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Modified method of vacuum therapy in the treatment of infected post-sternotomy wounds

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ABSTRACT

Sternal wound infections are a terrible complication that require long and complex treatment.

The aim of the study was to evaluate the results of using the modified method of vacuum therapy to treat purulent-septic complications of post-sternotomy wounds in clinical practice.

Materials and methods. According to the applied method of vacuum therapy, all patients with infectious complications of post-sternotomy wounds were divided into two groups (n = 25, average age 56.6 years). The classical vacuum therapy was used in the first group consisting of 12 patients. In the second group, 13 patients were treated with the help of the modified method of vacuum therapy.

Results. In the first group, 1 patient (8.3%) experienced osteomyelitis of the sternum, following a partial resection of bone plates; 1 patient (8.3%) developed sternal fistulas, which required long-term treatment; 1 patient (8.3%) had bleeding due to the injury of the left brachiocephalic venous trunk because of the direct contact of the polyurethane pad with the blood vessel wall. The bleeding was eliminated by fixing the damaged area of the vascular wall with U-shaped sutures using polytetrafluoroethylene pads. In the second group, no complications of this nature were observed. The modified method of vacuum therapy allows for the effective evacuation of the hemorrhagic discharge of the wound surface, the reduction of the degree of pathogen contamination in the adjacent tissues, and the elimination of bleeding risk.

Conclusion. The modified method of vacuum therapy in combination with effective algorithms for treating purulent-septic complications of post-sternotomy wounds allows physicians to avoid fatal complications and achieve good clinical results.

Key words: median sternotomy, sternal infection, postoperative mediastinitis, vacuum therapy, reosteosynthesis of the sternum.

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Conformity with the principles of ethics. All patients signed an informed consent to participate in the study. The study was approved by the local Ethics Committee at Ulyanovsk State University.

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Применение модифицированного метода вакуум-терапии при лечении инфицированных постстернотомных ран

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РЕЗЮМЕ

Актуальность. Раневая стернальная инфекция является грозным осложнением, требующим длительного и сложного лечения.

Цель исследования. Оценка результатов применения модифицированного метода вакуум-терапии при лечении гнойно-септических осложнений постстернотомных ран.

Материалы и методы. Все пациенты с инфекционными осложнениями постстернотомных ран (n = 25, средний возраст 56,6 лет) разделены на две группы. В 1-ю группу вошли 12 пациентов, у которых использовался классический метод вакуум-терапии. Во 2-й группе для лечения 13 пациентов применялся модифицированный метод вакуум-терапии.

Результаты. В 1-й группе у 1 (8,3%) больного наблюдался остеомиелит грудины, выполнена частичная резекция костных пластин, у 1 (8,3%) возникли стерно-кутальные свищи, что потребовало длительного лечения, у 1 (8,3%) вследствие травматизации левого венозного брахиоцефального ствола на фоне прямого контакта полиуретанового наполнителя со стенкой сосуда – кровотечение. Кровотечение удалось ликвидировать, ушив поврежденный участок сосудистой стенки п-образными швами с использованием прокладок из политетрафторэтилена. Во 2-й группе осложнений подобного характера не наблюдалось. Применение модифицированного метода вакуум-терапии позволяет эффективно эвакуировать геморрагическое отделяемое раневой поверхности, уменьшить степень контаминации патогеном прилежащих тканей, исключает риск возникновения кровотечения.

Заключение. Применение модифицированного метода вакуум-терапии в сочетании с эффективными алгоритмами лечения гнойно-септических осложнений постстернотомных ран позволяют избежать фатальных осложнений и добиться хороших клинических результатов.

Ключевые слова: срединная стернотомия, стернальная инфекция, послеоперационный медиастинит, вакуум-терапия, реостеосинтез грудины.

Конфликт интересов. Авторы декларируют отсутствие явных и потенциальных конфликтов интересов, связанных с публикацией настоящей статьи.

Источник финансирования. Авторы заявляют об отсутствии финансирования при проведении исследования.

Соответствие принципам этики. Все пациенты подписали дали информированное письменное согласие. Исследование одобрено решением локального этического комитета Ульяновского государственного университета.

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INTRODUCTION

More than 57,000 open heart operations to treat cardiac pathology are performed annually in Russia [1]. A tendency to increase the total number of cardiac surgery interventions remains due to the development of large medical centers and the establishment of new cardiac surgery departments. Despite the proliferation of minimally invasive and interventional technologies, open heart surgery using median sternotomy as a surgical access remains one of the main treatment methods.

The active use of sternotomy as an access is due to this method being relatively simple and effective, as it provides visualization of all the main cardiac structures and vessels. However, despite the advantages of median sternotomy, the main disadvantages are the degree of traumatization and risks of infectious complications.

In order to prevent purulent-septic complications after sternotomy, guidelines for the elimination of sternal infection were developed and introduced into clinical practice [2]. Despite this fact, the incidence of post-sternotomy infectious complications remains quite high and ranges from 0.25 to 10% [3].

Vacuum therapy is among the most effective treatment methods of postoperative sternomediastinitis. However, the complex architectonics of post-sternotomy wounds, heterogeneity of tissues, and spread of bacterial strains resistant to antibiotics and antiseptics do not allow for complete cleansing of the wound cavity in 100% of cases.

The aim of the research was to evaluate the results of using the modified method of vacuum therapy in clinical practice to treat purulent-septic complications of post-sternotomy wounds.

MATERIALS AND METHODS

From January 2015 to December 2018, 379 open heart surgeries were performed using median sternotomy as a surgical access in the Department of Cardiac Surgery and Heart Rhythm Disorders of the Ulyanovsk Regional Clinical Hospital. In 10 cases (2.65%) the postoperative period was complicated by bleeding due to coagulopathy. In 3 cases (0.8%) the postoperative period was complicated by acute myocardial infarction. Purulent-septic complications of the wound surface of various severity developed in 25 cases, which is 6.6% of the total number of patients operated on.

Patients with infectious complications of the sternal wound were divided into two groups according to the method of vacuum therapy used for treatment. Patients were comparable by gender and age in both groups. The average age was 56.6 years old. The number of elderly patients (over 60 years old) was 10 people (40%) (Table 1). The first group (comparison group) included 12 patients whose purulent-septic complications of the sternal wound were treated with the standard method of vacuum therapy. The second group (main group) included 13 patients who underwent a course of the modified vacuum therapy (RF patent No. 183866, authors A. L. Charyshkin, A. A. Guryanov) (Fig. 1).

Table 1

The distribution of patients by age

Age (years old)	The 1st group (n = 12)	The 2nd group (n = 13)
18–39	1 (8.3%)	0 (0%)
40–59	7 (58.4%)	7 (53.8%)
60–74	4 (33.3%)	6 (46.2%)

Note. The number of patients – n.

Figure 1. General view of the modified system

The developed vacuum system provides effective vacuum drainage of wounds using a device that consists of an air-tight dressing connected to a container for collecting wound discharge and a vacuum source (creating alternating negative pressure) though a vacuum-wire port. The vacuum-wire is placed in the center of the porous pad along its entire length beforehand (Fig. 2, *a*, *b*). In places where the pad comes into contact with potentially dangerous wound sites (the aortic wall, myocardium, coronary bypass grafts, left brachiocephalic vein, etc.), the polyurethane pad is covered with a film of synthetic material that is perforated with a 21G injection needle, 6 to 9 holes per 1 cm^2 are made throughout the film (Fig. 3).

The vacuum-wire located in the middle of the porous pad, as well as a special structure of the tube provides a uniform, more effective wound drainage. The synthetic film protects the porous pad from the granulation tissue germination. Moreover, the risk of bleeding during the

pad removal is eliminated. The film also prevents vulnerable sections of the wound from direct vacuum exposure. The perforated surface of the film retains adhesive properties of the pad.

To determine nature, extent and localization of the pathological process in the postoperative period, patients underwent chest CT with 3D reconstruction, ultrasound of soft tissues, wound culture test, and antibiotic sensitivity test.

a

b

Fig. 2. Installation of the drainage in the pad

Fig. 3. Perforated protective film

RESULTS

In both groups of patients, the same phasing of treatment was observed. Initially, the prevalence of infection was determined. When the infection was localized within the skin and subcutaneous tissue (8 patients (66.6%) in the first group; 8 patients (61.5%) in the second group), soft tissues were expanded to the sternum. Ligatures from the skin and subcutaneous tissue were removed, consistency of sternal sutures and their involvement in the inflammatory process of the sternum and retrosternal space were evaluated. If the sternal sutures were consistent, and the sternum and retrosternal space were intact, the wound was debrided with antiseptic solutions and a vacuum system was installed.

If sternal sutures were inconsistent, meaning that there was severe diastasis of the sternal edges or presence of an infection on the anterior mediastinum (4 patients (33.4%) in the first group; 5 patients (38.5%) in the second group), wire ligatures were removed and the sternal edges were spread. After that, the wound was debrided with antiseptic solutions and a vacuum system was installed. Removing sternal sutures in these conditions is a mandatory procedure, since otherwise they contribute to the destruction of the sternal edges during breathing and coughing. In addition, fragments of a wire suture can damage nearby structures, such as the lungs, heart, and great vessels [4].

When using vacuum systems in the Department of Cardiac Surgery of the Ulyanovsk Regional Clinical Hospital, both standard and modified methods were employed. In the modified system, a four-channel silicone tube, located in the center of the polyurethane pad throughout the wound, was used for drainage. Given the size of the wound surface, the complex structure of the wound and the heterogeneity of tissues, this arrangement of drainage made it possible to evacuate wound discharge as efficiently as possible and create a uniform rarefaction in all areas of the wound cavity. Considering that the polyurethane pad quite often comes into contact with such surfaces as the aortic wall, myocardium, suture area, mammary-coronary and aortocoronary bypass grafts, as well as their anastomoses, there is a risk of damage to these structures from direct vacuum exposure. It is also important that the polyurethane pad can tightly adhere to tissues after a prolonged contact, making further removal of the pad from the wound extremely dangerous (Fig. 4), since it can cause damage to the above structures.

In both groups the duration of vacuum therapy ranged from 48 to 72 hours, after that the system was removed, and the wound cavity was carefully debrided with antiseptic solutions before the vacuum system was reinstalled. This algorithm was followed until the wound cavity was cleansed and the level of contamination by the infectious agent reduced to acceptable parameters, less than 10^3 CFU [5]. These drugs were used as antiseptics in both groups: 3% hydrogen peroxide solution; 10% betadine solution; 1% dioxidine solution; Baneocin.

When the wound reached the optimal condition, further tactics were determined according to the size and location of the defect. If infection was limited to soft tissues, in both groups the wound was closed with vicryl No. 1 thread through all layers, using MacMillan – Donati sutures. In the case of retrosternal space involvement in the pathological process and the need for reosteosyn-

thesis of the sternum, the strategies of defect closure in the first and second groups were slightly different.

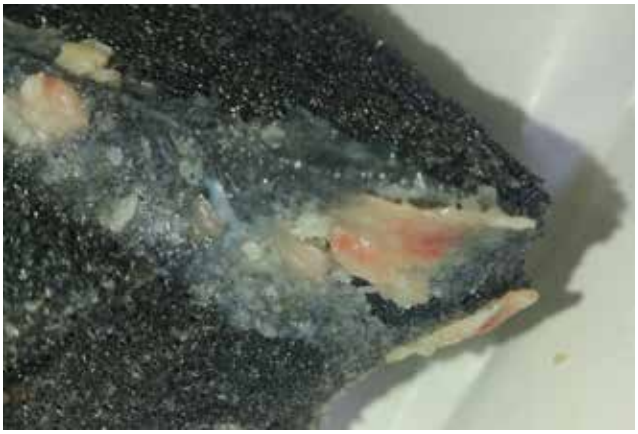

Fig. 4. Germination of the pad into adjacent tissues

Good revascularization of granulation tissue and sternal edges facilitate bleeding of different severity when sternum reosteosynthesis and re-closure of a postoperative wound are being performed. To reduce the risk of re-development of purulent-septic complications after sternum reosteosynthesis and soft tissue approximation in the first group of patients with deep sternal infection, the method of flow-washing drainage was used, and in the second group the method of gradual closure of the wound using vacuum therapy was employed.

During gradual closure of the wound, the first stage was reosteosynthesis of the sternum and suturing of the soft tissues of the upper half of the postoperative wound. A negative pressure system was installed at the lower part of the wound. Vacuum therapy was carried out for 3 days, after that the defect of the lower wound segment was closed.

This method made it possible to effectively evacuate the hemorrhagic discharge of the wound surface, preventing the formation of extensive hematomas, which subsequently lead to a relapse of infectious complications. In addition, the modified vacuum therapy allows the reduction of pathogen contamination of the adjacent tissues, diminishing risks of a relapse. While using this method in our department, we did not register a single case that required additional surgical hemostasis.

According to the results of treatment, in the first group, one patient (8.3%) suffered from sternal osteomyelitis that subsequently required a partial resection of the bone plates. One patient (8.3%) developed sternal fistulas in the long-term postoperative period, which required further prolonged treatment. One patient (8.3%) had bleeding due to the injured left venous brachiocephalic trunk because of the direct contact of the polyurethane pad with the vessel wall. The bleeding was eliminated by suturing the damaged part of the vascular wall with P-shaped sutures using polytetrafluorethylene pads. In the second group, complications of this nature were not observed. Mortality was absent in both groups.

DISCUSSION

According to many authors, the use of vacuum therapy in the treatment of infected post-sternotomy wounds is an effective method to achieve good results. However, experience of using such systems shows that it is not always possible to achieve complete cleansing of the wound. The large size, complex and heterogeneous structure of the wound cavity, as well as the infectious agent resistance greatly complicate the task.

To increase the operating efficiency of the vacuum system in our hospital, a non-standard way of arranging the evacuation drainage in relation to the polyurethane pad was used. We used the silicone drainage with a four-channel structure that was located in the center of the pad equidistant from all wound sections, which, in our opinion, ensured more effective elimination of the infectious agent and wound discharge.

One of the problems of using vacuum therapy in the treatment of deep sternal infection is the risk of damage to structures such as the great vessels walls, myocardium, coronary bypass grafts due to direct exposure to vacuum, or a combined effect of infection and negative pressure on tissues [6, 7, 8]. In order to prevent such problems in our hospital, we used a synthetic film to cover the polyurethane pad, while the adhesive properties of the pad due to perforation of the film were maintained.

Early detection of purulent-septic complications of post-sternotomy wounds allows to resort to active surgical tactics in a timely fashion, thereby to prevent the spread of infection and deeper structures from being involved in the pathological process [9, 10]. This contributes to effective treatment with less aggressive surgical tactics in the future. If sternal sutures become inconsistent and a patient with sternomediastinitis develops diastasis of the sternal edges, it is necessary to remove sternal sutures and expand the post-sternotomy wound completely. This allows to adequately sanitize the retrosternal space, and also to avoid further destruction of the sternal edges and damage to nearby organs by wire fragments.

CONCLUSION

The modified structure of a vacuum system allows to provide a more efficient evacuation of exudate and to create uniform rarefaction in all parts of the wound cavity. Coating the polyurethane pad with a film at the places of contact with the most vulnerable areas allows the avoidance of such terrible complications as damage

to the myocardium, walls of large vessels, and coronary bypass grafts. The gradual closure of the wound using vacuum therapy reduces the risk of septic complications relapse, because it prevents hematoma formation in soft tissues and further reduces the contamination degree of the wound until it is completely closed.

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