Helmet Continuous Positive Airway Pressure in the Emergency Department: A Practical Guide

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Contribution to Emergency Nursing Practice

- Helmet continuous positive airway pressure is usually performed using a flow of fresh gas (>60 L/min) supplied through a continuous flow generator. Heat and moisture exchanger filters are often used to reduce the noise level inside the helmet and to reduce the viral spread.
- The interactions among filters, flow generators, and positive end-expiratory pressure valves may modify flow and fraction of inspired oxygen delivered. Knowing their effects is essential to guarantee the correct performance of helmet continuous positive airway pressure.
- Correctly assembling the breathing circuit for the helmet continuous positive airway pressure can improve patient comfort and reduce treatment failure. For every nurse, it is fundamental to know each component needed to deliver a continuous positive airway pressure with a helmet.

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Abstract

Helmet continuous positive airway pressure is a simple, noninvasive respiratory support strategy to treat several forms of acute respiratory failure, such as cardiogenic pulmonary edema and pneumonia. Recently, it has been largely used worldwide during the COVID-19 pandemic. Given the increased use of helmet continuous positive airway pressure in the emergency department, we aimed to provide an updated practical guide for nurses and clinicians based on the latest available evidence. We focus our attention on how to set the respiratory circuit. Moreover, we discuss the interactions between flow generators, filters, and positive end-expiratory pressure valves and the consequences regarding the delivered gas flow, fraction of inspired oxygen, positive end-expiratory pressure, and noise level.

Key words: Continuous positive airway pressure; Noninvasive ventilation; Respiratory insufficiency; Noise; Flow; Emergency department

Background

Continuous positive airway pressure (CPAP) is widely used in the acute care setting for the treatment of hypoxemic respiratory failure due to acute cardiogenic pulmonary edema[1-4] and pneumonia.[5-7] Moreover, in the last 3 years of the COVID-19 outbreak, CPAP played a pivotal role in treating patients with viral pneumonia and respiratory failure.[8,9] To date, in the acute care setting, CPAP is delivered mainly through a helmet or a face mask.[8,10,11] Helmet CPAP (H-CPAP) is broadly used in southern Europe and particularly in Italy, mainly for the treatment of hypoxemic respiratory failure and acute cardiogenic pulmonary edema.[12] Recently, the helmet has also been introduced in emergency departments and wards to support patients with acute respiratory failure.[8,10,11]

The helmet is a soft, nonextensible, transparent hood that fits over the patient's head, usually anchored to a soft, extensible collar around the patient's neck.[13] It is a reusable, single-patient interface equipped with 2 ports: a gas flow inlet and outlet. The hood is often equipped with an antiasphyxia valve to open the circuit in case of sudden flow drop.[14] This safety system is particularly important for its use outside of the intensive care unit.[14]

Compared to a face mask, the hood reduces the risk of facial pressure lesions and could decrease viral spread in the case of contagious disease.[15,16] In addition, a recent randomized controlled trial demonstrated that in patients presenting to the emergency department with acute cardiogenic pulmonary edema or decompensated chronic obstructive pulmonary disease, H-CPAP was noninferior to face mask CPAP, resulting in greater comfort and lower intubation rates.[17] In contrast, it is characterized by higher noise levels, potentially limiting patients' comfort.[18] Given its relatively new use in these settings, it is useful for emergency nurses and physicians to be aware of H-CPAP functioning, equipment, and management.

Based on the latest scientific evidence, the aim of this article is to describe how to correctly choose the equipment, assemble the H-CPAP circuit, and evaluate its proper functioning.

How to Perform H-CPAP

PATIENT MANAGEMENT

Clinical (eg, respiratory rate and pattern) and instrumental (eg, pulse oximetry and blood gas analysis) evaluation of the respiratory function is the first assessment that emergency nurses and physicians perform to define indication for H-CPAP and, subsequently, to monitor the response to CPAP treatment over time.[8,11,19] Moreover, arterial blood pressure should be measured before and after H-CPAP is started. Indeed, the application of positive end-expiratory pressure (PEEP), reducing the venous return, may have a hypotensive effect.[20]

During H-CPAP treatment, nurses and physicians should pay attention to accidental gas flow drops delivered inside the helmet. Flow drops can be caused by circuit obstruction, disconnection, or leaks, and generate helmet depressurization with the risk of patients' rebreathing and asphyxia.[21] The sudden interruption of the noise generated by the gas flowing through the expiratory PEEP valve is a warning signal indicating a sudden depressurization of the helmet.

Compared to face masks, the removal of the helmet requires 2 persons and a slightly longer time. To overcome this limit, in the case of urgent need, the front port of the helmet allows access to the patient and quick interruption of the treatment.

FUNCTIONING AND EQUIPMENT

To perform H-CPAP, a fresh gas flow is delivered inside the helmet, and a PEEP is generated through an expiratory valve placed at the outlet port.[22] When H-CPAP is delivered, 3 variables have to be set: gas flow rate, fraction of inspired oxygen (FiO_2) of the gas mixture, and PEEP. Moreover, to improve patients' comfort, further attention should be paid to reduce the noise inside the helmet and to find the most comfortable fixing systems.[23] Thus, the correct choice and use of flow generators, PEEP valves, filters, circuits, and fixing systems are essential to deliver H-CPAP properly and increase patients' tolerance.[24]

Gas Flow and Flow Generators

For 2 reasons, it is important to use a high gas flow rate to perform H-CPAP. First, it is important to overcome the patient's peak inspiratory flow, thus ensuring a continuous and stable positive airway pressure during the entire respiratory cycle. Second, this prevents carbon dioxide rebreathing,[25] increasing the efficacy of the respiratory support. Indeed, due to its high instrumental dead space, the helmet has a higher risk of carbon dioxide rebreathing than a face mask, and therefore, higher gas flows are required for an adequate carbon dioxide washout.[25] Generally, 60 L/min of flow is considered adequate,[26] but higher flows may be required for patients with severe acute respiratory failure and for high-minute ventilation.[27,28] In the absence of a flow meter for a precise gas flow measurement, the flow delivered can be titrated until the helmet reaches the desired pressurization and no PEEP drop is observed during the patient's inspiration.[29] The presence of pressure swings during the patient's respiratory cycle points toward an insufficient gas flow rate.[30] For this purpose, helmets are often equipped with an integrated spring pressure gauge that allows monitoring of the PEEP inside of it.

Three different types of flow generators can be used to generate gas flow for H-CPAP: air-oxygen blenders, turbines, and Venturi systems.[31] All of these have different performances regarding flow delivery and the noise produced both inside and outside of the helmet, with additional differences according to the manufacturer.[32] Among these, turbine-driven systems may be preferred because they are associated with the lowest noise level inside the helmet and allow the precise setting of gas flow and FiO_2. In contrast, it is the most expensive system and needs a power source instead of a simple oxygen port.

Noise and Inlet Port Filter

The noise inside the helmet is the most frequent cause of patients' intolerance and can lead to treatment failure.[33] Different types of flow generators produce different levels of noise inside the helmet. Air/O_2 blenders are the loudest flow generator, followed by Venturi, whereas turbine-driven systems are the least noisy.

To improve patients' comfort, a heat and moisture exchanger filter (HMEF) is often interposed in clinics along the circuit at the inlet port of the helmet to muffle the noise inside of it.[18,34] When air/O_2 blenders and Venturi systems are used, the application of HMEF significantly reduces the noise level inside the helmet. When a filter is used, attention should be paid to its effect on delivered gas flow and FiO_2, which may change according to the type of flow generator used. Of note, with air/O_2 blenders, a stable flow and FiO_2 are guaranteed after HMEF application. On the contrary, when Venturi systems are used, together with the noise reduction, the application of a filter generates a significant drop in the gas flow delivered and slightly increases the FiO_2 as a consequence of the gas mixture variation.[32] Thus, attention should be paid to guarantee an adequate gas flow and the preset FiO_2, which should be checked by connecting an oximeter along the circuit.[18] Compared to air/O_2 blender and Venturi systems, turbine-driven systems do not require filter application because without it they are also the least noisy, thus being the most comfortable system for the patient.[32]

PEEP and PEEP Valves

Several types of PEEP valves are commercially available: water-sealed valves, precalibrated fixed PEEP valves, and adjustable PEEP valves. Among these, adjustable valves have shown a variable degree of flow dependency, potentially leading to a higher-than-expected PEEP.[22] On the contrary, fixed PEEP valves have a flow-independent behavior even at the highest tested gas flows, thus being reliable and safe and therefore preferable. Adjustable PEEP valves can be used when a filter is placed in the outlet port. Indeed, the filter increases the PEEP inside the helmet, and adjustable valves allow better PEEP regulation. Regardless of the chosen valve, close monitoring of the pressure inside the helmet is mandatory.[22,30]

Viral Spread and Outlet Port Filter

The application of a filter at the outlet port before the PEEP valve is recommended in the case of contagious diseases, because it can reduce environmental viral spread (Figure). However, electrostatic or HMEF filters placed at the outlet port increase the flow resistance, thus generating a pressure inside the helmet higher than the selected PEEP. Therefore, monitoring the pressure inside the helmet is again fundamental, and it may be necessary to adjust the PEEP valve to reach the target pressure.[30,35]

Fixing the System

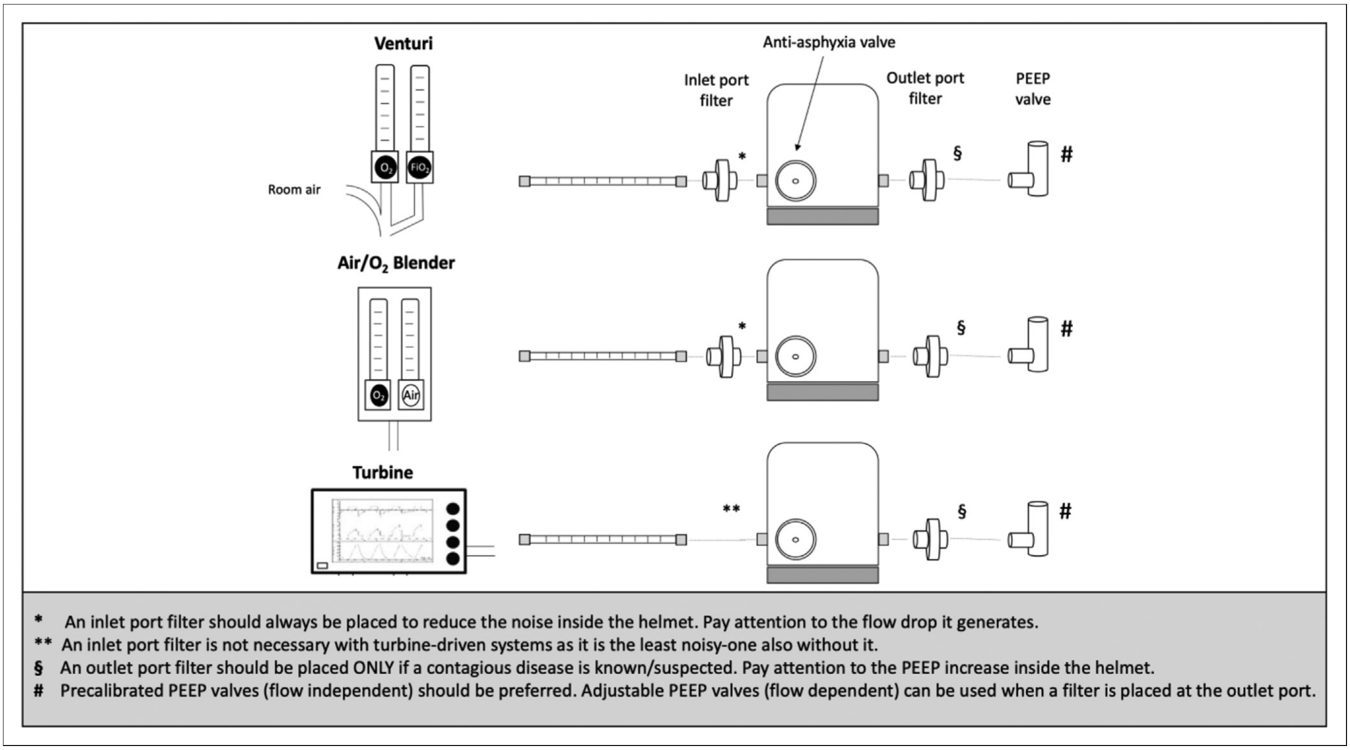
Both standard armpit straps and counterweights can be used to fix the helmet to the patient. The armpit straps are quick and easy to use but can cause pain and pressure ulcers if used for a long time, whereas the counterweights guarantee better comfort and are usually better tolerated. Therefore, we suggest using standard armpit straps when the H-CPAP is started in an emergency setting, and then applying counterweights as soon as possible to improve patients' comfort.[23]

Implications for Emergency Nurses

The emergency nurse must choose an appropriate interface that provides adequate patient comfort, which often determines the success of CPAP. In addition to equipment and staff experience, the choice of interface is determined by facial anatomy, breathing pattern, and patient preference. Moreover, increasing knowledge can help to increase the comfort of patients treated with H-CPAP and improve their long-term treatment compliance.

Conclusion

To perform H-CPAP properly, an adequate flow and a preset FiO_2 and PEEP should be guaranteed. Filters are useful to reduce the noise inside the helmet and should be used to improve patient comfort. In the case of known or suspected contagious diseases, filters can be applied to the outlet port to reduce viral/bacterial spread. When managing patients with H-CPAP, clinicians and emergency nurses should be aware of the interactions between the circuit components,



FIGURE

Assembling the H-CPAP breathing circuit. H-CPAP, Helmet continuous positive airway pressure; PEEP, positive end-expiratory pressure.

because they can reduce the flow and increase FiO_2 and PEEP.

Author Disclosures

Conflicts of interest: none to report.

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