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Original Article

Vacuum-Assisted Closure (VAC) Treatment In Thoracic Surgery: A Single-Center Experience

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ABSTRACT

Objective: The aim of this study was to evaluate the effectiveness of vacuum-assisted closure (VAC) therapy in thoracic surgery patients who developed chronic infections or large tissue defects for different reasons.

Methods: A total of 10 patients who underwent VAC therapy in our clinic between February 2017 and December 2020 were included in the study. Age, gender, length of hospital stay, primary pathology etiology, duration of VAC stay, number of sponge changes, microbiological culture results from the wound site, recurrence, presence of comorbidity, morbidity, and mortality data of the patients were analyzed.

Results: Of the 10 patients, 7 were male and 3 were female. The mean age was 47 (23–71). The average length of hospital stay was 61.3 days (13–141 days) and the mean VAC stay was 43.2 days (12–102 days). VAC changes were made at 3–4-day intervals and it was determined that changes were made every 3.6 days on average. Two patients were treated for gunshot wounds, one for sternal dehiscence (SD) after coronary bypass surgery, one for traumatic tissue defect due to fall from height, one for bronchopleural fistula (BPF) and empyema after cyst hydatid surgery, and three for chronic infection after chest wall malignant mass (two primary, one metastasis) resection and two for BPF after pulmonary resection (primary lung cancer). The most commonly isolated microorganism in wound cultures was the pseudomonas subspecies. Two patients were re-treated after the completion of VAC treatment. No mortality was observed in the patients during hospitalization or after discharge.

Conclusion: VAC application is a system that works on the basis of controlled negative pressure used to support and accelerate wound healing in wounds or infections where there is no normal healing. VAC is a useful and safe method for the management of thoracic infections and the reduction of dead space.

INTRODUCTION

The goals in the management of intrathoracic empyemas are to provide effective drainage, strong antibiotherapy for infection, improvement of the patient's current condition, and prevention of recurrent infections by obliteration of the existing cavity. Recurrent empyemas and postpneumonectomy empyemas present a challenging treatment plan despite all the developing treatment modalities. In addition, large tissue defects should be closed without disturbing the respiratory physiology. Open window thoracostomy and its improved adaptations are good alternatives that can be recommended in such conditions.[1] It provides easy and fast drainage of infected material in patients unsuitable for surgery and repetitive debridement sessions can be easily conducted.[2] However, it requires rib resection and muscle division, which may not be possible in patients with poor conditions.

Vacuum-assisted closure (VAC) treatment offers a good alternative for these patients. The VAC system was first applied in the treatment of intrathoracic pathologies by Ditterich et al.[3] One of the three patients died due to cancer metastases while on treatment, and the other two were treated successfully. Technically, VAC aims to increase the granulation tissue by providing effective drainage of the wound with intermittent negative pressure. It reduces edema and increases tissue blood supply. As a result, it reduces the total volume of the cavity.[4] Also, its application under sedation provides an advantage in cases that cannot tolerate the risks posed by general anesthesia. Successful results reported with VAC, particularly in the treatment

of persistent empyemas and infected large tissue defects, have encouraged thoracic surgeons to use this method in the management of thoracic infections, regardless of the cause. The use of VAC in combination with conventional management such as the Clagett window increases the chance of surgical success. In this study, VAC methods applied in patients with infected cavities and tissue defects due to various etiologies were examined in terms of their clinical features and outcomes.

MATERIALS AND METHODS

The study was carried out in accordance with the World Medical Association Declaration of Helsinki and approved by the Gülhane Scientific Research Ethics Committee on October 15, 2020, No: 2020-395.

The data of 10 patients who underwent VAC treatment in our clinic between February 2017 and December 2020 were retrospectively reviewed. Only thoracic surgery patients who underwent VAC treatment were included in the study. Patients who underwent a single session of VAC without sufficient vacuum were excluded from the study (two patients). Age, gender, length of hospital stay, etiology of primary pathology, duration of VAC stay, number of sponge changes, microbiological culture results from the wound site, recurrence, presence of comorbidity, morbidity, and mortality data of the patients were analyzed. Table 1 shows the clinical characteristics of the patients.

Two patients were treated for gunshot wounds, one for sternal dehiscence (SD) after coronary bypass surgery, one for traumatic tissue defect due to fall from height, one for bronchopleural fistula (BPF) and empyema after cyst hydatid surgery, three for chronic infection after chest wall malignant mass (two primary, one metastasis) resection, two for BPF after pulmonary resection (primary lung cancer). Benign pathologies were detected in five patients whereas the primary disease was malignant in five patients.

All patients were treated with empirical broad-spectrum antibiotics, after receiving the consultation of infectious diseases. Antibiotherapy was conducted pathogen-specific according to the microbiological wound site culture results. No patient was started on prophylactic antifungal therapy. Antifungal therapy was added to the treatment of the patients, as fungal infection were detected in two patients in the culture results (*C. Albicans, A. Fumigatus*).

Table 1. Clinical characteristics of the patients

Patient	Sex	Age	Hosp. Stay (day)	VAC (day)	Dressing change	Identified organism	Etiology	Comorbidities
P1	M	55	13	12	3	Staphylococcus epidermidis	Chronic infection after sternal plasmacytoma resection	Diabetes Mellitus Smoking history + Plasmacytoma
P2	F	31	24	15	4	Pseudomonas Aeruginosa	Chronic infection after desmoid tumor resection	Low BMI (16,8) Aggressive desmoid tumor
P3	F	23	116	56	16	Aspergillus fumigatus Pseudumonas stutzeri	Empyema fistulized to the skin after a hydatid cyst surgery	Low BMI (18,4)
P4	M	45	23	18	5	–	Sternal dehiscence (SD) after bypass surgery	Coronary artery disease Chronic renal failure
P5	M	38	127	102	28	Morganella Morganii Klebsiella pneumonia Pseudomonas Aeruginosa	Gunshot	Smoking history+
P6	M	23	62	57	17	Pseudomonas Aeruginosa	Gunshot	Low BMI (15,6)
P7	M	57	141	97	27	Pseudomonas Aeruginosa Corynebacterium striatum Enterococcus faecalis	Bronchopleural fistula after pneumonectomy	Cardiac arrhythmia Smoking history+ Nonsmall cell lung ca.
P8	M	71	58	32	9	Corynebacterium species Staphylococcus Hominis Candida Albicans	Bronchopleural fistula after lobectomy	Coronary artery disease Smoking history + Nonsmall cell lung ca.
P9	F	61	34	31	8	–	Traumatic chest wall defect	–
P10	M	66	15	12	3	Staph. Lugdunensis Stenotrophomonas maltophilia	Chronic infection after metastasectomy	Metastatic colon ca. (Chemotherapy + Radiotherapy)

Hosp.: Hospital; VAC: Vacuum-assisted closure; F: Female; M: Male; BMI: Body mass index.

Surgical technique

In the VAC application procedure, first, debridement is applied to remove necrotic and infected tissues, and then VAC sponges are placed into the cavity. Sponges should be cut to the appropriate shape and size for the cavity and should be placed in layers. After the cavity is filled to the extent of its elasticity, VAC drape should be adhered to the incision site so that it is not exposed to air from its edges. Care should be taken to make a hole with a diameter of <1 cm in the middle of the cover, and then the aspiration tape should be placed at the center on this hole. The aspiration is initiated in a controlled manner within the pressure range of 80–120 mmHg before the patient is awakened and the air is discharged after the aspiration tube is connected to the device. The aspiration is, then brought to the pressure range of 80–100 mmHg and should be maintained as such. Rapid and aggressive aspiration should not be performed as it may disrupt the cardiac rhythm and respiratory physiology. During dressing sessions when it is observed that sufficient revascularization of the tissues increases and the drainage of infected material is completed, reducing the amount of sponge will minimize the potential cavity. The remaining cavity should be closed using an omentum or muscle flap or procedures such as thoracoplasty to prevent the occurrence of re-infections depending on the anatomical structure of the patient. It will not be possible to maintain negative pressure in non-large air leaks such as damaged parenchyma. In this condition, sponges must be filled after covering the damaged parenchyma with a drape. This process helps create negative pressure by preventing airflow from passing through the sponge, while providing enough time and space for the leaking surface to simultaneously repair itself.

RESULTS

Of the 10 patients included in the study, 7 were male and 3 were female. The mean age was 47 (23–71). The mean hospital stay length was 61.3 days (13–141 days) and the mean VAC stay was 43.2 days (12–102 days). VAC changes were made at intervals of 3–4-days and it was determined that changes were made every 3.6 days on average. In 8 of the patients, proliferation was detected in the culture. The most commonly isolated microorganism in cultures was pseudomonas subspecies (*Pseudomonas aeruginosa* in 4 patients and *Pseudomonas stutzeri* in 1 patient). Fungal proliferation was detected in the culture in two patients (*Candida albicans and Aspergillus fumigatus*). No mortality was observed during hospitalization or after discharge. Two patients were retreated after the completion of VAC treatment. Both patients were discharged with short-term treatments without major complications. The first of these patients underwent debridement and antibiotherapy 8 months later due to skin wound infection. The second patient was admitted 27 days later due to fluid accumulation between the subcutaneous and graft. Drainage was provided with a subcutaneous drain, and the patient was treated successfully with antibiotherapy.

Two patients were treated with VAC due to complications after gunshot wounds (P5, P6). A 38-year-old male patient (P5), developed a large tissue defect in the left hemithorax including 5–10 ribs and chest wall due to gunshot injury (Fig. 1). Debridement and VAC were initiated to the patient to control the infection and repair the defect. A total of 28 VAC changes were performed in the 102-day period and the wound was closed primarily (Fig. 2). No complications were observed in the subsequent follow-ups of the patient who was discharged on the 127th day of his hospitalization. Two patients (P7, P8) were treated with VAC due to BPF and empyema after primary lung cancer resections. They were 57 and 71 years old male patients

Figure 1. The wide chest wall defect on chest X-ray before VAC treatment in a gunshot injury patient.

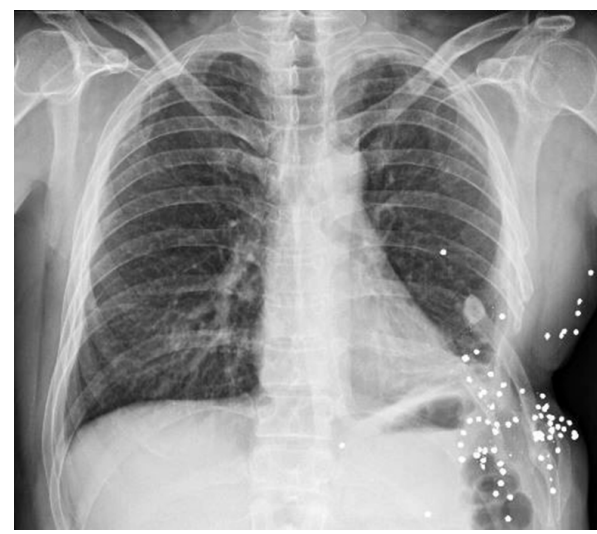

Figure 2. Chest X-ray after VAC treatment. The chest wall defect have been completely closed.

and were operated on with the diagnosis of squamous cell carcinoma. The 71-year-old patient developed BPF after right bi-lobectomy inferior and surgical repair in the early period, followed by VAC treatment. Another 57-year-old patient developed BPF after right pneumonectomy and was treated with VAC after bronchial leakage was controlled with an omentopexy+endobronchial blocker.

Two patients (P1, P2) were treated with VAC due to chronic infection following surgery for chest wall primary malignancies. A 55-year-old male patient (P1) underwent reconstruction surgery with 2 titanium bridges and PROLENE® mesh after sternal resection due to plasmacytoma in the sternum. 25 days after discharge, he was hospitalized again due to the development of a wound site infection. The patient was treated with wound debridement and VAC without complications. A 31-year-old female patient (P2) underwent chest wall resection 8 years ago due to an aggressive desmoid tumor involving the 6–10th ribs. She had chronic empyema fistulizing to the skin since then (Fig. 3, 4). Debridement and VAC were applied to the patient by opening the Clagett window (Fig. 5). The cavity was completely obliterated and sterilized after the treatment and the defect was closed by primary suturing (Fig. 6).

A 66-year-old male patient (P10) underwent chest wall resection and reconstruction with a sandwich graft, due to the detection of metastasis in the right chest wall 5 years ago. Fistulized empyema developed on the skin after the graft became infected. The graft was surgically removed the infected and completely necrotic lower lobe of the lung was resected, and VAC treatment was initiated. VAC was terminated in the 3rd session upon the development of cardiac arrhythmia. The chest wall was reconstructed with a titanium bar and GORE-TEX® Mesh. The patient was hospitalized 27 days after his discharge due to fluid accumulation between the skin and the graft. He was treated with drainage and antibiotherapy and discharged on the 14th day.

Figure 3. Empyema image fistulized to the skin after chest wall resection.

Figure 5. Intraoperative view of the VAC application following clagett window.

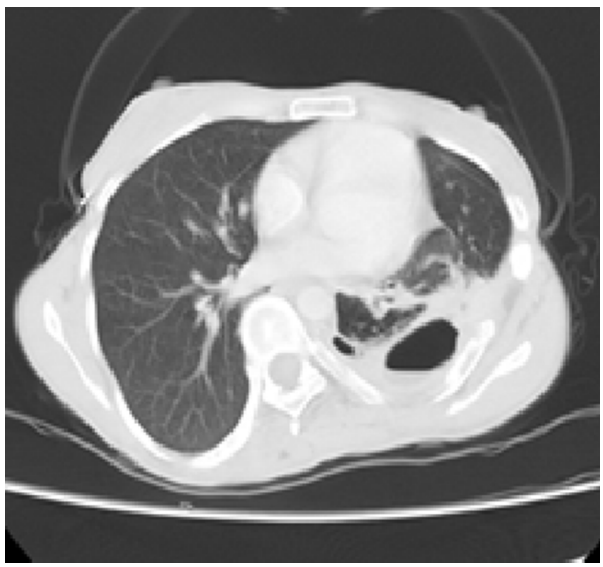

Figure 4. The thorax CT view of the skin fistulised cavity.

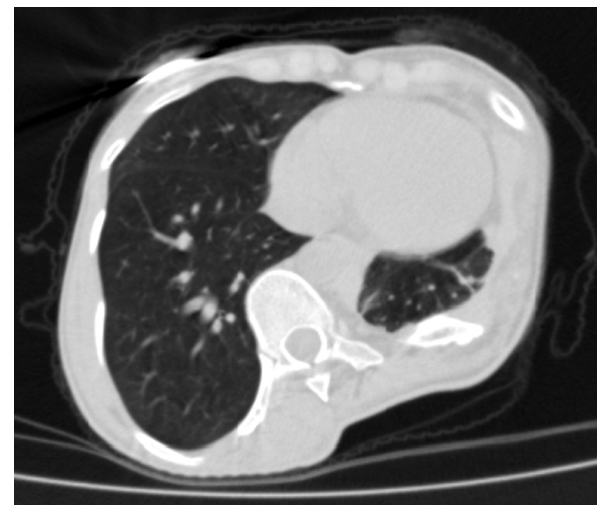

Figure 6. CT image of the thorax after the VAC treatment of the patient. It is observed that the fistula and the infected cavity have been completely obliterated.

Patient 3 was a 23-year-old female who was treated for chronic empyema that developed after hydatid cyst surgery. Lower necrotic lobe resection and the cavity debridement were performed, and VAC sessions were initiated. When the desired result was achieved with VAC treatment, thoracomyoplasty was performed. One of the patients who underwent VAC treatment had SD after coronary bypass (P4), and one had a large tissue defect due to falling from a height (P9). The infection involving the skin, subcutaneous tissues, and pectoral muscles could be controlled with VAC in the case of SD after coronary bypass surgery (P4). The SD was closed with granulation tissue and successful reconstruction was achieved without disrupting the respiratory physiology of the patient in the case of osteomyelitis. One patient (P9) was hospitalized due to a tissue defect involving the axillary region and the first 4 ribs due to falling from a height. The developing infection could be controlled by applying VAC, after the hemodynamic stabilization of the patient.

DISCUSSION

In intrathoracic pathologies, the VAC system was used for the first time by Ditterich et al.[3] VAC treatment has been tried in many different etiologies in thoracic surgery and its importance has gradually increased over the years. In our article, we aimed to show an effective and safe complementary treatment tool that can be used after the main surgical procedure in similar situations by analyzing 10 patients with different etiologies. VAC accelerates the process, preventing additional contamination, and preventing prolongation of hospital stay by closing the dead space in the thorax. Thus, antimicrobial resistance due to prolonged antibiotic use is also prevented.

Resistant infections in wounds increase with factors such as patient-related diabetes, smoking, alcohol abuse, radiation therapy history, obesity, malignancy, malnutrition, and cardiovascular diseases.[5] Five patients had malignant etiology as the primary disease in our study. One patient had a history of diabetes, three patients had a history of cardiovascular disease, and one patient had a history of renal failure. Four patients had a history of smoking and three patients had a low body mass index (<19). A high-calorie anabolic diet was planned throughout hospitalization with the advice of a dietitian for three patients with low BMI. Eight patients underwent multiple surgical procedure before VAC sessions.

The microorganisms are physically removed from the region with the help of the negative pressure provided by VAC. In addition, it accelerates blood flow, reduces edema, and provides a suitable micro-environment for the formation of granulation tissue. The negative pressure effect provided by VAC becomes evident when combined with the specific pressure changes of the thorax in normal respiratory physiology. This wound is critical for healing. Increasing blood supply by reducing edema provides additional benefits when integrated with the dynamic structure of the thoracic wall.[6] It is important to perform the procedure under general anesthesia, especially in the first session due to the size of the tissues to be debrided and the surgery being more painful. Since only sponge and dressing changes will be done in the next sessions, it would be wise to perform the procedure under sedation. This will also reduce the anesthesia burden on the patient. We believe that effective debridement, especially in the first sessions, both accelerates the development of granulation tissue and provides secondary benefits by increasing tissue blood supply. For this reason, we almost always perform the first sessions under anesthesia in our clinic. The source of infection (e.g. foreign body or bone tissue with developed osteomyelitis, etc.) should definitely be removed from the environment in the first operation. At the end of the VAC process, the area where drainage will be provided must be created. This site is often formed through the debridement incision and often a new incision is not required. SD cases that develop after sternotomy may be in the form of sterile wound separation, or may present with a severe mediastinitis condition with a high mortality rate. Classical methods such as debridement, fasciocutaneous flap, or revision with muscle flap are available in the treatment.[7] Patients who developed SD were evaluated in two groups as those receiving VAC treatment and conventional treatment in a study conducted by Tarzia et al.[8] VAC treatment was found to be much more successful than conventional methods in terms of complications such as mortality, sepsis, mediastinitis, need for surgical revision, delayed infection, and provided lower treatment costs as a result of the study. One patient (P4) was treated with VAC due to SD after bypass surgery in our study. The patient, who had no proliferation in tissue culture, was medically given only empirical antibiotherapy. The wound was closed primarily and the patient was discharged without complications after 5 sessions of VAC treatment.The first goal in the management of high-energy traumas leading to large tissue losses in the thorax is always to connect the patient to the life. In these patients, in whom the catabolic process regress, functional deterioration caused by the defect and accompanying secondary infections are difficult problems to cope with. Three patients developed extensive chest wall tissue loss as a result of trauma in our study. Two of them were with gunshot wounds, one was with falling from a height.

BPF is a complication with severe mortality and morbidity and seen in 4.5–20% after pneumonectomy and 0.5% after lobectomy.[9] There is a need for rapid regression of the existing infection and acceleration of tissue regeneration although effective drainage is provided in the treatment of BPF. This is possible by providing a blood supply to the active tissue. Antibiotherapy applied to patients can easily reach the targeted area and provide maximum effect in this way. There are concerns that the negative pressure provided by the VAC may increase the size of BPF in clinical practice, but no data are available to support this hypothesis. Gulyuz et al.[10] found that the VAC group was more advantageous in terms of length of hospital stay, duration

of empyema, and patient comfort vaccine in their study in which they compared VAC and open window thoracostomy in the treatment of postpneumonectomy. Intrathoracic vacuum therapy (mini-VAC) with a minimally invasive technique has been reported to be safe even in patients with poor septic conditions and accelerated empyema healing. Open window thoracostomy, which was almost inevitable for these patients in the past, has been replaced by mini-VAC.[11] VAC has been reported to shorten the length of hospital stay and reduced morbidity in addition to standard procedures in the treatment of empyema developing after lung resection.[12]

The ideal timing of VAC treatment varies depending on the general condition of the patient and the condition of the tissue. These patients are metabolically sensitive due to the complex surgeries and treatments they have undergone in a short time. All patients who underwent VAC had at least one history of operation in our study. VAC should not be seen as a method to replace surgical repair procedures, but as a complementary method that accelerates tissue healing after its application in clinical practice.

Clinicians should be careful about the cardiac effects of VAC-induced negative pressure and patients with mediastinal instability should be carefully monitored. In one of our patients (P10), cardiac arrhythmia developed due to the effect of vacuum after the 3rd session and VAC treatment was discontinued earlier than planned. This patient was hospitalized again on the 27th day after discharge, and drainage and antibiotherapy were applied to the infected collection. We think that early termination of VAC in this patient caused complications. VAC treatment should be continued and until the appropriate conditions are met to achieve the ideal result, and should not be rushed. However, it would be the right approach to switch to conventional methods in the presence of any complications that may impair hemodynamics.

Another drawback regarding VAC treatment is that the application may damage the parenchyma if there is intact parenchymal tissue inside. This problem can be overcome by placing sponges in the cavity after a drape is placed over the parenchyma with or without parenchymal leakage. There is no clear definition of a day range for replacing the VAC drape. The frequency can be increased on days when active emphysematous/serious drainage continues and the infection is not under control. The interval between sessions can be increased as tissue regeneration increases and the existing cavity shrinks. However, we generally apply exchange sessions on Mondays and Thursdays, considering working days in our clinic.

The mean length of hospital stay was 61.3 days (13–141 days) in VAC patients in our study. Our length of stay in three patients was over 100 days. Saadi et al.[13] determined the mean VAC stay as 22 days in 27 patients who underwent VAC for post-resectional intrathoracic empyema treatment. The mean VAC stay was 43.2 (12–102 days) days in our study. The longer length of hospital stay and VAC dressing time in our study may be due to the heterogeneous etiology of our patients compared to similar publications. It will be possible to determine more objective data in large and homogeneous series.

An important advantage of this technique is that it does not restrict movement in mobile patients and is easy to use and apply. The need for material supply, recurrent sedation, or anesthesia can be counted as a disadvantage. Negative aspiration may be interrupted due to reasons such as the removal of drape, incorrect placement of sponges, filling of collector chamber. It may require extra sessions that do not fit with the team's working days. However, we often think that patients and the team have developed maximum compatibility with the device and its attachments and that it is easy to use. It should be kept in mind that sponge pieces that may remain inside during VAC sponge replacement may cause persistent infections. Therefore, it is appropriate to place the sponges without splitting them into small pieces. The process can be facilitated by soaking the sponge with saline in areas resistant to separation, especially since it is very integrated with granulation tissue.

The most common complication is pain, especially during dressing changes and the initial application of vacuum.[14] The first sessions of our patients were performed under general anesthesia, and subsequent dressing changes were performed under sedation. Therefore, we did not encounter any significant pain complaints in our patients. The limitations of our study are that it is retrospective, small in size, and reflects a single-center experience. In addition, our patients have heterogeneous etiology and multiple comorbidities.

VAC application is a system that works on the basis of controlled negative pressure used to support and accelerate wound healing in wounds or infections where there is no normal healing. VAC is a useful and safe method for the management of thoracic infections and the reduction of dead space.

Ethics Committee Approval

This study approved by the Health Sciences University Gülhane Scientific Research Ethics Committee (Date: 15.10.2020, Decision No: 2020-395).

Informed Consent

Retrospective study.

Peer-review

Internally peer-reviewed.

Authorship Contributions

Concept: H.I., M.Ş.İ., E.S., K.K., Ö.A.; Design: H.I., M.Ş.İ., H.Ç., S.G.; Supervision: H.I., M.Ş.İ., H.Ç., S.G.; Fundings: E.S., K.K., Ö.A., H.Ç.; Materials: E.S., K.K., Ö.A.; Data: H.I., M.Ş.İ., Ö.A.; Analysis: E.S., K.K., H.Ç., S.G.; Literature search: E.S., K.K., Ö.A.; Writing: H.I., M.Ş.İ., E.S., K.K.; Critical revision: H.Ç., S.G.

Conflict of Interest

None declared.

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Göğüs Cerrahisinde Vakum Yardımlı Kapatma (VAC) Tedavisi: Tek Merkez Deneyimi

Amaç: Bu çalışmanın amacı, farklı nedenlerle kronik enfeksiyon veya büyük doku defektleri gelişen göğüs cerrahisi hastalarında vakum yardımlı kapatma (VAC) tedavisinin etkinliğini değerlendirmektir.

Gereç ve Yöntem: Şubat 2017–Aralık 2020 tarihleri arasında kliniğimizde VAC tedavisi uygulanan toplam 10 hasta çalışmaya dahil edildi. Hastaların yaş, cinsiyet, hastanede kalış süresi, primer patolojinin etiyolojisi, VAC kalış süresi, sünger değişikliği sayısı, yara yerine mikrobiyolojik kültür sonuçları, nüks, komorbidite varlığı, morbidite ve mortalite verileri analiz edildi.

Bulgular: On hastanın yedisi erkek, üçü kadındı. Ortalama yaş 47 (23–71) idi. Ortalama hastanede kalış süresi 61.3 gün (13–141 gün) ve ortalama VAC kalış süresi 43.2 gün (12–102 gün) idi. VAC değişiklikleri üç–dört günlük aralıklarla planlandı ve ortalama 3.6 günde bir değişim yapıldığı tespit edildi. İki hasta ateşli silah yaralanması, biri koroner baypas cerrahisi sonrası sternal dehissens (SD), biri yüksekten düşmeye bağlı travmatik doku defekti, biri kist hidatik cerrahisini takiben gelişen ampiyeme bağlı ve ikisi pulmoner rezeksiyon sonrası (primer akciğer kanseri) bronkoplevral fistül (BPF), üçü ise göğüs duvarı malign kitle (iki primer, bir metastaz) rezeksiyonu sonrası kronik enfeksiyon için tedavi edildi. Yara kültürlerinde en sık izole edilen mikroorganizma, psödomonas alttürleriydi. VAC tedavisi tamamlandıktan sonra iki hastaya ek tedavi gerekti. Hastalarda yatış sırasında ve taburcu olduktan sonra ölüm görülmedi.

Sonuç: VAC uygulaması, normal iyileşmenin olmadığı yara veya enfeksiyonlarda yara iyileşmesini desteklemek ve hızlandırmak için kullanılan kontrollü negatif basınç temelinde çalışan bir sistemdir. VAC, torasik enfeksiyonların yönetimi ve ölü alanın azaltılması için yararlı ve güvenli bir yöntemdir.

Anahtar Sözcükler: Ampiyem; göğüs cerrahisi; VAC; vakum yardımlı kapama.