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## SURGICAL TREATMENT OF POST-OPERATIVE STERNOMEDIASTITIS (LITERATURE REVIEW)

Postoperative sternomediastinitis is an infectious complication occurring after sternotomy with the sternal bone tissue and mediastinal tissues being involved into the infectious process, with the involvement or noninvolvement of superficial soft tissues and with the stable or unstable sternum. According to domestic authors [3], up to 8,000 reconstructive surgical operations for postoperative sternomediastinitis are performed annually in the developed countries. According to various sources, infectious complications occur up to 6.9% of cases [8]. Due to the rapid development of cardiac surgery in the late 20<sup>th</sup> century, the number of studies on postoperative sternomediastinitis has increased significantly. At present cardio-surgical patients are people of older age with multiple comorbid diseases determining a great number of risk factors, which lead to the complicated healing of surgically operated tissues. Postoperative sternomediastinitis morbidity increases the early in-hospital mortality to 7% as compared to patients having no inflammatory changes in the sternum with mortality rate of 1.8% [30], and the risk ratio of decreased long-term survival of patients after a deep sternal infection is 1.91 [30]. Postoperative sternomediastinitis aggravates the clinical status of the patient and increases the duration of the treatment, and the long-term expensive treatment of post-operative complications caused by cardiac surgery interventions makes us consider the economic dimension [15]. The cost of treatment of deep postoperative sternum infection doubles the cost of overall treatment of cardiac patients [15]. Thus in the US specialized centers this cost is about 500,000 dollars which even with an infection rate of less than 1% presents impressively high expenses for a country.

**Keywords:** thoracic surgery, postoperative sternomediastinitis, purulent complications of cardiac surgery

**Historical stages of treatment of postoperative sternomediastinitis.** First, sternomediastinitis was treated by an open method which included re-exploration and surgical revision of the wound with dressings of the wound applied constantly, and the expectation of

spontaneous closure of the wound with granulations followed by epithelization. The treatment took a long time. The mortality reached 50%, with the death usually being caused by the development of sepsis, bleeding or the direct damage to the heart inflicted by the sharp bone fragments or the edges of the sternum [31].

Later a surgical treatment of the wound was proposed in combination with the system of continuous flow irrigation of the wound with antibiotics or antiseptics, among which 0.5% povidone-iodine solution was most often used. According to the data of foreign authors [34], treatment with the system of continuous flow irrigation of the wound lasted 12.7 days on the average, with 87% of such cases recognized as being treated effectively, 13% of cases characterized by sternal

instability, and 13% of lethal cases due to deep infection.

Another technique suggested an open management after surgical treatment with further using a variant of musculoplasty, or with the preservation of the wound until complete granulation. In this case, the mortality rate reached 50%, and the development of a new technology for surgical treatment of the pathology in question was required.

In 1975, a radical surgical d-bridement of sternotomy wounds with myoplasty or omentoplasty but without continuous flow irrigation of the wound or open treatment were proposed, which decreased the mortality to 10% [14].

By the end of the XX-th century foreign researchers [22] offered a more active use of the surgical treatment technique applying reconstructive methods of

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plasty with muscle flaps or omentoplasty which allowed to decrease the mortality from 15.3% to 8.1%.

Gottlieb L.J. et al. [28] began to perform reosteosynthesis of the sternum using titanium microplates after the surgical treatment of the wound and a thorough sternum vascularization.

R. Wettstein et al. [26] performed a radical removal of the sternum along the cartilaginous joints of the ribs and the sternoclavicular joints using plastic surgery of the chest wall defect with flaps of the rectus abdominis muscle or the lat. His method resulted in early mortality of 5.1% and limited local complications in 44% of cases, which required minor surgeries. No recurrence of the disease was noted.

Later on, the risk for the recurrence of the disease in case of instantaneous surgical treatment was proven, and the double-staged treatment with reconstructive plasty after the wound infection resolution was recommended.

**Vacuum therapy.** In 1997, LC. Argenta and MJ. Morykwas [12] conjointly proposed negative pressure wound therapy for infected wounds, which in its turn, being used widely in clinical practice showed its efficacy and sufficient reliability in the management of wounds. Evenly distributed negative pressure provides complete drainage of the wound surface while the structure of the vacuum therapy system implies the restoration of the chest frame. The use of a porous material to fill the wound cavity allows the stress to be evenly distributed, bringing the wound edges closer together. At the same time, direct and complete contact of the bottom of the wound with the bandage, and the continuous removal of the wound discharge, stimulates metabolic processes in the tissues of the wound. As a result, swelling is reduced, creating faster wound clearance, reducing microbial colonization of the wound, and preventing recontamination from the skin.

Comparing the open method of treatment with the negative pressure wound therapy technique in patients with sternomediastinitis has confirmed that vacuum therapy accelerates decolonization of the infected wound, speeds up the decrease of C-reactive protein, reduces the mortality and shortens the treatment duration. Gorbunov V.A. et al. [9] carried out a comparative analysis of the continuous flow irrigation and drainage of postoperative sternomediastinitis method with the negative pressure therapy. The results of histological examination of wounds showed that during vacuum therapy, an

increase in the lymphoid-plasmacytic reaction of the tissue and the proliferation of the vessels of the microvasculature are observed by the end of the second week of treatment, which is clinically manifested by the cleansing of the wound and the formation of granulation tissue.

Atkins BZ et al. [16] propose to use the negative pressure treatment system as preparation for reconstructive surgery. The use of this technique makes it possible to preserve the sternum tissue and to perform sternum reosteosynthesis in 50% of patients in the future, with the average duration of vacuum therapy before the debridement of the infected wound being 26 days. Domestic authors [10] note that the use of vacuum therapy in preparation for the reconstructive stage of surgical treatment can reduce the treatment time in half.

Today, vacuum therapy is actively used as an intermediate stage before the reconstructive myoplastic stage of surgical treatment of the pathology under consideration, allowing preliminary preparation of the soft tissues of the wound and sternum for the forthcoming surgical intervention [16].

**Myoplasty in the treatment of postoperative sternomediastinitis.** Foreign authors in the 90s of the XX century [23] proposed to perform plastic surgery of the chest wall defect with flaps of the greater pectoral muscles in sternomediastinitis, while achieving satisfactory functional and cosmetic results. The close location to the wound, sufficient muscle volume, and low difficulty in isolating the flaps further led to the most frequent plasty of the defect in this area by the pectoral muscles.

However, in the case of an extensive defect of the chest wall, flaps of the greater pectoral muscles are not always sufficient, since the latter are over-tensioned, especially in the distal regions where a residual space is formed, which may result in the failure of reconstructive surgery and requires a combination of various vascularized flaps.

Depending on the degree and extent of the lesion of the sternum, some authors [18] proposed to perform additional plasty with a flap of the rectus abdominis muscle; less often the broadest muscle of the back (latissimus dorsi muscle) is used, and myoplasty with a scapular skin flap is possible.

**The role of the greater omentum in the management of postoperative infection of the anterior mediastinum and sternum.** In addition to the myoplastic reconstruction of the chest wall, plasty of the chest wall defect with a flap of the

greater omentum is carried out, especially in extensive defects of the chest wall.

A.B. Lee Jr. et al. [33] first proposed the use of the omentum in postoperative sternomediastinitis. Later on, omentoplasty found its application in the chest wall reconstruction and began to be actively used in thoracic surgery. The main advantages of the greater omentum are its big size, the ability to fill any cavities, a long pedicle and an abundant vascular and lymphatic network. However, Cartier R. et al. [11] revealed through experiment angiogenic activity of the omental lipid fraction stimulating the formation of new vessels in the ischemic tissue.

T. Krabatsch et al. [19] carried on the analysis of the omental flap vascularization in the postoperative period of the reconstructive surgery, which revealed the presence of vascular anastomoses of the advanced flap and surrounding tissues. At that, the greater omentum is characterized by a pronounced immunocompetent function, which makes it possible to isolate and eliminate the purulent process. Korymasov E.A. et al. [8] believe that the best method for reconstructive surgery stage in sternomediastinitis is omentoplasty in combination with a mesh implant.

R. Saltz [29] was the first to propose the laparoscopic extraction of the greater omentum flap with the aim of decreasing the injury rate, lowering the risk of postoperative complications and increasing cosmetic efficiency, the idea which was later developed by the domestic and foreign authors.

A.A. Pechetov et al. [5] presented their own results of step-by-step management of sternomediastinitis. The first step is to perform the surgical treatment of the wound with the resection of nonviable tissues, economical resection of the sternum, followed by the complex therapy including the use of antibiotics, treatment of concomitant pathology, local treatment of the wound with bacterial contamination control. Provided that the wound is macroscopically clean and the bacterial load is less than  $10^3$ , the second stage – final thoracomentoplasty with endoscopic harvesting of the greater omentum flap – is performed. The authors pointed out minor local complications in 2 (14.3%) of patients; there were no severe complications requiring repeated surgery. No recurrences of the underlying disease were noted.

**Complications of reconstructive surgery.** Despite the long experience of myoplastic and omentoplastic reconstructive operations for sternomediastinitis, the recurrence of chest wall wound

infection is still possible. Meta-analysis conducted by J.J. Van Wingerden et al. [24] highlighted reoperation rate associated with flap necrosis or recurrent infection from 3% to 18%, mortality rate reaching 29%, chronic pain syndrome noted in 50% of patients, and postoperative ventral abdominal hernia present in 5% of cases.

According to [35], recurrent hernia with the rate of up to 21% is the most frequently occurred disease on the donor's side after laparotomy harvesting of the greater omentum flap, which can significantly affect the patient.

PC. Pairolero et al. [25] analyzed the treatment of 98 patients. 79 patients with myoplasty with various muscle flaps were analyzed, in 4 patients with omentoplasty and in 15 patients with omentomyoplasty, when assessing long-term results of treatment (on average 4.2 years), recurrence of infection was noted in 26% of cases.

Kokhan E.P. [4] believes that the recurrence of sternomediastinitis is due to the insufficient removal of the affected tissues of the sternum and costal cartilages and that improved diagnostics and active surgical tactics are required when the disease process becomes chronic.

P.R. Ringelman et al [21] assessed the remote results of sternomediastinitis treatment using omentomyoplasty in 48 months on the average. The study revealed constant dull pain and discomfort in the chest and shoulders in 51% of patients, feeling of numbness and paresthesia in the anterior surface of the chest in 44% of patients, instability of the chest in 42.5%, and general dissatisfaction with the quality of life in 36% of patients who could not perform the actions they carried out before the primary surgery. Besides, 52% of patients failed to return to previous work.

**Current treatment of postoperative sternomediastinitis.** At present, the treatment of postoperative sternomediastinitis requires a complex multidisciplinary approach of cardiac surgeons, thoracic and plastic surgeons. Still there is no consensus on the most optimal surgical technique and a universal treatment protocol [17]. However all researchers agree that the early sternotomy wound exploration with an extensive surgical treatment of the affected tissues is necessary.

At present, the most prevalent management of sternomediastinitis is a two-stage treatment [6] including an early initial surgical debridement of the wound, preparation of the wound for reconstruction, more often using vacuum therapy, with the final stage consisting of recon-

structive surgeries preserving the sternum tissue or its complete removal. In case the bone tissue is preserved, the restoration of the sternum integrity is achieved by interrupted, Z-shaped or circlage sutures made with a surgical wire. Gorbunov V.A. et al. [9] also perform sternum reosteosynthesis using titanium nickellide clips with a memory effect. In case of the sternum tissue incompetence, reosteosynthesis is carried out with U-shaped sutures through the body of the sternum or cartilages on metal perforated plates. At this, the recurrence rate was 16.2%, while reoperations occurred in 5.4% of the observed cases.

According to domestic specialists [10], the extent of the sternum resection must be determined for each individual case depending on the degree of the sternal tissue and cartilages involvement into the inflammatory process, and the presence of concomitant pathology aggravating reparation of the bone. Belov Iu.V. et al. [10] very rarely recommend to resort to sternum extirpation with costal cartilages resection. The final stage of surgical intervention involves different types of myoplasty and omentoplasty with harvested flaps of greater pectoral muscle (pectoralis major) being used more often.

Carlesimo B. [20] reported positive remote results of myoplasty performed with flaps of pectoral muscles. Frequently enough the rectus and the lat are used for plasty of the sternal defect, while for the prevention of seromas, tissue adhesive was proposed for use at the point of flap harvesting. V.V. Golovtsev et al. [2] offered to combine cellular implants with myoplasty in case of an extensive defect of the chest wall after removal of the sternum.

Domestic authors [1] use deepithelialized fasciocutaneous flaps of the chest wall for sternal defects plasty. In superficial forms (osteomyelitis of the sternum and the ribs), E.A. Korymasov et al. [8] performs limited sequestrectomy and removal of ligatures, with further wound healing occurring by secondary intention. In deep forms, debridement of the mediastinum is carried out using vacuum therapy, and depending on the result of the wound cleansing the pus pocket is opened widely which leads to the adequate drainage of pus, removal of foreign bodies and abnormal tissues. After that, a reparative surgery for elimination of the cavity in the sternum or in the mediastinum along with stabilization of the sternum is performed. The second stage includes removal of ligatures after debridement therapy with negative pressure which is aimed at prevention of the

impairment of external respiration due to the possible instability of sternocostal framework.

Foreign authors [32] propose a method of reconstructive surgery including myoplasty and the use of 3-4 titanium plates in order to preserve the skeleton and stability of the chest. Domestic authors [9] also highlight the importance of the restoration of the sternal structure on finishing the sternomediastinitis treatment as it maintains the satisfactory breathing biomechanics and allows to prevent such complications as hernias of the anterior chest wall.

M. Kalab et al. [27] effectively used allogeneic bone transplantation to stabilize the sternum, while other specialists successfully treated patients with extensive defects of the anterior part of the chest using cellular titanium implant.

Dornseifer U. et al. [13] described the cases of successful application of the free musculocutaneous flap of anterolateral femoral surface in sternomediastinitis treatment.

The efficacy of sternomediastinitis treatment, according to A.V. Potemkin et al. [7], depends on how soon the disease was diagnosed after the complications appeared, on the stability of the sternum and the extent of its damage, the condition of the surrounding soft tissues, concomitant pathology as well as the intensity of exudative and destructive inflammation. As E.A. Korymasov et al. [8] point out, one should strictly follow a certain sequence of steps and timely come up with the indications for the final stage of the reconstructive surgery to achieve a positive result in sternomediastinitis treatment. The above-mentioned measures can be provided if the continuity of patient's treatment is observed in the same thoracic surgery unit with the aim of implementing a comprehensive set of actions for the treatment of a purulent complication.

Thus, in spite of the long history and solid experience in the field of the pathology studied, some unsolved problems remain in the treatment of postoperative sternomediastinitis so far. Complications of transsternal approach are still possible regardless of the preventive measures taken during the cardiac surgery. Expensive long-term treatment of patients with this complication and frequently unfavorable outcome make the problem of postoperative sternomediastinitis extremely urgent. At the same time, the possibility of the infection recurrence after the treatment of the pathology under review can not be excluded, which indicates the necessity of further active development of



innovative technologies for the complex treatment of postoperative sternomediastinitis.

**Summary.** The study of the historical development of the treatment of postoperative sternomediastinitis, based on the literature data, was carried out. At the initial stages, open treatment of chest wounds was performed, then treatment was carried out using the flow-washing system, both methods were accompanied by a high incidence of complications and mortality. Later, a more active use of the surgical method of treatment in combination with volumetric reconstructive operations was proposed as the wound was cleared, which contributed to a decrease in the mortality rate (from 50 to 5.1%) from this pathology. However, the likelihood of complications of trans-sternal access and recurrence of infection persists regardless of the preventive measures taken during cardiac surgery, which indicates the expediency of active development at the present time of innovative approaches to the complex treatment of postoperative sternomediastinitis.

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