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Recommendations for respiratory support in the newborn (IV). High frequency ventilation, ex-utero intrapartum treatment (EXIT), extracorporeal membrane oxygenation (ECMO)☆

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Abstract The recommendations included in this document will be part a series of updated reviews of the literature on respiratory support in the newborn infant. These recommendations are structured into 12 modules, and in this work module 8 is presented. Each module is the result of a consensus process amongst all members of the Surfactant and Respiratory Group of the Spanish Society of Neonatology. They represent a summary of the published papers on each specific topic, as well as the clinical experience of each one of the members of the group.

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◊ Los miembros del Grupo Respiratorio y Surfactante (RESPISURF) de la Sociedad Española de Neonatología se presentan en anexo.

PALABRAS CLAVE
Ventilación de alta frecuencia;
Ex útero *intrapartum treatment* (EXIT);
Oxigenador de membrana extracorpórea (ECMO);
Recién nacido

Recomendaciones para la asistencia respiratoria en el recién nacido (IV). Ventilación de alta frecuencia, *ex-utero intrapartum treatment* (EXIT), oxigenador de membrana extracorpórea (ECMO)

Resumen Las recomendaciones incluidas en este documento forman parte de una revisión actualizada de la asistencia respiratoria en el recién nacido. Están estructuradas en 12 módulos, y en este trabajo se presenta el módulo 8. El contenido de cada módulo es el resultado del consenso de los miembros del Grupo Respiratorio y Surfactante de la Sociedad Española de Neonatología. Representan una síntesis de los trabajos publicados y de la experiencia clínica de cada uno de los miembros del grupo.

High-frequency ventilation

General principles

Conventional mechanical ventilation attempts to imitate spontaneous breathing by administering tidal volumes similar to physiological volumes at normal respiration rates. When tidal volumes need to be increased in order to maintain an adequate gas exchange, this produces increases in pulmonary pressures that may foster the development of bronchopulmonary dysplasia or air leaks.

High-frequency ventilation (HFV) attempts to minimise such lung injury. It uses very small tidal volumes (smaller than the anatomical dead space) at supraphysiological frequencies (of more than 150 breaths/min), thus maintaining adequate ventilation.

High-frequency ventilation was first described in 1969,[1] with positive results in the animal model.

There are 3 main types of HFV based on the devices used to deliver it[2]:

High-frequency oscillation ventilation (HFOV). Consist in a closed circuit that maintains a continuous positive pressure with an integrated piston pump or oscillating membrane. The movements of the piston displace the air volume within the circuit towards the lung during inspiration, creating a positive pressure, and pull air away during expiration by generating a negative pressure. Thus, expiration in this type of ventilation is active. It is the type of ventilation used most frequently in our hospitals.[3]

High-frequency jet ventilation (HFJV). It delivers pulses of humidified gas at the level of the endotracheal tube through a jet injector. Expiration is passive.

High-frequency flow interruption ventilation (HFFIV). It is a mixed type of HFV that uses a solenoid valve that functions as a shutter, opening and closing at a high frequency.

Different types of ventilators for HFV are available in Spain. Table 1 describes some of them.

Important concepts

Continuous distending pressure of the lung (cmH_2O) (CDP). It is the pressure maintained in the ventilator circuit and applied to the alveoli. It is used for alveolar recruitment and therefore for oxygenation.

Amplitude ($\triangle P$). Difference in pressure above and below the CDP expressed in cmH_2O (expressed as a percentage in some ventilators). It is responsible for alveolar ventilation.

Respiratory rate in hertz (Hz) (RR). Frequency of oscillations at the given amplitude; 1 Hz = 60 cycles/min.

Ventilation and oxygenation

Ventilation. The elimination of CO_2 is determined by the square of the tidal volume multiplied by the RR (a concept known as DCO_2). Tidal volume is the greatest determinant of CO_2 clearance.

Tidal volume is influenced by amplitude. Small changes in amplitude or lung compliance (and thus in tidal volume) have significant effects on ventilation. The RR is inversely correlated to tidal volume. Tidal volume increases as RR decreases.

The precise mechanism by which gas exchange takes place has yet to be elucidated. Different hypotheses have been proposed: direct alveolar ventilation, the pendelluft effect, and facilitated diffusion (convection).[4]

Oxygenation. The greatest determinant of oxygenation is the maintenance of functional residual capacity (FRC) through the CDP.

Indications

Preterm newborn with respiratory distress syndrome. The various controlled trials that have compared HFV with conventional ventilation have not had the encouraging results obtained in animal experiments. They have failed to demonstrate significant improvements in the variables under study. These discrepancies in the results are most likely due to the different therapeutic strategies used, variability in clinical practices between centres, variability in the included patients, and advances in conventional mechanical ventilation.[5,6]

The outcomes observed in the more than 4000 infants studied in the various clinical trials comparing HFV, with a high volume strategy, and conventional mechanical ventilation, with respiratory rates of more than 60 cycles per minute and minimal tidal volumes, were similar.

With the high lung volume strategy, there was a higher incidence of air leak syndrome and there was not an