A new, tubeless radiological test for duodenogastric reflux

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Summary

As a modification of the double-contrast barium meal, a tubeless radiological test for duodenogastric reflux, not involving the administration of any pharmacologically active substances, is described. The procedure minimizes the possible occurrence of artefacts. It allows for the examination of duodenogastric reflux in relation to both duodenal and pyloric motility. Previously much emphasis has been laid on the role of duodenal contraction waves, but the results show that the dynamic state of the pyloric sphincteric cylinder may be of greater importance, as reflux only occurred while this structure was relaxed or partially contracted. The test can be used on a routine basis in pathological conditions (such as gastric ulceration) and may help to clarify some of the controversial aspects of duodenogastric reflux. The findings in 14 normal controls and in 100 patients are described.

Regurgitation of alkaline duodenal juice into the stomach has long been of interest. About 50 years ago it was assumed to be a normal, protective reaction in cases of gastric hyperacidity. The studies by Du Plessis1-3 and Lawson4 in this country tended to show the converse, namely that it might be damaging to the gastric mucosa. It was found that transpyloric duodenogastric reflux constituted one of the causes of chronic and atrophic gastritis, with an attendant decrease in gastric mucosal resistance to ulceration.2-4 Trans-stomal reflux after gastro-enterostomies caused a severe atrophic gastritis.3 Under experimental conditions in canines, duodenogastric reflux caused superficial gastritis, atrophic gastritis and epithelial proliferation with an increase in mitotic activity.4 The canine gastric mucosal barrier was destroyed by lysolecithin and phospholipase A, and if the human gastric mucosa behaved similarly, regurgitation of duodenal contents could be damaging.5 In guinea-pigs, lysolecithin produced gastric mucosal damage with macroscopic erosions, showing that reflux from the duodenum was an important factor in causing gastritis and gastric erosions.6 Bile salts caused a degradation of gastric mucus in pigs, thus damaging the protective layer on the luminal surface of the epithelium.6,8

Previous tests

Various tests have been devised to determine the ability of the keeper of the gate, the pylorus (from Greek: pyl = gate and ouros = guard), to prevent duodenogastric reflux. The concentration of bile acid conjugates in fasting gastric aspirates has long been used as a quantitative measure of duodenogastric reflux.2-11 Although it is a useful guide it has obvious limitations and may not always be satisfactory. Duodenogastric regurgitation may result simply from the presence of an indwelling gastric tube itself.12 A radiological test was devised by Capper et al.12 By threading a thin-bore soft rubber tube through the pylorus, gastrografin was injected directly into the lumen of the duodenum. (Rigid plastic tubes were unsuitable as their stiffness interfered with the normal sphincteric action and rendered the pylorus incompetent.) With the tube in situ, and with no contrast medium in the stomach, reflux could be observed on the radiological TV monitor, being categorized as minimal, moderate or gross. Special attention was paid to the relationship of reflux to duodenal contraction waves.

In his investigations, Grech13 used Capper's test with minor modifications. Keighley et al.14 employed a further modification. After injection of 20 ml dilute barium suspension into the duodenum through the transpyloric tube, the tube was withdrawn, followed by 3 minutes of radiographic screening to observe whether reflux was present.

Using a radioactive test, Rhodes et al.15 injected a dose of 14C-tagged bile salts intravenously. The concentration of secreted radioactive bile salts in aspirated gastric juice was measured, this value serving as an index of duodenal regurgitation. In Wormsley's test16 an indicator substance (polyethylene glycol) was injected into the duodenum, followed by aspiration of gastric juice. This entailed the use of both an intragastric and an intraduodenal tube.

Kim et al.17 and Keighley et al.14 pointed out that the diagnosis of reflux alkaline gastritis could be made by a combination of gastric analysis, gastroscopy and biopsy. Reflux was present endoscopically, according to Hooare et al.,11 if there was a pool of bile in the stomach or if reflux occurred throughout the examination. It was acknowledged that the presence of a duodenal tube or gastroscope might lead to reflux. Previously, Flint and Grech14 had stated that gastroscopy was not a satisfactory method of assessing pyloric reflux when vaga blocking drugs were used. Connell12 stated that endoscopy in itself had marked effects on gastro-intestinal motility, and implied that it was not satisfactory for assessing pyloric reflux.

More recently, sophisticated electrical pacing techniques have been used experimentally. Kelly and Code18 examined duodenogastric reflux in canines, in which pacing from a site in the distal duodenum reversed the direction of the pacesetter potential from aborad to orad, reversing the direction of propagation of duodenal contents, and resulting in duodenogastric reflux. Clinically, Valenzuela and Defilippi10 used manometric techniques for direct measurement of pyloric sphincter pressures. This entailed the presence of polyvinyl catheters through the pylorus. By the combined use of duodenal marker perfusion and miniature intraluminal strain gauge transducers, Rees et al.21 determined the relationship between antroduodenal motor activity, duodenogastric reflux and gastric

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had stated previously that even the nausea felt by most
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slight duodenogastric reflux is
1. The duodenal bulb Is filled with barium while the pyloric sphincteric
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emptying. While these refined techniques have yielded valuable
data, there remains the lingering suspicion that the presence of
gastric or transpyloric tubes might have influenced the results.
Cole22 reiterated that tube studies could impair the normal
closing mechanism of the pylorus.
Recently, a new radioactive test was described by Nicolai et
al.24 Following the intravenous administration of 99m Tc-labelled
diethyl-IDA, which is completely secreted into the bile, the
tracer was aspirated from the stomach through a double-lumen
nasogastric tube, thus allowing quantification of reflux. The test
also involved the intravenous injection of cholecystokinin to
produce gallbladder contraction, with constriction of the pylorus
as a side-effect.

Method
As a modification of the double-contrast barium meal we have
developed the following radiological test, which does not entail
the use of catheters, intubation or medication, for
duodenogastric reflux.
The patient, standing behind the radiological TV monitor
after a 12-hour overnight fast, is instructed to swallow 4 - 5
mouthfuls of a micropulverized barium suspension, e.g.
Micropaque (Adcock-Ingram; Johannesburg) ordinarily used
for barium meals. Immediately afterwards a gas-producing
agent is swallowed, e.g. 2 × 50 Gastrast tablets (i.e. 100 tablets)
(Toho Kagaku Kenyusho; Tokyo), followed by 2 mouthfuls of
water containing a few drops of Telament liquid (Adcock-
Ingram; Johannesburg). The barium accumulates in the lower
part of the stomach while the gas distends the fornix. While the
patient is instructed not to eructate, the table is immediately
tilted into the horizontal position. With the arms abducted
throughout the examination, the supine subject is now rotated
into the left anterior oblique position (right side down), till
barium enters the duodenal bulb. As soon as duodenal filling is
achieved, the subject is rotated rapidly through 90° into the right
anterior oblique position. This causes the remaining barium in
the stomach to descend into the fornix, while the gas is displaced
and ascends into the pyloric region, which now constitutes the
uppermost part of the stomach. Consequently the first part of the
duodenum is filled with barium, while the pyloric region up to
the ring is filled with gas (Fig. 1). The competence of the pylorus
can now be studied, radiographs being taken for record
purposes. Duodenogastric reflux through the pylorus into the
gas-containing part of the gastric lumen is clearly visible (Fig. 2).
(Thus should not be confused with the normal oral movement of
barium often seen during contraction of the terminal antrum.)
Should no reflux be observed, or should the duodenum empty,
the rotating movements are repeated. Generally speaking,
the manoeuvre is repeated 4 - 5 times for each test. In the
right anterior oblique position the second part of the duodenum
may easily be compressed by the gloved hand, so that the effect of
duodenal compression can also be studied.

Results
Is the pylorus normally competent, i.e. does it always prevent
reflux? According to Du Plessis,2 slight duodenogastric reflux is
a normal occurrence. Capper et al.12 found no reflux in 15 normal
controls, while it occurred in 1 out of 12 normal subjects in Flint
and Grech’s18 series. Nevertheless, these authors were of the
opinion that the pylorus was normally competent. Rovelstad21

Fig. 2. The arrow denotes reflux of barium from the duodenum into the
pyloric sphincteric cylinder, which is relaxed.

The main advantages of this method appear to be that no
medication (e.g. anticholinergics) is administered, thus allowing
the study of pyloric competence in the absence of
pharmacological modification. There is no gastric intubation
(thus eliminating nausea) and the pylorus is not traversed by a
tube (or has been traversed immediately before observation, as in
the test of Keighley et al.14). The competence of the pylorus can
be studied in relation to both duodenal contraction waves and
motility of the adjacent prepyloric gastric segment ('pyloric
sphincteric cylinder' or 'canalis egestorius'). Little attention has
been paid to the latter in previous investigations. The test is
quick and simple to perform, and may be followed by a
'conventional' barium meal to exclude macroscopic organic
lesions in the upper gastro-intestinal tract. Radiation to the
patient is minimal, since a small (11 × 8 cm), localized aperture is
used, not more than two 11 × 8 cm film-exposures are needed,
and screening time generally does not exceed 90 - 120 seconds.

The disadvantages are that in a minority of patients,
depending on the direction of the pyloroduodenal axis, it may
not be possible to obtain a side view of the duodenum and
pylorus, the barium-filled bulb being projected over the pyloric
aperture. Secondly, because of technical factors, a double-
contrast meal to demonstrate the areae gastricae is not possible at
the same time. Lastly, the examination is performed in the
supine position only.

Fig. 1. The duodenal bulb is filled with barium while the pyloric sphincteric
cylinder is gas-filled.
stated that it was debatable whether duodenogastric reflux was a normal phenomenon, while Donovan et al.\textsuperscript{24} found no reflux in normal controls. On the other hand, Nicolai et al.\textsuperscript{24} demonstrated a median reflux of 4.3% of the intravenously injected dose in controls.

Normal subjects
The test was performed on 14 informed, volunteer, asymptomatic male medical students between the ages of 23 and 27 years. In 9 of the 14 subjects no duodenogastric reflux occurred. In 2 subjects there was minimal reflux, occurring on one occasion only (three further ‘rotating manoeuvres’ failing to elicit reflux). In 3 subjects moderate reflux occurred. In each it was seen two to three times during four ‘manoeuvres’. In 1 of these subjects a repeat test a week later gave the same results.

**Duodenal motility:** In all normal subjects the duodenum emptied normally. In all there also occurred some degree of spontaneous retrograde movement of barium, which appeared to result from contraction waves in the third part of the duodenum, at times forcing some barium in an oral direction as far as the bulb. In all subjects the second part of the duodenum was compressed to a certain extent with the gloved hand. This did not occlude the lumen completely, did not prevent aboral movement, and did not initiate retrograde movement.

**Pyloric motility:** Adhering to the anatomy as described by Cunningham,\textsuperscript{26} Forsell\textsuperscript{27} and Torgersen,\textsuperscript{28} the pyloric ring was considered to be the terminal annular thickening of the pyloric sphincter cylinder (‘canalis egestorius’). The cylinder, which is 3 - 4 cm in length, was seen to contract in the normal, segmental (as opposed to ‘peristaltic’) way, as documented previously.\textsuperscript{29} As the ring forms an inherent part of the cylinder, it closes and opens with contraction and relaxation of the cylinder respectively.\textsuperscript{30} In all subjects these contractions were normal. Reflux in the 5 subjects occurred either during full relaxation of the sphincteric cylinder, or when it was in a state of partial contraction — never during full contraction.

**Patients**
The test was performed on 100 patients between the ages of 18 and 79 years, who were referred for barium meal investigation because of upper gastro-intestinal symptoms.

**No lesion detected:** In 48 patients no macroscopic organic lesion could be demonstrated in the upper gastro-intestinal tract. Of these, 18 (± 37%) had minimal-to-moderate duodenogastric reflux. In all cases reflux occurred during those stages of the pyloric cycle when the pyloric sphincteric cylinder was relaxed (Fig. 2) or partially contracted (Fig. 3), and never during full, ‘systolic’ contraction.

**Duodenal ulceration:** Du Plessis\textsuperscript{3} stated that in some cases of duodenal ulceration, reflux was excessive. Capper et al.\textsuperscript{12} found moderate or gross reflux in 33% of duodenal ulcer cases. Donovan et al.\textsuperscript{25} in 24%, while Valenzuela and Defilippi\textsuperscript{10} stated that the incidence of reflux in patients with duodenal ulceration was not significantly different from that in controls. Out of 7 cases Nicolai et al.\textsuperscript{24} found increased reflux in only 2, in which pyloric deformity was also present.

In our series there were 25 cases of active duodenal ulceration or duodenal deformity typical of ulceration, 18 (i.e. approximately 72%) showing moderate duodenogastric reflux.

**Gastric ulceration:** According to Du Plessis\textsuperscript{2} the concentration of bile acid conjugates in fasting gastric aspirates was abnormally high in cases of gastric ulceration. Capper et al.\textsuperscript{12} found moderate or gross reflux in 66% of gastric ulceration patients, while Rhodes et al.\textsuperscript{13} and Delaney et al.\textsuperscript{11} mentioned an increased incidence of bile reflux in patients with gastric ulceration. Flint and Grech\textsuperscript{10} stated that the pylorus was incompetent in gastric ulceration and chronic alcoholic gastritis, while the results of Valenzuela and Defilippi\textsuperscript{10} suggested pyloric sphincter incompetence in gastric ulceration. Nicolai et al.\textsuperscript{24} found increased reflux in 18 gastric ulcer cases.

In our series there were 9 cases of benign ulcer on the gastric lesser curvature, 7 showing moderate reflux. In one case, with the ulcer on the gastric lesser curvature close to the pylorus (Carman-type ulcer), there was moderate-to-marked reflux. In the second case, with the ulcer at the incisura angularis, no reflux was seen.

**Sliding hiatus hernia with gastro-oesophageal reflux:** Donovan et al.\textsuperscript{25} found duodenogastric reflux in 35% of patients with hiatus hernia. In 10 cases Nicolai et al.\textsuperscript{24} did not find increased reflux. There were 9 cases in the present series, 4 showing reflux of duodenal contents (these being cases with a potential for biliary oesophagitis).

**Combined lesions:** In the present series 7 cases had combined lesions, e.g. duodenal ulceration and hiatus hernia. Most of these showed reflux. In one case diagnosed radiologically and endoscopically as antral gastritis and spasm with a deformed duodenal bulb, a long spastic pyloric segment was seen (Fig. 4), associated with moderate-to-marked duodenogastric reflux.

**Duodenal motility:** In the last 40 patients of the series, special attention was given to duodenal motility. In 82% of these the aboral and oral movements of intraluminal barium were identical to those in normal controls. In 18% no oral movement of contrast was seen in the second and third parts of the duodenum, yet in half of these cases duodenogastric reflux occurred. One’s impression is that natural duodenal movements are probably of little consequence in the mechanism of reflux. (By experimentally reversing the pacesetter potential in the duodenum in canines by electrical stimulation, Kelly and Code\textsuperscript{20} did produce reflux.)

**Pyloric motility:** As in normal controls, reflux in patients only occurred while the pyloric sphincteric cylinder was either relaxed or in a state of partial contraction. Partial contraction, depending on its permanence, may be indistinguishable from spasm of the pyloric cylinder and denotes a type of pyloric dysfunction. Conversely, ‘sluggish’ or ‘diminished’ peristalsis causes a relaxed sphincteric cylinder. In both instances one’s visual impression of the TV image is that the amplitude of contraction is lessened. As the pyloric ring forms part of the...
cylinder it fails to contract fully in these instances, i.e. it fails to close the pyloric aperture.

Discussion

A new, tubeless radiological test shows that minimal-to-moderate duodenogastric reflux occurred in 5 out of 14 normal subjects, and in 18 out of 48 patients with no radiologically demonstrable organic disease in the upper gastro-intestinal tract. One concludes that the pylorus is not always fully competent normally. This is at variance with the majority view, which holds that the pylorus is normally competent, but confirms the original postulate of Du Plessis\(^2\) that slight duodenogastric reflux is a normal occurrence. On the other hand, quoted experimental evidence can leave no doubt that excessive duodenogastric reflux is damaging to the gastric mucosa.

Of 25 duodenal ulcer cases, moderate duodenogastric reflux was shown in 18, which is a surprisingly high incidence. In relation to gastric ulceration, most authors mentioned increased reflux. In the present series 7 out of 9 benign gastric ulcer cases showed reflux.

With the present test artefacts are excluded to a large extent as there is no need for gastric tubes (which may cause nausea) or catheters through the pylorus, neither does it involve the administration of pharmacologically active substances, which may influence motility profoundly. Whereas previously much attention has been paid to duodenal motility as a factor in the mechanism of reflux, it now appears as if the dynamic state of the pylorus may be of greater significance. Duodenogastric reflux is interpreted in relation to the concept of an anatomical sphincteric cylinder at the pylorus. Reflux occurred, both in normal controls and in patients, only during those stages of the pyloric cycle when the sphincteric cylinder was relaxed or while it was in a state of partial contraction.

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