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Reappraisal of Contrast Media Used To Detect Upper Gastrointestinal Perforations

Comparison of Ionic Water-Soluble Media with Barium Sulfate¹

Iodinated water-soluble compounds have been widely recommended as the most suitable contrast media for diagnosis of gastrointestinal perforations. However, the authors present 6 cases in which mucosal tears and transmural perforations of the upper gastrointestinal tract were either unrecognizable or inadequately shown during initial evaluation with methylglucamine diatrizoate. Re-examination with barium sulfate demonstrated the precise location and extent of the perforations. Reasons for the higher diagnostic yield of barium studies are explained on the basis of experimental and clinical observations.

Index terms: Contrast media, comparative studies (GI system, water-soluble examination, 7[0].1232) • Esophagus, perforation, 7[1].710 • Gastrointestinal tract, perforation, 7[0].710

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PPOTENTIAL side effects of the contrast media used in the radiological evaluation of gastrointestinal perforations have been the subject of extensive investigations (1-5). Iodinated water-soluble compounds are widely advocated for this purpose due to their relative safety and rapid resorption following extraluminal leakage (2, 6-9). However, several authors have pointed out that 25-50% of esophageal perforations are not seen during esophagography with aqueous contrast agents (10-12). Considerable difficulty in demonstrating extravasation at the site of gastric perforations has also been reported (12-15). Unfortunately, we know of no comparative studies of diagnostic accuracy of barium sulfate *versus* iodinated opaque media. We have reviewed 6 cases in which initial evaluation of the upper gastrointestinal tract with methylglucamine diatrizoate (Gastrografin, Squibb) failed to disclose mucosal tears and perforations that were clearly evident on re-examination with barium sulfate.

MATERIAL AND METHODS

Five men and 1 woman ranging from 22 to 67 years of age were studied. In addition, we conducted a simple experiment by obtaining radiographs of two polyethylene tubes with an inner diameter of 1.5 mm. One was filled with a 50% suspension of barium sulfate (50% w/w) and the other with undiluted Gastrografin (37% iodine). Both tubes were placed over a 19-cm-thick Plexiglas phantom to simulate the density of abdominal soft tissues. Serial radiographs were then obtained at 90, 100, 110, and 120 kV and 200 mA and phototimed. A 1.2-mm focal spot and Du Pont Cronex-4 film were used.

RESULTS

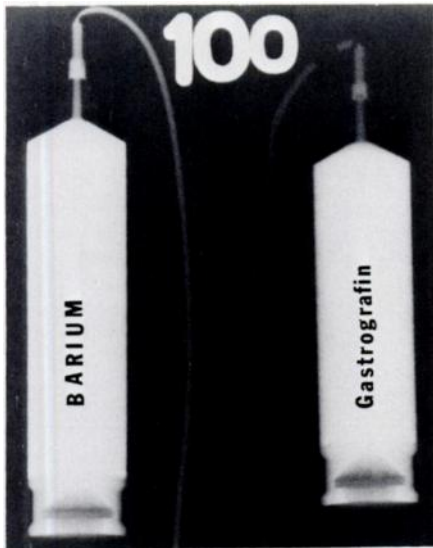
In the phantom experiment, subjective evaluation and densitometric measurements demonstrated remarkably superior visibility of the barium-filled tube at all four exposures (Fig. 1). This suggests that minimal extravasation and a narrow fistulous tract would also be seen better when opacified with barium instead of Gastrografin in the above concentrations. Our findings in the 6 patients are reported below.

CASE REPORTS

CASE I: This 67-year-old man was undergoing upper gastrointestinal endoscopy for evaluation of a bleeding duodenal ulcer and suspected cancer of the gastroesophageal junction demonstrated on a recent barium study. Considerable difficulty was encountered during insertion of the flexible

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Figure 1

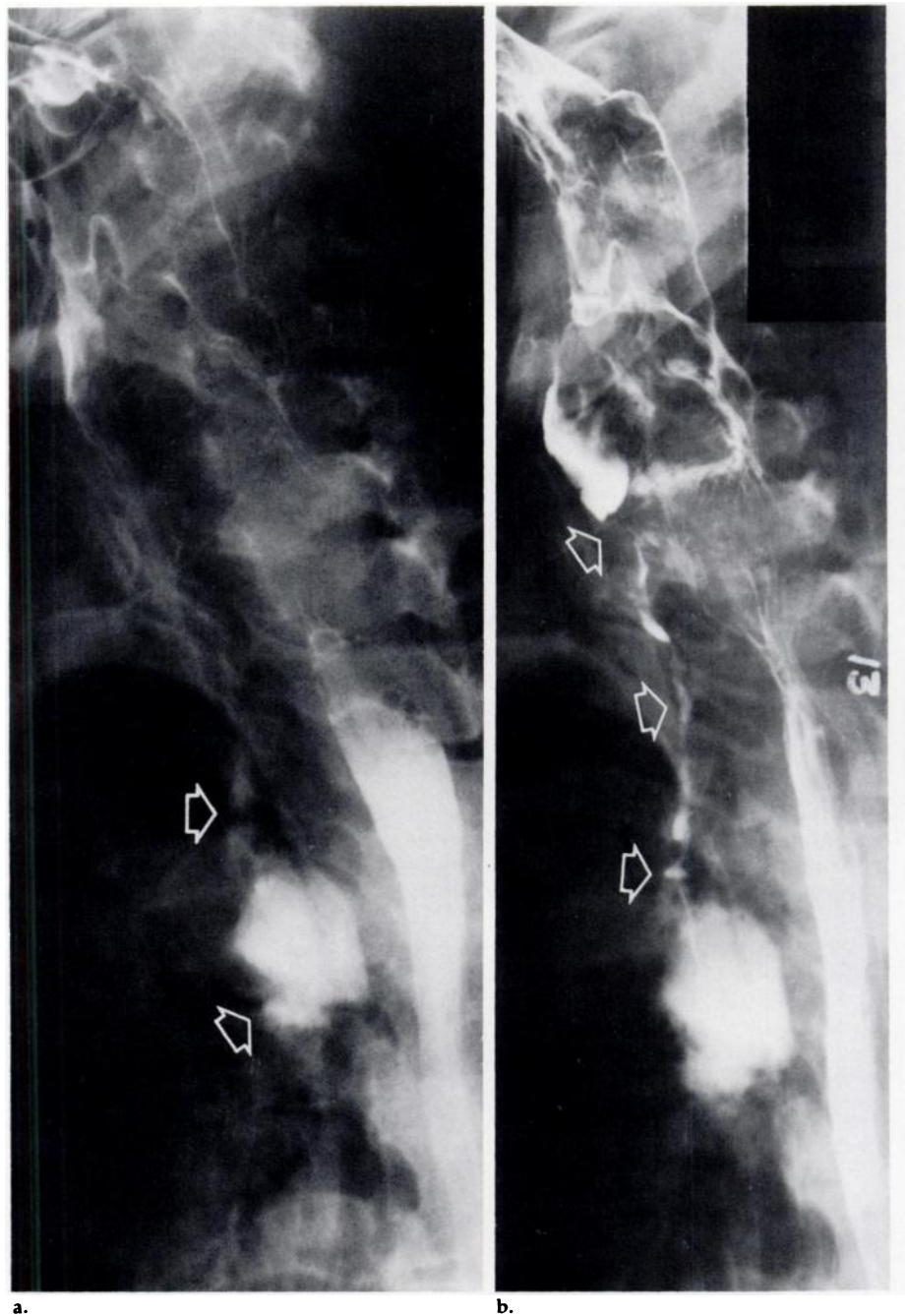


Comparative densities of barium sulfate (50% w/w) and undiluted Gastrografin (37% iodine). Radiograph exposed at 100 kV shows the plastic tube (1.5 mm i.d.) to be markedly denser and seen better when filled with barium rather than Gastrografin.

fiberscope into the cervical esophagus, causing bleeding and resulting in termination of the procedure. A chest radiograph showed pneumomediastinum and subcutaneous emphysema of the right side of the neck. Following immediate ingestion of Gastrografin, multiple views demonstrated an extraluminal collection of contrast material in the right upper mediastinum, but the precise location of the tear could not be identified (Fig. 2, a). A small amount of barium, however, was sufficient to clearly outline the site of perforation in the apex of the right pyriform sinus and the narrow track leading to the previous accumulation of Gastrografin (Fig. 2, b). Surgical closure of the tear and mediastinal drainage were carried out without complications.

CASE II: A 57-year-old man with a history of vagotomy and pyloroplasty was evaluated for recurrent epigastric pain and melena. The fiberoptic endoscope was inserted into the esophagus with relative ease, and what appeared to be diffusely hemorrhagic esophageal mucosa was observed. However, the instrument could not be advanced into the stomach. Immediate examination of the upper gastrointestinal tract with Gastrografin showed an essentially normal esophagus (Fig. 3, a). To improve visualization of the mucosa, a small amount of barium was administered and serial spot views demonstrated submucosal dissection of the entire esophagus due to false passage of the endoscope through a mucosal tear in the cervical esophagus. The mucosal flap was now clearly visible, separating the

Figure 2. Case I.



Endoscopic perforation of the pyriform sinus.

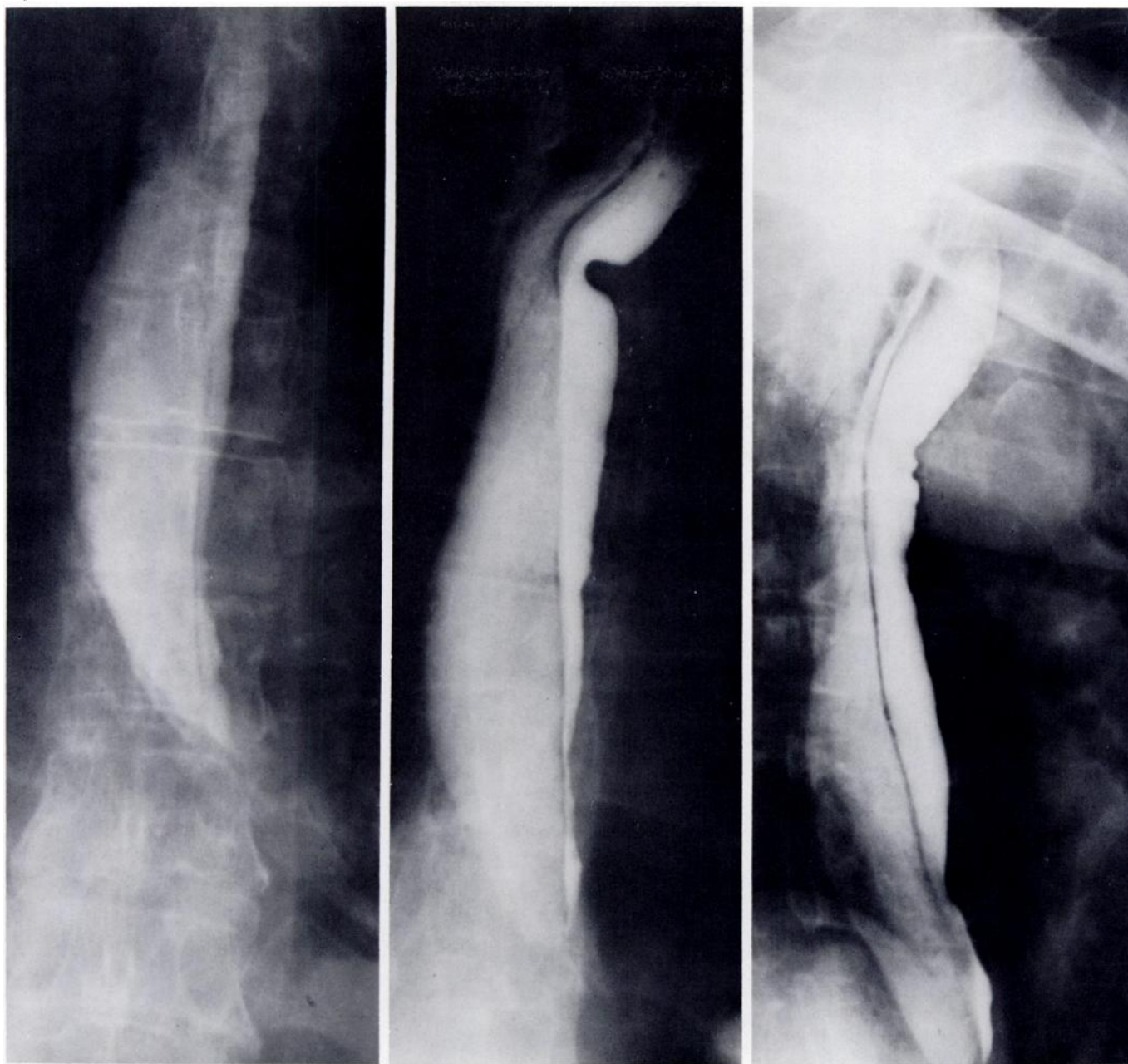
- a. Gastrografin study shows extravasation into the right upper mediastinum (arrows).
- b. Barium examination reveals the exact site of perforation at the apex of the right pyriform sinus. There is improved mucosal coating in the hypopharynx, and barium clearly outlines the false passage leading to the previous extraluminal collection of Gastrografin (arrows).

barium-filled true lumen from the iatrogenic submucosal space, which was still opacified by retained Gastrografin (Fig. 3, b and c). Conservative management led to complete healing within two weeks.

CASE III: This 63-year-old man had undergone a right hemicolectomy for adeno-

carcinoma of the hepatic flexure. One week later, fever, epigastric pain, rebound tenderness, and upper gastrointestinal bleeding developed. There was no evidence of free air in the abdomen on plain radiographs. Because of clinical suspicion of a penetrating peptic ulcer, however, Gastrografin was ingested and showed prominent

Figure 3. Case II.



a.

b.

c.

Submucosal dissection of the esophagus.

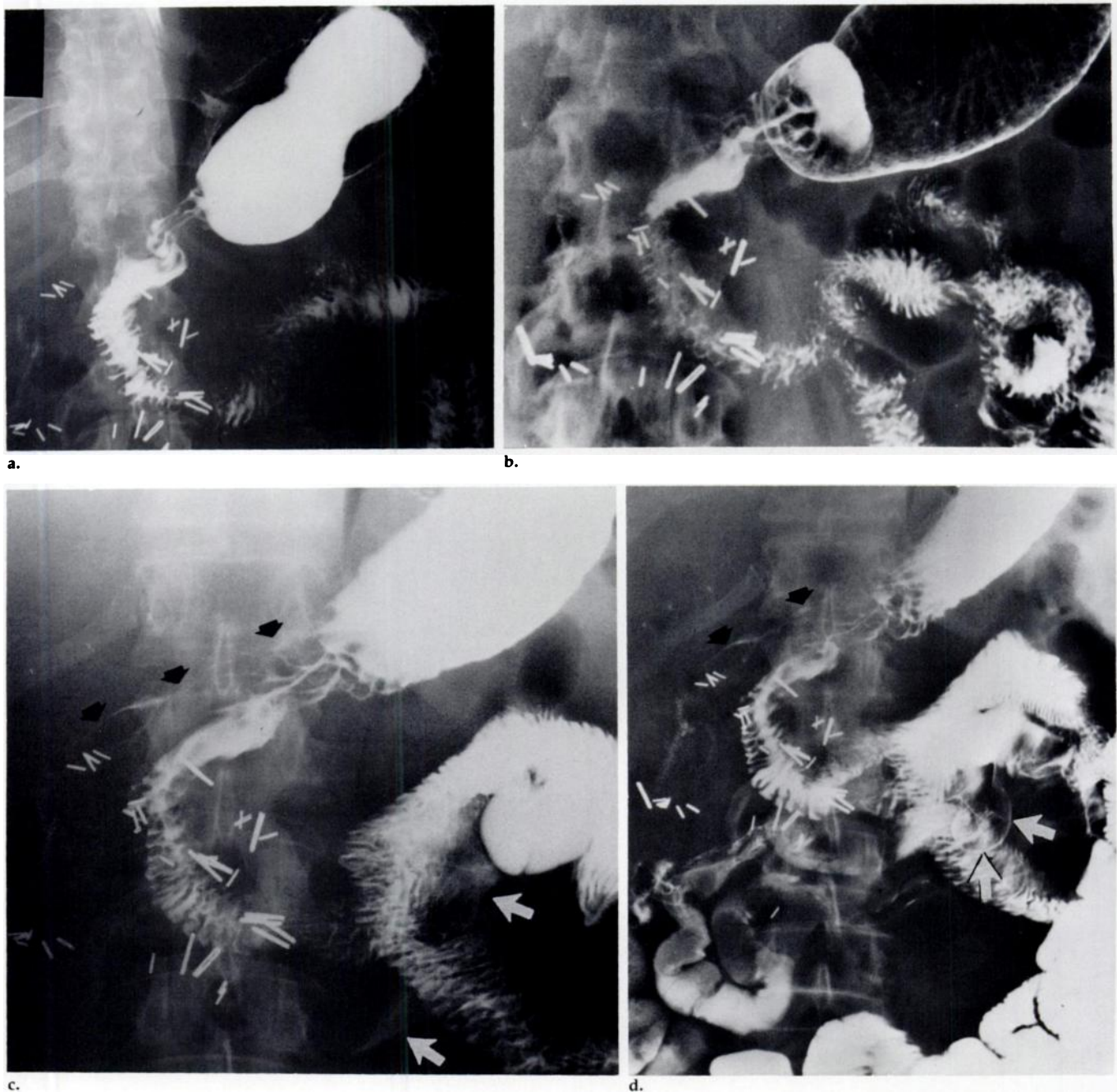
- a. Radiograph obtained during administration of Gastrografin shows a patent esophageal lumen. This is the only one of 6 spot views in which a faintly outlined mucosal stripe of the distal esophagus was recognizable on retrospective evaluation.
- b and c. Esophagograms with barium sulfate clearly demonstrate the longitudinally dissected mucosal flap. Note the higher density of barium within the true lumen, compared with Gastrografin retained in the large submucosal space.

nodular folds in the antrum and a deformed duodenal bulb with no evidence of leakage of contrast material (Fig. 4, a and b). For the follow-up small-bowel series, barium was administered and the subsequent radiographs demonstrated a small perforating antral ulcer with minimal extravasation under the liver and into the peritoneal cavity (Fig. 4, c and d). The perforation was repaired.

CASE IV: A 43-year-old man presented with a three-day history of cramping epigastric pain, nausea, and loss of appetite. Radiographs of the abdomen were unremarkable. An upright chest radiograph showed small collections of subdiaphragmatic air. Immediate evaluation of the upper gastrointestinal tract with Gastrografin revealed a distended stomach containing a large amount of retained secre-

tions. Passage of contrast material beyond the apparently normal duodenal bulb was markedly delayed, but no extravasation could be seen (Fig. 5, a). A nasogastric tube was inserted and $\frac{1}{2}$ liter of bloody gastric contents removed, after which therapy with antibiotics and intravenous fluid was initiated. Five hours later, a chest radiograph showed slight increase of the pneumoperitoneum. To aid in locating the perforation

Figure 4. Case III.



Perforated antral ulcer.

a and b. Prone and supine radiographs from the Gastrografin study show nodular folds in the antrum and slight deformation of the duodenal bulb.

c and d. Follow-up small-bowel series with barium sulfate demonstrates a small antral ulcer with extravasation under the liver (black arrows) and into the root of the small-bowel mesentery (white arrows).

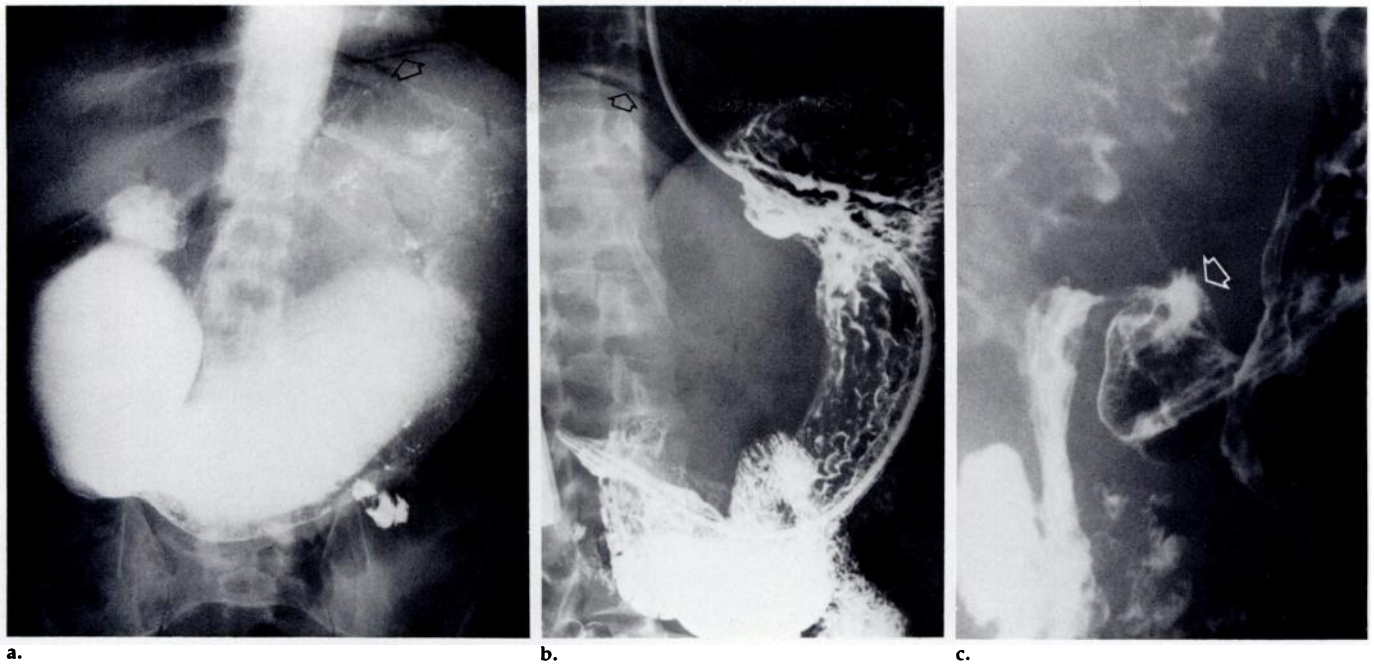
site, barium was administered through the nasogastric tube, demonstrating an 8-mm ulcer crater in the duodenal bulb which was causing minimal leakage of air and barium into the lesser sac (Fig. 5, b and c).

CASE V: A 44-year-old woman underwent a Whipple procedure for resection of

pancreatic carcinoma. Two weeks later, peritonitis developed and anastomotic leakage was suspected. Gastrografin failed to reveal any leakage; however, due to persistent pneumoperitoneum the patient was re-examined two days later with oral barium sulfate, which clearly showed minimal extravasation from the gastrojejunostomy suture line (Fig. 6).

CASE VI: A 22-year-old man sustained blunt abdominal trauma and facial injuries during an assault and was vomiting bloody material on entering the emergency room. Gastrografin was introduced through a nasogastric tube but showed nothing remarkable (Fig. 7, a and b); however, there was inadequate opacification of the duodenal sweep and proximal small bowel. On

Figure 5. Case IV.



Perforated ulcer of the duodenal bulb.

- Gastrografin study demonstrates a distended stomach and small pneumoperitoneum (arrow).
- Following nasogastric suction, infusion of barium through the tube has improved mucosal coating. A pneumoperitoneum (arrow) and small gas collections posteromedial to the stomach are evident.
- Spot view shows minimal extravasation into the lesser sac from the perforated duodenal bulb ulcer (arrow).

the following day, plain views of the abdomen and an excretory urogram demonstrated a mottled gas pattern in the region of the right kidney but no free air in the abdomen. Re-examination with barium demonstrated retroperitoneal extravasation from a large tear in the third portion of the duodenum (Fig 7, c).

DISCUSSION

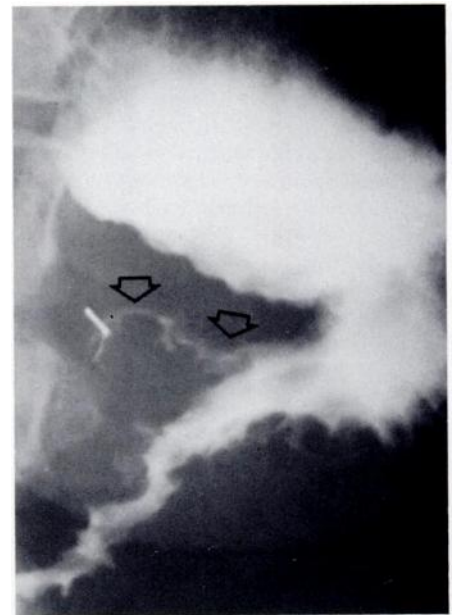
Gastrografin and similar aqueous agents are widely advocated as the contrast media of choice in patients with suspected gastrointestinal perforation or mucosal tears (1, 3, 8, 9). This recommendation is supported by experimental and clinical data which show that these media are rapidly absorbed following extravasation, do not exacerbate inflammation in an already contaminated mediastinum or peritoneum, and usually do not induce significant changes in the exposed tissues (3, 4, 6-9). However, deleterious systemic effects due to the hypertonicity of these iodinated compounds may develop following both oral and rectal administration in infants and debilitated elderly patients. These include electrolyte imbalance, significant fluid shift from the vascular compartment, pulmonary edema if aspirated, or in-

testinal necrosis in some cases of obstructed bowel (16-21).

Barium sulfate is universally accepted as the contrast medium of choice for gastrointestinal studies due to its high radiographic density, iso-osmolality, inert nature, and low cost (22). However, isolated clinical observations and extrapolations from animal experiments indicate that peritoneal contamination with barium and fecal material can result in significant complications such as foreign-body granulomas and peritoneal adhesions (1-5, 23, 24). Therefore, many authors advise against the use of barium if gastrointestinal perforation is suspected (2, 3, 8, 9, 23, 24). More recently, James *et al.* (7) compared barium and Gastrografin alone and in combination with bacteria following mediastinal soft-tissue contamination and showed that barium causes granuloma formation in the mediastinum but has no further deleterious effects when mixed with bacteria.

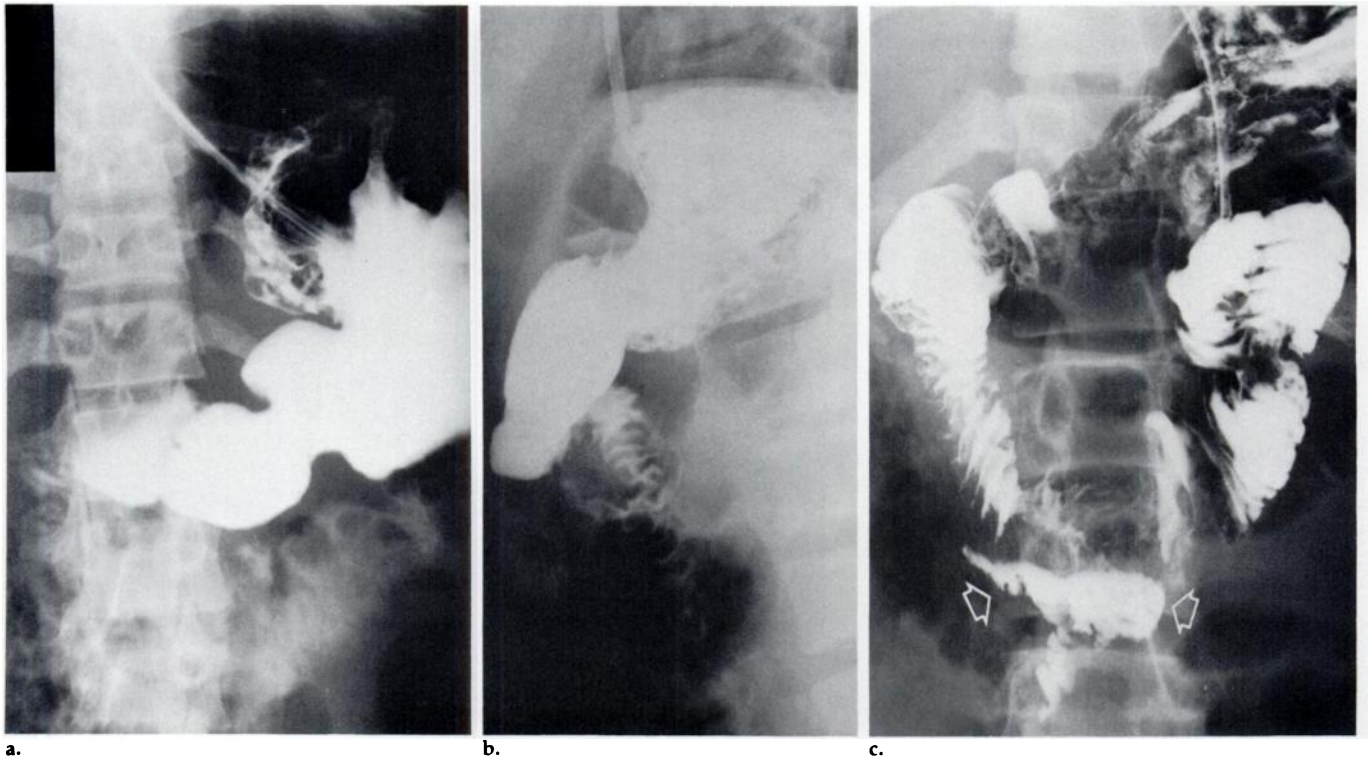
In actual clinical situations, several factors other than the different densities of the two contrast media account for improved visualization of small perforations on barium studies. These include better mucosal coating and

Figure 6. Case V.



Minimal leakage from the gastroenterostomy suture line (arrows) was disclosed only during re-evaluation with barium sulfate.

Figure 7. Case VI.



Traumatic duodenal rupture.

a and b. Radiographs of the upper gastrointestinal tract with Gastrografin were interpreted as normal.

c. Barium examination one day later clearly shows retroperitoneal leakage due to duodenal rupture (arrows). There is residual Gastrografin in the ascending colon and a mottled gas collection within the right anterior pararenal space.

adherence of barium to sites of extraluminal leakage (Figs. 2-7). In contrast, Gastrografin flows more readily through perforations and diffuses within the adjacent tissues (4, 6-9, 12, 15, 22). Such inherent physical properties of barium obviously enhanced visualization of extravasation in our patients: yet the minimal amount of extravasated barium in the present series was easily cleared during operative closure of the sites of leakage and did not cause any complications over follow-up periods ranging from eight months to three years.

Our experience also provides an explanation for reported failures to detect upper gastrointestinal perforations with iodinated compounds: for example, extravasation of water-soluble contrast media has been noted to occur in only 50% of perforations of the cervical esophagus and 75-80% of those involving the thoracic esophagus (10-12). Meyers and Ghahremani (12) have pointed out that aqueous contrast agents may also fail to show extravasation at the site of gastric perforations induced during endoscopy, probably

accounting for the concept of "spontaneous postgastroscopy pneumoperitoneum" (12-14). Frequent difficulty in demonstrating gastrointestinal perforations has even led to development of a urine test for Gastrografin (15), indirectly confirming extraluminal leakage with subsequent resorption and excretion of contrast material.

We fully support previous authors in advocating the use of water-soluble iodinated agents in the initial radiographic evaluation of suspected gastrointestinal perforations (6-12). Nearly all large perforations can be demonstrated by Gastrografin during a careful fluoroscopic examination. However, small tears, fistulas, and penetrating ulcers may not be recognizable due to the physical characteristics of Gastrografin. Therefore, negative or equivocal findings do not exclude perforation. In such cases, immediate re-examination with barium sulfate is a safe and simple method of detecting small upper gastrointestinal perforations and improving radiological accuracy.

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