organism has also been regarded as pathogenic in a number of reported instances. Meningitis (Aronson and Alderman, 1943; Rabinowitz and Schiffrin, 1952), bacterial endocarditis (Hawe and Hughes, 1954), infections of the urinary tract (Wheat *et al.*, 1951; Taylor and Keane, 1962), empyema (Papapanagiotou and Aligizakis, 1959), and septicaemia (Graber *et al.*, 1960; Emanuel *et al.*, 1963) have all been reported as being due to *S. marcescens* infection. The case described by Emanuel *et al.* (1963) followed rupture of the dialysing coil during haemodialysis.

The presence of mucus at the site of infection has been postulated as a means of increasing the virulence of this organism (Taylor and Keane, 1962). Gale and Lord (1957) have shown experimentally that the usually low virulence of *S. marcescens* for animals is greatly enhanced by the presence of mucus in the inoculum. In a critical review of *S. marcescens* infections, Haiby *et al.* (1961) concluded that there were seven reported fatalities in which the organism had played an important part. Of the three cases described above one patient (Case 1) would seem to have died partly as a result of peritonitis, since the infection remained active until his death, prior to and after which *S. marcescens* was obtained in pure culture from the peritoneum.

The association of *S. marcescens* with other enteric organisms, particularly with the enterobacteria, is noteworthy (Wheat *et al.*, 1951; Papapanagiotou and Aligizakis, 1959; Taylor and Keane, 1962; Emanuel *et al.*, 1963). *E. coli* and *Ps. aeruginosa*, both of which were found in instances reported here, are the most commonly associated bacteria. This suggests that *S. marcescens* is more liable to show enhanced virulence not only in chronic debility (Haiby *et al.*, 1961) but also where infection by another organism has been established.

Just as important is the significance of the organism as an indicator of cross-infection and flaws in technique, especially of catheterization. The failure to discover the source of the organism in these three cases is puzzling, but Taylor and Keane (1962), who described seven instances of cross-infection by *S. marcescens* following bladder catheterization, were also unable to trace the source of the organism.

There is no doubt, however, that *S. marcescens* can easily be missed in laboratory culture. This can be avoided by retaining all cultures for a further 48 hours at room temperature after initial incubation. Under these conditions the typical red pigment produced can be readily identified.

The treatment of *S. marcescens* infection with antibiotics, especially in the presence of renal failure, presents special prob-

lems. This organism is commonly associated with known pathogens, such as *Ps. aeruginosa* and *E. coli*, which may have a limited and entirely different antibiotic sensitivity. Since the evidence in these and other cases suggests that the isolation of *S. marcescens* should not be lightly regarded, two appropriate antibiotics may be needed to combat that organism as well as any concomitant pathogen. With a few exceptions, all recently reported strains have shown marked resistance to most antibiotics with the exception of neomycin and kanamycin. It has been suggested that treatment with either of these antibiotics should be begun as soon as the organism is isolated, without waiting for the results of sensitivity tests (Emanuel *et al.*, 1963). However, the systemic use of kanamycin in a patient with renal failure may be complicated by severe ototoxic effects arising from these antibiotics, so that strict control of therapy by frequent estimation of the antibiotic levels in the patient's serum is essential.

Summary

Three instances, two fatal, of acute renal failure are described, in which treatment by peritoneal dialysis was complicated by *Serratia marcescens* infection of the peritoneum. This organism seems to be pathogenic in a variety of sites and circumstances, particularly in association with chronic debility and with other established bacterial infections. The very limited antibiotic sensitivity of the organism is discussed.

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Preliminary Communications

Determination of the Emptying-time of the Stomach by Use of Enteric-coated Barium Granules

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An easy method of assessing the emptying-time of the stomach has not yet been described. Methods which entail repeated intubation are of doubtful acceptability to the average patient.

Van Liere and Sleeth (1935, 1940) employed barium sulphate mixed with a standard carbohydrate meal and assessed the emptying-time by serial radiography. Although

their technique gave constant results for individuals, it was criticized by W. M. Capper (personal communication, 1964) on the grounds that barium sulphate is an irritant to the stomach and promotes early emptying. It was also claimed that the heavy barium sulphate would separate and empty before the meal. A similar technique was employed by Oberhelman (1959), who mixed barium sulphate with a meal consisting of meat, eggs, milk, toast, and cereal. With this technique the emptying-time for normal subjects was from three to six hours; in patients with gastric ulcer it was 8 to 15 hours.

To avoid the criticisms which have been made in regard to barium sulphate we have used it in enteric-coated granules. This avoids any possibility of irritation of the gastric mucosa by the barium sulphate and also gives a compound similar in specific gravity to food.

This preliminary communication describes the use of enteric-coated granules of barium which are given with a meal and which act as an indicator of the position of the meal in

FIG. 1.—Enteric-coated barium granules are seen as small high-density opacities in the stomach at four hours after ingestion.

the upper alimentary tract (Fig. 1). This technique has the merit of being easily carried out and of being acceptable to the patient.

THE BARIUM GRANULES

The barium granule mixture¹ is prepared from barium sulphate with sucrose and acacia to give a final content of 50% barium sulphate w/w. After drying, the granules are coated with cellulose acetate phthalate. The individual granules vary in size from 0.5 to 3 mm., just over 50% being between 1 and 2 mm. and a quarter being over 2 mm. The granules have a specific gravity of 1850, compared with 4500 for pure barium sulphate.

A series of patients have been examined after a breakfast consisting of porridge, bacon, egg, toast, and tea. The granules were mixed in the porridge, and the patient was asked to swallow the porridge at intervals during the meal in an attempt to get the granules evenly distributed throughout the food in the stomach. The patient was also asked to avoid chewing the actual food containing the granules so as to preserve their enteric coating intact as much as possible. The composition of the meal can be varied to suit the requirements of the particular study.

RADIOGRAPHIC PROCEDURE

During the examination no restriction on the patient's activities are made except that after the breakfast has been taken all food and drink are withheld until the examination has been completed.

It has been found easier to determine the location of the granules in the stomach when the radiographs are taken in the prone position than if they are taken in the supine position. This is because in the prone position the gastric contents gravitate into the region of the pyloric antrum, which can usually be distinguished radiographically from the small and large bowel without difficulty.

If the stomach is intact the first film is taken three hours after completion of the meal. Further films are taken at

hourly or two-hourly intervals until the stomach is empty, depending on the estimated rate at which the stomach is evacuating its contents. After gastrectomy radiographs must be taken at half-hourly or hourly intervals after completion of the meal.

INTERPRETATION OF THE RADIOGRAPHS

The shape of the stomach, and sometimes the duodenum as well, and also peristaltic waves in the stomach, can be identified quite easily. The enteric coating protects the granules from breakdown in the stomach very effectively for many hours, but when they enter the small bowel disintegration is rapid, the granular pattern being replaced as the meal progresses through the small and large bowel by a more homogeneous appearance due to the barium sulphate mixing with

FIG. 2.—Appearance as the granules disintegrate in the small bowel.

the intestinal contents (Fig. 2). Location of the granules to the stomach is not difficult when that organ is full at the beginning of the examination, but sometimes there is difficulty when relatively few granules remain in the stomach at the end of the examination. It has been found that in most patients the granules are evacuated completely in the observed time, but in a small number a few granules (about 4 to 10) are trapped, presumably between mucosal folds in the stomach. A tube passed at this stage shows the stomach to be empty.

The purpose of the present preliminary communication is to describe the technique. In 13 normal subjects the emptying-

FIG. 3.—Range of emptying-time in 13 normal subjects.

¹ The barium granules are manufactured and supplied by Messrs. Paines and Byrne Ltd., Pabryn Laboratories, Perivale, Greenford, Middlesex, to whom we wish to express our gratitude.

time varied from four to eight hours, with a maximum incidence of five to six hours (Fig. 3). Emptying is considerably slower after vagotomy and faster after gastrectomy.

SUMMARY

A technique is described in which the gastric emptying-time is measured by radiographic observation of enteric-coated granules of barium. These are taken with a meal and become dispersed in the food within the stomach. Serial radiographs are taken to assess the emptying-time, which is found to range

from four to eight hours, with a maximum incidence of five to six hours.

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Medical Memoranda

Duodenal Ischaemia Complicating
Acute Pancreatitis

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Intestinal obstruction is a rare complication of acute pancreatitis, and when it does occur it is usually due to spasm of the colon in the region of the splenic flexure, noted by the radiologists as the "colon cut off" sign (Price, 1956; Stuart, 1956).

A review of the literature is presented in the Table, and it is evident that mechanical, paralytic, and spasmodic types of obstruction can occur in pancreatitis.

Incidence of Site of Obstruction in Review of Literature

Site of Obstruction	No. of Cases	Author	Cause	How Discovered	Procedure
Splenic flexure	11	Schwartz and Nadelhaft (1957)	Spasm	Barium enema and plain radiographs	Exploratory laparotomy
Hepatic flexure	1	Aronson and Davis (1961)	Spasm	Barium enema	—
Jejunum	1	Moore (1956)	Adhesions of loop to inflammatory mass	Plain radiographs and laparotomy	Separation of adhesions
Duodenum	1	Street (1959)	Pressure due to traumatic pancreatic cyst	Barium meal and laparotomy	Gastro-enterostomy
	1	Brust and Kuei-chi Chen (1962)	Pressure due to haemorrhagic mass in retroperitoneal tissue	"	"

The combination of pancreatitis, in a child, complicated by duodenal obstruction of ischaemic nature merits narration.

CASE REPORT

A 10-year-old boy was admitted to North Lonsdale Hospital on 28 February 1963 with a three-day history of abdominal pain and vomiting, beginning after he had eaten an "ice lolly." The pain was central and constant. The vomiting started about three hours after the pain and its character changed from food residue to dark brown fluid, and the volume of vomiting was 5½ l. During this period there were no other symptoms and the bowels were open regularly.

No history of jaundice or of any previous attacks of abdominal pain could be elicited.

On admission the oral temperature was 37° C., and the pulse was 140 per minute. At the time of examination the pain had subsided, the child was feeling much better, and did not appear dehydrated. Abdominal examination showed no distension but there was slight tenderness and rigidity in the right iliac fossa. No mass could be palpated. Rectal examination revealed slight tenderness and the presence of faeces. The urine contained 100 mg. albumin and some acetone. Because it was suspected that the child had appendicitis with perforation and general peritonitis, an appendicectomy was performed through a right grid-iron incision by a colleague of mine. The appendix, though it was kinked in its middle by a band, was not inflamed. The mesenteric glands were enlarged, but there was no free fluid and no evidence of peritonitis. A course of penicillin and streptomycin was administered.

The day after operation the patient's condition deteriorated. He became dehydrated and shocked, the pulse was very rapid (150) and thready, the skin felt cold and clammy, and soon his temperature rose to 38.3° C. His tongue was very dry and coated. The abdomen was distended, especially in the epigastric region. There was definite gastric splash, but no visible peristalsis. The bowel sounds were weak, and there was no evidence of tenderness or rigidity in the abdomen. A naso-gastric tube was passed, and 1½ l. of dark brown fluid aspirated. Intravenous fluids were given and antibiotics continued. By evening the patient's condition had gradually improved and the aspirate had become greenish yellow. No splash could be elicited now, but waves of peristalsis could be seen in the epigastrium, going from left to right, and suggesting an obstruction to the pyloric end of stomach. He continued to maintain his improvement on conservative treatment until 4 March 1963, when an examination by a Gastrografin meal was made (Fig.). This showed a constant constriction of the upper half of the second part of the duodenum, measuring 2 cm. with a narrowing of the lumen to 5 mm. Anti-peristalsis was occurring in this area. A gastric residue was still present after four hours. It was thought that this duodenal obstruction was possibly due to an annular pancreas, involved in an acute inflammatory process, for the area of constriction was appropriately localized. Unfortunately, a first blood sample sent for estimation of the serum amylase level was insufficient in quantity, and thus no initial determination was obtained. A second specimen submitted on 3 March 1963 had a serum amylase level of 10 units/ml. (B), considered normal in our laboratory.

Haemoglobin was 108%, and blood urea 106 mg./100 ml. The results of tests of electrolytes and liver function were as follows: Na 320 mg./100 ml. (139 mEq/l.), K 14 mg./100 ml. (3.6 mEq/l.), Cl 380 mg./100 ml. (65 mEq/l.). Total bilirubin less than 0.5 mg./100 ml., thymol turbidity 2 units, zinc sulphate 4 units, ammonium 2 units, alkaline phosphate 12 units/100 ml. Culture of the vomitus yielded a growth of monilia.

On 7 March 1963 a second laparotomy was performed by Mr. H. A. Daniels, but it demonstrated neither free fluid nor any evidence of peritonitis. The stomach and first part of the duodenum were