The Hunterian lectures on the pathology and surgery of intussusception : delivered at the Royal College of Surgeons of England / by D'Arcy Power.

The Hunterian Lectures

ON THE

PATHOLOGY AND SURGERY

OF

INTUSSUSCEPTION

Delivered at the Royal College of Surgeons of England.

BY

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THE PATHOLOGY AND SURGERY OF INTUSSUSCEPTION.

[Abstract.][1]

Lecture I.—Some Points in the Minute Anatomy of Intussusception.

[Mr. D'Arcy Power began his course of lectures with an apology for selecting so time-worn a subject as intussusception, but he justified his choice by saying that it was one which had occupied the thoughts of John Hunter, the great master in pathology, after whom the chair he occupied was named. Very little seemed to be known about the minute anatomical changes occurring in intussusception, though the various museums attached to the medical schools and hospitals throughout the country contained an abundance of material for its study.

The earliest changes were shown in sections from the intestine of a child, aged 8 months, upon whom the lecturer had performed an operation successfully 13½ hours after the appearance of the first symptoms of intussusception. The child died a few days later, with symptoms of paralysis of the bowel, but without peritonitis. The mucous membrane of the invaginated colon was healthy except for an increased number of goblet cells in its crypts of Lieberkühn. Much blood had been extravasated into the submucous tissue, though no clotting had occurred. The circular layer of muscle was healthy, but the longitudinal layer was œdematous, and was separated from the serous coat by many large venous and lymphatic channels.

The next section was taken from an experimental invagination made in a cat a week previously. The histological changes were again more marked in the mucous and submucous layers than in the muscular coat, but the extravasation of blood was chiefly in the mucous membrane whilst the swelling of the submucous tissue was due to œdema. The sections from the experimental invagination in a cat were compared with a spontaneous intussusception which had killed a dog. The extravasation of blood in the dog's intestine had done serious injury to the mucous membrane and to the submucous tissue, but the chief alteration in its structure had taken place in the muscular coat, where the circular fibres were separated by the œdema and had degenerated.

Some of the later changes in intussusception were illustrated by sections taken from John Hunter's own specimen,

[1] The full text of this lecture will be published in the forthcoming number of the *Journal of Pathology and Bacteriology*.

which was particularly well preserved, because at the time the patient died spirit was so cheap and strong that its retailers used to advertise that their customers might be "drunk for a penny, dead drunk for twopence, and straw to lie upon for nothing." Hunter's specimen, which led him to write his celebrated paper upon "Introsusception," was taken from the body of a child who died sixty hours after the first symptoms of illness had been recognised. Microscopical examination showed that the mucous membrane of the intestine was healthy, but that parts of its surface were covered with blood clot. The whole of the submucous tissue was engorged and œdematous. The circular layer of muscle was more injured than the longitudinal layer, whilst the mesocæcum was thickened by bands of fibrin. A lymphatic gland which had been involved in the invagination was congested.

The latest changes occurring in intussusception were shown in sections taken through the ilea of children in whom the submucous and serous coats of the intestine were suppurating whilst the mucous and muscular layers were comparatively healthy.

The changes which take place in the intestines of adults as a result of intussusception were next shown to be identical in some points with those occurring in the more delicate tissues of children, though in other points they differed widely. The frequent association of adult intussusception with polypi and other growths in the intestinal canal led to the changes being of a more chronic nature. The villi of the mucous membrane, therefore, became converted into mere tags of connective tissue, but the extravasation of blood into the submucous tissue remained a marked feature in the invaginated bowel. In a case of chronic intussusception taken from the body of a man, aged 27, the submucous and muscular layers had become converted into dense fibrous tissue, whilst the villi were congested but had not undergone any mummifying change into connective tissue.

Sections from portions of bowel which had been exfoliated, with and without the recovery of the patient, were then exhibited. It appeared that the intestine occasionally underwent a sclerosing process before it was cast off, but that more frequently it had undergone so much tryptic digestion as to leave only a skeleton of connective tissue (reticulin) which was still sufficiently coherent to be passed as a complete cylinder. An examination of the scarred intestine at the point of separation showed that the mucous membrane repaired itself, and that the submucous tissue became continuous with the serous coat by layers of scar tissue which ran through the interrupted muscular coat. The exact method of repair in these cases required more careful examination, for the specimens which had been examined were not sufficiently well preserved to allow a satisfactory microscopical examination to be made.

The rarer forms of intussusception were then considered, and sections were shown from a case of ascending and retrograde intussusception occurring in the same patient. It was clear that in this instance the descending or ordinary form of invagination was the primary one, whilst the retrograde invagination had been produced much later, though it was not of the "agonic" type. Sections were then shown from a polypoid tumour associated with an intussusception occur-

Table of Measurements at the Ileocolic Angle.

Number.	Age.	Sex.	Type of Cæcum.	Length of Mesentery.	Diameter of Ileum, mm.	Diameter of Colon, mm.	Breadth and Direction of Ileocæcal Slit (mm.)	Direction of Axis of Ileum.	Arrangement of Peritoneal Folds and Mesenteric Glands.
1	Fœtus near term.	—	A.	—	6	6	—	Upwards	Figured and measured by Professor Struthers, *Edinburgh Medical Journal*, October, 1893 (Figs. 1 and 2).
2	,,	—	—	—	9	12		Upwards	
3	5 days	F.	E.	—	11	12	8, horizontal	Horizontal	A well-marked ileocolic fossa; wide ileocæcal pouch.
4	5 weeks	M.	C.	38	11	16	8, horizontal	Horizontal	Shallow ileocolic fossa; no ileocæcal pouch. Many small glands in ileac mesentery.
5	8 weeks	F.	D.	46	13	20	12, horizontal	Upwards	Deep ileocolic fossa; no ileocæcal pouch. A collar of lymphatic glands in ileocolic fold (Fig. 6).
6	15 weeks	F.	A.	47	15	19	10, puckered	Curved downwards	Good ileocolic fossa; wide and deep ileocæcal pouch. One large gland in ileocolic fold (Fig. 4).
7	5 months	M.	C.	37	13	22	7, horizontal	Upwards	No ileocolic fossa; ileocæcal pouch is behind and above instead of behind and below, as is usual. Capacity of colon 10 ounces.
8	5 months	M.	A.	34	15	25	10, oval	Horizontal	Very deep ileocolic fossa; no ileocæcal pouch. Glands in ileocolic fold and in ileocolic mesentery.
9	6 months	F.	E.	50	14	20	10, horizontal	Horizontal	Well-marked ileocolic fossa; deep ileocæcal pouch, with crescentic edge. One gland in ileocolic mesentery.
10	6 months	M.	A	—	14	25	8, gaping	Upwards	—
11	7 months	M.	E.	41	14	20	10, oval	Horizontal	Shallow ileocolic fossa; deep ileocæcal pouch. Glands in ileac mesentery and one in ileocolic fold over colon.
12	7 months	F.	A.	50	18	22	8, horizontal	Horizontal	Deep ileocolic fossa; very deep ileocæcal pouch with thin crescentic edge. Capacity of colon 40 ounces.
13	9 months	M.	E.	47	11	15	8, circular	Curved downwards	Shallow ileocolic fossa; no ileocæcal pouch. One lymphatic gland in ileocolic fold.
14	9 months	M.	D.	55	13	22	7, oval	Upwards	Deep ileocolic fossa; very shallow ileocæcal pouch. Lymphatic glands few and small.
15	9 months	M.	A.	44	15	24	12, horizontal	Horizontal	Deep ileocolic fossa; well-marked ileocæcal pouch. A large mass of glands in ileocolic mesentery.
16	11 months	M.	A.	47	16	20	9, semicircular	Upwards	No ileocolic fossa; no ileocæcal pouch. One large gland in ileocolic mesentery.
17	11 months	M.	E.	50	14	26	9, horizontal	Horizontal	Shallow ileocolic fossa; very large and deep subcæcal pouch. One lymphatic gland in ileocolic mesentery.
18	15 months	M.	A.	56	15	25	9, horizontal	Horizontal	No ileocolic fossa; ileocæcal pouch narrow and deep. No glands.
19	16 months	M.	A.	38	11	15	6, circular	Horizontal	Shallow ileocolic fossa; deep ileocæca pouch with wide mouth. Glands in ileocolic mesentery; none in ileocolic fold.
20	16 months	F.	D.	38	22	29	8, horizontal	Upwards	No ileocolic fossa; shallow and wide ileocæcal pouch. A chain of lymphatic glands lies parallel with the colon.
21	18 months	M.	A.	—	17	20	9, horizontal	Semicircular downwards	Shallow ileocolic fossa; deep ileocæcal pouch opening far forwards beneath ileum. Glands of ileocolic junction.

23	2 years	M.	E.	45	24	28	12, horizontal	Horizontal	Shallow ileocolic fossa; well-marked and wide ileocæcal pouch. Glands in ileocolic mesentery and fold.
24	$2\frac{1}{12}$ years	F.	A.	45	19	32	9, horizontal	Curves upwards	Deep ileocolic fossa; deep and wide ileocæcal pouch. Large gland in mesentery; none in ileocolic fold.
25	$2\frac{5}{12}$ years	M.	A.	—	15	26	13, horizontal	—	Shallow ileocolic fossa; deep ileocæcal pouch. Glands in ileocolic fold.
26	$2\frac{5}{12}$ years	F.	E.	—	16	25	11, horizontal	Horizontal	Shallow ileocolic fossa; deep ileocæcal pouch, with small opening. Glands in mesentery at a distance from ileocolic fold.
27	$2\frac{5}{12}$ years	M.	A.	53	15	30	15, horizontal	Convex upwards	Shallow ileocolic fossa. Mesentery of appendix is derived from lower border of ileum. It is double, and forms a very definite pouch $\frac{3}{4}$ inch in depth. No glands in ileocolic junction, large one in mesentery (Fig. 3).
28	3 years	M.	A.	46	17	30	8, vertical	Upwards	Shallow ileocolic fossa; very deep ileocæcal pouch. Glands greatly enlarged; ileocolic fold thickened.
29	$3\frac{1}{2}$ years	M.	A.	50	16	23	12, oval	Horizontal	Shallow ileocolic fossa; wide and deep ileocæcal pouch. Many lymphatic glands.
30	4 years	F.	A.	—	15	42	17, horizontal	Horizontal	Good ileocolic fossa; ileocæcal pouch very deep, with pinhole opening. Glands in ileocolic fold and in mesentery. Ileocæcal valve admits tip of little finger.
31	4 years	M.	B.	—	16	20	9, oval	Upwards	Shallow ileocolic fossa; deep ileocæcal pouch, with a thin edge. Glands in mesentery; none in ileocolic fold.
32	4 years	M.	A.	57	18	30	18, horizontal	Upwards	Shallow ileocolic fossa; very complex ileocæcal pouch. Two large glands at ileocolic angle with a few smaller ones. Intestinal wall thick and muscular. Died of colocolic intussusception.
33	$4\frac{5}{12}$ years	F.	A.	45	20	35	22, horizontal	Upwards	No ileocolic fossa; no ileocæcal pouch. No glands.
34	5 years	F.	—	100	16	28	—	—	——
35	6 years	M.	D.	—	18	29	—	—	——
36	9 years	F.	A.	50	17	33	15, horizontal	Upwards	Fair ileocolic fossa; shallow and wide ileocæcal pouch. Glands in mesentery at a distance from ileocolic junction.
37	9 years	F.	E.	57	17	45	18, horizontal	Upwards	Well-formed ileocolic fossa; very deep ileocæcal pouch, with minute orifice. Several glands in mesentery, and one in ileocolic collar.
38	9 years	M.	A.	—	26	40	20, horizontal	Horizontal	Shallow ileocolic fossa; deep and complex ileocæcal pouches. No glands.
39	10 years	F.	C.	81	23	63	10, circular	Horizontal	No mesenteric attachment to upper border of ileum. Ileocolic junction concealed by the cæcum. Ileocolic fossa deep. No ileocæcal pouch. Capacity of large intestine 79 ounces.
40	11 years	F.	A.	58	15	47	21, horizontal	Horizontal	A singularly deep ileocolic fossa; no ileocæcal fossa. Glands in mesentery only (Fig. 1).
41	13 years	M.	E.	50	16	34	20, horizontal	Upwards	No ileocolic fossa; no ileocæcal pouch. One gland at junction of ileocolic in the ileocæcal fold.
42	14 years	F.	E.	100	17	42	19, horizontal	Horizontal	Shallow ileocolic fold; complex ileocæcal fossa. Large gland in mesentery. Capacity of large intestine 40 ounces.
43	14 years	F.	D.	82	22	87	24, horizontal	Horizontal	Very deep and complete ileocolic fossa; no ileocæcal pouch. Ileocæcal valve easily admits the forefinger (Fig. 5).
44	$15\frac{1}{2}$ years	F.	A.	72	20	49	14, horizontal	Horizontal	No ileocolic fossa; large and deep ileocæcal fossa, with shallow subcæcal fossa. Very few lymphatic glands.

ring in a woman. The tumour proved to be a sarcoma, but the intestinal villi contained numerous oval bodies which seemed to be thrombosed vessels. The thrombosis was limited to the villi, for the blood vessels in the deeper part of the mucous membrane and in the submucous tissue contained ordinary *post-mortem* clots.

Mr. Power concluded his lecture, which was illustrated throughout with microphotographs, by an allusion to Dr. Vierhuff's and Dr. Sutherland's cases of intussusception occurring in the course of attacks of purpura. He also pointed out the various ways in which a Meckel's diverticulum, whether it was open or closed, might cause the rarest forms of intussusception; and he showed a specimen in which an obscure case of intussusception in an old person was proved by microscopic examination to be associated with carcinoma, that most usual cause of invagination in late adult life.]

Lecture II.—The Pathology of Intussusception.

In the former lecture, Sir, we ascertained some of the minute structural changes which take place in invaginated portions of the intestine, and we were then on the firm ground of fact. In the present lecture I propose to consider some points in the pathology of intussusception, and we shall find that we are almost at once driven to theorise. Every advance in pathology must be made by combining the results obtained from a consideration of anatomical, physiological, and clinical facts, for the science is the mistress of all these its handmaidens. It will therefore be necessary to follow intussusception along these lines, and afterwards to draw certain conclusions from the premisses thus obtained.

Anatomical.

It behoves us to make a careful anatomical examination of the ileo-cæcal portion of the alimentary canal, because 40 to 60 per cent. of all the recorded cases of intussusception are said to occur at this part of the intestine. My work, therefore, has been limited to the ileo-colic angle, and I have been very greatly assisted by Dr. Pickard and Dr. Hayne, successively the senior resident medical officers at the Victoria Hospital for Children. These gentlemen have given me many opportunities to examine the ileo-cæcal region in the bodies of children from a few days old up to the age of 15 years. The results of our observations are set out in the preceding table.

It should be stated that the mesentery 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 its tissue is very easily stretched. All the other measurements were made when the specimen had been hardened for twenty-four hours in Müller's or in Foà'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.

a. The Mesentery.

The length of the mesentery is a matter of interest in considering the pathology of intussusception, because the size of the invagination depends materially upon the length of the mesentery or upon its extensibility. Time does not allow me to consider the matter in detail, but it is obvious from a consideration of the table 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 its proportion to the length of the body was much greater in infants than in older children. Increased length of mesentery is necessarily associated, other things being equal, with an increased range of movement in the intestine. The intestines should therefore be capable of a greater range of movement in children than in adults. This result is confirmed by the practical experience of all surgeons who have had to open the abdomen for the relief of intussusception in children, for the intestines are nearly always so freely movable that it is easy to bring the tumour into the wound. A few cases are recorded, however, 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 off 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 to form 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,[2] Lockwood,[3] 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 might prove an important

[2] *Vierteljahrschr. f. d. prakt. Heilkunde*, Prag, vol. i, 1853, p. 113.
[3] *Hunterian Lectures on Hernia*, London, 1889, p. 24.

factor in the causation of intussusception if it extended as far as the ileo-colic junction, by hindering the movement of one border of the intestine. I therefore took the trouble to stain and make a microscopical examination 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.

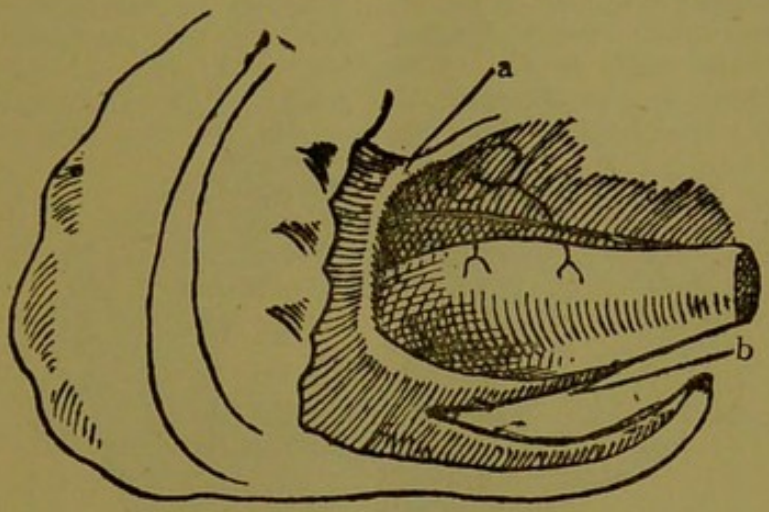

Fig. 1.—A simple but complete form of ileo-colic angle from a girl, aged 11 years. The ileo-colic fossa is well formed, and the axis of the ileum is almost horizontal. (*a*) The ileo-colic fold. (*b*) The ileo-cæcal fold.

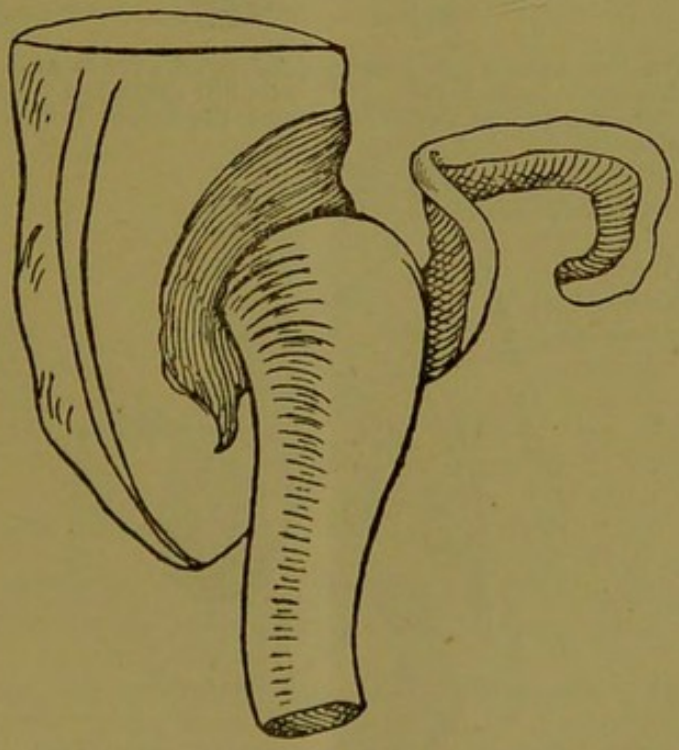

Fig. 2.—The ileo-colic angle of a child, aged 23 months. The ileo-colic fossa is absent, and the axis of the ileum is directed upwards to end in the large intestine

b. The Ileo-colic Angle.

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 (Fig. 1) in 20 cases; in 15 it sloped upwards to open into the large intestine (Fig. 2); in

3 it was curved concavely downwards (Fig. 3), and in one it was curved convexly downwards (Fig. 4). The actual line of union of the ileum with the colon is hidden both in front and behind by folds of the peritoneum, whose arrangement has been made familiar to us by the works of Mr. Treves,[4] Dr. Rolleston and Mr. Lockwood,[5] in England, and of Dr. Pérignon,[6]

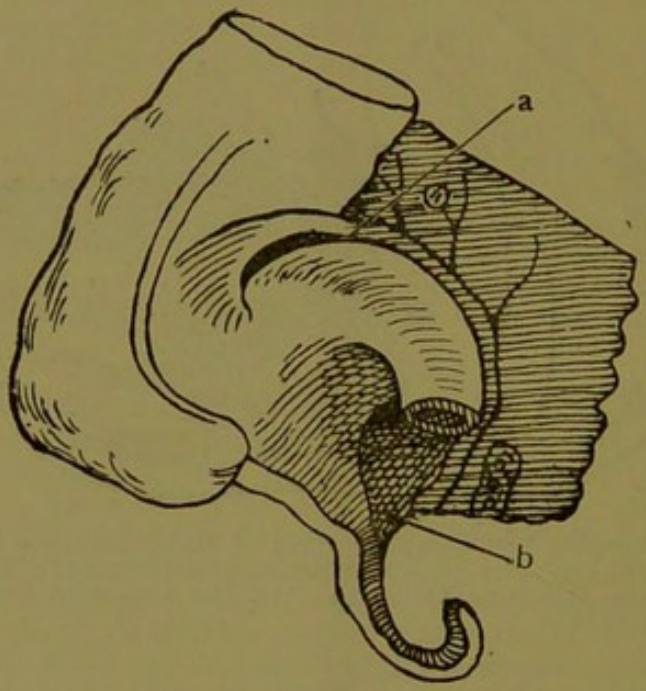

Fig. 3.—The ileo-colic angle from a child, aged 2 years and 8 months. The ileo-colic fossa (*a*) is incomplete, but there is a very large and deep ileo-cæcal fossa (*b*). The axis of the ileum is concave downwards.

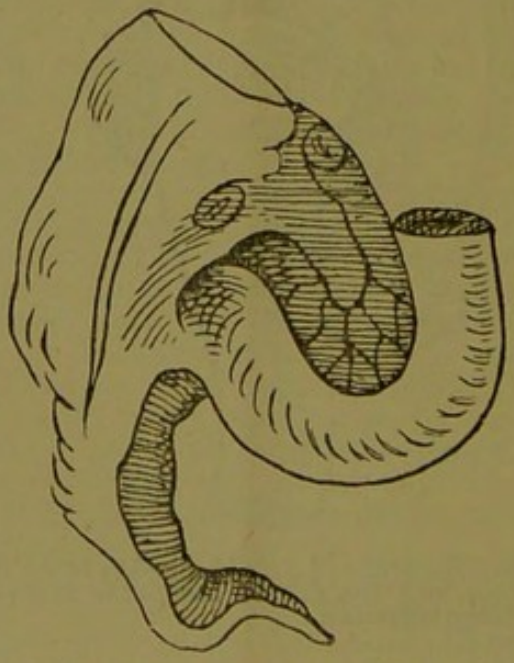

Fig. 4.—The ileo-colic angle of a child, aged 15 weeks. The ileo-colic fossa is incomplete, and the axis of the ileum is convex downwards.

[4] *The Anatomy of the Intestinal Canal and Peritoneum in Man*, 1885.
[5] *Journ. of Anat. and Physiol.*, xxvi, 1892, p. 130.
[6] *Thèse de Paris*, 1892, No. 4.

in 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 and below it. The ileo-colic fossa resolves itself into two great types, the complete (Fig. 1) and the incomplete (Fig. 6), whilst in some cases (Fig. 2) it is entirely absent. The complete fossa (Figs. 1 and 5), which is usually coexistent with the simpler types of cæcum, is that in which the ileo-colic fold stretches in a wide sweep from the ileo-colic mesentery across the ileum to form the mesentery of the appendix. This fold is attached to the cæcum externally, and terminates internally in a crescentic margin

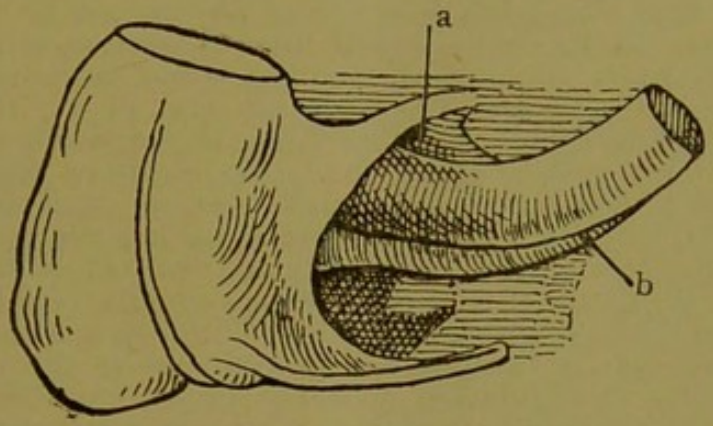

Fig 5.—The ileo-colic angle of a girl, aged 14 years. The ileo-colic fold (*a*), and the ileo-cæcal fold (*b*) are unusually well developed. The axis of the ileum is nearly horizontal.

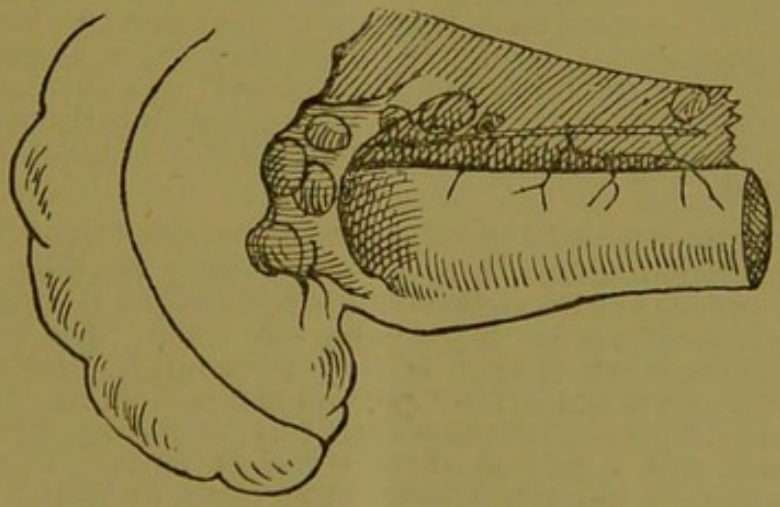

Fig. 6.—The ileo-colic angle of a child, aged 8 weeks. The ileo-colic fossa is incomplete, but its roof is studded and thickened with lymphatic glands. The axis of the ileum is horizontal.

which forms the mouth of the ileo-colic fossa. This border is sometimes thick and rounded (Figs. 1 and 6), at other times thin and membranous (Fig. 5), and the ileo-colic fold may often contain one or more lymphatic glands (Fig. 6). The lower wall of the pouch is formed by the ileo-cæcal fold in the most simple instances. This fold is attached for a varying distance along the lower border of the ileum, but, like all the other structures in this region, it varies greatly in its development, and is often wholly absent. Numerous modifications of this type are seen (Figs. 1 and 5), but they agree in having a pouch of greater or less depth which involves the

whole width of the ileum. The incomplete form of pouch (Figs. 3, 4, and 6) occurs when the ileo-colic fold terminates on the anterior surface of the ileum. When there is no pouch (Fig. 2) the ileo-colic fold is attached to the ileum in its whole extent.

The peritoneal folds lying behind the ileo-cæcal junction are much larger and more complex than those situated in front of it, and the fossæ formed by them vary so greatly in width, depth, and structure that I have no time at present to describe them adequately. It must suffice to say that they are divisible broadly into the ileo-cæcal (Fig. 3, *b*) which runs upwards behind the ileo-colic junction and the subcæcal fossæ, which are situated behind the cæcum, 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 easily be reduced 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 must necessarily be formed which will soon cause the intussusception to become irreducible. Such cases will therefore run an acute course. The nature of the mouths of the pouches must also be taken into account, for in some cases they are so wide that the fossæ are merely depressions, whilst 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, or would become distended by the products of inflammatory exudation.

c. Relative Diameters of Ileum and Colon.

It is of importance, too, in considering the anatomical points connected with an ileo-colic 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, and before birth its diameter is usually the same, or even a little less; at the age of 15 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 its function 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 at first almost stationary in length, whilst, 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,[7] who occupied this chair in 1885. He executed his task with such skill and assiduity that I did not think it worth while to work over the same ground, but 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

[7] *Anatomy of the Intestinal Canal and Peritoneum in Man*, 1885, pp. 9 and 10.

capacity, though for a time its length may remain stationary. Thus in the specimen 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, the small intestine remaining of almost the same diameter (No. 7 in the Table), 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.[8]

These facts seem to have an important bearing upon the question of the origin of intussusception. The colon is growing rapidly and continuously in width from birth onwards, but at about the age of 4 months it also begins to grow in length. The small intestine has grown steadily in length and breadth from the beginning, but the increase in its circumference is less rapid than the increase in its length. During the early months of 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, but to this we shall recur presently. Clinical evidence shows that spontaneous intussusception occurs most frequently between the fourth and sixth months, when the large intestine is beginning to grow in length as well as in width.

d. 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 textbooks of anatomy is substantially correct in a large number of cases, but in many the arrangement differs. The orifice is often oval or circular in the hardened specimens, instead of being horizontal, and a part of the valve is frequently so defective that the opening appears to be horseshoe-shaped when it is seen from cæcum. In one or two cases the orifice very closely resembled the pyloric opening in the stomach. 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 on one side than upon the other, and in a few cases the mucous membrane of the ileum was distinctly prolapsed into the large intestine.

Physiological.

Let us turn now from the anatomical to the purely physiological side of the question as to the cause of intussusception. 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 coats of

[8] Intussusception is said to be so uncommon amongst the native population of India, that I asked Surgeon-Major Gibbons, I.M.S., and Surgeon-Captain O'Kinealy, I.M.S., to obtain for me the ileo-colic angles of Hindu children. After much trouble they have been successful in sending me two, of which the measurements were: (1) M., aged 2 years, ileum, 17 mm.; colon, 27 mm.; no ileo-colic fold. (2) M., aged 3 years, ileum, 18 mm.; colon, 24 mm ; no ileo-colic fold.

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.

The experimental work of Dr. Leubuscher,[8] elaborated and carried to a more successful issue by Professor Nothnagel,[9] 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 vigorous 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, which is 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 specimens[10] which came from the museum of Mr. George Langstaff. They were taken from dogs which had been dosed with turpith mineral for the cure of the distemper. The signs of intussusception began almost directly after they had taken the drug. The first dog lived two days, the second dog three days. 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 intestines. 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 artificial invagination being afterwards fixed with a few point sutures of silk or horsehair. Turpith mineral, black sulphide of mercury, eserin, barium chloride, calomel, rhubarb, magnesium sulphate, croton oil, and castor oil were administered with varying results. Some of these drugs, like croton oil, turpith mineral, and the black sulphide of mercury, were administered on account of their irritant action; some, like rhubarb, Epsom salts, barium chloride, and castor oil, because they increased in various ways the peristaltic action of the bowel; whilst others, like eserin, were given because they produced a tonic contraction of the coats of the intestine.

Time fails me to detail the experiments I have performed; it must suffice for the present to give results. Turpith mineral and black sulphide of mercury cause enteritis, and so modify the irritability of the intestine as to lead to its muscle being thrown into a series of localised 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 could possibly be produced. I endeavoured to modify this uniform contraction by excising pieces of the mesentery and by administering purgatives to the animal before the eserin was injected, but without any satisfactory result. The effects of barium chloride were of great interest.

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[8] *Virchow's Archiv*, vol. lxxxv, 1881, p. 83.

[9] *Beiträge zur Physiol. und Pathol. des Darmes*, Berlin, 1884, p. 42; *Spec. Path. and Therap.*, Bd. xvii, Theil ii, 1896, p. 297.

[10] Museum of the Royal College of Surgeons of England, Nos. 2,725 and 2,726.

The increased peristalsis produced by the injection of 6 minims of a 2 per cent. solution of barium chloride was sufficient in a cat to reduce the ileac portion of an artificial invagination, though the cæcum remained completely invaginated within the colon. A different result occurred in another invagination, for the increased peristalsis led to the intestine becoming M-shaped at the point of invagination, the kink being so sharp that the animal died of complete intestinal obstruction.

A simple invagination of the intestine in a cat produces little or no discomfort to the animal, for it leads neither to gangrene, strangulation, nor acute symptoms. This specimen (Fig. 7) was taken from a cat in which the

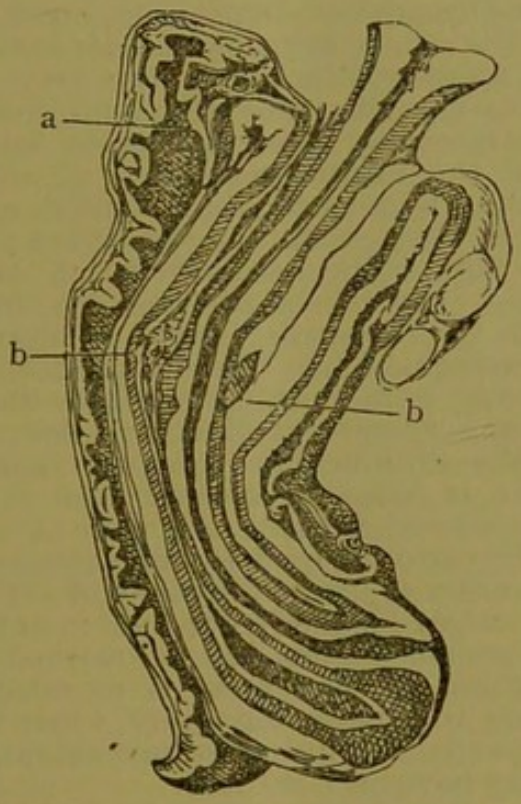

Fig. 7.—An ileaco-ileo-colic invagination produced experimentally in a cat. The invagination was removed, and the cut ends of the intestiue were united by Maunsell's operation a week after the intussusception had been produced. The ileo-cæcal valve is seen in section at *a*, whilst *b b* mark the position of the sutures which a week previously were inserted at the neck of the invaginated intestine.

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 great thickness of the muscular coat in these animals. The sutures therefore hardly passed into the submucous layer, and they consequently held badly and threatened to cut their way out of the brittle muscular coat when 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 cut their way out, and that the invagination had reduced itself. For a week the animal took its food and behaved exactly 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 anæsthetised, and a second incision was made to the right of the first one, which had nearly healed. The invagination still existed, so I removed it by cutting through the intestine above and below the tumour. The ileum and colon were then joined by Maunsell's method, the operation being completed in thirty-five minutes from the first incision, and half an hour later the cat was lapping milk.

The invaginated portion of the intestine (Fig. 7) 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, whether the contraction be a descending one, as is usual, or retrograde, as is less often seen. 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. The whole length of the intussusception is 75 mm., and as the sutures mark the original neck, the invagination has advanced 32 mm. in eight days—that is to say, it has nearly 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 normal, and has not become invaginated. The intussusception is pervious throughout, a fact which explains the freedom of the cat from any symptoms of obstruction. The invagination is of the chronic form, for the apex of the invaginated ileum is alone congested. The intussusceptum, 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 intimately blended by the union of the mesenteric folds. 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.

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 position 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,[11] of Aberdeen, who says that in dogs a weight of 8 to 10 g. is sufficient to prevent a well-developed peristaltic wave from executing its object, whilst the traction exercised by a weight of 5 g. produced much hindrance and caused spasmodic contraction of a propulsive character which created most distinct discomfort or colic.

Pathological.

A considerable number of the cases of intussusception are merely invaginations of one piece of bowel into another

[11] *Proc. Roy. Soc.*, vol. 41, 1887, p. 230.

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,[12] 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.

1. Strangulation.

Strangulation in intussusception is more often chronic than acute. 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 bigger than itself, as in the enteric form, or only slightly larger, as in the ileo-cæcal variety ; whilst 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 my first lecture, 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—that is to say, at the end of the intussusceptum and at the point 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 imprisoned, for, as I have endeavoured to show, 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 shows 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 watched 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. The continuance of peristaltic contractions show 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 paralysed 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.

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[12] *Lancet*, ii, 1886, 1219.

2. 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 parts 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,[13] 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.[14] It runs a more chronic course 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 intestine, for the gangrene in chronic cases nearly always begins in the intussusceptum, though it may afterwards involve the intussuscipiens.

3. Ulceration.

The occurrence of ulceration or of necrosis of the intussuscipiens 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 that micro-organisms begin to traverse the intestinal wall when a loop of bowel has been constricted for a period of from 4 to 48 hours, and that the more completely the blood supply is arrested the more rapidly do they

[13] *Trans. Path. Soc.*, xxviii, 1877, p. 131.
[14] *Holmes's System of Surgery*, Ed. 3, vol. ii, p. 767.

pass. 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[15] and of Halstead[16] 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 wants to be worked out, for Drs. Adler and Meltzer[17] 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, though it is full of interest.

Clinical Factors.

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[18] 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[19] in the case of a child, aged 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[20] 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. In a few cases such advanced intussusceptions have receded spontaneously, whilst in others when the abdomen has been opened the surgeon[21] has rejoiced to find that the invaginated bowel unfolded itself spontaneously as soon as the merest touch had released the constriction at its neck.

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[15] *Charité Annalen*, xi, 1884, p. 770.
[16] *American Jour. of the Med. Sci.*, xciv, 1887, pp. 437 and 451.
[17] *The Journal of Experimental Medicine*, i, 1896.
[18] Hutchinson, *Med.-Chir. Trans.*, vol. lix, 1876, p. 100; Bryant, Harveian Lectures, p. 12, Case 17.
[19] *Lancet*, 1891, i, p. 1312.
[20] Pick, *Lancet*, i, 1891, p. 1312; *Archives of Pediatrics*, xiii, 1896, p. 616.
[21] Marsh, *Med.-Chir. Trans.*, vol. lix, 1876, p. 81; Fagge and Howse, *Med.-Chir. Trans.*, vol. lix, 1876, p. 88; Shepherd, *Lancet*, ii, 1892, p. 1155.

The effects of the constriction in untreated cases are essentially chronic, for strangulation, gangrene, and ulceration are secondary changes which may never make their appearance in the course run by an ordinary intussusception.

Conclusions.

The evidence derived from anatomical, physiological, pathological, and clinical data render it legitimate to assert that spontaneous ileo-cæcal intussusceptions occur where the colon is 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, 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, but this is probably a factor of very rare and subordinate importance.

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 spontaneous invagination whether it is of the enteric variety, the ileo-cæcal, or the colic. The physiological factor is much less easy to specify than the anatomical, 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 large intestine. 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 sarcoplasm, whilst the ordinary tetanus and twitch is 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 sarcoplasm 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 intussusception is obscure, but clinical evidence shows that it may be produced mechanically though the spontaneous form is the more common. Amongst such mechanical causes are direct injury to the

belly,[22] sudden and violent muscular efforts,[23] gymnastic movements,[24] jolting or dandling,[25] paroxysmal coughing as in whooping cough,[26] or it may even be the reward of greediness, as in the cases recorded by Max Baur[27] and Leichtenstern,[28] 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 portion, 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 lymphatic glands, will allow the intussusception to run a chronic course, even though the amount of bowel invaginated is very great. Complex fossæ, with numerous glands at the ileo-colic angle and prolongations of mesentery along the end of the ileum will, no doubt, so far steady the ileum as to render its intussusception less likely. But if it should occur, the additional amount of tissue invaginated will render the impaction so peculiarly tight that if gangrene is not produced at once early adhesions will be formed and the intussusception will soon become irreducible.

[22] *Guy's Hosp. Rep.*, 1869, p. 290; *Trans. Clin. Soc.*, xvi, 64; *Lancet*, ii, 1888, 315; ii, 1892, 482.
[23] *Lancet*, ii, 1888, 315.
[24] *Lancet*, i, 1893, 651.
[25] *New York Medical Record*, vol. xlix, 1896, p. 73, Case xiv
[26] *Trans. Clin. Soc.*, xxii, 1889, p. 282.
[27] *Berl. klin. Woch.*, No. 33, 1892, p. 817.
[28] *Deutsch. Archiv. f. klin. Med.*, xii, 1874, p. 381.

Lecture III.—The Treatment of Intussusception.

I called your attention, Sir, in my previous lectures to the scientific aspects of intussusception, and I have now to deal with the subject from a practical standpoint. I showed you first the minute anatomical changes which take place in the tissues injured by invagination, and afterwards I brought before you certain anatomical, physiological, and pathological factors which appeared to be of importance in causing the affection. These points are only of subordinate interest to the practical surgeon, for though a knowledge of them helps to elucidate the cause of intussusception, it does not in any way assist in its cure.

Turning, then, from the theoretical to the more severely practical aspects of intussusception, there can be no doubt that all cases of the affection have to be treated upon the assumption that they are either reducible or irreducible. I do not propose to occupy your time with a 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, and is not the mind-narrowing vocation that some would have us believe—will find that Professor Ashhurst,[1] Dr. Leichtenstern,[2] and Mr. Jonathan Hutchinson[3] have published admirable summaries of it from different points of view.

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 to delay is death.

a. Reducible Intussusception.

Clinical and pathological evidence show that an invaginated portion of the intestine has a constant tendency to reduce itself until its muscular coat becomes paralysed, 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, 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.

1. Treatment by Irrigation.

Injection is preferable to inflation, because the force employed can be graduated with much greater accuracy, whilst the apparatus is always at hand. But irrigation is not of the least service in the enteric form of intussusception—where one part of the small intestine is invaginated into another, for many observers[5] 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[6] 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.

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. The valuable experiments of Mr. Mortimer[7] in London and of Mr. Mole[8] 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 neutralised, for the intestinal wall is then compressed between two opposing forces. Mr. Mortimer experimenting upon the unopened bodies of children, 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 overdistended 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 2½ lbs.—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 overdistension. 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.

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 the capacity of the colon in any individual case of intussusception, nor can he judge the amount of pressure that 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 in a child,[9] aged 3 months, though the injection was made by one of the most careful and experi-

enced surgeons in the profession; whilst in another child,[10] aged 7½ months, three quarts under a head of 5 feet pressure were injected into the intestinal canal without doing any injury.

Dr. Muir, at my instigation, has measured the capacity of the colon in the bodies of several children, with the results shown in the table I presented to you in my second lecture. The measurements show how widely different is the capacity of the colon in different children of almost the same age. Thus in a male child of 5 months old 10 ounces of water were sufficient to distend the colon, whilst in a girl of 7 months 30 ounces could easily be passed into the large intestine.

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 anæsthetised patient. 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 performed, and he must carefully avoid great variations of pressure. A sudden and uniform enlargement of the whole abdomen during irrigation raises a strong suspicion that the bowel has been ruptured, because rupture of the colon almost always takes place before there is any great distension of the small intestine. 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 the 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 Sympson[11] 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 brought to your notice in the last lecture. 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 their reduction has been once begun.

A chronic case with a great deal of glairy discharge, whose 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[12] 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[13] investigated

this point, and found that in one case when the colon was overdistended 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 contraindicate 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 contraindicates the treatment of intussusception by irrigation, for it points to the early recurrence of gangrene.

A great disadvantage attends the use of irrigation for the cure of intussusception apart from the danger of rupture, which has already been sufficiently discussed. This disadvantage is the liability to recurrence after reduction. Dr. F. H. Elliott [14] 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 [15] had a less satisfactory experience, for an intussusception recurred on five separate occasions until the patient—a boy aged 3 years—died of exhaustion. When recurrence is a very marked feature in a case, it is better to open the abdomen at once rather than to trust to repeated irrigation of the bowel, for it appears [16] that reinvagination can positively 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, however, for a child is now under my care who apparently has been cured of an intussusception, though irrigation had to be done on five separate occasions before the tendency to recurrence was overcome.

There appear to be several reasons for this tendency to recurrence. The first and the least satisfactory is that the conditions which led to the original intussusception may persist. An intussusception would then recur after any method of treatment, but it is particularly likely to do so when the reduction has been brought about by distension of 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 therefore open to the objection that they predispose to a fresh invagination of the congested, compressed, and partially paralysed 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 it is necessarily performed with 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 he 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 necropsy. Dr. Goodhart[17] 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[18] also quotes a case in which the appendix was found unreduced after death, and still invaginated within the cæcum. 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[19] 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 intussusception.

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 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. 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 had been opened is 67.2 per cent. Dr. Wiggin,[20] 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 the 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 has 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 on to a successful issue.

Shock is the great and immediate cause of danger in every case of 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 ascending 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 one-fiftieth of a grain of strychnine, 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, though 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 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 still further and very greatly lowered.

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[21] 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. 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 some form 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 peritoneal 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 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 very 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.

An intussusception sometimes recurs after it has been reduced, 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[22] 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 had 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 two healthy motions, and seems to be on the highway to recovery, but within a few hours or a few days he again becomes constipated, his belly

becomes distended with flatus and he dies. A case of this kind recently came[23] under my care in the person of a boy aged 8 months who had suffered 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 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.[24] Brun's case recorded by Müller[25] 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 your attention has been called already show that the bowel in these cases is paralysed 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 eserin. 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 the early stages one layer is injured more seriously than the other, and the circular layer more often than the longitudinal.

When an intussusception has been successfully reduced after laparotomy, the surgeon should satisfy himself before he closes the abdomen that he has overcome the 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[26] published 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 I have already mentioned the less uncommon cases of double intussusceptions. Double intussusceptions usually run in opposite directions, and are separated by an interval of healthy intestine, but occasionally[27] they may overlap each other so that the retrograde invagination, which is generally the 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,[28] occurred in a woman aged 29, in whom an intussusception associated with a polypus was com-

plicated with a volvulus at two different parts of the intestine. In yet another case—occurring in a girl of six months old—recorded by Mr. Clinton Dent,[4] 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.

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 if enterectomy were 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.

b. 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.

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 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.

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 ex-

perimental 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[30] 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 befel Mr. Makins[31] 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,[32] in which the symptoms of intussusception were of three months' duration, and by Dr. Leichtenstern,[33] where they had lasted eleven months, and yet the *post-mortem* examination showed that hardly any adhesions were present. Dr. Carver,[34] too, met with a remarkable case of the same kind, in which a boy aged 2 years and 9 months suffered from symptoms of intussusception for seven weeks. He had fæcal 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 intussusception, and their extent, at any rate in the ileo-cæcal forms, depends, I assume, upon the varying relations of the mesenteric folds which were described in my second lecture. 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.

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. I have already occupied some part of your time with a consideration of gangrenous intussusception, so that I shall not deal further with its pathology or causation, except to say that it 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 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.

1. Simple Irreducible Cases.

In chronic cases, when the end of the intussusceptum is gangrenous; when the intussusception is short and when it is irreducible from adhesions landed to its neck from the presence of a polypoid tumour, or from a bulbous enlargement of the end of the intussusceptum, the method recommended by Barker,[35] Jessett,[36] and Greig Smith[37] may give excellent results. The broad principle underlying each modification of the operation is to ensure the union of the intussuscipiens with the intussusceptum by inserting a continuous suture at the neck of the tumour, 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[38] left the piece of bowel in the large intestine to be dealt with by Nature, and the patient recovered.

These methods are useless when the intussusceptum is attached to the returning layer by firm adhesions for any great distance, as in these cases the two cylinders of intestine may form a continuous tube. Mr. Sidney Jones[39] recorded such a case occurring in a child, aged 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 whole 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[40] 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.

2. 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[41] 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[42] in Germany, and in 1887 that Mr. Lawford Knaggs[43] 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 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.

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. 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, for in all the cases where 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. It must necessarily prove less useful in intussusceptions involving the large intestine because the appendices epiploicæ then render it impossible to bring the two surfaces into regular and uniform apposition.

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,[44] 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, as may be seen in this specimen. It is part of the intestine of a cat from which ten inches of the ileum and colon with a small experimental intussusception of a week's duration were removed by Maunsell's operation on August 6th, 1896, the animal being killed on February 2nd, 1897. 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, though I have not yet had time to make a microscopic examination. 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.

I find that in performing Maunsell's operation especial care must be taken to suture securely the mesenteric borders of the intestine, for the bleeding and the increased thickness of the tissues at this point 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 part 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 is all that is needed to bring the cut edges of the mesentery together.

The outlook for cases of irreducible intussusception treated by enterectomy is distinctly favourable, whatever method be adopted. When Braun[45] 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[46] of 25 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 four more recoveries are to be added to this list. Two of these occurred in America,[47] where the operation was done for the relief of chronic intussusception in women, and two were done in England for subacute gangrenous intussusception in children. One of these cases is recorded by Dr. Mitchell Banks,[48] who tells me that the boy is still alive and well. The other case came under the care of my colleague, Mr. Pickering Pick, and, though it is still unpublished,[49] he has very kindly given me leave to say that it was a girl aged 8¾ years who had complained of intense stomach-ache 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 ninth day after the operation.

Conclusions.

My time, Sir, has almost ended; not so my task, if, indeed, a labour of love can be called by so harsh a name. There is much more that I could have 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 so interesting an affection. For the sake of completeness I will sum up the conclusions at which I have arrived in this lecture. 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. All the animals, however, to which purgatives were administered after the 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 intussusception, in cases where the symptoms are very acute, or in those where the absence of signs or symptoms, with a subnormal temperature, leads the surgeon to suspect that the intestine is becoming gangrenous. In these cases, and when the intussusception is not reduced after irrigation has twice been tried, and when after reduction the intussusception has thrice occurred, 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 that is 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 an attempt to complete the operation by reducing or removing the intussusception. Such half measures as the formation of an artificial anus are hardly ever justifiable, and the results obtained by them are usually 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 enterectomy has to be done for an enteric intussusception, whilst Maunsell's operation is best adapted for the cure of ileo-cæcal and colo-colic forms of intussusception.

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