Rehabilitation

Should my son survive with some disability then I would expect the family to plan with the remedial therapists and psychologists a rehabilitation programme. I would hope that a psychiatrist skilled in the problems which face the young disabled and their families would be available to counsel both us and him; and not just in broad general terms but in dealing with the frustration and crises which I know would arise. Together we would hopefully analyse the eventual disability and capability, and teach him how to adapt physically and mentally to it; and then to adjust our present lives and our expectations for the future to take account of the changes.

Epilogue

Not all those invited to contribute to this series have been willing to do so. None of us who have done so have found our task easy. Contemplation of personal disaster is no more attractive to doctors than to others; and prediction of how one will react to hypothetical circumstances is notoriously unreliable. But the value of submitting to the discipline of marshalling thoughts on issues such as these is that it may lead to a reappraisal of current practice. I suspect that in the future some of us may find ourselves confronted with our own prescriptions for good care. And we may be asked whether we are indeed now endeavouring to ensure that as many of our patients as possible are being dealt with as we have said we would ourselves wish.

References

1 Reilly, P L, *et al*, *Lancet*, 1975, **2**, 375.
2 Rose, J, Valtonen, S, and Jennett, B, *British Medical Journal*, 1977, **2**, 615.
3 Jennett, B, *British Medical Journal*, 1975, **2**, 267.
4 Jennett, B, and Carlin, J, *Injury*, in press.
5 Strang, I, *et al*, *Injury*, in press.
6 Galbraith, S, *British Medical Journal*, 1976, **1**, 1438.
7 Miller, J D, and Jennett, B, *Lancet*, 1968, **2**, 991.
8 Conference of Royal Colleges and Faculties of the United Kingdom, *Lancet*, 1976, **2**, 1069.
9 Jennett, B, *et al*, *Lancet*, 1976, **1**, 1031.

Today's Treatment

Use of antibiotics

Surgical infections

M R B KEIGHLEY

British Medical Journal, 1978,**1**, 1603-1606

Most infections in general surgical practice result from micro-organisms in the intestinal or respiratory tracts. Intestinal infections may present as a complication of underlying gastro-intestinal disease. Alternatively, intestinal or respiratory sepsis may occur as a complication of surgical treatment. Postoperative sepsis is responsible for most bacterial infections on surgical wards, of which the most important are respiratory and wound sepsis, septicaemia, and abscess. (Urinary infections are dealt with elsewhere in this series.)

Postoperative sepsis has important medical and financial implications: the stay in hospital is longer, which is expensive, reduces turnover, and may adversely affect surgical waiting lists. It may be associated with serious metabolic and thromboembolic complications. Subsequent operations may be necessary, such as drainage of an abscess, resuturing a wound, or closure of a fistula. All of these factors contribute to increased mortality.

Unlike established surgical infections, many acquired hospital infections (postoperative sepsis) can be prevented either by attention to preoperative management and operative technique or by prophylactic antimicrobials. Reduction of postoperative sepsis may therefore profoundly influence morbidity, mortality, and the efficiency of a surgical service.

Department of Surgery, General Hospital, Birmingham
M R B KEIGHLEY, MS, FRCS, consultant and senior lecturer

Intestinal and respiratory flora

The oesophagus usually contains only a few oral commensals, and acid gastric contents are usually sterile. Any condition that is associated with an increase in the pH of gastric contents is commonly accompanied by bacterial overgrowth. The organisms may include *Streptococcus viridans*, *Streptococcus faecalis*, *Escherichia coli*, and occasionally faecal anaerobes. Most of these bacteria are sensitive to the cephalosporins or the newer semi-synthetic penicillins. Many pathogenic organisms are isolated from gastric juice in patients with pernicious anaemia or gastro-oesophageal carcinoma and from some patients with gastric ulcer. Bile is usually sterile, but many *E coli*, *Klebsiella aerogenes*, *Strep faecalis*, and *Clostridium welchii* are present, mixed or alone, in 30% of patients with biliary disease. Most of the bacteria in bile are sensitive to cephalosporins or a combination of a penicillin with an aminoglycoside. Infection is particularly common in acute cholecystitis and choledocholithiasis, and in patients with non-malignant jaundice.

The jejunum and ileum normally contain only a few enterobacteriaceae and faecal anaerobes. The counts of these bacteria are greatly increased in patients with acute intestinal obstruction and small intestinal Crohn's disease. Even in the absence of disease, there are vast numbers of organisms in the colon (up to 10^{11}/g). Here the numbers of anaerobic species such as bacteroides, bifidobacteria, clostridia, and peptostreptococci exceed the numbers of aerobic bacteria (coliforms, lactobacilli, and enterococci) by a factor of 10 000-100 000.[1] The faecal anaerobes are resistant to most antibiotics except for chloramphenicol, rifampicin, clindamycin, and metronidazole. Of these, metronidazole is the least toxic and should probably be the only antimicrobial used for prophylaxis against these organisms.

Except for faecal streptococci, most of the aerobic bacteria are sensitive to the aminoglycosides.

The commensal organisms of the respiratory tract include neisseria, haemophilus, diphtheroids, bacillus, micrococci, and streptococci. Haemophilus and *Streptococcus pneumoniae* are most commonly associated with respiratory infection. Occasionally coliform organisms are isolated from the sputum in postoperative respiratory sepsis, but they are of doubtful clinical importance. Most of the common respiratory pathogens are susceptible to penicillin or the cephalosporins.

Established surgical infections

GASTROINTESTINAL

Infections that occur as a complication of underlying gastrointestinal disease usually present either as acute inflammation of the organ concerned, such as cholecystitis, appendicitis, and diverticulitis or as peritonitis, septicaemia, and abscess.

Acute cholecystitis is a good example of a condition that often resolves without antibiotics. The main indication for antibiotics in established biliary infection is for patients with cholangitis, where the clinical manifestations of disease are due to dissemination of bacteria into the systemic circulation. In these cases it is important to use an antibiotic that achieves adequate serum concentrations such as an aminoglycoside or a cephalosporin, because antibiotics like rifampicin, which are normally excreted entirely into the bile, rarely achieve adequate bile concentrations in obstructive biliary disease.

There is no evidence that acute pancreatitis is caused by a bacterial infection, and clinical data do not support the view that antibiotics reduce the mortality or morbidity of pancreatitis. Antibiotics are not indicated for uncomplicated diverticular disease and should be reserved for patients with a peridiverticular abscess. Although it has been suggested that long-term antibiotics might reduce the incidence of complications in Crohn's disease, there have been no clinical data to substantiate this. Acute appendicitis usually needs emergency surgery and antibiotics are needed only for prophylaxis in patients with a non-perforated acutely inflamed appendix or for management of appendix abscess.

Patients with peritonitis usually need surgery, and antibiotics should be given only to control severe systemic illness caused by repeated bacteraemia. Furthermore, peritonitis is not always due to a bacterial infection, such as in patients with a perforated peptic ulcer or pancreatitis, and in these cases antibiotics are unnecessary. By contrast, bacterial peritonitis is inevitable in patients with perforation or infarction of the small or large bowel, so that they should be given antibiotics early to reduce the incidence of abscess and Gram-negative septicaemia.

Any clinical evidence of septicaemia presenting with rigors, intermittent fever, or septic shock should be treated by appropriate antibiotics according to the sensitivity of the organisms isolated from blood cultures. If the episode of septicaemia is caused by a gastrointestinal disorder *E coli* and *Bacteroides fragilis* are the organisms most often responsible for sepsis. If urgent treatment is indicated before the results of the blood cultures are known metronidazole and an aminoglycoside should be given intravenously. One of the new cephamycins—cefoxtin—is effective against faecal aerobes and anaerobes, and early clinical results of this antibiotic have been encouraging. If the septicaemia is a complication of a urological disorder "the best guess" systemic antibiotic would be an aminoglycoside or a cephalosporin, but both antibiotics should be used with caution in uraemic patients. If the organism has been isolated but the sensitivity results are not known treatment should not be delayed. Metronidazole should be used against all anaerobic bacteria except clostridia when penicillin is to be preferred. In Britain gentamicin is still one of the most effective antimicrobials against *E coli* and *Kl aerogenes*, but tobromycin is generally more effective than gentamicin against *Pseudomonas aeruginosa*. Amikacin should never be prescribed unless there is evidence of gentamicin-resistant coliforms. Ampicillin is the most effective antimicrobial against *Strep faecalis*.

It is important to distinguish an intra-abdominal inflammatory mass from a pus-filled abscess cavity. When patients present with an abdominal mass as a complication of intestinal disease an operation should be avoided so as not to disturb the inflammatory reaction responsible for sealing the infective process. Conservative management with antibiotics effective against the probable infecting organisms is therefore desirable, provided that there is continual clinical improvement. By contrast, patients with unresolving abscess need surgical drainage under antibiotic cover.

Surgical treatment of an abscess in the casualty department by incision and primary closure under antibiotic cover is superior to conventional incision and drainage.[2] This technique gives a better cosmetic result, affords rapid return to work, and means that daily dressings are unnecessary. This principle is particularly appropriate for the treatment of perianal abscess and infected pilonidal abscess, when lincomycin is effective and without complication.

OTHER SURGICAL INFECTIONS

There are many other common surgical infections, such as breast abscess, cellulitis, and oestomyelitis, where the infecting organisms are not derived from gastrointestinal bacteria. Breast abscess is usually staphylococcal and at the stage of mastitis treatment may be with antibiotics such as flucloxacillin, fusidic acid, or clindamycin. Once there is a fluctuant abscess, drainage and primary closure under antibiotic cover is recommended.

Cellulitis may affect any part of the body: cervicofacial cellulitis is almost always caused by streptococci and invariably responds to systemic penicillin. Cellulitis in a drip arm is usually due to a chemical thrombophlebitis and does not need antibiotics. Pelvic cellulitis is usually caused by anaerobic bacteria and should be treated by metronidazole.

Acute osteomyelitis is often difficult to diagnose, and an organism may not always be isolated either from repeated blood cultures or even after exploring the bone. Nevertheless, this is a condition where early aggressive chemotherapy should always be used even if the causative organisms are unknown. If the organism is unknown treatment should be with penicillin and an antibiotic effective against coagulase-positive staphylococci such as cloxacillin, clindamycin, or fusidic acid.

Acute mastoiditis is fortunately a rare complication of otitis media, but if it is unrecognised mastoid infection may progress and affect the meninges or be responsible for brain abscess, cavernous sinus thrombosis, and septicaemia. Treatment by early drainage under antibiotic cover. Subdural and intracerebral abscess carry a high mortality, usually because of cerebral compression or infection of the ventricles. If the infection is secondary to otitis media the organism is usually an aerobic Gram-positive coccus. Metastatic brain abscess may be of intestinal or respiratory origin, and anaerobic bacteria may be implicated. Treatment of brain abscess is by antibiotics and surgical excision or drainage.

Hospital-acquired infections

POSTOPERATIVE RESPIRATORY SEPSIS

Acute respiratory disease is one of the most common complications of upper abdominal or thoracic operations. In many instances symptoms are due to patchy basal atelectasis rather than to a bacterial infection.[3] Factors that predispose to postoperative respiratory sepsis include pre-existing respiratory disease, smoking habits, age, sex, obesity, and inadequate analgesia.

Most postoperative respiratory infections can be treated

successfully by adequate physiotherapy and analgesia. Clinical trials have shown no significant advantage in giving antibiotics for established postoperative chest infections, though prophylactic antibiotics may prevent this complication.

In view of the dangers of unnecessary antibiotic prophylaxis (see below), most uncomplicated postoperative respiratory infections would be better treated by physiotherapy alone, unless there is evidence of cardiorespiratory failure or the need for artificial ventilation. Occasionally, respiratory sepsis may be complicated by an empyema or a lung abscess. An empyema usually needs either repeated aspiration or decortication. Fortunately most lung abscesses resolve with appropriate chemotherapy and postural drainage.

STAPHYLOCOCCAL SEPSIS

Most staphylococcal infections are exogenous and occur during operations that are not contaminated by the contents of the intestinal tract, such as herniorrhaphy, vascular surgery, and elective orthopaedic procedures. The incidence of exogenous infections is low—usually less than 5%. Most staphylococcal sepsis is acquired during operation from the theatre environment, the patient's own nasopharynx, or the surgical team. Some staphylococcal infections develop after operation from cross-infection on the wards. Factors that are significantly related to the incidence of exogenous infections include the density of bacterial contamination in the theatre environment, the amount of movement, numbers of surgical personnel present, incidence of glove puncture, adequacy of haemostasis, type of skin preparation, and use of drains.[4]

Staphylococcal infections may be sporadic or epidemic. When there is an outburst of staphylococcal sepsis, the source of cross-infection must be identified by phage typing the staphylococci and the patient should be treated with antiseptic shampoo, topical agents in the nose, and with repeated applications of povidone iodine or chlorhexidine to the skin. Successful protection against staphylococcal sepsis has been achieved by avoiding shaving, and using topical antiseptics and closed suction drainage. In elective orthopaedic operations there has been a striking reduction in postoperative sepsis by reducing the bacterial population in the operating theatre.[5]

Staphylococci are an important cause of septicaemia if they contaminate intravenous catheters, especially when these are placed into a central vein and used for total parenteral nutrition. Infection of an intravenous infusion usually occurs because of inadequate skin preparation before catheterisation or from inadequate catheter care after its insertion. Alternatively, the infusion system may become infected from injecting additive solutions into the bottles or giving sets. Treatment of intravenous catheter sepsis is removal of the catheter rather than antibiotics.

INTESTINAL SEPSIS

The highest reported incidence of surgical sepsis occurs after operations for intestinal disorders.[6] Most occur during operation because of inoculating intestinal organisms into the blood stream, wound, or peritoneal cavity. Occasionally endogenous intestinal sepsis occurs later in the postoperative period owing to dehiscence of an intestinal anastomosis. The rate of wound sepsis in patients not receiving antibiotics undergoing elective gastric operations or biliary surgery ranges from 10% to 20%. Infection in the wound has occurred in 30 to 50% of patients after elective colonic resection.

Antibiotics are rarely indicated for most established postoperative infections, such as wound sepsis and abscess. The important surgical principle in both of these conditions is free drainage. Antibiotics are indicated only for treating postoperative septicaemia or for an abscess complicated by repeated episodes of bacteraemia.

The incidence of postoperative sepsis can be successfully reduced by careful preoperative management. The risk of an intestinal anastomosis breaking down is related to age, adequacy of bowel preparation, and the nutritional state of the patient.[7] Anastomotic dehiscence is responsible for severe postoperative sepsis, and it has been suggested that this could be avoided by correcting a negative nitrogen balance and by adequate preoperative bowel preparation. The risk of sepsis is also influenced by operative technique.

The timing of the operation has an important relation to the incidence of sepsis. Whenever possible operations should be deferred if there is persisting abdominal sepsis when, for instance, an acute attack of cholecystitis or intra-abdominal abscess has not fully resolved. Sepsis may also be avoided by carefully isolating sites of potential contamination, by changing instruments before wound closure, and by using closed suction drainage, placed through a separate incision. If there is gross contamination of a wound it may be preferable to allow the incision to heal by secondary intention or by delayed primary closure.

Despite careful preoperative preparation and operative technique there is still a high incidence of sepsis after gastrointestinal operations, which can be reduced by appropriate short-term prophylactic antibiotic treatment (see below).

OTHER HOSPITAL-ACQUIRED INFECTIONS

Sepsis after cardiovascular surgery is often associated with the loss of life or limb. Endocarditis is the most important infection after cardiac surgery and may occur from a heart valve previously affected by subacute bacterial endocarditis or as a result of introducing exogenous bacteria into the circulation during the operation. If organisms are introduced into the blood stream during insertion of a foreign body (heart valve, Dacron patch) the infecting organism is extremely difficult to eradicate by antibiotics and further valve replacement may be necessary, though the mortality for reoperation is high. Graft sepsis, a serious complication of peripheral vascular surgery, is usually due to staphylococci or *E coli* and is particularly common after femoral vessel anastomosis. It is associated with early graft occlusion, suture line dehiscence, and later aneurysm formation. The incidence of subsequent amputation approaches 40%. Gas gangrene is an occasional complication of amputation for peripheral vascular disease.

Sepsis after neurosurgical operations is uncommon, but intracranial infections carry a high death rate and may complicate ventriculoperitoneal or ventriculoatrial shunt for hydrocephalus. Loss of sight may occur after postoperative orbital infections, though complete resolution usually accompanies early systemic or topical antibiotic treatment.

A burned patient is particularly likely to develop hospital-acquired infections, and the risk of sepsis is related to the extent and depth of burn. Burn sepsis may delay healing and convert a partial thickness defect to a full thickness burn. Infection may jeopardise the results of skin grafts, but the most serious consequence of burn sepsis is septicaemia. Topical antibiotics or antiseptic dressing minimise the colonisation of burns, but systemic antibiotics should be reserved for treatment of septicaemia.

Wound sepsis or pelvic cellulitis may complicate gynaecological operations. Risk of postoperative sepsis is related to vaginal carriage of pathogenic bacteria, which is most common in pre-menopausal patients particularly during the second half of the menstrual cycle. The most important vaginal pathogens are anaerobic streptococci and the genus *Bacteroides* sp.

Prophylactic antibiotics

Opinion about using prophylactic antibiotics has changed considerably during the past ten years. Initial evaluation of the

benefit of antibiotic prophylaxis was derived from retrospective information based on unreliable clinical data. Recent clinical trials have repeatedly shown that antibiotic prophylaxis will protect against sepsis after gastrointestinal operations, provided the antibiotic is given immediately before operation and is effective against the bacteria likely to be encountered during operation. The role of prophylactic antibiotics for most other hospital-acquired infections is largely unknown.

TIMING OF ANTIBIOTIC TREATMENT

Prophylactic antibiotics should be given immediately before or during the operation. Experimental studies have shown that appropriate antibiotic administration will protect against postoperative sepsis only if given within three hours of inoculating bacteria into surgical wounds.[8] Adequate concentrations of an appropriate antibiotic must therefore be present in the tissues when the organisms are introduced into the wound and before multiplying bacteria cause tissue necrosis.

In accordance with these findings clinical trials have failed to show any influence on wound sepsis with postoperative antibiotic treatment. Prophylactic antibiotics cannot therefore be expected to protect against infections occurring after emergency operations for a perforated infected viscus unless the antibiotic treatment is started very soon after the onset of symptoms, such as in civilians with gunshot wounds or stab injuries affecting the gastrointestinal tract.

DANGERS OF PROPHYLACTIC ANTIBIOTICS

Indiscriminate prophylactic antibiotics have been rightly condemned because of the fears of inducing antibiotic-resistant organisms. The use of unnecessary antibiotics will also increase the risk of complications, such as hypersensitivity reactions, superinfection, toxicity, side effects, and antibiotic-induced colitis. Resistant bacteria are likely to emerge in patients receiving prolonged courses of antibiotics, particularly if these are prescribed at inadequate dosage. The correct dose of antimicrobial is one that achieves a peak serum concentration at least four times greater than the minimum inhibitory concentration of those organisms likely to be encountered at operation.

Antibiotics to which the patient has a known allergy must never be used for prophylaxis. Certain broad-spectrum antibiotics may cause overgrowth of staphylococci or candida, particularly in patients after transplantation or with malignant disease receiving steroids or immunosupression treatment. Drugs with potentially serious side effects should not be used for prophylaxis. Lincomycin and clindamycin should be avoided because of the dangers of colitis, and chloramphenicol would not be advised because of its effect on the bone marrow. Aminoglycosides should be used with caution in the elderly because of eighth-nerve drainage. Cephaloridine and potent diuretics may precipitate renal failure and should be avoided. It has even been suggested that prophylactic antibiotics might increase the risk of local recurrence after resection for colorectal cancer. Pseudomembranous colitis is a complication of many antibiotics and is probably caused by overgrowth of a toxin-producing clostridium.

ROUTE OF ADMINISTRATION

Prophylactic antibiotics may be administered as topical agents into the wound by aerosol spray, irrigation, or powder. Treatment aims to prevent inoculated organisms from multiplying in the wound. Unfortunately, this method does not provide predictable serum concentrations of antibiotic and is therefore unlikely to protect against more serious complications, such as abscess and septicaemia. Antibiotic powder may not be distributed to all the potential sites of infection.

Antimicrobials may be used with bowel preparation in an attempt to reduce the numbers of bacteria in the colon at operation. This method of prophylaxis, however, is usually unsuccessful in obstructing colonic lesions and is inappropriate for patients needing emergency operation. Both of these methods of prophylaxis increase the risk of inducing antibiotic resistant organisms and for this reason it is preferable to rely on selective systemic antibiotic cover.

DURATION AND SELECTION OF PATIENTS NEEDING ANTIBIOTIC COVER FOR GASTROINTESTINAL OPERATIONS

Effective prophylaxis depends on providing high serum concentrations of an appropriate antibiotic immediately before the intestinal tract is opened. Recent clinical trials have shown that short-term prophylaxis with one or two doses of antibiotic appears to be as effective as conventional treatment for five or seven days. The incidence of postoperative sepsis is related to the numbers of bacteria disseminated at operation and is usually associated with operations performed in the presence of more than 10^6 organisms per ml.[9] Patients with more than 10^6 organisms who are at risk from sepsis include those needing elective operations for gastro-oesophageal carcinoma or non-malignant obstructive jaundice, small intestinal resection for Crohn's disease, and all colonic resections unless oral antimicrobials have been used with bowel preparation.

More precise definition of the choice and indications for prophylactic antibiotics in gastric surgery can be obtained by identifying the numbers and types of organisms aspirated during preoperative gastroscopy. The presence and type of biliary organism may be accurately defined by peroperative Gram-staining of bile, a technique that can be used to provide selective peroperative antibiotic cover.

The following antibiotic policy would therefore seem to be appropriate in elective gastrointestinal operations: short-term systemic cephalosporins for cover against the enterobacteriaceae in patients needing elective resection for gastro-oesophageal carcinoma and in patients with non-malignant jaundice. For colorectal surgery and small bowel resections in Crohn's disease, cover is also indicated against the faecal anaerobic bacteria, and a combination of short-term systemic gentamicin and metronidazole would be advised.

ANTIBIOTIC POLICY IN OTHER GROUPS

It is much more difficult to define a policy of prophylactic antibiotics in other areas of general surgery because of the lack of data from clinical trials. Nevertheless, it would seem appropriate to prescribe short-term cover against endogenous sepsis in urological operations when the urine is infected and to use prophylactic metronidazole for premenopausal patients having a hysterectomy.

Attention to the theatre environment has obviated the need for antibiotics in clean general surgery and in most elective orthopaedic and neurosurgical procedures. On account of the dangers of infecting implanted foreign bodies in cardiovascular operations, a short course of a broad-spectrum antibiotic would seem appropriate for valve replacement and in patients needing prosthetic grafts in peripheral vascular disease.

References

[1] Gorbach, S L, *Gastroenterology*, 1971, **60,** 1110.
[2] Jones, N A G, and Wilson, D H, *British Journal of Surgery*, 1976, **63,** 499.
[3] Wightman, J A K, *British Journal of Surgery*, 1968, **55,** 86.
[4] Cruse, P J E, *Canadian Medical Association Journal*, 1970, **102,** 251.
[5] Charnley, J, and Efbekhar, N, *British Journal of Surgery*, 1969, **56,** 641.
[6] Keighley, M R B, *British Journal of Surgery*, 1977, **64,** 315.
[7] Irvin, T T, and Goligher, J C, *British Journal of Surgery*, 1973, **60,** 461.
[8] Burke, J F, *Surgery*, 1961, **50,** 161.
[9] Gatehouse, D, *et al.* In press.