Objective: In an attempt to estimate the incidence and severity of the functional and mechanical problems associated with colon interposition for benign oesophageal disease, a retrospective analysis of a single centre experience was undertaken. Methods: Between 1961 and 1990, a total of 365 patients who survived the postoperative stay in hospital were followed up over 7–38 years and form the basis for this study. Upper gastro intestinal symptoms in these patients were investigated clinically, radiologically, endoscopically and in the oesophageal laboratory. Mechanical and functional abnormalities requiring surgical intervention for relief of symptoms were documented. Results: There were two late presentations of colo bronchial fistulae, two instances of persistent colo cutaneous fistulae, three cases of diaphragmatic herniation and two adenocarcinomata of the colo gastric junction in the patients with short segment colon interposition. Amongst the long segment colon interposition patients there was one hiatal obstruction, two thoracic inlet delays associated with pseudo diverticulosis and one hiatal obstruction. One other patient presented with an adenocarcinoma of the intrathoracic colon. There were four patients requiring revision of the cervical oesophago colic anastomosis, two of them on recurrent occasions. The remaining sequelae were functional and were associated with increasing redundancy of the colonic segments at different levels. There were 17 such patients, two of whom developed significant redundancy at two different levels. Conclusions: Although the patients with short segment colon interposition developed predominantly avoidable iatrogenic complications, those undergoing long segment colon interposition developed functional sequelae requiring re-operations in later life. © 1999 Elsevier Science B.V. All rights reserved.

Keywords: Colon interposition-sequelae; Benign oesophageal disease

1. Introduction

Since the beginning of this century the colon has proved to be an organ suitable for part or total replacement of the oesophagus [1–5]. Although the feasibility of this technique with safety and low operative mortality has been established, functional sequelae have been sporadically reported in the surgical literature [6,7]. Physical development and growth of children who had undergone oesophageal replacement with colon for atresia have been observed to lag behind the normal [8]. We retrospectively reviewed the incidence and nature of the sequelae in our patients operated upon in one thoracic surgical department.

2. Methods and materials

One hundred and seventy three adults and 212 children who survived the immediate postoperative hospital stay after colon interposition formed the basis of this study. Sixty nine of these patients had undergone a sub-total replacement of the oesophagus with a long isoperistaltic segment of left hemicolon based on the left colic vessels. In a long segment colon interposition, the segment of colon was inserted proximally to the remnant of the cervical oesophagus after trimming the edges of the cervical oesophageal anastomosis, two of them on recurrent occasions. The remaining sequelae were functional and were associated with increasing redundancy of the colonic segments at different levels. There were 17 such patients, two of whom developed significant redundancy at two different levels.
stomach low down on its body, the colon being positioned in the posterior mediastinum and passing through the oesophageal hiatus in the diaphragm. Two hundred and ninety six had undergone a short segment colon interposition for replacement of the lower oesophagus with either the transverse colon based on a middle colic vasculature, or more frequently the splenic flexure based on the upper left colic vessels. A short segment colon interposition extends from the sub-aortic level where it is anatomized to the cut end of the thoracic oesophagus down to the posterior surface of the stomach low on the body. The details of the technique of reconstruction of the oesophagus with colon in benign disease has been previously described by the authors [5,9] (Tables 1 and 2).

All 365 of these patients were reviewed at regular intervals – after 6 weeks, 3 months, 6 monthly and then annually after 12 months and 2 years after 5 years. Upper gastrointestinal symptoms at review were investigated clinically, radiologically with barium studies, endoscopically with oesophagogastroscopy, and in the oesophageal laboratory with ambulatory manometry and pHmetry. Mechanical and functional sequelae requiring surgical intervention for release of symptoms were documented for this analysis.

3. Results

Of the 296 short segment colon interpositions, the sequelae encountered were iatrogenic in five instances. These were two patients with transhiatal herniation of abdominal viscera, 3 and 10 years after surgery. One other patient presented with an incisional herniation of abdominal viscera through a peripheral incision in the diaphragm 2 years after the original surgery. All three patients had been operated in the early years of this series and had experienced vague abdominal symptoms for some months prior to presentation.

Two patients had persistent colo cutaneous fistulae requiring excision of the tracts and two others developed respiratory tract symptoms 2 and 14 years after short segment interposition, and investigations revealed colo bronchial fistulae at the level of the oesophago-colic anastomosis. These required surgery for excision of the tract. Neoplastic transformation of the colo gastric junction was diagnosed in two patients, 14 and 17 years after the original surgery. Both proved to be unresectable and required palliative endoprosthesis (Table 3).

Table 1
The indications for colon interposition in this series of benign oesophageal disease

<table>
<thead>
<tr>
<th>Condition</th>
<th>Duration</th>
<th>Type of Colon Interposition</th>
</tr>
</thead>
<tbody>
<tr>
<td>Congenital atresia</td>
<td>2-5 years</td>
<td>Long segment colon</td>
</tr>
<tr>
<td>Corrosive strictures</td>
<td>5-13 years</td>
<td>Short segment colon</td>
</tr>
<tr>
<td>Recurrent Hiatal herniation</td>
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4. Discussion

Whilst the majority of the delayed sequelae following

Table 2
The age distribution in relation to the aetiology and the extent of colon interposition in the original reconstruction

<table>
<thead>
<tr>
<th>Condition</th>
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<tr>
<td>Children</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Congenital atresia</td>
<td>2-5 years</td>
<td>Long segment colon</td>
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<tr>
<td>Recurrent Hiatal herniation</td>
<td>5-13 years</td>
<td>Short segment colon</td>
</tr>
<tr>
<td>Adults</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Corrosive strictures</td>
<td>13-70+ years</td>
<td>Long segment colon</td>
</tr>
<tr>
<td>Recurrent Hiatal and peptic strictures</td>
<td>13-70+ years</td>
<td>Short segment colon</td>
</tr>
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Of the 69 long segment interpositions, anastomotic strictures at the oesophago-colic site occurred in four patients, two of whom recurred after surgery and needed further revision, and at the colo gastric level in seven patients (Fig. 1). There were two patients who developed thoracic inlet delay, requiring surgery to release band-like adhesions. One patient developed an adenocarcinoma in the intrathoracic colon. The remaining but more frequent sequelae, were associated with functional changes occurring in the colon at various levels and giving rise to ‘mechanical’ obstructive symptoms, requiring surgical intervention. Four patients developed supra-aortic redundancy (Fig. 1) of such severity as to be persistently symptomatic and required resection and reconstruction. Similarly, 11 patients needed surgery for supra-diaphragmatic redundancy (Fig. 2), in two of whom earlier attempts at reduction and fixation had failed. One patient developed a recurrence of redundancy requiring surgery. Sub-diaphragmatic redundancy causing symptoms needed surgery in seven patients, four of whom had colo-gastric diversion and three resection and re-anastomosis. Symptomatic improvement in this group of patients was never complete (Table 4). Chronic peptic ulceration with massive haemorrhage was encountered in one patient who had the redundant segment, bearing the ulcer, resected. Stenosis of the colo gastric diversion required revisional surgery in seven patients.

4. Discussion

Whilst the majority of the delayed sequelae following
short segment colon interposition are iatrogenic and therefore avoidable, the occurrence of neoplastic changes in the colon and cologastric junction are predictable. In contrast, the sequelae following long segment colon interposition are predominantly those of ischaemic stenosis of the anastomotic sites, and functional problems related to changes in the long segment colon transposed to the posterior mediastinum and left hemithorax (Fig. 3).

When the left hemicolon is mobilized on the left colic vasculature for an isoperistaltic transposition, the colonic visceral length far outstretches the length of the vascular pedicle. Whilst the vascular mesocolon remains in the posterior mediastinum as a tort sheet, the colon assumes a tortuous convoluted shape in the thorax and neck. The cervical anastomosis is far remote from the source of the vessel and is therefore liable to stricture formation, even if immediate postoperative anastomotic sub-clinical leak problems are overcome by drainage of the cervical tissues. Four of the 69 patients who underwent long segment colon interposition, presented with delayed cervical oesophago-colic anastomotic strictures and two of them required revision of the stenosis twice and still require endoscopic dilations. The colon, being a thin-walled hollow viscous, responds to the negative intrathoracic pressure by passively dilating above any potential obstructing anatomical land marks. These occur at the cervical inlet at the aortic arch level, the crossing of the descending aorta and of the hiatus in the diaphragm. With increasing age the colon appears to elongate as well as dilate in this new environment. The disproportion of the colonic length to the vascular pedicle length renders the dilation and tortuosity more likely as is demonstrated in the 15 patients requiring 17 procedures to correct increasing symptomatic redundancy several years after the original procedure. In addition, such attenuation of blood supply may account not only for early anastomotic necrosis but also for the delayed strictures at the cervical (proximal) anastomosis. Ahmed and Spitz [7], in studying the outcome of colonic replacement of the oesophagus in 112 children over a 30 year period had an operative mortality of 15,
proximal oesophago-colic leakage in 54 (48.2%), with strictures developing in 34 of them (30.3%) and the need for revision of the oesophago-colic anastomosis in 20 of these 34. In their series, the clinical outcome, however, was graded as excellent in 43 of the 77 survivors (56%). Similarly excellent results have also been reported by German [8] and by Pampeo et al. [10]. In a multivariate analysis of 50 patients undergoing colon interposition for a variety of indications, Thomas et al. [11] concluded that the single independent predictor of a good functional result was the placement of the colon in the posterior mediastinum.

Objective functional evaluation of the results of colon interposition for a variety of indications have been carried out with manometry, using a fluid filled system by Benages et al. [12]. The presence of segmental contractions prompted these authors to conclude that these can propel the contents of the colon into the stomach. Moreno-Ossett et al. [13] in the same institution comparing an isoperistaltic tube of stomach, jejunum and of colon as oesophageal substitutes, concluded that the steady, homogenous colonic responses contributed an active role in the transit of the food bolus. Using a similar fluid filled system combined with pH metry, Isolauri et al. [14] considered the rarity of reflux of acid from the stomach into the colon as being the result of the vagotomy associated with the surgery and the availability of colonic alkaline mucus. Peppas et al. [15], employing ambulatory manometry and pH metry in 14 patients with colon interpositions, confirmed the earlier observations by Narducci et al. [16], who documented colonic motility patterns in the normal abdominal environment. In addition to the three main types of contractions, synchronous, sequential and segmental, five sub-types were observed based on the amplitude of contractions. It was also noted that some of the patients with over 10 years follow-up, showed a type of contraction with a high amplitude and long duration associated with a probable obstructive effect of the diaphragmatic oesophageal hiatus. Radionuclide studies of transposed colonic segments have not entirely been helpful in evaluating patients in the long-term. Isolauri et al. [17] noted that colonic transit was slower than in the normal oesophagus, with no discernible difference between isoperistaltic and anti-peristaltic interpositions. This last observation is not borne out by the accumulated experience of the vast majority of institutions.

5. Conclusion

The colon has proved to be a useful organ for replacement of the oesophagus in benign oesophageal disease. Whilst the short segment of colon has been found to be an excellent substitute both functionally and in the rarity of the need for revisional surgery, the long segment of colon for total replacement has its problems, both mechanical and functional. These are partly attributable to the anatomic configuration of the long segment in relation to its vascular pedicle, and partly to the new intrathoracic negative pressure environment it finds itself in. Functionally, the slow segmental contractions noted in ambulatory manometry may be contributory to the propagation of the food bolus. These being inherently sluggish, are responsible for some of the vague...
symptoms in the short- and long-term follow-up of these patients.

References


Appendix A. Conference discussion

Dr T. Lerut (Leuven, Belgium): I think, in the long segment colon interposition, there are, as far as the pouch formation and the redundancy problem concerns probably two different mechanisms responsible. The majority of those long segments were done for esophageal atresia cases and I suspect that the lower part of the redundancy is probably much more related, to the technique, where it all comes down to measuring exactly the length you need. However, in the upper pouch formation, I think it’s much more related to the underlying pathophysiology of the atresia. As you have an atretic segment, i.e. absence of the formation of the complete esophagus, you need at the time of coloplasty to create an artificial passage through the thoracic inlet. Also, in my own experience, when I came back from Bristol, I’ve had to do a couple of revisional surgeries as well, because this inlet sometimes, for an unknown reason, probably due to scar tissue formation, gets narrow again with pouch formation above the stenosis and you need to widen it up again to solve the problem. I think that this pouch formation results from different mechanism than the redundancy phenomenon. Also, I suspect that whatever viscous (and it is not specific to the colon) if you are going to use the posterior mediastinal route, you will have to deal with this problem because of this artificial creation of a passage through the thoracic inlet.

Mr Jeyasingham: As you know, Professor Lerut is a co-author of this paper and I agree entirely with what he said. One has to accept that these colonic interpositions in the long segment were applied in those situations where there was no other alternative, except perhaps small bowel. One might say ‘Why didn’t you bring up the stomach?’, but in children, one prefers not to displace the stomach into an abnormal situation, not knowing what the long-term consequences are.

The colon, in the short segment, however, is an excellent substitute. In addition, it acts as an antireflux mechanism, which is the purpose of doing what the long-term consequences are. Mr T. Lerut

Secondly, with the sluggish movements of the colon, overcoming obstruction is difficult. Therefore, as is usual in any bowel situation, it tends to either dilate or contort itself proximal to obstruction. And that happens afterwards is, firstly, the fact that the colon is now placed in an intrathoracic, negative-pressure atmosphere. It is a thin-wall viscous, and therefore will dilate automatically subjected to a negative pressure.

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do you perform on the neck to avoid these strictures or salivary fistulas?

Secondly, in our practice, a serious problem is the reflux through the gastric anastomosis in the interposed colon. This is the reason that for the last 10 years we have performed a kind of valve anastomosis between the colon and the stomach in children and in most adults. Do you have such experience?

Mr Jeyasingham: The upper anastomosis is end-to-end, single layer, and in the earlier series it was entirely with stainless steel wire. Recently, of course, we have been using Vicryl. The lower anastomosis, as you saw in the pictures, on the initial two pictures, the colon is brought retrogastric, lower down on the posterior aspect of the stomach, and that acts as an antireflux mechanism to a great extent. Also, the opening is as large as one needs to do with the circumference of the colon, no larger. We always accompany it with a pyloroplasty.