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CASE REPORT

Impact of extensive negative pressure wound therapy on neonatal respiration: A case report

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Abstract

An extensive topical negative pressure wound therapy (NPWT) from the abdominal to chest walls in neonates may decrease the compliance of the chest wall. Therefore, it is important to monitor respiratory function carefully during the procedure.

KEYWORDS

chest wall compliance, negative pressure wound therapy, neonate, respiratory system compliance

1 | INTRODUCTION

Topical negative pressure wound therapy (NPWT) is widely used for pediatric patients. However, an extensive NPWT from the abdominal to chest walls in neonates may decrease the compliance of the chest wall. Therefore, it is important to monitor respiratory function carefully while applying extensive NPWT in neonates.

Topical negative pressure wound therapy (NPWT), such as the vacuum-assisted closure (VAC) therapy, is one of the useful management modalities of complex wound care that shortens the interval between debridement and coverage. By providing negative pressure to the wound tissue, NPWT improves blood flow, promotes granulation tissue, and decreases edema and bacterial counts.[1] Because NPWT has a low occurrence of serious complications, it is widely used in infants and can be effectively used in surgical and nonsurgical disciplines.[2] Indeed, when NPWT is used for the treatment of post-sternotomy wounds, NPWT reduces the need for mechanical ventilation by closing the thoracic cavity.[3–5] NPWT in sternotomy wounds has little effect on respiratory mechanics because the propagation of negative pressure is limited to superficial parts of the lungs and the sternum is stabilized during breathing. However, when NPWT is performed on the chest wall other than the sternum, it may affect the respiratory function, particularly in infants and children who have higher chest wall compliance than adults do. In this study, we report our experience with a sudden decrease in chest wall compliance in a neonate after starting VAC therapy at −100 mmHg.

2 | CASE

A 6-day-old, full-term girl, born by uncomplicated vaginal delivery, birth weight 3726 g, was admitted to our hospital because of necrotizing omphalitis and received surgical debridement and drainage (day 1). Intraoperative findings showed inflamed dermis and subcutaneous necrosis, extending from the periumbilical area to the left chest wall, without evidence of abscess or fascial and muscular involvement (Figure 1A). The wound remained open, and she was transferred to the pediatric intensive care unit. The progress of wound healing was satisfactory after surgical intervention. VAC therapy was initiated with a negative pressure of −75 mmHg applied on day 12. On day 16, a VAC replacement procedure was performed while she was managed on mechanical ventilation. The dynamic compliance of the respiratory system was 2.3 ml/cmH_2O without VAC; however, it decreased to 1.3 ml/cmH_2O immediately after the new VAC was applied with a negative pressure of −100 mmHg. Accordingly, peak inspiratory pressure was raised from 14 cmH_2O to 16 cmH_2O (Table 1). Later, spontaneous breathing returned and dynamic compliance improved. She was extubated on day 17 and was transferred to the general ward on day 27. The VAC system was continued until day 28, and skin grafting was performed on day 41.

3 | DISCUSSION

Negative pressure wound therapy is widely used for pediatric patients and has a low frequency of serious complications.[2] However, we found that the extensive VAC system from the abdominal to chest walls decreased the compliance of the chest wall. It may have been caused by covering a large area from the abdomen to the chest, applying excessive negative pressure, and the soft chest wall of the neonate.

The relationship between total respiratory system compliance (C_{RS}) and NPWT is not established. Most studies have shown that NPWT use on sternal wounds does not have any negative influence on the respiratory system.[3–6] However, the use of NPWT for extensive wounds from the abdomen to the chest wall has not been well studied. In this case, because the lung compliance and airway resistance were not considered to have changed during the VAC replacement procedure, it is assumed that the decrease in the chest wall compliance (C_{CW}) contributed to the reduction of dynamic compliance (C_{dyn}) of the respiratory system. The relationship between C_{RS}, lung compliance (C_L), and C_{CW} is indicated by following formula:

$$1/\ C_{RS} = 1/\ C_L + 1/\ C_{CW}$$

The static and dynamic compliances in ventilated neonates are well correlated,[7,8] and the C_{CW}/C_L ratio was reported to be about 3.0 in neonates.[9,10] Assuming that the static compliance was equal to the dynamic compliance, and the C_L was assumed constant during the VAC replacement, we calculated C_L and C_{CW} under three conditions, namely prior to VAC replacement with a pressure of −75 mmHg, during VAC removal, and after VAC replacement with a pressure of −100 mmHg (Table 2). At each time point during the VAC exchange, the calculated C_{CW} was 5.8 ml/cmH_2O, 9.0 ml/cmH_2O, and 2.3 ml/cmH_2O, respectively, under these three conditions. The chest wall is comprised of the rib cage and the diaphragm. The negative pressure of extensive NPWT restricts the motion of the rib cage and the diaphragm. This may stiffen the chest wall and reduce its compliance. This clinical condition is similar to extensive burn scarring of the chest, which leads to limitation of rib excursion and sometimes requires chest escharotomy. In this case, the location of NPWT was placed over the anterior axillary line, which is the incision location for chest escharotomy,[11] suggesting the possibility that the location of NPWT might restrict thoracic mobility. Therefore, when extensive NPWT on

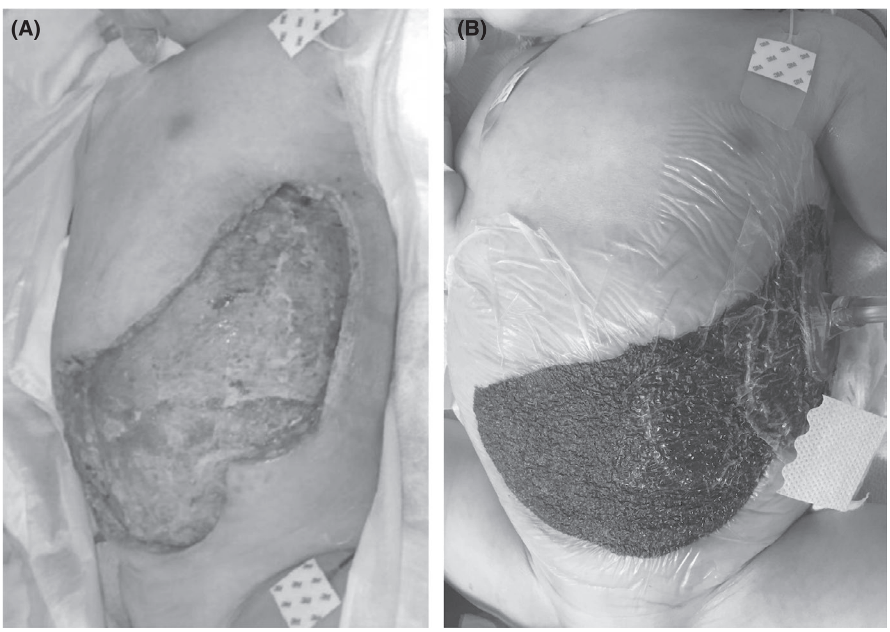

FIGURE 1 (A) Wound from the abdomen to the left side of the chest on day 19. (B) Vacuum-assisted closure therapy for wound from the abdomen to the left side of the chest on day 19

TABLE 1 Ventilator data during the VAC exchange procedure

	VAC at −75 mmHg	Without VAC	VAC at −100 mmHg
PIP, cmH_2O	14	14	16
PEEP, cmH_2O	5	5	5
Driving pressure, cmH_2O	9	9	11
Tidal volume, ml	18	20	14
C_{dyn}, ml/cmH_2O	2.0	2.3	1.3

Abbreviations: C_{dyn}, dynamic compliance; PEEP, positive end-expiratory pressure; PIP, peak inspiratory pressure.

TABLE 2 Calculated results for each compliance during the VAC exchange procedure

	VAC at −75 mmHg	Without VAC	VAC at −100 mmHg
C_L, ml/cmH_2O	3.0	3.0	3.0
C_{CW}, ml/cmH_2O	5.8	9.0	2.3
C_{CW}/C_L	1.9	3.0	0.8

Note: The respective C_L and C_{CW} values were calculated under the assumptions that static compliance was equal to dynamic compliance, C_L was constant during the procedure for VAC exchange, and the ratio of C_L to C_{CW} was 1:3 when the VAC was removed.

Abbreviations: C_{CW}, chest wall compliance; C_{dyn}, dynamic compliance; C_L, lung compliance; PEEP, positive end-expiratory pressure; PIP, peak inspiratory pressure

the abdominal and chest wall is applied, it may affect the chest wall compliance. Hence, the respiratory function should be observed carefully.

The excessive negative pressure of NPWT may have a negative effect on respiratory function. In the application of NPWT in thoracic wounds, a pressure setting of −50 mmHg to −70 mmHg has been recommended.[12] The pressure of −100 mmHg in this case might have been excessive and interfered with the respiratory mechanics, but we were unable to identify the studies which examined detrimental effects of NPWT on respiratory mechanics.

The adverse effect on respiratory mechanics by applying NPWT on the abdominal and chest wall may be more likely to occur in infants than in adults. By the second year of life, chest wall stiffness increases to the point that the chest wall and lung are nearly equally compliant, as in adulthood.[9] In addition, the outward recoil of the chest wall in infants is lower than in adults,[13] suggesting that the chest wall may not counter the negative pressure of NPWT in infants. Therefore, infants may be more prone to the development of negative effects on respiratory mechanics when applying extensive NPWT than adults are.

In conclusion, the extensive VAC system on the abdominal and chest wall decreased C_{CW} and tidal volume in the neonate. The respiratory mechanics must be carefully monitored during an extensive NPWT application to neonates.

ACKNOWLEDGEMENTS

Not applicable.

CONFLICTS OF INTEREST

The authors declare no conflicts of interest.

AUTHOR CONTRIBUTIONS

Ichiro Osawa, Norihiko Tsuboi, and Nobuyuki Nosaka contributed to collecting clinical data, data analysis, and writing the manuscript. Nao Nishimura and Satoshi Nakagawa contributed to discussions about the patient. All authors drafted the manuscript, critically revised the manuscript, and read and approved the final manuscript.

CONSENT

Written informed consent for publication of clinical details and clinical images was obtained from parents of the patient.

DATA AVAILABILITY STATEMENT

The data that support the findings of this study are available on request from the corresponding author. The data are not publicly available due to privacy or ethical restrictions.

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