ASEPSIS IN LARGE-BOWEL SURGERY

E. S. R. HUGHES M.D., M.S., F.R.C.S., F.R.A.C.S.

Royal Melbourne Hospital, Melbourne

AUSTRALIAN AND NEW ZEALAND surgeons can claim a special place in the memorials to John Hunter. The great Joseph Banks, who accompanied Captain Cook in the *Endeavour* on that historic journey to our part of the world from August 1768 to July 1771, returned with all sorts of specimens for Hunter. The Swede, Dr. Daniel Carl Solander, did likewise from the second great voyage in the *Resolution* from 1772 to 1775.

> 'Pickersgill made the ladies sick by shewing them the New Zealand head . . . preserved in spirit and I proposed to get it for Hunter, who goes down with me tomorrow on purpose, when we expect the ship will be at Deptford. . . .' (Solander, in *The Endeavour Journal of Joseph Banks*[1].)

John White, the first Surgeon-General to the settlement of New South Wales, specially acknowledged Hunter in the foreword to his *Journal*, published in 1790, and some of the specimens collected by John White were in the original Hunterian Collection, with John Hunter's detailed description:

> 'The Non-descript Animals of New South Wales occupied a great deal of Mr. White's collection, and he preserved several of them in spirits, which arrived in England in a very perfect state. There was no person to whom they could be given with so much propriety as Mr. Hunter, he perhaps being most capable of examining accurately their structure.' (Shaw, in John White's *Journal*, 1790.)

Lord Brock's analysis[2] of the famous portrait of John Hunter by Sir Joshua Reynolds showed that one of the skulls depicted in the open folio on the table belonged to an aboriginal—a present from Banks, or from Solander, or was it from John White?

Sir Gordon Gordon-Taylor[3], in his George Adlington Syme Oration to the Royal Australasian College of Surgeons 25 years ago, reminded the surgeons of the day that John Hunter had studied and described kangaroos, opossums, lizards, and other creatures peculiar to Australasia. One might well wonder what other original descriptions of Australian and New Zealand fauna and flora were lost for all time with the destruction of Hunter's papers in 1823. No one has denounced this catastrophe with more outspoken ferocity and bitterness than the Australian Professor Kenneth Russell, Reader in the Gordon Craig Library, Royal Australasian College of Surgeons—'an act of villainy almost unequalled in the history of medicine'[4].

Sir Gordon also drew attention to another tie between Hunter and Australia which brings me to the doors of my own hospital. James Frederick Palmer, born in 1804, practised medicine in London. At the age of 33 he edited the works of John Hunter in four volumes. Two years later, in 1839, he departed for Australia. Within 10 years he had become Mayor of Melbourne, and he laid the foundation stone of the Melbourne Hospital in 1846. He later became President of the hospital, which post he held with distinction for 6 years.

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John Hunter wrote a treatise on inflammation in wounds caused by war. I propose to give an account of inflammation in wounds caused by surgeons operating on the large bowel.

The problem under investigation

With knowledge of cancer as it is at this time the surgeon has gone as far as he can in the actual surgical treatment of large-bowel cancer. There are differences of opinion regarding techniques, it is true—this will always be so—but earlier diagnosis has not improved results[5]. The limit to the extent of resection has been reached. Operative mortality and morbidity are low, but with room for improvement. The same applies to benign tumours, diverticulitis, and other conditions for which large-bowel surgery is required.

In a situation reaching such stability the surgeon can look at the ancillary procedures which tend to be accepted with little question and which, for some surgeons, have become indispensable rituals—"custom reconciles us to everything," wrote Edmund Burke, who was born and who died in almost the same years as John Hunter. In the investigation here reported bowel preparation for large-bowel surgery is reviewed and reassessed in an attempt to decide what and how much is necessary.

Mode of study

Various observations have been made on groups drawn from a personal series of 2,312 patients who, between 1950 and 1971 inclusive, were subjected to large-bowel excision or incision for conditions other than ulcerative colitis. (Patients with ulcerative colitis tend to have multiple operations on the large bowel and inclusion confuses the numbers.) All were fully documented, had personal day-to-day hospital care, and have been followed up subsequently.

The availability of this large volume of patients who were referred to me personally for treatment had two advantages. Firstly, it removed the unpredictable variables introduced by multiple surgeons, teams, and regimens—variables that need an extremely large number of cases to offset. Secondly, it allowed properly organized prospective studies which could be completed in a reasonably short time. Retrospective surveys are valueless if only because conditions change with experience and with the passage of time.

> 'Never ask me what I have said or what I have written, but if you will ask me what my present opinions are, I shall tell you.' (John Hunter quoted by George Mather[6].)

Standard basic technique

The patient is admitted to hospital one clear day before surgery to allow for an X-ray of the chest, blood-matching, and the anaesthetist's assessment.

At operation the utmost care is taken to avoid contamination of the operative field[7]. After draping, the skin area is sprayed with Vi-drape adhesive and a Vi-drape protective film (24 × 48 in; 60 × 120 cm) is stretched over the area and pressed firmly into position. This film protects the draping from the bacterial flora released when the bowel is opened—a protective property proved by bacteriological studies.

The incision, usually paramedian, is as atraumatic as possible and, except along its medial edge, the rectus muscle is not disturbed. Haemostasis is meticulous. After the abdominal viscera have been explored the wound is adjusted to its correct length. The wound edges are protected with plastic sheeting. The effectiveness of this measure can be shown bacteriologically by suturing swabs to the wound before resecting and culturing afterwards. Currently, the ingenious Vi-drape-7 ring wound protector is used.

At the start of the resection the viscera are packed away from the operative field and, to minimize their contamination, it is important that the anaesthetist be aware that there must be no straining. In cancer cases the ends of the bowel are swabbed with mercury perchloride, although there is some evidence that this may delay healing of the suture line.[8] A sucker is used to keep the open ends of the bowel clean, the assistant taking care to prevent the sucker coming into contact with uncontaminated areas of the abdomen or instruments. All contaminated instruments and packs are discarded as soon as used. Contamination is to be expected during this phase, but every effort is made to keep it minimal.

At the conclusion of the anastomosis and *before removal of the plastic protecting sheets* the surgeon must be quite satisfied that all is in order—haemostasis adequate, no bowel twists, pack counts correct. When certain that closure can be started, but before proceeding, the surgeon orders his team to stand clear and change gloves and gowns. Before changing, the scrub sister discards all instruments and packs that have been used, while the surgeon grasps the head end of the original plastic protective film and gently pulls it and the ring wound protector away from the drapes and from the skin incision area. With care it is possible to complete this manoeuvre without splashing and without gross contamination marring the operation. Nevertheless, clean drapes are placed over the original drapes as an extra safety precaution.

With the surgical team regowned and regloved and the patient redraped, and with a new set of sterilized instruments, the abdominal wall is sutured. Drainage tubes are not often necessary, but if one is to be used the decision must be made before the plastic drapes are removed. If the surgeon changes his gown and gloves and then re-explores the contaminated operative area he is making a mockery of aseptic procedures. It is even more outrageous to overlook the need to change the

gloves and gowns—a point not made clear in similar investigations reported in the literature[9].

Assessment of results

Three clinical criteria were used to test the efficacy of mechanical bowel preparation and the influence of antibiotic therapy.

Wound infection. Unfortunately there is no standard international grading for wound infection. In these studies the classification of Ralston and Cowling[10] has been used: Grade 1, a small amount of pus; and Grade 2, a larger quantity with separation of wound edges. Redness without pus has not been regarded as indicating wound infection.

Peritonitis. This is due to contamination at operation, leakage from the anastomosis, or both. Intraperitoneal contamination at operation may lead to infection and infection to separation of the anastomosed ends, as seen in Grade 2 wound infection. Alternatively, there may be a primary breakdown of the anastomosis with secondary intraperitoneal infection. Whether primary or secondary, routine barium enema examinations show that anastomotic defects are common[11].

Mild degrees of peritonitis may pass unnoticed or produce abdominal distension. It is recognized that there are other causes of postoperative distension, but as reoperation is rarely required the precise pathology remains uncertain. Abdominal distension requiring gastric suction was generally considered to indicate peritonitis, but the reliability of this interpretation is open to doubt.

More severe degrees of peritonitis may lead to abscess and faecal fistula formation. It is notable that intra-abdominal infection may develop without wound infection.

Death. In this series no patients died from wound infection, but in some cases death followed intraperitoneal infection, proved or suspected. Autopsy was not always possible.

The mortality accompanying palliative resections was twice that associated with curative resections. Fatal intraperitoneal sepsis after curative anastomosis was infrequent.

Special difficulties in comparing results

Delayed wound infection. A wound may seem to heal in an uncomplicated fashion and the patient is sent home. Two weeks or more later an area in the wound becomes tender, induration develops, and the wound discharges pus. This delayed type of wound infection has been included in these studies.

Drainage tubes. If a drainage tube is inserted it is common to get some sort of reaction to its presence, even though the remainder of the wound is clear[12]. If this reaction led to purulent discharge, it was

classified as a wound infection. In the earlier years of the investigation drainage tubes were used frequently, and the wound infection rate was accordingly high.

Intraperitoneal infection. The greatest difficulty lies in the interpretation of an intra-abdominal disorder following operation—in determining whether infection is present and whether it is the result of contamination at operation or subsequent to the breakdown of the anastomosis. It has far more significance than wound infection but is much more difficult to assess. However, the effort must be made in each individual case.

Preexisting infection. In diverticulitis and, much less frequently, carcinoma of the bowel there may be a pericolic infection or even an abscess at the time of the initial operation. Such cases have been included in this series.

Method of investigation

As a rule, only one factor was investigated at a time, although it is appreciated that two or more variables may need grouping together.

At the time of booking for operation patients were allocated at random to receive either standard preparation or standard preparation plus (or minus) the factor under investigation. The results were assessed by an independent observer who was not a member of the operative team. Neither the surgical team nor the observer was aware of the preparation given.

At the end of the trial, before the double-blind procedure was broken, certain patients were discarded—those who did not have a resection or intraperitoneal incision of the large bowel and those in whom observations were incomplete for some reason.

Mechanical bowel preparation

Results were available from 46 patients who underwent preparation of the bowel as indicated in the table and from 51 who did not.

STANDARD MECHANICAL PREPARATION OF BOWEL

Preoperative day	*Laxative*	*Diet*	*Enema*
−4	Bisacodyl (10 mg)	–	–
−3	–	Low-residue	–
−2	–	Low-residue	Enema
−1	–	Non-residue	Enema
0	–	–	–

Wound infection. There were 7 wound infections in the 46 prepared patients, of which 5 were trivial Grade 1 infections. There were

10 wound infections in the 51 patients without preparation, of which 6 were Grade 1 infections.

Peritonitis. In 6 of the 46 patients whose bowel was prepared abdominal distension required postoperative gastric intubation. Five of the 51 patients with no bowel preparation required postoperative gastric suction.

Deaths. There were 3 deaths (2 from peritonitis and one from severe chest infection) among the 46 patients who underwent bowel preparation and 2 deaths (one from peritonitis and one from pulmonary embolism) among the 51 who had no bowel preparation. Of the 3 patients who died from peritonitis (suspected in 2), 2 were grossly overweight and the third had partial obstruction from a sigmoid carcinoma. Moreover, 2 of the 3 underwent palliative resections.

Conclusions. Clearly, those patients who underwent mechanical bowel preparation fared no better than those who did not. Indeed, quite frequently bowels that had been mechanically prepared were loaded, while those that had not been prepared were quite empty.

Use of antibiotics

Preoperative oral antibiotics. The results of trials conducted with neomycin and kanamycin have been reported previously[12, 13]. The incidence of wound infection was not greatly influenced. Out of 39 treated patients undergoing intraperitoneal anastomosis, one died from what was considered to be peritonitis; of 42 patients given a placebo, one died following burst abdomen. A report from Goligher's department also casts doubt on the value of neomycin[14].

Topical antibiotics. Polybactrin powder, containing neomycin, polymyxin B, and bacitracin, was effective in halving the incidence of wound infection[12, 13]. The powder was sprayed into the wound during incision as well as during closure. Of 68 patients undergoing intraperitoneal anastomosis who were so treated, 2 died from suspected peritonitis and the diagnosis was considered in a third, indicating that topical antibiotics did not influence anastomotic breakdown.

Preoperative intravenous penicillin. An intravenous injection of 10 megaunits of crystalline benzylpenicillin in 10 ml of physiological saline containing 2% sodium citrate was given three separate trials at different times. The penicillin was injected at the time of induction of anaesthesia after skin testing had shown no sensitivity.

Initial reports of this type of treatment from Campbell[15] were encouraging, with no deaths from peritonitis. In a double-blind trial which we reported in 1970[16] the incidence of infection was reduced and none of 34 patients undergoing intraperitoneal anastomosis died of peritonitis.

Five-year follow-up of the earlier double-blind studies appeared to show increased local recurrence rate after resection for malignant disease

under cover of penicillin chemoprophylaxis[17]. This was not apparent in the neomycin group despite reports to the contrary[18, 19]. The fact that our observations were made 5 or more years later, after a complete follow-up of a double-blind trial, added weight to their significance.

As a result the penicillin series was suspended for a 3-year period to permit early follow-up of a further series. In this second series penicillin chemoprophylaxis did not produce an increased local recurrence rate[20]. This has enabled us to proceed with the studies.

Preoperative intramuscular gentamicin. Gentamicin, given intramuscularly at the time of premedication in a dose of 80 mg, is at present under investigation. The current series is as yet small (50 cases) and the results show no dramatic difference between the gentamicin and placebo series, though there is a trend in favour of gentamicin which, if continued in the latter half of the series, may prove to be statistically significant.

Postoperative penicillin and streptomycin. A series of patients given penicillin (1 megaunit twice daily for 3 days) and streptomycin (0.5g twice daily for 5 days) after operation showed a marginal reduction in wound infection, but this was insufficient to justify recommending this treatment as a routine. There were 27 patients in the series who had intraperitoneal anastomosis, one of whom died of suspected postoperative peritonitis. Among 31 patients given a placebo there were no deaths.

General conclusions

Need for an aseptic approach. The practice of aseptic large-bowel surgery is much more feasible with well-controlled anaesthesia and with the plastic impervious protective sheeting now available. It is relatively easy to reduce contamination to the minimum. The precise influence of this has not been tested, because it is unthinkable to expose a patient to the possible consequences of contamination of completely unprotected wounds.

> 'Nor do I go further than I now think I would have performed on myself were I in the same situation.' (Hunter, quoted by Moynihan, 1927.)

There are no short cuts in aseptic techniques, there is no place for carelessness, and the surgeon in charge must satisfy himself that the team is aware of the underlying principles and of the detailed procedures.

In Goligher's department it is recognized that there is no substitute for meticulous attention to surgical technique, but details are not provided in the relevant publications[21]. Indeed, few surgeons emphasize the need for wound protection[9]. An exception is the survey by Longland *et al.*[22] from Glasgow, which showed that wound protection in appendicectomy is important.

Mechanical bowel preparation. This study has shown that vigorous mechanical preparation is not necessary. Omission of enemas and bowel washes from the preoperative procedures will be welcomed by both patient and nursing staff. A laxative before operation should clear the bowel sufficiently, and if this is given as early as the fourth night before operation the presence of watery faecal material in the lumen is avoided. A low-residue or non-residue diet on the 3 days before operation will help to keep the bowel nearly empty. Nevertheless, it is surprising how empty the bowel can be without any preparation at all and how loaded a prepared bowel can remain—facts also noted by others[23].

Antibiotics. It is difficult to compare the results of the present investigations with those of others because the basic technical practices may not have been the same. Certainly with aseptic techniques a minimal reduction in wound infection rates followed preoperative oral antibiotics, as noted also in Goligher's department[14] and by Everett *et al.*[23] The disappointing effects of 'routine' postoperative antibiotic therapy has also been recorded by others[24]. Topical antibiotics (Polybactrin) reduced the incidence of wound infection quite considerably, although in other reported trials the results have varied from disappointing[25] to good[26]. However, topical antibiotics did not influence intraperitoneal sepsis when used only on the wounds. Intravenous penicillin in massive doses given before operation was effective in reducing the incidence of perineal wound infection after abdominoperineal excisions and did appear also to reduce the incidence of fatal intraperitoneal sepsis, which gives it special priority over topical antibiotics. This may be related to the experimental evidence showing that antibiotics protect the anastomosis in devascularized bowel[18]. Many more clinical cases would be necessary, however, to produce statistically significant figures.

Clinical trials now show that antibiotics, once regarded as important, have a very restricted part to play in large-bowel surgery—and possibly in many other condition in which they are used almost empirically.

Malignant recurrence and antibiotics. Reports have suggested that a protective antibiotic cover increases the tendency to local neoplastic recurrence[17, 19, 27, 28]. A recent double-blind study of this aspect of penicillin chemoprophylaxis has not produced evidence to support the concern expressed previously, and this paves the way for further studies. It can be said categorically that a complete review of all chemotherapeutic methods used in this series has not produced statistically significant variations in local or suture-line recurrence of malignant disease.

'Failure' after large-bowel resection. Wound infection per se is relatively unimportant after large-bowel resections. It is the intraperitoneal infection associated with anastomotic breakdown that gives

rise to major problems, although this should be, and in fact is, an unusual state of affairs after curative resections or resections for benign conditions. In some of these cases failure can be anticipated—for example, an obese patient with a low and difficult anastomosis. These patients should be recognized before and during operation, and the appropriate measures, such as penicillin or gentamicin intravenous chemoprophylaxis, adopted. In a very small number of cases the failure comes unexpectedly, whether due to primary sepsis with secondary anastomotic disruption or to primary anastomotic disruption and secondary sepsis. Each of these cases needs individual study—an honest, painstaking, Hunterian curiosity should prevail over the assumption that it is 'an act of God'.

The proposed plan. The proposed plan to be followed can now be outlined:

(*a*) When a patient is booked for surgery for large-bowel resection he is prescribed a laxative (bisacodyl) to be taken on the fourth night before operation.

(*b*) He is given a low-residue diet on the third and second days before surgery and a non-residue diet on the day before operation.

(*c*) If enemas and bowel washouts are omitted, it is reasonable to spare the patient the preoperative shave in the ward, and instead do this in the theatre under anaesthetic.

(*d*) Full aseptic technique is practised, with drape and wound protection combined with fresh equipment for the abdominal closure phase.

(*e*) If contamination seems likely to occur—e.g., perforated tumour, adherent tumour with a possible operative contamination, loaded bowel, or a difficult technical job—either intramuscular gentamicin or intravenous penicillin is given.

(*f*) No postoperative antibiotic therapy is given unless indicated.

(*g*) A thorough analysis of all 'failed cases' is necessary to establish the causes and the necessary remedies.

Hunter was at his peak of fame when Australia was discovered. Australia never knew pre-Hunterian surgery—only post-Hunterian; surgeons of today add the names of Lister and Moynihan, and history will select others who have exerted unique influence. I have given lectures dedicated to the memory of Moynihan and to Lister—it is an ambition fulfilled to have done likewise for John Hunter.

REFERENCES

1. Beaglehole, J. C. (1963) *The Endeavour Journal of Joseph Banks, 1768–1771*. 2nd edn. Sydney, Angus and Robertson.
2. Brock, Lord (1971) *Ann. roy. Coll. Surg. Engl.*, **48**, 219.
3. Gordon-Taylor, G. (1947) *Aust. N.Z. J. Surg.*, 17, 75.
4. Russell, K. F. (1939) *Aust. N.Z. J. Surg.*, 7, 335.
5. Hughes, E. S. R., and Milne, P. Y. (1972) *Med. J. Aust.*, 2, 65.
6. Mather, G. E. R. (1893) *Two Great Scotsmen—the Brothers William and John Hunter*. Glasgow Maclehose.

7. HUGHES, E. S. R., and MOYNIHAN, B. (1969) *Med. J. Aust.*, **2**, 905.
8. HALE, J. E. (1971) *Brit. J. Surg.*, **58**, 304.
9. WILLIAMS, J. A., OATES, G. D., BROWN, P. P., BURDEN, D. W., MCCALL, J., HUTCHISON, A. G., and LEES, L. J. (1972) *Brit. J. Surg.*, **59**, 142.
10. RALSTON, M., and COWLING, D. (1959) *Med. J. Aust.*, **1**, 424.
11. GOLIGHER, J. C., GRAHAM, N. G., and DE DOMBAL, F. T., (1970) *Brit. J. Surg.*, **57**, 109.
12. RUBBO, S. D., HUGHES, E. S. R., BLAINEY, B., and RUSSELL, I. S. (1965) *Antimicrob. Agents Chemother.*, **5**, 649.
13. HUGHES, E. S. R. (1967) *Med. J. Aust.*, **2**, 663.
14. ROSENBERG, I. L., GRAHAM, N. G., DE DOMBAL, F. T., and GOLIGHER, J. C. (1971) *Brit. J. Surg.*, **58**, 266.
15. CAMPBELL, P. (1965) *Lancet*, **2**, 805.
16. HUGHES, E. S. R., HARDY, K. J., CUTHBERTSON, A. M., and RUBBO, S. D. (1970) *Med. J. Aust.*, **1**, 305.
17. HUGHES, E. S. R., HARDY, K. J., and CUTHBERTSON, A. M. (1970) *Med. J. Aust.*, **1**, 369.
18. COHN, I., LANGFORD, D., and RIVES, J. (1957) *Surg. Gynec. Obstet.*, **104**, 1.
19. COHN, I., and ATIK, M. (1961) *Amer. J. Surg.*, **101**, 3.
20. HARDY, K. J., HUGHES, E. S. R., and CUTHBERTSON, A. M. (1972) *Aust. N.Z. J. Surg.*, in press.
21. BARKER, K., GRAHAM, N. G., MASON, M. C., DE DOMBAL, F. T., and GOLIGHER, J. C. (1971) *Brit. J. Surg.*, **58**, 270.
22. LONGLAND, C. J., GRAY, J. G., LEES, W., and GARRETT, J. A. M., (1971) *Brit. J. Surg.*, **58**, 117.
23. EVERETT, M. T., BROGAN, T. D., and NETTLETON, J. (1969) *Brit. J. Surg.*, **56**, 679.
24. SANCHEZ-UBEDA, R., GERNAND, E., and ROUSSELOT, L. M. (1958) *New Engl. J. Med.*, **259**, 1045.
25. JACKSON, D. W., POLLOCK, A. V., and TINDAL, D. S. (1971) *Brit. J. Surg.*, **58**, 565.
26. NASH, A. H., and HUGH, T. B. (1967) *Brit. med. J.*, **1**, 471.
27. VINK, M. (1954) *Brit. J. Surg.*, **41**, 421.
28. HERTER, F. P., and SLANETZ, C. A. (1968) *Surg. Gynec. Obstet.*, **127**, 49.

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