staphylococci that appeared avirulent to us could infect wounds, and also the simple form of isolation might not suffice to prevent the spread of the virulent strains. Only trial will tell.

Summary

During an eight-months survey, 311 patients were admitted to a general surgical ward and 17 (5.5%) developed staphylococcal wound sepsis or some other staphylococcal infection (for example, pneumonia, urinary infection, entero-colitis) while in the ward. Only one of the eight cases of wound sepsis was attributable to infection in the operating theatre.

The reservoirs of staphylococci in nasal carriers and in inanimate objects and the air were examined regularly, and staphylococci from all these sources, as well as from patients' wounds, were examined for bacteriophage type.

Some 186 different types of *Staph. aureus* were recognized, but only 13 of these caused disease, and only three were responsible for disease in more than one patient.

The air and dust sampling revealed nine occasions when staphylococci of a single phage type reached the level of 0.1 particle per cu. ft. (3.5 per cubic metre) of air. These nine broadcasts were due to seven different types of staphylococci; the three types that were present in the air in the greatest numbers failed to cause any manifest secondary infections. This, and the fact that there were so many types of staphylococci that never caused sepsis, suggested that some staphylococci were more "virulent" than others.

Several of the staphylococcal broadcasts could be attributed to patients with infected lesions who were peculiarly apt to disperse, such as an infected tracheotomy wound, infected urine in an incontinent patient, an infected wound requiring very frequent redressing.

Patients infected with tetracycline-resistant staphylococci were, when possible, barrier-nursed in a side-room. This appeared to be effective in limiting the spread of their infection. Ten patients (with four different types) were nursed in isolation, and only one secondary case appeared in the ward.

We are indebted to Mr. C. Naunton Morgan and Mr. D. F. Ellison Nash for permission to make these observations in their ward. Our thanks are also due to the Medical Research Council for a grant in support of the work, and to Miss P. M. Davies and Miss Anne Deacon for laboratory assistance.

REFERENCES

- Anderson, E. S., and Williams, R. E. O. (1956). *J. clin. Path.*, 9, 94.
 Baldwin, J. N., Rheins, M. S., Sylvester, R. F., jun., and Shaffer, T. E. (1957). *A.M.A. J. Dis. Child.*, 94, 107.
 Barber, Mary, and Kuper, S. W. A. (1951). *J. Path. Bact.*, 63, 65.
 Blowers, R., and Wallace, K. R. (1955). *Lancet*, 1, 1250.
 Hare, R., and Thomas, C. G. A. (1956). *Brit. med. J.*, 2, 840.
 Hutchison, J. G. P., and Bowman, W. D. (1957). *Acta paediat. (Uppsala)*, 46, 125.
 McDonald, Sheila, and Timbury, Morag C. (1957). *Lancet*, 2, 863.
 Shooter, R. A., Griffiths, J. D., Cook, Josephine, and Williams, R. E. O. (1957). *Brit. med. J.*, 1, 433.
 — Taylor, G. W., Ellis, G., and Ross, J. Paterson (1956). *Surg. Gynec. Obstet.*, 103, 257.
 Williams, R. E. O., and Rippon, Joan E. (1952). *J. Hyg. (Camb.)*, 50, 320.

The Nuffield Provincial Hospitals Trust has approved a grant of £7,500 spread over three years to assist in the establishment of a sheltered workshop, for long-stay patients with chronic psychotic illnesses, at Cheadle Royal Hospital, Cheshire. The project will be under the direction of the senior medical hospital staff. The Trust is also providing £1,500 for an investigation into the cost of mental illness.

LONG-TERM RESULTS OF VAGOTOMY AND GASTRO-ENTEROSTOMY IN CHRONIC DUODENAL ULCERATION A COMPARISON WITH GASTRECTOMY

BY

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AND

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In 1950 one of us (H. B.) initiated an investigation into the results of vagal-nerve section in the treatment of chronic duodenal ulceration. Mr. A. V. Pollock was invited to undertake this work. Some 1,300 cases were collected from teaching and non-teaching hospitals in this country. This series included 489 cases treated by vagotomy and gastro-enterostomy (Pollock, 1952). It was decided to file the names and addresses of these patients and to use them as the basis of a long-term study. In 1955 Mr. John Lloyd Davies undertook a review of these cases, and his results were published (Lloyd Davies, 1956). Of the initial cases, permission to study was granted in 198, and these formed the basis of his report. We have now, two years later, made a further study of these cases, and we have been able to add a further 103 of the original series. We now therefore report on 301 cases, the earliest being seven years after operation and the latest nine.

This review has been made by questionnaire and personal interview. The series included 69 war pensioners, but, while they have been included for the purpose of assessing the proved recurrence rate, they have been omitted in our studies of post-operative symptomatology. In another group of 103 cases the follow-up study was made on our behalf by the department of surgery concerned. In assessing the post-operative picture with regard to symptoms, we have chosen to limit ourselves to a series of 130 cases which we have ourselves investigated.

Of this series of 301 cases, only six are untraced and 13 have died from causes known to have no connexion with peptic ulceration, leaving 282 cases followed to seven to nine years after operation.

Analysis of the Post-operative State

Mortality.—One of us (H. B.) used this operation in 1949 and 1950 but stopped using it then because its results were unknown. We did, however, come to use it again when the results of Mr. Lloyd Davies's work became known, and we have used it in all cases of duodenal ulceration needing surgical treatment since that time. We can report a series of approximately 100 cases without a death. Other workers have reported a very low mortality from this operation. Crile (1952) recorded 0.4% mortality in 445 patients and Hoerr (1953) a mortality of 0.5%.

Recurrence Rate.—The proved recurrence rate, as shown by perforation, haemorrhage, or operation, has been found to be 4.25%. As is discussed below, this figure must be considered in the light of evidence of a high incidence of incomplete nerve section.

Nutritional State.—One feature of this operation is that the patients are able to eat meals of normal size. It is not

surprising, therefore, to find that the nutritional state is good. Weight has been gained in 14%, has remained steady in 75%, and has been lost in 11%.

Post-operative Anaemia.—Post-operative haemoglobin investigations were done on an unselected group of 50 cases from this series. Eight years after operation only one of the 50 had a haemoglobin level below 85%. This reading was 84%, and the same case was one of suspected tuberculosis. Of the remaining 49 patients, 12% were found to have a haemoglobin level below 90%. These figures show that anaemia, at eight years, is not a common complication of this operation.

Physical State.—Approximately one-third of this series were interviewed personally and inquiry made into their work and physical state. It was found that many were occupied in heavy work, and in no case was the ability to undertake it reduced.

Change of Bowel Habit.—To the question, "Do you have diarrhoea or loose motions?" 30% of patients replied in the affirmative. In our series the incidence of this symptom is approximately the same in all surgical centres from which these cases were drawn. We inquired further into the bowel habit of these 30% and we found that the symptoms take on a specific pattern consisting of bouts of diarrhoea or loose motions lasting from one to three days, with three or four loose or liquid motions daily. These attacks recur at intervals varying from one to three months, and between attacks the patient is symptom-free. Many other patients state that the bowel habit has been improved by the operation in that they no longer have constipation and that their motions are now regular and not hard. This symptom of diarrhoea or loose motions appears to cause little disability; only direct questioning has brought it to light. We have found no patient who has sought advice for it. The mechanism of this symptom is not clear. X-ray examination has failed to show gastric delay or intestinal hurry. We are at present engaged in further investigation into this problem.

Post-cibal Symptoms.—It has long been known that post-cibal symptoms occur after gastro-enterostomy, though much less frequently and with less severity than after partial gastrectomy. The incidence in this series is 16%. Symptoms were mild and no case of severe "dumping" was recorded.

Bilious Regurgitation.—This was found in 13% of cases and was regarded as secondary to the gastro-enterostomy.

Comparison with Gastrectomy

Mortality.—The mortality of gastrectomy in expert hands is probably 1-2%, but it seems that the overall mortality in this country is a good deal higher. The operation of vagotomy and gastro-enterostomy exposes the patient to almost no risk either of mortality or of post-operative morbidity, for there is no inherent risk in the operation as there is in partial gastrectomy. We may regard the risk as that of gastrectomy less its inherent risks of stump leakage, haemorrhage, and loop obstruction.

Recurrence Rate.—The proved recurrence rate of ulceration after partial gastrectomy probably varies from 2% to 6%, depending upon the extent of gastric resection. The proved recurrence rate in our series of vagotomy and gastro-enterostomy is 4.25% at eight years. Again we emphasize the high incidence of incomplete nerve section in this series.

Nutritional State.—It is well known that after gastrectomy many patients cannot eat full meals, and, perhaps as a result of this, loss of weight is not uncommon. Ivy, Grossman, and Bachrach (1950) found the post-operative weight steady or increased in 53% and decreased in 47%. This is a very different figure from our findings after vagotomy and gastro-enterostomy, in which only 10% showed weight loss.

Post-operative Anaemia.—One of us (H. B.) has investigated anaemia after partial gastrectomy. The incidence of microcytic anaemia was shown to increase considerably with the passing years. A study of 300 male patients, 50 in each year group from one to six years after Polya gastrectomy,

Post-operative Incidence of Anaemia

Haemoglobin	Years after Gastrectomy					
	1	2	3	4	5	6
Under 85% ..	12	12	22	32	38	58
" 80% ..	6	8	10	20	26	36
" 75% ..	2	6	4	14	18	24
" 70% ..	0	0	0	4	6	18

is shown in the Table. It will be seen that post-operative anaemia after gastrectomy is a common condition. Often undiagnosed and untreated, it can result in considerable disability. As stated above, at eight years anaemia does not appear to be a complication of vagotomy and gastro-enterostomy.

Physical State.—The physical fitness of patients after vagotomy and gastro-enterostomy is very much better than after gastrectomy. Not many patients return to heavy manual work after gastrectomy.

Change of Bowel Habit.—We have written already at some length about this symptom after vagotomy and short circuit. The same symptom occurs after gastrectomy and, as with vagotomy and short circuit, it has been brought to light only by direct questioning. In a series of 200 post-gastrectomy patients, in reply to the direct question, "Do you have diarrhoea or loose motions?" 20% replied in the affirmative. This compares with 30% after vagotomy and short circuit. Exactly the same pattern exists in both operations, but the attacks occur somewhat less often after gastrectomy.

Post-cibal Symptoms.—There is no need to state here the incidence and severity of post-cibal symptoms after gastrectomy. These are only too well known. It is generally agreed that the incidence and severity of these symptoms after gastrectomy are related to the extent of gastric resection. The operation of vagotomy and short circuit carries with it a much lower incidence and less disability.

Bilious Regurgitation.—As with the post-cibal "dumping" symptoms, so with bilious regurgitation, the incidence and severity are much less after vagotomy and gastro-enterostomy than after gastrectomy.

Discussion

We believe that all workers who have studied these two operations will agree that, given no increased incidence of recurrent ulceration, vagotomy and gastro-enterostomy is a better operation than gastrectomy. The proved recurrence rate in this series is within the limits sometimes given for gastrectomy. Unfortunately we have no record of the number of nerve trunks found in this series of cases, but we think that the finding of three or four nerve trunks was not common at that time. Anatomical studies of the number of vagus-nerve trunks in man at this level have been made by several workers (Chamberlin and Winship, 1947; Dragstedt *et al.*, 1947; Jackson, 1949). It seems that only two nerve trunks were found to be present in approximately 80% of cadavers. It is, however, interesting that, since we have used, during operation, a test for completeness of nerve-trunk section, we have found in our small series of 16 patients only 2 (12.5%) with two nerve trunks. The remaining 14 (88%) have had three or more trunks.

There is good evidence that, at the time these cases were operated on, there was a high incidence of incomplete nerve section. We know of two cases in which the surgeon failed to find the anterior nerve. Both these cases developed anastomotic ulceration shortly afterwards. It is clear from many studies that incomplete nerve section, as shown by the insulin test meal, was common at this time. Lloyd Davies (1956) found that a positive insulin test was present in every case of recurrent ulceration where the results of this investigation were known.

Now that a method of proving completeness of nerve-trunk section can be used during operation (Burge and Vane, 1958), it may be that the recurrence rate after this operation will be

reduced to a figure as low as, or lower than, the best after gastrectomy.

We at one time thought that the incidence of changed bowel habit after vagal-nerve section might weigh in favour of gastrectomy. However, a study of these symptoms after gastrectomy reveals exactly the same problem, although, to a somewhat less degree.

In trying to assess the place of vagotomy and gastro-enterostomy, we do not believe that it is indicated only in certain types of patient, as, for example, in women and elderly men. If it is to be used at all, then in our view it should be used in all cases where surgery is necessary. In the present state of our knowledge, based on this eight-year study, we believe that, given complete nerve-trunk section, vagotomy and gastro-enterostomy is the operation of choice. At one time we thought that a surgeon experienced in this operation could in every case achieve complete nerve-trunk section without the use of a test. Since such a test has been available we have satisfied ourselves that this is not true and that even an experienced surgeon will obtain better results with this help.

It will be interesting, in the future, to study the late results of this operation in cases in which complete nerve-trunk section has been proved at operation.

Summary

301 cases, of which only 6 are untraced, of duodenal ulceration treated by vagotomy and gastro-enterostomy are reported. All patients have been followed up for at least seven years. The proved recurrence rate was 4.25%, and this in spite of evidence of a high rate of incomplete nerve section. There has been no proved recurrence in this series since an earlier review in 1955.

The results of this operation are compared with those of gastrectomy, and it is concluded that vagotomy and gastro-enterostomy is a better operation so long as there is no great increase in the recurrence rate as shown by a long-term study. From the point of view of nutritional state, anaemia, maintenance of weight and ability for heavy work, vagotomy and gastro-enterostomy is more satisfactory than gastrectomy. The only less favourable symptom after this operation is some looseness of the bowels, which takes on the picture of occasional loose motions. This same symptom, with the same pattern though in somewhat milder form, is found to occur also after gastrectomy. No patient in this series seems to have sought advice for this symptom.

This high incidence of incomplete nerve section in the past is good evidence that this operation is better undertaken with the help of a test for complete nerve trunk section which can be used *during* operation. Such a test is now available (Burge and Vane, 1958).

It is concluded that vagotomy and gastro-enterostomy is the operation of choice in either sex and at any age when surgery is indicated for chronic duodenal ulceration.

This investigation has been made possible by the financial help of the Dan Mason Research Foundation of the West London Hospital Medical School. We thank all those surgeons who so kindly gave permission for us to follow their cases through all these years. We would thank the Ministry of Pensions and National Insurance for permission to study the war pensions cases. We are especially indebted to Mr. I. F. McNeill for the time and work he so kindly gave to these investigations.

REFERENCES

- Burge, H., and Vane, J. R. (1958). *Brit. med. J.*, 1, 615.
 Chamberlin, J. A., and Winship, T. (1947). *Surgerv.*, 22, 1.
 Crile, G. (1952). *Ann. Surg.*, 136, 752.
 Davies, J. A. L. (1956). *Brit. med. J.*, 2, 1086.
 Dragstedt, L. R., Fournier, H. J., Woodward, E. R., Tovee, E. B., and Harper, P. V. (1947). *Surg. Gynec. Obstet.*, 85, 461.
 Hoerr, S. O. (1953). *Arch. Surg. (Chicago)*, 67, 436.
 Ivy, A. C., Grossman, M. I., and Bachrach, W. H. (1950). *Peptic Ulcer*. Churchill, London.
 Jackson, R. G. (1949). *Anat. Rec.*, 103, 1.
 Pollock, A. V. (1952). *Lancet*, 2, 795.

METHOD OF TESTING FOR COMPLETE NERVE SECTION DURING VAGOTOMY

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The method described here was devised to allow the surgeon to test the completeness of vagotomy before the abdomen was closed. It consists in the application of a simple physiological technique to the human and, as such, was first validated on cats. It has now been applied successfully to patients, and is both safe and reliable.

Method

Cats.—Cats were anaesthetized with chloralose (80 mg./kg.). The blood pressure was recorded on a kymograph with a mercury manometer connected to a cannula in the left carotid artery. The intragastric pressure was also recorded on the kymograph, using a water manometer connected through the system, as shown in Fig. 1, to a tube

FIG. 1.—Diagram of recording technique. With the screw clip on the top inlet of the bottle open, the stomach can be filled with a known amount of water. The clip is then closed and the bottle moved up or down to bring the baseline on the pressure recorder to a convenient level.

passed down the oesophagus into the stomach. The oesophagus was sealed by an inflated cuff on the gastric tube and the pylorus was occluded by ligation. The stomach was distended with warm water. Platinum electrodes were used to stimulate the vagus nerves, either in the neck or on the oesophagus above or below the diaphragm with the chest open. Square wave pulses (0.5–25/second frequency, 0–50 volts, and 0.5–5 milliseconds' duration) were applied through the electrodes for periods of from 0.5–2 minutes. In some animals electrodes were made to encircle the oesophagus to correspond with the technique to be applied in man.

Man.—The patient was anaesthetized with thiopentone and nitrous oxide. Gallamine triethiodide was used to achieve muscular relaxation. Because the method depends upon recording the effects of vagal-nerve stimulation upon stomach motility, premedication with atropine or atropine-like drugs was avoided. Atropine was given during the operation after the test was finished. The abdomen was opened by a left upper paramedian incision; the left coronary ligament of the liver was divided to allow the left hepatic lobe to be retracted to the right. A small rubber tube was placed around the lower oesophagus for traction. There has been no difficulty in ensuring that the posterior vagus nerves were included within this tube. The upper part of the small omentum was divided between ligatures to give a better exposure of the lower oesophagus. A large-bore cuffed rubber tube was passed by the mouth until its