Neuromuscular Blocking Agents and Monitoring in the Equine Patient

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KEYWORDS

• Equine • Neuromuscular block • Acceleromyography • Cisatracurium • Vecuronium • Rocuronium

KEY POINTS

- Neuromuscular blocking agents (NMBA) interrupt transmission at the neuromuscular junction, resulting in paralysis of skeletal musculature.
- NMBA do not contribute to sedation/hypnosis, hence the appropriate level of anesthesia needs to be assessed.
- Neuromuscular blockers may allow for smaller doses of general anesthetics to be administered, because immobility provided solely by general anesthetics may require large doses.
- Residual neuromuscular block is a potential complication every time neuromuscular blocking agents are used, and needs to be addressed before general anesthesia is interrupted.

INTRODUCTION

Neuromuscular blocking agents (NMBA), commonly called muscle relaxants or paralytic agents, compose a unique group of drugs used during general anesthesia: in contrast to most other agents administered during general anesthesia, NMBA do not participate in the provision of sedation, hypnosis, or analgesia, nor do they cross the blood-brain barrier or placenta in significant concentrations. NMBA are largely hydrophilic compounds with limited distribution. The only (intended) effect attributable to these drugs is the relaxation of skeletal muscle, which is achieved by interfering with normal neuromuscular transmission; neurotransmitter released from motor neurons are unable to stimulate skeletal muscle to produce contraction. This specific action results in a patient incapable of producing motor activity, even in response to noxious stimulation. As a consequence, the anesthetist needs to consider that some common

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signs used for the assessment of anesthetic depth will be completely abolished; attention must be focused on the maintenance of a suitable depth of hypnosis. Indeed, the inclusion of NMBA when people are anesthetized has resulted in a higher incidence of awareness under anesthesia.[1] For obvious reasons, spontaneous ventilation cannot occur, or at least not efficiently, in the presence of complete or partial neuromuscular block. The administration of NMBA without the means for providing mechanical ventilation (both in terms of equipment and skills) is contraindicated.

The introduction of NMBA into clinical anesthesia occurred only little more than half a century ago, and changed the practice of general anesthesia.[2] This change in anesthetic practice was not without complications: Beecher and Todd[3] documented in 1954 that the inclusion of NMBA in the anesthetic protocol increased mortality. It is not clear whether this was the result of NMBA use, poor use of mechanical ventilation, or reversal from relaxation and/or monitoring. As already mentioned, the use of these agents was also associated with an increase in the incidence of awareness under anesthesia.[1] It should be noted, however, that general volatile anesthetics produce immobility mainly through effects on the spinal cord. Movement in response to noxious stimuli may reflect insufficient analgesia, not insufficient hypnosis. Because awareness occurs as a result of insufficient hypnosis, an argument can be made that awareness under anesthesia occurs not because movement in response to noxious stimulation is blunted by NMBA, but simply because hypnotic agents are not administered in sufficient quantities.

The main purpose for including a NMBA in the anesthetic protocol is to enhance muscle relaxation without the necessity of administering large doses of general anesthetics. Both injectable and inhalational anesthetics may produce sufficient muscle relaxation for most surgical procedures in horses; however, the doses required to abolish muscular responses are considerably higher than those needed to produce hypnosis.[4–6] (More details on end points of inhalational anesthesia, and their relationship to the concentration administered, are discussed in the article written by Brosnan on inhalational anesthetics elsewhere in this issue.) The addition of an NMBA to the anesthetic protocol allows the anesthetist to administer a general anesthetic at doses only sufficient to provide hypnosis. When an analgesic drug is also included, this technique is referred to as balanced anesthesia, whereby all 3 major components of general anesthesia (hypnosis, analgesia, and muscle relaxation) are provided by the combination of different agents, rather than by the administration of a large dose of 1 agent. Because most general anesthetics produce a dose-dependent depression of cardiovascular functions, the reduction in the doses of general anesthetics administered typically results in improved and more stable hemodynamics.

In some cases, administration of NMBA may be actually necessary for some procedures to be completed. Ophthalmologic surgery may require the eye to be immobile, relaxed, and in a central position, which is easily achieved by paralyzing the patient. Fractures or luxations may be easier to be reduced in the absence of muscular tone. Muscle relaxation can aid in the institution of positive-pressure ventilation, and also can prevent substantial increases in intrathoracic pressure that may result from unsynchronized mechanical ventilation over spontaneous breathing from the patient. Profound muscle relaxation may also prevent accidents provoked by a horse's reflex response to noxious stimulation. Equipment damage from horses moving under anesthesia has occurred, implying not only a substantial loss in economic terms but also potential injury to the patient or the staff in the operating room. Anesthesiologists may also administer NMBA in very unstable and critically ill horses during colic surgery to reduce the amount of inhalational agents being used, without the risk of patient movement during surgery, at least until progress has been made in terms of