Journal of Clinical Anesthesia (2016) **36**, 16–20

ELSEVIER

Journal of Clinical Anesthesia

Original Contribution

Frequency of inadequate neuromuscular blockade during general anesthesia☆,☆☆,★

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Received 7 January 2016; revised 20 July 2016; accepted 7 September 2016

Keywords:
Neuromuscular blockade;
Neuromuscular monitoring;
Neuromuscular blocking agents

Abstract

Study Objective: We used electronic health record data to define frequency of inadequate intraoperative neuromuscular blockade (NMB).

Design: Retrospective observational study using electronic health record data.

Setting: Operating room in a tertiary care academic hospital.

Patients: A total of 129,209 adult patients with American Society of Anesthesiologists physical status 1 to 5 undergoing general anesthesia in an outpatient or inpatient setting who received nondepolarizing NMB. We excluded patients intubated before arrival to the operating room, patients undergoing a liver transplant or cardiac surgery, and patients who remained intubated at the end of the operation.

Interventions: None.

Measurements: The primary outcomes were inadequate NMB defined by (1) documentation of patient movement and (2) documentation of surgical request for additional NMB, followed by NMB agent administration.

Main Results: A total of 1261 patients (1.0%) demonstrated either intraoperative movement (369 or 0.29%) or prompted surgical request for additional NMB agent (921 or 0.71%). Trend analysis showed a variation in the annual rate of inadequate NMB, with an increase from 2004 to 2013 for criteria 1 and 2.

☆ Conflict of interest: The author(s) declare that they have no conflict of interest.

☆☆ Authors' contributions: Timur Dubovoy and Sachin Kheterpal were involved with the study design, review and analysis of data, manuscript preparation, and the decision to submit the manuscript for publication. Amy M. Shanks was involved in study design, analysis of data, and manuscript preparation. Scott Devine was involved with the study design, drafting of the manuscript, and the decision to submit the manuscript for publication.

★ Sources of financial support: All work and funding are attributed to the Department of Anesthesiology at the University of Michigan Medical School (Ann Arbor, MI) and Merck, Sharp, and Dohme, Inc (Whitehouse Station, NJ).

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http://dx.doi.org/10.1016/j.jclinane.2016.09.020

Conclusions: Nearly 1% of all general anesthetic procedures involving NMB exhibit inadequate relaxation resulting in procedural interruption. These data suggest that current use of neuromuscular blocking drugs and NMB monitoring expose patients to inadequate blockade. The risk of this phenomenon warrants further study.

1. Introduction

Nondepolarizing neuromuscular blockade (NMB) agents are part of a balanced anesthesia technique aimed to prevent undesired patient movement and to facilitate surgical and anesthetic procedures. Conservative use of these drugs is appropriate considering high incidence of residual postoperative NMB [1-4] and is supported by the current guideline "to use the lowest possible dose that will provide adequate relaxation for surgery" [5]. Ideally, following the recommended initial dose (twice the effective dose for which 95% of the population exhibit the effect) to promote tracheal intubation, subsequent maintenance doses are reduced to one-fourth (short- and intermediate-acting NMB agents) to one-tenth (long-acting NMB agents) while maintaining 1 twitch visible on train-of-four (TOF) stimulation (90%-95% blockade) [5].

In clinical practice, however, variable pharmacokinetic properties of NMB drugs and limited use of objective neuromuscular monitoring may lead to exceeding the ideal state of NMB, thus risking residual paralysis or weakness or using less than adequate amounts of neuromuscular blockers resulting in suboptimal surgical conditions [6]. Although residual NMB is a well-described phenomenon [7-10], there are few systematic analyses of characteristics and prevalence of inadequate intraoperative NMB. We sought to use intraoperative electronic health record data to identify episodes of inadequate NMB that have direct impact on a surgical procedure.

2. Materials and methods

Institutional review board approval (University of Michigan, Ann Arbor, MI) was obtained for this retrospective analysis of deidentified patient data. Patient informed consent was waived because all patient identifiers were removed before data analysis. All intraoperative anesthesia records of adult patients (>18 years old) with American Society of Anesthesiologists (ASA) physical status 1 to 5 undergoing general anesthesia in an outpatient or inpatient setting receiving one of the contemporary nondepolarizing NMB agents (atracurium, pancuronium, cisatracurium, vecuronium, or rocuronium) were evaluated. We excluded patients intubated before arrival to operating room, patients undergoing a liver transplant or cardiac surgery, and patients who remained intubated at the end of the operation. Figure 1 summarizes patient inclusion and exclusion criteria.

All patients receiving nondepolarizing NMB agents were monitored with tactile TOF counts every 15 minutes per our institutional standard of care using MiniStim MS-IV (Life-Tech, Stafford, TX) peripheral nerve stimulator. Clinical providers were required to document all administered medications and TOF monitoring results in a timely fashion in our intraoperative electronic health record (Centricity, General Electric Healthcare, Waukesha, WI) as an integral part of the anesthetic record. In addition, clinical providers documented intraoperative events and observations using free text entry if they deemed it to be necessary or relevant part of the intraoperative documentation.

The primary outcome was inadequate intraoperative NMB defined by one of the following criteria: (1) "patient movement" defined as documentation of a direct interruption of procedure due to the patient moving, coughing, or "bucking" and (2) "surgeon request" defined as documentation of a surgeon request for NMB concurrent with administration of a muscle relaxant 5 minutes before or 15 minutes after such a request.

First, criteria 1 and 2 were assessed via automated free-text search of the entire intraoperative health records for the terms *cough*, *buck*, *move*, *tight*, *paralysis*, *relax*, *muscle*, *surgeon*, *request*, *additional*. Each potential instance of inadequate intraoperative NMB identified by this automated search was then manually reviewed by one of the study investigators (SK or TD) to verify consistency with the intent of criterion 1 or 2. Time bracketing (5 minutes before or 15 minutes after) was applied to criterion 2 to improve the likelihood that the 2 events were related, while allowing for minor discrepancies between actual event and its documentation in the intraoperative record.

Patients exhibiting inadequate NMB meeting one or both of these criteria were tabulated to assess the frequency of inadequate NMB overall and individually by each of the 2 criteria. The intraoperative period was defined as the time from "anesthesia induction end" to "surgery dressing end" or the time of neostigmine administration if the latter was not documented. Basic patient anthropometrics, including patient age, sex, body mass index, ASA classification, emergent classification, and procedural information regarding each case, were extracted from the record database.

Age and surgical case duration were examined for normality. Age was parametric and reported as means and SDs, whereas case duration was not normally distributed and reported as medians and interquartile ranges for each of the 2 inadequate intraoperative NMB criteria. Basic frequencies were used to describe various patient characteristics, the incidence