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LOCALIZING OBSCURE UPPER GASTROINTESTINAL BLEEDING
BY THE FLUORESCIN STRING TEST*

IRVIN R. REISBERG, M.D. AND WILLIAM S. HAUBRICH, M.D.

OBSCURE upper gastrointestinal bleeding poses a common diagnostic problem. Endoscopy and radiography can assist the clinician in defining the source in many instances. Other helpful laboratory aids include the bromsulfalein test,\(^1\) the blood ammonia concentration,\(^2\) azotemia,\(^3\) and the 2-hour uropepsin test,\(^4\) but these are limited in their scope, provide only circumstantial evidence, and can be misleading. Splenic pulp manometry,\(^5\) \(Cr^{51}\) tagged red blood cell test,\(^6,7\) and selective arteriography\(^8\) have been helpful in selected cases of gastrointestinal bleeding but are not always readily available or applicable. There remains a need for a safe, rapid, and accurate method for localizing the site of upper gastrointestinal tract hemorrhage.

In 1909, Einhorn\(^9\) first introduced the string test as a new method of recognizing mucosal ulceration in the upper gastrointestinal tract. In a later report by Einhorn,\(^10\) he pointed out that the string test may be used to help localize the ulcer, \(i.e.,\) to distinguish gastric and duodenal ulcers. Einhorn claimed that a small superficial ulcer, which might evade detection even at laparotomy, could stain with blood a swallowed string. It is to be remembered that Einhorn’s development of the string test antedated the advent of effective gastrointestinal roentgenography.

In ensuing years, several adaptations and modifications were applied to Einhorn’s original string test.\(^11,12\) However, the simple string test alone cannot distinguish a focus of active bleeding and a collection of old blood possibly removed from the site of hemorrhage.

Realizing the need for a rapid and safe method of localizing the active site of upper gastrointestinal tract hemorrhage, Traphagan and Karlan\(^13\) in 1958 introduced the use of the fluorescein string test whereby the presence of fluorescein dye in the blood could be easily detected at the level from which it exuded from a mucosal lesion. Haynes and Pittman\(^14\) subsequently reported their experience with the same principle.

*From the Division of Gastroenterology. (Dr. Reisberg’s present address: The Akron Clinic, Akron, Ohio.)
This paper outlines the methods by which we have performed the fluorescein string test and reports our experience with its use at the Henry Ford Hospital.

**METHODS AND MATERIALS**

Thirty-eight patients from the medical and surgical services comprised the subjects of this series. Our indications for using the fluorescein string test were persistently guaiac-positive stools, a dropping hemoglobin level, or hematemesis in a patient whose site of upper gastrointestinal hemorrhage was not evident in customary x-ray or endoscopic examinations or in a patient whose studies demonstrated two or more possible sites of hemorrhage, such as esophageal varices and peptic ulcer.

We use two types of strings for the intravenous fluorescein test. Both are commercially prepared by Advanced Laboratory Associates, Inc., of New Jersey.

Type-1 string, the Traphagan and Karlan modification, is 3/16-inch cotton braid, 10 feet long, with bonded radio-opaque markers at 2-inch and 1-foot intervals. A specially prepared lead weight is attached to one end of the string to facilitate swallowing.

Type-2 string, the Haynes and Pittman modification, is 5 feet long and consists of 2 braids 1/4-inch wide and bonded together with radio-opaque markers at 2-inch and 1-foot intervals between the braids. A mercury bag is attached at the end of the string to hasten its passage.

Both strings contain a linear radio-opaque monofilament, and their disposition, after being swallowed, is readily apparent in plain films of the abdomen (Figure 1).

If the site of upper gastrointestinal bleeding is suspected of being within the reach of the 5-foot string, we prefer the type-2 string because it affords a larger surface area for the absorption of blood and fluorescein dye.

The dye we use is 5 per cent sodium fluorescein solution, especially buffered with sodium bicarbonate, and prepared by the Moore Kirk Laboratories, Inc., of East Woodstock, Connecticut, as Fluorescite®. A reliable standard ultraviolet light (Wood's lamp), a pair of rubber gloves, a 20 ml syringe, a large shallow container of water, and recourse to facilities for obtaining a plain film of the abdomen complete the necessary materials.

**PROCEDURE**

The patient is permitted nothing by mouth for at least two hours preceding the test. The entire procedure is explained to the patient before the test is started. We have not found it necessary to anesthetize the patient's throat before having him swallow the string. The string is swallowed by the patient with the aid of sips of water. Within 30 seconds, approximately 40 cm. of the string is easily swallowed, indicating that the end of the string is at the level of the esophagogastric junction. The patient is then placed on his left side for 5 minutes to allow the end of the string to pass into the stomach. The patient is next instructed to lie on his right side with his hips slightly elevated for 20 minutes, and he is told to swallow about 2 inches of tape every 5 minutes. Then the patient is allowed to walk about, taking occasional sips of water.

When it is calculated that the swallowed end of the string has reached at least the area of suspected bleeding, the string is taped at the patient's mouth, and a plain film of the abdomen is obtained. The course of the string is identified on the film as it passes through the stomach and the C-loop of the duodenum (Figure 1). Ideally, the end of the string should extend beyond the ligament of Treitz. If the string is coiled or doubled on itself, it is partially withdrawn and allowed to pass again. When the string reaches the desired position, 20 ml. of Fluorescite® is injected intravenously. Within 2 or 3 minutes the patient's skin turns yellow indicating that the dye has permeated the total body circulation.

 Routinely we wait four minutes after injecting the dye before withdrawing the string. We then immerse the string in water to wash off any secretions or debris that may adhere to the string. The string is next examined for stains of gross or occult blood and then for fluorescence under the ultraviolet light.

The next step is the precise localization of the site of bleeding. The horizontal marker nearest the fluorescent dye on the string is identified by counting back the number of markers from the end of the string. The position of this marker is then located on the x-ray film. This area closely approximates the anatomical site of bleeding.
GASTROINTESTINAL BLEEDING

Figure 1

Scout film of the abdomen taken after the patient has swallowed the specially prepared string. Note the clearly visible markers at 2-inch intervals. In this instance, the string has traversed the stomach, duodenum, and most of the jejunum.

INTERPRETATIONS

There are four possible interpretations of the results of this string test (Table I). To these interpretations we would add the falsely positive result of faulty or careless technique by the operator. An example of this is the failure to wear rubber gloves either when injecting the dye or withdrawing the string and then inadvertently touching a dye-stained finger to the string. Also, too vigorous manipulation of the string as it is withdrawn from the patient may result in abrasion of the mucosa and factitial bleeding.

267
RESULTS

The intravenous fluorescein string test was employed in 38 patients with evidence of upper gastrointestinal bleeding: in 20, both fluorescein dye and blood were found on the string (Group A); in 14, blood was seen but fluorescein was absent (Group B); and in 4, neither blood nor fluorescein dye was detected (Group D). We encountered no patients with fluorescein dye in the absence of blood on the string (Group C).

Of the 20 patients in Group A, the initial barium x-ray examination confirmed a lesion at the site localized by the fluorescein string test in 10. Six of these lesions were duodenal ulcers (three active ulcer craters and three deformed duodenal caps). One patient had radiographically apparent esophageal varices. In one patient, x-ray changes were suggestive of gastritis, and this was confirmed by gastroscopy. One patient had only a hiatus hernia, while another had both a hiatus hernia and a duodenal ulcer demonstrated radiographically.

Ten patients in Group A had negative initial barium x-ray examinations. Repeated radiography in one case showed a duodenal ulcer 10 days after the initial x-ray study when special attention was directed to the area localized by the fluorescein string test. Another patient had a marginal ulcer demonstrated seven days after the initial negative examination, confirming the bleeding site indicated by the string test. Six patients in Group A responded favorably to medical management, no specific lesions having been demonstrated radiographically. In four of these patients, bleeding was localized by the fluorescein string test in the first portion of the duodenum, presumably from ulcers too shallow to appear in contrast studies. One patient in Group A had negative barium radiographs although the fluorescein string test clearly indicated bleeding from the first portion of the duodenum; she failed to respond to medical management. Although at operation no ulcer could be palpated, a "blind" Billroth II gastrectomy was done, and bleeding has not recurred. One man in Group A had a bleeding site shown by the fluorescein string test in the body of the stomach; subsequent gastroscopy revealed hemorrhagic gastritis.

Table I

<table>
<thead>
<tr>
<th>Findings on String</th>
<th>Interpretations</th>
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<tbody>
<tr>
<td>Group A</td>
<td>Blood present, fluorescence present</td>
</tr>
<tr>
<td>Group B</td>
<td>Blood present, no fluorescence</td>
</tr>
<tr>
<td>Group C</td>
<td>Fluorescence present, no blood</td>
</tr>
<tr>
<td>Group D</td>
<td>No blood, no fluorescence</td>
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</tbody>
</table>
GASTROINTESTINAL BLEEDING

Of the 14 patients in Group B, 6 had lesions which were demonstrated in the initial upper gastrointestinal x-ray examinations. Three of these lesions were duodenal ulcers (1 ulcer crater, 2 deformed duodenal caps). One patient had a pre-pyloric gastric ulcer, and another had a gastric polyp which was confirmed at gastroscopy. One patient had both esophageal varices and duodenal deformity apparent at the initial x-ray examination. Eight patients in Group B had no lesion shown by either radiography or endoscopy. All of these patients were treated medically, and three of these improved with no further bleeding episodes. One of these patients subsequently had recurrent upper gastrointestinal hemorrhage; at operation the surgeon could not palpate a lesion, but unfortunately he did not directly inspect the mucosal surface in the area localized by the fluorescein string test.

Four patients in Group D had completely negative string tests. Clinical signs indicated that the patients had stopped bleeding at the time the fluorescein string tests were performed. Three of these patients had stools negative for occult blood on the day of the tests, and a fourth had negative stools on the day following the string test.

ILLUSTRATIVE CASE REPORTS

The following cases demonstrate the unique assistance offered by the fluorescein string test in localizing obscure upper gastrointestinal bleeding.

CASE 1. R. M., a 47-year-old man, was admitted because of melena for six days preceded by vague epigastric distress. A duodenal ulcer had been diagnosed nine years ago. His initial hemoglobin was 12 Gm. (hematocrit 38 per cent). Stools were strongly positive for occult blood. Upper gastrointestinal radiography showed both a moderate-sized hiatus hernia and an ulcer crater in the duodenal bulb. An intravenous fluorescein string test revealed both blood staining and fluorescence at the level of the duodenal bulb. He responded promptly to an ulcer regimen, and bleeding has not since recurred.

Comment. This case illustrates how the intravenous fluorescein string test can distinguish the location of active bleeding when there is more than one possible bleeding site. This specific information is invaluable to the surgeon should operative intervention become necessary.

CASE 2. K. K., a 75-year-old woman, was admitted because of hematemesis and melena for two days. In the emergency room, her hemoglobin was 9 Gm. (hematocrit 28 per cent). Through a Levin tube blood-stained gastric juice was aspirated. An intravenous fluorescein string test showed both blood and fluorescein dye at 5 cm. proximal to the pylorus. Emergency upper gastrointestinal radiography showed both a moderate-sized hiatus hernia and an ulcer crater in the duodenal bulb. An intravenous fluorescein string test revealed both blood staining and fluorescence at the level of the duodenal bulb. He responded promptly to an ulcer regimen, and bleeding has not since recurred.

Comment. This case illustrates how the intravenous fluorescein string test can distinguish the location of active bleeding when there is more than one possible bleeding site. This specific information is invaluable to the surgeon should operative intervention become necessary.

CASE 3. I. L., a 53-year-old man, was admitted because of weakness, fatigue, light-headedness, and melena for three days. He admitted drinking three or more ounces of whiskey daily for many years. His hemoglobin was 9 Gm. (hematocrit 28 per cent). An
upper gastrointestinal x-ray examination showed only a small hiatus hernia. An intravenous fluorescein string test revealed both blood and fluorescein dye in the area of the duodenal bulb. Signs of bleeding ceased following a strict ulcer regimen. Radiography repeated seven days later, with attention directed specifically to the duodenal cap, revealed an ulcer crater.

Comment. In this case, the radiologist successfully demonstrated a lesion when his efforts were specifically directed to the site indicated by the fluorescein string test.

SUMMARY AND CONCLUSIONS

The intravenous fluorescein string test has been shown to be a safe, simple, and accurate method for localizing otherwise obscure upper gastrointestinal bleeding. In our experience with over 38 cases so tested, important information has been obtained thereby which has guided appropriate and effective treatment. The materials for the test are generally available, the technique is easily learned, and we commend its use.

REFERENCES