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Research Article

VIDEO-ASSISTED TECHNIQUES IN SURGERY OF BENIGN ESOPHAGEAL DISEASES

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Abstract

The *aim* of this study was to investigate the clinical results of the surgical treatment of the patients with benign esophageal diseases (total and subtotal strictures and finish-stage achalasia or cardiospasm) after video-assisted and open subtotal esophageal resection with esophagoplasty.

Materials and methods. Between 2010 and 2018 years in the Surgical Department №1 of Petrovsky Research Center of Surgery 57 subtotal esophageal resections with esophagoplasty were performed in patients with benign esophageal diseases. All patients were divided on 2 groups depending on the type of surgical treatment: the groups were similar in terms of age, gender, diagnosis and physical states. In 1st 2nd group 9 procedures were made by video-assisted surgery, including 20 thoracoscopic esophageal resections with laparotomy and 9 total minimally invasive esophageal resections, in the 2nd 2nd group 8 open procedures were made: 9 - using transthoracic approach, 19 – with transhiatal approach.

Results. The average time of the transthoracic operations in 1st group was lower than in 2nd group (447 (390-540) vs 470 (382;700) minutes, $p = 0,317$), but the time for all operations was higher in the 1st group ($p = 0,002$). The conversion was performed in 2 cases (7%) and caused by technical difficulties during esophageal mobilization. Average blood loss was statistically lower in the 1st group than in the 2nd group (250 (112-337) vs 400 (300-600) ml, $p = 0,01$). Postoperative respiratory complications were detected in the 17% of the patients in the 1st group, and in 50% - in the 2nd group ($p = 0,012$). The rate of the other complication including anastomosis leaks, vocal cord paresis and suppuration of surgical wound were similar in both groups.

Conclusion. Video-assisted subtotal esophageal resection may be considered as the effective alternative for open procedures in patients with benign esophageal diseases because of lower blood loss and decreasing of the postoperative respiratory complications rate.

Keywords: Subtotal Esophageal Resection, Thoracoscopic Subtotal Esophageal Resection, Cardiospasm, Achalasia, Esophageal Strictures, Esophagoplasty.

Abbreviations

MIB – mass-index of body

SRE – subtotal resection of the esophagus

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INTRODUCTION:

The main indications for subtotal esophageal resection (SRE) in patients with benign esophageal diseases are scar strictures of various genesis (burn, peptic), the ineffectiveness of their conservative treatment and maintenance, the development of various complications, including those caused by iatrogenic damage to the esophagus during medical manipulations, as well as terminal stages of neuromuscular diseases of the esophagus with the loss of the anatomical structure of the esophagus and its function [1-6]. Despite of the fact that these diseases are benign, traumatic surgery itself, compromised initial physical status of patients and comorbidity lead to a significant frequency of postoperative complications and mortality, which according to various authors can reach 4% [7]. Surgery not only includes mobilization of the esophagus in three areas (chest, abdomen and neck), but also the formation of a transplant from the stomach or colon segment to perform esophagoplasty, which leads to an increase in the duration of operation and anesthesia, as well as the risk of complications.

Video-endoscopic techniques in surgery of the esophagus was proposed in the late 1990-ies with the aim of reducing the risk of postoperative complications and mortality, which are characteristic of "open" operations [8-11]. The advantages of video endoscopic SRE in comparison with the "open" operation are the precision dissection of anatomical structures of the mediastinum, small intraoperative blood loss, minor postoperative pain, short postoperative period, less trauma in general [12]. One way to reduce the trauma of approach is the use of video endoscopic surgical techniques, but their use in benign diseases of the esophagus has not been studied enough. *The aim* of the study was to study the effect of video endoscopic SRE on the immediate results of treatment of patients with benign esophageal diseases when performing subtotal resection of the esophagus with simultaneous esophagoplasty.

MATERIALS AND METHODS:

From 2010 to 2018 the comparative retrospective study included 57 patients in the 1st Department of

surgery (Dep. of esophageal and stomach surgery) of Petrovsky National Research Center of Surgery, Moscow, Russia, was performed on the case of benign diseases of the esophagus with simultaneous esophagoplasty. Operations with the use of video endoscopic surgical techniques were performed in 29 patients (1st group), including 20 patients – SRE from thoracoscopic approach with the formation of the graft "open" method, 9 patients - thoracoscopic SRE with laparoscopic-assisted plastic of the esophagus gastric tube. In 28 patients the operations were performed in an "open" way (2nd group): in 8 patients the esophagus was removed transthoracically ("from 3 approaches"), including 2 cases-as a result of approach conversion (conversion rate - 7%), in 19 patients - transhiatally, in 1 case the transthoracic SRE was performed in combination with gastrectomy. In all cases the esophagoplasty was performed with the formation of the anastomosis on the neck.

The mean age of patients was 41.4 ± 14 in 1st group and 48.5 ± 13.1 years in 2nd group ($p = 0.43$), the ratio of men and women in groups was 1:1.3 and 1:1.2, respectively ($p = 0.599$). In 1st group, scar strictures of the esophagus were an indication for surgery in 23 patients, cardiospasm and achalasia of the cardia on the stage 4 – in 5 patients, esophageal damage – in 1 patient. In 2nd group indications for surgery were stricture formation of the esophagus in 15 patients, cardiospasm and achalasia of the esophagus on the stage 4 – in 11 patients, damage to the esophagus – in 2 patients. Gastrostomy before admission to the our Surgery Center was imposed in 14 patients of 1st group and 8 patients of 2nd group.

The main clinical indicators in the study groups are shown in table 1. The groups were comparable by sex, age, physical status. Mass-index of body (MIB) in 1st group was significantly lower than in 2nd group ($p = 0.012$), which can be explained by the predominance in the main group of patients with extended esophageal strictures and severe dysphagia (80% in 1st group and 54% in 2nd group).

Table 1. The main clinical indicators of patient after subtotal resection of esophagus

Diagnosis	Group 1 (n = 29)	Group 2 (n = 28)	p
Scar stricture of esophagus	23 (80%)	15 (54%)	0,052
Cardiospasm/ achalsia of cardia, 4th	5 (17%)	11 (39%)	0,082
Damage of esophagus	1 (3%)	2 (7%)	0,611
Presence of gastrostomy	14 (48%)	8 (29%)	0,175
MIB	20,2±3,7	24,5±8	0,012
ASA III	16 (55%)	18 (64%)	0,555

For the purpose of comparative analysis, the following parameters were studied:

- preoperative demographic and clinical parameters (gender, age, class accruing ASA (American Society of Anesthesiologists), MIB);
- intraoperative parameters (duration of surgery, blood loss, intraoperative complications, and approach conversion rate);
- postoperative parameters (frequency of respiratory complications, anastomosis failure on the neck, total complication rate according to Clavien - Dindo classification) [13].

Mathematical and statistical processing of the data was carried out using the program "Excel" from the package "Microsoft Office" and the program SPSS (IBM) 25.0.0.0. The significance of the differences of the compared quantitative values for the data with normal distribution was carried out with the calculation of the mean value ($m \pm \sigma$) and Student criterion (t), for nonparametric data - with the calculation of the median (Me) indicating 25 and 75 percentiles (P25; P75) and using the Mann-Whitney criterion (U). The calculation of the significance of the qualitative differences were obtained using Fisher exact test or criterion of " χ^2 ". Differences were considered statistically significant at $p < 0.05$.

Surgical tactics

Traditionally the 1st Department of surgery (surgery of the esophagus and stomach) Federal state budgetary institution Petrovsky Research Center of Surgery in benign diseases of the esophagus "open" versions of the SRE with simultaneous plasticity of the gastric tube or segment of the colon (transhiatal or transthoracic) with the formation of the anastomosis on the neck was performed. Since 2013 video endoscopic techniques have been introduced into the practice of the Department, starting with

thoracoscopic mobilization of the esophagus at the stage of its subtotal resection and finishing with laparoscopic-assisted esophagoplasty.

All patients with benign diseases of the esophagus were undergone a comprehensive examination, the mandatory elements of which were x-ray contrast and endoscopic examination of the upper gastrointestinal tract, chest x-ray, spirometry, electrocardiography, irrigography. According to the indications, multispiral computed tomography of the chest organs and fibrobronchoscopy were additionally performed. Patients with severe violations of the nutritional status (MIB less than 18.5 kg/m², albumin less than 30 g/l) were mandatory preoperative enteral and parenteral preparations. Since 2014 in order to reduce the frequency of complications and early rehabilitation of patients after surgery the Department has introduced a standardized Protocol of perioperative management [14], based on the principles of the program of accelerated recovery (fast track surgery).

Thoracoscopic stage

As in open surgery videoendoscopic SRE was the first stage of the operation of the three during reconstructive operations for benign diseases of the esophagus. The operation was performed in the position of the patient on the abdomen (prone position). The left hand was brought to the body, the right hand was moved aside at an angle of 80-100°. The operating surgeon was located to the right of the patient, the assistant (camera) - to the left of the surgeon, the operating sister - in the legs to the right of the patient. Currently, most often the thoracoscopic stage is carried out without the participation of the second assistant, but if necessary additional traction of the esophagus during its mobilization it was located to the right of the operating surgeon. Endoscopic rack Karl Storz (Karl

Storz SE & Co KG., Germany) was used for video endoscopic SRE, side optics camera, ultrasonic scalpel Harmonic Ethicon (Ethicon Endo-Surgery, Johnson & Johnson, USA).

Standard 3 thoracoports were located in the following sequence (figure 1):

- first thoracoport (10 mm, for camera) was integrated into the 5-6th intercostal space to the right, immediately below the angle of the scapula. Examination of the right pleural cavity for the presence of adhesions, mooring was performed. The

insufflation gas was used only when necessary to further collaborative easy;

-the second thoracoport (10 mm) was installed under the control of a video camera in the 8th intercostal space along the posterior axillary line;

-in the 4th intercostal space a third (5 mm) thoracoport was installed along the spatula line. If additional traction of the esophagus was necessary one more 5 mm port was installed along the paravertebral line in the 7th intercostal space.



Figure 1. Localization of the thoracoports

Mobilization of the esophagus was begun from its middle third using a monopolar L-shaped electrode. The mediastinal pleura was dissected, the esophagus was mobilized with surrounding tissue from the diaphragm to the upper aperture of the chest. To mobilize the esophagus in the upper third of the Vena azygos was cut using a sewing machine Series Echelon Flex™ Endopath (Ethicon Endo-Surgery, Johnson & Johnson, USA) with vascular tape. The esophagus in the chest cavity was not cut. After controlling hemostasis the thoracoscopic phase of the operation was completed by drainage of the right pleural cavity with a single drain No. 18 through a puncture in the 8th intercostal space, thoracoport was removed under camera control, the wound was sutured. The patient was turned to a back position with the head turned to the right for further abdominal and cervical stages of the operation.

Abdominal stage

A median laparotomy and revision of organs of abdominal cavity were performed. The left lobe of the liver and the abdominal esophagus with sagittal diaphragmatic were mobilized. In the presence of gastrostomy, the latter was cut off, the hole in the stomach was sutured with a two-row suture. After assessing the possibility of reconstruction using a gastric tube mobilization of the stomach with preservation of blood supply to Arteria gastroepiploica dextra was performed. The esophagus was cut on the L-shaped clamp. With the help of linear cross-linking devices, an isoperistaltic narrow gastric tube of sufficient length was formed, a mechanical seam was additionally covered with a single-row suture (Vicryl 3/0, Ethicon, USA).

During the plastics segment of the large intestine the caecum, ascending, descending and sigmoid colon

were mobilized by dissection of the peritoneum ligament, hepatic angle – the intersection of the colonic-renal and colonic-duodenal ligament, splenic angle – the intersection of the colonic-diaphragmatic ligament, transverse colon – separation from the gastrointestinal ligament. Mandatory appendectomy was performed (if it was not performed earlier). After test cross-clamping of the vessels with soft clips the colonic graft of sufficient length (often from the left half with the preservation of the blood supply to Arteria colica media) was formed. The continuity of the colon was restored with double-row anastomosis "end to end". The graft was performed through the hole created in the small omentum and the "end-to-side" type of cologastroanastomosis was formed with the anterior wall of the antral region in the transverse direction.

The operation was completed by drainage of the abdominal cavity with 2 silicone drains №24. For conducting early enteral nutrition in 30 cm from the ligament of Treitz the pendant microjejunostomy of Witzel- Eiselsberg, was formed on drain No. 12. The laparotomic wound was sutured in layers.

Cervical stage

A skin incision along the Muscle sternocleidomastoideus sinister the cervicotomy was performed. The cervical part of esophagus was isolated from the surrounding tissues, completing the final mobilization of the esophagus. The mobilized part of the esophagus was "removed" into the wound on the neck, simultaneously placing the formed gastric tube in the posterior mediastinum. During the plastic segment of the colon the graft was placed behind sternum forming a tunnel with spoons Yudin. Hand esophagostomy "end-to-end" was formed

with discrete single-row sutures or a non-interrupt suture (Vicryl 3/0, Ethicon, USA) on the large probe, one silicone drainage paper No. 18 was set, the wound was sutured in layers.

Thoraco-laparoscopic Subtotal resection of the esophagus

Since 2016 the Department started performing thoraco-laparoscopic SRE, now it is 9 operations. After thoracoscopic SRE the patients were transferred to the "reverse" position of Trendelenburg with divorced legs to perform the laparoscopic stage. The operating surgeon was located between the legs, assistants-to the right and left of the patient. Laparocentesis was performed above the navel with the use of the Veress needle. After applying carboxyperitoneum, 12.5 mm trocar was installed for the camera. Further, under the visual control the fan-shaped 4 working trocar were installed at standard points. The operation was carried out with intra-abdominal pressure of 10-12 mm Hg. After the examination of the abdominal cavity the mobilization of the stomach and abdominal esophagus were performed using an ultrasonic scalpel Harmonic Ethicon (Ethicon Endo-Surgery, Johnson & Johnson, USA). After cutting the esophagus the gastric tube was formed extracorporally through the upper-middle mini laparotomy (4-5 cm). The cervical stage was performed according to the previously described scheme. Abdominal stage was also completed with the formation of microjejunostomy and two abdominal drainages, suturing wounds.

RESULTS:

The characteristics of operations performed in patients from our study are presented in table 2.

Table 2.Character of performed operations in examined groups of patients

Operation (approach)	Group 1 (n = 29)	Group 2 (n =28)	p
Thoracoscopic SRE	20 (69%)	-	-
Thoracoscopic SRE with laparoscopic-assisted plastic	9 (31%)	-	-
Transthoracic SRE ("from 3 approaches")	-	8 (28%)	-
Transchiatic SRE	-	19 (68%)	-
Transthoracic SRE + gastrectomy	-	1 (4%)	-
Variety of esophagus plastic			
With gastric tube	23 (75%)	24 (92%)	0,730
With segment of colon	6 (25%)	4 (8%)	

The conversion of the approach was performed in 1 patient (3,4%) with extended burn stricture of the esophagus due to technical difficulties during mobilization of the esophagus because of pronounced periesophageal, and in 1 patient (3,4%) with

cardiospasm of stage 4 during significant expansion and lengthening of the esophagus with a narrow chest. All were in the 1st group.

Intra-and postoperative parameters are given in table 3.

Table 3: Postoperative complications in examined groups of patients

Indicators	Group 1 (n = 29)	Group 2 (n = 28)	P*
Complications according Clavien – Dindo, the 2nd degree	11 (38%)	21 (75%)	0,017
Respiratory complications	5 (17%)	14 (50%)	0,012
pneumonia	3 (10%)	10 (36%)	0,029
pneumothorax	2 (7%)	2 (7%)	1
hydrothorax/ pleuritis	1 (3%)	2 (7%)	0,611
chylothorax	0	2 (7%)	0,236
subcutaneous emphysema	0	1 (4%)	0,491
empyema of pleura/ mediastinitis	0	1 (4%)	0,491
exacerbation of tracheobronchitis	3 (10%)	3 (11%)	1
thromboembolism of pulmonary artery	0	0	-
Paresis of vocal chords	2 (7%)	3 (11%)	0,670
Несостоятельность пищеводно-желудочного/пищеводно-кишечного анастомоза Failure of esophageal-gastric/esophageal-intestinal anastomosis	9 (31%)	11 (39%)	0,585
Heart rhythm disturbance	3 (10%)	5 (18%)	0,470

Notice. * p was accounted with note of criteria of Fisher

The average duration of surgery (for all patients) in 1st group was 510 (395-562) minutes, in 2nd group – 337 (258-450) minutes (p = 0.002), when performing transthoracic interventions – 447 (390-540) and 470 (382-700) minutes, respectively (p = 0.317). The duration of the transthoracic stage in 1st group was 140 (101.5-157.5) minutes, in 2nd group (only for SRE " of 3 approaches" (n = 9; 45%) – 137 (97,5-203) minutes (p = 0.499). With the accumulation of experience the minimum duration of thoracoscopic SRE was reduced to 63 minutes, the duration of the entire surgery – to 300 minutes, in 2nd group these indicators were 85 and 350 minutes, respectively.

The average volume of intraoperative blood loss in 1st group was 250 (112-337) ml, which was significantly lower than in 2nd group (400 (300-600) ml) (p = 0.01). Intraoperative complications that required

conversion of approach were not noted. In 3 patients of 1st group (10%) bleeding from the place of thoracoport installation in the 5th intercostal space was the hemostasis was achieved by coagulation.

Postoperative complications in the studied groups of patients are shown in table 3. There were significant differences in the total number of complications and the incidence of respiratory complications (pneumonia, pneumo- and hydrothorax, exacerbation of tracheobronchitis). The frequency of other complications including the failure of anastomosis on the neck and paresis of the vocal cords were not differed in the groups. There were no cases of death.

DISCUSSION:

The use of video endoscopic surgical techniques in the course of SRE is aimed for decreasing the trauma of approach achieving a better cosmetic effect,

reducing the frequency of complications, primarily from the respiratory system, as well as reducing the time of hospitalization of patients with the possibility of their earlier postoperative rehabilitation [7; 12; 15]. Unfortunately, in the literature the results of the use of video endoscopic SRE in benign diseases are insufficiently covered, the problems of treatment of patients with esophageal cancer are much more often covered [16; 17].

Traditionally methods of subtotal resection of the esophagus are divided into transthoracic (with thoracotomy) and transhiatal (without thoracotomy with access to the esophagus from the abdominal cavity). A similar approach can be applied to video endoscopic techniques of subtotal esophageal resection [18].

In our study all operations in 1st group, both in esophageal strictures and in terminal stages of neuromuscular diseases, were successfully performed using transthoracic thoracoscopic approach, including 9 cases supplemented with laparoscopic-assisted esophagoplasty.

According to Chernousov A. F. implementation of SRE in patients with extensive burn strictures of the esophagus is technically more difficult than esophageal cancer due to the development of periesophagitis [2]. In our study in most cases the thoracoscopic SRE in esophageal strictures was performed without technical difficulties, but in 1 case in a patient with total burn stricture the severity of periesophagitis, involvement of the trachea and the right main bronchus in the scar process was the reason for the conversion of approach due to the impossibility of clear differentiation of tissues in the absence of tactile sensitivity, which is confirmed the data of other authors [5].

When performing SRE for cardiospasm and achalasia of the cardia the transhiatic approach with further formation of the gastric graft is traditionally used [2; 6; 19], however, there are reports of the use of thoracoscopic SRE [20; 21]. It is known that with stage 4 of cardiospasm, the size of the esophagus and its length can be significantly increased, which makes it difficult to isolate the esophagus with video endoscopic technique. In our study a significant expansion of the esophagus in stage 4 of cardiospasm (esophagus significantly elongated, S-shaped deformed, expanded more than 10 cm) in a patient with a "narrow" chest created significant difficulties for adequate mobilization of the posterior wall of the esophagus, in connection with which it was decided to carry out approach conversion.

We would like to note that the need for open surgery in patients in these two cases of conversion was due to the characteristics of benign diseases of the esophagus, without the development of intraoperative complications. The frequency of paresis of the vocal cords and chylothorax in the groups were not differed, which allows us to evaluate the video endoscopic SRE as an effective and safe procedure.

Back in 2010 Hamouda et al. have demonstrated a significant reduction in the operation time during video endoscopic SRE when compared with the "open" Ivor-Lewis operation ($p = 0.006$), but it is still believed that this technique is lasted longer than open intervention [22; 23]. In our study the average duration of surgery (for all operations) in 1st group was significantly longer, while the average duration of transthoracic intervention in the groups did not differ statistically ($p = 0.317$), although it was less in the group of thoracoscopic SRE. It should be noted that with the accumulation of experience the duration of both the thoracoscopic stage and the entire operation was reduced to a minimum of 63 minutes for thoracoscopic SRE and 300 minutes for all 3 stages of the operation.

In our opinion such results can be explained by the fact that both thoracoscopic and thoraco-laparoscopic interventions ($n=9$) were performed in the main group, and the increase in the average duration of surgery may be due to the stage of development of video endoscopic techniques. At the same time the 2nd group was dominated by transhiatal SRE (68%), which is always less long due to the absence of the need to change the position of the patient on the operating table. In addition the esophagoplasty by the colon segment was performed more frequently in 1st group (21% in 1st group and 14% in 2nd group), which also extended the total time of surgery.

We would like to emphasize that the duration of surgery not always depends on the technical skills and abilities of the operating surgeon. Significant factors affecting the duration of surgery in the performance of SRE in patients with benign diseases are considered as the presence of adhesions in the pleural cavity and mediastinum (periesophagitis), as well as changes in the size of the esophagus and its deformation.

In the study of Cuschneri A. et al. in 1992, for the first time, the positive effect of video endoscopic methods of surgery on the incidence of respiratory complications in the performance of SRE was demonstrated, and later these results were confirmed in several studies, including our [8; 17]. We believe that the decrease in the frequency of respiratory

complications during video endoscopic SRE can be explained by several factors, which include the position of the patient on the abdomen during the transthoracic stage, less trauma to the tissues and the chest frame, the use of 1 drainage instead of 2 (unlike lateral thoracotomy), which leads to a decrease in the severity of postoperative pain syndrome and allows for early activation of patients. It is also important to increase the possibility of implementing the Protocol of the accelerated recovery program in this category of patients. [14]. In our opinion, the change of approaches to postoperative management of patients after esophagoplasty using early activation, active rehabilitation, as well as the rejection of unjustified long-term follow-up in intensive care department (the minimum period of observation of the patient in the intensive care unit in our study in 1st group was less than 12 hours) plays an important role in reducing the frequency of postoperative complications.

SUMMARY:

- 1) video endoscopic methods of operations in the treatment of patients with benign esophageal diseases are safe and effective;
- 2) thoracoscopic subtotal resection of the esophagus can be used in patients with esophageal strictures and in the terminal stages of neuromuscular diseases;
- 3) video endoscopic techniques are accompanied by less intraoperative blood loss and the frequency of postoperative respiratory complications.

CONCLUSION:

The use of video endoscopic SRE is not inferior to the "open" methods and can be considered as an effective alternative to open operations during SRE in patients with benign diseases of the esophagus, as it is accompanied by less intraoperative blood loss and reduces the frequency of postoperative respiratory complications

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