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Negative pressure therapy as a safe alternative in the treatment of massive subcutaneous emphysema in critically ill patients COVID-19

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ABSTRACT

Many surgical treatments have been described for massive subcutaneous emphysema (MSE) over the recent years. However, there is no consensus on which is the most recommended and there is great diversity in treatment. With new advances in minimally invasive therapy performed at the bedside, especially in intensive care units, it has been possible to increase therapeutic efficacy. During the COVID-19 pandemic, some therapeutic techniques have been discussed in critically ill patients with SARS-COV-2 respiratory infections, because of the potential overexposure of healthcare personnel to an increased risk of contagion after direct exposure to air trapped in the subcutaneous tissue of infected patients. We present the clinical case of an 82-year-old male patient, SARS COV-2 infected, with MSE after 48 h with invasive mechanical ventilation in critical intensive care. He was treated with negative pressure therapy (NPT) allowing effective resolution of the MSE in a short period (5 days) with a minimally invasive bedside approach, reducing the potential air exposure of health personnel by keeping the viral load retained by the emphysema. Therefore, we present NPT as an effective, minimally invasive and safe therapeutic alternative to be considered in the management of MSE in critically ill patients infected with SARS COV-2.

Introduction

Minimally invasive techniques have revolutionized the bedside treatment of patients in intensive care. In the treatment of subcutaneous emphysema (SE), numerous strategies have been described to palliate symptoms and ventilatory compromise until the cause is resolved: from surgical procedures by open thoracotomy or video-assisted thoracoscopic surgery (VATS)[1]; to less invasive methods, such as simple 'blow hole' incisions,[2] with or without compressive bandages; as well as the placement of needles or multiperforated drains.[3] However, some of the techniques are limited in patients with SARS COV-2 infection, because of viral airborne dissemination and the increased risk of exposure for healthcare personnel. This is especially so in intensive care units (ICUs), where numerous bedside treatments are used and sometimes—in situations of acute instability of patients—adequate protective measures are not implemented.

Throughout the COVID-19 pandemic, there has been an increase in the number of patients admitted to ICUs who require invasive mechanical ventilation with protective criteria aimed at preventing ventilator-induced lung injury. The current approach to protective ventilation, which became universally accepted after the acute respiratory distress syndrome (ARDS) Network trial,[4] is based on tidal volume reduction to about 6 mL^{-kg-1} of ideal body weight while maintaining airway plateau pressure below 30 cm H_2O.[5] Therefore, the occurrence of major macroscopic signs of barotrauma, such as pneumothorax, pneumomediastinum, and SE, has become unusual.[6] However, after the onset of the COVID-19 pandemic, an increase in the incidence of massive subcutaneous emphysema (MSE) has been reported in SARS COV-2-positive patients subjected to the same protective ventilation strategy.[7]

Patients with elevated pulmonary fibrosis such as those with ARDS, obstructive pulmonary diseases or SARS-COV-2 infection who are ventilated with positive pressure ventilation have a major risk of developing pulmonary injury, which can result in complications such as pneumomediastinum, and SE.[8] Positive pressure ventilation can lead to elevation of the transalveolar pressure or to a difference in pressure between the alveolar pressure and the pressure in the interstitial space. This elevation in the transalveolar pressure can lead to

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alveolar rupture, which results in leakage of air into the extra-alveolar tissue, leading to a pneumomediastinum, SE or MSE. .[9, 10, 11, 12]

Negative pressure therapy (NPT) is a well-known minimally invasive technique that is not used in the management of MSE but could well be considered. This methodology improves the clinical evolution of the patient because it allows a continuous suction of subcutaneous air and collapse of the dissected cavity. Furthermore, the subcutaneous air is isolated in the NPT device, decreasing the risk exposure to the healthcare personnel in charge of the patient's care.

Clinical case

In this case, NPT was performed in an 82-year-old male patient, American Society of Anesthesiologists (ASA) grade III with SARS COV-2 infection who developed ARDS and required ICU admission for invasive ventilation. After 24 h of intubation, signs of moderate SE were observed, which progressed in the following 24 h to MSE. Treatment with the NPT technique was applied (Fig. B.1) with resolution of the MSE in 5 days.

Pre- and post-NPT control X-rays were performed to verify resolution of the emphysema (Fig. B.2). One minor complication, surgical wound minor bleeding (Clavien−Dindo grade I) secondary to therapeutic anticoagulation doses (120 mg^{day-1} of Enoxaparine) because of the high risk of thrombotic events in COVID-19 infection, was recorded. This complication was resolved with silver nitrate cauterization at the bedside. The patient stayed in the ICU for 10 days, being extubated on day 7th and was discharged from the hospital on day 16th.

Discussion

MSE can have several etiologies (surgical, traumatic, infectious, or spontaneous), the most frequent being traumatic, such as traumatic orotracheal intubation with associated bronchial injury, thoracotomy or placement of a chest tube.[13] On the other hand, possible MSE caused by barotrauma has been described in the literature. This is considered in relation to the increased need for ventilatory pressure during invasive mechanical ventilation; however, in most ICU centers, ventilatory protection protocols are followed, without reaching high pressures. In fact, a study of >5000 mechanically ventilated patients showed that the presence of air outside the tracheobronchial tree (pneumothorax, pneumomediastinum, SE) was not related to airway pressures or tidal volume.[7] Other studies with case series of SARS-COV2-positive patients have described SE without invasive ventilation.[14] According to the literature on the pathophysiology of SARS COV-2, the development of both SE and MSE might arise from inflammation, consolidation and necrosis occurring in the lung parenchyma during infection, leading to the formation of cystic and cavitary lesions in the lungs over time. In fact, because of the increased risk of fistulation between the parenchyma and pleura, a spontaneous pneumothorax can be triggered. Therefore, the automatic association between barotrauma and presence of air outside the tracheobronchial tree in mechanically ventilated patients should be reconsidered.[14, 15] In fact, the term 'barotrauma' should be used when air is present outside the tracheobronchial tree when air is circulating at elevated airway pressure. Furthermore, the development of MSE is a complication in the evolution of critically ill patients that affects their prognosis. The lethality of MSE is explained by the increase and entrapment of external air, dissecting the subcutaneous and muscular cellular tissue planes, compromised by the increase of ventilation with extrathoracic pressure, impairing cardiac function and swallowing.

Numerous invasive procedures have been described in the past 20 years to decrease trapped air in cases of MSE, improving ventilation of the patient with different treatment intervals (Table A.1) .[16-21] However, none of these has been established as a reference procedure for MSE because of its aggressiveness and prolonged treatment (some described a resolution in 3 h although they referred to a clinical improvement and not to a complete resolution of the MSE). NPT is employed in daily practice in surgical specialties for the management of complex wounds, stimulating wound microvascularization, granulation tissue proliferation and aspirating various wound secretions.[22,23] Applying this last therapeutic principle, NPT could be considered in the treatment of MSE. The subcutaneous air can be removed continuously, avoiding the dissemination of the air and the spreading of possible microorganisms. NPT also allows collapse of the dissected cavity, decreasing the rate of wound infection. Therefore, this technique could be considered a therapeutic alternative in the management of patients with respiratory isolation who present with MSE with compromised ventilation, as it has advantages over other treatments described in the literature, being an effective technique. Maintaining a continuous negative pressure over time provides an advantage over other types of drainage with vacuums that decrease their suction capacity over time.[24] The technique is safer in ICUs than conventional drainage procedures in patients requiring air isolation as in the case of patients infected with SARS-COV-2. It reduces the exposure of healthcare personnel to contaminated air that is stored in the MSE device. It also is minimally invasive, as it is performed under local anesthesia at the bedside, which is very useful in critical patients where the risk of a surgical procedure cannot be assumed; and reproducible, as it is already used by medical and nursing personnel in complex cases.

As limitations, minor complications such as local bleeding can occur during the drainage incision, especially in patients with therapeutic doses of anticoagulants, which could be solved with traditional hemostatic measures such as compression or chemical hemostatics, such as silver nitrate or hemostatic matrices. However this complication could be similar for all procedures. In addition, the duration of treatment is similar to that of other classic techniques; however, the negative pressure also plays a key role to decrease the affected area. To the best of our knowledge, NPT has never been proposed as an effective, minimally invasive and safe strategy for the management of MSE in patients infected by airborne agents such as SARS COV-2.

Conclusion

NPT is a safe treatment alternative for MSE, offering greater protection for the healthcare personnel in charge of the SARS-COV2-positive patient and with a duration similar to that described by other classical treatments.

Funding

None

Ethics approval

The Clinical Ethics Committee of Elche University Hospital approved the use of this technique.

Consent

The patient gave written consent for the use of images and personal information for scientific dissemination.

Authors' contribution statement

ASS and LSG analyzed and interpreted patient data regarding the TPN technique. All authors have read and approved the final manuscript.

Declaration of Competing Interest

None

Appendix

Table A.1

Table A.1
Different treatment strategies for subcutaneous emphysema.

Treatment strategy	Time of treatment
Manual decompression via 'blow hole' incisions.[2]	3–4 days
Chest tube in the midaxillary line and tunneling it through the subcutaneous tissues to the jugular notch	Not indicated
Bilateral anterior mid-chest Jackson–Pratt drain.[17]	3 h
Inserting a fenestrated angiocatheter into the subcutaneous spaces at the infraclavicular regions.[18]	12 h
Subcutaneous Penrose drains and colostomy bags.[19]	Not indicated
Subcutaneous incisions with or without massage.[20]	2 days
Subcutaneous infraclavicular drain (12 frames) on continuous high suction at −150 mmHg aided by manual decompressive massage.[21]	3 days

Fig. B.1

Fig. B.1. NPT Technique description step by step. A. Locating the area of emphysemica. B. Two simple incisions were made in the subcutaneous cellular tissue. C. These were filled with hydrophobic reticulated polyurethane sponge (HRPS). D. These were covered with two larger HRPS fragments to connect both incisions. E. Applying a perforated dressing. F. Placement of the dressing with aspirative drainage and connecting the NPT device in the continuous therapy mode (−150 mmHg) over 5 days.

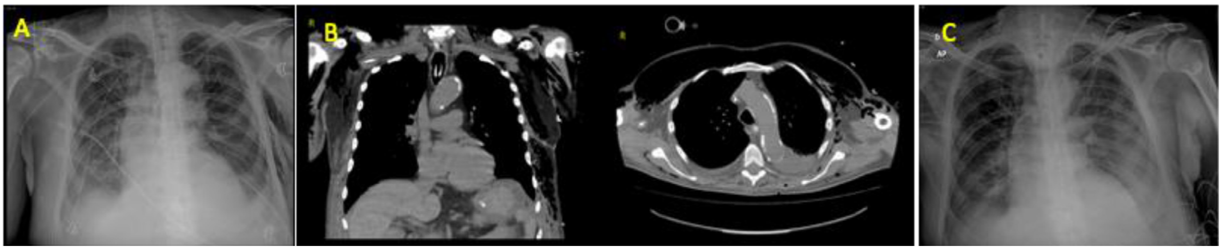

Fig. B.2. A. Chest radiograph showing subcutaneous emphysema of the left axilla after removal of the left chest tube. B. Thoracic computed tomography scan showing extended subcutaneous emphysema, after 4 days of conservative treatment of subcutaneous emphysema secondary to using a left chest tube. C. Chest radiograph: Subcutaneous resolution of the emphysema after 5 days of negative pressure therapy at −150 mmHg.

Fig. B.2

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