blind distal resection might be avoided if the symptoms were controllable by diazoxide. They hoped that growth of the lesion during an interim period of this treatment might make a second exploration easier and a more limited resection possible. However, a study of the problem of the occult insulinoma in a series of 1067 cases reported by Stefanini *et al.* (1974) did not show any correlation between tumour size and duration of symptoms, and they conclude that progressive left to right resection remains the procedure of choice. The data of Stefanini *et al.* (1974) and of Harrison *et al.* (1973) show that there is no characteristic location for these tumours, and success is therefore a matter of adequate resection guided perhaps by frozen section together with a measure of luck. Subtotal resection may enable postoperative diazoxide therapy to succeed when it had failed preoperatively. Uncontrollable recurrence will require pancreatico-duodenectomy.

Following a subtotal resection diabetes mellitus is unusual although it may be eight weeks or so before the remnant functions adequately and the insulin resistant state subsides. If insulin injections are required it is advantageous to use a monocomponent preparation, which will make follow-up IRI measurements possible. Postoperative fractionation studies may confirm success and monitor recurrence.

The diagnosis and treatment of insulinoma is a multidisciplinary challenge but one of great interest. In view of the severity of the surgery and its complications, preoperative diagnosis must be as secure as possible and this remains a field in which clinical acumen and biochemical expertise can be fruitfully combined.

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Gastric Emptying After Vagotomy

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One of the main objectives of the introduction of highly selective vagotomy without pyloroplasty in the treatment of duodenal ulceration has been to avoid the alteration in gastric emptying which has been observed after truncal vagotomy and pyloroplasty. In fact clinical studies after pyloroplasty alone have shown that postprandial symptoms are very common in this group of patients and that, in particular, they suffer from epigastric fullness and dumping in almost the same proportion as patients who have had a truncal vagotomy as well as pyloroplasty (Douglas & Duthie 1972). Previous studies of gastric emptying after highly selective vagotomy have used fluid meals or a mixture of food and barium (Pedersen & Amdrup 1970, Clark & Williams 1972, Wilkinson & Johnston 1973). In the present study a solid meal has been used and the patient has been maintained in the semi-upright position throughout.

Methods

Male patients with duodenal ulceration have been studied before, and one week, one month and six months after operation. Ten patients have been submitted to truncal vagotomy and pyloroplasty and 5 patients to highly selective vagotomy without pyloroplasty. The meal used has had a total weight of 250 g of which 110 g were protein. It consisted of meat, potatoes and peas. A radioactive label has been incorporated in the potato. The tracer used has been indium-113m as a non-absorbable chelate (DPTA) in a dose of 1 mCi. *In vitro* testing showed that the label remained

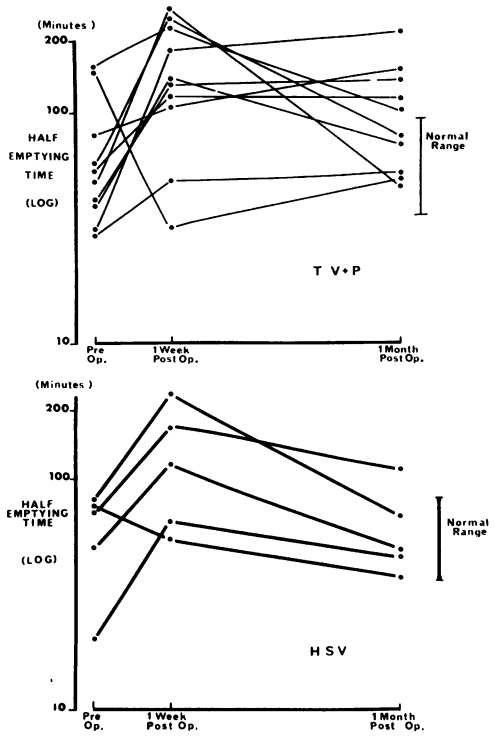

Fig 1 *Gastric emptying of a solid meal expressed as time for half of the radioactive label to disappear from the stomach. Above, 10 patients before and after truncal vagotomy and pyloroplasty. Below, 5 patients before and after highly selective vagotomy*

attached to the meal. The subject consumed the meal in a period of 10 minutes and thereafter the gamma camera was put in place in front of the upper abdomen and recording continued for 90 minutes. The radioactivity shown on the screen was then carefully outlined by an electronic apparatus which allowed exclusion of any radioactivity which was not in the gastric contour. This permitted the radioactivity which left the stomach and went into the small bowel to be excluded from the counting with the exception of the condition in which a loop of small bowel passed behind the lower part of the stomach. The electronic selection device then fed the results to a rate meter from which the disappearance curve of radioactivity was determined. The disappearance curves were analysed on a computer and, for the purposes of this paper, the best exponential line was fitted to the readings. From this line a half-time of disappearance of radioactivity from the stomach was calculated ($T\frac{1}{2}$). Control studies were done in 10 normal subjects and the range of the half-time was from 35 to 87 minutes. In reproducibility studies the $T\frac{1}{2}$ was accurate to within 10%.

Results

In the 10 patients who were studied before and after truncal vagotomy and pyloroplasty the emptying time was within the normal range in six cases in the preoperative tests (Fig 1 above). When the patients were examined one week after operation there was a significant increase in the time taken for half the meal to empty from the stomach in all but one subject, who had shown a delayed gastric emptying before operation which was remedied by the drainage procedure. The results at one month showed a return towards the normal range in 6 cases, and 5 of the subjects had results within the normal range. Further testing done six months after operation again showed half the patients with emptying times outside the normal range. In the 5 patients tested before and after highly selective vagotomy without pyloroplasty, 4 of the preoperative tests were in the normal range (Fig 1 below) and the tests done one week after surgery also showed a slowing of gastric emptying in 4 of 5 cases. This is not so extensive as after truncal vagotomy and pyloroplasty and recovered by the time the one-month tests were performed in 4 of the 5 patients. At six months no patient had delayed emptying.

Discussion

One of the questions raised in studies measuring the emptying of the stomach is whether the meal used is truly physiological. We have attempted to overcome this objection by utilizing a mixed meal of meat, potatoes and peas and by maintaining the patient in the semi-upright position with his body 70 degrees above horizontal. The angle is not completely ideal but is the nearest to the vertical position that could be obtained while permitting the counting head of the gamma camera to scan the epigastrium. The technical problems of selecting the area of interest in the gamma scan to exclude any radioactivity which had passed from the stomach into the small bowel has been largely overcome by the use of the electronic device to outline the stomach at its initial appearance on the recording. Computation of the gamma scan has been obtained by counting at one minute intervals the intensity of the radioactivity, which is then plotted as a disappearance curve. The mathematical handling of these 90 points of data allows several different forms of analysis. The most usual is that of fitting a best exponential line and assessing the time for half the radioactivity to disappear, which has been utilized in the present paper. Other methods which have some merit are those of principal component analysis combined with discriminant analysis (Barber *et al.* 1974). Use of the half-time of disappearance of radioactivity in the present study has given results which are reproducible.

The main question concerning the usefulness of measuring gastric emptying is whether it gives an indication of the likelihood of postprandial symptoms because of alteration in the normal emptying pattern produced by operation. In these small groups it can be seen that there is greater chance of abnormal emptying in patients after truncal vagotomy and pyloroplasty, in which group about half still have a slowing of gastric emptying with this solid meal six months after operation. On the other hand, after highly selective vagotomy, none of the patients has an emptying time at six months slower than the normal range. The exact correlation with such symptoms of epigastric fullness and dumping awaits the extension of numbers in the groups to allow for a fuller comparison. In general, these results differ from previous gastric emptying studies done after highly selective vagotomy, first of all in that the meal is a solid meal and the study is done with a radioactive label. Much of the previous work has been done with fluid meals which have been shown to empty faster than normal (Clark & Williams 1972). When tests were done with food mixed with barium the patients also showed a slightly faster emptying after highly selective vagotomy (Pedersen & Amdrup 1970, Wilkinson & Johnston 1973). The extent of the alteration of gastric emptying after highly selective vagotomy in all these studies is considerably less than after truncal vagotomy and pyloroplasty and so provides further objective evidence for the clinical reports that postprandial symptoms after highly selective vagotomy are lower in incidence than after truncal vagotomy and pyloroplasty (Humphrey *et al.* 1972).

Summary

Using a solid meal labelled with radioactive indium, the half time of the emptying of the stomach has been measured with a gamma camera in 10 patients before and after truncal vagotomy and pyloroplasty and in 5 patients before and after highly selective vagotomy. There is less alteration of gastric emptying when the innervation to the gastric antrum is preserved and pyloroplasty is not performed.

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Highly Selective Vagotomy or Truncal Vagotomy and Pyloroplasty for Duodenal Ulcer

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The trend towards increasingly conservative surgery in the treatment of duodenal ulcer has extended to the use of denervation of the fundus and parietal cell area of the stomach with preservation of the rest of the abdominal vagal innervation, in particular that to the gastric antrum. This operation has been styled highly selective vagotomy (Johnston & Wilkinson 1970), parietal cell vagotomy (Amdrup & Jensen 1970), or proximal selective vagotomy (Holle & Hart 1967), and has been used widely without the addition of a drainage procedure. Several encouraging initial reports are available of consecutive series of highly selective vagotomy. In this study we present a concurrent use of this operation together with the more standard truncal vagotomy and pyloroplasty.

Material and Method

All male patients with duodenal ulcer treated electively by highly selective vagotomy (HSV) or truncal vagotomy and pyloroplasty (TV+P) in the Professorial Unit at the Royal Infirmary, Sheffield, between July 1971 and June 1973 inclusive, have been followed up.

One hundred and twenty-five operations were performed. Of these 81 were TV+P and 44 HSV. The operations were done concurrently in the unit by all grades of surgical staff. The series was not randomized but the proportion of HSV remained steady after the first six months.

One patient died six hours after HSV from coronary thrombosis. Two later deaths in the HSV group were of causes unrelated to the operation. One hundred patients have been assessed by personal interview with particular reference to recurrent ulcer symptoms, postprandial symptoms and episode diarrhœa. Twenty-two patients did not attend for interview but replied to a detailed questionnaire.

Results

The two groups were comparable as regards age, weight, duration of symptoms and time off work after operation (Table 1).

The length of follow up is slightly shorter after highly selective vagotomy and this can be attributed to the initial training period of the surgeons during the first six months of the series when fewer highly selective vagotomies were done than in the later stage.