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Pressure-optimized high flow therapy

José Manuel Carratalá Perales[1], Juan Luis Sánchez Rocamora[2], Gonzalo Fuentes Rodríguez[2], Benjamín Brouzet[3], Salvador Díaz-Lobato[4*]
[1] MD PhD, Short-Stay Unit, Department of Emergency, Hospital general de Alicante, Spain
[2] MD, Department of Emergency, Hospital General de Villarrobledo, Albacete, Spain
[3] MD, Short-Stay Unit, Department of Emergency, Hospital general de Alicante, Spain
[4] MD PhD, Department of Pulmonology, Hospital Universitario HLA Moncloa Madrid, Spain

Abstract
High flow nasal cannula therapy has a mild airway pressurization effect. These relatively low pressures can compromise the effectiveness of the technique, especially in those clinical scenarios where greater airway pressurization is required. Finding ways to increase this pressure would allow its use in patients with high pressurization requirements. We have therefore analyzed the increase in pressure achieved by coupling Boussignac® CPAP to the high-flow device circuit. Our preliminary results have shown that the pressure measured at the nasal cannula achieved with the AIRVO 2® can be significantly increased by associating Boussignac® CPAP. The FiO2 was stable and maintained during the study. We did not observed water condensation into the tubes. Studies are needed to confirm these results and their involvement in patients with various types of acute respiratory failure.

Keywords: high flow nasal cannula; boussignac cpap; airway pressurization

Introduction

High flow nasal cannula therapy (HFNC) has become a valid alternative for the treatment of patients with respiratory failure of diverse origin, with greater evidence in patients with acute hypoxemic respiratory failure [1, 2]. It consists of the administration of a gas through specific nasal cannulas, at flows that exceed the patient's inspiratory flow demand, with a controlled, stable and known FiO2, and under optimal temperature (37^0C) and humidity conditions (100% relative humidity, 44 mg H20/L absolute humidity). The patient receives an efficient, optimized gas that ensures constant FiO2 in the airway, between 21 and 100% [3]. Various mechanisms have been described by which HFNC acts on patients with respiratory failure [4] and there is a growing trend to consider HFNC within respiratory support devices [5]. The HFNC produces the wash of CO2 from dead space, reduces nasopharyngeal resistance, improves pattern ventilatory and generates a discrete positive pressure in the airway, being a comfortable and well tolerated by the patient [6]. The positive pressure produced by HFNC has been assessed in different studies and depends on the flow administered, the size of the nasal cannula and the mechanical characteristics of the ribcage [7]. It has been estimated that an average of 1 cm of H2O pressure is generated for every 10 liters of programmed flow [8]. These relatively low pressures can compromise the effectiveness of the technique, especially in those clinical scenarios where greater airway pressurization is required. Finding ways to increase this pressure would allow its use in patients with high pressurization requirements. We have therefore analyzed the increase in pressure achieved by coupling Boussignac® CPAP to the high-flow device circuit.

Methods

We have designed a prospective, controlled study aimed at analyzing the pressure reached in nasal cannulas when Boussignac® CPAP (Vygon) is associated to the AIRVO 2® (Fisher&Paykel) high flow equipment. Both devices were connected via the aerosol therapy port of the AIRVO 2® humidifier chamber. The Boussignac valve was coupled directly to this level without the need for an adapter. The flow of the AIRVO 2® was generated by its turbine. The flow of the Boussignac® CPAP was generated using a 50 L/min flowmeter. The pressure in the circuit was monitored with the Boussignac system pressure gauge at two levels: at the Boussignac valve and at the nasal cannula by means of an adapter piece connecting the nasal cannulas to the tubing with a port for connecting the pressure gauge (figure 1).

The subjects remained seated, connected to the high flow device through the nasal cannulas. The pressures at the Boussignac valve and at the nasal cannulas were measured in different scenarios by regulating 40, 50 and 60 L/min at the AIRVO 2® and 0, 20, 30, 35 and 40 L/min at the Boussignac valve. The subjects remained seated, connected to the high flow device through the nasal cannulas. Each study period lasted 10 minutes. The relationship between the quantitative variables was analysed using Pearson's correlation test. The study was approved by local Ethical Committee.

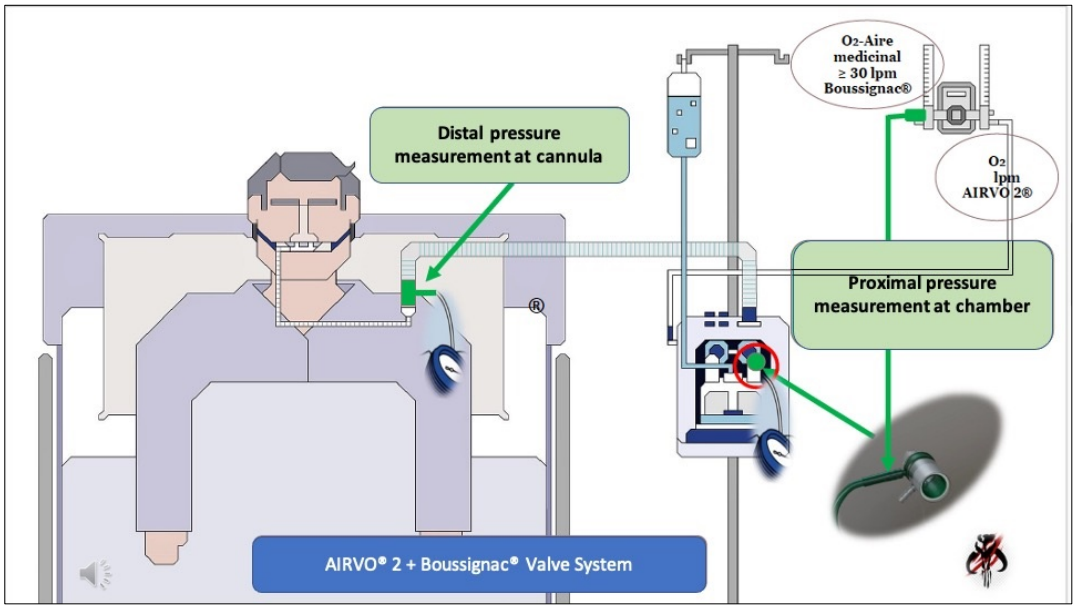

Fig 1

Results

Ten healthy volunteers were included in the study. The pressure reached in the nasal cannulas in each of the AIRVO 2® and Boussignac® CPAP flow combinations is shown in table 1. The resulting pressure depended on the flow provided to the Boussignac® CPAP. With flows of 40, 50 and 60 L/min in AIRVO 2®, an average pressure of 5.9 ± 0.77 cmH2O was achieved regulating 20 L/min in the Boussignac® CPAP; 9.69 ±1.1 cmH2O when 30 L/min was setting; 11.4 ± 1.15 cmH2O with 35 L/min was setting; 14.2 ±1.02 cmH2O when 40 L/min was setting and 15.3 ± 1.01 cmH2O with a setting of 45 L/min. Nasal cannula pressures above 13 cmH2O were poorly tolerated by the participating subjects. The mean pressure drop between Boussignac valve and nasal cannula was 5.14 ± 0.96 cmH2O. There was a significant correlation between the flow and the pressure achieved. These results show that the pressure measured at the nasal cannula achieved with the AIRVO 2® can be significantly increased by associating Boussignac® CPAP. The FiO2 was stable and maintained during the study. We did not observed water condensation into the tubes.

Table 1: Pressures in Boussignac valve and nasal cannula according to the regulated flows in the high flow device and in the CPAP flow meter.

AIRVO 2 ® (L/min)	Boussignac ® CPAP (L/min)	Pressure at Boussginac ® valve (cmH2O)	Cannula Nasal pressure (cmH2O)
40	No	0	3.22 ± 0.56
50	No	0	4.35 ± 0.81
60	No	0	5.6 ± 0.61
40	20	9.4 ± 0.39	5.9 ± 0.77
40	30	14.7 ± 1.27	9.35 ± 0.62
40	35	17.6 ± 1.15	11.5 ± 1.22
40	40*	No valorado	No valorado
50	20	9.8 ± 0.35	6 ± 1.33
50	30	15.45 ± 0.95	9.72 ± 1.2
50	35	17.55 ± 1.11	11.2 ± 1.03
50	40*	No valorado	No valorado
60	20	9.95 ± 0.43	6.05 ± 0.92
60	30	15.25 ± 1.03	10.1 ± 0.96
60	35	17.65 ± 1.31	11.55 ± 1.36
60	40*	No valorado	No valorado
50	45*	No valorado	No valorado
60	45*	No valorado	No valorado

*Regulations that were not tolerated by the patients L/min: litres per minute. CPAP: continuous positive airway pressure.

Discussion

The pressure that high-flow devices generates in the airway has been the subject of controversy since the beginning of therapy as the magnitude of this pressure has been questioned. Parke *et al* [9] have measured the pressure at the nasopharyngeal level in post-surgical patients using different flows and have found that the pressures reached values of around 3 cmH2O when they received 50 L/min keeping their mouths closed. However, physiological studies using impedance tomography, have showed a significant increase in tele-expiratory lung volume suggesting significant alveolar recruitment secondary to the PEEP effect generated [10]. Okuda *et al* [11] have also observed an increase in the pressure at

the end of expiration using an oesophageal probe in healthy volunteers, reaching values of 9.9 ± 3.1 cmH2O at 50 L/min. It has been shown that when flows of up to 100 L/min are administered to healthy volunteers, the lung volume at the end of expiration increases linearly [12] and Roca *et al* [13] have recommended reducing the degree of collapse of the inferior vena cava measured by ultrasound as an indirect method of assessing the intrathoracic pressure generated by the HFNC.

Many studies have shown the importance of the pressure generated by HFNC and the beneficial effects it has on patients. Our preliminary results indicate that it is possible to optimize the pressure of HFNC applied with the AIRVO 2® by coupling it with Boussignac® CPAP. The regulation of 40 L/min on the AIRVO 2® and 35 L/min on the Boussignac® CPAP achieves a significant increase in pressure at the junction between nasal tube and cannula with optimal tolerance of the subjects participating in the study. Studies are needed to confirm these results and their involvement in patients with various types of acute respiratory failure.

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