

Reconstruction of the oesophagus

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Introduction

In 1935 Tudor Edwards performed a total transthoracic oesophagectomy on a woman of 57, for a carcinoma of the lower third. Under spinal anaesthesia, supplemented by oxygen administered by a face mask, the resection was performed through a left thoracotomy in the sixth interspace and was completed in two hours. No blood transfusion was given during the operation but the patient received one unit later. The patient, left with a gastrostomy and cervical oesophagostomy and made an uneventful recovery. Continuity was restored with only partial success by an external rubber prosthesis. Tudor Edwards' plan to construct later an antethoracic skin tube was frustrated by the death of the patient from metastases seven months later.

Tudor Edwards was ahead of current surgical practice on three counts. First, his advocacy of total oesophagectomy irrespective of the location of the tumour. Second, his refusal to attempt to restore continuity by an intrathoracic oesophago-gastric anastomosis in view of the unacceptable operative mortality following this procedure reported by other surgeons. Third, his insistence on the elimination of all oral and dental sepsis prior to operation. In his report of this case Tudor Edwards discussed 'blind' oesophagectomy as advocated by Denk and later by Gray Turner only to condemn the procedure as a retrograde step akin to blind prostatectomy. Had Tudor Edwards survived to this day he would have observed further cogent reasons for a similar condemnation.

In 1935 the only techniques available for oesophageal reconstruction following resection, usually for malignant tumours, were by intrathoracic oesophagogastronomy or by an antethoracic jejunal transplant combined with a skin tube. Attempts to relieve the obstruction caused by undilatable benign strictures were confined to bypass procedures by similar techniques. Attempts to devise inert prostheses for the restoration of continuity all ended in disaster.

The relief of malignant or benign obstruction presents two quite distinct problems. Following resection of malignant tumours the object of reconstruction is short term palliation as few patients will survive for more than two years. Intrathoracic oesophagogastronomy may be justified. Reconstruction for benign lesions demands satisfactory long term functional results that restore permanently the patients' ability to eat and drink with pleasure and satisfaction. The stress is on the late results of surgery and this is the problem under consideration.

The technical problems presented by reconstruction following resection, and bypass procedures with no resection of the primary lesion, are similar.

INDICATIONS FOR RESECTION OF BENIGN LESIONS

Corrosive strictures risk of subsequent malignancy.
Barrett's oesophagus complicated by peptic stenosis; high incidence of malignancy in the gastric lined oesophagus.

Based on the Tudor Edwards Memorial Lecture given at the Royal College of Surgeons on September 22, 1982

Recurring haemorrhage and anaemia complicating ulcerative peptic stenosis where no antireflux procedure has succeeded.
Type 11 congenital oesophageal atresia where a major portion of the organ is absent and resection of the remaining lower segment is indicated owing to vulnerability to subsequent reflux oesophagitis.

Undilatable benign lesions where bypass would leave an extensive blind oesophageal diverticulum with the attendant risk of aspiration pneumonitis.

Persisting fistulae between the oesophagus and adjacent viscera.

The direct transmediastinal route presented by resection carries a lower risk of necrosis of transplanted viscera due to mechanical obstruction of the vascular pedicle.

Uncertainty regarding the diagnosis of the pathology of an oesophageal stricture and the difficulty of ruling out malignancy on endoscopic biopsy evidence alone.

INDICATIONS FOR BYPASS WITHOUT RESECTION OF OBSTRUCTIVE BENIGN LESIONS

1. Cases where the obstruction is incomplete and non-progressive but does not respond satisfactorily to dilatation.
2. Extensive chronic mediastinitis resulting from instrumental ruptures and perforations complicating attempted dilatation. Unless previously ruptured, corrosive strictures are commonly easier to resect than peptic strictures owing to the absence of peri-oesophagitis.
3. Previous failed attempts to resect and reconstruct the oesophagus.

During the last three decades the surgical approach to reconstructive surgery for benign lesions has become far more critical in terms of the late functional results. Operative morbidity and mortality have been reduced to an acceptable level in centres specialising in this problem.

INDICATIONS FOR RECONSTRUCTION

Undilatable strictures.

Extensive inflammatory strictures where mural fibrosis has eliminated all propulsive functional activity, where dilatation, even when possible, fails to relieve the dysphagia.

Recurring chronic peptic stenosing oesophagitis following multiple failed antireflux procedures.

Certain gross junctional disorders where more conservative measures have failed to restore normal swallowing ability.

The term 'undilatable stricture' calls for exemplification: where perforation or rupture has already occurred during previous attempts at instrumental dilatation; where the passage of any dilator is technically impossible without the use of unreasonable and dangerous aggression; where dilatation although possible fails to restore acceptable relief of the dysphagia; geographical factors; where dilatation is technically difficult in the hands of an experienced operator familiar with the patient and his stricture and where emergency endoscopy for acute obstruction might be necessary when the patient is travelling abroad.

The main relative indication for reconstruction is the

ability of a surgeon experienced in this field to guarantee an improved functional result, compared with the predictable results of less dramatic procedures, with no increased risk to the patient.

ALTERNATIVES TO RECONSTRUCTIVE OR BYPASS SURGERY

In certain cases of short dilatable strictures secondary to chronic peptic oesophagitis the Collis gastroplasty combined with some form of antireflux fundoplication, as in the Pearson operation, may be employed as a satisfactory alternative. The stricture is left in situ and further dilatation may be necessary. Unfortunately a negative endoscopic biopsy examination does not exclude the presence of malignancy with any degree of certainty. Advocates of this technique admit the possibility of leaving a malignant stricture in situ. The procedure is not without risk and Orringer has reported an impressive list of complications following this technique. The other alternative programme is repeated dilatation, with its attendant risks and frequently inadequate symptomatic relief. In the management of other benign obstructive lesions, corrosive, traumatic, postoperative, strictures, congenital defects, and extensive benign tumours, there are no satisfactory alternatives to recotraction or bypass.

Criteria for an acceptable technique for reconstruction or bypass

1. Complete and permanent relief of dysphagia, with no side effects or late sequelae.
2. Acceptable operative morbidity and mortality, not above 5%.
3. Applicable to infants and children.
4. Must permit replacement of the entire oesophagus when indicated.
5. Should permit synchronous resection and reconstruction in a single stage procedure.
6. Communication; the technique must be teachable to the trainee surgeon of average technical ability.

Antethoracic skin tubes are no longer necessary and have been abandoned. Attempts to devise inert, synthetic, prostheses with which to restore continuity have inevitably ended in disaster. There are currently practiced a number of techniques which will be reviewed in the light of the six criteria listed above.

END-TO-END OESOPHAGO-OESOPHAGOSTOMY

Reanastomosis following resection of short strictures may appeal to the conservative surgeon. However, even local resections result in greater shortening than anticipated and the tension caused by reanastomosis frequently disrupts the precarious antireflux mechanism at the cardia and creates reflux. An attempt to conserve as much normal oesophagus as possible is commendable but this technique is justifiable only in the management of very short strictures such as those resulting from epidermolysis bullosa in the cervical oesophagus, and the operator should be prepared to perform a synchronous anti-reflux procedure to prevent future complications.

INTRATHORACIC OESOPHAGOGASTROSTOMY

Historically this was the first true internal reconstruction to be attempted. During the last three decades there has emerged increasing disillusionment with both the early and late results of this technique. The postoperative mortality rate is higher than that following any other technique, chiefly from anastomotic leaks and acute fulminating aspiration pneumonia. The death rate following a leak is 50% or higher. The only method for salvaging the patient in this desperate situation, with a reasonable chance of success, is to abandon the reconstruction, return the stomach to the abdomen, exteriorise the remainder of the oesophagus, and establish a cervical oesophagostomy for drainage of saliva and a feeding gastrostomy. If the patient survives, a further reconstruction by an alternative method can be attempted at

a later date when the septic complications have been controlled.

Late complications following intrathoracic oesophagogastrostomy

1. Recurrent reflux, peptic oesophagitis above the anastomosis, recurrent fibrous stenosis.
2. Type II hiatal hernia syndrome with recurring haemorrhage, anaemia, occasionally torsion, and perforation of the intrathoracic stomach.
3. Nutritional and growth problems in children.

A 30% incidence of recurrent peptic stenosis has proved the main reason for abandoning this technique in the management of benign obstruction. Numerous attempts have been made to devise valvular anastomoses, mainly by ink-well invagination procedures, to prevent postoperative reflux, but there is no convincing evidence that any of these attempts has any lasting success. The appeal of oesophagogastrostomy lies in the technical simplicity of the procedure and a single anastomosis. It may be justified as palliation for malignant tumours where the patient is unlikely to survive for more than two years, but in cases with a better prognosis an alternative method of reconstruction is indicated.

CERVICAL OESOPHAGOGASTROSTOMY

Franklin observed that the higher an intrathoracic oesophago-gastric anastomosis, the lower was the incidence of recurrent peptic oesophagitis above the anastomosis. Confirmation of this observation led ultimately to the extension of the principle and the development of the cervical oesophagogastrostomy. Following the resection, the cardia is closed, the apex of the fundus is moved up through the mediastinum or retrosternal route and anastomosed end-to-end with the cervical oesophagus through a separate neck incision. The main advantage of this procedure is the greatly reduced operative morbidity and mortality. An anastomotic leak may lead to a local abscess or empyema, but the patient will survive with suitable drainage. Aspiration pneumonia remains the major cause of postoperative morbidity and the risk is increased by dilatation of the stomach as a result of pylorospasm or failure to confine the intrathoracic stomach to the mediastinum or retrosternal tunnel. The risk of recurrent peptic oesophagitis is not eliminated but in the experience of the author this is a rare late complication contrasted with the high incidence following an intrathoracic anastomosis.

REVERSED GASTRIC TUBE

The use of a gastric tube constructed from the greater curve of the stomach, supplied with blood from the splenic and short gastric vessels, interposed in an antiperistaltic direction, was first proposed by Beck and Jianu, practiced by Meyer and Lotheissen, and later popularised by Gavriliu mainly for reconstruction following resection for malignant tumours or as a bypass procedure. The technique has been employed by Anderson in children in the management of Type II congenital atresia. The procedure is technically more demanding, with a gastric suture line from the level of the umbilicus to the neck, than interposition of the entire stomach. It offers a field day for the stapler enthusiast. The critical factor is the late functional activity of the antiperistaltic gastric tube as a propulsive conduit and information is sparse on the results of motility studies and the late complications. Previous gastric surgery or splenectomy, intended or accidental, prohibit the use of the technique. It would appear to have no advantages and significant disadvantages as compared with reconstruction with the entire stomach, when available.

JEJUNAL INTERPOSITION

The advantage of jejunum as an oesophageal substitute lies in the vigorous peristalsis and comparable calibre to that of the normal oesophagus. Wide anatomical variations in the vascular supply to the proximal jejunum frequently confine application to short reconstructions of the lower oesophagus and may frustrate attempts to replace more extensive sec-

tions. In infants and children the blood supply may be even more precarious and prohibit the use of this technique. Jejunal interposition therefore does not fully meet all the criteria for a generally applicable reconstructive technique.

In cases where no alternative organ is available and jejunal interposition is obligatory extensive mobilisation of the proximal jejunum is necessary until a viable vascular pedicle has been achieved. At the completion of the interposition a tight 'bowstring' pedicle will be supporting an extensive redundant loop of transplant within the pleural cavity owing to the distance between the bowel and the primary vascular arcades. Intermittent obstruction by mechanical kinking of the redundant loop may occur subsequently, calling for a partial resection of the transplant to restore tolerable swallowing. Experience has demonstrated that the optimum time for the trimming back procedure is at the time of the initial reconstruction. The redundant loop can be excised without compromising the main vascular pedicle. An additional end-to-end jejunal anastomosis is incurred but without adding materially to the overall risk of the operation and a later corrective intervention may thus be avoided. A late complication reported by Allison was alkaline oesophagitis.

ALTERNATIVE RECONSTRUCTIVE TECHNIQUES EMPLOYING JEJUNUM

In the absence of gross functional disorders such as achalasia the patient's own oesophagus will remain superior to any substitute as a propulsive swallowing mechanism. In the replacement of obstructing lesions of the upper oesophagus sacrifice of the major portion of the organ should be unnecessary. Two techniques for conservative reconstruction have been devised and merit further trial.

Kasai has perfected a technique for fashioning a long vascular pedicle supporting a limited segment of proximal jejunum which will reach to the apex of the chest or to the neck for isoperistaltic interposition to restore continuity following limited resections of upper oesophagus. In cases where the jejunal blood supply is sufficiently robust to justify this technique it should prove a valuable addition to the spectrum of reconstructive techniques. The procedure is essentially an extension of the principle of the long jejunal transplant with synchronous resection of redundant bowel. The second technique is the use of isolated segments of jejunum supported by vascular anastomoses to adjacent vessels. Advances in vascular microsurgery have now extended this technique beyond the experimental stage. However, the technical skill necessary to justify the procedure as a routine method of oesophageal reconstruction will probably remain confined to a relatively small group of surgeons. Peraccia has reported encouraging results but the overall statistical risks of the procedure are not yet apparent. As yet there is little clinical or manometric evidence relating to the functional activity of these interposed isolated segments. Once this information is available, the technique may assume a much wider clinical application. The theory is attractive but the battlefields of surgery are littered with the wrecks of attractive surgical theories.

Reconstruction with colon

Initially right colon, occasionally including terminal ileum, supported by the middle colic artery was preferred. The advantage was the creation of an isoperistaltic transplant. The disadvantages of right colon are:

1. An additional laparotomy is necessary for mobilising the transplant.
2. Right colon is bulky and the calibre greatly at variance with that of the organ being replaced.
3. Right colon is trained to propel a fluid bolus rather than the solid bolus normally propelled by the oesophagus.
4. The blood supply in the ileocaecal region may be defective.

The use of transverse colon supplied by the middle colic artery promised to be a technically easier procedure, but

usually created an antiperistaltic transplant with unsatisfactory and sometimes disastrous results. Waterston applied the technique to the correction of congenital oesophageal atresia by a multistage procedure.

Kelling first proposed the use of isoperistaltic transplants of left colon in 1911. About the same time Vulliet promulgated the heresy that since colon does not normally exhibit peristalsis, antiperistaltic transplants of colon should prove as effective as isoperistaltic transplants. This fallacious reasoning, ignoring the unidirectional propulsive activity of normal colon, peristaltic or otherwise, perpetuated the use of transverse colon and resulted in untold disability and disaster from the complications of antiperistaltic transplants. The use of colon fell into disrepute.

In 1955 a clinical trial was initiated to study synchronous resection and reconstruction with isoperistaltic segments of left colon and splenic flexure supported by the left colic artery as an alternative to right colon interposition. The theoretical advantages of left colon that stimulated the trial are: An extended left thoracotomy incision with peripheral detachment of the diaphragm permits synchronous resection of the oesophagus and reconstruction through a single incision; the calibre is closer to that of the organ being replaced; left colon is better trained to propel a solid bolus; left colon is less bulky than right colon; the anatomical relationship of the marginal artery to the bowel permits a linear interposition with no kinking; the anatomy of the left colic artery is subject to few variations.

The trial was initially confined to reconstruction and bypass for benign obstructive lesions but later the technique was extended to the management of malignant lesions with a more promising long term prognosis where the late functional results become increasingly important.

TECHNIQUE OF LEFT COLON INTERPOSITION

Certain technical points must be observed to avoid later complications.

1. Preoperative preparation. An empty, dry, colon is achieved by the standard technique with washouts or by placing the patient on a low residue diet for three weeks prior to operation and restricting fluid intake for the last 24 hours.
2. Preoperative antibiotic therapy has been found to be unnecessary and often harmful by causing enteritis.
3. The exposure is through an extended left sixth interspace thoracotomy with peripheral detachment of the anterior margin of the diaphragm. A separate cervical incision may be needed for a high anastomosis.
4. The transplant is prepared, supported by both branches of the left colic artery. The marginal artery and colon are not divided until the necessary length of the transplant has been determined. Sufficient length to avoid all tension on the pedicle is essential.
5. Delaying the mediastinal dissection till the transplant has been prepared will reduce blood loss.
6. A cologastric anastomosis on the posterior aspect of the rotated stomach, close to the greater curve, and one third the length of the stomach distal to the closed cardia, maintains an 8–10 cm length of transplant within the high pressure zone and constitutes an effective antireflux mechanism. Tension or kinking of the vascular pedicle is avoided.
7. The direct mediastinal route for the transplant reduces the risk of mechanical embarrassment of the vascular pedicle and particularly the venous drainage.
8. If a cervical anastomosis is indicated the proximal end of the transplant is closed temporarily and passed up deep to the aortic arch.
9. All anastomoses are formed with a single layer of interrupted inverting sutures of non-absorbable material. In the author's experience 6/0 monofilament stainless steel wire has proved an ideal suture material and eliminates the risk of anastomotic strictures.

10. It is essential to avoid any redundancy of the colon above the diaphragm. On completion of the anastomoses the transplant is gently stretched distally, any redundant viscus is replaced in the abdomen, and the seromuscular layer of the colon is anchored to the margin of the hiatus, avoiding the pedicle, to prevent subsequent prolapse of the colon back into the thorax.

SPECIFIC COMPLICATIONS OF LEFT COLON INTERPOSITION

Necrosis of the transplant due to mechanical embarrassment of the pedicle.

Redundancy of the transplant.

Progressive fibrous stenosis of the proximal end of the transplant.

Gastrocolic reflux and peptic colitis.

Intrinsic colonic disease occurring later.

Sluggish colon.

Kinking of the pedicle is more likely to occur if an indirect route, such as the retrosternal, is selected for the transplant. The fibrous stenosis of the proximal end of the transplant that has occasionally been reported is probably due to obstruction of the venous drainage and chronic venous engorgement, an avoidable complication.

Malcolm has reported ten cases of peptic colitis due to reflux following colon interposition. In every instance this complication followed a cologastric anastomosis to the cardia or on the anterior aspect of the stomach. It has not been encountered following a low posterior cologastric anastomosis. A further disadvantage of the anterior anastomosis is possible kinking of the pedicle round the lesser curve of the stomach. The posterior anastomosis is preferred even when the retrosternal route is used.

In 15% of cases the long term functional result has been impaired by an inherent lack of activity in the transplanted colon. No obstruction can be demonstrated but the patient has to eat more slowly. The activity tends to improve with the passage of time. Further progress must involve more sophisticated techniques for the preoperative assessment of colonic activity to permit an alternative reconstructive technique to be selected when colonic propulsive activity appears to be inadequate for oesophageal replacement.

CONTRAINDICATIONS TO LEFT COLONIC INTERPOSITION

Intrinsic colonic disease minor degrees of diverticulosis with no history of inflammatory complications have not been found to constitute a contraindication.

Anatomical anomalies of the marginal artery encountered four times in 368 attempted reconstructions with left colon.

Mesenteric endarteritis may be encountered in cases of severe systemic hypertension. Inadequate palpable pulsation in the left colic artery, or inadequate bleeding on division of the marginal artery, indicates an alternative reconstructive technique.

Inherently sluggish colon the diagnosis is based on the history of bowel activity, radiology, and hopefully in the future on more objective manometric or radionuclide transit studies.

Rectal atresia calling for a pull-through procedure is not a contraindication to reconstruction with left colon in cases of congenital oesophageal atresia provided the preliminary colostomy is not sited in an area of colon destined for transplantation.

Early results of reconstruction with left colon for benign disease

The details of results are shown in Tables I, II, and III. The object of documenting Western and Middle Eastern series was to emphasise the importance of contemporary ancillary intensive care in reducing postoperative morbidity and mortality. In fact this study failed in this objective and merely demonstrated that correct performance of the operative procedure is the more important element in the control of postoperative complications. Also demonstrated by these statistics is the unimportance of the age of the patient or the extent of the reconstruction on morbidity.

TABLE I Reconstruction with left colon for benign disease

	Operative deaths	
	Number	%
Western series, 287 cases		
Peptic strictures	219	13
Corrosive strictures	17	
Recurrent hiatus hernia	6	
Congenital atresia	45	1
	287	14
		4.8
Middle Eastern series 56 cases		
Peptic strictures	2	0
Corrosive strictures	54	3
	56	3
		5.4
Combined series	343	17
		5.0

TABLE II Operative mortality in various age groups

	Under 5	5-12	13-69	Over 70
Western series patients	69	27	173	18
Middle Eastern series patients	19	15	22	
	88	42	195	18
Mortality:	4.5%	4.7%	5.1%	0

TABLE III Operative mortality related to the length of reconstruction or bypass for corrosive strictures

	Resected		Bypass
	Short segment	Long segment	Long segment
Western series	3	15	
Middle Eastern series	12	26	18
	15	41	18
Operative mortality	6.6%	7.3%	0

'Short segment' indicates an oesophagocolic anastomosis below the aortic arch; 'long segment' replacement or bypass of the entire oesophagus with a cervical anastomosis.

Late results of reconstruction with left colon

The clinical trial of reconstruction with left colon was commenced in 1955. There has been ample opportunity to assess late results in an intensive follow-up system in which all patients operated upon in the UK are encouraged to attend regularly for an indefinite period. In 85% of cases the patient has been satisfied with the result. In 15% the result was less satisfactory owing to inadequate colonic motility. This defect may be avoided in future by better case selection based upon more sophisticated preoperative studies of colon motility and its functional ability to replace the oesophagus. Two important observations have emerged from this study. First, with the passage of time the transplant tends to assume the calibre of the normal oesophagus. Skinner and Paris have independently demonstrated that the transplanted colon can develop true peristalsis. Both studies were conducted within 12 months of the operation. Repetition of the studies 3 to 5 years after the operation might produce more convincing evidence of the suitability of left colon as an oesophageal substitute. Second, when used in infants and children for reconstruction in cases of Type 2 congenital atresia or following resection of peptic or corrosive strictures, the transplant has been observed to develop at the same speed as the patient into adult life.

Failed reconstruction

A major persisting problem is the management of the case where a previous attempt at reconstruction has failed. The common causes of failure are: Necrosis of transplanted viscera; antiperistaltic transplants; previous removal of the stomach or other abdominal organs, and previous surgical trauma, often complicated, to the mediastinum, thoracic viscera, or abdomen.

It is now generally recognized that antiperistaltic transplants of jejunum or colon are not only inadequate functionally but may ultimately lead to the death of the patient from recurring aspiration pneumonitis and progressive lung destruction. Some cases are uncorrectable. Those that can be treated need to be subjected to major surgery with no guarantee of a successful outcome. Preventing these problems involves the whole question of surgical training in special techniques in limited fields. The major problem is organization so that sufficient clinical material is concentrated in a limited number of centres to justify the maintenance of a viable resident training programme.

Conclusions

Reconstruction of the oesophagus remains a major surgical exercise that is best avoided by the more enlightened early treatment of the benign lesions ultimately calling for reconstruction. Of the available techniques only the interposition of isoperistaltic segments of left colon fulfils all six criteria previously stipulated. The most acceptable alternative technique is cervical oesophagogastrostomy. Both techniques are equally applicable as bypass procedures. Isoperistaltic jejunal interposition is satisfactory for replacing the lower oesophagus and oesophagogastric junction. Further development of the Kasai technique and the use of revascularised isolated jejunal segments may eventually eliminate the necessity to excise or bypass long segments of normal oesophagus to relieve obstruction caused by localised benign lesions.

'Plastic Surgery of the Face' by the late Sir Harold Gillies, CBE, FRCS,
originally published in 1920 by the Oxford University Press.

The President and Council of the British Association of Plastic Surgeons wish to announce that by kind permission of Lady Gillies and the Oxford University Press, arrangements have been made with Gower Medical Publishing Ltd., of London, to reprint a facsimile edition of the original work with a new foreword by Sir Benjamin K Rank, CMG, FRCS. There will be two editions: a cased facsimile edition (approximate price \$100) and a special numbered facsimile edition (limited to 250 copies) with half-leather binding (approximate price \$200).

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