The effect and safety after extended use of continuous negative pressure of 75 mmHg over mesh and allodermis graft on open sternal wound from oversized heart transplant in a 3-month-old infant*

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ABSTRACT
Negative pressure therapy (NPT) has been reported to be effective in treating infants with open chest wounds. This report further supports its effectiveness by treating a 3-month-old infant with a 12 × 7 cm sized opening in its chest after an oversized heart transplantation. After applying a mesh and allodermis over the defect, 75-mmHg continuous negative pressure was set and used for an extended period of 104 days. The haemodynamic status was evaluated during this period. The wound was closed with secondary intention and it healed well after NPT. There was no haemodynamic instability during the treatment course. The extended use of a continuous negative pressure of 75 mmHg over the mesh and alloderm graft was a reliable and safe option to close the massive defect in the chest of a 3-month-old infant.

Key words: Heart transplant • Negative pressure therapy • Paediatric sternal wound

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INTRODUCTION

Negative pressure wound therapy (NPWT) has shown many promising results in various types of wounds (1, 2). Since the first report of negative pressure therapy (NPT) by Argenta and Morrykas, the application of this method has been extended from simple pressure ulcer wounds to complicated sternal wounds (3).

Previous research has shown that a negative pressure of 125 mmHg is optimal for wound healing, but there have been reports of life-threatening complications such as cardiac rupture and massive bleeding when applied to sternal wounds (4). Because of the pressure-susceptible organs of the mediastinum, different pressures were studied which presumed to achieve the goal of wound closure as well as have minimal complications. Several previous studies suggested that 75–80 mmHg is a safe and effective negative pressure for sternal wound treatment, without significantly compromising the haemodynamics and sternal stability, and the same findings were reported for infants as well (5–7).

Mostly, the NPT is needed to close the chest wounds arising from a median sternotomy procedure that results in inability to close wound or mediastinitis after primary closure. The usual moderate-sized defects that may occur from median sternotomy can be closed within the first 2 months using the NPT.

However, this is a unique report in which a massive and possibly the largest initial defect is reported to have occurred so far because of the inability to close the sternotomy wound as a result of the discrepant, large transplanted heart. The efficacy and safety of continuous 75 mmHg NPT during an extensive period, exceeding 3 months, were evaluated.

PATIENT CASE

The patient was a 100-day-old male infant who coincidently presented a murmur on his regular vaccination schedule, and was diagnosed with subaortic valvular stenosis. Three consecutive operations were performed, which failed to correct the haemodynamic imbalance, and heart transplantation was planned.

The donor was a 4-year-old male with a heart size four times bigger than the recipient. Because of the insufficient volume and dimension of the recipient’s thoracic cage, the sternal wound could not be closed.

The initial size of the opening was 12 × 7 cm. The wound was 37.5% of the entire chest, in horizontal width. The gap was covered with a sandwich graft made of acellular allogenic dermis (Alloderm®, Life Cell Corp, The Woodlands, TX) on the top and bottom, with prolene mesh in the middle.

After covering the defect with the graft, open-cell foam was cut to an adequate shape, and with a suction drain tube attached to the foam, transparent film dressing was covered without any leakage (Curavac®, Daewoong Pharmaceuticals, Seoul, Republic of Korea). A 75-mmHg continuous negative pressure was applied using a wall-mounted suction device.

The patient was then monitored in the paediatric intensive care unit. Systolic blood pressure (SBP), diastolic blood pressure (DBP), central venous pressure (CVP) and pulse rate were measured. Also oxygen saturation and end-tidal CO₂ (ETCO₂) concentration were measured every hour. Body temperature was checked, chest X-ray was taken to visualise the heart and chest cage, and serial echocardiogram was performed to evaluate the haemodynamic status of the patient. Indexes such as ejection fraction, interventricular septal thickness at diastole, interventricular septal thickness at Systole and fraction shortage were evaluated. Values from these tests were compared with the values obtained before applying negative pressure wound dressing.

Every 3 days, negative pressure wound dressing was changed in the intensive care unit and the wound was examined and documented in terms of its size and character.
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cell counts, blood culture and swab culture of the wound. Because the patient was intubated, respiratory function was evaluated through the mechanical ventilation parameters.

RESULTS

From postoperative day 0–104, negative pressure wound dressing was applied on the wound of the patient. Size of the wound, initially 12 × 7 cm, decreased to a wound without defect in 104 days. During the treatment time, there were no signs of infections and elevated levels of C-reactive protein, WBC count was in a normal range and no microorganism was grown from the culture (Figure 1).

Vital signs were evaluated. Comparing the data of SBP, DBP and CVP, there were no significant changes before and after applying negative pressure wound dressing. The range of blood pressure and CVP was in the range of a normal infant, and for the respiratory function, comparing the values of ETCO2 and saturation, there was no significant difference before and after applying negative pressure wound dressing (Figure 2). Haemodynamic evaluation of the heart was carried out by serial echocardiography, and the finding also

Key Points

– from postoperative day 0–104, negative pressure wound dressing was applied on the wound of the patient
– size of the wound, initially 12 × 7 cm, decreased to a wound without defect in 104 days
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Figure 1. (A) A 100-day-old infant with a massive sternal defect of 12 × 7 cm after transplantation of a fourfold larger heart from a 4-year-old is presented. Note the allodermis–mesh–allodermis coverage of the defect. (B) The wound was treated with continuous negative pressure therapy of 75 mmHg and the granulation was noted with slight reduction of size at 1 week. (C) Near-complete healing is noted at 104 days after treatment when NPT was stopped and conventional treatment using dressings was started.
Effect and safety after extended use of continuous negative pressure of 75 mmHg

Key Points

- after 104 days, the negative pressure dressing was removed and dressed to gain secondary intention healing
- the wound was successfully healed without any complications
- however, the patient suffered renal failure 3 months after wound closure and expired unrelated to cardiac function
- measures to prevent infection of the open sternal wound and also maintaining the stability of the thorax were an important issue of this monumental case, not much to say, avoiding any complications such as bleeding or dysfunction of the mediastinal organs
- because the recipient was in an immunosuppressed state, avoiding infection of the wound was a very important issue, and also the measures should not interfere or endanger the function of the newly transplanted heart
- at the same time acceleration of healing time of the wound was needed
- any kind of flap coverage would be the choice but the massive defect ruled out any chance to harvest a flap in this infant
- this is why the authors decided to cover the defect with mesh and allogermis in a sandwich style

showed that there was no significant difference before and after applying vacuum-assisted closure on the sternal wound (Figure 3).

After 104 days, the negative pressure dressing was removed and dressed to gain secondary intention healing. The wound was successfully healed without any complications. However, the patient suffered renal failure 3 months after wound closure and expired unrelated to cardiac function.

DISCUSSION

Measures to prevent infection of the open sternal wound and also maintaining the stability of the thorax were an important issue of this monumental case, not much to say, avoiding any complications such as bleeding or dysfunction of the mediastinal organs.

There were many considerations in choosing the right management for this patient. Because the recipient was in an immunosuppressed state, avoiding infection of the wound was a very important issue, and also the measures should not interfere or endanger the function of the newly transplanted heart. At the same time acceleration of healing time of the wound was needed. Any kind of flap coverage would be the choice but the massive defect ruled out any chance to harvest a flap in this infant. The next choice would be to provide compartmentalisation of the intrathoracic cavity as well as allow good vascularisation to allow cutaneous healing. This is why the authors decided to cover the defect with mesh and allogermis in a sandwich style. The inner layer of allogermis was used to minimise the intrathoracic tissues from adhering to the mesh and the rib cartilage and bone that may cause complications during negative therapy. The negative pressure may alter the position of the heart towards the sharp sternal edges and may cause fatal complications (8). Thus anticipating the movement of the heart and as

Figure 2. Serial findings of vital signs prior to graft and negative pressure therapy and after transplantation and application of negative pressure therapy show minimal change. BT, Body temperature (°C); ETCO2, End tidal CO2; SpO2, Saturation by pulse oximetry (%); CVP, Central venous pressure (mmHg); DBP, Diastolic blood pressure (mmHg); SBP, Systolic blood pressure (mmHg).

Figure 3. Serial echocardiogram findings showing minimal change prior to and after graft and negative pressure therapy application. EF, ejection fraction (%); FS, fraction shortage (%); ESVI, end systolic volume index (ml/m2); LVIDs, left ventricular internal diameter at end-systole (mm).
the heart was over sizing the recipient’s cavity, it was important to cover the mesh and sternal edges with allodermis. Second reason why the authors chose this barrier was that it would minimise haemodynamic compromise. Although numerous papers report the success of treatment in infants, it was not concluded from the view of haemodynamics (5–7).

A paper by Petzina et al. has shown that there is a decrease in haemodynamic function of up to 13 ± 1% when NPT was used directly, whereas an 8 ± 1% reduction was noted when a four-layer paraffin guaze was used as a barrier between the negative pressure dressing and the heart (9). The authors hypothesised that this three-layer approach would minimise any chance for physical as well as functional complications. As shown in the section on Results, the haemodynamics of the heart showed minimal variation during the NPT. The third reason for this approach was to provide a matrix for granulation while resisting infection especially for the outer layer of sandwich style coverage.

It is reported that allodermis resists infection and thus can be the choice of matrix in this high-risk patient (10). We have observed the outer layer to work as a matrix to promote granulation over the synthetic mesh. In this study, we have observed no signs of infection while under extended treatment for 104 days till closure.

Negative pressure wound dressing has proved to be a safe and effective method for managing sternal wounds (7,11–13). But the controversy regarding the ideal negative pressure is not resolved. This is especially true for infants and neonates who can be more susceptible to pressure on the heart.

There have been numerous papers advocating a negative pressure of 75–80 mmHg which maximises the blood flow and healing (5–7). It can be assumed that tailoring of negative pressure should be made to accommodate the wound tissue composition while minimising the risk of major complication. There has been concerns that low negative pressure might bring insufficient sternal stability, but Mokhatri et al. reported that low negative pressures (−50 to −100 mmHg) stabilise the sternum just as efficiently as do high negative pressures (−150 to −200 mmHg), and the foam at a low negative pressure (−50 mmHg or −75 mmHg) adapts better to the shape of the wound than a high-negative pressure porcine model (14).

The authors used the negative pressure under continuous mode based on the findings that continuous drainage of the infection and capillary vasodilatation of muscular and subcutaneous tissues which increases blood perfusion may produce optimal results (6,15). In our case, we have used successfully a continuous negative pressure of 75 mmHg during the extended 104 days of treatment for achieving the goal of healing a massive-sized defect.

By using allodermis with mesh graft and applying NPT of 75 mmHg on the extensive open sternal wound from oversized heart transplant, we were able to manage the massive-sized wound without infection while maintaining good haemodynamic function and achieved successful closure within 104 days. This method may present a safe and effective alternative for infants with extensive defects of the chest.

REFERENCES


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