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Special Articles

A national survey on the practice patterns of anesthesiologist intensivists in the use of muscle relaxants

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Objective: **To determine the practice patterns of anesthesiologist intensivists (with the special certificate of competence in critical care medicine from the American Board of Anesthesiology) in the use of neuromuscular blocking drugs, in the ICU setting.**

Design: **A survey.**

Participants: **All anesthesiologists with the special certificate of competence in critical care (n = 374) were selected for this study. Of the 339 who could be contacted and who were still actively practicing, 185 (55%) completed the survey.**

Results: **In the ICU setting, anesthesiologist intensivists most commonly used vecuronium (52%) administered by bolus injection, bolus injection followed by infusion, or by continuous infusion. The most frequent indication for muscle relaxation was facilitation of mechanical ventilation (89%). Neuromuscular blockade was most commonly monitored clinically (55%), with only 34% of respondents using a peripheral nerve stimulator. All respondents indicated the concomitant use of sedatives or narcotics with muscle relaxants.**

Conclusions: **This study was created to address the dearth of information regarding actual usage of muscle relaxants in the ICU setting. The survey population was chosen as one with great familiarity in the use of muscle relaxants. The 55% response rate was significantly greater than the expected response rate for a single mailing survey. In the ICU setting, neuromuscular blocking drugs are most frequently used to facilitate mechanical ventilation. The prevalence of vecuronium use is of interest in light of recent case reports of prolonged neuromuscular blockade after long-term vecuronium administration. The low frequency of peripheral nerve stimulator monitoring during muscle relaxation may contribute, in part, to the problem of prolonged blockade after drug withdrawal. Muscle relaxants are not used in the absence of sedation and/or analgesia by this practitioner population. (Crit Care Med 1992; 20:1341–1345)**

KEY WORDS: **anesthesiologists; muscle relaxants; intensive care medicine; neuromuscular blocking agents; paralytics; critical illness; mechanical ventilation; sedatives; vecuronium; pancuronium**

Critically ill patients receiving mechanical ventilatory support may require sedative-amnestics and/or narcotic analgesics to facilitate gas exchange and maintain patient comfort and acceptance of ventilatory support (1). On occasion, neuromuscular blocking drugs (commonly referred to as muscle relaxants), such as atracurium, metubine, pancuronium, and vecuronium, are also administered to ventilated patients (2–4). Neuromuscular blockers may be used in the ICU for more prolonged periods (days to weeks) than when they are administered intraoperatively during general

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anesthesia. There are limited data on the practice patterns of physicians using muscle relaxants in the ICU (5). Recent studies (6–14) emphasize potential problems associated with prolonged muscle relaxant use in the ICU and raise several questions: which muscle relaxants are most appropriate in the ICU setting? which method of delivery is optimal? what type of monitoring is indicated? and should muscle relaxants be used in the ICU at all? In addition, several studies (10–12, 15) reported prolonged neuromuscular blockade after withdrawal of muscle relaxants. Finally, there are few data regarding the use of adjunctive sedative, amnestic, or analgesic agents in ICU patients receiving long-term muscle relaxants (14). Since neuromuscular blocking drugs are devoid of these properties, the potential exists for a patient to be awake and uncomfortable while pharmacologically paralyzed and unable to communicate distress (16).

To address some of these issues, a survey was developed that polled anesthesiologists who have special certification of competence in critical care awarded by the American Board of Anesthesiology. Anesthesiologist intensivists were chosen because of their familiarity with the clinical use and pharmacologic effects of muscle relaxants in normal patients as well as in those patients with end-organ dysfunction or failure.

MATERIALS AND METHODS

A 24-question, multiple-choice survey (Table 1) was constructed on a FOXBASE+/Mac™ database for ease of data entry and collation. A list of all current anesthesiologists with the special certificate of competence in critical care was obtained and cross-referenced with the membership of the American Society of Critical Care Anesthesiologists, American Society of Anesthesiologists, and Society of Critical Care Medicine to facilitate contact. The total number of such eligible intensivists discovered was 374. Of these 374, 29 could not be contacted, and of those intensivists who could be reached, six indicated that they no longer practice critical care medicine. Therefore, 185 of 339 practitioners surveyed completed the questionnaire, yielding a 55% response rate. At the onset of the study, physicians were contacted by telephone, and the practitioner completed the survey during a 5- to 10-min interview. Although this approach supplied immediate feedback, telephone interviews were found to be overly time-consuming and inefficient, requiring multiple phone calls to contact the physician and complete the questionnaire. Therefore, a mass mailing was undertaken. The remaining practitioners were asked to anonymously indicate their responses to the survey, which was administered previously by telephone. Inquiries contained a brief cover letter and background comments concerning the study rationale. The questionnaire solicited information from the practitioners on the type of facility in which they practiced, size of their ICU, indications for muscle relaxant use, agent(s) used, mode of administration, monitoring techniques, concurrent use of sedatives and analgesics, and methods of determining adequacy of sedation and analgesia.

Table 1. Survey questions regarding muscle relaxant use in the intensive care unit (ICU)

1. Type of ICU
2. Number of beds in your ICU
3. a. Type of hospital
   b. Hospital affiliation
   c. Hospital modus
4. Number of patients requiring neuromuscular blockade per month
5. Average number of patient-days on neuromuscular blockade (use your most recent month as an example)
6. What are your indications for neuromuscular blockade?
7. a. Which muscle relaxants do you use?
   b. Which is the primary one used if more than one is selected?
   c. What criteria do you use in choosing a neuromuscular blocker?
8. a. Mode of delivery of neuromuscular blocker
   b. If intermittent boluses are used, who decides whether the patient needs another bolus?
   c. What technique do they use to determine redosing?
9. a. Routine method of monitoring neuromuscular blockade
   b. If clinical monitoring is used, what parameters are followed?
10. What sedatives/narcotics do you use along with neuromuscular blockade?
11. How do you assess the adequacy of sedation/analgesia?
12. a. What agents do you use to reverse neuromuscular blockade?
    b. How do you decide to discontinue neuromuscular blockade?
    c. Do you think that it is important to have neuromuscular blockade reversed on a periodic basis for comprehensive patient evaluation? (for example, every 24 hrs for a complete neurologic examination)
    d. If yes to 12c, list the time interval in hours
    e. If yes to 12c, should the agents be allowed to spontaneously wear off or be reversed?
13. Additional comments on experience with neuromuscular blocking agents that shape current use

RESULTS

Population. A total of 185/339 (55%) eligible anesthesiologist intensivists completed the survey. The majority of respondents practiced in a surgical or medical/surgical ICU with an average of 19 beds (range 6 to 64). The respondents were nearly equally divided between university hospitals and university-affiliated or community hospitals (47% and 48%, respectively), with the

remainder practicing in Veterans Administration hospitals. Overall, the average number of patients requiring neuromuscular blockers per month per unit was ten. Anesthesiologist intensivists, limiting their practice to pediatric critical care, made up 11% of those physicians responding to the survey. Although the size of the pediatric ICU was smaller on average, physicians in these units administered muscle relaxants more frequently than their adult ICU counterparts (19 patients per month as compared with ten for adult units).

Indications for Neuromuscular Blocking Agents. Neuromuscular blockers were most frequently used to facilitate mechanical ventilation (89%). Other indications included use in patients with increased intracranial pressure (35%), high oxygen consumption (25%), agitation or combativeness (with sedation) (23%), or for facilitation of procedures or diagnostic studies (15%). Additional indications were included as part of supportive therapy for tetanus or severe rigidity in patients with cardiovascular instability.

Muscle Relaxant. Vecuronium was listed as the primary neuromuscular blocking agent used in the ICU by the majority (52%) of respondents. Pancuronium was indicated as the primary relaxant used by 28%, metubine by 5%, and atracurium by 3% of respondents. The most frequently cited criterion for vecuronium selection was its paucity of hemodynamic side-effects. Mode of drug metabolism, cost, duration of action, and ease of delivery as a continuous infusion were also, but less frequently, cited.

Mode of Drug Delivery. Neuromuscular blockers were given as frequently by intermittent bolus, as by bolus injection followed by continuous infusion, or by continuous infusion by the respondents.

Monitoring of Degree of Neuromuscular Blockade. Neuromuscular blockade in the ICU was most frequently monitored using clinical judgment (55%). Thirty-four percent of respondents used a peripheral nerve stimulator in addition to clinical assessment. Eleven percent of respondents indicated that no monitoring was used. One respondent routinely used a Servo-controlled computer with a muscle relaxant infusion titrated to a specific electromyographic response.

Adjunctive Therapy. All respondents indicated concomitant use of sedatives or narcotics during the administration of muscle relaxants to their critically ill patients. Midazolam and morphine (85% and 74%, respectively) were the most commonly used sedative and/or narcotic adjuncts used by the survey responders.

Bias. In order to address methods bias, the data from the telephone contacts (61 surveys, 100% response rate) were analyzed, and showed no statistical difference from the mail-in data (124/278 surveys, 45% response rate).

DISCUSSION

The goals of this survey were to determine current practice patterns of muscle relaxant use in the ICU and to provide a basis for further study of the optimal use of these drugs in the ICU setting. The study population focused on anesthesiologist intensivists, a small group of experts familiar with the use of neuromuscular blocking agents. The 55% response rate was significantly better than expected for a single mailing survey such as this one, for which "typical response rates are 40% to the first mailing and perhaps 60% after three mailings" (17). One needs to take into account the possibility that the remaining 45% may or may not have had similar practice characteristics. Statistically, those intensivists who do not answer mail-in surveys tend to be less familiar with and/or less interested in the subject matter of the survey. In addition, one can only speculate on the use of neuromuscular blocking drugs in the ICU by nonanesthesiologist intensivists, such as surgeons, internists, pediatricians, and related subspecialists. An outgrowth of this small study might be a larger polling of multispecialty intensivists regarding the overall use of these agents, with particular emphasis on the indications, contraindications, and side-effects of muscle relaxants.

Neuromuscular blockade in the ICU under the direction of intensivists who are board certified by the American Board of Anesthesiology is most commonly provided to facilitate mechanical ventilation. With the advent of newer modes of mechanical ventilation and gas exchange, such as inverse ratio ventilation, permissive hypercapnia, and extracorporeal membrane support, muscle relaxants have been advocated by some (18) to optimize these therapies. These drugs may be of benefit in synchronizing ventilation, limiting peak airway pressures, and decreasing the work of breathing. The use of muscle relaxants, however, is not without potential deleterious side-effects or sequelae. Some side-effects are: catastrophic hypoxia, if there is an unrecognized disconnect or ventilatory malfunction; alteration in gas distribution secondary to changes in diaphragmatic motion and chest wall compliance; the elimination of cough with the accumulation of secretions; and the potential of prolonged duration of effect. In addition to adverse ventilatory consequences of neuromuscular blockade, muscle relaxation also impairs evaluation of neurologic function, and can hinder evaluation of patient sedation. Thus, although muscle relaxation in the ICU setting may provide advantages, the use of neuromuscular blockers in this patient population cannot be considered benign, leading to recommendations that these drugs not be used in the ICU setting (9).

Vecuronium was the most commonly chosen muscle relaxant and was as likely to be administered by intermittent bolus, initial bolus followed by a continuous infusion, or continuous infusion. Vecuronium was chosen based on its paucity of hemodynamic side-effects.

The choice of vecuronium and the mode of administration in patients receiving this intermediate duration muscle relaxant is noteworthy in light of recent case reports and studies. Several studies (11, 12) described prolonged effects of vecuronium, particularly in patients with associated renal failure. Segredo et al. (11) described persistent neuromuscular blockade after withdrawal of long-term vecuronium therapy due to 3-desacetylvecuronium, a pharmacologically active metabolite of vecuronium that is renally excreted, and was thought by these authors to be 50% to 70% as potent as the parent molecule. The use of steroid-related blockers (i.e., vecuronium and pancuronium) along with high-dose glucocorticoids has also been reported (7, 15) to lead to weakness and a prolonged myasthenic syndrome. Smith et al. (19) questioned the routine use of continuous infusions of vecuronium in the critically ill, citing the potential for prolonged neuromuscular blockade. Therefore, they (19) advocated the use of bolus injections if vecuronium is the relaxant of choice. Prolonged neuromuscular blockade necessarily means prolonged mechanical ventilation and the pursuant increase in iatrogenic morbidity and mortality associated with continued ICU exposure. Thus, despite its lack of hemodynamic side-effects, vecuronium may not be the muscle relaxant of choice in the ICU setting due to problems with persistent blockade in patients who are in renal failure or receiving steroid therapy. Several authors (20, 21) advocated the more routine use of atracurium in the critically ill patient because of the lack of reports of prolonged neuromuscular weakness after its use. This intermediate-acting drug is degraded by ester hydrolysis and Hofmann degradation and is not dependent on end-organ metabolism or excretion. As opposed to vecuronium and pancuronium, the metabolites of atracurium are not active as neuromuscular blockers. Atracurium has some potential limitations as well, however. When atracurium is administered as an iv bolus, hypotension and tachycardia can result secondary to histamine release. This effect can be limited by slowing the speed of injection. In addition, laudanosine, a renally excreted metabolite of atracurium, has been shown to be a convulsant in laboratory animals. However, there has not been a documented case of laudanosine-induced seizures in humans. Finally, expense is an issue with this drug as well as the other newer muscle relaxants, such as vecuronium, doxacurium, and pipecuronium.

This survey demonstrated that neuromuscular blockade is not routinely monitored with a peripheral nerve stimulator in the ICU by the majority of physicians in this group. This finding is in contradistinction to a recent recommendation by Partridge et al (10). These authors (10) advocated the routine use of peripheral nerve stimulator monitoring in ICU patients receiving muscle relaxants as a means to measure the depth of neuromuscular blockade and to titrate the effect of muscle relaxants to avoid excessive doses and, possibly, prolonged effects. If nerve stimulator monitoring is infrequent among anesthesiologist intensivists, it is presumably even less commonly used by other specialty intensivists who may be less familiar with the technology of bedside evaluation of levels of neuromuscular blockade.

The question of long-term effects of neuromuscular blockade remains incompletely answered. Various reports (22–24) described long-term residual weakness in critically ill patients. Some of these reports were thought to represent long-term blockade from the muscle relaxant or its metabolites, relaxant-drug interactions, or acquired polyneuropathy of the critically ill. This latter problem has been best studied by Canadian investigators (23) in the setting of sepsis. Finally, there are few, if any, data showing whether drug holidays from neuromuscular blockers would be of benefit or whether less dense degrees of paralysis may lead to a lower occurrence rate of postrelaxant weakness. Thus, questions concerning the safest drugs to use, the optimal mode of drug delivery, the degree of block that should be obtained, and how to best monitor the degree of block remain unanswered.

In regard to reversal of neuromuscular blockers, 55% of the practitioners thought it was important for comprehensive patient evaluation, but in practice, only 25% of the practitioners reversed the neuromuscular blockade of their paralyzed patients. Neostigmine was the reversal agent of choice and was used twice as frequently as edrophonium.

In summary, this survey established a point of reference for current muscle relaxant use in the ICU. It also showed that concerns regarding the optimal use of these drugs (which drugs should be administered, for what indications, and how neuromuscular blockade should be monitored) are justified in light of current clinical practice. It was reassuring to see that sedative and analgesic agents are routinely administered and clinically monitored during the administration of muscle relaxants by this practitioner population. This technique is an appropriate ongoing attempt to avoid the potential of having a patient paralyzed, but aware.

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