THE SURGICAL MANAGEMENT OF THE MALIGNANT COLON

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HISTORY

The history of modern colonic surgery, so far as is known, begins in 1832 when Reybard excised a carcinoma of the sigmoid and did end-to-end suture, the patient dying of recurrence a year later. He was so roundly castigated for his temerity by his professional brethren that if he repeated the offence, it is not on record. A hundred years previously the prolonged European wars of the first half of the eighteenth century had stimulated the interest of military surgeons in intestinal suture and much was done. Linen and catgut sutures were used, being steeped in wines and spirits. Suture of bowel over a hollow cylinder was much in use, wood or animal trachea being employed. The use of these was followed at the beginning of the nineteenth century by the india-rubber tube. These were the forerunners of the Murphy and the Allingham Button so much in use at the turn of the present century. Thiersch in 1843 did an unsuccessful resection with anastomosis, but it was not until the advent of Listerian methods of antiseptics that colonic surgery began to be popular. In 1884 Billroth reviewed 17 cases with a mortality of 60 per cent. by 1890 48 cases had been published with a mortality of 45 per cent.

EXTERIORISATION

When we consider the hazards of end-to-end anastomosis as experienced by the pioneers of colonic surgery and the high mortality which resulted, we cannot be surprised that fertile minds were seeking new methods of dealing with the problem. As is usual, different men in different countries hit on the same solution and exteriorisation was born. Schrede in 1879 was the first to exteriorise both bowel ends as he could not approximate them after resection, and in the same year Billroth, after resecting the pelvic colon, closed the distal end and took the proximal loop out as a colostomy. Thereafter, however, he continued his practice of primary anastomosis with high mortality.
In 1891 Bloch, 3 of Copenhagen, published the first extrusion operation, and was followed by Paul, 4 of Liverpool, in 1895 and by Mikulcz 5 in 1902. Beginning as a simple extrusion of the pelvic colon with the tumour on its summit, and modified by Paul to removal of the extruded loop with a fairly wide mesenteric area and drainage of the proximal end by his well-known tube, the practice of exteriorisation extended until, in more modern times, after wide removal of colon and gland bearing area has been accomplished, decision has to be made whether to safely exteriorise or to risk primary anastomosis. The spur was destroyed at first by clamps, later by dissecting forceps and scissors, and later still by freeing the loop from the abdominal wall and restoring the continuity of the bowel by suture. Exteriorisation, by the end of the last century had reduced the mortality of resection of the colon to 15 per cent. and made surgery of the malignant colon possible, leading not only to bolder and wider resections but to a more intimate knowledge of pathology and spread.

Many of the disadvantages of exteriorisation are now past history. At an earlier period, insufficient removal of bowel and mesentery, recurrence at the site of extrusion, and difficulty in exteriorising widely separated loops were noted. For many years, however, its position has been that after wide resection of bowel and mesentery, the bowel ends are brought to the surface of the abdomen instead of being anastomosed, and these disadvantages have disappeared, the area resected being that of choice. It was for long the safest method of renewing bowel continuity after resection and only in the past ten years have newer methods brought primary anastomosis to an equal or increased margin of safety. Its real disadvantages are obvious—a discharging colostomy over a sometimes prolonged period, sepsis and following herniae at the site of extrusion, and multiple procedures in a frequently old and debilitated patient—but it was reasonably safe, with an operation mortality varying from 17 per cent. in the time of Paul, to 10 per cent. and under, fifty years later. Its closure was often tedious—clamps for crushing the spur were, in the main, inefficient, protruding awkwardly from the abdomen, and only gripping the superior portion of the spur, the blades tending to diverge. A really efficient clamp has recently been made by Swanson, which lies snugly and grips equally along its length. Freeing of the exteriorised loops from the abdominal wall, with anastomosis and replacement of the sutured bowel in the abdominal cavity, is quicker and more simple. For this type of closure, however, no spur must be made at the time of exteriorisation, the loops being sutured together for a distance of only half an inch at as wide an angle as possible, and the loops drained. This has been my own method for many years and no leakage of faeces into the abdominal cavity has occurred, but stricture may appear at the site of anastomosis, usually five to seven years later, necessitating reanastomosis. If destruction of the spur by clamps is to follow exteriorisation a longer spur must be made. Vertical rotation of the
ends of the extruded bowel can be carried out before suture to prevent later crushing of the mesentery and to ensure easier obliteration of the spur. An advantage of exteriorisation in debilitated patients is its free external drainage of the proximal loop—there is no bowel distension, and, as a rule, an easy post-operative recovery from the resection. I have found drainage of the loops preferable to closure of the openings with clamps by the Rankin obstructive method. Exteriorisation will still play some part in cases of obstruction where, after resection, the proximal loop is still found to be hypertrophied and inflamed, and where primary anastomosis is judged unsafe.

**Aseptic Anastomosis**

In 1920 a new wave swept colonic surgery and for the next ten years aseptic or closed anastomosis became the dominant method in colon anastomosis. Based on the belief that infection of the abdominal cavity at the time of operation was responsible for the general peritonitis, the most ingenious methods, about fifty in all, were devised to prevent soiling of the abdomen during the anastomosis. All of these, however, had the same basis, the temporary closure of the cut ends of the colon by some occluding agent—clamp, ligature or suture—and suture of the bowel by Lembert’s method over the closing agent, which was then removed. The cut edges for a varying distance were thus inverted into the lumen of the bowel in the form of a cuff, and peritoneal apposition was attained except at the bare mesenteric border. This area however, at the points most frequently resected, was narrow and could often be covered by adjacent peritoneum.

First suggested in 1908 by Parker and Kerr, whose simple basting stitch method is still used, closed anastomosis is associated with the names of Seton Pringle, Fraser and Dott, Rankin and many others. The method favoured quick adhesion in that peritoneal surfaces were approximated, and vascularity in that, theoretically at least, the suture was seromuscular. In the hands of many surgeons it proved successful, and good results were obtained, the mortality at this period being in the region of 10-15 per cent. Mortality in less experienced hands, however, was much higher. It is significant that, after ten years of intensive use, closed anastomosis was replaced by a fresh wave of exteriorisation, although it retained some measure of support and is still the method of choice by some surgeons. In order to avoid the inversion of a long cuff into the lumen, clamps were narrow, holding the cut edge flush while anastomosing sutures were applied as near the clamp as possible, but necessarily at some distance from the cut edge, leaving some degree of inverted cuff, whose vitality was endangered not only by pressure with clamps, but by vascular damage owing to distant constriction by suture. Failure was generally due to gangrene, in whole or in part, of the inverted cuff, spreading to the suture line with late slough and leakage. Further, in a thin colonic
wall, seromuscular suture is often impossible, the needle perforating the lumen with leakage. A successful aseptic anastomosis in this type of colon requires a high degree of technical skill as well as a measure of good fortune, but, in the hands of surgeons with experience of this type of anastomosis, good results were, and still are, obtained. It is not, however, an operation for a beginner.

The ten-year period following 1930 was one of indecision and of stock-taking. It had become evident that the right half of the colon presented a completely different problem from that of the left, the latter being incomparably more difficult. It had long been recognised that a hemicolectomy and primary side-to-side or end-to-side anastomosis could, in the absence of obstruction, be done with reasonable safety on the right side, while a similar operation on the left was fraught with danger. The challenge of the left colon, however, was still unanswered and many surgeons had reverted to the exteriorisation method.

Writings and reports of this period are confused and conflicting. The hopes of safe immediate anastomosis by the aseptic method had not materialised—meticulous investigation into the blood supply of the colon in a search for optimum sites of section had not markedly decreased mortality. The most careful avoidance of Sudek's critical point, of the inclusion of parallel vessels in the cut edge, and the planning of colonic section with exposure of vessels to ensure efficient blood supply at the suture line, while decreasing the percentage of leakage, left an unsatisfactory percentage of failure. The variety of operative procedures in this period well illustrates the confusion of thought and practice of the time—hemicolectomy with preliminary proximal drainage, hemicolectomy with proximal drainage at the time of operation, short circuit drainage followed by excision a few weeks later, aseptic anastomosis, hemicolectomy followed by exteriorisation of various types, open, closed, protruding proximal loop, and many others. It was a period of varying success and failure but one in which the operability percentage was markedly raised, and when more radical operations in the presence of invasion by the growth of neighbouring organs had become common. Wider resections, too, of the lymphatic drainage were being carried out.

Devine's Defunctioned Colon

The comparative success in excision of the right colon had for long been noted and minds were turning to the relatively low bacterial content of the ileum as an important factor in its attainment. Devine, of Melbourne, was the first to translate thought into action. Stating that the operation mortality for cancer of the colon varied in different clinics from 15-57 per cent., he published in 1935 his method of defunctioning and detoxicating the affected segment of the left colon, later doing a one-stage resection and anastomosis. The transverse
colostomy through two separate openings to exclude any possibility of passage of faeces into the distal colon, and the cleansing and disinfecting of the excluded loop for several weeks by irrigation from both ends, reduced its infectivity and made anastomosis of the left colon safe. Its disadvantages were obvious—many operations—a long stay in hospital—and the leaving of a tumour in situ for a month or more before removal. Devine showed, however, that a left colon, when empty and detoxicated, could be resected and anastomosed with a safety hitherto unattained, anticipating, in some measure, modern pre-operative chemotherapy.

**Open Anastomosis**

From this time onward, until chemotherapy was introduced, more and more attention was to be given to the vascularity of the cut edge of the bowel. Clamps close to the cut ends were being discarded and open anastomosis was becoming more popular, the peritoneal cavity being protected by gauze packs. Increased interest was being taken in the effect of sutures on the blood supply of the bowel, and interrupted sutures began to replace the continuous one. The danger of the tight continuous suture had been stressed by Grey Turner as far back as 1929 but the ever present fear of leakage had so far assured its popularity. In 1938 Wilkie, who had contributed so much to this subject, further stressed that safety in colonic suture depended on maintaining the integrity of the blood supply to the cut edges rather than on immediate security against leakage. Two layers of interrupted sutures now became popular—the inner being carried through all coats, the outer being seromuscular. Not only so, but too close apposition of sutures was deprecated, the risk of devascularising the cut edge being rated higher than that of leakage. In the absence of obstruction, exteriorisation was being abandoned and colonic resection with primary anastomosis was given another trial. Results varied but those of experienced surgeons improved greatly. Between 1941 and 1943 Vagensteen and Toon performed primary resection and anastomosis in 61 cases with one death. In the years 1943-45, with preliminary chemotherapy, 78 cases were operated on by them in a similar manner with 6 deaths. It will be seen, therefore, that bowel infectivity, although one of the major causes of gangrene and leakage, was not the sole one, and that strict attention to other factors, notably the blood supply of the cut edge, was, before the advent of intestinal chemotherapy, beginning to achieve the measure of success which had been so long striven for.

**Chemotherapy**

Discovery of the sulphonamides introduced a new weapon into the surgical armoury. The criteria of an efficient colonic antiseptic are the competence of its action on colonic organisms, and its non-
absorbability from the intestinal tract, with localisation of action within the lumen. Poth et al.\textsuperscript{13} in 1941, investigating the action of succinyl-sulphathiazole or sulphasuxidine, found that it satisfied both these criteria, only 5 per cent. of the ingested drug being excreted by the kidneys and its effect on the faeces being marked. In the investigation of 250 patients, within one to seven days of administration, the faeces became semi-solid, small in bulk, relatively odourless and the bacterial flora of the colon became considerably altered. The count of \textit{Bacillus coli} dropped from an average of 10 million to less than one thousand organisms per gm. of wet stool. Of these 250 patients, 14 had resection and primary anastomosis of the left colon without death, the post-operative period being smooth. Poth\textsuperscript{14} further found that the course of anastomosis, after sulphasuxidine premedication, differed materially from that in the untreated case. Diffuse peritoneal reaction, œdema, and easy disruption were absent, and healing was orderly and uncomplicated, when contrasted with the infection and delayed healing of the untreated colon. Sulphathaladine has the advantage of acting on anaerobic as well as aerobic organisms and does not render the faeces so fluid and so liable to leakage. It is, however, antagonistic to penicillin, which in the post-operative phase, may be required for chest complications. Recent reports on the results of primary resection anastomosis, with preliminary chemotherapy, have been most encouraging. A report in process of publication by a member of my own unit, Barclay,\textsuperscript{15} included 23 consecutive primary resection anastomoses of the left colon operated on by him within the past two years with no mortality. In this series, sulphasuxidine was used for preliminary chemotherapy—open anastomosis was used without clamps, the peritoneal cavity being protected by gauze packs, and the bowel united by end-to-end interrupted sutures of No. 0, twenty-day catgut, not too closely applied and not tied too tightly. The inner layer of sutures picked up the whole thickness of the bowel wall. The outer layer was seromuscular. One anastomosis was done well down in the extra-peritoneal part of the rectum and convalescence was uneventful. A mild degree of dilatation and hypertrophy was present in all cases, except one in which a preliminary caecostomy had to be done in the presence of complete obstruction. In the first 14 patients alternate proximal drainage and complete closure were done in order to compare results, but when it was evident that all had an equally smooth recovery proximal drainage at the time of resection was abandoned. In doubtful cases, however, it does provide a measure of safety. The quietude of the post-operative period in these cases has been most impressive, none of the patients giving rise to any anxiety. The full action of chemotherapy still remains to be assessed, but its value is becoming evident, and, combined with a better appreciation of the preservation of the blood supply in the cut edge, gives promise of lowering the risk of primary anastomosis to that of an ordinary major abdominal operation.
CAUSES OF FAILURE IN BOWEL ANASTOMOSIS

The mortality of primary anastomosis of the colon was due, in the large majority of cases, to general peritonitis and in a lesser degree to extra-abdominal complications, pulmonary, renal and cardiovascular. After three to ten days of normal recovery a greyish look in the patient's face, with a slight distension of the abdomen, ushered in a stage of rapid deterioration and death. Post mortem usually revealed a general peritonitis, a leak of varying size at the suture line often, but not always, at the mesenteric angle, and frequently accompanied by an area of gangrenous slough at the site of leakage. In the general disorder of general peritonitis it was never easy to reconstruct the series of events which led to the leakage. Experience of the past quarter century has crystallised our knowledge of the causes of failure of colonic anastomosis into three main channels:

1. Difficulties in complete peritoneal approximation.
2. Vascular failure at the suture line.
3. The high infectivity of the colonic contents.

To those may be added a thin colonic wall, undue tension at the line of suture due to inadequate mobilisation, and the presence of appendices epiploicae.

Adequate Peritonealisation.—The importance of complete peritoneal apposition around the anastomosis has long been recognised. In 1834 Travers, of Guy's Hospital, published his investigation into the healing of anastomosed intestine and stressed the rôle of the opposed peritoneum in promoting quick adhesion of the cut ends, preventing leakage and holding the bowel ends together while the more slowly uniting middle and inner coats consolidated. Lembert, sixty years later, confirmed Travers' findings and the Lembert suture, with its inverting apposition of peritoneum, played a large part in the advance of gastrointestinal surgery of his time. A more recent investigation has shown that while peritoneum adheres to peritoneum within twenty-four hours and in three days is firmly attached, anastomosis of a serous-covered segment of bowel to a segment devoid of peritoneum takes fourteen to twenty days to unite firmly. The danger of the uncovered mesenteric angle is obvious. The adhesion of peritoneal surfaces, therefore, at the site of anastomosis, affords, during the first five to six days, a period of safety within which the early processes of repair in the main coats of the bowel can establish themselves. Well peritonealised portions of bowel, should, as far as possible, be used for end-to-end anastomosis, the sigmoid, the transverse colon and the ileum being ideal segments. In these, bare areas occupy only about 5 per cent. or less of the bowel circumference and can be readily covered at the site of anastomosis by adjacent peritoneum. In the ascending colon less than 50 per cent. of the circumference is covered, making it unsuitable for this type of anastomosis.
Peritonealisation of the descending colon varies within wide limits from 50-90 per cent, and investigation should be made before deciding on its use. The presence of appendices epiploicæ in the immediate vicinity of the cut edge may make efficient approximation of peritoneum difficult. The terminal vessels encircling the bowel at right angles to the lumen send fine branches into the appendices and there is some danger of thrombosis if the appendices are removed and the vessels ligated. It is said also that the long terminal vessel may send a fine loop of its own length into the base of the appendix, and this may be ligated with the base. If the appendices interfere with peritoneal apposition, however, they should be gently removed as the danger of thrombosis is, in my own experience, slight, and peritoneal adhesion is an important factor in successful union. It may be possible to choose a site for bowel section with this in view.

Vascularity of Cut Ends.—The thinness of the colonic wall and consequent lack of protection to its blood vessels render the bowel liable to damage by clamp or sutures. The most difficult problem in end-to-end suture was, and is, that of suturing the ends firmly enough to prevent both haemorrhage and leakage, but not so tightly as to produce vascular obliteration and gangrene. Undoubtedly many of the leakages were due to primary gangrene, produced by occlusion of blood supply by suture, and the delay in the onset of peritonitis, often of a week's duration, fits in with this picture. Thinness of the colonic wall may also make a seromuscular type of suture impossible without perforation, making inclusion of the whole bowel wall imperative, and interfering with blood supply from the sub-mucosal networks. Vascular causes of failure may lie either in the region of the anastomosis, or more centrally by interference with the main arterial supply to the segment of the bowel. Clamps too closely applied to the suture line are an obvious cause. The tight continuous suture in the presence of a thin atrophied bowel wall is another. In addition, thickening and narrowing of the colonic vessels as part of a generalised vascular disease will increase the risk of gangrene, even when neither clamps nor continuous sutures are employed. The colonic vessels break up near the bowel into a series of arcades from which smaller vessels divide into long and short terminal arteries, the antimesenteric border being supplied largely by the long terminal artery after it has partially encircled the bowel. Interrupted sutures give rise to less strangulation of the cut edge, and an oblique section, with removal of more of the antimesenteric region makes for safety. Section of the mesentery should be along natural lines of arterial supply, and before section a visual appreciation should be made that the loops to be anastomosed have a satisfactory blood supply. Resections will, naturally, fall between the distribution of the main colic arteries but these are apt to vary and a clear exposure of vessels is necessary.

Infectivity.—As has been shown the high infectivity of the contents of the colon makes healing of the anastomosis that of an infected
wound, with oedema, inflammation and delay in the reparative processes. The danger of cutting out of sutures and leakage under such conditions need not be stressed. With regard to soiling of the peritoneal cavity during operation, the peritoneum can take care of any slight soiling and it is doubtful if this factor has any great bearing on mortality.

**Morbidity**

The measure of success in the surgical treatment of malignant disease rests on its late, no less than its early survival rate, and as put so aptly, if ironically, the question of “Can you sew two bowel ends together?” is less important than “Can you remove all of the cancer?” Approximately 40-70 per cent. of those patients successfully operated on have died within five years, the majority living less than three years. Survival rate is in inverse ratio to the operability rate, the criteria of which, among different surgeons, may differ widely. Wilkie, whose experience and skill in this branch of surgery ranks high, showed in his last series of cases a five year survival rate of 33½ per cent., but his operability rate was high. Thus statistics can be misleading, but at best late survival rate is unsatisfactory. Death is, apart from other causes, largely due to recurrences in the region of the anastomosis or to metastases in the lymphatic drainage with wide extension inside the abdomen. Operability has steadily advanced. Fixation of the tumour to neighbouring organs is being more radically dealt with, contra-indications to resection being peritoneal spread, secondary deposits in the liver and invasion of vital vascular channels, such as aorta or portal vein. Glandular enlargement should not contra-indicate resection as inflammatory involvement of glands from the ulcerated surface of the lumen is common. Frequently a presumed invasion proves to be merely adhesion and a stripping off can be successfully carried out. Most non-vital abdominal organs can be partially or wholly resected with the tumour. Tumours of the caecum and ascending colon with late appearance of symptoms, frequently are found invading the abdominal wall, large portions of which can be removed with surprisingly easy closure. A more formidable problem is invasion of coils of small intestine, but after resection, the lie of the mesentery aids the necessary reconstruction of the loops in an iso-peristaltic direction.

**Lymphatic Spread**

There was a tendency in the past to minimise the incidence of dissemination in colonic cancer both locally and in its lymphatic distribution. Tumours of the colon, however, vary widely in their grade of malignancy, and the more anaplastic tumour tends to quick local extension and to early lymphatic dissemination. In this type enlarged glands are usually evident, and the presence of a localised tumour with no apparent glandular enlargement should not preclude
wide resection with both local and lymph drainage eradication. Thorough investigation of the lymph drainage area has been made difficult and laborious by the high incidence of inflammatory enlargement of glands and the necessity for serial histological section of each individual gland to exclude small nodes of malignancy in the surrounding inflammation. These are easily missed, and the labour and time expended in a meticulous search for lymph metastases in any individual case can be very great. Craig and McCarthy in 1923, found an incidence of glandular involvement in 100 colonic resections to be 37 per cent. In 1939 Simpson and Mayo reported an incidence of 41 per cent. in 120 cases. As the Glasgow Royal Cancer Hospital, in some of my own cases, Woodhouse Price found a high incidence of microscopic malignant foci in otherwise inflammatory glands, occasionally in lymphatic areas adjacent to the normal lymph run. The brilliant and painstaking work of Gilchrist and David, published in 1947 involving a labour of years, in a meticulous investigation of 200 resected cases of rectum and colon, showed a lymphatic involvement in 62 per cent. of cases. Using their modification of the Spalteholtz method of clearing the tissues and visualising the lymphatic drain, they were able to make a more complete search than had hitherto been possible. Coller et al. in 1941 had published similar results in the resected specimens of 46 cases of colonic cancer, using similar methods and finding that 60 per cent. showed evidence of regional lymph node metastases. It is interesting to note that in Coller's series the highest percentage—75 per cent. and over—was in the caecum and transverse colon, the splenic flexure and descending colon having 66 per cent. In Gilchrist and David's series the right colon showed 86 per cent. lymph metastases, while 44 per cent. were present in transverse colon, splenic flexure and descending colon. The lowest five year survival rate, however, was in the latter group, being 37 per cent., suggesting that here lymphatic eradication tended to be incomplete. It seems clear, in view of these findings, that operative removal of the colon will have to include a more careful resection of the lymphatic drainage area than in the past has been considered necessary.

The classic work of Jamieson and Dobson20 established our knowledge of the lymphatic drainage of the colon. The intramural lymphatic network in the intestinal wall itself drains into the extramural system of lymph vessels and glands which are grouped around the blood vessels and follow them centrally to their origins. The epicolic glands, situated on the colonic wall, and the paracolic glands, situated mesially but close to the bowel, present a simple surgical problem. More difficult is the problem of eradicating the chain of lymphatic drainage running centrally along the blood vessels towards the central group of glands surrounding the origin of the main artery, with the intermediate glands situated along the same path in the mesentery itself. Blockage of a normal drainage route by metastases or by inflammatory enlargement tends to spill the lymph flow into
adjacent lymph areas—or a tumour may be situated in one main drainage area corresponding to its blood supply, but so close to another that lymphatic metastases may be present in two areas. Selection of sites for resection will vary according to the site of the tumour but one must take into consideration not only removal of all mesentery up to and including the central group of glands, but any probable overflow into adjacent lymph areas. Areas of resection are largely determined by the direction of the main colonic arteries and clear cut regions between main arterial systems have been mapped out as safe areas for resection. The arterial arcades at the point of entry to the colon, however, provide a far from scanty blood supply and it is possible that danger of gangrene from lack of collateral circulation at the periphery between adjacent arterial areas has, to some extent, overrated. If this proves to be so, more freedom in resection will result, and adjacent areas of lymph overflow can be dealt with more freely. It is, however, a cardinal rule that where the origin of a main vessel is ligated the corresponding segment of its distribution should be removed.

Operative Procedures

Right Colon, Cæcum, Ascending Colon and Hepatic Flexure.—Tumours of the right colon are late in giving rise to symptoms and may attain a large size before discovery, the presence of a painless mass in the right side of the abdomen often being the first sign. The ileo colic group of lymph vessels drains the terminal ileum, cæcum and the greater part of the ascending colon, and the ileo colic central glands may extend as high as the duodenum and pancreas. Hemicolectomy will include the terminal 5-6 in. of the ileum and the proximal portion of the transverse colon with a mesial resection of the mesentery including the ileo colic and right colic groups of vessels up to their origins. Coller has shown, that, when the hepatic flexure is the seat of growth, in addition to the downward spread in the ileo colic channels, there is apt to be a mesial invasion of the middle colic region of drainage, which should be removed. This entails a wider resection of transverse colon with a large portion of omentum. The anastomosis of ileum to transverse colon may be end-to-end, end-to-side or side-to-side. It is important that in the last two methods no blind pouch should be left, as elongation and dilatation of this may occur to a surprising degree.

Transverse Colon.—The branches of the middle colic artery supply the proximal two-thirds of the transverse colon while the ascending branch of the left colic artery supplies the distal third. The lymphatics follow the same course. The lymphatic vessels of the transverse colon, however, communicate with those of the omentum, which may be invaded, with secondary involvement of the glands along the greater curvature of the stomach, in addition to both middle and left colic areas of drainage. Complete eradication will entail not only removal
of the middle and left colic drainage areas, but complete removal of the omentum with the gland bearing areas in the region of the pancreas and greater curvature of the stomach. This would involve section at points in the ascending colon and descending colon with difficult approximation, incomplete peritonealisation and unsatisfactory anastomosis. If the condition of the patient permits, a wider resection of the right colon with end-to-side anastomosis of the ileum to upper sigmoid makes for more satisfactory union. A more local excision is best suited to patients with a poor operative risk—the middle colic branches, should, however, be visualised and a good arterial supply to the bowel ends assured.

_Splenic Flexure and Descending Colon._—An oblique incision gives good exposure. Tumours of the splenic flexure are often adherent but with care can usually be stripped from their surroundings. Lymph drainage of this region may overflow mesially into the middle colic area or downwards into the inferior mesenteric lymph group. The splenic lymph glands may be involved or dissemination may occur in the omentum. As wide a resection as possible should be done and in tumours of the descending colon should include the upper sigmoid loop and its drainage area as well as part of the transverse colon. Thorough mobilisation may be necessary for approximation without tension.

_Sigmoid._—The inferior mesenteric chain of glands drains both sigmoid and rectum, the intermediate nodes which drain the sigmoid lying along the sigmoid vessels, while the central groups draining into the aortic glands lie around the origin of the inferior mesenteric vessels. The sigmoid drainage communicates above with the left colic area and below with the superior hæmorrhoidal. In lesions of the upper sigmoid intra-peritoneal operations can be done, with excision of the adjacent left colic and sigmoid regions, and eradication of the inferior mesenteric glandular area. At the lower sigmoid region, however, the character of arterial entry into the bowel changes. From the splenic flexure to the distal end of the sigmoid a continuous marginal artery descends close to the gut with arcades and free anastomosis. The marginal artery ends at the recto-sigmoid junction, as the superior hæmorrhoidal artery does not form arcades, and at this point vascular collaterals between lower sigmoid artery and superior hæmorrhoidal are not so free.

_Lower Sigmoid._—Growths of the lower sigmoid present a more difficult problem and the methods employed fall into two groups:—

1. Miles' abdmino-perineal operation.
2. Various methods of reconstitution of the bowel continuity with preservation of the anal sphincters.

The abdmino-perineal operation, which has a small mortality in experienced hands, provides an efficient clearance of both sigmoid and superior hæmorrhoidal lymph drainage areas and has a good late survival rate. It is an ideal operation marred only by the necessity
for a permanent colostomy. In the second group, with retention of the anal sphincters, various methods have been attempted. As early as 1889 Hochnegg \textsuperscript{22} pulled the open end of the proximal sigmoid through the anus after resection, a practice revived in recent years. Rutherford Morison and Lockhart-Mummery \textsuperscript{23} sutured the sigmoid end to the stump of the rectum over a wide rubber tube. Crile \textsuperscript{24} in 1920 did a primary suture to the rectal stump with a safeguarding proximal transverse colostomy. In the past decade renewed attempts in this direction have met with greater success, and the present-day anterior resection with primary anastomosis is becoming widely used. Wagensteen \textsuperscript{12} and Dixon \textsuperscript{25} have each reported a series of primary anastomosis with a mortality of 6 per cent. Standard and Mulholland \textsuperscript{26} report a series of 40 cases with two deaths. Two cases have been done in my own wards recently, one dying of broncho-pneumonia and the other making an uninterrupted recovery. The chief difficulty in making the anastomosis is lack of accessibility, particularly in stout subjects, which may permit of the insertion of only one layer of sutures. The lack of peritoneal covering to rectum at the level of anastomosis is a hazard, as is also the infectivity of the perirectal tissues. Intestinal chemotherapy, however, reduces delay in healing and risk of leakage, and has converted a difficult and hazardous procedure into a routine operation.

Doubts have been expressed as to the adequacy of lymph drainage removal in this type of operation. It is generally agreed that lymph flow from the recto-sigmoid junction is mesial and upwards and that there is little downward extension. Where enlarged glands, however, are present in the normal lymph drain, a downward overflow must be suspected, and the abdomino-perineal excision will, in this type of case, be preferable to the leaving part of the rectum and its surroundings. Safety margins have been expressed in terms of centimetres, but the malignant cell, as we know it, has little regard for the metric system, and a wide series of five years' results is necessary before the success of this type of operation in removing lymphatic extensions can be determined.

**Pre-operative Treatment**

Attention to the general condition of the patient is important. Most patients with cancer of the colon have a mild secondary anaemia, and in right-sided cancer this may be marked. A hemoglobin standard of at least 80 per cent. should be aimed at before operation, and blood transfusion should be given pre-operatively to achieve this. More difficult is the problem of lowered plasma proteins. Binkley \textit{et al.}\textsuperscript{27} found that in cases of cancer of the colon hypoproteinanaemia was present in 36 per cent. and that this incidence increased to 86 per cent. after operation, the serum albumen being mainly reduced. These findings have been confirmed and vigorous attempts have been made to raise the plasma protein. Intravenous transfusions of amino acids
in forms such as Casydrol have not, in the main, proved successful although in some individual cases clinical improvement has been noted. The present preparations are quickly excreted by the kidneys and little rise of serum protein has been noted in the blood plasma. My own experience of intravenously administered amino acids has been disappointing, but a newer preparation is being tried which has the advantage of slower excretion and may be more successful. Transfusion of blood plasma is also disappointing, large quantities raising the protein level by a small percentage only. A high protein diet is more effective but takes time. Dehydration is common, and the most practical results in the raising of the patient's vitality were attained by the daily intravenous administration of large amounts of glucose saline in the first four days of the preparation period. This is repeated after operation. A low residue diet is given and is continued after operation but diet should be adequate and have a high protein content and vitamin value. Fresh butter and eggs, oatmeal, milk and fruit juices are invaluable. Too low a diet is to be avoided and a moderate amount of faecal content at operation is preferable to a half-starved patient. Vitamins, especially C, D and K can be given, although their effect on wound healing has been disappointing. Laxatives are avoided and the bowel is prepared for operation in the following way: An enema is given on admission and is repeated the following day. On the second day the administration of sulfasuxidine is commenced in daily dosage of 0.25 gm. per kilo of body weight. This dose is divided into four equal parts and given four-hourly during the day. This treatment is continuous until the day of operation, which is generally on the fifth day after the commencement of chemotherapy. As the faeces become more fluid, natural motions tend to occur and the bowel at operation may contain a varying amount of soft greyish-black faeces, with low infectivity. An enema is given on the evening before operation.

Operation.—Anaesthesia is induced by pentothal sodium followed by nitrous oxide and oxygen, intravenous curare being used for muscle relaxation. This has been satisfactory and chest complications have been few. Intravenous transfusion has not been used during the operation, which should be done without hurry but as quickly as is compatible with efficiency. Resection of a large segment of colon with its lymph drainage takes up time and the last stage of anastomosis cannot be hurried. In resection of the left colon stretching of the anal sphincter helps the readier passage of flatus.

Post-operative Treatment.—In the absence of any degree of blood loss blood transfusions are seldom necessary. A glucose saline drip is given for the first twenty-four hours after operation and is continued so long as is found necessary. The Miller Abbot tube is only used if abdominal distension occurs and over-enthusiasm in suction is deprecated. The rectal flatus tube is passed four-hourly only under similar conditions and may aid in the passage of flatus. As far as
is possible the patient is given peace to recover. A high protein, low residue diet, as nourishing as possible, is given as soon as possible after operation and is continued for a week. Plasma protein level can be re-estimated and plasma and amino acids given intravenously but their value is doubtful and reaction may do harm. On the eighth day a gentle enema is given and is repeated on subsequent days until normal bowel movement is restored. Penicillin is begun immediately after operation as a prophylactic against bronchial complications, and administration of sulfasuxidine is continued for eight days, post operatively.

**Obstruction**

The presence of obstruction makes primary resection anastomosis dangerous and, when it is marked, prohibitive. Obstruction, however, is a relative term varying from a mild hypertrophy and distension of the proximal segment to a wide distension of the whole colon proximal to the growth. In mild degrees of obstruction, the bowel at the site selected for section may be normal, and a primary anastomosis may be safely carried out. Where obstruction is marked, however, a period of drainage is necessary before resection can be attempted. The method adopted will vary with the site of the growth. In tumours of the right colon with its wide lumen and liquid contents, obstruction is uncommon and, where present, its extension proximally is limited by the action of the ileo-caecal valve. The lower ileum is usually unaffected and can be safely anastomosed to the transverse colon by a side-to-side or end-to-end junction. Where obstruction is not complete a unilateral exclusive operation should be done, the ileum being severed completely and its distal end closed. Where obstruction is complete, however, a simple short-circuit prevents the danger of a closed loop with distension and possible gangrene. Hemicolecotomy can usually be done in ten to fourteen days. Occasionally, however, incompetence of the ileo-caecal valve may give rise to either acute dilatation of the terminal ileum or a thickened dilatation with congestion, making a short-circuit hazardous. Decision in this type of case may be difficult. Ileostomy is a misery to both patient and surgeon, with constant efflux of ileal contents and severe skin irritation. The alternatives are the risking of a short-circuit with unsuitable bowel, or an immediate hemicolecotomy with exteriorisation and renewal of bowel continuity as soon as possible, the crushing of the spur being commenced within a week. Right lumbar drainage should be employed. Contra indications to immediate hemicolecotomy are an inflammatory condition of the obstructed bowel, an adherent growth with surrounding infection, or any degree of general peritonitis. Each case must be judged individually and the varying risks assessed. It is fortunate, however, that this type of case is rare.

For growths distal to the middle of the transverse colon cecostomy gives simple and efficient decompression. It is important that any
pre-resection colostomy should not interfere with later intestinal chemotherapy, and decompression rather than defunctioning should be aimed at. Extrusion of a whole loop of colon is undesirable. A caecostomy, which allows onward flow of part of its contents, makes later chemotherapy possible. Before operation additional sulfasuxidine in suspension can be introduced through the caecostomy into the colon and similarly, per rectum, into the lower segment.

The value of decompression by suction through a swallowed tube which reaches the lower ileum or caecum is on trial. Tubes of various types, the Miller Abbot, Levine and Harris, can pass from the stomach into the lower ileum and caecum and suction of bowel content can decompress the obstructed bowel. The problem is, how far their use can convert an obstructed colon into one which can safely be subjected to a primary resection anastomosis, making pre-operative colostomy unnecessary. Whipple 28 has reported good results from its use in obstructive lesions in the right colon, permitting primary resection anastomosis to be done, but much wider experience of its use is necessary for a determination of both its scope and its limitations. Assessment of its value is difficult as the condition of the colon before the institution of suction is a matter of conjecture rather than of knowledge.

CONCLUSIONS

In conclusion, progress during the past ten years gives promise of a growing safety in resection with primary anastomosis of the colon and the attainment of a mortality rate more approximating that of an ordinary major operative risk. Many factors have contributed to this, including greater attention to the general condition of the patient with increased pre- and post-operation precautions, and safer methods of anaesthesia. The two factors which predominate, however, are:

1. A greater appreciation of the necessity for vascularity and viability in the cut edge, with elimination of clamps and constricting types of suture.

2. The introduction of intestinal chemotherapy which makes the healing of the anastomosis one of first intention rather than that of an infected wound.

It must be remembered that modern operative methods are based on experience accumulated over the past half century by the endeavours of three generations of surgeons, with varying hopes and disappointments, failure and success. Among these the names of Francis Caird and David Wilkie, of this distinguished school, rank high.

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