

# Peculiarities of intra-thoracic colon interposition—eso-coloplasty: indications, surgical management and outcomes

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**Abstract:** Stomach is the usual organ of choice for oesophageal replacement. Gastric pull-up is a standardized, fast and secure procedure, requiring only one anastomosis and usually performed with mini-invasive techniques. Colon is used when the stomach is not available, for tumours of the upper oesophagus or the hypopharynx, for benign or paediatric diseases. It is a complex surgery requiring a specific pre-operative management, three or four anastomoses, and a careful choice of the route of reconstruction. Early post-operative complications, such as anastomotic leakage, are frequent. Long-term outcomes are marked by strictures of the anastomosis and redundancy, but the reported quality of life of the patients is good. Eso-coloplasty remains a safe and feasible alternative to gastric pull-up for oesophageal replacement, for specific indications.

**Keywords:** Esophagectomy; coloplasty; gastric pull-up; redundancy; colon interposition

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## Introduction

Stomach is the usual organ of choice for oesophageal replacement. Gastric pull-up is a standardized, fast and secure procedure, requiring only one anastomosis either in the thorax or in the neck, and is usually performed with mini-invasive techniques (1-3).

Colon interposition was first described in 1911, and remained the organ of choice for oesophageal replacement during the first half of the 20<sup>th</sup> century (4). Nowadays, it is mainly used when the stomach is not available, for tumours of the upper oesophagus or the hypopharynx, or for benign diseases (5).

This paper will focus mainly on the indications of intra-thoracic colon inter-position, the specific early complications of this surgery and the long-term follow-

up. We will also briefly describe the specific aspects of the surgical technique.

## Indications

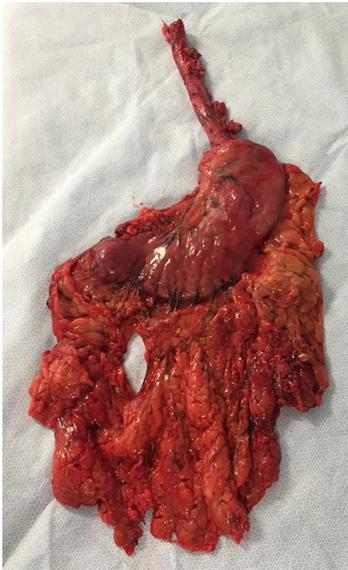
Nowadays, a colon graft is chosen as the organ of choice for oesophageal replacement instead of the stomach in very specific situations.

### *The stomach cannot be used during an esophagectomy for cancer*

When patients have a history of gastrectomy, either for carcinomas or for peptic disease, or when the stomach must be removed at the same time (Siewert III tumors) another organ of replacement must be chosen (5-10) (*Figure 1*). A

Colon graft is the organ of replacement of choice in this situation. Both intra-thoracic and cervical anastomoses can be performed, depending of the extent of the oesophageal disease and the resection needed.

Some teams use preferentially a jejunum graft, performing an intra-thoracic anastomosis on a Roux-en-Y loop. But when compared to a colon graft, utilisation



**Figure 1** Subtotal esophagectomy associated with a gastrectomy for cancer.

of the jejunum is more complex, the transplant length is limited, and only experienced teams perform it. Overall, the indications of jejunal interposition are limited (*Table 1*) (11).

#### *The stomach is deliberately not chosen as the organ of replacement*

For tumours of the upper oesophagus or of the hypopharynx, a long length of graft is necessary (12). Thus, a long colonic transplant, with a good vascularisation, can be a better option for an organ of replacement in order to avoid the presence of ischemic tissue at the upper part of the graft. And ultimately avoid necrosis of the graft or leakage of the anastomosis.

For benign disease in young patients, such as end-stage achalasia or strictures secondary to caustic and peptic injuries, several teams report good outcomes when colon is used over the stomach as a replacement for the oesophagus (7,13,14). Because the stomach and its function as a reservoir are kept intact, it allows a good quality of life for the patients. Thus, dumping syndrome, nausea and vomiting, regurgitation, reflux and oesophagitis are less frequent, and the quality of life increases (15). Finally, the stomach is still available if the graft fails, or if secondary complications arise.

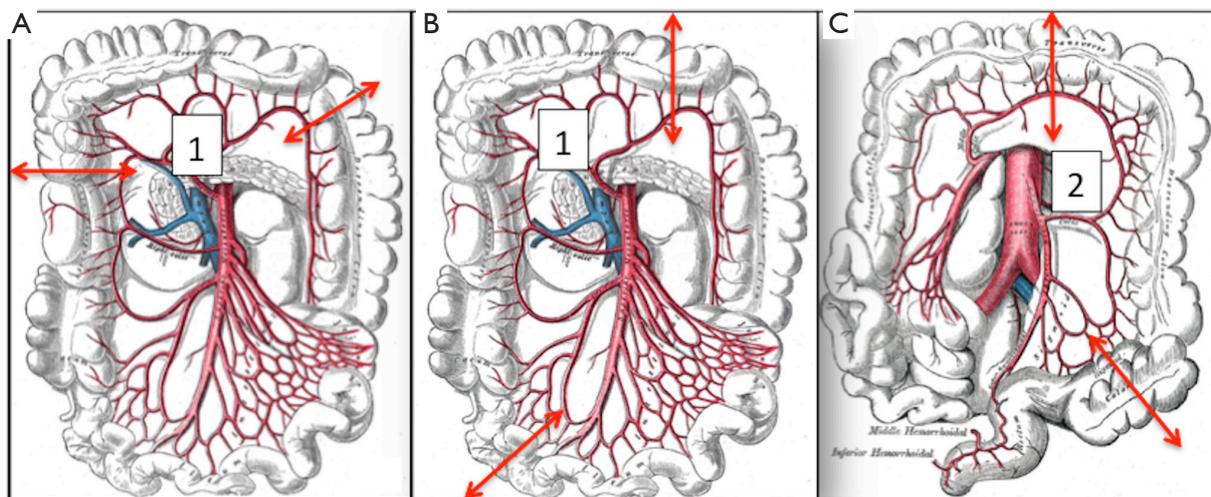
#### *The specific case of pediatrics: atresia of the esophagus*

There is no consensus on which organ of replacement

**Table 1** Respective advantages and inconvenients of colon transplants, jejunum transplants and gastric interposition after esophagectomy

Type of graft	Advantages	Disadvantages
Colon interposition	Long transplant Quality of life Reduced Reflux Wide margins of resection (distal tumors)	Complex Three to four anastomoses High rate of morbidity/mortality
Jejunum interposition	Anterograde segmental contraction Low leakage rate	Extremely complex procedure Microvascular anastomosis Experienced center Limitation in length
Gastric interposition	Fast, safe and standardized One anastomosis Low rate of necrosis Minimally invasive techniques	Loss of the gastric reservoir Reflux Shorter margins for distal oesophagus or GEJ tumors

GEJ, gastro-esophageal junction.



**Figure 2** Short and long colon transplants and their associated vascularisation. (A) Short transverse colonic transplant; (B) long right colic transplant with the distal ileum; (C) long left colic transplant. 1, middle colic artery; 2, left colonic vessels.

must be chosen in the case of atresia of the oesophagus (16). Gastric transposition in children has shown excellent results, with more than 90% of good or excellent outcomes (17). Colon interposition offers good results as well, and is a valid second choice for the treatment of atresia with more than 50% of the patients asymptomatic in the long term.

Colon interposition is also a possible choice for treatment of strictures secondary to caustic burn injuries and complex peptic stenosis (18).

### Surgical technique

The surgical technique of colon interposition has been described in detail elsewhere (10,19,20). This section will focus on the main steps of the surgery, as well as the precautions that must be taken for intra-thoracic colon grafts.

### Pre-operative examinations

For patients over 45 to 50 years old, or with a history of colic surgery or abdominal aneurysm, an angiography of the colic vessels should be considered (21). The examination should also be performed for patients with atherosclerosis, with potential affected visceral arteries.

Bowel preparation should be performed during the days preceding the surgery associating cathartics and an appropriate diet, or iterative water enemas through a

jejunostomy when oral feeding is not possible.

### Choice and preparation of the graft

Depending of the primary disease, two types of colon transplants can be chosen: either a short one or a long one.

Short colic transplant with an intra-thoracic eso-colic anastomosis are considered for:

- (I) Tumours of the gastro-oesophageal junction;
- (II) Benign stenosis of the lower third of the oesophagus;
- (III) End-stage functional disorders.

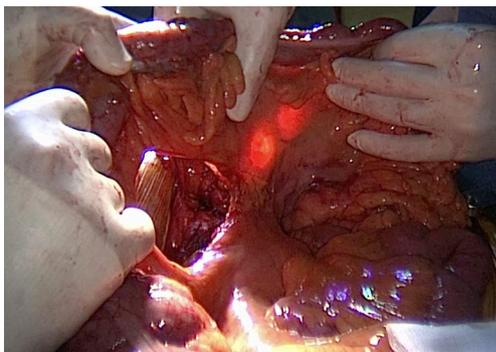
Long colic transplant with a cervical anastomosis are chosen for:

- (I) Sub-total esophagectomy (caustic burn, papillomatosis, carcinoma of the oesophagus with a previous gastric resection);
- (II) Oesophageal exclusion;
- (III) Impossible use of the posterior mediastinum as the route of reconstruction.

Intra-operative findings, especially regarding the vascular supply, can influence the choice of the graft (*Figure 2*):

- (I) Short transverse colon: vascularised by the middle colic artery;
- (II) Long transverse colon: vascularised by the left colonic vessels;
- (III) Long right colon with the terminal ileum: vascularised by the middle colic artery.

Whatever the choice made, it is mandatory to check the correct vascularisation of the graft after the mobilization



**Figure 3** The correct vascularisation of the chosen transplant is checked by trans-illumination of the meso for identification of the vascular supplies.

of the colon, and identification of all the vascular supplies (Figure 3) (22). The Right colic transplant has the additional benefit of an ulterior rescue surgery in case of a failed transposition, with a possible second coloplasty based on the transverse colon.

#### **Route of reconstruction (Figure 4)**

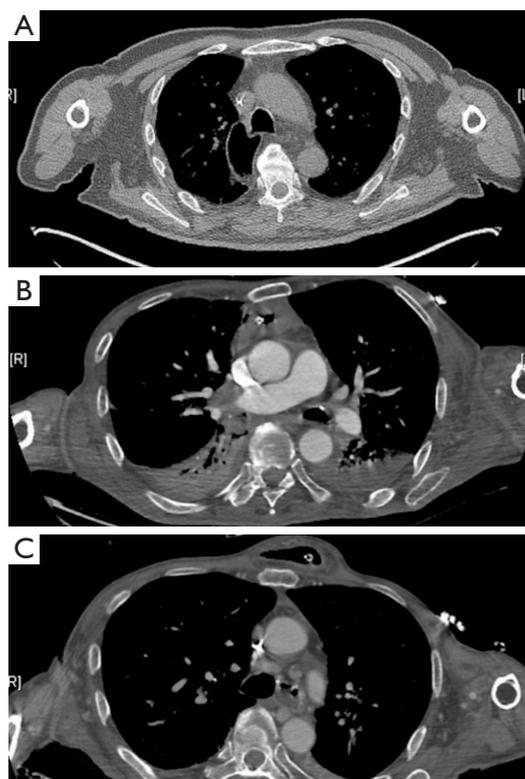
When the oesophagus is resected as the same time as the colon interposition, the transplant is usually placed through the posterior mediastinum. For short colonic transplant with an intra-thoracic eso-colic anastomosis, it is the only route available. For long colonic transplants other routes can be chosen.

When the colon interposition is performed after the esophagectomy, for example after a caustic injury with esophageal exclusion, or a failed gastric tube during a previous surgery, it is placed through a retro-sternal route. If the posterior mediastinum is hostile, previous radiotherapy or future one planned, it is also the route of choice (Figure 5).

When the retro-sternal route is not available, the graft can be placed sub-cutaneously in front of the sternum (Figure 6). Some teams choose preferentially this route of reconstruction, though the reported leakage rate is high (11).

Exceptionally, the colic graft can be place through the pleura, with an associated phrenotomy. For example when the posterior mediastinum is unavailable, and the patient has a history of sternotomy. But the results are disappointing and this route should be avoided if possible.

Whatever the route chosen, the length of the transplant must be checked, and the intra-thoracic graft should then be



**Figure 4** The different routes of reconstruction. (A) The colic transplant is placed through the posterior mediastinum; (B) the transplant is retro-sternal; (C) the colon is placed in front of the sternum, sub-cutaneously.

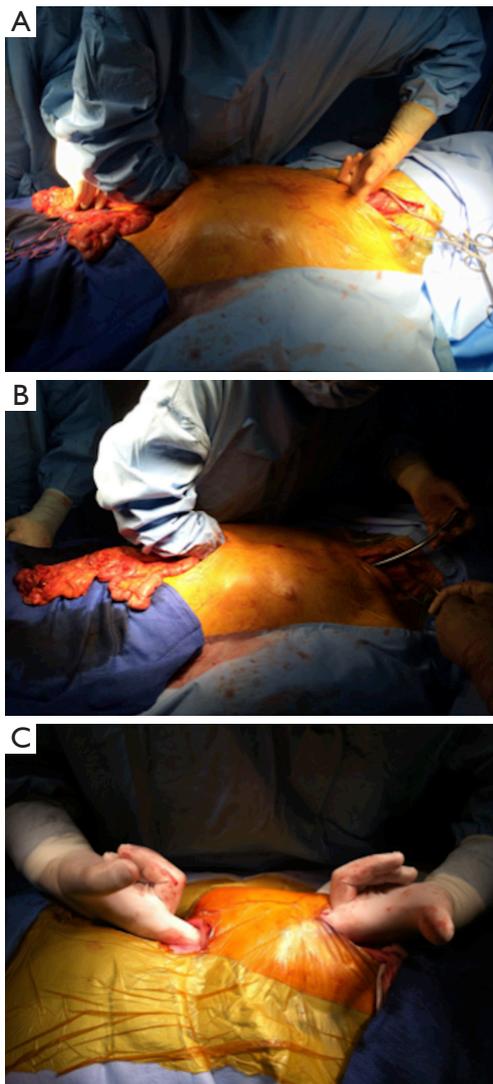
positioned as straight as possible to avoid future redundancy (Figure 7).

#### **Surgical approaches (Table 2)**

Several approaches can be described. They are dependent of two factors: firstly if the oesophagus is resected at the same time as the reconstruction, secondly if a short or a long transplant is needed.

The Oesophagus is resected at the same time as the coloplasty: the posterior mediastinum is free.

- (I) For long colonic transplants: a right thoracic approach is performed for the dissection of the oesophagus, whether through thoracotomy or thoracoscopy. In a second time a median laparotomy is performed and a left cervicotomy for the anastomosis;
- (II) For short colonic transplant, first a laparotomy is performed for the preparation of the colon,



**Figure 5** Retro-sternal Route. (A) The retro-sternal route is divided manually from the abdomen and the cervicotomy; (B) the coloplasty is pulled toward the neck; (C) pediatric case.

followed by a right thoracic approach for the dissection of the oesophagus and the intra-thoracic anastomosis;

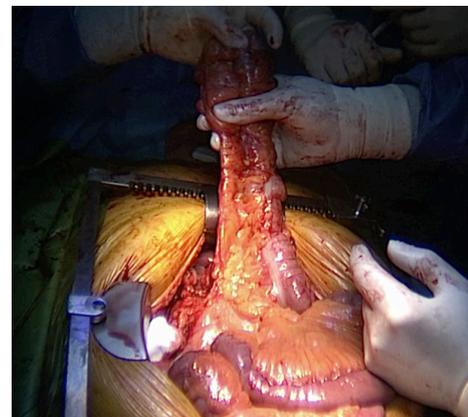
- (III) As an alternative to this approach, some teams prefer a left thoraco-phreno-laparotomy: the esophagectomy and the reconstruction with a short colonic transplant are performed at the same time.

The oesophagus has already been resected, the posterior mediastinum is unavailable and another route must be chosen.

- (I) A laparotomy is performed for preparation of the



**Figure 6** Dissection of the sternal sub-cutaneous zone for a pre-sternal coloplasty.



**Figure 7** The length of the transplant is checked before it is positioned through a retro-sternal route.

graft, followed by and a left cervicotomy for eso-colic anastomosis.

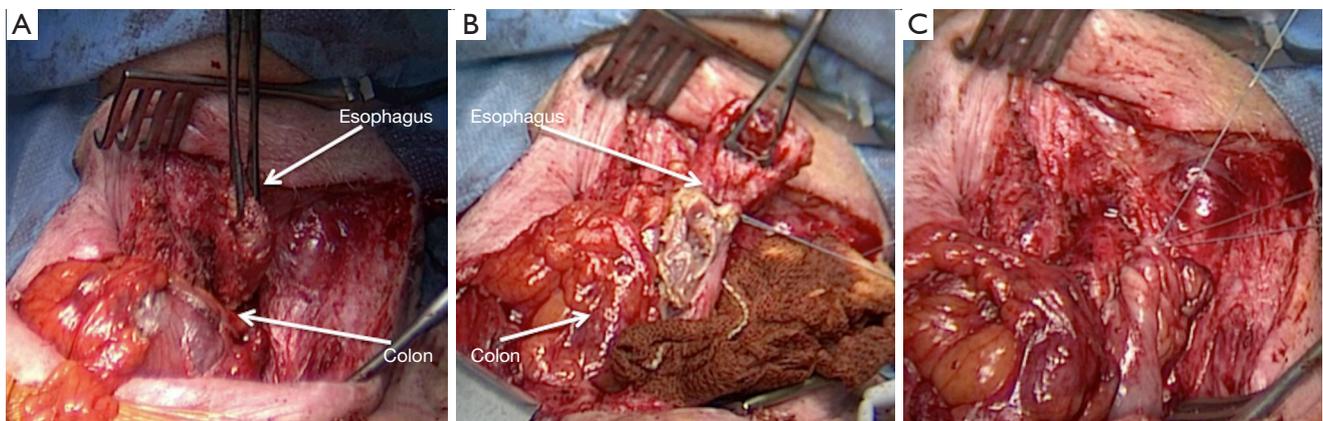
### *Anastomoses*

When the stomach is left in place, three anastomoses are performed:

- (I) The eso-colic anastomosis, either in the neck or in the thorax (*Figure 8*);
- (II) The colo-gastric anastomosis;

**Table 2** Different surgical approaches for eso-coloplasty

Indications	Route	Anastomosis
Short colonic interposition	Posterior mediastinum	Intra-thoracic anastomosis
Gastro-intestinal junction tumour Siewert III	Laparotomy followed by a right thoracotomy	
End-stage functional disorders (achalasia)	Left thoraco-phreno-laparotomy	
Non-tumoral stenosis (peptic stricture)		
Long colonic interposition	Posterior mediastinum	Cervical anastomosis
Subtotal oesophagectomy	Right thoracic approach and laparotomy	
Oesophageal exclusion	Left thoraco-phreno-laparotomy	Left cervicotomy
	Retro-sternal (posterior mediastinum unavailable)	
	Laparotomy and left cervicotomy (intra-pleural)	



**Figure 8** Eso-colic cervical anastomosis. (A) The distal extremity of the colon is placed into the neck without tension; (B) posterior running stitch; (C) the anterior running stitch is completed.

(III) And finally the colo-colic one.

When the stomach has been removed four anastomoses are needed, because of the Roux-en-Y loop performed between the distal extremity of the colic transplant and the jejunum. Thus the colo-gastric anastomosis is replaced by a colo-jejunal anastomosis and a jejuno-jejunal one.

Additional steps, superdrainage and supercharge techniques, can be performed on the eso-colic anastomosis to improve the vascular supply of the graft (23,24).

### Outcomes and complications

Because of the complexity of colon interposition, high

mortality and morbidity rates are observed. Thus, the reported mortality ranges from 0 to more than 16% for some teams, and the associated risk of graft necrosis ranges from 0 to 10%, and 0 to 15% for anastomotic leaks (5-11,25-31) (Table 3). Risk factors such as diabetes, cardiovascular diseases and chronic obstructive pulmonary disease (COPD) have been described and should be addressed before the surgery (32). During the surgery, compression on the colon graft should be avoided at all cost, in order to preserve the transplant. Thus, dissection of the retro-sternal path or the thoracic inlet should be done carefully. If needed the plate of the manubrium, the clavicle or the first rib can be removed as well (33).

**Table 3** Short-term and long-term complications after eso-coloplasty

Authors	Year of publication	Anastomotic leak (%)	Graft necrosis (%)	Mortality (%)	Secondary stricture (%)
Curet-Scott	1987	9.4	7.5	3.8	15.1
Isolauri	1987	4	3	16	M
DeMeester	1988	4	3.4	9	2
Cerfolio	1995	3.3	6.2	9.4	24
Thomas	1997	10	5	8.3	7.4
Mansour	1997	14.8	3	5.9	M
Wain	1999	5.8	5.8	4	46
DeMeester	2001	9.4	M	4.7	4
Davis	2003	14.3	2.4	16.7	9
Knezevic	2007	9.2	2.4	4.2	4.5
Motoyama	2007	9	0	0	9
Doki	2008	46	0	M	M
Mine	2009	13	0	5.3	M
Klink	2010	3	9	16	M
Kesler	2013	9	M	9	0

M, missing data.

The management of failed colon transplant can be challenging, and optimal medical treatment (nutrition resuscitation, sepsis control, limitation of inflammation...) should be performed in association with surgery (33). Whenever it is possible, if removal of a necrotic transplant must be performed, as much length of the colic graft should be preserved for future reconstruction.

One of the main complications of gastric pull-up is biliary reflux and secondary reflux disease in the graft, leading to alimentary discomfort (3,34). For young patients with benign diseases, especially if a vagal sparing esophagectomy has been performed, the rate of biliary reflux and associated symptoms decreases. Thus in the long term, the overall quality of life reported after colon interposition is good (5,14,35-38). Symptoms such as diarrhea, dysphagia, reflux and dumping syndrome are observed in the early post-operative period but improve over time (10). Chronic aspirations are needed in less than 10% of the patients.

Two additional complications are described in the long term.

Stricture of the graft occurs in 0 to 40% of patients, and is more often observed in overweight patients or after anastomotic leaks. Most of the time, strictures are managed successfully with endoscopic dilatations

(5,7,9,14,25,28,29,39).

The exact number of patients needing revision surgery remains unknown, whether it is in the early post-operative period for anastomotic leakage or necrosis of the transplant, or in the long-term. Redundancy of the graft is one of the causes of late revision surgery, where segmental resection of the colic transplant is usually performed. The frequency increases over time, the reported rate ranging from 0 to 40% (33,40). During the initial surgery, several precautions should be taken in order to limit the rate of redundancy: performing first the oesophago-colic anastomosis, measuring the graft carefully in order for the transplant to have a course as straight as possible, remove any structure potentially obstructing, anchoring the anti-mesenteric border to the crura or the diaphragmatic opening (5,8,20,40).

## Conclusions

Colon interposition is a complex surgery with specific indications. It has a high morbidity and mortality, though in the long term the survival rate is similar to gastric pull-up and the quality of life is good. Thus it remains a valid choice for oesophageal replacement.

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## Footnote

*Conflicts of Interest:* The authors have no conflicts of interest to declare.

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