CURRENT TRENDS IN CARDIAC SURGERY: CLINICAL EXPERIENCE IN THE TREATMENT OF MEDIASTINITIS WITH STERNAL WOUND INFECTION THROUGH NEGATIVE PRESSURE THERAPY

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ABSTRACT

Introduction: During the last decades, a general amelioration of clinical outcomes has been reported because of the evolution of cardiac surgery techniques. However, infective complications as mediastinitis still represent a major problem in terms of morbidity and mortality in cardiac surgery, with severe suffering of the patient. Furthermore, the incidence of this complication has remained stable over the last three decades and this condition also determines a significant prolongation of hospitalization with an increase in costs. The procedures used for the treatment of mediastinitis have undergone deep modifications over the years but, in despite of these improvements, mortality has remained high. Over the last years, the negative pressure therapy (ie the Vacuum Assisted Closure-Therapy) is taking over all the other treatments.

Materials and method: From January 2010 to December 2015, at University of Bari Cardiac Surgery Center have been performed 3123 median sternotomy for cardiac surgery. Deep sternal wound infection occurred in 35 patients (1.1207%). In all of these patients was performed vacuum therapy.

Results: The duration of vacuum treatment was 14.4 ± 6.7 days. Inflammatory indexes showed a marked decline. At the end of vacuum therapy, in some cases, the reconstruction of the wound was carried out with plastic reconstruction by means of a pectoral flap. No deaths for mediastinitis were recorded, neither any relapse or treatment-related complication. Hospital stay was 30.4 ± 13.5 days from the beginning of treatment.

Conclusion: The results obtained in our center with vacuum therapy are much more better than those obtained with classic procedures used in the past. Based on our experience and from analysis of literature, vacuum therapy should be the procedure of choice for the treatment of post-sternotomy mediastinitis. Furthermore, this approach has shown satisfactory results in terms of hospital stay time and costs.

Keywords: Infective complications in cardiac surgery, Mediastinitis, Sternal wound infection and/or dehiscence, Negative Pressure Therapy and/or Vacuum-Assisted Closure Therapy (VAC Therapy).

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Introduction

Surgical treatment of cardio-vascular diseases used, since the 90s, new scientific and technical knowledge, which on one hand have gradually reduced the operative risk in open heart surgery with extracorporeal circulation and on the other hand they have reduced the invasiveness of the surgical treatment itself. As important examples of this we include the applications of knowledge on the “stunned” and “hibernating” myocardium within the field of ischemia-reperfusion injury of the heart and myocardial protection in cardiac surgery11; moreover we have assisted to the evolution of the myocardial protection, and its relative methods and solutions, used in order to preserve cardiac muscle structure and its function during cardiac interventions12-20; the birth and the evolution of the endo-vascular surgery and mini-invasive techniques21-25, the techniques in mini-toracotomy, TAVI procedures26, etc.
These techniques not only have reduced the invasiveness of surgical treatment, but also improved the clinical outcome. Moreover, these new procedures allow treatment of heart disease even in very elderly patients and/or in them considered very fragile, which are so difficult to treat with conventional procedures, rather than with those minimally invasive, being the first burdened by a surgical risk much higher than the latter \(^\text{14-16}\).

In front of this fruitful evolution, however, today there are areas in cardiac surgery, where they are still present, in significant measure, morbidity and mortality. Among these areas have an important role infective complications such as endocarditis \(^\text{17,18}\) and mediastinitis \(^\text{19}\).

In particular, the infective complications of cardiac surgical wound site with or without involvement and dehiscence of the sternum, ie mediastinitis, represent a major problem in cardiac surgery in terms of outcome, with severe suffering of the patient, also increasing the length of hospital stay and the related costs \(^\text{20-22}\). The incidence of surgical site infection in cardiac surgery varies between 0.9 and 20\%, according the literature, with an average incidence of about 10\% \(^\text{20-22}\).

**Evolution in the treatment of surgical mediastinitis**

The procedures used for the treatment of mediastinitis have undergone deep modifications over the years. The therapeutic approach represented by an isolated, continuous antibiotic therapy was abandoned because of the high mortality. The difficulty of the medical treatment of the sternal wound infections is heightened by the high incidence of antibiotic resistance that bacteria have developed, and this feature is now endemic in many cardiac surgery centers \(^\text{23}\).

In 1963 Schumaker described the technique of debridement of the wound with the sternum closure and closed irrigation of the mediastinum. The use of an iodine solution at 0.5\% or antibiotic diluted for irrigation of the mediastinum lead to a reduction in morbidity and mortality. While representing the Schumaker therapy a treatment of choice for mediastinitis in the last three decades, the incidence of morbidity and mortality turned out to be high. The disappointing results of the first reports on the closed irrigation and the evidence of iodine toxicity \(^\text{24,25}\) ignited considerable interest in numerous plastic surgery procedures in the alternative to the closed irrigation of the mediastinum \(^\text{26-28}\), as the use of pectoral flap. In the therapeutic protocols is also provided an aggressive surgical debridement, followed by a plastic reconstruction with muscle flap or omentum, depending on the severity of infection.

Many retrospective studies have compared the closed irrigation with reconstructive surgery in the treatment of mediastinitis. The operative mortality rate for both treatment varies from 0\% to 16\% and is almost constant in these studies \(^\text{26-28}\). In the broadest of these statistics, Scully et al. \(^\text{28}\) found that the closed mediastinal irrigation, practiced in 19 patients and the intervention of delayed transposition of the pectoral muscle, practiced in 22 patients, offer similar short-term and long-term results. Despite these improvements, mortality remains high and this complication involves a significant prolongation of hospitalization with an increase in costs \(^\text{26-28}\).

In 1985 Trouillet described the use of granular sugar in the treatment of mediastinitis. The rationale of this medicament consists in determining an osmotic shock for any type of bacteria present in the infectious areas. However, wound healing with sugar-based treatment may take a long time, prolonging the hospital length of stay. In diabetic patients, moreover, it is required an increase in insulin dose during this treatment \(^\text{29}\).

**Negative Pressure Therapy / Vacuum-Assisted Closure Therapy**

In recent years, a new therapy is taking over all the others: the Negative Pressure Therapy (N.P.T.) or Vacuum-Assisted Closure Therapy (VAC Therapy). Since it was introduced by Argenta and Morykwas in 1997 for the treatment of chronic ulcers \(^\text{30}\), the treatment with the VAC system has been, rapidly over time, applied with clinical indications ever more extensive, including the treatment of post-cardiac surgery mediastinitis \(^\text{30,31}\). The principle of operation of this system is based on the application of a polyurethane sponge into the wound below the sternum. In such a sponge it is inserted a drain connected to a vacuum pump, generally at -125 mmHg. Before insertion of the VAC system is required aggressive surgical debridement to remove all necrotic tissue that would otherwise hinder healing and facilitate bacterial colonization. Treatment options available at the time of the debridement depend essentially on the apparent depth and severity of infection.
The VAC therapy appears to offer several advantages over traditional methods. The uniform negative pressure applied to the wound results in arteriolar dilation with improved microcirculation. Continuous suction, reducing excess fluids and tissue edema, reduces bacterial colonization and prevents the spread of the same to the systemic circulation. Finally, the suction causes a stabilization of the sternal margins which allows early mobilization of the patient and prevents the rupture of the right ventricle. The net effect of these mechanisms on the wound is the increase of the granulation, the tissue proliferation and acceleration of healing. The VAC therapy was thus proven in our experience as a treatment of recurrent postoperative mediastinitis.

**Materials and methods**

In the period from January 2010 to December 2015, at University of Bari Cardiac Surgery Center have been performed 3123 median sternotomy for cardiac surgery. Deep sternal wound infection was found in 35 patients (1.1207%); mean age 62.7 ± 6.8 years. Among the risk factors for mediastinitis reported in the literature, in our patients we reported:

1) surgical isolation of the left internal mammary artery (LIMA) in twenty-five patients,

2) diabetes in twenty,

3) obesity in fifteen,

4) chronic obstructive pulmonary disease (COPD) in nine patients.

The diagnosis of mediastinitis was postulated, according to the guidelines of the U.S. Center for Disease Control and Prevention. It must meet at least one of the following criteria:

1) Patient has organisms identified from mediastinal tissue or fluid by a culture or nonculture based microbiologic testing method which is performed for purposes of clinical diagnosis or treatment.

2) Patient has evidence of mediastinitis on gross anatomic or histopathologic exam.

3) Patient has at least one of the following signs or symptoms: fever (>38.0°C), chest pain, or sternal instability (with no other recognized cause) and at least one of the following:

   a. purulent drainage from mediastinal area
   b. mediastinal widening on imaging test

4) Patient ≤1 year of age has at least one of the following signs or symptoms: fever (>38.0°C), hypothermia (<36.0°C), apnea, bradycardia, or sternal instability (with no other recognized cause) and at least one of the following:

   a. purulent drainage from mediastinal area
   b. mediastinal widening on imaging test.

In our study, the main isolated pathogens were: coagulase-negative staphylococci in 48% of patients; *Staphylococcus aureus* in 29%; Gram negative bacteria in 23% of patients. A Methicillin-resistance (MRSA) was found in 30% of cases.

The clinical presentation of mediastinitis in our patients was variable and characterized by: fever onset in 11 patients; WBC at the beginning: average 13800 ± 5200 / uL; CRP at the beginning: mean 19.2 ± 6.3. The VAC therapy was performed in all patients.

**Results**

VAC treatment duration was 14.4 ± 6.7 days. There has been no deaths for mediastinitis, so as any VAC-related complication. Inflammatory indexes have recorded a marked decline. Particularly, WBC from 13800 ± 5200 to 6400 ± 1400; CRP to the removal of the VAC was 5 ± 2.6.

At the end of vacuum therapy, in some cases, the reconstruction of the wound was carried out with plastic reconstruction by means of a pectoral flap. There has been no deaths for mediastinitis, neither any relapse or treatment-related complication.

<table>
<thead>
<tr>
<th>Clinical characteristics</th>
<th>No of patients (%)</th>
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<tbody>
<tr>
<td>Diabetes</td>
<td>20 (57.14%)</td>
</tr>
<tr>
<td>Obesity</td>
<td>15 (42.85%)</td>
</tr>
<tr>
<td>Use of LIMA</td>
<td>25 (71.42%)</td>
</tr>
<tr>
<td>COPD</td>
<td>9 (25.71%)</td>
</tr>
<tr>
<td>Patients underwent coronary artery by pass</td>
<td>25 (71.42%)</td>
</tr>
<tr>
<td>Patients underwent cardiac surgery other than bypass</td>
<td>10 (28.58%)</td>
</tr>
</tbody>
</table>

Table 1: Patients’ clinical characteristics.
Hospital stay was 30.4 ± 13.5 days from the beginning of treatment.

**Discussion**

The mediastinitis is a serious and feared complication after open heart surgery. Despite all the improvements in the field of antibiotic therapy, and of the postoperative management, the incidence of this disease has remained stable over the last three decades. This can be explained by the important role of preoperative risk factors in the development of deep sternal wound infections(32,34).

On the other hand the evolution of mediastinitis treatment showed a significant decrease in mortality and morbidity. The treatment with the antibiotic therapy alone is ineffective and unjustified in modern practice(35). Irrigation with closed chest catheter, introduced by Shumaker, represented a treatment of choice for a long time, having as a result a range of mortality between 4.8 and 10.8%. At the same time, even the plastic reconstruction techniques, such as the pectoral muscle flap, after careful surgical debridement, showed short and long-term similar results, as reported by Scully et al.(29).

Alternative techniques such as the use of granular sugar showed good results, while being burdened by hospitalization times on average longer if compared to the procedures mentioned above. The therapy with granular sugar also requires high doses of insulin in diabetic patients(29).

A new therapy, in recent years, is taking over all the others, thanks to the first encouraging results: the VAC therapy. The principle of this procedure, first introduced for the treatment of infected surgical wounds by Argenta Morykwas in 1997(30), is based on the application of a negative pressure on the wound(30,31). The mechanisms responsible for the effects of this therapy were partially identified. Wackenfors et al. have shown, in experimental studies on pigs, a correlation between the intensity of the negative pressure and the blood flow into the microvascular bed(30). They identified the range -75 to -100mmHg, as head of the maximum increase of blood flow into the muscular microcirculation around the wound. The uniform negative pressure applied to the wound allows arteriolar dilation, increasing the microcirculation. Continuous negative pressure, reduces excess fluids and tissue edema, reducing therefore bacterial colonization. These positive effects lead to a granulation tissue, proliferation and acceleration of the healing process. The final subsequent surgery as a primary closure, or reconstructive plastic surgery through the chest flaps, can be earlier and easily applied. Already in 1999 Obdeijn had applied the VAC therapy for the treatment of post-sternotomy mediastinitis(37). This procedure has shown excellent results in terms of ultimate healing from infection and shorter cure times that the classic treatments(31,38-40).

In our surgical cardiac center we followed, in subsequent periods, different therapeutic procedures, with varying results, not always satisfactory, sometimes very disappointing in terms of clinical outcome.

In recent years, driven by encouraging and promising results of VAC therapy, we have treated all patients with mediastinitis through this technique.

The main bacterial strains responsible for mediastinitis, in our study, were staphylococci, accounting for 77% of total infections. In the group of *Staphylococcus aureus* isolates, a high percentage (30%) of methicillin resistance was detected. Such data confirm the endemic presence of *Staphylococcus* spp. in hospitals and the importance of this microorganism in infective complications in surgical units in general, also in cardiac surgery patients. Another related issue is the increasing incidence of bacterial resistance, in particular for molecules with high efficacy as methicillin. Gram negative bacteria were isolated in the remaining 23% of patients with mediastinitis. No resistant strains were isolated in these group of patients.

All patients with wound infection and minimal sternal instability underwent an early reopening of the wound, removal of sternal points and an accurate curettage of infected tissues. In all patients was performed VAC therapy for a period of about 10-12 days. At the end of VAC therapy, in some cases, the reconstruction of the wound was carried out with plastic surgical reconstruction by means of a pectoral flap. The results obtained by us with VAC therapy are better than those obtained with classic procedures used in past years(31,38-40).

In conclusion, based on our experience and from analysis of the literature data, the procedure of choice to be used for the treatment of mediastinitis post-sternotomy, should consist of an early
debridement of the wound, application of VAC therapy followed, if necessary, by plastic reconstruction through a flap of the pectoral muscle. Furthermore, this approach has shown, in our cardiac center, satisfactory results also in terms of hospital stay time and reduced costs.

References


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