Improvement of surgical methods for the treatment of spontaneous rupture of the esophagus complicated by purulent mediastinitis

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Abstract

Aim. To improve surgical treatment outcomes of patients with spontaneous rupture of the esophagus complicated by purulent mediastinitis.

Methods. Over the past 30 years, we have experience in the surgical treatment of 31 patients with spontaneous rupture of the esophagus complicated by purulent mediastinitis. Depending on the tactics and techniques of surgical treatment, we identified two groups of patients. The first group (n=8) consisted of patients operated with conventional techniques: thoracotomy, transpleural mediastinotomy according to Dobromyslov, suturing of the esophagus with drainage of the mediastinum and pleural cavities, "blind" mediastinal drainage. The second group (n=23) consisted of patients treated with "programmed re-thoracotomy". Re-thoracotomy was performed along with the postoperative thoracotomy wounds. The delimited foci of purulent mediastinitis were opened and sanitized (necrotic tissues were excised and removed). Preventive hemostatic methods were used in the area of pressure ulcers from drainage tubes. Replacing and changing the position of the drainage tubes in the mediastinum was a strictly compulsory technique. Pus and necrotic soft tissue that appeared in the thoracotomy wound were subsequently eliminated by a device consisting of two titanium brackets connected by a lock embodied in the form of an oval ring during the wound suturing at the stage of programmed re-thoracotomy. The groups were comparable in age and comorbidities. The average diagnosis of spontaneous esophageal rupture took 3.5 days; the maximum time is 10 days. The statistical significance of differences in immune status indicators was assessed by using the Student's t-test and Pearson's χ^2 test.

Results. A systematic approach using the tactical and technical surgical techniques developed by us (such as suturing esophageal wall defects regardless of the rupture time, multifunctional nasoesophagogastric tube installation; the imposition of a purse string suture to prevent reflux from the stomach into the esophagus; programmed re-thoracotomy using the method of temporary fixation of the ribs) allowed to reduce the number of complications, such as haemorrhage from the mediastinal vessels, by 3 times, sepsis — 1.5 times, mortality — almost 2 times.

Conclusion. The introduction of patented techniques allowed to reduce the number of life-threatening complications and mortality in patients with spontaneous rupture of the esophagus complicated by purulent mediastinitis.

Keywords: spontaneous rupture of the esophagus, Boerhaave's syndrome, purulent mediastinitis.

Background. Spontaneous rupture of the esophagus (SRE; the International Classification of Diseases code K22.3), a non-traumatic rupture of all layers of the wall of the previously intact esophagus, was described in 1724 by Hermann Boerhaave (1668−1738). He discovers a rupture of the lower third of the esophagus during the autopsy of the body of the Grand Admiral of the Dutch naval forces Gerrit-Jan van Wassenar who died of mediastinitis [1].

The key factor in a successful treatment is the period from the SRE to the provision of surgical care in a specialized department. On day 1, the diagnosis of SRE was made in 37.8% of patients [2]; and accordingly [3], the time to surgical treatment was late in 37%. According to different authors,

the terms of admission to the hospital varied from 8 hours to 9 days [4]; from 10 hours to 11 days, averaging 3−3.5 days [5], 15.5 hours [6], 3 hours to 4 days (on average 16.7 hours) [7], and 2.4 days [8]. Thus, surgical interventions for SRE are performed with a great delay.

Currently, no generally accepted treatment algorithms are available for SRE [9]. If the surgery is delayed for >24 hours, then the risk of an unfavorable outcome exceeds 50%, and up to 90% of patients die if the preoperative period exceeds 48 h [10, 11]. The mortality rate among patients with a delayed diagnosis was 40% [9].

Colleagues from the USA proposed a schematic but correct ratio of the mortality rate and the time to start treatment for mediastinitis, where the mortality rate is 12.5% within the first 6 h after the thoracic esophageal rupture, 25% in 6–12 h, 50% in 12–24 h, and 100% after 24 h [12].

Suturing the esophagus is possible only within the first 6 h. In all cases, the surgery of choice should be covering the rupture with a cuff from the stomach fundus [13]. There is an opinion about the need to suture the defect of the esophagus at any time [11]. When choosing the approach of surgical treatment of SRE, some authors prefer drainage surgeries [14], while others [15] believe that the prognosis is significantly improved with a suture of the esophagus. The modern approach involves thoracotomy, esophageal suturing, and drainage of the mediastinum and the pleural cavity [16].

Surgical treatment results are certainly determined by the prevalence of infection with para-esophageal tissue of the mediastinum, and it increases the probability of lethal outcome several times [17]. Insufficiency of esophageal sutures developed in 40% of patients on days 5−6 of the postoperative period [18]. According to the authors [4, 13], purulent complications in SRE are registered in 80% of patients.

Treatment difficulties and prognosis in SRE are caused by purulent mediastinitis. Mediastinitis (International Classification of Diseases code J85.3), which is an "abscess of the lung and mediastinum" with life-threatening consequences, does not tend to decrease [16, 19]. The rate of failure of lavage of purulent cavities in the mediastinum, as a method of drainage, reaches 50% [12]. The cellular space of the posterior mediastinum in undrained zones acquires the form of a "honeycomb" with multiple small abscesses. They cause arrosive bleeding from the aorta or its branches after 3−4 weeks. Such bleeding is also caused by necrosis of their walls due to mechanical prolonged pressure of the adjacent drainage tubes [12]. These two reasons for purulent mediastini-

Table 1. Distribution of patients depending on the time from the moment of esophageal rupture to the provision of specialized surgical care.

Time, h	Group 1 (n = 8)		Group 2 (n = 23)	
	n	%	n	%
6–12	1	12.5	1	8.7
12–24	2	25	6	26.1
>24	5	62.5	16	69.6

tis account for more than half of the cases of arrosive bleeding.

All connective tissue bridges must be separated for complete sanitation of the cellular spaces of the neck [20]. This most important technique for sanitizing the cellular space of the mediastinum during drainage is not performed. Multicenter studies revealed that resection of the esophagus under conditions of inflammatory mediastinal infiltration ends in 30%–60% complications and mortality [12, 21], thus it has not become widespread. "Shutdown of the esophagus" with esophagogastric- or jejunostomy, which subsequently requires difficult reconstructive surgeries, also was not supported [21–25].

Therefore, the treatment of SRE is undoubtingly focused on the need to preserve the esophagus, prevent the esophageal suture failure, and sanitize the cellular space of the mediastinum with a change in the drainage tube location.

Thus, this study aimed to search for surgical methods to reduce the number of life-threatening complications and mortality in SRE that are complicated by purulent mediastinitis.

Materials and methods. The study was conducted from 1991 to January 2021. Over the past period, 31 patients with SRE that is complicated by purulent mediastinitis were hospitalized in the department of thoracic surgery of the Novgorod Regional Clinical Hospital.

Two groups of patients were identified based on the approach and technical methods of surgical treatment. Group 1 consisted of 8 patients who are treated using conventional technologies (1991–2002). Group 2 consisted of 23 patients who are treated using technologies patented by us (2003–2021). It took 3.5 days on average to make the diagnosis of SRE, with a maximum period of 10 days.

Table 1 presents the distribution of patients based on the time from the moment of the esophageal rupture to the provision of specialized surgical care.

Patients were distributed depending on the diagnoses; thus, the perforated gastric ulcer was registered in 24.20% of cases; acute pancreatitis in 24.20%; pleuropneumonia in 10.3% of cases; spon-

Table 2. Distribution of patients with concomitant chronic diseases in the study groups.

Concomitant chronic diseases (by organs and systems)	Number of cases ($n = 59$)				p
	Group 1 ($n = 18$)		Group 2 ($n = 41$)		
	n	%	n	%	
Respiratory organs	6	33.3	12	29.3	0.7127
Circulatory organs	10	55.6	20	48.8	0.9156
Digestive organs	5	27.8	12	29.3	0.7705
Urinary organs	3	16.7	6	14.6	0.9685
Nervous system	1	5.6	3	7.3	0.7539
Endocrine system	1	5.6	4	9.8	0.9685
Musculoskeletal system	1	5.6	2	4.9	0.7539

taneous pneumothorax in 13.70%; pyopneumothorax in 10.30%; and SRE in 17.30% of patients.

The groups of patients were comparable in terms of age (44.0 ± 3.1 and 44.6 ± 2.0 years, $p = 0.406$) and the nature of concomitant pathology (Table 2).

In group 1, surgeries were performed in the form of "blind" drainage of the mediastinum, thoracotomy, transpleural mediastinotomy, and esophageal suturing with drainage of the mediastinum and pleural cavities.

The surgery technique is as follows. Lateral thoracotomy was performed in the intercostal space 5–6. In 1 out of 8 cases, thoracotomy was performed on the right (12.5%) since the defect was located on the right wall in the lower third of the esophagus and there was purulent pleurisy on the right in addition to purulent mediastinitis. The criteria for choosing the side of thoracotomy include topographic and anatomical rupture site location, the presence of purulent complications from the pleural cavity, and the supposed technical advantages of access. The lung was pushed anteriorly, and the mediastinal pleura was widely dissected. The wound defect in the esophagus was tightly sutured with interrupted sutures (vicryl 2/0) with the mucous membrane and with nylon interrupted sutures with the muscle wall. The pleural cavity was thoroughly washed with an antiseptic solution and drained. A double-lumen drainage tube was installed along the esophagus in the mediastinum, which was led out through a separate incision to the anterior chest wall along the diaphragm slope. The thoracotomy wound was sutured.

Purulent pleurisy (62.5%) and pneumonia (50%) were frequent complications. Esophageal suture failure was registered in 4 (50%) patients, of whom 3 (75.0%) died and 1 had an esophageal-pleuro-thoracic fistula. Additionally, unarrested purulent-necrotic inflammation of the mediastinal tissues and arrosive bleeding from the mediastinum vessels were revealed in 25.0% of cases each, as
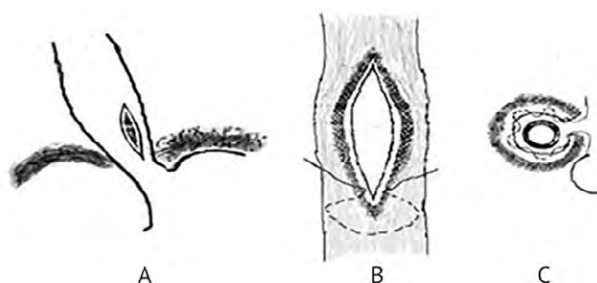

Fig. 1. Scheme of a purse-string intraluminal suture on the mucous membrane of the esophagus through a defect in its wall.

well as purulent-necrotic inflammation of the thoracotomy wound with the same number of cases. Sepsis was recorded in 12.5% of cases and multiple organ failure in 12.5% of cases. Lethal outcomes were observed in 4 (50%) patients.

The causes of mortality in group 1 include arrosive bleeding (50%) and purulent-septic complications (50%).

These life-threatening complications prompted us to develop techniques for the prevention and treatment of such SRE complications (patent RU No. 2274422 C1 dated 05/21/2004) [26].

In group 2, right-sided thoracotomy was performed in 3 (13.0%) patients, whereas access was in the form of left-sided thoracotomy (87.0%) in the remaining patients (21 patients).

Before suturing the defect in the lower third of the esophagus through it from the inside, a purse-string suture was applied to the mucous membrane below the wound using absorbable suture material ("common" catgut with an atraumatic needle, USP = 3/0), which was tied around the probe (Fig. 1).

In any condition of esophageal trauma, preserving it is necessary since esophagectomy and subsequent reconstructive surgeries bear a high risk for the patient.

To ensure adequate drainage and sanitation of the lumen of the lower third of the thoracic esophagus and ensure enteral nutrition of the patient,
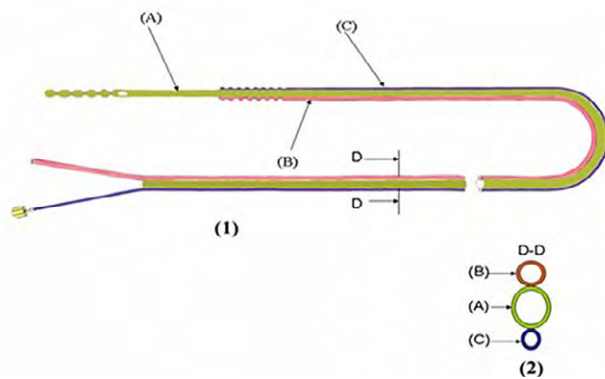
Fig. 2. Scheme of the nasoesophagogastric probe.

Fig. 3. The technique for preventing suture failure when suturing a defect in the lower third of the esophagus.

we have developed a three-lumen multifunctional nasoesophagogastric tube consisting of three silicone tubes glued together along the longitudinal axis. Tube 1 (A) with a diameter of 10 Fr on the Charriere scale is used as a nasogastric part of the tube and provides enteral nutrition to the patient. Tube 2 (B) with a diameter of 4 Fr is intended for the aspiration of esophageal contents. Tube 3 (C) with a diameter of 1 Fr serves as an inspiratory part and provides antiseptic liquid irrigation into the esophageal lumen.

The tubes are connected so that the distal ends of tubes 2 and 3 are at a distance of 22 cm from the distal end of tube 1. The distal end of tube A has 10 holes around the circumference of the tube, and most importantly, this section should be in the stomach. The distal ends of tubes B and C have 8–10 holes located on the free lateral surfaces. The distal ends of tubes B and C should be located at the level of the sutured wound of the esophagus (Fig. 2, 3).

Probe characteristic:
– the total length was 80 cm;
– the length of the proximal end of the nasogastric part was 22 cm;
– the length of the aspiration part was 70 cm;
– the length of the inspiration part was 70 cm;
– the diameter of the nasogastric tube (A) was 10 Fr on the Charriere scale;
– the diameter of the aspiration tube (B) was 4 Fr on the Charriere scale;
– the diameter of the inspiration tube (C) was 1 Fr on the Charriere scale.

Rethoracotomy (re- + thoracotomy) is repeated thoracotomy with pleural cavity opening by separating the edges of the previously sutured surgical wound. We would like to clarify our opinion on this concept. We repeatedly enter the pleural cavity, thus the prefix "re" is quite justified, and "thoracotomy" does not indicate the essence of this intervention since we do not perform any incision,
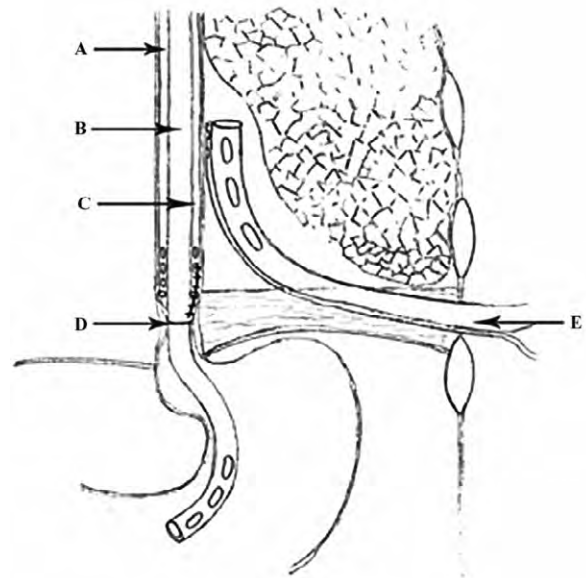
we only move the ribs apart for further surgical intervention. We have developed and implemented a method for the surgical treatment of diffuse purulent mediastinitis to improve the results of surgical treatment in patients with purulent mediastinitis (patent No. RU 2318454 C1 dated 03/10/2008) [27].

The number of programmed rethoracotomies in the treatment of SRE complicated by mediastinitis was:
– 2–4 in 7 (31%) patients;
– 5–8 in 12 (52%) patients;
– 9–11 in 4 (17%) patients.

Results. Complications were registered in the postoperative period in group 2, which were distributed as presented in Table 3. In 2 (8.7%) patients, arresting the purulent-necrotic inflammation of the mediastinal tissues was impossible, which subsequently caused arrosive bleeding. The greatest number of complications in group 2 was caused by purulent-septic inflammation of the thoracotomy wound (43.5%). These complications were represented by wound suppuration, necrosis of the soft tissues of the chest, and osteomyelitis of the ribs. The increased complications in the thoracotomy wound resulted from multiple rethoracotomies. All this indicated the need to develop measures aimed at improving the safety of programmed rethoracotomy.

Therefore, a method of temporary fixation of the ribs during programmed rethoracotomy and a device for its implementation have been developed (patent No. RU 2474389 C1 dated 05/25/2011) [28]. Thus, we have formed two subgroups, IIA and IIB, in group 2 (Table 4).

Table 4 presents that the incidence of complications in the skin, subcutaneous tissue, and ribs was

Table 3. The comparative analysis of the incidence of complications in patients in the two study groups.

Types of complications	Group 1 (*n* = 8)		Group 2 (*n* = 23)		p
	Number of complications		Number of complications		
	n	%	n	%	
Arrosive bleeding	2	25.0	2	8.7	0.0424
Purulent pleurisy	5	62.5	8	34.8	0.0641
Pneumonia	4	50.0	7	30.4	0.0837
Inconsistency of esophageal sutures	4	50.0	3	13.0	0.0313
Purulent-necrotic inflammation of the thoracotomy wound tissue	2	25.0	10	43.5	0.0598
Unrelieved purulent-necrotic inflammation of the mediastinal tissues	2	25.0	2	8.7	0.0424
Multiple organ failure	1	12.5	3	13.0	0.5937
Sepsis	1	12.5	3	13.0	0.9056

70.0% (subgroup IIA) before the implementation of the patented method of chest wall wound suturing. Afterward, it decreased to 23.1% (subgroup IIB). All this ultimately contributed to the elimination of signs of progression of the purulent-inflammatory process of the thoracotomy wound tissues.

The number of deceased patients was 6 (26.1%).

In group 2, multiple organ failure (50.0%) ranked first among the causes of mortality, followed by sepsis (33.3%) and arrosive bleeding (16.7%). Of 4 clinical cases with multiple organ failure as the main cause of death, 2 (50%) had no signs of mediastinitis during autopsy. Concurrently, using the method of programmed rethoracotomy and temporary rib fixation, we were unable to interrupt the mechanism of multiple organ failure in these patients.

The comparative analysis of the incidence of complications in patients in the two study groups (Table 3) revealed that purulent pleurisy was the most frequent complication (62.5% and 34.8%, respectively) in both groups. Concurrently, this indicator decreased by 27.7% in group 2 that is, almost by 2 times.

Pneumonia ranked second and was registered in 50.0% and 30.4% of patients in groups 1 and 2, respectively. This type of complication was also 19.6% less common in patients of group 2.

The failure (partial) of the esophageal sutures among patients of group 2 was detected in 3 (13.0%); the defect was sutured during rethoracotomy in 1 case and an esophageal-pleuro-thoracic fistula was formed in 2 cases. Recovery was noted in all cases.

The most severe and life-threatening complications include the unarrested purulent-necrotic inflammation of the mediastinal tissues and, as a result, arrosive bleeding from the mediastinal vessels

Table 4. The number of cases with purulent-necrotic complications in group 2 is based on the method of suturing the thoracotomy wound (subgroups IIA and IIB).

Complication	Number of clinical cases (*n* = 23)			
	IIA (*n* = 10)		IIB (*n* = 13)	
Purulent-necrotic inflammation of the tissues of the thoracotomy wound	n	%	n	%
	7	70.0	3	23.1

was detected in 25.0% and 8.7% of patients in group 1s and 2, respectively. Thus, the number of life-threatening complications decreased by 2.9 times.

Concurrently, it should be emphasized that due to the increased number of rethoracotomies in group 2, the number of purulent-necrotic inflammation of tissues of the thoracotomy wound was >25.0% and 43.5% in groups 1 and 2. That is, we detected an increase in such types of complications as suppuration of a thoracotomy wound, necrosis of the soft tissues of the chest, and osteomyelitis of the ribs by 18.5%.

A patented method of temporary fixation of the ribs when performing a programmed rethoracotomy was introduced to eliminate this fact. Comparative data in two subgroups (IIA used the method of programmed rethoracotomy and IIB the methods of programmed rethoracotomy and temporary rib fixation) showed the following. The frequency of complications in purulent-necrotic inflammation of the thoracotomy wound tissues was 70.0% in subgroup IIA before the introduction of the patented method of suturing the chest wall wound, then it decreased to 25.0% in subgroup IIB after the introduction of this method that is, by 2.8 times.

When conducting a comparative analysis of the causes of mortality in the two study groups

Table 5. The comparative analysis of the causes of mortality in the study groups.

Cause of mortality	Number of deceased patients (n = 10)			
	in the group 1 (n = 4)		in the group 2 (n = 6)	
	n	%	n	%
Arrosive bleeding	2	50.0	1	16.7
Sepsis	2	50.0	2	33.3
Multiple organ failure	—	—	3	50.0

(Table 5), mortality was 50.0% in group 1 and 26.1% in group 2. The main causes of mortality in group 1 were sepsis and arrosive bleeding from the mediastinal vessels (50.0%) since the installed drainage tubes in a certain position, especially for a long time, contributed to the formation of pressure ulcers in the thoracic aorta wall and/or its branches. Mortality from sepsis in group 2 was 1.5 times lower (33.3%) and mortality from arrosive bleeding was 3 times lower (16.7%).

Table 3 indicates that 50% of patients from group 2 died from complications, such as multiple organ failure. We intend to explain this aspect by the fact that in group 2, life-threatening complications were less common, and they "live" to multiple organ failure due to hospital pneumonia with respiratory failure and the addition of insufficiency of the circulatory system and/or hepatic-renal or other systems.

In group 1, 3 (75.0%) patients were deceased and 4 (66.7%) in group 2; of whom, the time from the moment of the esophageal rupture to the provision of specialized surgical care exceeded 24 h.

Discussion. A systematic approach using our developed approach and technical surgical methods, such as suturing an esophageal wall defect regardless of the rupture timing, installing a multifunctional nasoesophagogastric probe, applying a purse-string suture to prevent reflux from the stomach into the esophagus, and programmed rethoracotomy using the method of temporary fixation of the ribs, reduced the number of complications, such as arrosive bleeding from the mediastinal vessels by 3 times ($p < 0.05$) and sepsis by 1.5 times. The lethality has decreased by almost 2 times.

CONCLUSION

The implementation of patented techniques reduced the number of life-threatening complications and mortality in patients with a spontaneous esophageal rupture that was complicated by purulent mediastinitis.

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