Modifications and Complex Esophageal Reconstructions

1. Modifications of esophageal reconstructions

Esophageal reconstructions with the use of pedicled intestinal segments are difficult procedures and require perfect mastering of the surgical technique. However, despite excellent professional skills of the surgeon, in view of individually differentiated and not always adequate vasculature in the region of the small and large intestine, there may always occur intraoperative difficulties in obtaining long enough and at the same time well supplied with blood graft.

For this reason it is seems reasonable to present various management modalities providing a positive outcome to the reconstructive surgery. Since reconstructions with the use of free intestinal flaps and vascular anastomosis are not the subject of the report, they will not be discussed here.

Below are presented following modifications and complex reconstructive surgeries:

- Single and double resection of redundant intestine
- Double-pedicle esophageal reconstructions
- Secondary mobilization of a pedicled intestinal graft

1.1. Resection of redundant intestine

The resection of redundant intestine is performed for two reasons. The first includes increasing mobility of the graft, the second reason is to improve blood supply to the mobilized intestinal segment.

A. Single resection of redundant intestine

This type of resection, so-called single resection, concerns the caudal portion of the mobilized graft. The surgical technique is relatively simple and involves parietal ligature and transection of straight vessels followed by resection of a 2-3 cm segment of the intestine in the caudal portion of the graft. Continuity of the graft pedicle remains intact (Fig. 1, 2).

The above-presented modification provides a double advantage. Resection of few-centimeter long intestinal segment in the caudal portion of the graft increases mobility of the mobilized intestinal segment. At the same time, resection of a few-centimeter intestinal segment in the peripheral portion of the graft, with unchanged source of blood supply, improves blood supply to the mobilized intestinal segment.
B. Double resection of redundant intestine

Double resection of redundant intestine involves resection of redundant intestinal loop in the medial and caudal portions of the graft. This variant is used in cases in which the mobilized intestinal segment forms significantly excessive loop in relation to the length of the vascular pedicle. Such situations occur during reconstructive surgeries with the use of the jejunum or the ileum. In case of jejunum, the main reason is the presence of strong, but short vascular trunks, which form effective, but narrow anastomosing arcades. On the other hand, the mesojejunum is relatively short, and the vessels form generally multilayer arcades. Performance of a double resection may help achieve two aims. Firstly, it increases the graft’s mobility by resecting the intestinal redundancy in the caudal portion, secondly – it improves blood supply by resecting redundant intestine in the medial portion. Moreover, double resection leads to straightening of the graft, what shortens the passage through the substitutive esophagus, and thus improves its function.

The surgical technique includes parietal ligature and transection of straight vessels, followed by resection of a several-centimeter intestinal segment in the caudal portion of the mobilized
graft, and similarly, in the medial portion of the graft, where the intestinal redundancy is most significant, with the continuity of the vascular pedicle left intact. After resection of the redundant intestine in the medial portion of the graft, the remaining stumps should be end-to-end anastomosed (Fig. 3, 4).

**Figure 3** Diagram of double resection of redundant intestine in the medial and caudal portions of the graft

Double resection of redundant intestine is associated with a number of mentioned above advantages. However with inadequate skills of the surgeon, it may result in severe complications in form of insufficiency of anastomosis in the medial portion of the graft.

2. Management of ischaemia in the cephalic portion of the jejunal graft

Insufficiency of vascular arches leads to ischaemia in the cephalic portion of the mobilized graft. This intraoperative complication occurs most commonly in reconstructions using the jejunum. The ischaemic segment of the graft must be resected. Successful completion of a reconstructive surgery seems in such cases impossible. Solution to this difficult situation lies in the knowledge of corrective procedures, which allow to obtain elongation of the graft in the cephalic portion. Presented below are the following techniques of corrective surgery:

- Insertion from the ileum on middle colic vascular pedicle
- Insertion from the colon on ileocolic vascular pedicle
• Insertion from the colon on left colic vascular pedicle
• Secondary mobilization of a pedicled intestinal graft

The choice of a kind of corrective surgery with the use of an insertion is based on an extremely thorough evaluation and analysis of vasculature in the small intestine and the whole colon. An insertion in the cephalic portion of the graft must have its own long vascular pedicle, what will enable adequate elongation of the primary graft and successful termination of the reconstructive surgery.

Another way out of the ischemic problem in the cephalic portion of the graft is the method of its secondary mobilization. Secondary mobilization enables elongation of the graft by several centimeters without insertion on another vascular pedicle, what gives a chance to produce a substitutive esophagus on primary vascular pedicle.

2.1 Insertion from the ileum on middle colic vascular pedicle

This variant of corrective surgery should be chosen when there are adequate vascular arrangements between the ileocolic vessels and the vessels in the terminal portion of the ileum, and at the same time the anastomosing arcades between the ileocolic vessels and right and middle colic vessels are broad and effective. Only this kind of vascular anastomosis provides an opportunity to create an insertion on a very long middle colic vascular pedicle.

The surgical technique involves ligating and transecting the ileocolic and right colic vessels and intestinal trunks in the terminal portion of the ileum beyond their ramifications, maintaining the blood flow through the anastomosing arcades. The procedure is associated with the necessity of resecting the caecum and the ascending colon (Fig. 5).
The next stage includes anastomosing the distal, caudal portion of the primary graft from the jejunum with the insertion made from the ileum. In this way a graft is formed on two independent vascular pedicles consisting in its caudal portion of the jejunum and in the cephalic portion – of the ileum (Fig. 6).
Subsequent stages of the procedure include positioning of the graft in the retrosternal canal, reconstruction of the gastrointestinal tract continuity in the abdomen and anastomosing the graft with the cervical esophagus and the stomach.

A drawback of this type of corrective surgery is that it leaves a relatively large intestinal defect in the abdominal cavity.

However its main advantage is a chance to complete successfully the esophageal reconstruction. Thus the function of the esophagus created in this way, as shown in remote follow up of patients operated on with this method, is very good, what may be attributed to the fact that the whole graft is made from the small intestine with a vivid peristalsis (Fig. 7).

2.2. Insertion from the colon on ileocolic vascular pedicle

If the vasculature in the ileocolic angle is inadequate for a corrective surgery by means of a modality described above, and at the same time anastomoses between the ileocolic and the right and middle colic vessels are long and effective, there are good conditions to produce an insertion from the colon on a long ileocolic vascular pedicle.

![Image](image.png)

*Figure 7* Radiogram of the double-pedicle substitutive esophagus from the jejunum with an insertion from the ileum on middle colic vascular pedicle (lateral projection)

The surgical technique is similar to this described above. After mobilization of the terminal segment of the ileum and the right colon, the graft on ileocolic pedicle should be isolated from the distal segment of the right colon. The right and middle colic vessels are ligated and transected and the caecum and proximal portion of the ascending colon are resected. Thus a graft from the colon on a long ileocolic vascular pedicle is mobilized (Fig. 8).

In the next stage the primary jejunal graft is anastomosed with the insertion produced from the colon. Thus a double-pediced graft is formed, the caudal portion of which consists of the jejunum, and the cephalic portion – of the colon (Fig. 9).

Subsequent stages of the procedure include positioning of the double-pedicle graft in the retrosternal canal, reconstructing the gastrointestinal tract continuity in the abdomen by anastomosing the
ileum with the left part of the transverse colon and anastomosing the graft with the stomach and cervical esophagus.

Figure 8 Diagram of mobilization of an insertion from the colon on ileocolic vascular pedicle

It is worth mentioning that insertion from the colon prepared according to this modality is positioned antiperistaltically, and the distal part of the graft made from the jejunum – isoperistaltically.

Figure 9 Diagram of a double-pedicle substitutive esophagus from the jejunum with an insertion from the colon on ileocolic vascular pedicle
The main advantage of this variant of corrective surgery is the possibility of completing the reconstructive procedure.

The main disadvantage, similarly as in the first presented variant, is a relatively large intestinal defect in the abdominal cavity.

The function of this substitutive esophagus, as shown in remote examinations of involved patients, is good (Fig. 10).

Figure 10 Radiogram of a double-pedicle substitutive esophagus from the jejunum with an insertion from the colon on ileocolic vascular pedicle (lateral projection)

2.3. Insertion from the colon on left colic vascular pedicle

The third variant of corrective surgery involves preparation of an isoperistaltic insertion from the colon on left colic vascular pedicle. This surgical modality is possible when there are exceptionally advantageous vascular arrangements between the right and left colic vessels. In order to enable precise evaluation of vasculature, the right colon and the transverse colon have to be mobilized. Mobilization of the insertion may be undertaken only if the evaluation proves positive. The greater omentum has to be resected. The middle and right colic vessels are ligated and transected. Following transection at an appropriate level of the arch anastomosing the ileocolic and right colic vessels, a segment of the ascending colon, long enough to be used to produce an insertion, has to be isolated. The hepatic flexure of the colon, proximal portion of the transverse colon and the caecum are resected. Thus an isoperistaltic segment of the ascending colon on a long left colic vascular pedicle is isolated (Fig. 11).
Next the prepared insertion has to be anastomosed with the remaining portion of the primary graft. In this way a double-pedicle graft, consisting from a jejunal segment in the caudal portion, and of an isoperistaltic segment of the colon in the cephalic portion, is produced (Fig. 12).

Subsequent stages of the procedure include positioning of the graft in the retrosternal canal, reconstructing the gastrointestinal tract in the abdomen by anastomosing the ileum with the left transverse colon and anastomosing the graft with the cervical esophagus and the stomach. This variant of surgery, similarly to both previously presented modalities, possesses an important advantage, i.e. the possibility of successful completion of the reconstructive surgery.

A relatively significant intestinal defect in the abdominal cavity is considered to be the main disadvantage.

Remote evaluation of patients operated on according to this modality displayed and efficient function of the esophagus reconstructed in this way (Fig. 13).

Summing up the above presented double-pedicle reconstructions, it should be emphasized that they belong to extremely complicated techniques and require perfect mastering of the surgical technique as well as enormous experience of the surgeon. And it should be emphasized again that the modalities are original and unique modifications of the reconstructive surgeries, which enable successful completion of the surgery.
2.4. Secondary mobilization of the graft

Another original solution, which extends the possibility of using the jejunum to create a substitutive esophagus and enables a successful termination of reconstructive surgery involves secondary mobilization of the pedicled graft, proposed and used in esophageal reconstructions by Bernat in 1980.

The below presented modality is especially useful in cases in which the mobilized jejunal graft appears too short to be anastomosed with the cervical esophagus.

Excessive stretching and tension in the vascular pedicle of a too short graft lead to narrowing or even obstruction of a lumen in the apex of vascular arches in so-called critical points, what results in ischaemia of the graft and subsequently leads to necrosis (Fig. 14).

A possible solution to this difficult situation may include elongation of a too short graft by one of the means described above, i.e. by means of an insertion from the ileum or the colon on a long vascular pedicle. Another solution, less complicated than production of an insertion on a separate vascular pedicle, is secondary mobilization of the graft according to Bernat.
The method of secondary mobilization involves placement of a too short graft in the pre-sternal subcutaneous canal for several weeks. For this reason the jejunal graft mobilized on a vascular pedicle should be translocated beyond the colon and beyond the stomach to the epigastrium. The distal, caudal segment of the graft should be anastomosed to the stomach, and the proximal, cephalic segment – closed in a cul-de-sack manner. Subsequently, a subcutaneous, pre-sternal canal is formed and the graft is placed in it. Gastric fistula, performed as the first stage prior to the esophageal reconstruction, or during the procedure, allows full nutrition of the patient in the postoperative period (Fig. 15).

The next stage of the surgery may be undertaken after 4-5 weeks, and it includes mobilization of the graft from the subcutaneous canal and placement in the retrosternal canal. The prester-
nal canal is opened with a skin incision above the sternum and continuing to the epigastrium and next the graft together with its vascular pedicle is prepared gently up to the level of the graft’s anastomosis to the stomach (Fig. 16).

**Figure 16** Intraoperative picture of mobilization of the graft from the presternal subcutaneous canal. The elongated graft reaches high up the neck to the level of the mandibular angle.

Next the retrosternal canal is created according to the method described in previous chapters. The mobilized graft is passed in the retrosternal canal and anastomosed to the cervical esophagus.

**Figure 17** Radiogram of a substitutive esophagus from the jejunum after secondary mobilization (lateral projection)

**Figure 18** Picture of a patient after completed esophageal reconstruction by means of secondary mobilization of the graft
The advantages of the presented modality include elongation of the graft placed for few weeks in the subcutaneous canal, after secondary mobilization even by 6-7 cm, strengthening of the vascular pedicle, as well as broadening and strengthening of anastomosing arcades. Thus secondary mobilization leads to elongation of the graft and improvement of blood supply, what gives chance for successful termination of the reconstructive surgery.

The only disadvantage of the modality is that the surgical procedure is prolonged by several weeks.

Using this modality, it is possible to achieve a very good final outcome, what was confirmed in postoperative follow up (Fig. 17, 18).

Recapitulating the chapter on complex esophageal reconstructions, it should be emphasized that they belong to highly specialist procedures and should be undertaken by centres with highly educated and trained surgical staff. The main desire of a surgeon is not only to create a substitutive esophagus, but also to attain function of the newly created esophagus most closely resembling this of a natural esophagus. Being aware of this, and having expert knowledge and skills, the surgeon should always strive to choose optimal surgical modality in every single case.

3. References


