

CLINICAL PRACTICE

Association between intraoperative non-depolarising neuromuscular blocking agent dose and 30-day readmission after abdominal surgery

T. Thevathasan^{1,†}, S. L. Shih^{2,†}, K. C. Safavi¹, D. L. Berger³, S. M. Burns¹, S. D. Grabitz¹, R. S. Glidden⁴, R. D. Zafonte², M. Eikermann^{4,5,*} and J. C. Schneider²

¹Department of Anesthesia, Critical Care and Pain Medicine, Massachusetts General Hospital, Harvard Medical School, 55 Fruit Street, Boston, MA 02114, USA, ²Department of Physical Medicine and Rehabilitation, Massachusetts General Hospital, Spaulding Rehabilitation Hospital, Harvard Medical School, 300 1st avenue, Boston, MA 02129, USA, ³Department of Surgery, Massachusetts General Hospital, Harvard Medical School, 55 Fruit Street, Boston, MA 02114, USA, ⁴Department of Anesthesiology, Beth Israel Deaconess Medical Center, Harvard Medical School, 330 Brookline Ave, Boston, MA 02215, USA and ⁵Klinik für Anästhesiologie und Intensivmedizin, Universitätsklinikum Essen, Hufelandstraße 55, 45147 Essen, Germany

*Corresponding author. E-mail: meikerma@bidmc.harvard.edu

†The authors made equal contributions to the manuscript.

Abstract

Background. We hypothesised that intraoperative non-depolarising neuromuscular blocking agent (NMBA) dose is associated with 30-day hospital readmission.

Methods. Data from 13,122 adult patients who underwent abdominal surgery under general anaesthesia at a tertiary care hospital were analysed by multivariable regression, to examine the effects of intraoperatively administered NMBA dose on 30-day readmission (primary endpoint), hospital length of stay, and hospital costs.

Results. Clinicians used cisatracurium (mean dose [SD] 0.19 mg kg⁻¹ [0.12]), rocuronium (0.83 mg kg⁻¹ [0.53]) and vecuronium (0.14 mg kg⁻¹ [0.07]). Intraoperative administration of NMBAs was dose-dependently associated with higher risk of 30-day hospital readmission (adjusted odds ratio 1.89 [95% Confidence Interval (CI) 1.26–2.84] for 5th quintile vs 1st quintile; *P* for trend: *P*<0.001), prolonged hospital length of stay (adjusted incidence rate ratio [aIRR] 1.20 [95% CI 1.11–1.29]; *P* for trend: *P*<0.001) and increased hospital costs (aIRR 1.18 [95% CI 1.13–1.24]; *P* for trend: *P*<0.001). Admission type (same-day vs inpatient surgery) significantly modified the risk (interaction term: aOR 1.31 [95% CI 1.05–1.63], *P*=0.02), and the adjusted odds of readmission in patients undergoing ambulatory surgical procedures who received high-dose NMBAs vs low-dose NMBAs amounted to 2.61 [95% CI 1.11–6.17], *P* for trend: *P*<0.001. Total intraoperative neostigmine dose increased the risk of 30-day readmission (aOR 1.04 [1.0–1.08], *P*=0.048).

Conclusions. In a retrospective analysis, high doses of NMBAs given during abdominal surgery was associated with an increased risk of 30-day readmission, particularly in patients undergoing ambulatory surgery.

Key words: ambulatory surgery; general surgery; hospital readmission; neuromuscular blocking agents

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Editor's key points

- The association between intraoperative neuromuscular blocking agent (NMBA) dose and 30-day hospital readmission was retrospectively analysed for a single tertiary medical centre.
- Of 13,122 patients undergoing abdominal surgery, administration of a NMBA was dose-dependently associated with higher risk of readmission, length of hospital stay and costs.
- These findings suggest that efforts to reduce doses of NMBAs in abdominal surgery might improve outcomes, which should be validated in prospective studies.

The high prevalence of hospital readmissions continues to be a challenge for healthcare systems, with implications for the quality of patient care and excess financial costs. The aggregate cost of all-cause 30-day readmissions was more than \$52 billion in 2013 in the USA, and nearly one out of every five Medicare patients was re-hospitalised within 30 days of discharge.^{1–3} Consequently, the Centers for Medicare and Medicaid Services (CMS) now publicly report 30-day readmission data and implemented financial penalties for hospitals with excess 30-day readmissions in 2012.^{1,4} CMS has expanded the applicable conditions in its readmissions calculations to include hip and knee arthroplasties and coronary artery bypass graft surgery.⁴

Postoperative hospital complications are the strongest determinant of 30-day surgical readmission.^{5,6} Strategies to reduce 30-day surgical readmission rates at any stage of surgical hospitalisation are increasingly important. Thus, our group has recently begun to study important predictors of 30-day readmission that can be modified.⁷

Anaesthetists use different strategies to optimise surgical relaxation, including neuraxial anaesthesia, inhalation anaesthetics, and opioids.^{8,9} Dosing of neuromuscular blocking agents (NMBAs) varies widely across anaesthesia providers.¹⁰ Residual neuromuscular block in the post-anaesthesia care unit (PACU) is associated with increased risk for aspiration, inadequate emergence after anaesthesia, delirium, weakness, and delayed PACU discharge.^{11–15}

The primary aim of this study was to investigate the association of intraoperative administration of NMBA dose and 30-day hospital readmission risk after abdominal surgery. Secondary aims were to determine the association between intraoperative NMBA dose and other quality-of-care indicators, including hospital length of stay (LOS) and costs of index hospitalisation. We hypothesised that intraoperative administration of NMBAs is dose-dependently associated with increased risk for 30-day hospital readmission, prolonged hospital LOS, and increased costs of hospital care in patients undergoing abdominal surgery.

Methods**Data sources and study population**

This study was performed at a multidisciplinary, tertiary care hospital in Boston, MA, USA, where more than 40,000 surgical procedures are performed annually. This study was approved by Partners Healthcare Institutional Review Board and written

informed consent was waived by the ethics committee. The retrospective analysis was carried out within a consecutively enrolled cohort of adult patients who underwent abdominal surgery under general anaesthesia between 2007 and 2014, as described in other studies.^{7,16} Briefly, three databases were accessed for preoperative, intraoperative, and postoperative data. The Anaesthesia Information Management System (AIMS) provides information on preoperative patient status, intraoperative events, administered medication and physiological data from patient monitors (see Supplementary Material: "Data sources"). Preoperative and postoperative patient characteristics were obtained from the Research Patient Data Registry (RPDR), a centralised research registry with data including Charlson Comorbidity Index (CCI) scores, an index of comorbidity severity,^{17,18} and readmission diagnoses. Data regarding hospital LOS, costs of hospital care, principal surgical procedures, and discharge destination were retrieved from Enterprise Performance Systems Inc. (EPSi), a performance improvement and financial planning system. CCI and surgical procedures were coded based on the International Statistical Classification of Diseases and Related Health Problems, ninth revision (ICD-9). Surgical procedures were weighed for procedural severity based on risk quantification index for postoperative morbidity.¹⁹

Non-depolarising neuromuscular blocking agents

We divided intraoperatively administered NMBA doses (adjusted to body weight) by NMBA-specific ED₉₅²⁰ (i.e. the median effective dose required to achieve a 95% reduction in maximal twitch response from baseline), resulting in multiples of ED₉₅ for NMBAs administered during surgery.²¹ Based on the multiples of NMBA ED₉₅, the cohort was subdivided into five equally sized quintiles.²¹ Of note, these quintiles did not match one, two, three, four and five-fold ED₉₅ in this observational study. The first quintile comprised patients receiving the lowest NMBA equivalent dose whereas the fifth quintile comprised patients receiving the highest equivalent dose.

Outcomes

The primary outcome was hospital readmission within 30 days after discharge from the index hospitalisation. Readmissions were recorded from six Partners Healthcare hospitals. We evaluated two pre-defined secondary outcomes: hospital LOS and total costs of hospital care.²² Hospital LOS is defined as the number of days between hospital admission and discharge during the index hospitalisation. Total costs are defined as the sum of direct and indirect costs of patient services. Direct costs contain variable and fixed costs associated with patient services. Indirect costs are fixed costs allocated to direct departments in a step-down structure.

Statistical analysis

Data analysis was performed using STATA (StataCorp LP, version 13.2). Normality was assessed using Shapiro–Wilk analysis. Categorical and continuous variables were compared using χ^2 tests and Student's t-tests (normally distributed) or Fisher's exact test and Wilcoxon–Mann–Whitney U-test (non-normally distributed), respectively. To adjust for non-linear relationships, continuous variables were divided into quintiles or clinically relevant groups. Histograms of NMBA ED₉₅ per h of surgery were plotted for the most frequent abdominal surgical procedures. Normally-distributed continuous variables are expressed as mean (SD), non-normally distributed variables as median (IQR), and categorical

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