attributed to any extraneous cause. Many of these discharges (but by no means all) were sent by family doctors, and it may well be that patients with these "simple" discharges come to hospitals less often than those with more severe symptoms. It may be, too, that the growing interest in personal health leads women to complain to their doctors of symptoms which in an earlier age were borne in silence.

Summary

Of 561 specimens of vaginal discharge from women of reproductive age, 9 appeared to be due to bacterial infection. 134 were associated with *Trichomonas vaginalis*, and 64 with *Candida albicans*. The remainder were indistinguishable from normal vaginal secretion in any character except quantity.

13/16 vaginal discharges in children and 15/18 in women over 50 appeared to be due to bacterial infection.

A tentative classification of vaginal discharges based upon the reaction of the host and the parasite is suggested.

It is possible that *C. albicans* is parasitic, not on the vaginal wall, but on the secretions of the vagina.

My thanks are due to Mr. P. M. G. Russell for many interesting conversations on this subject and to Dr. Stella Henderson for supplying material from the Family Planning Clinic.

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ENDOSCOPIC EXAMINATION OF THE STOMACH AND DUODENAL CAP WITH THE FIBERSCOPE

BASIL I. HIRSCHOWITZ
B.Sc., M.D. W'srand, M.R.C.P., M.R.C.P.E.

ASSOCIATE PROFESSOR OF MEDICINE AND DIRECTOR, DIVISION OF GASTROENTEROLOGY, UNIVERSITY OF ALABAMA MEDICAL CENTER, BIRMINGHAM, ALABAMA

With illustrations on plate

SINCE a previous report on the fiberscope (Hirschowitz, Curtiss, and Peters 1958), work has progressed to the point where a clinically useful model of this completely flexible instrument has been made and used in the examination of the upper gastrointestinal tract. The current experimental model has been used successfully to examine the lower œsophagus, stomach, pyloric canal, duodenal bulb, and both afferent and efferent loops of jejunum for a distance of up to 12 in. beyond gastrojejunal anastomoses, all with sufficient resolution to describe fine mucosal detail. Furthermore, both still and movie photographs in colour have been taken through the instrument of the stomach and duodenum without additional illumination. Among the interesting findings are the observations on duodenal ulcer in situ and of a distinct sphincter at the apex of the duodenal bulb.

The Instrument

The fiberscope superficially resembles a conventional gastroscope, comprising a head which contains a lamp bulb, a prism, and a compound lens which focuses the image on to the distal (objective) end of the fibre bundle. The view is at right angles to the instrument. The shaft of the instrument contains the glass fibre bundle which transmits the image to the eyepiece and is *completely flexible throughout its entire length* (fig. 1).

The bundle is protected by a flexible flat bronze spiral which is also used to transmit torque. It is in turn covered by a smooth plastic sheath. The ocular (proximal) end contains a simple lens for magnifying the image from the proximal end of the fibre bundle, a ratchet for focusing the distal lens, and connections for air and electrical current supplied from a standard 10-volt variable transformer. The overall length is 38 in. (92 cm.) and the diameter just under 0·5 in. (11 mm.)

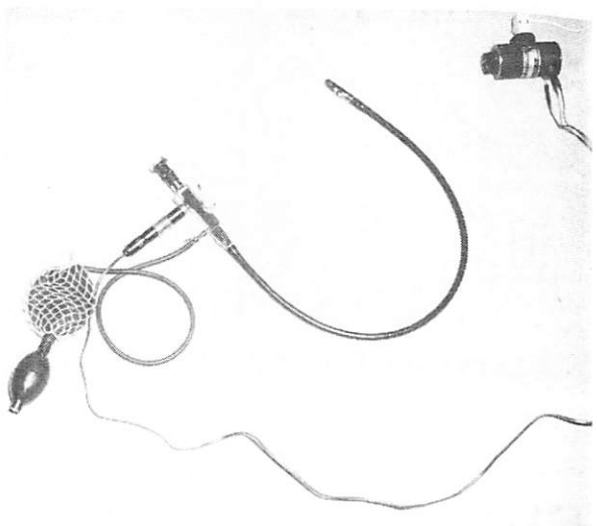


Fig. 1—The fiberscope with air and electrical connections.

The image is transmitted through a bundle of glass fibres traversing the length of the instrument and so arranged spatially that the orientation of the fibres is the same at each end, but, being unbound in the middle, the bundle is completely flexible. Each fibre (diameter 0·0006 in. or approximately 14 μ) transmits a spot of light and the image is transmitted as a composite of these spots of light. About 150,000 fibres are used to make one bundle of about 0·25 in. diameter, allowing high optical resolution. Light transmission through the fiberscope is about $2^1/_2$ times better than through the standard gastroscope, and each fibre is insulated to prevent light scatter from one to another.

The principle of transmission of light through the length of a fibre is that of total internal reflectance which depends on the refraction of light when passing from one optical medium to another of lesser optical density. Light beams are refracted closer to the interface as the angle of incidence becomes smaller. At the critical angle light is refracted along the interface between the two media and at any angle greater than the critical angle, light is reflected back into the medium of origin (in this instance glass). When light enters the end of a rod (or fibre) any light entering at a greater than critical angle (relative to the sides of the fibre) is automatically trapped and perforce has to proceed to the other end of the fibre. Once the light is trapped, curvature or bending of the fibre within wide limits will not cause the light to be lost before it appears at the other end. This briefly is the principle of the instrument used.

Its Clinical Use

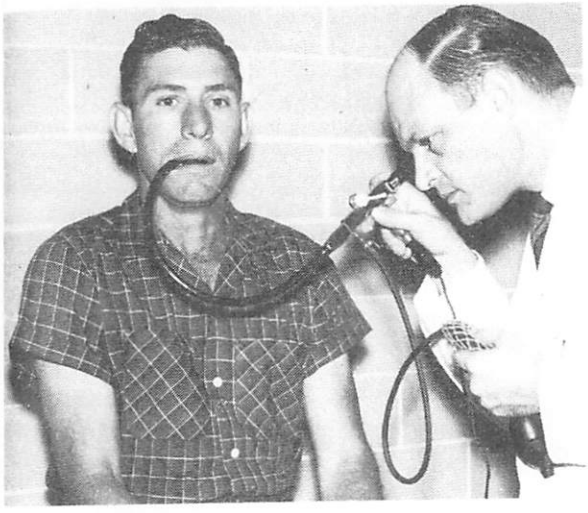
Preparation of the Patient

The principal indication for premedication is the prevention of nausea and gagging, rather than analgesia, since the examina-

n is painless. After trying a variety of drugs for premedica-n, including promazine (' Sparine '), dimenhydrinate Dramamine '), barbiturates and pethidine (demerol), either ne or in combination, as well as examining a number of tients without premedication, the following general method s been adopted. When the patient is first seen the activity of e gag reflex is graded 0, +, or ++. For those with little or gag reflex, preparation is confined to surface anæsthesia of e throat. Those patients with + gag reflex are given 25–50 g. pethidine and those with ++ gag reflex are given 50–100 g. pethidine intravenously 5–15 mins. before endoscopy. he throat is then anæsthetised with spray or gargle of the doscopist's choice (I have no special preference).

assing the Instrument

A drop of silicone antifoam * is placed on the tip of the strument to reduce bubbling (Hirschowitz, Bolt, and llard 1954). While an assistant holds the headpiece, the bricated instrument is passed readily into the stomach with e patient sitting on the side of the bed or couch facing the doscopist (fig. 2). In no instance has there been any difficulty



ig. 2—Stomach of outpatient being examined with the fiberscope.

n entering the stomach, and the blunt end seems preferable to ne rubber finger end both for swallowing and for transpyloric assage. Air is pumped into the stomach, as in the standard astroscopic examination.

Some of the œsophageal mucosa and the whole cardio-esophageal area can be seen since the focus of the instru-ment is so arranged to display surfaces in contact with he objective window. By moving the patient into ifferent positions, which can be done without discomfort r danger, a greater area of the stomach can be seen than vith the standard gastroscope. The fundus is an area vhich still cannot be examined, but there are no other " blind " areas. With the patient sitting upright the upper alf of the stomach can be seen, but if there is any fluid n the stomach the patient has to lie down on his back or ither side for examination of the lower half of the tomach.

Proceeding with the examination, the whole antrum is iewed from a point approximately opposite the angulus n the greater curve. Then, with the patient lying on the ight side, the instrument is advanced through the pyloric anal into the duodenal bulb. This has been possible very time it was attempted. The patient is then asked o lie on his back or left side to drain the duodenal ulb.

* Dow Corning.

When there is a gastroenterostomy the instrument can usually, though not always, be passed through the stoma for a distance limited by the respective lengths of the patient and instrument—usually for about 12 in. It is easier to pass the fiberscope into the efferent loop with the patient lying on his back or sitting upright; it is often necessary to advance the instrument into the afferent loop with the patient lying on the right side, and with some help from pressure through the abdominal wall.

Anteroposterior orientation is made relatively easy by observing transillumination through the abdominal wall. Once an organ is distended with air and the light is directed anteriorly, the whole outline of that organ can be readily made out on the abdominal wall. Anatomical sites are readily recognisable when once seen—this applies to the pylorus, duodenal bulb, and the jejunum (see below). Usually the position of the head can be confirmed by observing the outline of the transilluminated organ either jejunum (afferent or efferent loops) or the duodenal cap which is seen to the right of the midline beyond a dark band which represents the pyloric sphincter. The position of the head can also be confirmed by external palpation, and an ulcer can be further identified by finding point tenderness which corresponds to a lesion.

Because of its complete flexibility there is neither discomfort during the procedure nor afterwards. Nearly all the patients examined kept the instrument down for over 20 minutes, some as long as 60 minutes. The patient is not limited to any position, particularly the sword-swallowing one, and spinal deformity or inability to extend the neck no longer preclude examination. The patient can be examined anywhere and our patients have been examined in their beds, in the outpatient clinic, and even sitting in a chair. The instrument is manipulated by pushing and pulling and by rotation of the headpiece from which torque is transmitted to the distal end on a 1:1 ratio by the metal spiral incorporated in its shaft. A certain amount of manipulation can be done through the abdominal wall.

Observations

Œsophagus

Current models of the fiberscope were not designed to provide systematic examination of the œsophagus. Nevertheless, because objects in contact with the objective window can be brought into focus, an adequate view of the cardio-œsophageal area is readily obtained.

Stomach

Body of the stomach (fig. 3).—Resolution of the image is every bit as good as the conventional gastroscope provides, and because of greater light transmission the actual image seen is generally better. Colour reproduction is generally faithful, since transmission of light with wavelength above 5000 Å is close to 100%, being considerably reduced only below 5000 Å. The lesions seen so far include gastric cancer, acute ulcer (fig. 4), chronic ulcer, erosive gastritis, superficial gastritis, gastric mucosal atrophy (in pernicious anæmia), and hypertrophy or mammillation (in duodenal ulcer), and regional enteritis.

Antrum.—The entire pyloric antrum can always be seen and the motility of this area can be studied at leisure since the patient suffers no appreciable discomfort. Close-up views of the sphincter can always be obtained by advancing the instrument into the pyloric canal.

Pyloric canal.—Visible only occasionally with the conventional gastroscope, the pyloric canal can be very readily

examined with the fiberscope. Of particular importance is examination of the lesser curvature of the canal when the question of exact location of an ulcer relative to the pyloric sphincter and of malignancy of ulcers can be answered by direct inspection. Two benign ulcers, which resemble gastric ulcers, have been seen in this series.

Gastroenterostomy stoma (fig. 5).—In a Billroth-II gastrectomy, the stoma behaves very much like the antrum and pylorus in the intact stomach. Contraction waves pass towards the stoma and, unless the stoma is unduly large, close it. The contraction waves are generally not as large nor as well-organised as those at the antrum, being generally asymmetrically circular and larger towards the lesser than the greater curvature. In subtotal gastrectomy the contraction waves appear even less well-organised and are much feebler. It is almost as though propulsive motility waves originate at the angulus and are inherent in the lower part of the stomach. Large stomas which never closed were found in all 3 patients with dumping and bilious vomiting, indicating a possible mechanism for such symptoms.

Normal Duodenal Bulb and Bulbar Sphincter

By far the most important new area accessible to view with the fiberscope is the duodenal bulb or cap. It has been possible to examine the bulb in all 30 patients in whom the manœuvre was attempted.

Passage through the pyloric sphincter is easy to recognise. The bulbar mucosa is a lighter shade of pink than the antrum, and is more succulent than the antral mucosa. Folds of mucosa, generally longitudinal touch each other. Motility consists of circular contractions starting near the base and, becoming circular puckered rings, somewhat like those in the pyloric antrum, follow each other to the apex of the bulb where they close off the lumen in a distinct sphincter mechanism (fig. 6). In some patients the mucosal folds are so succulent that the sphincter itself is not evident and the closed lumen is slit-like rather than circular. Little or no reflux occurs through the closed sphincter.

Vomiting is preceded by obvious reverse peristalsis which appears as circular contractions running cephalad from the second portion of the duodenum and stopping at the bulbar sphincter; at the same time bilious fluid regurgitates into the bulb, and the bulbar contractions, though continuing, do not close the sphincter. Nausea is encountered occasionally when the duodenal bulb is distended with air.

Pathological Findings in the Duodenal Bulb

Deformed duodenal bulb without ulcer.—This X-ray diagnosis is often made and is generally presumptive evidence of ulcer of the duodenum. Three patients with deformed bulbs were examined. The findings were the same in each. No difficulty was encountered in entering the bulb. The shape was vaulted, resembling somewhat the vaginal vault seen through a speculum, and the walls were fairly rigid, flattening anteroposteriorly with compression through the belly wall and then resuming their shape with release of pressure. Mucosal folds were small, being 2–3 mm. high, 1–2 mm. wide, and separated from each other by 3–6 mm. of flat mucosa. They are generally arranged in longitudinal fashion and are irregular. One notable feature of these bulbs was the poor quality of the contractions, which seldom start more than 5–6 mm. proximal to the bulbar sphincter, are much more easily visible, because the overlying mucosa is not so succulent, and end in a very distinct sphincter which opens only partly to about 6–8 mm. and never closes completely. The whole impression is one of rigidity of this area. Mucosal colour is more tan than pink. Deformity of the bulb thus appears to be an endoscopically recognisable entity.

Fig. 7—X-ray of the first acute duodenal ulcer seen in situ by the fiberscope (see fig. 8).

Acute duodenal ulcer.—One such patient was examined twice within an interval of six days. Bleeding had occurred without ulcer symptoms preceding and the X-ray had shown a small crater (fig. 7). The patient was examined two days after bleeding and a small ulcer was seen on the inferior aspect of the bulb just beyond the pyloric sphincter. It appeared to be about 5 mm. in diameter, with a narrow rim of œdema, but no radiating folds, and a black base, presumably a blood-clot. This was the first ulcer seen in the duodenum and luckily could be photographed (fig. 8). The repeat examination showed no ulcer and only a small erythematous spot of œdema to mark the site of the ulcer. The mucosa of the rest of the bulb and the motility were apparently normal. A very similar ulcer was seen in another patient eighteen hours after bleeding. (Figs. 9 and 10 show other acute duodenal ulcers.)

Chronic duodenal ulcer (figs. 11 and 12).—This is the classic small crater with radiating folds seen so often on the X-ray. In one such patient an ulcer was seen in the mid-portion of the anterior wall of the bulb. It resembled very much a small chronic gastric ulcer with a yellow-grey base, sharp borders but ill-defined surrounding œdema and clear radiating folds. Point tenderness over the ulcer could be clearly determined. The remainder of the bulb, while poor in motility, showed only modest abnormalities of the mucosa.

Indolent duodenal ulcer (fig. 13).—One such ulcer was seen in a man with a duodenal-ulcer history of seventeen years. The contrast with the normal bulb, or even the chronic duodenal ulcer bulb, was very striking. The ulcer itself, on the anterior wall, was less well-circumscribed than the usual chronic gastric or duodenal ulcer and much larger than the acute or chronic duodenal ulcer, measuring about 2×1 cm., being roughly elliptical and in the longitudinal axis of the bulb. The base was bluish-grey wet granulation tissue, surrounded by low ridges of rather pink œdema. No new blood-vessels could be seen surrounding this area. The rest of the bulb was deformed, and mucosal folds were low and irregular and in parts appeared macerated. Contractions were weak and ran only a very short distance to a sphincter which did not close. Contractions did not run through the ulcer which extended almost to the sphincter. When the patient was asked to pin-point his ulcer he was able to do so exactly

with his finger. Pressure 1/2 in. away from the ulcer did not elicit pain.

Acute duodenitis.—In a patient with a six-year history of indigestion and alcoholism and a negative X-ray without bulbar deformity the duodenal mucosa was seen to be œdematous and covered with petechiæ and a punctuate yellowish exudate. While being observed an ecchymosis was seen to start in one of the petechiæ and spread submucosally for 4–5 mm. Pressure over the bulb produced tenderness. The lesions were confined to the duodenal mucosa. Re-examination after two weeks showed a return to normal with only 2 or 3 small erosions persisting. Another instance of duodenitis without the petechiæ was observed as a rather red mucosa covered with stringy yellow mucus, but no petechiæ; similar changes were present in the antrum and pyloric canal.

Active chronic duodenitis.—This condition was observed in a patient with a known long history of recurrent duodenal ulceration. The duodenal mucosa appeared macerated, but was not obviously ulcerated at the time of this examination. While not entirely rigid, motility was diminished and occupied only the extreme apex of the bulb near the sphincter. Active ulceration could easily be imagined as occurring in such a mucosa.

Jejunum

Normal appearances.—The jejunal mucosa is somewhat pinker that the gastric mucosa. The jejunal lumen is roughly cylindrical but with external compression is flattened. The mucosal folds are irregularly circumferential but are small and separated from each other. Though enough to get adequate views, the efferent loop does not hold air as long or as well as the stomach, duodenum, and afferent loop for prolonged viewing. No obvious differences were noted in appearance between afferent and efferent loops. The afferent-loop examination can be established by watching the transillumination of the loop through the abdominal wall and by observing bile flowing towards the instrument—in one examination it could be seen issuing from the ampulla of Vater.

Jejunitis.—4 patients have been examined because of symptoms suggestive of marginal or stomal ulceration, but with no demonstrable ulcer. In these patients the gastric side of the anastomosis and the efferent jejunum for a distance of about 1 1/2 in. (2–4 cm.) was obviously red and œdematous with loss of the mucosal ridging. 2 patients had superficial exudate in this area and external compression of the area in view of the fiberscope elicited tenderness. While many such cases are reported as normal on X-ray, repeat examination after three to six weeks of ulcer treatment reveals a return of the mucosal pattern due apparently to subsidence of œdema at the stoma. Jejunitis without ulcer seems to be a fairly common cause for recurrent pain after gastrectomy.

Jejunal ulceration.—Because the ulcer is in the efferent loop and often hidden by swelling around the stoma, conventional gastroscopy seldom allows display of marginal ulcers. The fiberscope, however, allows examination of the ulcers much more closely and certainly from beyond the stoma. One such instance was encountered.

Discussion

The application of fibre optics to the examination of the upper gastro-intestinal tract has opened new dimensions in diagnostic endoscopy. Areas not previously accessible are now readily displayed—the pyloric canal, the duodenal bulb, and both afferent and efferent loops of the jejunum through the gastroenterostomy stoma. These areas can not only be studied for abnormalities but also for motility for comparatively long periods. Furthermore, the complete flexibility of the fiberscope means that examination is very much easier for the patient, and introduction of the instrument requires no special skill. More important, damage to the œsophagus or stomach, particularly the œsophagus, is no longer a consideration as it was with the conventional gastroscope. Thus, many more patients can be examined easily and safely and the indications for its use should be much broader. Among the areas where the instrument will be particularly valuable are in diseases of the duodenal bulb, the post-gastrectomy syndromes, and in the direct photographic recording of motility of the upper gastrointestinal tract for periods long enough to be meaningful. The early examination of the upper gastrointestinal tract in bleeding will lead to more precise diagnoses and far fewer patients will leave hospital with upper gastrointestinal bleeding unexplained.

Several extremely interesting observations have been made in the duodenal bulb. For one, a sphincter at the apex of the bulb has been clearly seen, and corresponds to the radiological apex. It seems to represent an area where sphincteric motility of the upper gastrointestinal tract stops, and may well have something to do with the localisation of ulcers in the bulb. The attempted classification of duodenal ulcers into acute, chronic, and indolent seems to have some merit in terms of prognosis and possible surgery. It is the indolent ulcer that seems to be the "incurable" ulcer, and judging simply from the appearance of the mucosa of the bulb it would be more correct to consider ulceration as a recurrent episode in an incurable disease of the mucosa of the bulb.

Another syndrome which will bear much closer study is the one of jejunitis after gastrectomy, clinically resembling marginal ulceration with pain and slow bleeding and which responds to ulcer therapy. It remains to be seen whether stomal ulceration is part of this syndrome.

It may be stated unequivocally that the fiberscope has already reached the stage where it should replace the conventional gastroscope. We would no longer consider using the old instrument.

Summary

A completely flexible optical instrument employing fibre optics has been used successfully to examine the œsophagus, stomach, duodenal bulb, and both afferent and efferent jejunal loops through gastroenterostomy stomas. It has the advantages of easy passage, safety, and comfort to the patient. Image resolution is every bit as good and light transmission 2 1/2 times better than with the conventional gastroscope, making possible adequate colour photography without additional illumination. The conventional gastroscope has become obsolete on all counts. Among the observations made so far are: the finding of a distinct sphincter at the apex of the duodenal bulb; the recognition of three types of ulcer (acute, chronic, and indolent); and a syndrome of postgastrectomy jejunitis in patients with the clinical picture of marginal ulceration but without the ulcers.

The colour pictures were taken with an Exakta Varex II single-lens reflex camera with a 58 mm. lens coupled to the eyepiece of the fiberscope; the film is super-Ektachrome, ASA 160, at 1/2 sec. exposure. More than 60% of exposures taken are adequate. The photographs are not as sharp as the visual image, partly because of the long exposure time and partly because the ocular lens was designed for the eye rather than the camera. Minor improvements will, however, make sharp still and motion pictures part of any fiberscope endoscopy.

Production of the working model of the fiberscope for examination of the upper gastrointestinal tract is the result of hard, patient, and

frequently inspired work of Mr. L. E. Curtiss and Dr. C. W. Peters (who have been concerned in this project since its inception), as well as that of Dr. John Hett, with the unflagging optimistic support of Mr. F. J. Wallace, president of American Cystoscope Makers, Inc., Pelham Manor, New York, where the most recent work has been done, and from whom instruments may be obtained.

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A NEW CONCEPT OF CAPILLARY CIRCULATION IN BONE CORTEX

Some Clinical Applications

M. BROOKES
M.A., B.M. Oxon., D.L.O.
LECTURER IN ANATOMY, UNIVERSITY OF LIVERPOOL

A. C. ELKIN
M.B. Lond.
PHYSICIAN-IN-CHARGE, PHYSICAL MEDICINE, FINCHLEY MEMORIAL HOSPITAL, LONDON, N.12

R. G. HARRISON
M.A., D.M. Oxon.
DERBY PROFESSOR OF ANATOMY, UNIVERSITY OF LIVERPOOL

C. B. HEALD
C.B.E., M.D. Cantab., F.R.C.P.
CONSULTING PHYSICIAN, ROYAL FREE HOSPITAL, LONDON, W.

With illustrations on plate

ONE of us (Heald 1951) described an intensive study of 200 refractory cases of pain, of a type then called fibrositis. Many of these patients were treated by injection of oily solutions of salicylate deep into the muscles, sometimes by injections into the periosteum, and some by injection into the bony cortex. Because the late Dr. Laughton Hall had found that salicylate injections into the bony cortex were most effective, this technique was studied further by Mr. [illegible] Plewes and one of us (C. B. H.). The results were encouraging and encouraged further work.

A " spray-like effect " in muscles was discovered during these investigations. This is the name given to the radiological appearance following the injection of radiopaque oil into the neighbouring bone. Two of us (R. G. H. and M. B.) then began to investigate the anatomical background of this phenomenon; and we have been led to a new concept of the nature of circulation through bone cortex. Further work on treated cases was done by one of us (A. C. E.) in cases of painful-shoulder syndrome which had been resistant to other treatment. They were all cases of the supraspinatus-tendon rotator-cuff type, which had previously improved after injection into the bone of salicylic-acid preparation. By adding an equal amount of 'Hypaque' to the injection the track followed by the injection material could be studied. Continued clinical improvement was obtained in these patients.

Injection and Its Results

The injection consisted of 0·1% salicylic acid, 1% procaine, and 2% urea. To this was added an equal volume of hypaque. After the skin and periosteum had been anæsthetised with procaine, a special trocar needle was tapped into the cortex of the acromion process (fig. 1). This is not painful if the periosteum is infiltrated with 0·5% procaine.

The injection must be made into an area where there is direct attachment (not a tendinous insertion) of muscle-fibres to the periosteum. A radiograph was taken with the needle in situ, 2·5 ml. of the solution injected, and a further film

There is a sharp pain at the moment of injection, but this subsides almost at once. Surprisingly little force is needed to inject the solution. The position of the needle in the bone and the " spray effect " produced are shown in fig. 1.

The " spray effect " was most noticeable in younger subjects, and was less obvious in an older patient who had considerable sclerosis of the acromion process. In this series, the radiological appearances of the " spray effect " were identical with those produced in 1951.

The technique was repeated (R. G. H. and A. C. E.) on the body of a man aged 67, who had died only 6 hours before from carcinoma of the œsophagus. A mixture of hypaque and indian ink was used so that the result could be studied both radiologically and histologically; and observations were made on both acromion processes and the lateral epicondyles of the humeri.

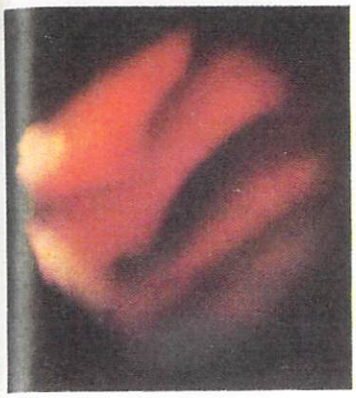
After confirming radiographically that a " spray effect " was obtained (figs. 2 and 3), the pieces of bone into which the injection had been made were removed together with a large part of the attached muscles, fixed, embedded in low-viscosity nitrocellulose, and a histological examination was made. Low-power microscopic investigation showed that the indian ink occupied the interfascicular spaces of the attached muscles in both cases (fig. 4). The needle had perforated the compactum of the acromion process, but not that of the lateral epicondyle. The diameter of the hole (fig. 5) was 0·3 mm., whereas the diameter of the needle was 1·0 mm. The indian ink had passed into the sinusoids of the cancellous bone in only a small quantity at both sites of injection, and had clearly not even had an opportunity of doing so in the lateral epicondyle.

In the acromion process the hole made by the point of the trocar of the injection needle was smaller than the orifice of its cannula, so hindering the passage of medium into the underlying bone. The path followed by the injection material was mostly from the orifice of the needle cannula into the periosteum, and from here into interfascicular spaces of adjoining muscle. The observed centrifugal spread of the injected

Fig. 4—Section through cortex (C) of acromion process and attached muscle (MM) of deltoid after injection of hypaque and indian ink.

This tissue was removed immediately after taking the radiograph in fig. 2. The site of perforation (P) of the compactum, and the filling of the interfascicular spaces of the deltoid by indian ink radiating from it, are clearly visible. Hæmatoxylin and eosin (× 3·5).

DR. HIRSCHOWITZ: ENDOSCOPIC EXAMINATION OF THE STOMACH AND DUODENAL CAP WITH THE FIBERSCOPE



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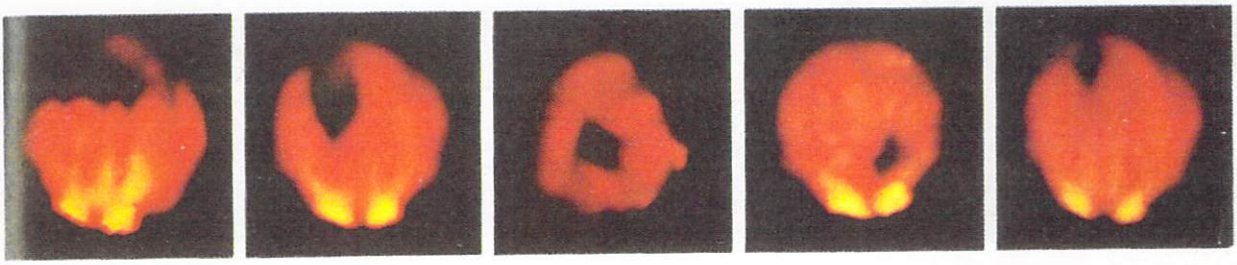

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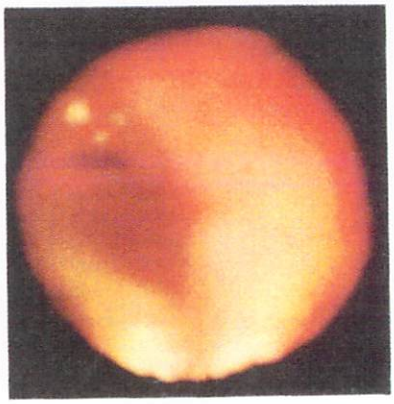

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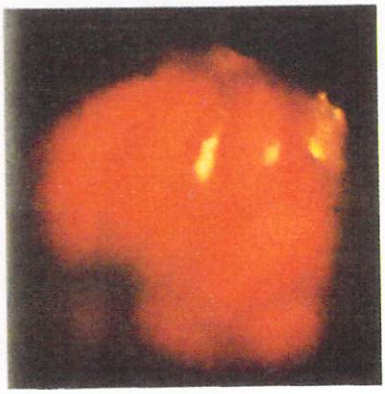

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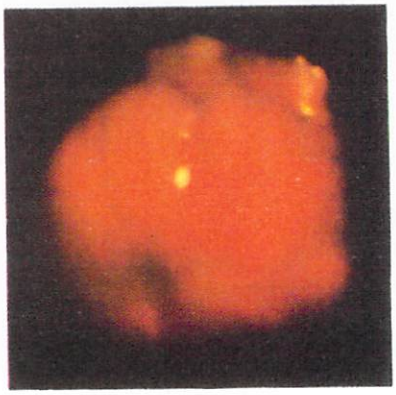

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