orally for an additional week. Complicated wounds involving devitalized scalp or bone will obviously require extraordinary treatment regimens.

The bacteriology of subgaleal abscess has not been previously reported, and our experience has included recently developed anaerobic culture techniques. We observed that four of five cases involved polymicrobial pathogens (Table 1). S. aureus was isolated in four cases, Streptococcus in three and anaerobic cocci in two cases. Therefore, combined therapy of methicillin and penicillin appears to be the treatment of choice. In patients allergic to penicillin, clindamycin or cephalothin is an excellent alternative since they are effective against S. aureus and Streptococcus, as well as anaerobic cocci.[3-5] The polymicrobial cause of subgaleal abscess supports the notion that bacterial synergism may be an important factor in the pathogenesis of serious soft tissue infections, and reaffirms the importance of early surgical intervention in these cases.[6-9]

Infection restricted to the scalp has been reported as a rare complication of fetal scalp monitoring (electrocardiographic) and blood sampling.[10,11] Such infections have usually been diagnosed at 4 or 5 days of age, and many of the cases were reportedly "sterile" on routine culture. Sophisticated anaerobic culture techniques were not employed in these studies. We do not know of a previous report of a subgaleal abscess complicating fetal scalp monitoring.

Meticulous attention to fundamental principles of surgical management remains the single most important factor in reducing the incidence and morbidity of subgaleal abscess complicating scalp wounds.

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Medical Information

Barium Peritonitis

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BARIUM MEAL (upper gastrointestinal) and barium enema studies have long been considered essential procedures for evaluating diseases of the gastrointestinal tract. While it is generally accepted that these procedures are safe and morbidity is low, unfortunately such procedures are not entirely innocuous and serious complications have been reported, including necrotizing proctitis,[1] peritonitis,[2] barium granuloma of the rectum,[3] septicemia,[4] embolization[5] and fatal intravasation.[6]

Between March 1974 and October 1975 three cases of barium peritonitis occurred in our hospital from perforation of the gastrointestinal tract during routine barium meal or barium enema examinations. In one patient there was extravasation through a normal cecum and hypovolemic shock developed while he was still on the x-ray table. In another patient, who had a gastric outlet obstruction, an anterior gastric ulcer perforated 72 hours after an upper gastrointestinal study. In a third patient, a normal rectum perforated and symptoms of peritonitis developed six hours after a barium enema procedure. The patients with the cecal and the gastric perforations were treated with aggressive fluid resuscitation; immediate surgical resection of the site of perforation; removal of the barium, feces or other foreign bodies, and peritoneal lavage with large volumes of physiological saline. The patient with the rectal perforation was treated medically with nasogastric suction, fluid therapy and antibiotics. All three patients survived the described treatment.

Rectal Laceration

Most rectal lacerations occur between 3 and 8 cm from the anal verge on either the anterior or

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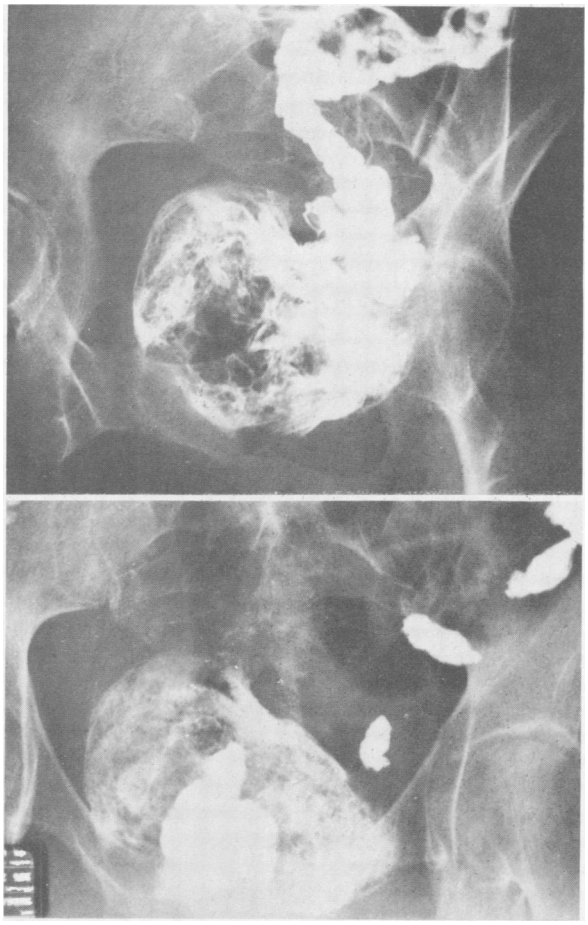

Figure 1.—Top, eight hours after a routine barium enema study. Evidence of barium extravasation from perforated rectum is seen. **Bottom,** 96 hours after barium enema examination. There is an extraluminal extravasation of barium from perforated normal rectum.

posterior wall of the rectum.[3] The causes of these complications include improper placement of the enema tip, overinflated enema balloon, placement of the balloon beyond the distensible area, recent rectal biopsy, excessive intraluminal pressure and preexisting rectal disease.[7-11] Most of the mentioned contributory factors could be reduced if one recognizes that these procedures are not hazard free. Rectal biopsy should be deferred until after a barium enema examination. The balloon should never be placed beyond the distensible rectal area and should not be distended more than necessary to obtain the proper examination.

Fortunately, the most frequently reported cases of barium extravasation occurred in the rectal and sigmoid colon. In most of the cases, the contrast medium was confined below the peritoneal refluxtion. In our patient, a Bardex® tube was used because of some inability to retain the barium. Six hours after the barium enema procedure, abdominal pain occurred accompanied by urgency and dysuria, and the temperature spiked to 39.6°C (103°F). On rectal and sigmoidoscopic examination, a 2½ cm oval laceration was noted in the anterior surface of the rectum at a 4 cm level from the anal verge. No other pathology was found up to the 20 cm level. Findings on an x-ray study included evidence of a perirectal extraluminal extravasation of barium (Figure 1). The patient was treated medically with nasogastric suction, fluid therapy and antibiotics. After ten days of medical management, the peritonitis subsided and the patient had an uneventful recovery.

Cecal Perforation

Perforation of a normal intraperitoneal colon and cecum, in particular, is most likely due to excessive intraluminal pressure.[9-10] When the colon begins to distend, the radius of the colonic lumen is increased and the law of La Place is invoked. According to this law, the pressure required to stretch the walls of a hollow viscus decreases in inverse proportion to the radius of the cylinder. Applying this law to the colon by giving an equal pressure throughout the colon, the greatest distention will occur in the portion of the colon with the largest radius. Because the cecum has the largest diameter, it is usually the site of rupture. To reduce the incidence of perforation of a normal cecum or right colon, the volume of barium should not exceed 4,500 ml in an average adult. The contrast medium should not be introduced too rapidly to avoid the incidence of sudden bursting pressure from colonic spasm.[10] In the event that a possible distal obstructive lesion is suspected, a water soluble contrast medium should be used in order to minimize the chance of precipitating a bowel obstruction and perforation, and to lessen the severity of peritonitis.[12] When a hyperosmolar water soluble material is used, the patient must be monitored closely for possible fluid and electrolyte imbalance.

In our patient, approximately 5,500 ml of barium was introduced during the barium enema procedure. Suddenly, an acute abdominal pain occurred. Fluoroscopic and x-ray study findings documented that extravasation of barium had occurred in the right side of the colon (Figure 2A). The patient immediately became cold, clammy and hypotensive. Hemoglobin level was 18 gm, while it was only 12 gm three hours before the perforation. He was operated upon less than 30

minutes from the time of perforation. Some 2,000 ml of serosanguineous fluid was present in the peritoneal cavity. The entire peritoneum, including the walls of the stomach, small and large bowels, omentum and mesenteries were notably edematous, hemorrhagic and friable. The right part of the colon was distorted to a pronounced degree by the infiltration of barium, making it impossible to do any lesser procedure other than a right colectomy, which was carried out. Large volumes of barium and feces were removed and the peritoneum was irrigated with copious volumes of normal saline. Some of the barium was firmly adhered to the peritoneal cavity and was impossible to remove. The patient received six liters of Ringer's lactate and three units of plasma by the end of operation (3⅓ hours from the time of perforation). The patient's hemoglobin level was 13 gm, still one gm higher than the level determined just three hours before the perforation. There was no gross pathology that could explain the cause of the perforation. Microscopic examination at the site of perforation failed to show any pathology other than barium infiltrated into the bowel wall. A series of x-ray films of the abdomen taken since the patient's discharge showed residual barium in the peritoneal cavity and the appearance has not changed in 24 months (Figure 2B).

Gastric Perforation

Barium peritonitis resulting from perforation following upper gastrointestinal examination is rare, but has been reported in the literature.[13-15] In our patient and the cases reported in the literature, there was indication that distal obstruction was the contributory factor for precipitating perforation. In our patient approximately 72 hours after the upper gastrointestinal procedure, an acute abdominal pain suddenly developed which quickly became generalized. On an x-ray study of the abdomen, the stomach was seen to be notably distended by residual barium; free air un-

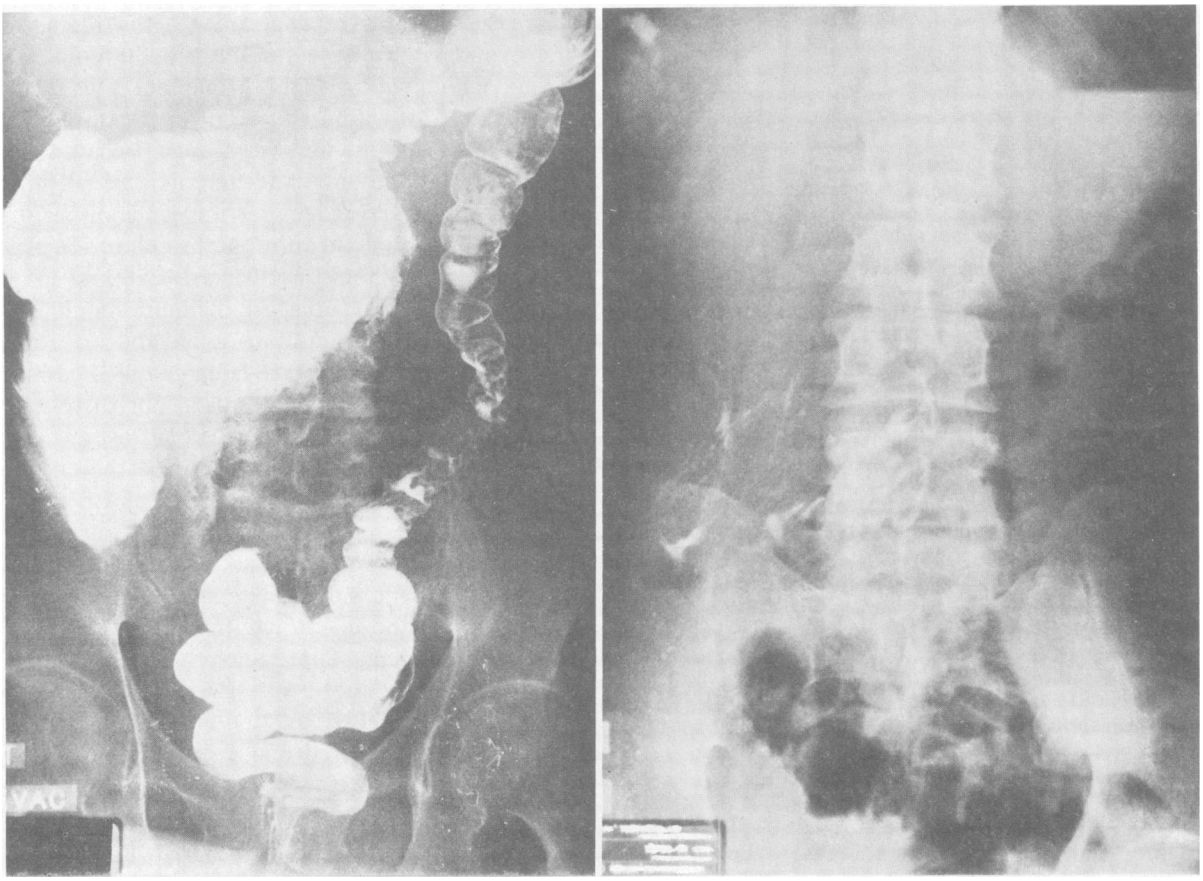

Figure 2.—Left, barium dissected along the entire wall of the right colon and perforated into the peritoneal cavity from a perforated normal cecum during a routine barium enema examination. **Right,** the residual barium in the peritoneal cavity has not changed in 24 months since the perforated normal cecum.

derneath the diaphragm was shown on an x-ray film of the chest (Figure 3). Surgical operation was done less than 1½ hours from the time of perforation; 3,000 ml of serosanguineous fluid mixed with barium was present in the peritoneal cavity. The entire peritoneum was edematous, hemorrhagic and friable. The barium and residual food particles were still leaking into the peritoneal cavity from an anterior perforated gastric ulcer at the antrum of the stomach. There was a second large ulcer at the lesser curvature of the stomach which had perforated into the lesser sac and the capsule of the pancreas. Edema and inflammatory processes from these ulcers had caused a gastric outlet obstruction. A subtotal gastrectomy was done and the patient is doing well 15 months postoperatively.

Discussion

In 1916 Rosenthal[13] reported the first case of barium peritonitis from an acute perforation of a duodenal ulcer immediately after a barium meal study complicated by intestinal obstruction. Since that time, there have been a few scattered reports of this complication, but it seems likely that this event occurs more frequently. In 1952 Zheutlin and co-workers[16] queried 100 teaching hospitals and collected 53 cases of barium extravasation occurring in the distal colon with a mortality rate of 51 percent. Lorinc and Brahme[17] found two perforations of the distal colon in more than 10,000 contrast studies, while Gardiner and Miller[18] reported an incidence of one in every 2,250 examinations. However, the true incidence of this complication is unknown.

Perforation of the gastrointestinal tract during barium examination is a rare but highly lethal complication. In untreated patients, mortality is 100 percent, as shown in laboratory models.[19,20] Even with aggressive surgical and medical management, mortality still exceeded 50 percent in both experimental and clinical experience.[12,16,18,20]

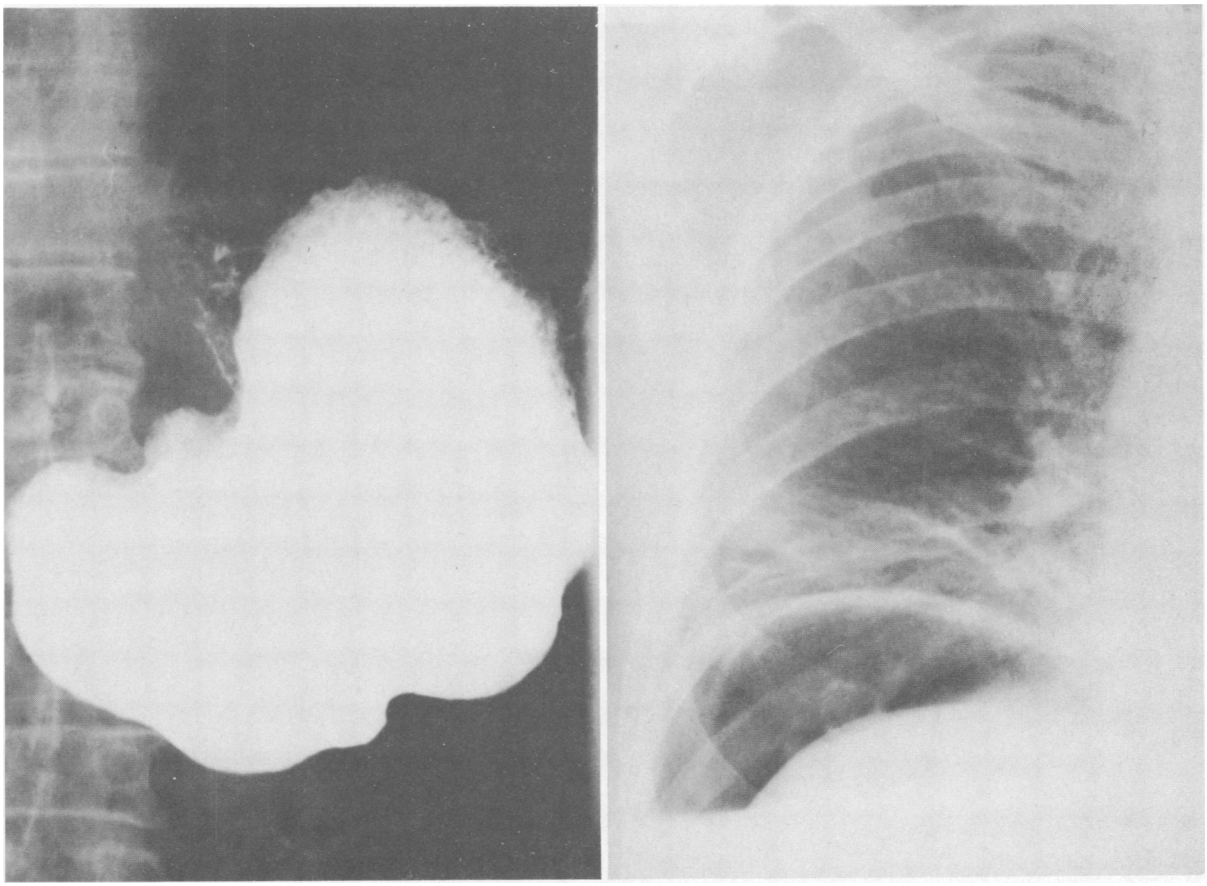

Figure 3.—X-ray films taken at the same time (72 hours after an upper gastrointestinal examination). **Left** shows residual barium in the stomach 72 hours after upper gastrointestinal study. **Right,** free air is seen underneath the diaphragm 72 hours after upper gastrointestinal study and 15 minutes after onset of acute abdominal pain.

Management of this complication should be tailored to the individual patient. Most rectal lacerations where barium extravasates usually are confined below the peritoneal refluxtion which can be safely treated medically with fluid and antibiotics. In perforation occurring above the peritoneal refluxtion with severe peritonitis, surgical intervention should be done as soon as possible after adequate resuscitation because continued spread of barium throughout the peritoneal cavity occurs within time. Increasing the severity of peritonitis by increasing the quantity of barium entering the peritoneal cavity has been documented by Westfall and associates.[20] The barium and other foreign bodies should be removed by irrigation and wiping the serosa with moist laparotomy pads to remove as much as possible. Copious lavage of the peritoneal cavity with physiological saline should also be carried out. The site of the perforation should either be repaired or resected, depending upon the local condition of the bowel wall.

It appears that loss of fluid into the third space is a significant factor in death of patients from barium peritonitis. Therefore, early aggressive intravenous fluid administration should be the mainstay of therapy for treatment of all barium peritonitis. We also recommend early surgical intervention for perforation occurring above the peritoneal refluxtion as soon as the patient's condition stabilizes.

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