective tissue has itself become converted into reticulin, a substance which can be obtained artificially by digesting it with trypsin—the pancreatic proteolytic ferment—or with papain. I have, therefore, no hesitation in saying that these pieces of intestine have undergone digestion within the body before they were eliminated, and that the changes which they show are not due to any process of maceration.

The ileum and a portion of the caecum have also been preserved<sup>1</sup> from the last case, so that it is possible to examine sections taken through the scar left after the separation of the intestine. The sections show that the mucous membrane is greatly congested, and is undergoing a series of changes similar to those seen in Fig. 15, whilst the submucous layer is infiltrated with small round cells. The muscular layers are in a state of advanced degeneration, but the adhesion has taken place by the serous surfaces, which have become converted into layers of such well-formed connective tissue that it is no longer possible to say where they blend.

Similar changes have taken place in another piece of intestine<sup>2</sup> obtained from the body of a man who had voided a part of his

<sup>1</sup> St. Barth. Hosp. Mus., No. 2,190.

<sup>2</sup> Mus. Roy. Coll. Surg. Eng., No. 2,717.

bowel many years before his death. The canal of the colon at the point where the section was made only measured  $\frac{1}{2}$  an inch in diameter. The mucous membrane is continuous, and is everywhere provided with crypts of Lieberkühn, and healthy solitary glands are present. The muscularis mucosæ has disappeared, and the submucous layer is greatly thickened. It consists of dense scar tissue, free from cells, and not very vascular at the part nearest the mucous membrane; more vascular, and containing many inflammatory cells, in the part lying just above the circular muscle. The circular muscle itself is still inflamed, for it is invaded by small round cells. It is greatly thinned in parts, and long bundles of connective tissue run through it to join the submucous with the serous coat. The longitudinal layer of muscle, like the circular coat, is interrupted by strands of fibrous tissue, whilst the serous coat is unduly vascular, though it is not greatly thickened.

These specimens show that the intestine may undergo at least two kinds of pathological change before it is passed from the bowel: the one a process of sclerosis of its connective tissue, which is probably associated with the long-continued irritation of such a growth as a polypus; the other, a process of tryptic digestion, which leads to the disappearance of everything but the connective-tissue framework of the bowel. This is probably associated with the more acute forms of inflammation. The actual process of repair after a piece of bowel has been cast off stands in need of further elucidation, for I have only examined these two specimens, and neither of them was in a sufficiently good state of preservation to give a series of satisfactory sections. It is evident, however, that the submucous tissue takes a large share in the reparative process, and the inflamed condition of the connective tissue, even after a long period of convalescence, gives clear evidence that a small amount of additional irritation would be sufficient to light up a fresh and acute inflammation of the bowel. We are therefore warned of the prolonged care which is needed to bring these cases to a successful issue.

All the sections which have been described so far have been taken from cases of intussusception, running the ordinary course. I propose now to deal with some of the less common forms.

**Changes in a Multiple Intussusception.**—The specimen from which the following sections are taken was from a case of double

intussusception, which was shown some years ago at a meeting of the Pathological Society of London.<sup>1</sup> It was sent to me by Dr. Emmerson, of Biggleswade, and it shows an intussusception of the ordinary ileo-colic type, with a second intussusception situated in the colon 3 inches nearer to the anus than the first one.<sup>2</sup> The second intussusception is retrograde; that is to say, it is an invagination of the more distal into the proximal portion of the colon. Both intussusceptions have a layer of lymph over the invaginated portions of the intestine. Fig. 16 is from a section of the first or ileo-colic invagination. It presents all the

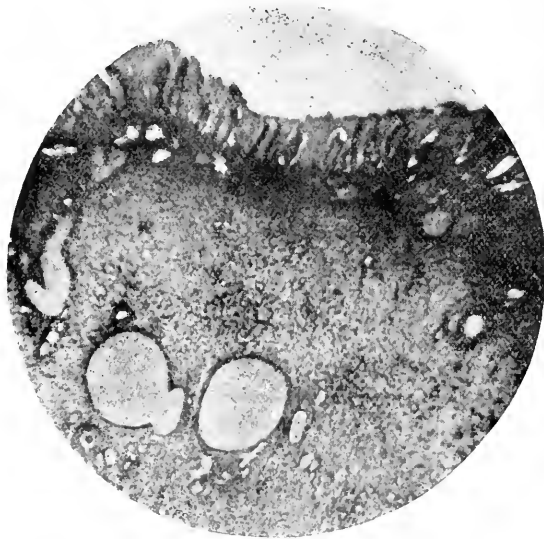


FIG. 16.—Section through the large intestine of a child who died with a double intussusception. The mucous membrane is not much affected, but the submucous tissue is greatly thickened. The chief extravasation of blood has taken place near the muscularis mucosæ, where the section appears darker in the drawing.

characters of an ordinary acute intussusception. Blood has been extravasated into the connective tissue between the crypts of Lieberkühn, which have thus been more widely separated from each other than usual. The submucous coat is also greatly thickened by congestion, and by the extravasation of blood into its connective tissue, but the muscular coats are not greatly

<sup>1</sup> *Trans. Path. Soc. Lond.*, 1886, vol. xxxvii., p. 240.

<sup>2</sup> *St. Barth. Hosp. Mus.*, No. 2,181 (a).



affected, nor is the mesentery inflamed. The greatest effusion of blood has taken place near the muscularis mucosæ, for the deeper portions of the submucous tissue and the muscular coats are merely congested and œdematous. The longitudinal layer of muscle is much less affected than the circular layer, as is usual in intussusceptions.

Fig. 17 represents a section taken from the second or retrograde intussusception. The relative thickness of the mucous, submucous, and muscular layers is unaltered, but the serous coat is congested and the mesentery is inflamed. It is therefore fair to assume



FIG. 17.—Section through the second or retrograde intussusception, from the same case as the preceding. The relative thickness of the mucous, submucous, and muscular layers is unaltered, but the serous coat is thickened and its vessels are congested.

that the retrograde invagination was formed later than the ileocolic intussusception. It seems to have been produced when the child was so exhausted that the wall of its alimentary canal hardly responded to the effects of pressure, yet the patient was not absolutely moribund, for there is a slight congestion of the blood-vessels in the submucous tissue, and the vessels in the serous coat and in the mesentery are greatly enlarged.

The patient was a boy, æt. 5 months, who was so suddenly

attacked with illness five days before his death that he was thought to have had a "fit." He suffered from the usual symptoms of intussusception, and on the day following the attack his motions consisted of "blood and slime." No abdominal tumour was felt until the third day of his illness. Injections and inflation failed to relieve him; but his parents refused to allow an operation for his cure.

**The Rarer Forms of Intussusception.**—Intussusception in children is nearly always spontaneous, and post-mortem examination does not often reveal any definite cause for its occurrence. A specimen<sup>1</sup> in the Museum of St. George's Hospital, however, is an exception to the rule. It is an ileo-cæcal invagination, which caused the death of a child, æt. 5 months. The cæcum contains three growths, each about the size of a split almond. Microscopical examination of one of the growths shows that it is a small, round-celled sarcoma, growing from the submucous tissue immediately beneath the muscularis mucosæ. The stress of the invagination has fallen upon the serous coat and the mesentery, which are greatly thickened by a plastic exudation, whilst the muscular and submucous layers are healthy. When an intussusception occurs in an adult, on the other hand, a determining cause can nearly always be found. It may be physiological, for the invagination may follow upon a direct injury to the abdomen, and in some cases it is as truly spontaneous as it is in children; but far more frequently the cause is some form of new growth, either innocent, like a polypus or a papilloma, or malignant, like a cancer, less often a sarcoma.<sup>2</sup> Vierhuff,<sup>3</sup> and more recently Dr. Sutherland, have seen intussusceptions begin during an attack of purpura; and in such a disease the mechanism of its production is easy to understand in the light of the histological details which have just been demonstrated. Polypi and carcinomata are the usual growths associated with intussusceptions in adults; polypi when the intussusception occurs in the small intestine, carcinoma when it is found in the large intestine, though Mr. Bryant has lately called attention<sup>4</sup> to papillomata causing intussusception of the large intestine in old people.

<sup>1</sup> St. George's Hosp. Mus., Ser. 9, No. 80 (*i*).

<sup>2</sup> The Middlesex Hosp. Mus., No. 1,534; *Trans. Path. Soc. Lond.*, 1867, vol. xviii., p. 114.

<sup>3</sup> *St. Petersb. med. Wochenschr.*, 1893, s. 320.

<sup>4</sup> *Med.-Chir. Trans.*, London, 1894, vol. lxxvii., p. 169.

Many of the spontaneous intussusceptions occurring in adults are found to be in the small intestine—at any rate, as the specimens are seen in the various museums; but I cannot help thinking that this is because they are preserved on account of their rarity, until, when they are all seen together, they form such a goodly array as to give a false idea of their relative frequency, for in reality they are very rare. Polypi are a much more frequent cause of adult intussusceptions, and of these I have found two unusual cases, the one rare in virtue of its position,<sup>1</sup> the other on account of its course.

The first is a specimen preserved in the Museum of Guy's Hospital (No. 1,091). It is an intussusception, measuring 18 inches in length, and situated at the top of the jejunum. It contains a polypoid growth at the apex of the intussusception, and other polypi are present in the duodenum. Dr. Shaw, the curator of the museum, has kindly allowed me to make a microscopic examination of one of the polypi, and I find that it is of a glandular nature. The specimen was obtained from the body of a girl, æt. 19, who had suffered for a year and a half before her death from periodical attacks of vomiting and abdominal pain, associated with progressive wasting. She was decidedly benefited by enemata of sulphate of magnesia, as obstinate constipation was a prominent symptom throughout her illness. Dr. Goodhart,<sup>2</sup> who examined her shortly before she died, found that she had a dilated stomach, with a tumour in the left flank, extending obliquely towards the pubes. This tumour underwent slow rhythmic alterations, being alternately hard and well defined, and soft and ill defined. At the autopsy, the coats of the intussuscepted intestine were found to be thickened, but not obviously inflamed. There were two other invaginations in the small intestine, but both were apparently of quite recent origin.

The second specimen appears to be most rare. It was presented to the Royal College of Surgeons of England by John Taunton, the founder of the City of London Truss Society, a most enthusiastic morbid anatomist, and the last of the great dispensary doctors in London. It is described in the catalogue of the museum (No. 2,719) as a "part of the ileum, in which is an intussusception about 6 inches in length. At the lower end of the

<sup>1</sup> See also Thompson, *Journ. of Anat. and Physiol.*, 1897, p. 392.

<sup>2</sup> *Trans. Clin. Soc. Lond.*, 1886, vol. xix., p. 146.

intussuscepted intestine there is a firm tumour, of oval form,  $2\frac{1}{2}$  inches in length, and 1 inch in diameter, attached to the mucous membrane, and projecting into the canal of the ensheathing part of the intestine. . . . The coats of all parts of the intestine are thickened." The patient, *æt.* 45, had been ill for three months before her death, complaining of extreme pain in the left side and back, as if something within the abdomen were pressing the ribs and spine outwards. She had also occasional nausea and vomiting, with constipation and a sensation of heat in her abdomen. She was variously treated, but without advantage, and gradually sank; vomiting of a *fæcal* character supervened shortly before her death. All the organs, with the exception of the part preserved, were found to be healthy.

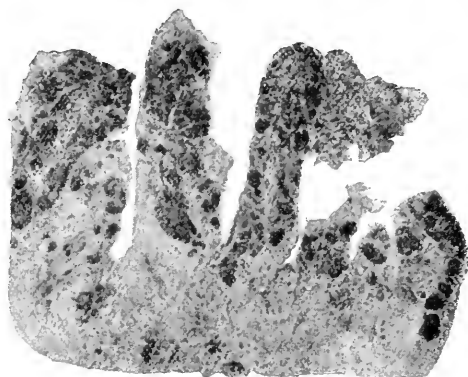


FIG. 18.—Section from the ileum of a woman who died of an intussusception associated with a sarcomatous growth. The villi contain numerous oval bodies, which appear to be thrombosed vessels.

Microscopical examination of the tumour shows that, in spite of its age—John Taunton died March 5, 1821—it is in an excellent state of preservation. The thickening of the coats of the bowel is due to a new growth—apparently a sarcoma—which has begun to grow in the serous coat, and has extended into the longitudinal and circular layers of muscle, completely disorganizing them. The submucous tissue is greatly thickened, the result of a chronic inflammation, but it is not invaded by the new growth. The muscularis mucosæ forms a continuous layer, except at the points where it is penetrated by large bloodvessels passing into the mucous membrane. These vessels, as well as those in the sub-

mucous tissue, contain blood corpuscles, aggregated by post-mortem clotting. In the mucous membranes the crypts of Lieberkühn are healthy, and present no unusual appearances. The villi are large and well defined. They have lost their coats of columnar epithelium, but they contain (Fig. 18) numerous oval and circular bodies, of whose appearance I am unable to give quite a satisfactory explanation. I thought at first that they were the results of parasitic infection, and were either psorosperms or amœbæ, but more careful examination leads me to believe that they are thrombosed vessels cut in various directions.

Intussusception of the colon, associated with cancer of the large intestine, runs a very chronic course, and may be present without giving rise to any symptoms except those which may fairly be attributed to the cancerous infiltration. The Museum of St. Bartholomew's Hospital contains a specimen<sup>1</sup> from a case where such a condition was not in the least suspected during life, and the cause of the invagination remained obscure until a section was made for the purposes of this work. The preparation consists of parts of the descending colon and sigmoid flexure which have been invaginated into the rectum. It was taken from a woman, æt. 40, who had suffered for the last two years of her life from attacks of obstruction of the bowels, sometimes accompanied by fæcal vomiting. She ultimately died of gangrene of the foot and leg. A microscopical examination showed that the intussusception was associated with an adenoid cancer of the rectum. The mechanism of such an invagination appears easy to explain. It seems to be of the paralytic variety, for the infiltrated portion of the intestine would be less capable of peristaltic contraction than the healthy gut. It would, therefore, be more liable to be engulfed by the distal part of the alimentary canal—a liability which would be increased by the constant forcing movements of the proximal part of the intestine which attend so chronic a form of obstruction, while the distal end of the bowel became invaginated in a similar manner, forming a retrograde intussusception.

**Summary.**—Such, then, are some of the minute anatomical changes which occur in the intestine as a result of intussusception. It is clear that any part of the intestinal wall may be affected. One portion usually suffers more than the others, and the stress

<sup>1</sup> No. 2,188 (b).

of the affection falls most often upon the submucous tissue and upon the circular layer of muscle. The mucous membrane, too, may be seriously injured, but the longitudinal layer of muscle and the serous coat are the least often affected. The earliest histological changes are correlated with an effusion of blood, but the amount of the extravasation varies greatly, at one time so slight as hardly to displace the tissues, at another time so considerable as utterly to destroy them. The seat of the extravasation, too, varies. It may be in the mucous membrane, and it seems to me that this occurs in the most acute cases; it is usually in the submucous coat, though it may be in the muscular layers or in the serous coat. The extravasation is followed by inflammatory changes, in which the submucous tissue and the circular layer of muscle are chiefly involved. These changes terminate in hyperplasia of the connective tissue, leading to sclerosis; in a tryptic digestion, leading to the disappearance of every cellular element in the wall of the bowel, and the conversion of its connective tissue into reticulin; in diffuse suppuration or in sloughing of the inflamed bowel, which is then separated and cast off by the ordinary process of ulceration.

## CHAPTER II.

### THE PATHOLOGY OF INTUSSUSCEPTION.

ATTENTION was drawn in the former chapter to some of the minute structural changes which take place in invaginated portions of the intestine. The present chapter will be devoted to a consideration of some points in the pathology of intussusception. The science of pathology is based upon data obtained from anatomy, physiology and clinical observation. It is therefore necessary to follow intussusception along these lines, and afterwards to draw certain conclusions from the premisses thus obtained.

#### 1. ANATOMICAL DATA.

**The Anatomy of the Ileo-colic Angle.**—The evidence derived from anatomy is more valuable than that to be obtained either from physiology or from clinical observation, for anatomy is more nearly akin to an exact science. From 40 to 60 per cent. of all the recorded cases of intussusception are said to occur in the ileo-cæcal portion of the alimentary canal. A careful anatomical examination of this part of the intestine has therefore been made. The results are set out in the accompanying table.

As intussusception is said to be a very rare affection amongst races who subsist largely upon cereals and eat but little, if any, meat, I applied to my various friends abroad, and after much trouble Surgeon-Major Gibbons and Surgeon-Captain O’Kinealy, I.M.S., stationed at Calcutta, succeeded in obtaining for me the cæca of two native children (Nos. 37 and 43 in the table). It will be seen, however, that the measurements do not differ greatly from those of European children of a similar age. But if

intussusception is really a rare condition in India, some interesting results might be obtained by a systematic series of measurements.

It should be stated that the mesentery in each case was measured as soon as the body was opened, but the measurements are only approximately correct, because it is difficult to obtain constant points from which to measure, and because the mesentery is very easily stretched. All the other measurements were made when the specimen had been hardened in Müller's fluid or Foa's solution, and afterwards in 30, 60 and 90 per cent. alcohol, remaining in each strength for twenty-four hours. I believe that by adopting so uniform a method of hardening more accurate results have been obtained for purposes of comparison than could have been gained by measuring the fresh intestines, a proceeding which is difficult on account of the extensibility of their walls. The actual width of the intestines seemed to be unimportant, as I was only interested in their relative diameters. The mesentery in each case was measured at a point in the colon 2 inches away from the top of the ileo-colic junction; the ileum was measured at the same distance above it, and the colon at the same distance below it. All the measurements are expressed in terms of millimetres for the sake of ease and accuracy.

**The Ileo-colic Mesentery.**—The length of the ileo-colic mesentery is a matter of interest in considering the pathology of intussusception, because the size of an intussusception must depend to a great extent upon this factor. Mr. Lockwood<sup>1</sup> has carefully measured the length of the mesentery in 100 individuals, and has arrived at the conclusion that the mesentery in children is longer than it is in adults. Mr. Lockwood's results are confirmed by the measurements I have collected. A reference to the table will show that the length of the mesentery is singularly constant in all the specimens measured, and as the age of the individuals varied considerably, this means that the proportion to the length of the body is much greater in infants than in older children. Increased length of mesentery is associated, other things being equal, with increased range of movement in the intestine. The intestines should therefore be capable of a greater

<sup>1</sup> Hunterian Lectures on the Morbid Anatomy, Pathology and Treatment of Hernia, 1889, pp. 16, 17, and 36.



Num. ber.	Age.	Sex.	Type of mesenteric sac.	Length of mesenteric sac.	Locum. Ter. of mesenteric colon.	Direction and Breadth of Flexed Valve.		Direction of Axis of Mesenteric Sac.	Arrangement of Peritoneal Folds and Mesenteric Glands.
						mm.	mm.		
1	6 to 8 months	—	B	—	5	6	—	upwards	
2	6 to 8 months	—	—	—	9	12	—	upwards	Figured and measured by Professor Struthers, <i>Edinburgh Med. Journal</i> , vol. 10, p. 1, 1833. Figs. 1, 2.
3	6 to 8 months	F	A	50	5	6	circular	upwards	Complex and deep superior fossa; inferior fossa deep and complex; glands numerous; capacity of colon, 6 ounces = 160 cc.
4	at 13 mo. 7 mo. 8 mo. 9 mo. 10 mo. 11 mo.	F	A	55	11	14	long oval	upwards	Shallow and incomplete superior fossa; deep inferior fossa; glands large; capacity of colon, 7½ ounces = 190 cc.
5	at 13 mo. 7 mo. 8 mo. 9 mo. 10 mo. 11 mo.	F	A	60	9	9	circular	convex upwards	Complex superior fossa; no inferior fossa; capacity of colon 8 ounces; vermiform appendix attached by three parts to its length to the back of the caecum.
6	5 days	F	E	—	11	12	hernial	horizontal	A well marked superior fossa; a wide inferior fossa
7	5 weeks	M	C	35	11	16	horizontal	horizontal	A shallow superior fossa; no inferior fossa; many small lymphatic glands in the mesentery.
8	5 weeks	M	A	52	11	14	circular	downwards	Shallow superior fossa; numerous complex inferior fossa; gland parallel with caecum; capacity of colon, 5 ounces.
9	8 weeks	F	D	46	13	20	horizontal	upwards	Deep superior fossa; no inferior fossa; a collar of lymphatic glands in the caecal fold. Fig. 24.
10	15 weeks	F	A	47	15	19	pecker-shaped	convex downwards	Wide superior fossa; wide and deep inferior fossa; one large lymphatic gland in the ileocolic fold. Fig. 22.
11	5 months	M	C	37	13	22	horizontal	upwards	No superior fossa; the inferior fossa is behind and above in 2/3 of its length to the back of the caecum.
12	5 months	M	A	31	15	25	oval	horizontal	Very deep superior fossa; no inferior fossa; lymphatic glands in the caecal fold and in mesentery.
13	5 months	M	C	42	17	22	leaf-shaped	upwards	Very shallow ileocolic fossa; shallow and wide ileocolic pouch; several glands in the caecal fold; capacity of colon, 13½ ounces.
14	6 months	F	C	50	13	11	transverse	—	Capacity of colon, 14 ounces; stomas of ileo-duct; wall of large intestine almost entirely.
15	6 months	F	E	50	14	20	horizontal	horizontal	Well marked superior fossa; deep inferior fossa; with one ileo-colic edge; one lymphatic gland in the caecal mesentery.
16	6 months	M	A	—	11	25	egg-shaped	upwards	Shallow superior fossa; deep inferior fossa; lymphatic glands in mesentery; and one in the caecal fold over colon
17	7 months	M	E	41	11	20	oval	horizontal	Deep superior fossa; very deep inferior fossa; with thin ileo-colic margin; capacity of colon, 30 ounces.
18	7 months	F	A	50	15	22	horizontal	horizontal	No superior fossa; no inferior fossa; glands in mesentery; capacity of colon, 25 ounces.
19	8 months	M	C	47	15	28	transverse	horizontal	Very shallow superior fossa; no inferior fossa; large glands in mesentery; capacity of colon, 18 ounces.
20	8 months	M	D	60	16	26	transverse	horizontal	Shallow superior fossa; no inferior fossa; one lymphatic gland in the caecal fold.
21	9 months	M	E	47	11	15	circular	downwards	Deep superior fossa; very shallow inferior fossa; lymphatic glands low and small.
22	9 months	M	D	55	13	22	oval	upwards	Deep superior fossa; no inferior fossa; capacity of colon 16 ounces; complete meso-colon.
23	9 months	F	C	45	15	18	horizontal	upwards	Deep superior fossa; well marked inferior fossa; a large mass of glands in the caecal mesentery.
24	9 months	M	A	41	15	24	horizontal	horizontal	No superior fossa; no inferior fossa; one large lymphatic gland in the ileocolic mesentery.
25	11 months	M	A	47	16	20	semicircular	upwards	Shallow superior ileocolic fossa; very large and deep sub-caecal fossa; one lymphatic gland in the ileo-colic mesentery.
26	11 months	M	E	50	14	26	horizontal	horizontal	Deep but incomplete anterior fossa; very deep posterior fossa; glands in mesentery; capacity of colon, 19½ ounces.
27	12 months	F	A	62	13	21	transverse	convex upwards	Shallow and incomplete anterior fossa; large and very deep posterior fossa; aggregated glands in mesentery; capacity of colon, 13 ounces.
28	14 months	M	A	51	15	15	transverse	horizontal	Neither superior nor inferior fossa very complex, but the superior fold is much thickened and congested. The caecal fold with treatment also ceases to infundibulose seventy-two hours after onset.
29	14 months	M	C	260	19	37	circular	upwards	No superior fossa; inferior fossa narrow and deep; no glands.
30	15 months	M	A	56	15	25	horizontal	horizontal	Shallow ileocolic fossa; though the fold contains two glands, no ileocolic pouch; capacity of colon, 25 ounces.
31	15 months	M	B	50	16	33	horizontal	upwards	Shallow superior fossa; inferior fossa deep, with wide mouth; gland in mesentery; none in the caecal fold.
32	16 months	M	A	38	11	15	circular	horizontal	No superior fossa; inferior fossa shallow and wide; a chain of lymphatic glands lies parallel with the caecum.
33	16 months	F	D	38	22	29	horizontal	upwards	Incomplete superior fossa; shallow posterior fossa; numerous discrete glands; capacity of colon, 31 ounces.
34	17 months	F	C	48	13	26	transverse	horizontal	Shallow superior fossa; deep inferior fossa; opening forwards; glands over the caecal junction.
35	18 months	M	A	—	17	20	horizontal	semicircular downwards	No superior fossa; inferior fossa wide and shallow; two glands in the caecal mesentery; the caecum is simply bent upon itself, to pass behind the ileum. Fig. 20.
36	25 months	M	A	63	11	21	very pecker-shaped	convex upwards	A Hindu child. No ileocolic fold; no inferior superior nor inferior fossa well marked.
37	2 years	M	C	60	17	27	horizontal	horizontal	Shallow superior fossa; well marked and wide inferior fossa; glands in the caecal mesentery; and one in the caecal fold.
38	2 years	M	E	45	21	28	horizontal	horizontal	Deep superior fossa; deep and wide inferior fossa; large lymphatic glands in mesentery; but none in the caecal fold.
39	2½ years	F	A	45	19	32	horizontal	convex upwards	Shallow superior fossa; deep inferior fossa; glands in the caecal fold.
40	2½ years	M	A	—	15	26	horizontal	—	Shallow superior fossa; deep inferior fossa; glands in the caecal fold.
41	2½ years	F	E	—	26	25	horizontal	horizontal	Shallow superior fossa; deep inferior fossa; with small caecal gland; in mesentery at a distance from the ileo-colic fold.
42	2½ years	M	A	33	15	30	horizontal	convex upwards	Shallow superior fossa; no inferior fossa; capacity is derived from lower border of ileum; it is double, and forms a very delicate pouch a inch in depth; no glands at ileo-colic junction; one large gland in the mesentery. Fig. 21.
43	3 years	M	A	60	18	24	vertical	horizontal	No ileocolic fold; no ileocolic fossa; neither superior nor inferior fossa well marked.
44	3 years	M	A	46	17	30	oval	upwards	Shallow superior fossa; very deep inferior fossa; glands greatly enlarged; complete ileocolic fold thick and narrow.
45	3½ years	M	A	50	16	23	vertical	horizontal	Shallow superior fossa; wide and deep inferior fossa; many lymphatic glands.
46	4 years	F	C	75	15	34	transverse	horizontal	No superior nor inferior fossa; a few glands; capacity of colon, 29 ounces.
47	4 years	F	A	—	15	42	horizontal	horizontal	Good superior fossa; inferior fossa deep with pouch caudal; glands both in the caecal fold and in mesentery.
48	4 years	M	A	57	18	39	horizontal	upwards	Shallow superior ileocolic fossa; very complex inferior fossa; two large glands at ileo-colic angle; with a few smaller ones. Deed of ileo-colic infundibulose; ileo-colic junction; one large gland in the mesentery. Fig. 24.
49	4 years	M	B	—	16	20	oval	upwards	Shallow superior ileocolic fold; deep inferior fossa; with thin edge; glands in mesentery; none in the caecal fold.
50	4½ years	F	A	45	20	35	horizontal	upwards	No superior fossa; no inferior fossa; no lymphatic glands.
51	5 years	M	C	67	14	28	prolapse of mucous membrane of ileum into caecal	upwards	Deep superior fossa; very deep inferior fossa; discrete glands in mesentery; capacity of colon, 24 ounces.
52	5 years	F	—	100	16	28	—	—	
53	6 years	M	D	—	18	29	—	—	
54	9 years	F	A	50	17	33	horizontal	upwards	Thin superior fossa; shallow and wide inferior fossa; glands in mesentery at a distance from the caecal junction.
55	9 years	F	I	57	17	45	horizontal	upwards	Well marked superior fossa; very deep inferior fossa; with a minute caecal pouch; several glands in mesentery; one in the caecal fold.
56	9 years	M	A	—	26	40	horizontal	horizontal	Shallow superior fossa; deep and complex inferior fossa; no glands.
57	10 years	F	B	—	15	35	transverse	horizontal	A shallow superior fossa; no inferior fossa; no glands.
58	10 years	F	C	51	23	66	circular	horizontal	No mesenteric attachment to upper border of ileum; the ileo-colic junction is surrounded by the caecum, but the superior pouch is deep; there are no inferior folds; the capacity of the large intestine was 79 ounces.
59	11 years	M	C	62	17	35	transverse	upwards	Deep and complete superior fossa; no inferior fossa; gland in mesentery; capacity of colon, 40 ounces.
60	11 years	F	A	58	15	47	horizontal	horizontal	A singularly deep superior fossa; no inferior fossa; glands in the mesentery only. Fig. 19.
61	13 years	M	E	59	16	34	horizontal	upwards	No superior fossa; no inferior fossa; one gland at junction of ileocolic with ileocolic fold.
62	11 years	F	E	109	17	42	horizontal	horizontal	Shallow superior ileocolic fold; complex inferior fossa; large gland in mesentery; capacity of colon, 40 ounces.
63	14 years	F	D	52	22	87	horizontal	horizontal	Very deep and complete superior fossa; no inferior fossa; ileocolic valve easily admits the fore finger. Fig. 23.
64	15½ years	F	A	72	29	49	horizontal	horizontal	No superior fossa; large and deep postero-superior fossa; with shallow postero-inferior fossa; very few lymphatic glands.



range of movement in children than in adults—a result which is confirmed by the practical experience of all surgeons who have had to open the abdomen for the relief of intussusception, for the intestines are nearly always so freely movable that it is easy to bring the tumour into the wound. A few cases, however, are recorded<sup>1</sup> in which the bowel seems to have been anchored with undue firmness.

Careful examination of the ileo-colic mesentery shows that the ileo-colic artery is always present, running parallel with the ileum, and sending numerous branches to it and to the lymphatic glands in its neighbourhood.

These glands vary greatly in their size and distribution; sometimes they lie parallel to the colon, sometimes parallel to the ileum, and sometimes they have no orderly arrangement. They are discrete and seed-like in many specimens; in others they are aggregated into a mass of lymphoid tissue, which often forms a collar or band thickening the edge of the anterior ileo-colic fold; whilst in children who die of tuberculous disease they are characteristically enlarged.

Treitz,<sup>2</sup> Lockwood<sup>3</sup> and others have drawn attention to a suspensory muscle of the duodenum and mesentery. It springs from a band forming the right side of the œsophageal opening in the diaphragm, and is prolonged onwards with the superior mesenteric artery into the mesentery. The presence of such a band of muscular fibres, if it reached as far as the end of the ileum, might form an important factor in the causation of

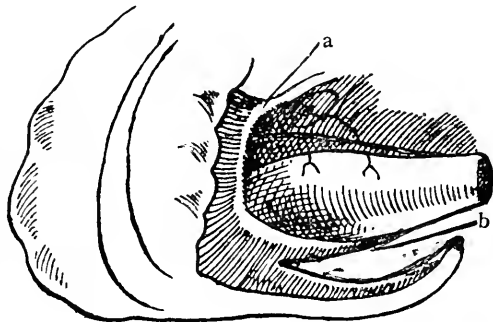


FIG. 19.—A simple but complete form of ileo-colic angle from a girl aged 11 years. The ileo-colic fossa is well formed, and the axis of the ileum is almost horizontal. (a) The ileo-colic fold; (b) the ileo-cæcal fold.

<sup>1</sup> *Trans. Med. Chir. Soc.*, vol. lix., 1876, p. 99.

<sup>2</sup> *Vierteljahrsschrift f. d. Prakt. Heilkunde*, Prag, 1853, p. 113.

<sup>3</sup> Lockwood, *Hunterian Lectures on Hernia*, London, 1889, p. 24.

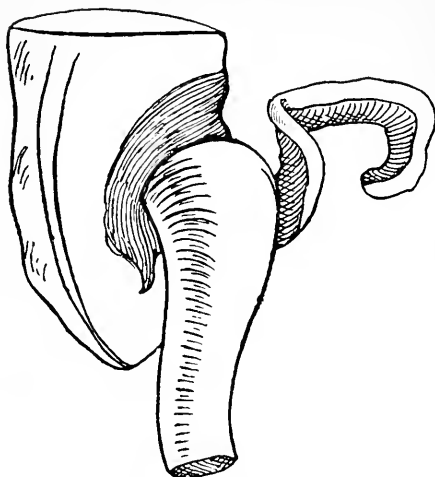


FIG. 20.—The ileo-colic angle of a child aged 23 months. The ileo-colic fossa is absent, and the axis of the ileum is directed upwards to end in the large intestine.

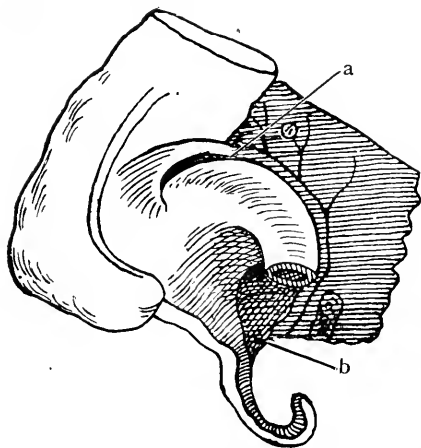


FIG. 21.—The ileo-colic angle from a child aged 2 years and 8 months. The ileo-colic fossa (a) is incomplete, but there is a very large and deep ileo-caecal fossa (b). The axis of the ileum is concave downwards.

intussusception by hindering the movement of one border of the intestine. I therefore took the trouble to stain and make a microscopicalexamination of a piece of the ileo-colic mesentery in each of the specimens, but in none was I able to find a single bundle of muscular fibres.

#### Peritoneal Pouches.—

The point of union of the small intestine with the large intestine next engaged my attention. The axis of the ileum at this point was horizontal in 28 cases (Fig. 19); in 24 it passed upwards to terminate in the large intestine (Fig. 20); in 1 it sloped downwards; in 1 it was concave downwards (Fig. 21); and in 3 it was convex downwards (Fig. 22).

The actual line of union of the ileum with the colon is hidden both in front and behind by folds of peritoneum whose arrangement has been made familiar to us by the works of Mr. Treves<sup>1</sup> and of Dr. Rolleston and Mr. Lockwood<sup>2</sup> in England, and of Dr. Perignon<sup>3</sup> in

<sup>1</sup> "The Anatomy of the Intestinal Canal and Peritoneum in Man," 1885.

<sup>2</sup> *Journ. of Anat. and Physiol.*, vol. xxvi., 1892, p. 130.

<sup>3</sup> *Thèse de Paris*, 1892, No. 4.

France. The folds give rise to pouches whose extent and complexity vary in each specimen, but as a rule those in front of the ileo-colic junction are simpler than those behind it. The anterior ileo-colic fossa resolves itself into two great types, the complete (Fig. 23) and the incomplete (Fig. 24), whilst in a few cases it is entirely absent. The

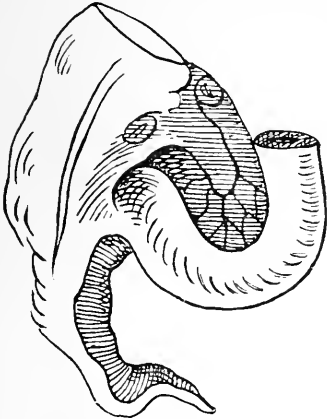


FIG. 22.—The ileo-colic angle of a child aged 15 weeks. The ileo-colic fossa is incomplete, and the axis of the ileum is convex downwards.

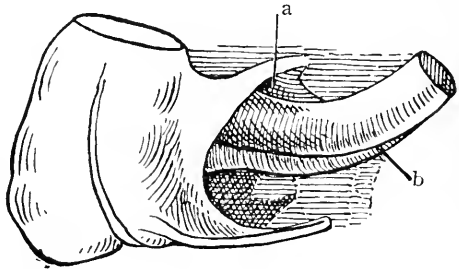


FIG. 23.—The ileo-colic angle of a girl aged 14 years. The ileo-colic fold (a), and the ileo-caecal fold (b) are unusually well developed. The axis of the ileum is nearly horizontal.

complete fossa, which is usually coexistent with the simpler types of cæcum (types A and B of Treves, Fig. 25), is that in which the

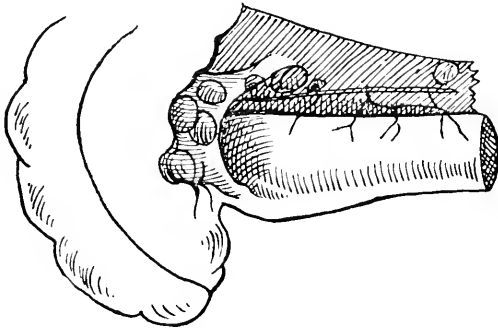


FIG. 24.—The ileo-colic angle of a child aged 8 weeks. The ileo-colic fossa is incomplete, but its roof is studded and thickened with lymphatic glands. The axis of the ileum is horizontal.

ileo-colic fold stretches in a wide sweep from the ileo-colic mesentery across the ileum to form the mesentery of the appendix in its simplest form. This fold is attached to the cæcum externally,

and terminates internally in a crescentic margin forming the mouth of the anterior ileo-cæcal fossa. This margin is some-

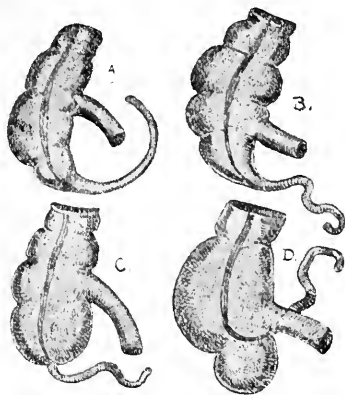


FIG. 25.—Various types of caecum (copied by permission from Treves' "Anatomy of the Intestinal Canal and Peritoneum in Man").

times thick and rounded, at other times thin and membranous, and the fold often contains one or more lymphatic glands. The lower wall of the pouch is formed by the ileo-cæcal fold, which is attached for a varying distance along the lower border of the ileum. Numerous modifications of this type are seen (Figs. 19 and 23), but they all agree in having a pouch of greater or less depth, which involves the whole width of the ileum. The incomplete form of pouch (Figs. 21, 22 and 24) occurs when the anterior ileo-colic fold terminates upon the anterior surface of the ileum.

It is most often found with the more highly developed types of caecum (Fig. 25, C and D). The pouch is then limited to the ileo-colic angle. When there is no pouch (Fig. 20), the anterior ileo-colic fold is attached to the ileum in its whole extent.

The peritoneal folds lying behind the ileo-colic junction are much larger and more complex than those situated in front of it. They are divisible broadly into the ileo-cæcal fossa (Fig. 21), which runs upwards behind the ileo-colic junction, and the sub-cæcal fossæ, which are situated behind the caecum and are less constant than either the ileo-colic or the ileo-cæcal pouches.

The course run by an ileo-cæcal intussusception will depend materially upon the arrangement of these peritoneal folds and their fossæ. When the folds are simple, the fossæ are small, and if lymphatic glands are absent the case is probably only a simple invagination, which can be reduced easily by irrigation of the bowel in its earlier stages, or if it be left unreduced will run a chronic course, killing the patient by exhaustion, or ending in sloughing and separation of the intestine. When the peritoneal folds are complex, the fossæ are large, and if the lymphatic glands are numerous, so much tissue is necessarily invaginated in

addition to the intestine that, if early strangulation does not occur, extensive adhesions of the puckered mesentery will soon be formed, and will make the intussusception irreducible. Such cases will therefore run an acute course. The nature of the mouths of the pouches must also be taken into account. In some cases they are so wide that the fossæ are merely depressions; in others they are no bigger than pinholes, and the fossæ are then closed sacs, whose walls would either easily be brought into apposition by pressure (when they would readily become adherent to each other), or the pouches themselves would become distended by the products of the inflammatory exudation.

**Relative Diameters of the Ileum and Colon.**—It is of importance, too, in considering the anatomical points connected with ileocolic intussusception, to ascertain the relative diameters of the ileum and colon. The width of the large intestine at birth is only a few millimetres greater than that of the small intestine. Before birth its diameter is usually the same, or even a little less, whilst at the age of 15 years it is from two and a half to three times as large. The colon begins to grow in girth directly after birth, as might be expected when we remember that the function of the large intestine is to store up and consolidate the refuse food materials until they can be cast out of the body at convenient times and places. It appears, however, that, while the colon grows in width, it remains almost stationary in length, but, on the other hand, the ileum grows both in length and breadth. The question of the growth of the large intestine in length was very carefully studied by Mr. Treves,<sup>1</sup> but he appears to have overlooked its increase in width. Mr. Treves stated that the length of the intestine is practically constant in the fœtus at birth. The average measurement of the small intestine is then 9 feet 5 inches, and of the large intestine 1 foot 10 inches. The small intestine grows about 2 feet during the first month after birth, and a like rate of growth may usually be recorded at the end of the second month of extra-uterine life; but after that period the development of the lesser bowel proceeds in a most irregular manner, due, perhaps, to physiological factors, for it may be associated with the functional activity, which depends to some extent upon the character of the diet. The length of the colon in the fœtus at

<sup>1</sup> "The Anatomy of the Intestinal Canal and Peritoneum in Man," London. H. K. Lewis, 1885, pp. 9, 10.

term is 1 foot 10 inches, a length which practically remains constant until the child is 4 months old. It grows steadily and regularly after this period, until, in a subject of a year old, it measured 2 feet 6 inches; at 6 years old it was about 3 feet; and at 13 years of age it was 3 feet 6 inches in length.

Mr. Treves executed this portion of his task with such skill and assiduity that I did not think it worth while to work over the same ground; but mindful of Owen, who built up with infinite care the vertebral theory of the skull, founded upon longitudinal sections, only to have it destroyed by Huxley, who cut his skulls across, I took the liberty to measure the widths of the large and small intestines in each of my specimens. These transverse measurements show that the colon increases very rapidly in capacity, though for a time its length may remain stationary. Thus, in the specimen (table, No. 7) obtained from a child aged 5 weeks, the small intestine has the same transverse diameter as in a child at birth; but the diameter of the colon has increased by a quarter, and in a child of 5 months old (table, No. 11), the small intestine remaining of the same diameter, the large intestine has nearly doubled its width. Individual measurements like this prove nothing, but a general review of the figures shows that, whilst the ileum only rarely doubles its diameter, if 11 or 12 millimetres be assumed to be a fair average width at birth, the large intestine not only often doubles its size, but may even treble or quadruple it (*cf.* table, Nos. 12, 29, 64, 58 and 63).

These facts seem to have an important bearing upon the question of the origin of intussusception. The colon is growing in width rapidly and continuously from birth onwards, but at about the age of 4 months—the exact time when spontaneous intussusception becomes common—it also begins to grow in length. The small intestine has grown steadily in length and breadth from the beginning, though the increase in its circumference is less rapid than the increase in its length. During the early months of a child's life, therefore, there is a rapidly increasing disproportion between the transverse diameters of the large and small intestines. Physiology teaches us that too rapid growth is often associated with perversion of function, especially when, as in this case, the increased rate of growth affects both the muscular and the nervous tissues. On the other hand, the anatomical arrangements at the ileo-colic angle may absolutely



prevent the occurrence of an intussusception, for Mr. Treves<sup>1</sup> has observed that "in not a few specimens the terminal part of the small intestine has been closely attached to the psoas muscle, not by direct adhesion, but by means of a fold of peritoneum that has passed from the left or under layer of the mesentery to the serous membrane covering that muscle. In some five specimens I have found the last inch or last few inches of the ileum closely adherent to the cæcum, owing to a certain readjustment of the parts."

**The Ileo-cæcal Valve.**—The last point of anatomical interest to which I directed my attention was the ileo-cæcal valve. The description found in the ordinary text-books of anatomy is substantially correct for most cases, but in many the arrangement differs. The orifice is often oval or circular in the hardened specimens, instead of being transverse to the axis of the intestine, and a part of the valve is frequently so defective that the opening seems to be horseshoe-shaped when it is looked at from the cæcum. In one or two cases the orifice very closely resembled the pyloric opening in the stomach. The end of the ileum nearly always projected for 4 to 7 millimetres into the lumen of the intestine, sometimes as a conical process, at other times more upon one side than upon the other, and in a few cases the mucous membrane of the ileum was distinctly prolapsed into the large intestine, and might thus have formed a starting-point for an intussusception, had the other factors been present.

## 2. PHYSIOLOGICAL DATA.

Let us now turn from the anatomical to the purely physiological side of the question. Experimental work seems more likely to help in the elucidation of the problem than simple observation. Observation tells us, however, that the peristaltic wave, passing along the small intestine, ceases at the ileo-cæcal valve, and that a new wave is developed there by the contraction of the muscular coat of the large intestine. It is quite possible, therefore, for the end of the ileum to be contracted, or even to be absolutely quiescent at the instant when the colon is contracting energetically.

<sup>1</sup> "The Anatomy of the Intestinal Canal and Peritoneum in Man," p. 42.

**Varieties of Intussusception.**—The experimental work of Dr. Leubuscher<sup>1</sup>—elaborated and carried to a more successful issue by Professor Nothnagel<sup>2</sup>—has taught us that intussusception is due to one piece of gut swallowing, so to speak, a neighbouring piece which has become constricted in consequence of local or other causes producing a powerful contraction of its circular layer of muscle. An intussusception, therefore, is essentially and usually spasmodic in origin, and though there may be occasionally a paralytic form secondary to other causes acting upon the intestinal wall, I do not believe that it ever causes a spontaneous invagination.

The important part which is played by the muscular coat of the intestine in producing an intussusception is well seen in two preparations from the museum of Mr. George Langstaff, which are now preserved in the Museum of the Royal College of Surgeons of England.<sup>3</sup> The specimens are portions of the intestines taken from dogs which had been dosed with turpith mineral for the cure of the distemper. Signs of intussusception began almost directly after the drug had been administered. The first dog lived two days, the second dog three days. In the second dog the mucous membrane was highly inflamed, blood was effused into the abdomen from the intestine, which had been ruptured, and there was acute peritonitis; in the first dog the effects were much less severe, but in each there was a well-marked intussusception.

**Effects of Irritants.**—These specimens led me to experiment with turpith mineral, to discover whether the intussusceptions were produced by it, or were merely of accidental occurrence, and they formed the beginning of a series of experiments upon the effects of increasing the peristalsis of the intestine in cases of experimental invagination. The experiments were made upon healthy cats, rabbits and guinea-pigs, as well as upon similar animals whose intestines had been invaginated by drawing the colon over the cæcum and ileum, the neck of the invagination being afterwards fixed with a few point-sutures of silk or horse-hair. In one series of experiments 0·33 gramme (5 grains) of turpith mineral, which is the yellow sulphate of mercury, was

<sup>1</sup> *Virchow's Archiv.*, vol. lxxxv., 1881, p. 83.

<sup>2</sup> "Beiträge zur Physiol. und Pathol. des Darmes." Berlin, 1884, p. 42; *Spec. Pathol. und Therap.*, Bd. xvii., theil ii., 1896, p. 297.

<sup>3</sup> Nos. 2,725 and 2,726.

administered to a young rabbit weighing 1,400 grammes ; a young guinea-pig, weighing 575 grammes, received a similar amount, whilst a second rabbit, weighing 2,800 grammes, received half a gramme of turpith mineral, because it was older and heavier. The drug was administered at 3.30 p.m., and on the following day at half past two the old rabbit and the guinea-pig were dead, whilst the young rabbit was dying.

A post-mortem examination showed that the whole of the intestinal tract of the guinea-pig was in a state of intense inflammation, whilst the jejunum, and to a smaller extent the ileum and the colon, were alternately dilated and contracted. Each dilated portion overlapped, to a small extent, the contracted part of the intestine, so as to form a series of " agonic " intussusceptions.

The young rabbit was killed, and though its intestines showed scarcely any trace of inflammation, I found that it was quite easy to produce slight intussusceptions by pinching or otherwise stimulating the intestinal wall—much easier, in fact, than in an ordinary animal which had just been killed.

The older rabbit had not suffered from enteritis, nor was there any trace of an intussusception in its intestines.

The experiments were repeated upon a rabbit and a guinea-pig, giving 0.33 gramme of the black sulphide of mercury instead of turpith mineral. The rabbit remained unaffected, but the guinea-pig died of enteritis six days afterwards, when two small intussusceptions were found in its jejunum.

**Results of varying the Peristalsis.**—When I had satisfied myself that it was correct to assume that an intussusception could be caused by so violent an irritant as turpith mineral, I began to study the effects of eserine and of barium chloride in normal and abnormal conditions of the intestine. Eserine has long been known<sup>1</sup> to exercise a powerful constricting influence upon the unstriped muscle of the small intestine, whilst the salts of barium so excite the convulsant action of the medulla and upper part of the spinal cord that, like picROTOXIN, they cause a great increase of peristalsis and repeated fluid motions. Hypodermic injections of eserine and barium chloride have been used, therefore, by veterinary surgeons in the treatment of animals suffering from

<sup>1</sup> Böhm and Mickwitz, *Arch. . exp. Path. und Pharmacol.*, vol. v.

“stoppages,” a term which is sufficiently vague and elastic to cover many conditions besides intussusception.

Twelve minims of a 2 per cent. solution of eserine was enough to kill a rabbit, weighing 2,700 grammes, in a quarter of an hour from the time of its injection beneath the skin. The small intestine in this animal was firmly contracted, but the large intestine was unaffected, and there was no trace of any intussusception.

Six drachms of pulv. rhei were mixed with the food of another rabbit, weighing 3,000 grammes. Rhubarb acts as a purge to rabbits, and I thought that by thus increasing the peristaltic action of the intestine, and afterwards injecting eserine, an irregular peristalsis might be set up which would be favourable to the formation of an intussusception. Accordingly, on the day following the administration of the rhubarb, 6 minims, or half a lethal dose, of a 2 per cent. solution of eserine, were injected into the rabbit, and the animal was killed twelve minutes afterwards. The upper part of the intestine was congested, and was filled with semi-fluid contents which smelt strongly of rhubarb. The lower part of the small intestine was so firmly contracted that it formed a white cord of about the size of a human ureter. There were a few small intussusceptions, but not more than occur in the body of any recently-killed rabbit, for it is not unusual to find “agonic” intussusceptions in these animals.

A similar experiment was performed upon another rabbit, castor-oil being used instead of rhubarb, but the results were equally negative.

On another occasion an intussusception was produced in a cat, and at the same time a good-sized piece of the mesentery was removed to destroy a part of the intestinal nerve-supply. Two days later 4 minims of a 2 per cent. solution of eserine were injected beneath the skin. Eleven minutes later the cat began to suffer from dyspnoea, with delusions and partial paralysis of its hind legs; it had quite recovered at the end of three-quarters of an hour. This animal was killed a week afterwards, but the intussusception had not advanced so rapidly as in a control animal from whom the mesentery had not been cut away, and which had not been injected with eserine.

An intussusception was produced in another cat, and 6 minims of a 10 per cent. solution of barium chloride was injected into

the wall of the intestine directly after the invagination had been produced. Violent peristalsis occurred, and the intussusception almost reduced itself in spite of the sutures which had been inserted at its neck.

A similar experiment in another cat led to the intestine becoming M-shaped at the point of invagination, for the sutures held in spite of the increased peristalsis; but the kink in the middle of the M was so sharp that the animal died of complete intestinal obstruction.

**Deductions.**—It seems fair to conclude from these experiments that violent irritants like turpith mineral may set up an over-sensitive condition of the intestinal wall. This may so modify the orderly contractions of the muscle as to lead to a series of localized contractions, separated from each other by relaxed portions of the intestine, an arrangement which is most favourable to the formation of a series of short intussusceptions. Eserin, on the other hand, produces so uniform a contraction of the intestinal muscle that no intussusception is possible. I tried to modify this uniform contraction by excising a piece of the mesentery and by the administration of such purgatives as castor-oil and croton-oil to animals before the eserin was injected, but without obtaining any satisfactory result.

**Effects of Purgatives.**—It appears reasonable to suppose that the administration of purgatives aggravates the symptoms of intussusception, and may lead to an earlier onset of gangrene. Clinical evidence and post-mortem examination often prove that this is the case. The influence of purgatives in aggravating an intussusception is well seen in a specimen presented to the Museum of St. George's Hospital<sup>1</sup> by Dr. Cecil Hastings, in which successive folds of small intestine have been carried into the large intestine and lie packed closely together in the cæcum. The specimen was taken from a child who had been constipated for five or six days, and had been treated with purgatives first by the mouth, and latterly by the rectum. There was no peritonitis.

Purgation produces strangulation, either by increasing peristalsis, and so causing more intestine to be swallowed than the colon, so to say, can digest comfortably, or it sets up irritation leading to an increased blood-supply. This completes the stagna-

<sup>1</sup> Series ix., No. 80 (b).

tion of the blood, and produces gangrene in the same manner as a slight injury may lead to senile gangrene.

It sometimes happens that the administration of a drastic purgative has been followed by the release of an intussusception,<sup>1</sup> whilst in other cases<sup>2</sup> even so mild a laxative as castor-oil has been followed at once by strangulation. The histological appearances of the intestine in cases of intussusception explain this difference. The stress of the injury has fallen in many cases upon the mucous and submucous tissues, as is shown by the effusion of blood into them, the muscular coat remaining healthy. The administration of castor-oil would be particularly disastrous in these cases. It would stimulate the muscularis mucosæ. This stimulation would lead to increased congestion, and to increased extravasation of blood into the submucous tissue, already seriously damaged, and so gangrene would be produced. But in some cases the muscularis mucosæ is so completely disorganized that no effect would follow its stimulation. The administration of a more powerful purgative to a patient in whom the circular layer of muscle is in the œdematous and degenerate condition seen in Figs. 7 and 8 would be followed by a peristalsis of the longitudinal layer of muscle. Such irregular peristalsis of the longitudinal layer might reduce a very short intussusception, especially if it happened to be one of those cases which only require an initial impulse to enable it to reduce itself. More often it would lead to so much additional inflammation as to cause gangrene.

I endeavoured to put this question of the action of purgatives to the test of experiment, but without any satisfactory results. An invagination was produced in a healthy cat, and on the day after the operation the animal was again anæsthetized, and 20 grammes of Epsom salts in solution were introduced into its stomach by means of a tube and funnel. The animal was disinclined to move on the following day, though it did so readily enough when it was coaxed. It then had a day's rest, and on the next day but one—five days after the intussusception had been made—I gave it 10 grains of calomel in a little milk. It still remained well, though it was disinclined to move or jump, as is usual in cats with intussusception. It was again allowed twenty-four hours' rest, and 2 drachms of pulv. jalapæ co. were

<sup>1</sup> *The Lancet*, vol. ii., 1892, p. 15.

<sup>2</sup> *Ibid.*, vol. i., 1892, p. 79.

administered. It then had a further rest for two days, when 2 drachms of pulv. jalapæ co. were mixed with butter and smeared upon its flanks. In four days' time the cat had licked the greater part of the butter off its flanks, and it was then killed. The invagination had not increased in size, but the intestine was remarkably kinked at the ileo-colic junction. A section through the intestine, after it had been hardened, showed that the cæcum was invaginated laterally into the colon at a point immediately below the ileo-cæcal valve, but the lumen of the intestine had remained patent through the intussusception, so that the animal had not suffered any great discomfort from intestinal obstruction. The lateral character of the intussusception seems to have been due to the tearing out of the suture uniting the ileum and colon on the outer side whilst that at the inner angle still held.

I was not sure whether the interval of a day which elapsed between the operation and the first administration of purgatives in this case might have retarded their action upon the invaginated intestine. I therefore repeated the experiment upon a second cat, putting 10 grammes of Epsom salts into its stomach before it had recovered from the anæsthetic used at the time of the initial operation; but the result was not more satisfactory than in the preceding experiment.

**Experimental Intussusception.**—A simple invagination in a cat produces little or no discomfort, for it leads neither to gangrene, strangulation, nor acute symptoms of any kind. The specimen drawn in Fig. 26<sup>1</sup> was taken from a cat in which the ileum was invaginated into itself, and was pushed into the colon, where it was secured with three interrupted sutures. The sutures were of silk, and as it was my first operation upon a cat, I did not allow for the greater thickness of the muscular coat in these animals as compared with that of the human subject. The sutures therefore held badly, for they hardly passed into the submucous layer, and they threatened to cut their way out of the brittle muscular coat even whilst I tied them. The intestine was replaced in the peritoneal cavity and the abdomen was closed. The cat appeared to be so well on the day after the operation that I felt sure the sutures had come out and that the invagination had reduced itself. For a week the animal took its food and behaved exactly

<sup>1</sup> The specimen is in the Museum of the Royal College of Surgeons of England, No. 2,726 (*e*).

like a healthy cat, except that it would not jump, and got down steep places by scrambling. Eight days after the first operation it was again anæsthetized, and a second incision was made to the right of the first one, which had almost healed. The invagination still existed, and was removed by cutting through the intestine above and below the tumour. The ileum and colon were then joined by Maunsell's method, but the cat died the next day.



FIG. 26.—An experimental ileo-colic intussusception. The sutures, originally placed at the neck of the invagination, are now seen in the centre of the section.

The invaginated portion of the intestine (Fig. 26) bears out the theory that intussusception is due to the swallowing of a piece of constricted intestine by a neighbouring portion, whose peristalsis is still active. The invaginated intestine has been divided longitudinally. The sutures are seen in position, but, instead of being at the neck of the sac, where they were inserted a week previously, they are now situated in the very middle of the intussusception, at a distance of 32 millimetres from its beginning as measured along the lesser curvature, or 42 millimetres measured along the great curve. The whole length of the intussusception is 75 millimetres, and as the sutures mark the original neck of the sac, the invagination has advanced a distance of 30 millimetres in a week; that is to say, it has doubled itself in this time. The intussusception is an excellent example of the ileaco-ileo-colic variety, for the cæcum is intact and the ileo-cæcal valve is in its natural position. The intussusception is pervious throughout, a fact which explains the freedom of the cat from any symptoms of intestinal obstruction. The invagination is of the chronic form, as the apex of the invaginated ileum is alone congested. The intussusception, as is usual, is curved towards the side of its mesenteric attachment. The two apposed serous surfaces can be separated from each other as low as the point of suture, but below it they are blended by inflammatory adhesions. The adhesions are much better



marked along the concave surface, where the mesentery is crowded into a small space, than along the greater curvature, where the two serous surfaces can be separated in their whole extent, except at the point where they have been sutured.

**The Force of Peristalsis.**—Amongst the other interesting points which this experiment with its resulting specimen teaches us is the important one that the force exercised by peristalsis is extremely slight even in an animal with so muscular an intestine as a cat. The sutures were barely capable of maintaining their hold when they were tied, yet as the invagination increased they must have turned over the edge of the intussusception without losing their hold. The feeble force of peristalsis has also been noticed by Professor Cash,<sup>1</sup> of Aberdeen, who says that in dogs a weight of 8 to 10 grammes is sufficient to prevent a well-developed peristaltic wave from executing its object, whilst the traction exercised by a weight of 5 grammes produced much hindrance, and caused spasmodic contraction of a propulsive character which created most distinct discomfort or colic.

### 3. PATHOLOGICAL DATA.

A considerable number\* of the cases of intussusception are merely invaginations of one piece of bowel into another, which is usually of larger calibre; and if there is a great disproportion in width, spontaneous reduction may take place, as in a case recorded by Mr. Thomas,<sup>2</sup> occurring in a boy aged 16 months, in whom he had distinctly felt the invaginated intestine per rectum. When the disproportion between the diameters of the ensheathed and ensheathing intestine is less marked, or when much additional tissue is invaginated, adhesions are formed, the intussusception becomes irreducible, and in process of time secondary changes take place in the intestine which lead to strangulation, to gangrene, or to ulceration of the neck of the bowel.

**Strangulation.**—Strangulation is more often chronic than acute in spontaneous intussusception. Its exact cause is unknown even in hernia, though its mechanism is well understood. It is of the true or elastic variety when it occurs in intussusception—that is to say, the invaginated bowel is enclosed in a lumen, which is either no

<sup>1</sup> *Proc. Royal Soc.*, No. 247, 1886, p. 230.

<sup>2</sup> *The Lancet*, vol. ii., 1886, p. 1219.

bigger than itself, as in the enteric form, or only slightly larger, as in the ileo-cæcal variety. In the ileo-colic type, where the ileum passes through the ileo-cæcal valve, the valve may form an additional constricting agent; for, as I showed in the first chapter (p. 12), hæmorrhage may take place into its substance, or it may become inflamed. During the actual invagination the lumen of the ensheathing intestine must be dilated to its utmost extent. The wall of this portion of the intestine then recoils, and exercises sufficient pressure upon the vessels of the mesentery to cause a marked congestion in the tissues of the intussusceptum. The congestion leads to a stagnation in the blood-flow, and so to a cellular infiltration, which is best marked at the two points where the vessels are doubled upon themselves. These points are the end of the intussusceptum and the place where the pressure is exercised, which is the neck. In children the tissues are so soft, and the peristaltic wave engulfing the gut is so feeble, that in some cases the intestine merely slips on and is held imprisoned; for, as I have endeavoured to show (p. 41), there is usually a very considerable difference in the relative diameters of the large and small intestines even in children between the ages of 4 and 6 months, the time when statistics show that intussusception is most common. Clinical evidence proves that there is so little interference with the contractile power of the muscular coat of the intestine, that in many cases the intussuscipiens certainly, and the intussusceptum, probably undergo rhythmical peristaltic contraction; for if the tumour be carefully examined in a well-marked case, its consistency will be found to vary greatly: at one time hard and easily felt, at another it is quite unrecognisable. It is probably for this reason that some cases of intussusception are overlooked in their earlier stages, for the observer has only felt for the tumour during its period of relaxation. The continuance of peristaltic contractions shows that the blood-flow is no more stopped through the intestine than it is in the gravid uterus, for if it were, the muscle would be paralyzed, and there would be no longer any peristalsis. In an intussusception, however, there is no arrangement for storing up the blood during the contractions, as there is in the uterus. The intestinal tissues therefore become engorged, œdema takes place, and the congestion leads to the extravasation of blood, which is so marked a feature in the microscopical sections taken from tissues thus affected.

**Gangrene.**—The inflammatory changes which result from a continuance of these conditions lead to gangrene, which may spread slowly from the apex towards the neck of the invaginated piece of gut, though in many cases it appears early, and may involve considerable portions of the invaginated bowel.

Gangrene, however, is less common in intussusception than it is in hernia, and there are several reasons for this difference between the two conditions, which have otherwise many pathological affinities. Intussusception is essentially an affection of children, and in children gangrene of any part is rare, even after the most serious injuries, partly because their vascular system is so healthy that it adapts itself readily to the most unfavourable conditions, partly because the blood-supply to all growing tissues is very abundant, and partly because all young tissues are soft and yielding. In an intussusception, therefore, the bowel passes through an elastic ring which, even when it is inflamed, never offers a resistance in any way comparable with that exercised by the rigid fibrous structures which compress a hernia or an internal strangulation.

When gangrene takes place early in intussusception, it often follows upon a particularly violent onset in cases where the invagination is ascribed definitely to some sudden muscular effort; to increased, prolonged, and violent peristalsis, as after the administration of purgatives; and occasionally to such rare conditions as the blocking of the narrowed lumen of the intussusceptum with blood<sup>1</sup> or portions of undigested food, or even to the grafting of a second intussusception upon an earlier one which was running an acute course. Gangrene occurring in the course of an intussusception is more limited, is more chronic, and is less likely to set up suppurative peritonitis, than a similar condition in strangulated hernia. It is more limited because the tissues are less liable to injury, as it is impossible to perform taxis for the relief of an intussusception.<sup>2</sup> Gangrene runs a more chronic course in intussusception than in hernia because it is associated with less perfect interference with the blood-supply, and the intestine is thus enabled to protect itself more perfectly by reparative changes. It is less likely to set up general peritonitis because the gangrenous portion is enclosed in a sheath of healthy

<sup>1</sup> *Trans. Path. Soc.*, vol. xxviii., 1877, p. 131.

<sup>2</sup> Holmes, "System of Surgery," 3rd edit., vol. ii., p. 767.

intestine, for the gangrene in chronic cases nearly always begins in the intussusceptum, though it may afterwards involve the intussusciens.

**Ulceration.**—The occurrence of ulceration or of necrosis of the intussusciens is a much greater danger than gangrene of the intussusceptum, but it is fortunately somewhat less common. It is, however, met with at either end of the intussusception, as well as in the bowel above and below that portion which has been invaginated. We do not yet know the exact course taken by the micro-organisms as they pass through the wall of the bowel, and, though I have been engaged in an endeavour to trace their passage, my results are not yet sufficiently advanced to warrant any definite statement. But there seems to be no doubt on the part of many observers that micro-organisms begin to traverse the intestinal wall when a loop of bowel has been constricted for a period of from four to forty-eight hours, and that the more completely the blood-supply is arrested the more rapidly do they pass.

**Peritonitis.**—Suppurative peritonitis is not usually set up in anything like so short a space of time, and when it does occur it is more often associated with rupture of the gut from the progress of ulceration due to accidental or additional causes than to the simple extension of suppurative processes through the wall of the intestine. The experiments of Grawitz<sup>1</sup> and of Halsted<sup>2</sup> have shown that even pure cultivations of pyogenic organisms, as well as suppurating tissues and particles of fæces, do not necessarily cause suppuration when they are introduced directly into a healthy peritoneal cavity. Accessory conditions must be present to enable pus-producing substances to set up a purulent peritonitis, and these accessory conditions seem to have in common the power of preventing absorption or removal of the pyogenic substances from the peritoneal cavity. The whole subject of absorption from the peritoneal cavity needs further investigation; for Drs. Adler and Meltzer,<sup>3</sup> in their excellent essay upon the path by which fluids are carried from the peritoneal cavity into the circulation, have done enough to show that it bristles with difficulties and is full of interest.

<sup>1</sup> *Charité Annalen*, No. 11.

<sup>2</sup> *Amer. Journ. of the Med. Sci.*, vol. xciv., 1887, pp. 437, 451.

<sup>3</sup> *The Journ. of Exper. Med.*, vol. i., 1896.

## 4. CLINICAL DATA.

There are good reasons to believe that intussusception is associated with peculiarities of structure and function in the alimentary canal. In a certain proportion of cases intussusception has occurred in more than one member of a family,<sup>1</sup> and in the children of parents who have themselves suffered from conditions associated with organic or functional disturbances of the bowels. A remarkable instance of this came under the notice of Mr. Pick<sup>2</sup> in the case of a child, æt. 15 months, who was admitted under his care into St. George's Hospital for the relief of an intussusception. The grandfather and the father of the child had been operated upon for strangulated hernia, and one brother had died of strangulated hernia. The defective condition, whether of structure or of function, may be repeated in different members of the family, or it may be peculiar to the individual. In the latter case the symptoms of intussusception may be preceded for months by an increase in the peristaltic contraction of the bowels, or they may be repeated at long intervals,<sup>3</sup> even when a post-mortem examination shows that the invagination has not been associated with any gross lesion in the alimentary canal, like a polypus, sarcoma, or cancer.

Many cases of intussusception have been cured by injection or inflation of the bowel through the rectum, even when the apex of the intussuscepted gut has protruded beyond the anus, and in a few cases such advanced intussusceptions have receded spontaneously, whilst in others, when the abdomen has been opened, the surgeon<sup>4</sup> has rejoiced to find that the invaginated bowel unfolded itself spontaneously as soon as the merest touch had released the constriction at its neck.

## CONCLUSIONS.

The evidence derived from anatomical, physiological, pathological and clinical data renders it legitimate to assert that spontaneous ileo-cæcal intussusceptions occur when the colon is

<sup>1</sup> Hutchinson, *Medico-Chir. Trans.*, vol. lix., 1876, p. 99; Bryant, Harveian Lectures, p. 12, Case 17.

<sup>2</sup> *The Lancet*, 1891, vol. i., p. 1312.

<sup>3</sup> Pick, *The Lancet*, 1891, vol. i., p. 1312; *Archives of Pediatrics*, vol. xiii., 1896, p. 616.

<sup>4</sup> Marsh, *Medico-Chir. Trans.*, vol. lix., 1876, p. 81; Fagge and Howse, *Medico-Chir. Trans.*, vol. lix., 1876, p. 85; Shepherd, *The Lancet*, vol. ii., 1892, p. 1155.

considerably larger than the ileum, and is so unduly movable that it readily allows itself to become invaginated when once the process has begun. This variety of intussusception is essentially an affection of childhood, and such an undue increase in the width of the colon implies either a congenital abnormality or an unduly rapid growth (see table, No. 29), for at birth the diameter of the large intestine is practically the same as that of the ileum. Such a rapid increase in the width of the large intestine may perhaps in some instances render the ileo-cæcal valve less competent to guard the end of the ileum, because the valve is not capable of very rapid growth if it is to be firm. Unduly rapid growth of the large intestine may thus allow the end of the ileum to become prolapsed into the colon, and under suitable conditions such a prolapse may serve as the starting-point of an intussusception.

Though anatomical peculiarities are important factors in the production of an intussusception, the physiological factors are no less important, for they apply in all probability to every form of invagination, whether it is of the enteric variety, the ileo-cæcal, or the colic. The physiological factor is much less easy to specify, for it is almost certainly an individual peculiarity. It may be stated broadly, however, that, as regards the ileo-cæcal portion of the intestine, the increased mobility, coupled with the unduly rapid growth in the width of the large intestine, is probably associated with increased and irregular peristaltic movements of the colon. Everyone who has had much experience in watching children must have noticed how subject they are to an irregular twitching of the muscles, and how greatly such inco-ordinate movements vary in different children and in different families. They are most common at the instant when the child drops off to sleep and during the act of awakening. They occur both in the voluntary and in the involuntary muscles, and are due, as physiologists think, to a contraction of the interfibrillar sarco-plasm, whilst the ordinary tetanus and twitch are caused by an additional shortening of the contractile fibres. This theory explains why the symptoms of intussusception so often appear at the instant when a child awakens, why it is that boys rather than girls, and the most active and the best-grown children, are attacked as often as those who suffer from chronic inflammatory affections of the alimentary canal. The muscular system in the active and well-grown is undergoing its greatest development, and its sarco-

plasm is in as unstable a condition as in the puny, where attacks of enteritis have unduly heightened the irritability of the intestinal muscle, and have thus led to the irregular twitchings which with suitable anatomical conditions may form the starting-point of spontaneous intussusception.

The cause of spontaneous intussusception is obscure, but clinical evidence shows that an invagination may be produced mechanically if suitable anatomical and physiological conditions be present. Amongst such mechanical causes are direct injury to the belly,<sup>1</sup> sudden and violent muscular efforts,<sup>2</sup> gymnastic movements,<sup>3</sup> jolting or dandling,<sup>4</sup> paroxysmal coughing, as in whooping-cough,<sup>5</sup> or it may even be the reward of greediness, as in the cases recorded by Max Baur<sup>6</sup> and Leichtenstern,<sup>7</sup> in which men were suddenly seized with symptoms of intussusception shortly after eating a quantity of cherries—stones and all. It is, indeed, no matter of surprise that such causes should produce an intussusception, for any of them might lead to a sudden and limited constriction of the intestine associated with an active peristaltic movement of a neighbouring portion sufficient to draw the receiving layer of the gut over the contracted part, which then becomes the apex of the intussusceptum. As soon as the intussusception has been started, the anatomical peculiarities again become of paramount importance, for they determine the character of the intussusception. In the ileo-cæcal forms, a wide colon with few and simple ileo-colic folds devoid of glands will allow the intussusception to run a chronic course, even though the amount of bowel invaginated is very great. Whilst complex fossæ with numerous lymphatic glands at the ileo-colic angle, and prolongations of mesentery along the end of the ileum, will no doubt so far steady this portion of the small intestine as to render its invagination less likely, though, should it occur, the additional amount of tissue invaginated will render the impaction peculiarly tight, so that if gangrene is not produced at once, early adhesions will be formed, and the intussusception will soon become irreducible.

<sup>1</sup> *Guy's Hosp. Rep.*, 1868, vol. ix., p. 290; *Trans. Clin. Soc.*, vol. xvi., p. 64; *The Lancet*, vol. ii., 1888, p. 315; *Ibid.*, vol. ii., 1892, p. 482; *The Brit. Med. Journ.*, vol. ii., 1897, p. 83.

<sup>2</sup> *The Lancet*, vol. ii., 1888, p. 315.

<sup>3</sup> *Ibid.*, vol. i., 1893, p. 651.

<sup>4</sup> *The New York Medical Record*, vol. xlix., 1896, p. 73, Case 14.

<sup>5</sup> *Trans. Clin. Soc.*, vol. xxii., 1889, p. 282.

<sup>6</sup> *Berl. klin. Woch.*, No. 33, 1892, p. 817.

<sup>7</sup> *Deutsch. Archiv. f. Klin. med.*, vol. xii., 1874, p. 381.

## CHAPTER III.

### THE TREATMENT OF INTUSSUSCEPTION.

**Classification of Intussusception.**—Turning now from the scientific to the more severely practical aspect of intussusception, there can be no doubt that all cases of the affection are divisible both clinically and pathologically into two great groups—the incarcerated intussusceptions and the strangulated intussusceptions. Such a division, however, is only of academic interest. It is convenient, but it is of no practical importance; for every case of intussusception needs immediate treatment. We may hope, indeed, that, as time progresses and our treatment improves, less and less will be heard of such a classification, since an incarcerated invagination will not be allowed to become strangulated. For the present, all cases of intussusception must be treated on the assumption that they are either reducible or irreducible.

**History of Treatment.**—It is unnecessary to enlarge upon the history of the treatment of intussusception. Those who are interested in such matters—and every surgeon ought to be, for the practice of surgery is part of a liberal education—will find that Professor Ashhurst,<sup>1</sup> Dr. Leichtenstern,<sup>2</sup> and Mr. Jno. Hutchinson,<sup>3</sup> have published admirable summaries of it from different points of view. Suffice it to say for our present purposes that injections and abdominal sections have been employed from time immemorial for the relief of the condition. Then came many years when crude mechanical means were used—for post-mortem examinations were few, and the anatomy of the condition had been forgotten. The abdomen was still opened occasionally, but the operation was usually unsuccessful because suppurative peritonitis was too often the result of imperfect surgical methods. In

<sup>1</sup> *Amer. Journ. of the Med. Sci.*, July, 1874, pp. 48, 285.

<sup>2</sup> *Vierteljahrsschrift f. d. prakt. Heilkunde*, 1873, vols. 119 and 120.

<sup>3</sup> *Medico-Chir. Trans.*, vol. lvii., 1874, p. 31.



this country, Mr. Phillips,<sup>1</sup> surgeon to the Westminster Hospital, made a spirited appeal in favour of abdominal section as early as 1847; but the operation found no favour in the eyes of the profession. It was only performed in isolated cases, like that by Sir Spencer Wells<sup>2</sup> in 1863, until the year 1873, when Mr. Jno. Hutchinson<sup>3</sup> deliberately suggested that the practice of inflation and injection should be supplemented by the performance of abdominal section, for the improvements in abdominal surgery were then sufficient to allow the operation to be done with a fair prospect of success. The time was not yet ripe for its general adoption, and the cases selected for operation came to the surgeon too late, as neither the parents nor the practitioners under whose care the patients first came were sufficiently alive to the paramount necessity for an early operation. Abdominal section for the relief of intussusception accordingly fell again into comparative disuse, though, as had always been the case since the time of Praxagoras, a few patients were submitted to operation.

Laparotomy in cases of intussusception was revived in 1885,<sup>4</sup> and it is now a recognised and almost a routine method of treatment for the condition. The great improvement which has taken place in the practice of abdominal surgery during the last decade has enabled us to advance a step further in the operative treatment of intussusception, for the brilliant success of Dr. Mitchell Banks, of Mr. Pickering Pick, and of Dr. Ainsley, has shown that even in its latest stages an intussusception may be prevented from killing the patient.

It is still necessary, however, to teach the majority of mothers that early advice and abstention from domestic remedies are required in all cases of painful constipation occurring suddenly in young children, just as it is only lately that men as well as women have come to understand that the immediate treatment of strangulated hernia means recovery, whilst delay is death.

**Treatment of Simple Intussusception.**—Clinical and pathological evidence shows that an invaginated portion of the intestine has a constant tendency to reduce itself until its muscular coat becomes paralyzed or adhesions are formed at its neck. This tendency to reduction is probably counteracted during the earlier stages of an intussusception by the tonic contraction of the ensheathing bowel,

<sup>1</sup> *Medico-Chir. Trans.*, vol. xxxi., p. 1.

<sup>2</sup> *Trans. Path. Soc.*, vol. xiv., p. 170.

<sup>3</sup> *Loc. cit.*

<sup>4</sup> Braun, *Verhandl. der Deutschen Gesell. f. Chir.*, vol. xiv., 1885, p. 474.

for if this be reduced or abolished by mechanical or other means, the intussusception can be easily reduced until hardly any invagination remains. Complete reduction is not easy, for the congestion and consequent œdema of the muscular coat at the apex of the intussusception render this the hardest part of the surgeon's task. Inflation or injection of the large intestine is therefore, upon the whole, the safest and the most satisfactory treatment for all cases of uncomplicated intussusception, provided that the patient has been seen early enough, that the distending force be applied gradually, and that it be not too great.

Injection is preferable to inflation, because the force employed can be graduated with much greater accuracy, whilst the apparatus is always at hand. Neither method is of the least service in the enteric form of intussusception—where one part of the small intestine is invaginated into another—for many observers<sup>1</sup> have shown by experiments on living and on dead bodies that fluid can only be made to pass through the ileo-cæcal valve when over-distension of the colon has caused a mechanical separation of its two segments. Such an over-distension, however, is in the highest degree dangerous, because it is usually accompanied by a cracking of the serous coat of the large intestine, which is soon followed by rupture of the muscular and mucous layers if the force be continued. Professor Senn<sup>2</sup> thinks that somewhat better results may be obtained in cases of enteric intussusception by distending the intestine with such a gas as hydrogen, for he finds that a gas passes through the ileo-cæcal valve under a much lower pressure than a fluid. But enteric intussusceptions are both rare and difficult to recognise, and it is better to open the abdomen at once in every case where this condition is suspected.

1. **Treatment by Irrigation.**—The method of irrigation under hydrostatic pressure is the most satisfactory way of distending the colon in cases of colo-colic and ileo-cæcal intussusception. The fluid is allowed to pass into the large intestine by its own weight, so that the force can be accurately estimated by observing the height to which the reservoir is raised above the recumbent body of the patient.

**Experimental Results.**—The valuable experiments of Mr. Mor-

<sup>1</sup> Bull, *Virchow's Jahresbericht*, vol. ii., 1878, p. 205; Heschl, *Wiener Med. Woch.*, 1881, No. 1; Debierre, *Lyon Medical*, No. 45, 1885; Senn, "Intestinal Surgery," Chicago, 1889, p. 221; Mole, *Bristol Med.-Chir. Journ.*, vol. xii., 1894, p. 65.

<sup>2</sup> "Intestinal Surgery," p. 229.

timer<sup>1</sup> in London, and of Mr. Mole<sup>2</sup> in Bristol, have greatly increased our scientific knowledge of the effects of irrigation in the treatment of intussusception. They have shown that the results depend partly upon the obstruction to be overcome within the intestine and partly upon the external support. The greater the pressure within the abdomen the more is the distending force neutralized, for the intestinal wall is then compressed between two opposing forces.

Mr. Mortimer experimented upon the unopened bodies of children, for the most part under 2 years of age. He points out that in an irreducible intussusception the large intestine is distended by almost the whole force of the stream when the abdominal walls are lax, as is usual in children under chloroform, and when there is not much tympanites. The intestine may kink if fluid be allowed to enter the bowel too suddenly or too forcibly, and the distending force is then prevented from acting upon the intussusception, so that the colon may become sufficiently over-distended to rupture. A similar accident may happen as a result of a sudden peristaltic contraction taking place whilst the pressure is being applied. There is apt to be cracking of the serous coat of the large intestine when the resultant pressure of the fluid distending the colon is about  $2\frac{1}{2}$  pounds—that is to say, when the irrigator is raised 5 feet above the body of the patient, and this accident usually happens when the irrigator is raised to 8 feet, though the bowel may be completely ruptured when the reservoir is only raised to a height of 6 feet.

Mr. Mole used a slightly different method of experiment, but he arrived at substantially the same results, and as he worked with the abdomen open he was able to see the exact manner in which the intestine ruptured as a result of its over-distension. When this accident is imminent, the peritoneal coat of the bowel splits longitudinally for a considerable length; the fluid then begins to leak through the wall of the gut, a small jet issues, and at last, if the pressure be continued, a large rent takes place with forcible expulsion of the contents of the bowel into the peritoneal cavity. Rupture of the large intestine is most likely to occur in the transverse colon at or near to the splenic flexure, whilst in the small intestine it takes place in the unprotected portion of the bowel which is situated between the two layers of the mesentery.<sup>3</sup>

<sup>1</sup> *The Lancet*, vol. i., 1891, p. 1144.

<sup>2</sup> *The Bristol Med.-Chir. Journ.*, vol. xii., 1894, p. 65.

<sup>3</sup> Senn, "Intestinal Surgery," p. 233.

**The Capacity of the Colon.**—It should be borne in mind, however, that these results are derived from experiments upon dead bodies and upon animals. It is impossible for the surgeon to estimate beforehand the capacity of the colon in any individual case of intussusception, nor can he judge the amount of pressure which may be applied with safety to the inflamed and softened intestinal wall at the neck of the tumour. A pint of fluid was sufficient to rupture the bowel<sup>1</sup> in a child aged 3 months, whilst in another child<sup>2</sup> aged 7½ months, 3 quarts under a head of 5 feet pressure were injected into the intestinal canal without doing any injury.

The following measurements of the capacity of the colon in the dead-house explain these results, for they show that the size of the colon in children varies enormously :

Sex.	Age.	Capacity of Colon.
Female ... ..	Stillborn (weight 5 lb. 9 oz.)	6 oz.
Female ... ..	Stillborn (weight 7 lb. 6 oz.)	7½ oz.
Female ... ..	Stillborn (weight 7¼ lb.)	8 oz.
Male ... ..	8 weeks	5 oz.
Male ... ..	5 months	10 oz.
Male ... ..	5 "	13½ oz.
Female ... ..	6 "	23 oz.
Male ... ..	12 "	24 oz.
Female ... ..	14 "	14 oz.
Female ... ..	7 "	30 oz.
Male ... ..	8 "	28 oz.
Male ... ..	8 "	18 oz.
Female ... ..	9 "	16 oz.
Female ... ..	12 "	19½ oz.
Male ... ..	14 "	13 oz.
Male ... ..	15 "	28 oz.
Female ... ..	17 "	21 oz.
Female ... ..	21 "	15 oz.
Male ... ..	2¼ years	19 oz.
Female ... ..	4 "	29 oz.
Male ... ..	5 "	24 oz.
Female ... ..	10 "	79 oz.
Male ... ..	11 "	40 oz.
Female ... ..	14 "	40 oz.

<sup>1</sup> *Trans. Clin. Soc.*, vol. xxi., 1888, p. 244.

<sup>2</sup> Wiggin, *New York Medical Record*, vol. xlix., p. 83, col. 2.

**Method of Irrigation.**—Forty-eight hours is the limit of time within which irrigation is likely to be successful in an ordinary case of ileo-cæcal intussusception with tolerably acute symptoms, and such pressure is alone justifiable, in a child of 2 years old, as can be obtained by raising a reservoir of water containing a quart of salt solution at 100° F. 2½ feet above the anæsthetized patient. The salt solution is made by putting rather more than a teaspoonful of salt into a pint of water, for the strength of normal saline solution has again been raised by physiologists, until it is now 1·025 instead of 0·75 per cent., as it has been of late years. It should be warmed to 100° F. I do not think that inversion of the patient renders irrigation more successful, but I am satisfied that long-continued distension under a low pressure is of more avail than rapid dilatation under a high pressure. The surgeon should keep one hand flat upon the abdomen whilst irrigation is being done, and he must carefully avoid great variations of pressure. A sudden and uniform enlargement of the whole abdomen during the operation almost certainly indicates a rupture of the bowel, because the colon nearly always yields before there is any great distension of the small intestine, though this rule is less absolute when the bowel is inflated with air or gas. A laparotomy must be done at once when this accident happens, and the seat of rupture should be looked for either on the left side of the abdomen or at the neck of the intussusception.

The length of an intussusception is no bar to its reduction by irrigation, for many cases are recorded in which an intussusception has been reduced even when the ileo-cæcal valve has protruded beyond the anus, and Dr. Mansel Sympton<sup>1</sup> recently cured a case by this means when 6 inches of the intestine were visible externally. This is not difficult to understand by the light of the anatomical facts already described (pp. 35-43). The progress of a very large intussusception is usually rapid, for the colon is disproportionately wide, and the mesentery is either unduly long or peculiarly extensible. A rapid advance presupposes, therefore, an easy reduction, and such large intussusceptions often unfold themselves spontaneously, when reduction has been once begun.

A chronic case with a great deal of glairy discharge, whose

<sup>1</sup> *The Brit. Med. Journ.*, vol. ii., 1896, p. 629.

onset has been heralded by similar attacks of less intensity, may be treated by irrigation after a very much longer time than is allowable in ordinary cases; indeed, some cases<sup>1</sup> of this nature have been cured when the symptoms have lasted from four to six months. The duration of the symptoms is perhaps always of less importance in an intussusception than their intensity, for a long-standing intussusception is often more easily reduced by irrigation than one of comparatively short duration. The longer the time the symptoms have lasted, however, the more likely it is that adhesions will have been formed. Slight adhesions are not an insurmountable barrier to reduction by irrigation, though they militate greatly against its success. Professor Senn<sup>2</sup> investigated this point, and found that in one case, when the colon was over-distended, the adhesions which had formed round an artificial invagination made three days previously gave way with an audible sound, and the intussusception was completely reduced. But the force required to overcome the adhesions ruptured the serous coat of the intestine in three different places, and the animal died on the following day with diffuse peritonitis. He was more successful in another experiment, for the intussusception was reduced without any injury to the walls of the bowel, and the animal survived the operation.

Abundant hæmorrhage would seem to contra-indicate any attempt to reduce the intussusception by irrigation. Much extravasation of blood implies destruction of the muscularis mucosæ, infiltration of the submucous tissue, œdema of the circular muscle, and consequently a swollen condition of the mucous and submucous layers, with paralysis of the muscular coat. The swollen tissues render reduction difficult, and if the intussusception be reduced, the paralysis of the muscle allows recurrence to take place, and may thus lead to the loss of much valuable time. Absence of hæmorrhage, on the other hand, associated with severe collapse, equally contra-indicates the treatment of intussusception by irrigation, for it points to the early occurrence of gangrene.

**Disadvantages of Irrigation.**—A great disadvantage attends the use of irrigation for the cure of an intussusception, apart from the danger of rupture, which has already been sufficiently

<sup>1</sup> Max Bauer, *Berlin. klin. Woch.*, No. 33, 1892, p. 817.

<sup>2</sup> "Intestinal Surgery," p. 154, Experiments 15 and 19.

discussed. This disadvantage is the liability to recurrence after reduction. Dr. F. H. Elliott<sup>1</sup> has published the details of a case of recovery from intussusception in a child aged 8 weeks, in whom recurrence took place twenty-four hours after the first reduction, five days after the second reduction, and thirteen days after the third reduction. Dr. Chaffey<sup>2</sup> had a less satisfactory experience, for an intussusception recurred on five separate occasions, until the patient—a boy of 3 years old—died of exhaustion. When recurrence is a very marked feature in a case, it is better to open the abdomen at once than to trust to repeated irrigation of the bowel, for it appears<sup>3</sup> that reinvagination can be prevented by shortening the mesentery at the point of invagination by folding it upon itself in a direction parallel to the bowel, and maintaining it in this position by a few catgut sutures. No absolute rule can be laid down for opening the belly in these cases, and a child was recently under my care who was cured of an intussusception, though irrigation had to be done five times before the tendency to recurrence was overcome; and Mr. C. B. Innes sends me from New Zealand a still more remarkable case, in which a child of 4 months old recovered after eight irrigations between May 21 and June 23.

There seem to be several reasons for the recurrence of an intussusception. The first, and the least satisfactory, is that the conditions may persist which led to the original intussusception. An intussusception will then recur after any method of treatment, but it is especially likely to do so when the reduction has been brought about by distending the large intestine. A rapid distension of the colon followed by its sudden emptying are exactly the conditions which lead to increased peristalsis of its active, and as yet uninjured, walls. All methods of treating intussusception by dilatation of the bowel are open, therefore, to the objection that they predispose to a fresh invagination of the congested, compressed and partially paralyzed portion of intestine which has just been released.

A second objection to this method of treatment lies in the fact that the operator cannot see what he is doing, and that the distension of the large intestine is necessarily performed with

<sup>1</sup> *The Lancet*, vol. i., 1887, p. 67.

<sup>2</sup> *Ibid.*, vol. ii., 1887, p. 17.

<sup>3</sup> Senn, "Abdominal Surgery," p. 95; Mr. A. E. Morison, *The Northumberland and Durham Medical Journal*, 1896, p. 282. There had not been any recurrence in this case.

uncertain guides. The reduction is therefore incomplete in some cases, for the last part of an intussusception is the most difficult to unfold, and in practice when the tumour has disappeared, as a result of irrigation, the operator is usually chary of continuing the process, and is quite content to allow the fluid to escape as soon as possible. Cases are well known in which such an incomplete reduction has been found at the autopsy. Dr. Goodhart<sup>1</sup> records one where a local œdema of the submucous tissue, with a slight invagination of all the coats of a part of the cæcum, remained after an intussusception had been reduced by inflation. He thought that the invagination was sufficient to start a fresh intussusception, though he confesses that it is more likely that the swelling would have subsided if the patient had lived a longer time. Professor Greig Smith<sup>2</sup> also quotes a case in which the appendix was found unreduced after death, and still invaginated within the cæcum. A similar case has been under the care of my colleague, Mr. Waterhouse, at the Victoria Hospital for Children, and Dr. Wright and Mr. Renshaw<sup>3</sup> record a case of recovery after laparotomy, when the base of the appendix had been pushed into the cæcum, carrying with it a part of the cæcal wall.

The ileo-cæcal valve, too, is sometimes a cause of trouble after the reduction of an intussusception: theoretically, because a hæmorrhage into its substance may make its segments gape, or may so stiffen them as to predispose to a fresh invagination of the ileum; practically, because it may be mistaken in its inflamed state for the tumour of an intussusception. This mistake has been made more than once, and on one occasion<sup>4</sup> it led the surgeon to open the abdomen of a child, aged 6 months, in the full belief that a previous irrigation had failed to reduce the whole of the intussusception.

**After-treatment of Cases reduced by Irrigation.**—The after-treatment of an intussusception which has been cured by irrigation must consist in keeping the patient absolutely at rest, in the administration of opiates, and in feeling the abdomen gently from time to time to ascertain that the tumour has not recurred.

## 2. Treatment by Abdominal Section.—When irrigation has failed

<sup>1</sup> *Trans. Clin. Soc.*, vol. xvi., 1883, p. 62, plate iii.

<sup>2</sup> "Abdominal Surgery," vol. ii., 1896, p. 678.

<sup>3</sup> *Brit. Med. Journ.*, 1897, vol. i., p. 1470.

<sup>4</sup> *The Lancet*, vol. ii., 1892, p. 880.



to relieve an intussusception, the method must not be continued for too long a time, because the patient may become collapsed, even though no injury be done to the bowel. Abdominal section must then be performed at once, and this forms the second great method of treating intussusception.

**Prognosis after Abdominal Section.**—The failure of irrigation, because it leads to the necessity for laparotomy, increases the surgical interest of the case tenfold, but, unfortunately, it adds greatly to its gravity; for whilst the mortality of intussusception in infants treated without operation is calculated in the latest series of tables at 59 per cent., the mortality amongst the cases in which the abdomen has been opened is 67·2 per cent. Dr. Wiggin,<sup>1</sup> who appears to have compiled these statistics with great care, explains that this high rate of mortality is due to the inclusion in his tables of all cases in which laparotomy has been performed. The risk of abdominal section is reduced to 22·2 per cent., if only those cases be reckoned which have been operated upon within forty-eight hours of the onset of symptoms, and if we only take into account the cases which have been submitted to operation since the year 1889, when the more perfect technique of abdominal surgery had become generally known. Such an estimate, however, is based necessarily upon published cases, and therefore upon a comparatively small number, and it is probably inaccurate, for no record has been kept of many unsuccessful operations.

The surgical interest of the case is heightened by the failure of irrigation to relieve an intussusception, for the curiosity of the operator is piqued to know what he will find. Irrigation fails to relieve the invagination in some simple cases, even when no adhesions are present; in others slight adhesions at the neck of a simple invagination prevent its reduction, whilst it may be that the case is so complicated as to need the whole of his ingenuity, first to find an appropriate method of treatment, and afterwards to carry it out to a successful issue.

**Laparotomy for Reducible Intussusceptions.**—Shock is the great and immediate cause of danger in every case of an abdominal section performed upon a young child for the relief of an intussusception, whether the invagination be simple or complex. Chilling of the body, bleeding, and powerful nerve stimuli ascend-

<sup>1</sup> *New York Med. Record*, vol. xlix., 1896, p. 85.

ing to the spinal cord from the splanchnic region, are the causes of shock, and they should be reduced to a minimum. Chilling of the body is easily prevented by placing the patient upon a hot-water bed and by swathing his arms and legs in cotton-wool, whilst the chest is covered with a roughly-made jacket of Gamgee tissue. The subcutaneous injection of  $\frac{1}{50}$  of a grain of strychnia with enemata of brandy and hot water will cause a temporary rally, lasting long enough for a simple abdominal section to replace a piece of invaginated intestine in a child; but in a long operation these measures must be repeated more than once. The anæsthetic should be given sparingly; the incision should be made in the middle line, and at first it should only be long enough to admit two fingers and a thumb into the peritoneal cavity, for in the simplest cases it is unnecessary to drag the intestine to the wound. Indeed, it is better not to do so, because such a proceeding stretches the mesentery, and so stimulates the nerves that the splanchnic vessels are first contracted and afterwards dilated, leading to as great a lowering of the blood-pressure as would be caused by a very serious hæmorrhage. The less the intestine is handled, therefore, the better it will be for the patient, and an intussusception can often be reduced by squeezing it gently from below upwards. But it is much better to enlarge the incision, and to bring the tumour into view, if there is any difficulty in reducing the intussusception, rather than to run any risk of tearing the serous coat by manipulating the intestine in too cramped a space.

All goes well in the simplest cases—that is to say, in those which have been seen sufficiently early, and in which the invagination, though too tight to be reduced by irrigation, is still easily reduced by a minimum of manipulation. In these cases it is only necessary to replace the invaginated intestine and to suture the abdominal wound to ensure the recovery of the patient. Rapidity, combined with caution, is the golden rule in all cases of abdominal surgery, and if it be followed in these cases, the operation of laparotomy, even in a young child, is no more dangerous than is the ordinary operation for the relief of a strangulated hernia in an adult. The mortality rate of 22·2 per cent. applies more especially to this class of cases, and though it is still far too high, we may hope that as time proceeds, and the cases are seen earlier, it will be much further and very greatly lowered. Indeed,

Mr. A. E. Barker, who has had a very large experience of these cases—for he was one of the first in England who systematically practised abdominal section for the cure of intussusception—tells me that he has now operated upon fourteen cases of acute intussusception. Thirteen of the patients were children under 13 years of age, and nine of the fourteen recovered; and an equal measure of success has attended the operations of other surgeons in London.

**Dangers of Laparotomy.**—Great care must be taken even in the simplest cases to prevent any cracking of the serous coat of the bowel during the reduction of an intussusception. This injury is always repaired by plastic inflammation, which is too often the starting-point of a diffuse suppurative peritonitis; or if this danger be escaped, it leads to the formation of adhesions which unite one coil of gut to another. Professor Senn<sup>1</sup> recognised the gravity of the accident when he recommended that the injured part of the bowel should be covered with a strip cut from the omentum, and sutured round the intestine so that its end should project just beyond the mesenteric border. I have usually found that in slight rents it is sufficient to bring the edges together with one or two point sutures to ensure union by first intention.

A certain amount of danger, too, attends the last part of the reduction of an intussusception, lest too great or too injudicious an exercise of force should tear the bowel at the neck of the tumour, where the tissues have become softened by inflammatory changes; for such an occurrence may require the instant performance of enterectomy. Washing out the peritoneal cavity is wholly unnecessary in the simpler cases. It lengthens the operation and increases the shock without yielding any adequate result.

Even when a simple intussusception has been cured, and the surgeon has satisfied himself that he has done all that it is possible for him to do, a final difficulty may arise in replacing the inflated intestines within the abdominal cavity. This difficulty is very commonly met with in children, and it may require that the originally small incision in the abdominal wall should be greatly enlarged, for less harm will be done by squeezing the distended intestines through a large hole than through a small one. The intestines sometimes have to be punctured in several places before they can be replaced, but I am always a little doubtful of the

<sup>1</sup> "Intestinal Surgery," p. 205.

wisdom of such a proceeding, for the distension is great, the holes are small, and the kinks are numerous, so that it is not possible to produce any great reduction by this method; besides, the gas is produced within the intestine, and is formed very rapidly. Additional care must be taken in suturing the wound when the intestines are much distended, for it is quite easy to kill the patient by passing one of the sutures through the distended gut, an accident which is especially likely to happen in closing the angles of the abdominal wound.

**Recurrence after Laparotomy.**—An intussusception sometimes recurs after it has been reduced by abdominal section, but recurrence is less usual after an abdominal section has been done than when reduction has been brought about by irrigation. In a few cases<sup>1</sup> the intestine has remained so œdematous that the tumour has been felt even after the wound has been closed, leading the operator to suppose that invagination has recurred. Such a condition may be distinguished from true recurrence by the fact that the swelling rapidly disappears, and with it the symptoms of obstruction. This is a rare accident, but Mr. Pearce Gould met with a rarer one when he had to perform a laparotomy twice at an interval of three months for the reduction of two separate intussusceptions in the same patient.

There is another condition which is equally uncommon, in which, after an abdominal section has been done and the intussusception has been reduced, the patient passes one or more healthy motions and seems to be on the highway to recovery, but within a few hours or a few days he is again constipated, his belly becomes distended with flatus, and he dies. A case of this kind recently came under my care<sup>2</sup> in the person of a boy aged eight months, who had suffered for thirteen and a half hours from symptoms of intussusception. Irrigation failed to reduce the intussusception, so I opened the abdomen and easily replaced the bowel without doing it any injury. The child afterwards passed two motions, one blood-stained, the other natural, and took his food well, digesting it. Forty-five hours after the operation he began to vomit, the intestines became distended, and he died with all the symptoms of intestinal obstruction. The

<sup>1</sup> Watson Cheyne, *The Lancet*, vol. ii., 1890, p. 1158; Farrer, *The Lancet*, vol. i., 1893, p. 829.

<sup>2</sup> *Brit. Med. Journ.*, vol. ii., 1895, p. 1356.

examination of the body in the post-mortem room showed that the intestines were distended with flatus to within a foot of the ileo-cæcal valve. The distension stopped suddenly, although there was no visible cause for its arrest either outside or within the intestine or abdomen. The colon, like the lower part of the ileum, was collapsed. There was no intussusception and no peritonitis.

A similar case is recorded by Mr. Pick.<sup>1</sup> It occurred in a child aged 6 months, in whom an intussusception had been reduced by inflation on the fourth day from the onset of the symptoms. The obstruction, however, continued until the abdomen was opened thirty-four hours later. It was found at the time of the operation that a piece of bowel about 6 inches long was contracted and empty. The child died the same day from an accidental cause. Brun's case, recorded by Müller,<sup>2</sup> seems to have been of a similar kind. It occurred in a boy aged 12 years, who died on the ninth day after excision of a piece of the small intestine for the cure of a chronic irreducible intussusception of the ascending colon, associated with a retrograde but reducible invagination of the upper part of the descending colon. The intestinal wound was found to be soundly healed after death, but the stomach and small intestines were greatly distended with flatus without any apparent cause.

The histological appearances to which attention has been already called (pp. 8-12), show that the bowel in these cases is paralyzed at the seat of invagination, for it is sufficiently injured to destroy its functional activity, but not badly enough to destroy its vitality. If a similar case should unfortunately happen again in my practice, I shall inject hypodermically a grain or two of barium chloride in solution. The drug is a powerful stimulant of peristalsis, but its action is less severe than that of eserine. Either drug should be serviceable, for it is only in rare and advanced cases of intussusception that both the circular and longitudinal layers of muscle are involved; in these early stages one layer is injured more seriously than the other, and the circular layer more often than the longitudinal.

**Complicated Intussusceptions.**—When an intussusception has been successfully reduced by laparotomy, the surgeon should satisfy himself before he closes the abdomen that he has overcome the

<sup>1</sup> *The Lancet*, 1891, vol. i., p. 1313.

<sup>2</sup> *Beiträge zur klin. Chir. zu Tübingen*, 1886, vol. ii., p. 499.

only cause of obstruction, and that the case he is treating is really as simple as it appears to be, for an intussusception may be complicated by a variety of troublesome and dangerous conditions. Dr. Handfield Jones and Mr. Page published<sup>1</sup> the details of such a complicated case in which there were two intussusceptions of the colon and one of the ordinary ileo-colic type in a boy aged 5 years, and the less uncommon cases of double intussusception have been already mentioned (pp. 27-30). Double intussusceptions usually run in opposite directions, and are separated by an interval of healthy intestine; but they may occasionally<sup>2</sup> overlap each other, so that the retrograde invagination, which is generally the more distal one, has to be reduced before the upper one can be released. Another complicated case coming under the care of Dr. Whipham and Mr. Turner<sup>3</sup> occurred in a woman aged 29, in whom an intussusception associated with a polypus was complicated with a volvulus at two different parts of the intestine. In yet another case, occurring in a girl of 6 months old, recorded by Mr. Clinton Dent,<sup>4</sup> a double intussusception—ileo-colic as well as ileo-cæcal—was still further complicated by an internal hernia which was apparently secondary. The hernia was strangulated by the sharp edge of a fold of mesentery attached to the ileum, and it was buried deeply in the cavity of the pelvis. All the abnormal conditions were relieved in spite of the complicated nature of the case, but the child died five hours after the operation.

Intestinal diverticula have something to answer for in producing the most rare forms of intussusception. The simplest cases are those occurring in boys and male adults<sup>5</sup> where a Meckel's diverticulum becomes inverted, and afterwards causes an intussusception in the same manner as does a polypus. This may cause the death of the patient,<sup>6</sup> or the intussuscepted portion of the intestine may slough off, carrying with it the diverticulum, and the patient may recover.<sup>7</sup> In other cases a diverticulum may lead by its inversion to a lateral intussusception. Dr. Rushton Parker, of Kendal, has recently published<sup>8</sup> an account of such a

<sup>1</sup> *Trans. Medico-Chir. Soc.*, vol. lxi., p. 301.

<sup>2</sup> *Trans. Path. Soc.*, vol. xxxvii., p. 240.

<sup>3</sup> *The Lancet*, vol. i., 1891, p. 198. <sup>4</sup> *Ibid.*, vol. i., 1887, p. 1030.

<sup>5</sup> Bryant, *Harveian Lectures*, 1885, p. 14, Case 21.

<sup>6</sup> St. Barth. Hosp. Mus., Nos. 2,183 and 2, 183 (a).

<sup>7</sup> *The Brit. Med. Journ.*, vol. ii., 1894, p. 123.

<sup>8</sup> *Ibid.*, vol. ii. 1896, p. 840.

case, and an examination of his drawing (Fig. 27) shows that the whole lumen of the bowel is not invaginated, for it is possible to pass a rod by the side of the intussusception from the dilated and hypertrophied part above to the narrower and frailer portion below. The rarest of these rare forms are those occurring in children in whom the diverticulum has remained open at its distal end. Barth<sup>1</sup> has seen a case in which the proximal portion of the bowel was invaginated into such an open diverticulum, leading to an ordinary descending intussusception, and Mr. Golding Bird<sup>2</sup> has recorded an analogous case in which the distal end of the bowel became invaginated in a similar manner, forming a retrograde intussusception. The apex of the invagination in each of these cases protruded through the navel.

**Laparotomy for Irreducible Intussusception.**—We have hitherto considered the operation of abdominal section for the relief of comparatively simple cases of intussusception in which the ingenuity of the surgeon is not taxed unduly, for the intussusception is reducible. The really serious and by far the most interesting cases are those in which the intussusception is found to be irreducible after the abdomen has been opened.

**Causes of Irreducible Intussusceptions.**—Intussusceptions become irreducible under many different conditions. In the first place, the intestine may be healthy, but it is kept invaginated by more or less extensive adhesions; by peculiarities of structure, such as twists in its axis, or the forcing of one piece of intestine upon another; by great swelling of the intussusceptum, or by the

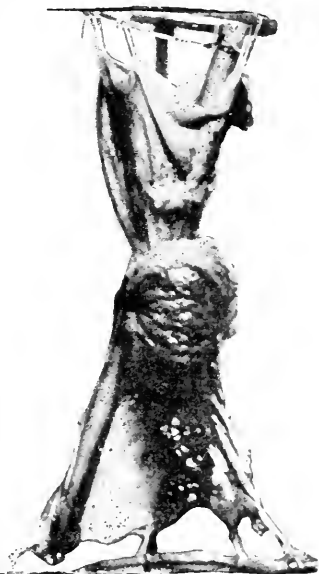


FIG. 27.—A lateral intussusception, apparently due to the inversion of an intestinal diverticulum (from a photograph kindly lent by Mr. Rushton Parker).

<sup>1</sup> *Deutsche Zeitschrift für Chirurgie*, vol. xxvi., 1887, p. 193.

<sup>2</sup> *Trans. Clin. Soc.*, vol. xxix., 1896, p. 32.

presence of large tumours in the intussuscepted bowel. Secondly, an intussusception may become irreducible because the bowel is so gangrenous or ulcerated that the surgeon dare not exercise traction upon the tumour, nor dare he leave the injured intestine within the peritoneal cavity.

(a) **Adhesions.**—It has already been pointed out that slight and newly formed adhesions do not necessarily render an intussusception irreducible, even by such a simple method of treatment as irrigation, though their presence is of unfavourable augury, because increased force is necessary to effect reduction. The adhesions formed in an ordinary case of intussusception, which has been allowed to run its course unchecked, may be very extensive and very dense. I found, in experimental invaginations produced in cats, that slight adhesions were formed between the intussusceptum and the returning layer of the intestine as early as twelve hours after the operation, and that the adhesions were formed earlier, and were more rapidly converted into scar tissue in the enteric than in the ileo-cæcal invaginations.

Clinical observations show how widely different is the tendency to the formation of adhesions in different persons. Mr. Marsh<sup>1</sup> performed abdominal section on a child about fifteen hours after the onset of symptoms, only to find that the intussusceptum had become so universally adherent to its sheath that it was impossible to effect a reduction. A similar experience befell Mr. Makins<sup>2</sup> in a child aged 4 years, who had suffered from symptoms of intussusception for forty-eight hours. The serous coats of the bowel were so firmly united to each other that they could only be separated with difficulty when the bowel had been laid open longitudinally after its removal from the body.

On the other hand, the formation of adhesions is sometimes delayed for an indefinite length of time, as in the cases seen by Dr. Lettsom,<sup>3</sup> in which the symptoms of intussusception were of three months' duration, and by Dr. Leichtenstern,<sup>4</sup> where they had lasted eleven months, and yet the post-mortem examination showed that hardly any adhesions were present. Dr. Carver,<sup>5</sup> too, met with a remarkable case of the same kind, in which a

<sup>1</sup> *The Lancet*, vol. i., 1891, p. 368.

<sup>2</sup> *Trans. Clin. Soc.*, vol. xxii., p. 282.

<sup>3</sup> *Phil. Trans.* vol. lxxvi., p. 305.

<sup>4</sup> *Deutsches Archiv. f. klin. Med.*, vol. xii., 1874, p. 38.

<sup>5</sup> *The Lancet*, vol. i., 1889, p. 171.



boy, aged 2 years and 9 months, suffered from symptoms of intussusception for seven weeks. He had faecal vomiting for twenty-five days, and the bowel protruded at the anus for a fortnight, yet the intussusception was easily reduced after the abdomen had been opened, as there were hardly any adhesions.

The adhesions are formed more readily along the concave than along the convex side of the intussusceptum, and their extent—at any rate, in the ileo-caecal forms—depends, I assume, upon the varying relations of the mesenteric folds, which were described in the second chapter (pp. 37-41). They are not necessarily associated with suppurative processes, and, in spite of the cases I have just quoted, they are more often found in chronic than in acute cases.

(b) **Gangrene and Ulceration.**—Gangrenous and ulcerating intussusceptions form the second great group of irreducible intussusceptions of the bowel—a group which can be further subdivided into those associated with peritonitis, and those in which there is no peritonitis, though the belly may be full of stinking gas. Gangrene is only produced with the greatest difficulty in experimental invaginations upon animals. I have quite failed to produce it in cats and rabbits, even when the vessels going to the neck of the tumour have been securely tied.

**The Prognosis of Irreducible Intussusception.**—The treatment of an irreducible intussusception is fraught with danger, whether it be irreducible from mechanical obstacles, on account of extensive adhesions, or because of gangrene. The prognosis in these cases was formerly considered desperate, and, with a few rare exceptions, the patients were left to die, even by those advanced surgeons who had dared to do a laparotomy. But the advance of abdominal surgery has led to a recognition of the extraordinary readiness with which wounds of the intestine repair, when their edges are kept in proper apposition, and we now have good hope that our efforts will be crowned with success even in the most unsatisfactory conditions.

**The Treatment of Moribund Intestine.**—When the surgeon has opened the abdomen and finds that the intussusception is greatly congested and has lost its gloss, he must not too hastily assume that it is dead; yet it is often a matter of no slight difficulty to decide whether or not the bowel is capable of recovery. A piece of intestine which is only congested will bleed if it be pricked,

even though it has lost its lustre, and if it be gently stroked until its vessels are emptied, the blood will be seen to pass along the vessels again as soon as the pressure is taken off them. A piece of intestine in such a condition must be handled very tenderly. It is unnecessary to remove it, and the patient is often so collapsed as to render any prolonged operation impossible, even were enterectomy advisable. The wisest thing to do in such cases is to wrap a layer or two of gauze round the injured intestine, as soon as the invagination has been released. One end of the gauze is left hanging out of the abdominal wound, the intestine is laid inside the peritoneal cavity, and the incision is lightly closed with temporary silk sutures. If the bowel ruptures, the intestinal contents may then find their way out of the abdominal cavity, whilst if it recovers, the gauze can be removed and the wound will close by granulations.

**The Treatment by Enterotomy.**—In chronic cases when the end of the intussusceptum is gangrenous, when the intussusception is short, and when it is irreducible from adhesions, from the presence of a polypoid tumour, or from a bulbous enlargement of the end of the intussusceptum, the method recommended by Barker,<sup>1</sup> Jessett,<sup>2</sup> and Greig Smith,<sup>3</sup> may give excellent results. The broad principle underlying each modification of the operation is to ensure the union of the intussuscipiens to the intussusceptum by inserting a continuous suture at the neck of the tumour, and then to slit open the intussuscipiens, remove so much of the intussusceptum as lies dead or free, stop the bleeding, and sew up the wound in the sheath. It is sometimes impossible to remove the intussusceptum after it has been divided, and in such a case Leszczynski<sup>4</sup> left the piece of bowel in the large intestine to be dealt with by Nature, and the patient recovered.

**The Treatment by Colotomy and Lateral Anastomosis.**—Enterotomy is useless when the intussusceptum is attached to the intussuscipiens by firm adhesions for any great distance, as in these cases the two cylinders of intestine may form a continuous tube. Mr. Sidney Jones<sup>5</sup> recorded such a case occurring in a child aged

<sup>1</sup> *The Lancet*, vol. i., 1892, p. 79.

<sup>2</sup> "Surgical Diseases of the Stomach," 1892, p. 133.

<sup>3</sup> "Abdominal Surgery," ed. 5, 1896, vol. ii., p. 675.

<sup>4</sup> *Pamiętnik: II. Zjazdu chirurgów polskich*, 1890, quoted by Rydygier in the *Verhandl. des Deutsch. Gesell. f. Chirurgie*, 24, Berlin, 1895, p. 439.

<sup>5</sup> *Trans. Path. Soc.*, vol. viii. p. 179.

9 months, in whom an intussusception proved fatal, after the symptoms had lasted nine weeks. The post-mortem examination of the body showed that a probe could be passed along the entire length of the intussusception, which began at the ileum and protruded through the anus. The apposed serous surfaces were adherent along their whole length by firm fibrous tissue. An artificial anus would alone be serviceable in the treatment of such a case, or, if the adhesions did not extend very low in the rectum, Halsted's operation of lateral anastomosis<sup>1</sup> might be employed. These extensive adhesions usually occur in chronic cases, and the surgeon can therefore select his time and the method of performing the most suitable operation. It should be remembered, however, that death has resulted from starvation in experimental operations, where long lengths of the intestine have been thrown out of action.

**Treatment by Enterectomy.**—Partial operations are useless when the neck of the sac is ulcerated, when the sheath of the intussusception is gangrenous, or when the invagination is associated with malignant disease of the intestine; and it is exactly in these cases that the greatest and most satisfactory advance has recently been made in the surgical treatment of intussusception. The old operation of making an artificial anus for the relief of the worst cases of irreducible intussusception had long been condemned by the more thoughtful surgeons, and Mr. Howse<sup>2</sup> performed a formal enterectomy for the relief of a ruptured intussusception in a child aged 5 months in September, 1876. But it was not until 1885 that Professor Braun,<sup>3</sup> in Germany, and in 1887 that Mr. Lawford Knaggs,<sup>4</sup> in England, called attention to the feasibility of section, and subsequent suture of the intestine in these cases, pointing out the great advantage to be gained by the operation over the older methods.

Slow but steady progress has been made since the publication of these papers. Resection was at first associated with simple end to end suture of the divided intestine, which is theoretically the most perfect, but practically the most difficult, method of

<sup>1</sup> *Amer. Journ. of the Med. Sci.*, vol. xciv., 1887, p. 437; and *Bull. of the Johns Hopkins Hospital*, ii., 1891, p. 1.

<sup>2</sup> *Med.-Chir. Trans.*, vol. lix., p. 94.

<sup>3</sup> *Verhandl. d. Deutsch. Gesell. f. Chir.*, xiv., 1885.

<sup>4</sup> *The Lancet*, vol. i., 1887, pp. 780, 1124, 1177.

obtaining union. The results of simple end to end suture proved most unsatisfactory, and this method has now been abandoned for more complex operations, which have resolved themselves into the union with and union without the aid of mechanical appliances, the methods of Senn and of Maunsell respectively.

**Maunsell's Operation.**—Personally, I have no hesitation whatever in giving in my adherence to the non-mechanical party, for it seems to me that its methods are more simple, whilst its results are at least as good as those obtained by the mechanical school. In cases of intussusception, where of necessity an immediate operation is required, it may cause the most serious results to be obliged to await the arrival of the proper appliance; for what surgeon or general practitioner keeps a supply of bobbins, plates or buttons ready for immediate use in such a remote contingency as an irreducible intussusception, which he meets perhaps but once in a lifetime? Maunsell's method, too, is particularly suited for the ileo-cæcal form of intussusception, which is the more common, for the two pieces of intestine vary greatly in their calibre, so that the invagination is easy. For the present, however, Murphy's button seems to have the advantage, though I think that it is but a temporary one. In all the cases when it has been used successfully the intussusception has been of the enteric form, where the serous surfaces are smooth, and can be brought into sufficiently close approximation to ensure union by first intention.<sup>1</sup> It must necessarily prove less useful in intussusceptions involving the large intestine, because the appendices epiploicæ render it impossible to bring the two surfaces into regular and uniform apposition.

Maunsell<sup>2</sup> claimed for his method that it is the only form of enterectomy yet devised in which perfect union is ensured by suturing a complete transverse section of the bowel with its circumferential peritoneal surfaces in exact apposition, and with all the knots of the sutures inside the intestine. The idea was suggested to him by the way in which a tailor sews a sleeve into a coat, for he invaginates the sleeve, and sews it circumferentially from the inside, passing all the stitches through the entire thickness of the cloth, so that when the invagination is withdrawn none of the stitches can be seen from the outside. The

<sup>1</sup> Mus. Roy. Coll. Surg. Eng., No. 2,726 (*n*).

<sup>2</sup> *The Lancet*, vol. ii., 1892, p. 476, col. 1.

firm suturing of all the layers of the intestine gives the ends of the gut an opportunity to exercise their unrivalled powers of repair, for they are held in close apposition, and are not likely to cut their way out of the softened tissues.

My own experiments, carried on without a knowledge of the very valuable and more extensive work done along the same lines by Messrs. Ballance and Edmunds,<sup>1</sup> have satisfied me that in animals Maunsell's method yields the most satisfactory results. It can be performed at a moment's notice, and the entire operation from the first incision to the last suture in the abdominal wall can be completed easily in thirty minutes. The sutures are carried through the whole thickness of the walls of both pieces of the bowel, so that even an operator with an unsteady hand, or one who has not had much experience of abdominal surgery, has but little to fear, and the after-results are admirable.

One of the specimens preserved in the Museum of the Royal College of Surgeons of England<sup>2</sup> is part of the intestine of a cat, from which 5 inches of the ileum and colon, with a small experimental intussusception of a week's duration, were removed by Maunsell's operation on August 6, 1896, the animal being killed on February 2, 1897 (*cf.* pp. 12-14). During this interval of 180 days the cat increased in weight from 2,070 grammes to 2,615 grammes. The line of union is marked externally by a slight bulging of the scar. The parietal layer of the peritoneum is adherent to the serous coat of the intestine for a distance of 22 mm. below the point of circular union. The longitudinal layer in the intestine is so completely healed that its position is only marked by three pinhole scars showing the situation of the sutures. Internally the line of circular union is absolutely complete, and it seems to be covered with healthy mucous membrane. The intestine is a little pouched at this spot because the scar has yielded. The line of the longitudinal incision is marked by a very faint scar in the valvulæ conniventes, but the lumen of the intestine is not narrowed by it. The valvulæ conniventes are modified over the actual line of union, but they extend for a distance of 55 mm. before the large intestine begins.

**Dangers of Maunsell's Operation.**—Especial care must be taken during the performance of Maunsell's operation to suture securely

<sup>1</sup> *Med.-Chir. Trans.*, vol. lxxix., 1896, p. 255.

<sup>2</sup> No. 2,726 (*f*).

the mesenteric borders of the intestine, for the bleeding and the increased thickness of the tissues at this part are apt to deceive the operator, so that he is likely to pass his needle through the wall of only one piece of the bowel. Leakage then takes place, and the animal dies. Several of my cats died from this cause, and in cases of doubt I now insert one or two sutures externally at this point after the intestine has been disinvaginated, taking care to pass the sutures into the submucous tissue, for otherwise they are likely to cut their way out when they are tied. A few point sutures are all that is needed to bring the cut ends of the mesentery together.

**Prognosis after Enterectomy.**—The outlook for cases of irreducible intussusception treated by enterectomy is distinctly favourable whatever method be adopted. When Braun<sup>1</sup> published his statistics in 1885, he could only find a single case where recovery had followed enterectomy for the relief of intussusception. Rydygier, in his addendum to Braun's list published ten years later, has been able to collect the records<sup>2</sup> of twenty-five cases, published between the years 1885 and 1895, in which recovery has taken place after the intestine has been resected, or an anastomosis has been made between two pieces of bowel for the cure of intussusception. I find that five more recoveries are to be added to this list. Two of these occurred in America,<sup>3</sup> where the operation was done for the relief of chronic intussusception in women, and three were done in England for acute gangrenous intussusception in children. One of these cases is recorded by Dr. Mitchell Banks,<sup>4</sup> who tells me that the boy is still alive and well. Another case came under the care of my colleague, Mr. Pickering Pick, who has recently published it in the *Quarterly Medical Journal*.<sup>5</sup> It was a girl, æt. 8 $\frac{3}{4}$  years, who had complained of pain after she had jumped off a form at school. The abdomen was opened on the seventh day after the onset of symptoms, and a stinking intussusception was found 2 inches above the ileo-cæcal valve. It was cut away, and the two ends of the ileum were brought together with a Murphy's button, which was passed on the eighth day after the operation.

<sup>1</sup> *Verhand. d. Deutsch. Gesell. f. Chir.*, xiv., Berlin, 1885, p. 491.

<sup>2</sup> *Ibid.*, xxiv., Berlin, 1895, pp. 446-459.

<sup>3</sup> "Annals of Surgery," vol. xxiii., p. 440; vol. xxiv., p. 733.

<sup>4</sup> *The Lancet*, vol. i., 1895, p. 487; *The Brit. Med. Journ.*, ii., 1896, p. 1197.

<sup>5</sup> Vol. v., 1897, p. 107.

Dr. Ainsley,<sup>1</sup> of Hartlepool, records the third case. It was that of a boy, *æt.* 15, who was found to have a gangrenous enteric intussusception three days after he had received a kick on the abdomen whilst he was playing football. Dr. Ainsley cut out the gangrenous piece of bowel, invaginated the upper into the lower end of the gut, and united them by Maunsell's method. As he was not quite satisfied with the strength of the end to end union, three Lembert's sutures were inserted to strengthen the weak points. The divided mesentery was then brought together with sutures, and the abdomen being closed, the boy made so good a recovery that he left the hospital three weeks afterwards, and has ever since remained in perfect health.

**Summary of the Treatment of Intussusception.**—Much more could be said upon this topic of intussusception, but I am satisfied for the present if I have advanced even but a little our scientific knowledge of this most interesting affection. For the sake of completeness, I will sum up the conclusions at which I have arrived. Intussusception is a condition which brooks no delay in its treatment, for something must always be done at once, except, perhaps, in those slight cases which are indistinguishable from severe colic. In all doubtful cases purgatives should be completely withheld. I found in my experiments that cats and rabbits bore a simple invagination with remarkable freedom from symptoms, and that after a varying period of time the invaginated bowel could be excised and the animal would recover. But several of the animals to whom purgatives were administered, after their intestines had been invaginated, died when enterectomy was performed. Clinical evidence teaches the same lesson, for all the records of cases show that the symptoms have been seriously increased when the patient has been purged.

The routine treatment of intussusception is to chloroform the patient, and steadily to fill his large intestine with hot salt solution under a hydrostatic pressure of not more than 3 feet in a child, the fluid being allowed to remain in the intestine at least ten minutes. The earlier this method is adopted after the appearance of the symptoms the better are the results obtained, but it should not be adopted in enteric intussusceptions, in cases where the symptoms are very acute, or in those where the absence of signs and symptoms, with a subnormal temperature,

<sup>1</sup> *The Brit. Med. Journ.*, 1897, vol. ii., p. 83.

leads the surgeon to suspect that the intestine is becoming gangrenous. In these cases, and when an intussusception is not reduced after irrigation has twice been tried, and when, after reduction, the intussusception has thrice recurred, the abdomen must be opened. The surgeon must then be prepared to deal effectually with the conditions he may find by such operative means as he can carry out with the least amount of shock, and in the shortest space of time compatible with the safety of the patient. This will be ensured if he uses the method with which he is the most familiar. But he should bear in mind that hardly a case can arise in which he is justified in closing the abdominal wound without at least attempting to complete the operation by reducing or removing the intussusception. Such half-measures as the formation of an artificial anus are only rarely justifiable, for the results obtained from them are generally most disastrous. In the light of our present knowledge, it appears that the use of a button or bobbin is most likely to give good results when complete enterectomy has to be done for an enteric intussusception, whilst Maunsell's operation is best adapted for the cure of the ileo-cæcal and colo-colic forms of intussusception.



## I N D E X .

- ADHESIONS, intestinal, dangers of, 64  
  extensive, 74, 76  
  formation of, 64, 74  
  not necessarily a bar to irrigation of the bowel, 64  
  position of, 75  
  treatment of, 74
- Adler, Dr., quoted, 54
- Adults, exfoliation of bowel in, 23, 24  
  histological changes in intussusception of, 20-27
- After-treatment of reduced intussusception, 66
- Agonic intussusception, 45, 46
- Ainsley, Dr., quoted, 59, 81
- Anastomosis, intestinal, in intussusception, 77
- Anatomical factors in intussusception, 56  
  peculiarities of intestine, their importance in intussusception, 56, 57
- Anatomy of ileo-colic angle, 35
- Appendix, invagination of vermiform, 66
- Ashhurst, Professor, quoted, 58
- Ballance, Mr., quoted, 79
- Banks, Dr. Mitchell, quoted, 59, 80
- Barium chloride, experiments with, 45, 46  
  treatment for paralyzed bowel, 71
- Barker, Mr. A. E., quoted, 69, 76
- Barth, Dr., quoted, 73
- Bird, Mr. Golding, quoted, 73
- Bowel, inversion of exfoliated, 24
- Braun, Professor, quoted, 77, 80
- Brun, Professor, quoted, 71
- Bryant, Mr., on intussusception, 30
- Cæca, varieties of, 40
- Calomel, experiments with, 48
- Capacity of colon, 62
- Carcinoma a cause of intussusception, 30, 32
- Carver, Dr., quoted, 74
- Cash, Professor, quoted, 51
- Castor-oil, experiments with, 46, 48
- Causes of intussusception, 56, 57  
  spontaneous ileo-cecal intussusception, 55
- Chaffey, Dr., quoted, 65
- Children, exfoliation of bowel in, 22  
  histological change in intussusception of, 8-20
- Clinical factors in intussusception, 55
- Colon and ileum, relative diameters of, 41  
  capacity of, 62  
  early histological changes in structure of, 8-14  
  growth of, 41  
  intussusception of, 32  
  position of rupture from over-distension, 61
- Colo-colic intussusception, treatment of, 60
- Colotomy in intussusception, 26
- Complicated intussusception, cases of, 71, 72
- Coughing a cause of intussusception, 57
- Dandling a cause of intussusception, 57
- Dent, Mr. Clinton, quoted, 72
- Diameters of ileum and colon, 41
- Digestion of exfoliated bowel, 26
- Distended intestines, treatment of, in laparotomy, 69
- Diverticula complicating intussusception, 72
- Double intussusception, 72  
  histological changes in, 28
- Duodenum, suspensory muscle of, 37
- Early histological changes in intussusception, 8-14
- Edmunds, Mr., quoted, 79

- Elliott, Dr. F. H., quoted, 65  
 Emmerson, Dr., case of, 28  
 Enterectomy in intussusception, 77  
   prognosis after, 80  
   recovers after, 80  
 Enteric intussusception, case of, 31  
   rarity of, 31  
   treatment of, 80, 82  
 Enterotomy in intussusception, 76  
 Epsom salts, experiments with, 48  
 Eserin, experiments with, 45, 46  
   for paralyzed bowel, 71  
 European children, anatomy of ileo-  
 colic angle in, 35  
 Excision of bowel in intussusception, 77  
 Exfoliation of bowel in adults, 22, 24,  
   25  
   in children, 23  
   in intussusception, 22-27  
   subsequent changes in, 26, 27  
 Experimental intussusception, 44-48, 79  
   histological changes in, 12-14  
 Extravasation of blood in intussuscep-  
 tion, 11, 13, 15, 16  
 Family history in cases of intussuscep-  
 tion, 55  
 Fibroid changes in intestinal wall, 21-23  
 Functional disorders causing intussuscep-  
 tion, 55, 56  
 Gangrene, difficulty of producing, in  
   animals, 75  
   of bowel, causes of, in intussuscep-  
   tion, 53  
   in intussusception, 53  
 Gangrenous intussusception, treatment  
 of, 77  
 Gibbons, Surgeon-Major, 35  
 Goodhart, Dr., cases of, 31, 66  
 Golding Bird, Mr., quoted, 73  
 Gould, Mr. Pearce, quoted, 70  
 Grawitz, Professor, 54  
 Greig Smith, Professor, quoted, 66, 76  
 Gymnastics a cause of intussusception,  
   57  
 Greediness a cause of intussusception, 57  
 Griffiths, Dr. Joseph, 25  
 Hacon, Mr., case of, 23  
 Hæmorrhage a contra-indication for  
   treatment by irrigation in intus-  
   susception, 64  
   into ileo-caecal valve, 12  
 Halsted, Dr., quoted, 54  
 Halsted's operation in intussusception,  
   77  
 Hammick, Sir Stephen, case of, 22  
 Handfield Jones, Dr., quoted, 72  
 Hernia complicating intussusception,  
   72  
   gangrene of bowel more frequent  
   than in intussusception, 53  
 Hippocrates' treatment of intussuscep-  
 tion, 7  
 Histology of intussusception, 7-34  
   circular muscle, changes in, 12,  
   15  
   colon, early changes in, 8-12  
   experimental intussusception,  
   changes in, 12  
   extravasation of blood, 11,  
   13, 15, 16  
   ileo-caecal valve, changes in, 12  
   ileum, changes in, 12  
   Lieberkühn, changes in crypts  
   of, 10  
   longitudinal muscle, changes  
   in, 11, 15  
   lymphadenoid tissue, changes  
   in, 10  
   mucous membrane, early  
   changes in, 9, 12, 13, 14  
   muscularis mucosæ, changes  
   in, 10, 13  
   serous coat, changes in, 12  
   submucous tissue, changes in,  
   10, 12, 13, 14  
   summary of changes, 15, 16  
   thrombosis of villi, 31  
   villi, changes in, 12, 13  
 History of treatment of intussusception,  
   58  
 Howse, Mr., quoted, 77  
 Howship, Dr., case of, 18  
 Hunter, John, case of, 7, 17, 18  
 Hutchinson, Mr. Jno., quoted, 58, 59  
 Hydrostatic treatment of intussuscep-  
 tion, 60-66  
 Ileaco-ileo-colic intussusception, 50  
 Ileo-caecal fold, 37-41  
 Ileo-caecal intussusception spontaneous,  
   theory of cause, 55  
   especially frequent in child-  
   hood, 56  
   treatment of, 60  
   valve, anatomy of, 43  
   hæmorrhage into, 12  
   histological changes in, 12-14  
   fallacies caused by, 66  
 Ileo-colic angle, anatomy of, 35  
   varieties of, 36-39  
   artery, 37  
   fold, 37  
   fossa, 38  
   intussusception, experimental, 50  
   mesentery, length of, 36

- Ileum and colon, relative diameters of, 41  
 growth of, 41  
 histological changes in, 12
- Incarcerated intussusception, 58
- Incomplete reduction of intussusception, 66
- Indian children, anatomy of ileo-colic angle in, 35
- Injury a cause of intussusception, 57
- Innes, Mr. C. B., quoted, 65
- Intestinal diverticula complicating intussusception, 72
- Intestine, diameter of, 41  
 effects of irritants on, 44  
 exfoliation of, 22-27  
 force of peristalsis, 51, 52  
 growth of, 41  
 peristalsis of, 45  
 relative diameters of, 41  
 rupture of, from over-distension, 61  
 treatment of moribund, 75
- Intussusception, 73  
 abdominal section in, 66  
 adhesions in, 64, 74  
 danger of, 64  
 agonic, 45  
 anatomical facts governing cause of, 42  
 anatomical peculiarities, their importance in cases of, 56, 57  
 causes of, 56, 57  
 chronic, treatment of, 63, 64  
 classification of, for operative purposes, 58  
 clinical factors in, 55  
 colotomy in, 76  
 complicated cases of, 71  
 complicated by diverticula, 72  
 by hernia, 72  
 by polyp, 21, 31, 72  
 by volvulus, 72  
 double, 72  
 due to carcinoma, 30, 32  
 treatment of, 22  
 to papillomata, 30  
 to polypi, 23, 30, 31  
 to purpura, 30  
 early histological changes in, 8-14  
 enterectomy in, 77  
 enteric, 31  
 histology of, 20  
 enterotomy in, 76  
 excision of bowel in, 77  
 experimental, 49  
 histology of, 12-14  
 extensive adhesions in, 74, 76  
 family history in cases of, 55
- Intussusception, functional disorders causing, 55, 56  
 gangrene of bowel in, 53  
 hæmorrhage a contra-indication for treatment by irrigation, 64  
 harmfulness of purgatives in, 59, 81  
 healthy children affected by, 57  
 history of treatment, 58  
 histology of, 7-34  
 changes in villi, 21  
 early changes, 8-17  
 exfoliation, 22-27  
 exfoliated intestine, changes in, 23-27  
 fibroid changes, 21-23  
 in adults, 20-27  
 in children, 8-27  
 later changes, 17-26  
 multiple forms, 27  
 rarer forms, 30  
 sclerosis of intestinal wall, 21-23  
 suppurative changes in, 18, 19  
 ileo-cæcal theory of cause, 55  
 ileo-ileo-colic, 50  
 importance of peritoneal fossa in determining the cause of, 57  
 incarcerated, 58  
 incomplete reduction of, 66  
 into a patent diverticulum, 73  
 invagination of vermiform appendix in, 66  
 irreducible causes of, 73  
 prognosis of, 75  
 irrigation in, 60  
 laparotomy in, 66, 67  
 lateral, 49  
 lateral anastomosis in, 76  
 local peristalsis a cause of, 57  
 Mannsells operation in, 78  
 mechanical cases of, 57  
 method of reducing after laparotomy, 68  
 minute anatomy of, 7-34  
 mortality after abdominal section 67  
 mortality after enterectomy, 80  
 multiple, 72  
 Murphy's button in, 78  
 of jejunum, 31  
 pathological data, 51-54  
 pathology of, 35-57  
 anatomical data, 35-43  
 physiological data, 43-51  
 peritonitis in, 53, 54  
 physiological factors in, 56  
 prognosis after enterectomy, 80  
 progress of, 49  
 purgatives, harmfulness of, 59, 81

- Intussusception, recurrence after laparotomy, 70  
 recurrent, 65  
 release of, 48  
 resection of, 77  
 routine treatment, 81  
 ruptured, treatment of, 77  
 signs of ruptured intestine in, 63  
 simple treatment of, 59  
 spontaneous, causes of, 56  
   histology of, 14, 15  
   reduction of, 51  
   reduction after laparotomy, 55  
   theory of its cause, 55  
 spontaneous recovery after exfoliation of gut, 23, 24  
 strangulated, 58  
 strangulation of bowel in, 51  
 time of occurrence of, 56  
 treatment of, 58-82  
 treatment by abdominal section, 66-82  
   prognosis, 67  
   by irrigation, 60-66  
   of cracks in serous coat of bowel, 69  
   of cases after reduction, 66  
   of inflated intestine in laparotomy for, 69  
   of moribund intestine, 75  
   of, summary of conclusions, 81  
 ulceration of bowel in, 54  
 varieties of, 44
- Inversion of exfoliated bowel, 24  
 Involution of exfoliated bowel, 24  
 Irreducible intussusception, causes of, 73  
   prognosis of, 75  
   treatment of, 74-82
- Irrigation of bowel, cases suited for, 63  
 contra-indications for, 64  
 in intussusception, 60-66  
 method of performing, 63
- Irritants, effects of, on intestine, 44-47
- Jalap, experiments with, 48  
 Jejunum, intussusception in, 31  
 Jessett, Mr. F. Bowreman, quoted, 76  
 Jolting a cause of intussusception, 57  
 Jones, Mr. Sidney, quoted, 76
- Knaggs, Mr. Lawford, quoted, 77
- Laparotomy, dangers of, 69  
 for irreducible intussusception, 73  
 paralysis of the bowel after, 8, 70, 71  
 for reducible intussusception, 67
- Laparotomy, treatment of distended intestine in, 69  
 Large intestine, growth of, 41  
 Lateral anastomosis in intussusception, 77  
 Lateral intussusception, 73  
 Lateral invagination, 49  
 Leichtenstern, Professor, quoted, 57, 58, 74  
 Leszczynski, Dr., quoted, 76  
 Lettsom, Dr., quoted, 74  
 Leubuscher, Dr., quoted, 44  
 Lieberkühn, crypts of, histological changes in, 10, 12, 19, 26, 29  
 Lockwood, Mr. C. B., quoted, 36, 37  
 Lymphadenoid tissue, histological changes in, 10
- Makins, Mr., quoted, 74  
 Marsh, Mr. Howard, quoted, 74  
 Maunsell's operation, 78  
   dangers of, 79  
 Max Baur, Professor, quoted, 57  
 Mechanical causes of intussusception, 57  
 Meckel's diverticula complicating intussusception, 72  
 Meltzer, Dr., quoted, 54  
 Mercury, black sulphide of, experiments with, 45  
   yellow sulphate of, experiments with, 44  
 Mesentery ileo-colic, length of, 36  
   measurements of, 36  
 Minute anatomy of intussusception, 7-34  
 Mole, Mr., quoted, 61  
 Moribund intestine, treatment of, 75  
 Morison, Mr. A. E., quoted, 65 *note*  
 Mortality after abdominal section in intussusception, 67  
   after enterectomy, 80  
 Mortimer, Mr. J. D., quoted, 61  
 Mucous membrane, early changes in intestinal, 9, 12-14  
 Müller, Dr., quoted, 71  
 Multiple intussusception, 72  
   histological changes in, 27  
 Murphy's button in intussusception, 78  
 Muscular coat of intestine, changes in, 11-15  
 Muscular efforts a cause of intussusception, 57  
 Muscularis mucosæ, histological changes in, 10, 13
- Nothnagel, Professor, quoted, 44  
 O'Kinealy, Surgeon-Captain, quoted, 35

- Overdistension of intestine, mode of rupture in, 61
- Page, Mr., quoted, 72
- Papillomata causing intussusception, 30
- Paralysis of the bowel after laparotomy, cases of, 70, 71  
causes of, 8  
treatment of, 71
- Parker, Dr. Rushton, quoted, 72
- Pathological data for intussusception, 51
- Peacock, Dr., case of, 23
- Perignon, Dr., quoted, 38
- Peristalsis, force of, 51, 52  
limited, a cause of intussusception, 57  
results of varying, 45
- Peritoneal absorption, necessity for further investigation of, 54  
coat of bowel, treatment of rents in, 69  
pouches, arrangement of, 38-40  
importance of, in intussusception, 40, 57
- Peritonitis, causes of, 54  
in intussusception, 54
- Peritoneum, treatment of, in laparotomy, 69
- Phillips, Mr., quoted, 59
- Physiological data of intussusception, 43  
factors in intussusception, 56
- Pick, Mr. Pickering, quoted, 55, 59, 71, 80
- Polypi complicating intussusception, 21, 31, 72  
intussusception due to, 23, 30, 31
- Praxagoras' treatment of intussusception, 7, 59
- Prognosis of intussusception after enterectomy, 80  
after abdominal section, 67  
after irrigation, 64  
of irreducible intussusception, 75
- Purgatives, clinical effects of, 48  
experiments with, 46, 47  
harmfulness of, in intussusception, 59, 81
- Purpura, intussusception in, 30
- Pyogenic organisms, their passage through the intestinal wall, 54
- Rarer forms of intussusception, histology of, 30
- Recovery, spontaneous, after exfoliation of gut, 23-25
- Recurrent intussusception after laparotomy, 70  
causes of, 65  
its treatment, 65
- Renshaw, Mr., quoted, 66
- Resection of intestine in intussusception, 77
- Reticulin, 25, 26
- Retrograde intussusception, histological changes in, 29.
- Rhubarb, experiments with, 46
- Rolleston, Dr., quoted, 38
- Ruptured intussusception, treatment of, 77
- Rupture of intestine, experiments upon, 61  
from over-distension, signs of, 63  
from over-distension, treatment of, 63  
mode in which it occurs from over-distension, 61
- Rydygier quoted, 80
- Sarcoma causing intussusception, 30
- Sclerosis of intestinal wall, 23
- Senn, Professor, quoted, 60, 64, 69
- Serous coat of intestine, histological changes in, 12  
treatment of cracks in, 69
- Shock, methods of diminishing, in children, 67
- Simple intussusception, treatment of, 59
- Small intestine, growth of, 41  
position of rupture from over-distension, 61, 62
- Smith, Professor Greig, quoted, 66, 76
- Society for the Improvement of Medical and Chirurgical Knowledge, account of, 17
- Spontaneous intussusception, causes of, 56  
histology of, 14, 15  
recovery after exfoliation of gut, 23, 24  
reduction of intussusception, 51
- Stewart, Professor Charles, 8
- Strangulated intussusception, 58
- Strangulation of bowel, effect of hæmorrhage in producing, 52  
in intussusception, 51  
mechanism of, 51, 52  
pathology of, in intussusception, 47
- Subcæcal fossæ, 40
- Submucous tissue, histological changes in, 10, 12-14
- Suppurative peritonitis in intussusception, 54

- Suspensory muscle of duodenum, 37  
 Sutherland, Dr., case of, 30  
 Sympson, Dr. Mansel, quoted, 63
- Taunton, John, case of, 31  
 Thomas, Mr., quoted, 51  
 Thrombosis of villi, 31  
 Time of occurrence of intussusception, 56
- Treatment of intussusception, 58-82  
 by abdominal section, 66-82  
 by abdominal section, dangers of, 69  
 by abdominal section, methods of diminishing shock in, 67  
 by abdominal section, mortality after, 67  
 by abdominal section, moribund intestine in, 75  
 by abdominal section, paralysis of the bowel after, 8, 70, 71  
 by abdominal section, recurrence after, 70  
 by colotomy, 76, 82  
 by enterotomy, 76  
 by enterectomy, cases of recovery after, 80  
 by Halstead's operation, 77  
 by the hydrostatic method, 60-66  
 by irrigation, after-treatment, 66  
 by irrigation, cases suited for, 63  
 by irrigation, contra-indications for, 64  
 by irrigation, dangers of, 63  
 by irrigation, disadvantages of, 64, 65  
 by irrigation, incomplete reduction after, 66  
 by irrigation, method of performing, 63  
 by irrigation, prognosis after, 65  
 by irrigation, recurrence after, 65  
 by laparotomy, adhesions, 74  
 by lateral anastomosis, 77
- Treatment of intussusception, colocolic, 60  
 enteric form, 60  
 gangrenous, 77  
 hydrogen inflation in, 60  
 injection preferable to inflation, 60  
 injuries to serous coat of intestine, 69  
 ileo-cæcal, 60  
 irrigation in, 60-66  
 laparotomy in irreducible, 73  
 malignant, 77  
 methods of diminishing shock in, 67  
 method of irrigating bowel, 63  
 moribund intestine, 75  
 over-distension in, 61  
 ruptured, 77  
 ruptured intestine, 63  
 rupture of intestine, its common seat in colon, 61  
 in small intestine, 62  
 simple, 59  
 ulcerated, 77
- Treitz, Professor, quoted, 37  
 Treves, Mr., quoted, 38, 41, 42  
 Turner, Mr., quoted, 72  
 Turpith mineral, experiment with, 44  
 Twitching of intestinal wall a cause of intussusception, 57
- Ulceration of the bowel, 54  
 Ulcerated intestine, treatment of, 77
- Valve, ileo-cæcal, 43  
 Vermiform appendix, invagination of, 66  
 Vierhuff, Professor, quoted, 30  
 Villi, histological changes in, 12, 13, 21  
 thrombosis of, 31, 32  
 Volvulus complicating intussusception, 72
- Waterhouse, Mr., quoted, 66  
 Wells, Sir Spencer, quoted, 59  
 Whipham, Dr., quoted, 72  
 Whooping-cough a cause of intussusception, 57  
 Wiggin, Dr., quoted, 67  
 Wright, Dr., quoted, 66

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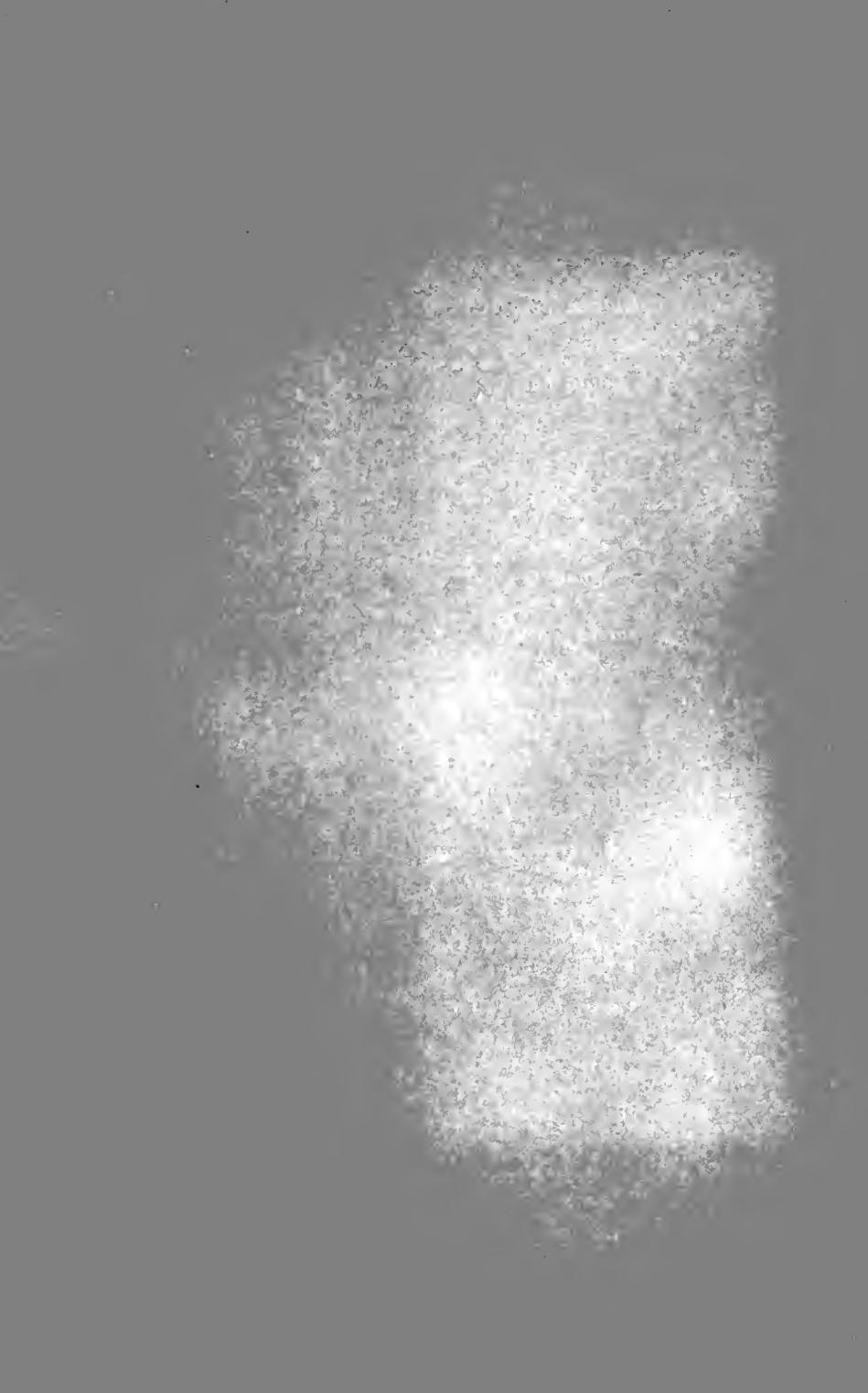
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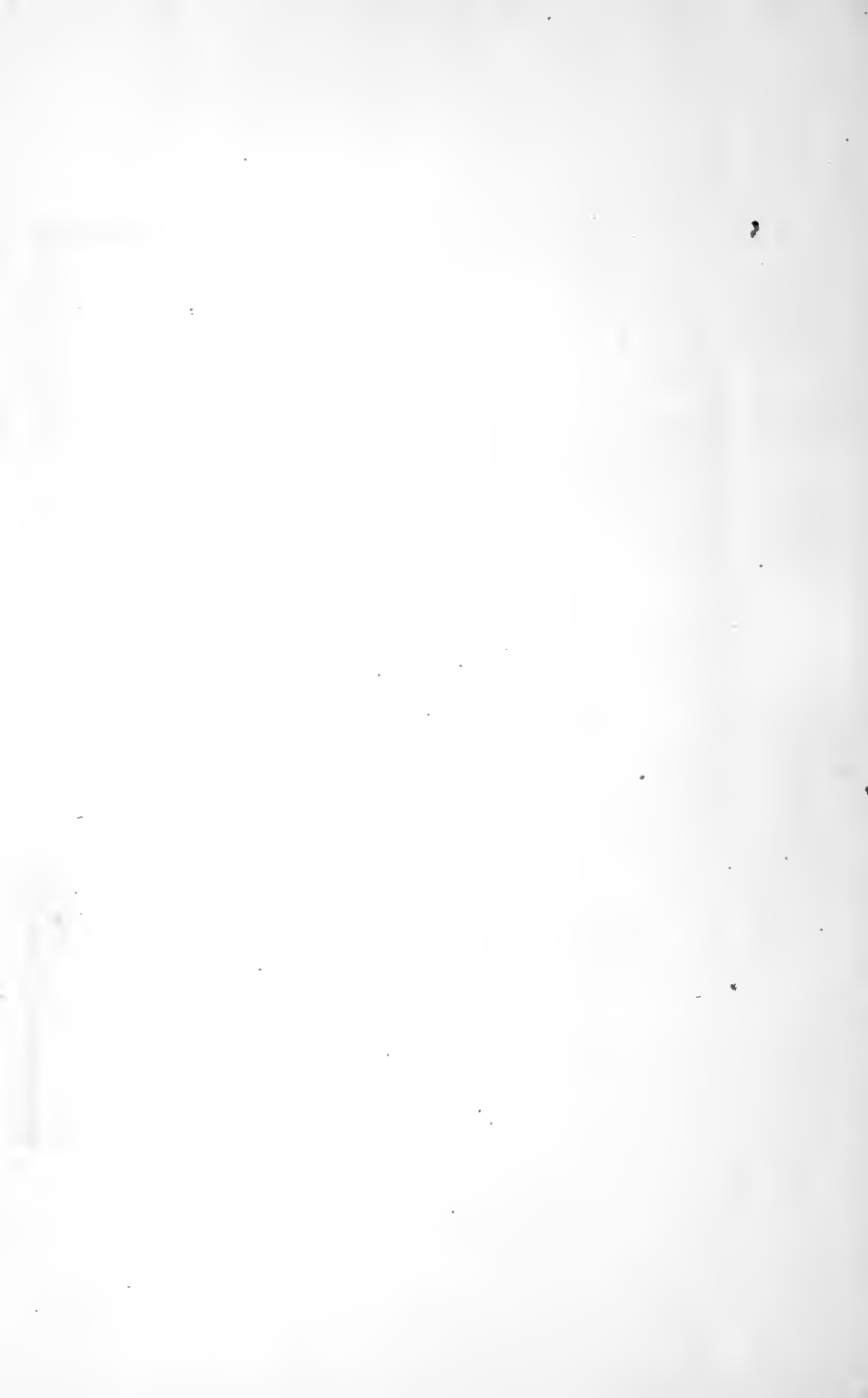
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