Case Report

HME filters: a boon or bane?

Sethulakshmi Prasad, Yogesh Gaude

Email: sethu2401@gmail.com

Abstract

Heat and moisture exchange filters (HMEFs) have been a controversial yet widely used adjunct to breathing circuit. Here we discuss a case scenario where clogging of HMEF with moisture presented as elevated peak airway pressures. Apart from stressing the importance of monitoring airway pressure, we discuss about the judicious use of HMEFs, problems associated with their use and measures to overcome the same. Being a ubiquitous adjunct, a thorough knowledge of its functioning and constant vigilance during its use is of paramount importance.

Keywords: Clogged HMEF, heat and moisture exchanger filter, high peak airway pressures

Introduction

Heat and moisture exchanger filter (HMEF) has become a part and parcel of modern anaesthesia circuit. Though the controversy of their risk versus benefits is an unsettled issue, its use in operation theatre (OT) and intensive care setting has increased over time. Here we report a case of clogged HMEF during a thirteen hour long surgery presenting as high peak airway pressures.

Case History

A 57 year old hypertensive male, diagnosed case of carcinoma of head of pancreas was posted for Whipple's pancreaticoduodenectomy. Preoperative evaluation revealed well controlled blood pressure and otherwise normal systemic examination. Patient was kept fasting as per standard guidelines. On the day of surgery, after shifting the patient onto operation theatre (OT) table, a five electrode electrocardiogram, noninvasive blood pressure and pulse oximeter were connected. An epidural catheter was secured in the T8-T9 intervertebral space.

Anaesthesia was induced with intravenous fentanyl and propofol, adequacy of bag and mask ventilation confirmed and neuromuscular blockade achieved with intravenous vecuronium. Trachea was intubated with 8 mm ID cuffed oral polyvinyl chloride endotracheal tube and fixed after confirming position by auscultation and wave form capnography. Patient was connected to Spacelabs BleaseFocus anaesthesia work station with circle absorber system and ventilated with volume controlled ventilation with a tidal volume of 450 ml and a frequency of 12 breaths per minute. Anaesthesia was maintained with 0.8-1.0% Isoflurane in 40-60% oxygen and nitrous oxide mixture (Low fresh gas flow of 1.2 litres/min) and vecuronium based on peripheral nerve stimulation (maintaining a train of four count of ≤ 2).

A fresh heat moisture exchanger filter (HMEF) was connected beyond the wye connector of the breathing circuit as per our routine practice, in order to reduce the risk of transmission of respiratory infections between patients. The baseline airway pressure (P_{aw}) was noted to be 17 cm H_2O which was stable till 11 hours of the procedure with minimal variation from 13 - 19 cm H_2O. A sudden increase in the P_{aw} was noted after 11 hours, going up to 35 cm H_2O with a decrease in delivered tidal volumes to 150 - 170 ml while endtidal CO_2 was 38 - 42 mmHg without any change in the capnographic tracing. The minute ventilation was also found to

Sethulakshmi Prasad, MD
Junior consultant, Lourdes Hospital, Kochi

Yogesh Gaude, MD
Assistant Professor, Kasturba Medical College, Manipal

How to cite this article: Prasad S, Gaude Y. HME filters: a boon or bane? *Ind J Resp Care* 2016; 5(2):): 745-48.

be low ~2-2.5 L/min *(Figure 1)*. On checking bag compliance, it was found to be tight with inability to deliver adequate tidal volumes. Auscultation of chest revealed decreased bilateral air entry without any adventitious sounds. Bronchospasm was ruled out by the absence of wheeze and by lack of improvement with endotracheal bronchodilator instillation. Throughout this period, the oxygen saturation was maintained between 99 to 100% with FiO_2 of 0.5. A sterile tracheal suction did not show any secretions and failed to improve the ventilation, thus ruling out the possibility of a mucus plug. Other possibilities such as endotracheal tube kink, circuit kink and ventilator dysfunction were ruled out. On further troubleshooting, the HMEF was noted to be clogged with moisture *(Figure 2)*. Though not considered as a very common cause of high P_{aw} in OT setting, a change of HMEF was considered. The change produced a drastic decrease in the P_{aw} from 34 to 17 cm H_2O and an improvement in the delivered tidal volumes as well as minute ventilation *(Figure 3)*. On auscultation, the air entry was equal bilaterally with normal breath sounds. Patient was ventilated with the same settings for remaining duration of surgery and postoperatively in intensive care unit (ICU) without any elevated peak airway pressures or reduced tidal volumes.

Figure 1: Shows ventilator parameters prior to change of HMEF

Figure 2: Shows the clogged HMEF after disconnecting from the breathing circuit

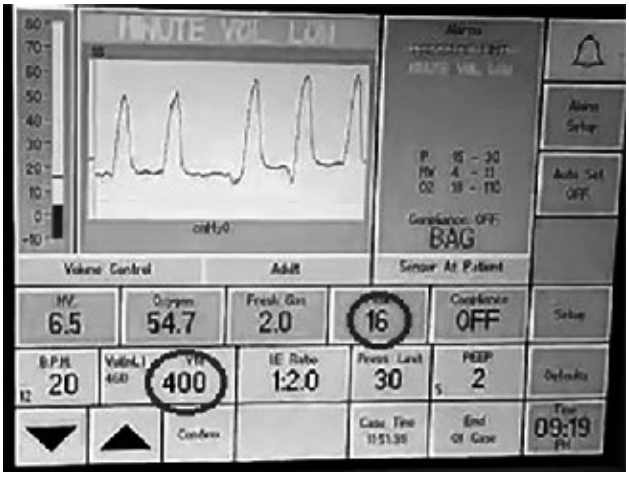

Figure 3: Shows improved ventilator parameters after change of HMEF

Discussion

Heat and moisture exchanger (HME) being a simple and cost effective method of moisture conservation has gained wide popularity in clinical practice. Also known as the artificial nose, it performs the function of warming and humidification of the inspired air. This function is by virtue of the hygroscopic material present in the HME that absorbs the exhaled moisture and adds humidity to subsequent breaths. Commonly used material is paper or foam coated with hygroscopic salt such as calcium chloride. In presence of bacterial and viral filter (HMEF), it prevents the entry of microbes from ventilator and circuit into patient's respiratory tract. This function explains the need for HMEF in intubated patients in whom the normal function of upper respiratory tract is bypassed. HMEFs can deliver moisture output of 30g.m^{-3} or more.[1]

HMEFs are of two types based on the type of filter used: electrostatic and pleated. Among these, the pleated fibres have high density and hence offer more resistance to gas flow.[2] According to Kleeman, a minimum inspired humidity level of 20g.m^{-3} was found to be sufficient to prevent damage to the mucosa of tracheobronchial tree up to 10 hours of mechanical ventilation.[3] Though use of low fresh gas flow with circle system adds moisture to the inspired gas from carbon dioxide absorber, use of a HMEF helps to reduce moisture loss from the patient.[4] Although there are no recommendations for use of HMEF according to CDC (Center for Disease control and prevention) and ASA (American Society of Anesthesiologists) guidelines, The Association of Anaesthetists of Great Britain and Ireland (AAGBI) recommends use of filters to prevent cross contamination.[5] Though product licenses currently require single use anaesthetic circuits to decrease the risk of cross contamination, this may not always be feasible in developing countries due to financial constraints. Instead, use of a fresh filter for each patient while retaining the circuit is an accepted and economical alternative.[6] This probably has paved way for the ubiquitous use of HMEF but use of any equipment without thorough analysis of its pros and cons can be hazardous.

We regularly use Draeger twinstar 55 HMEF, as was in this case. It has a dead space of 55 ml, dry weight of 28 grams, an electrostatic filter and a recommended maximum duration of use of 24 hours. HMEFs may get partially or completely obstructed over a variable time span. It has been used for prolonged surgeries lasting up to 14 hours without any significant problems. A study by Buckley demonstrated increased resistance to ventilation when humidified air was used through filter for 48 hours.[7] In our case an early increase in resistance was noted within 12 hours without the use of active humidification. Use of circle system with carbon dioxide absorber with low fresh gas flows has probably played a role in adding moisture to the inspired gases. On weighing the HMEF after removal, it was found to be 50 grams. Since the HMEF was connected beyond the wye connector, the clogging with moisture presented as high peak airway pressures. The usual differential diagnoses of bronchospasm, pneumothorax, tracheal tube block with secretions, tube kink, circuit or valve malfunction and ventilator dysfunction were ruled out. Clogging of HMEF with moisture may not be perceived easily when it is hidden under the drapes or in the absence of visible secretions, which was the scenario in this case. Clogging can occur either due to tracheal secretions or due to condensation of moisture from the breathing circuit. As a result, the filter offered excessive resistance to both inspiration and expiration presenting as high peak airway pressures and incomplete exhalation. If the blocked HMEF was not recognised early, the tidal volumes would have progressively declined leading to hypoventilation, hypercapnia, desaturation of the patient or even pneumothorax with severe obstruction. McEwan *et al* reported a case of bilateral tension pneumothorax due to obstruction of HMEF placed in the expiratory limb of breathing circuit.[8] Clogging of HMEF is inevitable; however, the risk can be reduced by placing it above the level of patient's lungs and with the filter in a vertical orientation. Also the significance of monitoring airway pressures, tidal volumes and capnography during general anaesthesia cannot be emphasised any further. They provide cues for early detection of such obstruction thus preventing major catastrophes.

A mention about the use of HMEs and HMEFs in paediatric patients is necessary as this population is more vulnerable to cross-infections. However, they increase the dead space, resistance to gas flow and work of breathing.[9] As children with upper or lower respiratory tract can present for surgery more often than adults, the possibility of HME blockade is more likely. Respiratory tract secretions can clog the HMEs and increase the work of breathing especially during periods of spontaneous ventilation such as prior to extubation. As this can cause respiratory fatigue and distress postoperatively, the risks and benefits of HME use must be analysed meticulously in children.

The discussion about HMEs would be incomplete without a reference about their use in intensive care units (ICUs). Several studies have shown that the use of HMEs in ICU was associated with increased

incidence of endotracheal tube occlusion, atelectasis and pneumonia.[10,11] Also the humidification achieved by HME and heated humidifier was found to be comparable.[11] Since patients in ICU tend to have increased tracheal secretions due to underlying pathology, the incidence of HME occlusion was significantly higher. Villafane *et al* even demonstrated a gradual reduction in the endotracheal tube diameter associated with an increase in resistance to air flow.[12]

Conclusion

This case is a gentle reminder of the significance of monitoring airway pressures during anaesthesia as well as inspecting the HMEF regularly during prolonged surgeries. Although it is customary to rule out patient and machine causes of raised peak airway pressures, additional observation of HMEF is beneficial in appropriate situations. Avoiding use of HMEF is probably not the solution to this inevitable problem, more so in this era of transmissible infections. We would suggest justified use of HMEF with a close vigilance for complications. After all, 'Eternal Vigilance' is the motto of every anaesthesiologist.

References

1. Wilkes AR. Heat and moisture exchangers and breathing system filters: their use in anaesthesia and intensive care. Part 1 – History, principles and efficiency, Anaesthesia 2011; 66: 31-9.
2. Wilkes AR. Breathing filters, humidifiers and nebulizers. In: Davey AJ, Diba A, eds. Ward's Anaesthetic Equipment, 5th edn. London: WB Saunders, 2005: 291–303.
3. Kleemann PP. Humidity of anaesthetic gases with respect to low flow anaesthesia. Anaesth Intens Care 1994; 22:396–408.
4. Wilkes AR. The moisture-conserving performance of breathing system filters in use with simulated circle anaesthesia breathing systems. Anaesthesia 2004; 59:271–7.
5. Blood Borne Viruses Advisory Panel. A Report Received by Council of the Association of Anaesthetists on Blood Borne Viruses and Anaesthesia: An Update (January 1996). London: The Association of Anaesthetists of Great Britain and Ireland, 1996.
6. Berry AJ, Nolte FS. An alternative strategy for infection control of anesthesia breathing circuits: a laboratory assessment of the Pall HME Filter. Anesth Analg 1991; 72:651-5.
7. Buckley PM. Increase in resistance of in-line breathing filters in humidified air. Br J Anaesth 1984; 56:637
8. McEwan AI, Dowell L, Karis JH. Bilateral tension pneumothorax caused by a blocked bacterial filter in an anesthesia breathing circuit. Anesth Analg 1993; 76:440–2.
9. Wilkes AR. Heat and moisture exchangers and breathing system filters: their use in anaesthesia and intensive care. Part 2 - practical use, including problems, and their use with paediatric patients. Anaesthesia, 2011; 66: 40-51.
10. Cohen IL, Weinberg PF, Fein IA, Rowinski GS. Endotracheal tube occlusion associated with the use of heat and moisture exchangers in the intensive care unit. Crit Care Med 1988; 16(3):277-9.
11. Roustan JP, Kienlen J, Aubas P, Aubas S, du Caliar J. Comparison of hydrophobic heat and moisture exchangers with heated humidifier during prolonged mechanical ventilation. Intens Care Med 1992; 18(2):97-100.
12. Villafane MC, Cinnella G, Lofaso F, Isabey D, Harf A, Lemaire F *et al.* Gradual reduction of endotracheal tube diameter during mechanical ventilation via different humidification devices. Anesthesiology 1996; 85(6):1341-9.