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Heat and Moisture Exchanger Occlusion Leading to Sudden Increased Airway Pressure: A Case Report Using ChatGPT as a Personal Writing Assistant

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Abstract

Heat and moisture exchangers (HMEs) are commonly used during general anesthesia to provide appropriate humidification and warming of inspired gases. While they play a critical role in mechanical ventilation, they can also lead to acute difficult ventilation if not correctly monitored and drained. We present a case of a 56-year-old female patient who underwent lower extremity vascular bypass surgery under general anesthesia and experienced sudden increased airway pressures due to occlusion of the HME caused by excessive moisture accumulation. Proper monitoring and management of the airway circuit and HMEs can help prevent complications and ensure proper ventilation during surgery. When acute difficult ventilation is encountered during general anesthesia, a systematic approach should be taken to differentiate between patient and external factors. Other differential diagnoses for acute difficult ventilation include bronchospasm, aspiration, endotracheal tube misplacement, pulmonary embolism, and tension pneumothorax. HME occlusion should be considered as part of the differential diagnosis for intraoperative hypoxia. Proactive replacement of HMEs in long cases can prevent occlusion and ensure proper ventilation.

Categories: Anesthesiology, General Surgery

Keywords: chatgpt, intubation complication, prolonged ventilation, hme, humidified moisture exchanger

Introduction

Acute hypoxia with increased airway pressures during general anesthesia is a common problem that requires prompt diagnosis and intervention. While patient factors such as bronchospasm, aspiration, and endotracheal tube misplacement are often the first considerations, problems with the airway circuit and heat and moisture exchangers (HMEs) can also lead to acute difficult ventilation [1,2].

HMEs are commonly used in anesthesiology to provide with appropriate humidification as well as warming of inspired gases during intubation and maintain the heat and moisture properties of the upper respiratory tract [3]. HMEs are placed between the breathing circuit and proximally to the endotracheal tube, where they humidify and warm inspired gases. While they play a crucial role in mechanical ventilation, they also have some potential risks [4,5].

We will explore the risk of occlusion of the HME with a case of sudden increased airway pressure during a lower extremity vascular bypass surgery under general anesthesia.

Case Presentation

A 56-year-old female patient with coronary artery disease status post percutaneous coronary intervention and ischemic systolic heart failure (ejection fraction (EF) 20%), hypertension, stage III chronic kidney disease, and a previous stroke underwent a left femoral to posterior tibial bypass surgery under general anesthesia. The patient was intubated with an endotracheal tube and connected to a breathing circuit with an HME to provide appropriate humidification and warming of inspired gases during the surgery. The patient was maintained under general anesthesia with sevoflurane (0.5-1.0 minimum alveolar concentration (MAC)), and muscle relaxation was achieved with rocuronium. Both sevoflurane and rocuronium were used for the duration of the procedure.

Twelve hours after the initial incision, the patient suddenly experienced a significant increase in peak airway pressures from 27 to 41 mmHg, decreased tidal volumes from 500 to 70 cc, and desaturation from 100% to 85% (Figure 1). The patient's ventilation mode was switched from volume control to spontaneous ventilation to evaluate for ventilator dyssynchrony. The fraction of inspired oxygen (FiO₂) was increased from 0.5 to 1.0. The anesthesiology team aggressively suctioned the airway, and albuterol (approximately 10 puffs) was administered down the endotracheal tube. Despite these interventions, there was no observed improvement in her condition. The endotracheal tube was disconnected from the circuit at the connection

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between the tube and HME. The HME used was a sterile, single-use, latex-free, high filtration efficiency HME with an electrostatic membrane filter (Teleflex 1589 Hudson RCI; Teleflex Inc., Wayne, Pennsylvania, United States). A large amount of thick moisture was observed in the HME filter, and upon squeezing the reservoir bag with the adjustable pressure limiting (APL) valve closed, the moisture was expelled from the HME. The circuit was then reconnected, and the patient was easily ventilated thereafter with complete resolution of the increased airway pressures. The patient's oxygen saturation quickly increased to 100%. The procedure was completed, and the patient was extubated with no further complications.

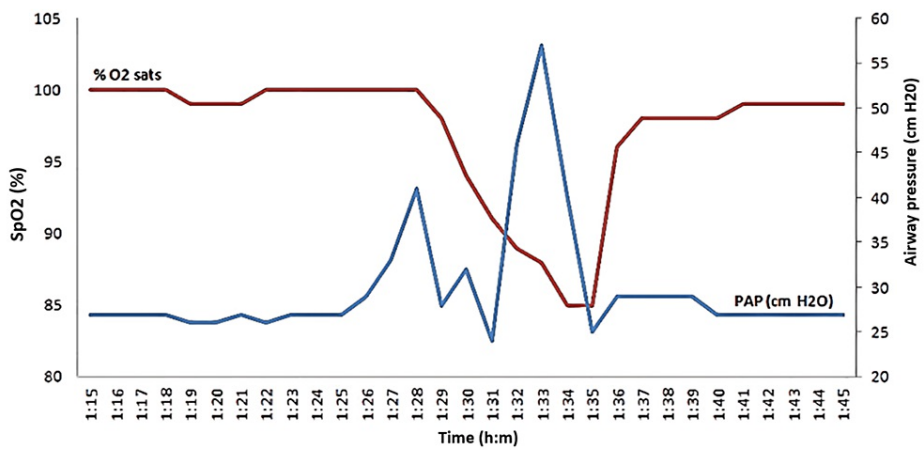


FIGURE 1: Desaturation with increased positive airway pressure over time

SpO2: oxygen saturation; %O2 sats: % of oxygen saturation; PAP: peak airway pressure

Discussion

HMEs are commonly used during general anesthesia to provide humidification and warming of inspired gases, which can help prevent airway irritation and injury. However, their use can also lead to complications such as HME occlusion, disconnections, unnoticed leaks, and risk of infections, which can result in an acute increase in airway pressure and difficulties with ventilation. HME occlusion can occur due to a variety of factors, including excessive moisture accumulation from the patient's exhalation or the breathing system, kinking of the HME tubing, or blockage of the HME filter [3,6]. In our case, the accumulated moisture was likely the result of a buildup of condensed exhaled gases, which had clogged the HME's electrostatic membrane filter.

Proper monitoring and drainage of the airway circuit and HMEs are important to prevent complications and ensure proper ventilation during surgery. In cases of acute difficult ventilation during general anesthesia, a systematic approach should be taken to differentiate between patient and external factors. One useful tool to differentiate patient factors from external factors is a flowchart (Figure 2). The first step in the flowchart is to connect the endotracheal tube to an Ambu bag and see if that improves the airway pressures [7]. If the airway pressures improve, it suggests that the problem is external to the patient and likely related to the airway circuit or HME. If the airway pressures do not improve, it suggests that the problem is likely related to patient factors such as bronchospasm or endotracheal tube misplacement. Other diagnostic tests such as chest X-rays, blood gas analysis, and bronchoscopy may also be useful in identifying the cause of acute difficult ventilation.

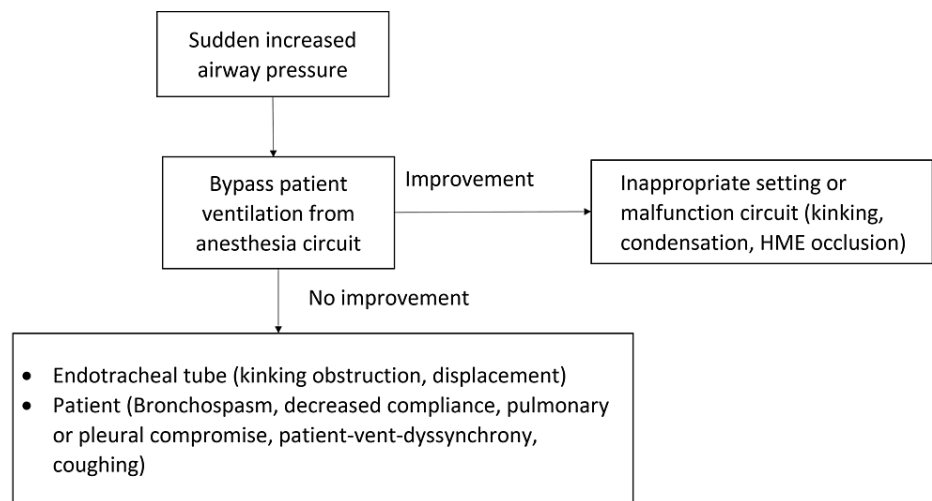


FIGURE 2: Algorithm for sudden increase in positive airway pressure

HME: heat and moisture exchanger

While HME occlusion is a rare cause of intraoperative hypoxia, it should be considered as part of the differential diagnosis. In our case, other differential diagnoses were also considered. Pneumothorax was unlikely due to the nature of the procedure and a lack of other supporting evidence (such as unilateral decreased breath sounds). Anaphylaxis was also considered; however, there were no observable signs of any skin rash or changes in blood pressure or heart rate, and no new medications were recently administered. Bronchospasm and mucus plugging were high on the differential diagnosis, and these were quickly addressed with bronchodilator administration and aggressive suctioning, respectively, without any resolution of the increased airway pressures. Ventilator dyssynchrony was also ruled out by taking the patient off the ventilator and ensuring adequate muscle relaxation. Other differential diagnoses for acute difficult ventilation include bronchospasm, aspiration, endotracheal tube misplacement, pulmonary embolism, and tension pneumothorax. Proper monitoring and management of the airway circuit and HMEs can help prevent complications and ensure proper ventilation during surgery, and excessive manipulation of the patient's airway can be minimized [1,2].

Teaching points

When a sudden increase in peak airway pressure and difficulties in ventilation are encountered, one should consider etiologies intrinsic and extrinsic to the patient. An HME occluded with condensed moisture is a rare but important cause of sudden increase in peak airway pressures and difficulty in ventilation, particularly in long cases. In long cases in which an HME is used, one should consider replacing the HME to prevent it from becoming occluded with secretions and moisture.

ChatGPT considerations

For this scientific paper, we employed ChatGPT 3.5 (OpenAI, San Francisco, California, United States) as a personal writing assistant to improve the coherency and clarity of our ideas (See Appendix). We utilized its capabilities to remove redundancies and streamline our writing process. Artificial intelligence (AI) is an excellent resource for academic writers, but it cannot replace the essential human element of writing a paper.

ChatGPT focuses on structured and straightforward writing without considering the hypotheses, suspicions, and nuances that are fundamental in academic writing. Therefore, using AI alone may limit the paper's ability to explore future research directions or potential implications fully. It is important for writers who are using ChatGPT as a tool to enhance their writing, to incorporate their own insights and knowledge, develop hypotheses, and add coherency to the results in the paper to ensure a well-rounded and comprehensive final product [8].

While AI is a powerful language model with a vast amount of knowledge, it currently does not have the ability to provide valid citations or high-quality sources. In fact, there have been instances where ChatGPT has generated inexistent references or added Digital Object Identifiers (DOIs) from fields outside of medicine, which can potentially lead to misinformation if not recognized and addressed by an expert on the topic [9]. As such, it is important for users of AIs to exercise caution and critical thinking when using the information provided by the AI [10]. The lack of adequate citation mandates users to have a strong understanding of the topic at hand and to seek out additional sources of information to verify the accuracy of ChatGPT's responses.

Despite these limitations, our approach to utilizing ChatGPT as a writing assistant ensured that authors added only high-quality, relevant information to the scientific literature. We carefully reviewed and fact-checked all content generated by ChatGPT to ensure its accuracy before incorporating it into our paper.

Future directions

We strongly encourage authors to consider the potential applications of AI, such as in education and research, and to explore these areas through well-defined projects. However, we want to emphasize that ChatGPT is currently in beta mode, and caution should be exercised when interpreting its responses. Some research questions that could be addressed in future projects include investigating the impact of ChatGPT on existing literature and on different types of users, examining differences between ChatGPT statements depending on the user's level of expertise, or exploring the potential of this AI as a tutor for novice authors.

Conclusions

HME occlusion is a rare but important cause of intraoperative hypoxia that should be considered as part of the differential diagnosis in cases of acute difficult ventilation during general anesthesia. A systematic approach, including the use of diagnostic tools such as flowcharts and diagnostic tests, is important to differentiate between patient and external factors and identify the cause of acute difficult ventilation. Proper monitoring and management of the airway circuit and HMEs can help prevent complications and ensure proper ventilation during surgery.

Appendices

A few things to note when writing this case report: the introduction should focus on determining the causes of acute hypoxia with increased airway pressures, and how HME occlusion is a rare cause of this problem. The discussion should focus on how to differentiate patient factors from other external factors, such as problems with the airway circuit, endotracheal tube, HME occlusion, etc. HME occlusion is just one (rare) cause of this problem that should be considered, but there are several other differential diagnoses that should also be considered. The case report should provide the reader with a good algorithm or flowchart for how to navigate causes of acute intraoperative hypoxia and increased airway pressure, which is the main takeaway from the case report.

FIGURE 3: Answer of ChatGPT to “Can you write a case report for the journal Cureus? Here are the details of the case:.....”

write an introduction of a scientific paper about the risk of humidified moisture exchanger occlusion in anesthesiology. Use the following information. 300 words minimum: Patients who require intubation also appropriate humidification and warming of inspired gases, but humidified moisture exchanger have also a significant impact on mechanical ventilation. [Giorgio A Iotti]

As heat and moisture properties of the upper respiratory tract are bypasses when airway management is provided through an endotracheal tube. [Alexander Doyle]

Inadequate humidity and temperature can lead to dysfunction of mucociliary defense, hypothermia, cell damage or affect airway pressure.

Heat and moisture exchangers (HMEs) are connected to the end of the breathing circuit and proximally to the endotracheal tube [Alexander Doyle]


Every piece required to connect the Humidified Moisture Exchanger (HMEs) require connecting to the endotracheal tube increases dead space due to their internal volume and increase in dead space ventilation. Humidified Moisture Exchanger with filters have a bigger internal volume compared to HMEs without filters. [Giorgio A Iotti]

HMEs also represents additional respiratory resistance and can lead to respiratory muscle fatigue and may increase intrinsic PEEP. [Giorgio A Iotti]

Accumulation of fluids or moisture condensation from either the patient or from the breathing system could potentially harm the patient by an increase in the resistance to airflow or interfering to wean the patient from respiratory support. In some cases, the accumulation of fluids could lead to complete occlusion, and it may be challenging to identify the filter as the culprit of the initial increase in peak airway pressure. [A. R. Wilkes]

This could be a source of harm and potentially increase morbidity and mortality [Alexander Doyle]

We will explore the risk of occlusion of the HME with a case of sudden increased airway pressure during a bypass surgery under general anesthesia.



Introduction:

Patients undergoing intubation require appropriate humidification and warming of inspired gases to maintain the heat and moisture properties of the upper respiratory tract. However, when airway management is provided through an endotracheal tube, these properties are bypassed, leading to inadequate humidity and temperature that can result in various adverse effects, including dysfunction of mucociliary defense, hypothermia, cell damage, or affect airway pressure.

To address these issues, Heat and Moisture Exchangers (HMEs) are connected to the end of the breathing circuit and proximally to the endotracheal tube. Although they play a crucial role in mechanical ventilation, every piece required to connect the HMEs to the endotracheal tube increases dead space, leading to an increase in dead space ventilation. HMEs with filters have a larger internal volume compared to HMEs without filters, which can result in additional respiratory resistance and may lead to respiratory muscle fatigue and increase intrinsic PEEP.

Furthermore, accumulation of fluids or moisture condensation from either the patient or the breathing system could potentially harm the patient by increasing the resistance to airflow or interfering with weaning the patient from respiratory support. In some cases, the accumulation of fluids could lead to complete occlusion, making it challenging to identify the filter as the culprit of the initial increase in peak airway pressure.

In this paper, we will explore the risk of occlusion of HMEs through a case study of sudden increased airway pressure during a bypass surgery under general anesthesia. The objective is to highlight the potential harm caused by HME occlusion and the importance of its prevention in anesthesiology. The findings of this study will be of significant benefit to anesthesiologists, respiratory therapists, and other healthcare professionals involved in the management of patients undergoing

Regenerate response

FIGURE 4: Asking ChatGPT to write an introduction based on information provided

2023 Hallo-Carrasco et al. Cureus 15(4): e37306. DOI 10.7759/cureus.37306

6 of 7



Abstract:



Humidified moisture exchangers (HMEs) are commonly used during general anesthesia to provide appropriate humidification and warming of inspired gases. While they play a critical role in mechanical ventilation, they can also lead to acute difficult ventilation if not correctly monitored and drained. We present a case of a 56-year-old female patient who underwent bypass surgery under general anesthesia and experienced sudden increased airway pressures due to occlusion of the HME caused by excessive moisture accumulation. Proper monitoring and management of the airway circuit and HMEs can help prevent complications and ensure proper ventilation during surgery. When acute difficult ventilation is encountered during general anesthesia, a systematic approach should be taken to differentiate between patient and external factors. Other differential diagnoses for acute difficult ventilation include bronchospasm, aspiration, endotracheal tube misplacement, pulmonary embolism, and tension pneumothorax. HME occlusion should be considered as part of the differential diagnosis for intraoperative hypoxia. Proactive replacement of HMEs in long cases can prevent occlusion and ensure proper ventilation.

FIGURE 5: Asking ChatGPT to write an introduction based on information provided

Additional Information

Disclosures

Human subjects: Consent was obtained or waived by all participants in this study. **Conflicts of interest:** In compliance with the ICMJE uniform disclosure form, all authors declare the following: **Payment/services info:** All authors have declared that no financial support was received from any organization for the submitted work. **Financial relationships:** All authors have declared that they have no financial relationships at present or within the previous three years with any organizations that might have an interest in the submitted work. **Other relationships:** All authors have declared that there are no other relationships or activities that could appear to have influenced the submitted work.

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