The vanishing threat: Stealthy malfunction of closed suction system

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Abstract

This case report presents a rare case of a mechanical ventilation leak that was initially missed by clinicians in a patient with a myxoedema coma. Despite all efforts to investigate the causes of the leak, including a bedside lung ultrasound and chest radiograph, the leak persisted. It was eventually discovered that the rhythmic inflation and deflation of the polythene covering the closed suction system was causing the leak. The closed suction system was replaced with a new one, and the tidal volume was restored, resulting in the resolution of the leak alarm. The volume leak alarm and low volume alarm are important indicators of potential problems during mechanical ventilation, and close suction system malfunction is a potential cause of volume leak that should be considered in mechanically ventilated patients. Regular monitoring and appropriate management of these alarms and potential causes can help prevent complications and optimize patient care.

Keywords: Mechanical ventilation, volume leak alarm, closed suction system, and myxoedema coma.

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Introduction

Mechanical ventilation leak is an unintentional escape of air from the ventilator circuit, usually around the endotracheal tube or tracheostomy, which reduces the effectiveness of ventilation. [1,2] Air leakage can lead to hypoventilation and inadequate oxygenation due to a decrease in delivered tidal volume (VT). [3]

Case Report

We present a rare case of a mechanical ventilation leak that was initially missed by clinicians. A 30-year-old female patient without any comorbidities presented with a one-day history of altered sensorium, vomiting, and general body weakness. Upon arrival at the emergency room, the patient had an altered sensorium and was intubated with a size 7 endotracheal tube that was secured at 20 cm. The patient was then transferred to the intensive care unit and evaluated for altered sensorium, which was found to be myxoedema coma. The patient was kept on mechanical ventilation for three days and was later weaned off. We used the Drager Infinity C300 model and Romson closed suction catheter system for ventilating the patient.

However, the mechanical ventilator's constant leak alarm remained active throughout the period. The ventilator settings were as follows: Volume Controlled-Assist control mode with a set VT of 340 ml, FiO_2 of 30%, respiratory rate of 14/min, PEEP of 5 cmH_20, and Ti-1.00 sec. The cause of the leak was investigated, including the cuff pressure of the endotracheal tube is maintained at 25-30 cmH_20, the connection of the breathing circuit being checked for loose connections, and the HME filter being replaced.

A bedside lung ultrasound showed an A profile with preserved lung sliding, and the chest radiograph showed no pneumothorax. Peak inspiratory pressures did not increase, and the position of the feeding tube was confirmed with a chest radiograph. The flow sensor of the mechanical ventilator was replaced with a new one, but despite all efforts, the leak persisted. It was observed that there was a rhythmic inflation and deflation of the polythene covering the closed suction system, synchronous with the respiratory cycle, which was causing the leak. Squeezing the polythene covering restored the VT, as shown in figure 1 and Table 1. The closed suction system was replaced with a new one, and the VT was restored, resulting in the resolution of the leak alarm.

Figure 1: The upper panel (top right) showing low tidal volume and inflation of close suction system synchronized with respiratory cycle (top left). The lower panel showing that the tidal volume was restored after squeezing the polythene.

Closed suction	Set VT	Expiratory VT	Leakage
Inflated	340	298	Present
Deflated	340	450	Absent

Table 1: Set versus Expiratory tidal volumes (ml).

Discussion

Mechanical ventilation is an essential component of intensive care management of critically ill patients to support the respiratory system till recovery from the illness. But mechanical ventilation is not devoid of any adverse events. [4.] There should be vigilant monitoring of the patient on mechanical ventilation for early identification of any complications, or malfunctions of the mechanical ventilation.

The alarm systems have made the monitoring of this patient easy for the early identification of the problem related to the patient as well as the ventilator. Applying the appropriate limit of the alarm detection system is a crucial part of the monitoring system. Otherwise, inappropriate alarms will cause delayed detection of the problem or false positive alarm activations. [5] Volume leak alarm and low volume alarm are one of essential alarm parameters that may indicate a problem with the ventilator or the patient's airway.

The volume leak alarm is activated when there is a significant loss of air from the airway of the patient or the ventilator. An additional leakage flow may impact the ventilation. If the leakage flow has reached the set trigger threshold, the ventilator may auto-trigger. The inspiration termination may not be reached due to the additional leakage flow. Leak compensation is an advanced algorithm to precisely calculate the VT that flows to the patient. The flow sensor in Drager is internal. The goal is to display the leakage-corrected values of the VT. If the function is activated, the flow waveform, the volume waveform, and the relevant parameter boxes display the corresponding information. Tidal volume alarms are based on the VT instead of expiratory tidal volume (VTe) which may decrease the number of alarms during high leak situations, but it is important to monitor the inspiratory tidal volume (VTi), VTe and the VT to ensure effective ventilation is delivered to the patient.

The possible etiology for the volume loss includes disconnection in the circuit of the mechanical ventilation, malfunction of the endotracheal tube or tracheostomy tube cuff, or volume loss through the intercostal drain in case of alveolar-pleural fistula. [6] Whereas the low volume alarm is activated in case of inadequate delivery of the volume of air to the patient due to a problem with the mechanical ventilator or the patient's airway. The possible reason behind this might be due to a blockage in the ventilator circuit, an obstruction in the patient's airway, or a malfunction of the ventilator itself. [7]

The alarm in a mechanical ventilator must be thoroughly evaluated whether it is true or false and then the priority has to be decided. [8] Prompt evaluation of the cause of the alarm should be done. The process may start with checking the ventilator settings, assessing the patient's airway, and performing diagnostic tests, such as chest X-rays or bronchoscopy as needed. [9]

One of the possible causes of volume leaks in mechanically ventilated patients is the malfunction of closed suction systems. Closed suction systems are commonly used in intensive care units. The advantage of the closed suction system over open suction system is that the former suction secretions from the patient's airway without disconnecting the ventilator circuit. However, malfunction of these systems may result in a loss of air volume and trigger the volume leak alarm.

A study by Sole and colleagues [10] revealed that the incidence of closed suction system malfunction was found to be 8% in mechanically ventilated patients. They also found that the malfunction of the closed suction system was associated with an increased risk of ventilator-associated pneumonia (VAP) and longer ICU length of stay.

Zhang and colleagues [11] reported that the incidence of closed suction system malfunction was as high as 47.4% and was associated with an increased risk of VAP, longer mechanical ventilation duration, and increased ICU length of stay.

In addition to closed suction system malfunction, other potential causes of volume leak in mechanically ventilated patients include disconnection of the ventilator circuit, cuff leak, tracheal stenosis, and tracheal injury.

In this case, the cause of the volume loss alarm was evaluated with an examination of the ventilator circuit for any damage, leak as well as endotracheal tube connections, cuff leak, etc. After all evaluations, the cause of volume loss was not found. There was alternative expansion and deflation of the polythene around the close suction system of the patient with the respiration of the patient. After squeezing the polythene of the closed suction system, the volume loss alarm disappeared. The volume leak problem

was solved by replacing it with a new closed suction system.

Regular monitoring of ventilator settings and alarms, proper placement and maintenance of the endotracheal tube cuff, and appropriate use of closed suction systems are the strategies to prevent and manage volume leak in mechanically ventilated patients. In addition, prompt investigation and intervention in response to alarms can help prevent serious complications and improve patient outcomes.

Conclusion

The volume leak alarm and low volume alarm are an important alarm that gives the intensivist an important clue for the problems during mechanical ventilation. Defect in the close suction system is a rare but potential cause of volume leak that should be considered in mechanically ventilated patients when all other potential causes have been ruled out.
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References

1. Restrepo RD, Walsh BK. Humidification during invasive and non-invasive mechanical ventilation. Respir Care 2012; 57(5):782-788.

2. Chatburn RL. Classification of ventilator circuits: update and analysis. Respir Care1996; 41(10):941-954.

3. Hess DR. Ventilator-associated pneumonia: minimizing its impact on survival. Respir Care 2005; 50(7):900-907.

4. Khilnani GC, Hadda V. Essentials of mechanical ventilation. Indian J Anaesth 2019; 63(10):770–778.

5. Branson RD, Johannigman JA. Understanding and preventing ventilator-associated lung injury. Respir Care 2005; 50(7):927–939.

6. Kallet RH, Branson RD. Ventilator-associated pneumonia in patients receiving mechanical ventilation: diagnostic difficulties and preventive strategies. Respir Care 2005; 50(7):900–915.

7. Marini JJ, Smith TC, Lamb V. Estimation of inspiratory muscle strength in mechanically ventilated patients: the measurement of maximal inspiratory pressure. J Crit Care 1986; 1(1):32–38.

8. Cvach MM, Stokes JE, Manzoor SH, et al. Ventilator alarms in intensive care units: frequency, duration, priority, and relationship to ventilator parameters. Anesth Analg 2020; 130(1):e9-e139.

10.Sole ML, Su X, Talbert S, et al. Evaluation of alarm settings for early detection of hemodynamic instability in critically ill patients. Am J Crit Care 2019; 28(1):10-18.

11.Zhang H, Su X, Liu D, et al. The occurrence of ventilator-associated pneumonia in a Chinese tertiary hospital: A prospective cohort study. Crit Care 2014; 18(3):R64.


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