VAC® for external fixation of flail chest

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Abstract

A large anterior wall defect following tumor resection was reconstructed with a Gore-Tex® membrane and a combined musculocutaneous rectus femoris and tensor fasciae latae free flap. Subsequent paradoxical respiration impeded weaning from the ventilator. Application of Vacuum Assisted Closure® (VAC®) resulted in immediate chest wall stability and a decrease in the patient’s need for respiratory support. Shortly thereafter, the VAC® was discontinued and the patient was discharged from the intensive care unit (ICU). This case report is the first to describe the successful use of VAC® as an adjuvant to a one-stage procedure for large thoracic wall reconstruction, allowing sufficient temporary external fixation to eliminate paradoxical respiration and plausibly shorten the stay in the ICU. No adverse effects on flap healing or haemodynamics were recorded. It is likely that external VAC® can improve thoracic stability and pulmonary function in a patient with flail chest and decrease the need for mechanical ventilation.

Introduction

In thoracic surgery the Vacuum Assisted Closure®-device (VAC®, KCI Medical Aps, Ballerup, Denmark), has shown promising results in the treatment of mediastinitis and thoracic instability in patients, who have undergone thoracotomy.1,2 This article describes an unprecedented employment of VAC®, promoting the recovery of a patient with flail chest following anterior thoracic wall resection for recurrent breast cancer and reconstruction with a Gore-Tex® (W. L. Gore & Associates Inc., Elkton, MD, USA) membrane and a microsurgical autologous free flap.

Case Report

A 44-years-old woman suffered from recurrent invasive oestrogen and progesterone receptor negative ductal carcinoma of the right breast. The course had encompassed subcutaneous lumpectomy, re-lumpectomy, subcutaneous mastectomy, lymph node dissection of the right axilla (1 metastatic lymph node out of 20 removed) and adjuvant combined radio- and chemotherapy. The patient had undergone breast reconstruction with a latissimus dorsi island flap combined with silicone-gel prosthesis.

Fourteen months later, the patient was re-referred to our department with a painful local recurrence. Computer assisted tomography (CAT) and magnetic resonance imaging scans showed tumour infiltration around the upper 7 cm of the corpus sterni, ending close to the manubrium. The mediastinum was not infiltrated. No other foci were found by whole body positron emission tomography/CAT-scans. The tumour was non-responsive to preoperative docetaxel (Taxotere® , Sanofi US, Bridgewater, NJ, USA) treatment.

Tumor ablation was performed with wide excision margins guided by frozen section analysis and included a large anterior thoracic wall resection, including the cartilages of the left ribs nos. II-IV, the caudal half of the manubrium, the corpus sterni, the xiphoid process and the anterior parts of the right ribs nos. II-VI, extending laterally to the axillary midline (Figure 1). Permanent section analysis later confirmed micrometastasis.

The defect was reconstructed with a 2 mm polytetrafluoroethylene (Gore-Tex®)-patch and a combined musculocutaneous rectus femoris and tensor fasciae latae free flap with a 20x20 cm skin paddle harvested from the right thigh. End-to-end microsurgical vascular microanastomoses were made to the left internal mammary vessels. Two suction tubes were placed before the flap was sutured (Figure 2). The primary donor defect was covered with a meshed split-thickness skin graft harvested from the opposite thigh.

Bilateral pleural drains (-25 cm H2O) were placed. Prophylactic cefuroxim, dextran, acetylsalicylic acid and low dose low molecular heparin was administered perioperatively.

Apart from separation of a simple haematoma between the Gore-Tex® membrane and the flap on the 6th day, the postoperative course was marked by insufficient respiration. The respiratory pattern was abdominal, with paradoxical movements of the flap. Roentgenograms showed expanded lungs with no pneumo- or haemothorax. The pleural drains were removed on days 7 and 8. Phasing out of the ventilator was impossible due to the thoracic instability. Some, but insufficient weaning progress was made during the first 5 days postoperatively. The reoperation set back the weaning process substantially (Figure 3). On day 8, external stabilisation of the thoracic wall was achieved with a VAC® device: a polyurethane foam under an airtight adhesive drape, placed on top of the flap, extending 5 cm beyond the borders of the flap. A hydrocolloid cast (Duoderm®, ConvaTec Inc., Skillman, NJ, USA) protected the suture lines. Continuous negative pressure of 125 mmHg was applied (Figure 4). Once daily, the VAC® was partially removed to inspect the flap.

Tracheostomy was performed on day 11. Bilateral Citrobacter freundii pneumonia was treated with ciprofloxacin. On day 15, the respiration was stabilized sufficiently to wean the patient off the ventilator. The VAC® was discontinued and the patient was discharged from the intensive care unit (ICU). The patient initially had a full recovery, with no subsequent respiratory problems and an uncomplicated healing of the transplants and all donor sites. The tracheal tube was removed on day 22 and the patient was discharged from the hospital on day 33.

Unfortunately, the patient developed another locoregional recurrence with pulmonary and hepatic dissemination only two months later and was referred to palliative chemotherapy.

Discussion

Flail chest, with the paradoxical respiratory movement of a segment of the thoracic wall, is...
a well-known adverse effect of sternotomy, cardiopulmonary resuscitation, costal fractures, and chest wall resection.

Flail chest compromises respiratory recovery and prolongs rehabilitation. Reconstruction of defects in the thoracic wall is a familiar challenge to plastic and thoracic surgeons, and different techniques are used to manage flail chest. The surgical means are various forms of internal fixation, while the predominant conservative approach is by means of analgesia, pulmonary toilet or continuous positive airway pressure.

Sporadic case reports describe an alternative conservative approach by use of continuous negative extrathoracic pressure (CNEP) provided by a cuirass respirator: a modern, portable version of the iron lung.

After an extensive anterior thoracic wall resection with soft prosthesis and free flap reconstruction, our patient developed flail chest. The paradoxical respiration of the reconstructed area rendered weaning from the ventilator impossible. Hypothesizing that topical negative pressure would stabilise the chest wall sufficiently to wean the patient from mechanical ventilation, a VAC® device was tentatively placed on top of the reconstructed area. The resulting thorax stability immediately decreased the patient's need of respiratory support and on day 10, a larger VAC® reduced the pressure support needed by 50% (Figure 3). After 7 days of temporary external stabilisation, the ventilator and the VAC® could be discontinued.

The optimal pressure for this clinical situation is uncertain. We chose a negative pressure of 125 mmHg, because this level is most commonly used, and results in optimal wound healing. In a porcine sternotomy model, it was found that maximum stability occurs at a low negative pressure of 50 to 100 mmHg.
Pressures below do not contribute further to stabilisation.2

Concern has been raised regarding possible adverse systemic haemodynamic effects of placing the VAC® in thoracic wall defects, but these appear to be minimal at -125 mmHg if muscle is interposed.8 No adverse effects on systemic haemodynamics were recorded in the present case.

The local effects of placing VAC® on top of a free musculo-cutaneous flap are not well addressed in literature. In this case, there was no adverse effect on flap survival; on the contrary, the increased microcirculation in the flap and the recipient wound edges, induced by the VAC®, may facilitate the take of the flap.1

It is likely that the ability of VAC® in neutralizing paradoxical respiration can be ascribed to its structural stabilising effect, due to the continuous negative pressure applied to the polyurethane foam, the flail segment and the surrounding thoracic wall. The observed clinical correlation between VAC® application and weaning from the ventilator cannot be established as causal with certainty in this case report. Several factors such as pneumonia, establishment of a tracheostomy and spontaneous rehabilitation could have influenced the course of the patient’s recovery. The pneumonia was caused by an opportunistic pathogen in a vulnerable patient weakened by cancer, and tracheostomy was performed on day 11, which is our institution’s standard of care when the need for invasive ventilation exceeds more than one week, and extubation is not likely to be achievable in the near future. Nonetheless, the application of VAC® and the reduction in pressure support (PS) (from 19 cm H2O to 6 cm H2O) occurred before the tracheostomy. Furthermore, the reduction in PS of 14 cm H2O was achieved in only two days, whereafter the patient’s pulmonary condition only improved (Figure 3). Despite these ameliorations the patient didn’t wean until after 7 days, which could indicate that cause and effect might not be entirely coherent. Nevertheless, it seems that VAC® aided in stabilising the flail chest, facilitated quicker weaning and early mobilization, thereby improving the clinical picture.

Some may argue that flail chest development should be avoided at the time of chest wall reconstruction. Hameed et al. studied a series of chest wall reconstructions in 20 patients with some similarity to our case, in which none developed flail chest.6 We ascribe this difference in outcome to the fact that the resection was more extensive in our case. For structural reconstruction, Hameed et al. chose a polypropylene mesh that was sometimes doubled to provide extra support, but the choice of prosthetic material (polypropylene versus Gore-Tex) should not per se affect the outcome.4

This case suggests how VAC® can help improve the thoracic stability and pulmonary function in a patient with flail chest, and potentially decrease the time spent in the ICU.

It demonstrates the success of using VAC® as an adjuvant to a one-stage procedure for anterior thoracic wall reconstruction, allowing sufficient temporary external fixation to aid elimination of paradoxical respiration without adverse effects on haemodynamics or flap healing.

As in the few previous reports, this case illustrates how CNEP can provide intermediate thoracic stability and render surgical stabilisation of flail chest needless.7

We suggest that VAC® can replace the cuirass ventilator as a CNEP device. VAC® is easier to apply and adjust, it is lighter and therefore more tolerable for the patient.

Further investigation of the use of VAC® in the conservative management of flail chest is desirable.

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