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Review

The basic principles of anesthesia for the neonate☆

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ABSTRACT

Introduction: There are significant developmental differences in physiology and pharmacology in neonates that make the conduct of a safe anesthetic much more challenging in a neonate.
Objectives: Complete a focused review of the current knowledge of the physiological and pharmacologic differences seen in newborns that impact the safe administration of anesthesia.
Methods: A selective review of literature in developmental changes in physiology and pharmacology was completed.
Results: This knowledge acquired in the review was used to establish common principles for the safe administration of anesthesia to newborn patients.
Conclusion: In spite of the persistence of large gaps in our knowledge in this physiology and pharmacology, common modern anesthetic management principles for neonatal surgery have significantly improved clinical outcomes.

Principios básicos de la anestesia neonatal

Palabras clave:
Recién, nacido
Anestesia, general
Farmacología
Anestesia de conducción
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RESUMEN

Introducción: Existen diferencias significativas de desarrollo en la fisiología y la farmacología de los neonatos que hacen que sea mucho más difícil llevar a cabo una anestesia segura.
Objetivos: Completar una revisión focalizada del conocimiento actual sobre las diferencias fisiológicas y farmacológicas observadas en recién nacidos que tienen un impacto en la administración segura de la anestesia.
Métodos: Se llevó a cabo una revisión selectiva de la literatura sobre cambios en el desarrollo fisiológico y farmacológico.
Resultados: El conocimiento adquirido en esta revisión fue usado para establecer principios comunes para la administración segura de la anestesia en pacientes recién nacidos.

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Conclusión: A pesar de la persistencia de grandes lagunas en nuestro conocimiento en esta fisiología y la farmacología, los principios modernos y comunes del manejo de la anestesia en cirugía neonatal han mejorado significativamente los resultados clínicos.

Introduction

One of the most challenging tasks an anesthesiologist will ever face is the provision of safe and effective anesthesia care of a newborn for surgery. Neonatal anesthesia demands a thorough understanding of the rapidly changing physiology and pathology of the neonate and both the pharmacokinetics and pharmacodynamics of the medications used to provide anesthesia. This knowledge is then incorporated into a well planned anesthetic plan of care. Furthermore, great manual skills and continuous experience with these unique challenges presented by neonates are essential for optimal clinical outcome for these vulnerable patients. This prospective review aims to provide a brief summary of theoretical aspects of neonatal anesthesia and present some practical guidelines of care for this patient population.

Physiology of the neonate

The respiratory system has to undergo major physiologic changes in function in seconds when transitioning from the fetal to neonatal environment. To facilitate easier passage through the birth canal, the neonate's chest wall (rib cage) is flexible with little calcification of the bones.[1] In contrast, the newborns lungs are populated with immature alveoli that contain little elastin; thereby making them stiff and difficult to inflate.[2] This combination of flexible chest wall and stiff lung increases the closing volume of the lung and promotes lung collapse.[3] Functional residual capacity (FRC) when normalized by body weight is relatively constant from birth through adult life.[4] Spontaneously breathing neonates will dynamically compensate for their immature respiratory mechanics with rapid breathing without expiratory pauses and expiratory air breaking through the larynx.[5] To overcome these developmental challenges under passive conditions, pediatric anesthesiologists will routinely recruit alveoli after each brief period of apnea and will use positive end-expiratory pressure (PEEP) when mechanically ventilating a neonate to maintain normal lung volumes.

In spite of equivalent FRCs, neonates will rapidly desaturate with apnea even with effective pre-oxygenation with 100% inspired oxygen.[6] This principally is due to a doubling of the rate of oxygen consumption when normalized by body weight in comparison to an adult.[7] To compensate for this high oxygen consumption, neonates also have twice the alveolar ventilation of an adult. Pediatric anesthesiologists routinely take advantage of this during inhalational induction of anesthesia where the rapid wash in of anesthetics leads to a more rapid induction of anesthesia in the young compared to an adult.[8]

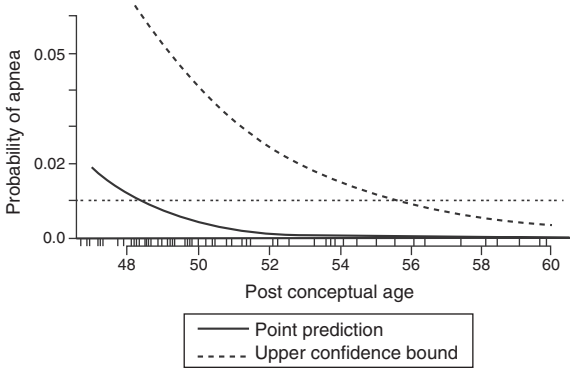

Fig. 1 – Predicted probability of apnea by postconceptional weeks (solid line) with 95% upper confidence limit (broken line). The 1% risk for postoperative apnea reaches 95% confidence at approximately 56 weeks postconceptional age.
***Source*: Reproduced with permission from Cote et al.[12]**

Anesthesiologists also must understand that neonates are obligate nose breathers and more easily experience airway obstruction under anesthesia due to the relatively larger tongue and more compliant (collapsible) airway soft tissue.[9] Similarly, practitioners in neonates realize the importance of the artificial airway diameter because airway resistance increases by the fourth power as radius decreases.[10]

During the neonatal period the control of breathing varies significantly from that seen in older children and adults. The increase in ventilation to hypercapnia is less in a neonate compared to an adult; however, it is the response to hypoxemia that differs dramatically. While an adult will have a sustained increase in ventilation when exposed to hypoxia, neonates will demonstrate a brief increase follow by a sustained depression of ventilator drive when exposed to hypoxemia.[11] The immaturity of the respiratory centers in the central nervous system in neonates are likely responsible in part of the pronounced affect anesthetics have in this population. In the only published systematic review of studies evaluating perioperative apnea in this population, general anesthesia increased the risk for postoperative apnea in premature infants less than 60 weeks postconceptional age.[12] This risk is further increased by anemia (Hct < 30%). Even at 56 postconceptional weeks the risk for postoperative apnea remains approximately 1% (see Fig. 1); therefore, most textbooks and leaders in the field of pediatric anesthesia recommend that patients under this threshold should be admitted to the hospital for monitoring for 12–24 h.[13]