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Evidence-based Recommendations for the Use of Neostigmine Versus Sugammadex in Patients Undergoing Thoracic Surgery

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Final Scholarly Project: Evidence-based Recommendations for the Use of Neostigmine Versus Sugammadex in Patients Undergoing Thoracic Surgery

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Abstract

Neuromuscular blocking agents play a vital role in the safe delivery of modern anesthetic practice. These medications provide patient paralysis for anesthesia staff to perform tracheal intubation and for surgeons to have a motionless surgical field. At the end of surgery, the effects of these paralytic agents must be fully reversed by reversal agents. Incomplete reversal impairs the patient's ability to maintain an airway, which can lead to various postoperative pulmonary complications such as respiratory failure, pneumonia, and atelectasis. Patients undergoing thoracic surgery are at high risk for this incomplete reversal due to deep levels of paralysis required to keep the diaphragm motionless for surgical manipulation. Therefore, optimal paralytic reversal strategies must be analyzed and incorporated into clinical practice to decrease residual paralysis and subsequent complications. Neostigmine has traditionally been the primary agent used for paralytic reversal. However, a newer alternative is available with the relatively recent introduction of Sugammadex. Literature has shown that in patients undergoing thoracic surgery, utilizing Sugammadex for reversal of neuromuscular blockade, compared to Neostigmine, improves patient outcomes by reducing postoperative pulmonary complications. This evidence-based practice project evaluates the most up-to-date literature to identify, plan, and implement recommendations for an optimal paralytic reversal strategy in patients undergoing thoracic surgery at a level-one trauma center in the Midwest United States.

Keywords: Neuromuscular blocking agents, Rocuronium, neuromuscular reversal agents, Sugammadex, Neostigmine, postoperative pulmonary complications

Introduction

Neuromuscular blocking agents (NMBAs) play a vital role in the safe delivery of modern anesthetic practice. Administration of NMBAs, such as rocuronium and vecuronium, result in patient paralysis to facilitate endotracheal intubation and provide a motionless surgical field for the surgeon (Wang et al., 2021). While using NMBAs is paramount in the safe care of patients undergoing various surgeries, the effects of these medications must be reversed quickly and reliably after the operation (Hristovska et al., 2017).

Anesthesia providers use reversal agents like Neostigmine and Sugammadex to achieve NMB reversal. Before the approval of Sugammadex by the Food and Drug Administration (FDA) in 2015, anesthesia providers used Neostigmine for the reversal of rocuronium and vecuronium-induced NMB (Li et al., 2021). Sugammadex has offered anesthesia providers a way to complete faster NMB reversal (Moon et al., 2020). Sugammadex is 6.6 times faster at reversing moderate NMB and 16.8 times faster at reversing deep NMB than Neostigmine (Hristovska et al., 2017).

While reversal agents are vital for reversing paralysis from NMBAs, use comes with the risk of incomplete reversal, known as residual NMB. This residual NMB occurs when some paralytic effects from the NMBA are present after administering a reversal agent. The residual NMB results in patient weakness and decreased respiratory effort. Even mild residual NMB negatively affects the patient's ability to breathe, swallow, and maintain their airway (Ledowski et al., 2021). Over 60% of surgical patients exhibit objective evidence of residual NMB after tracheal extubation due to provider variations of care and variable patient pharmacological responses (Kheterpal et al., 2020).

Residual NMB is a common occurrence in the postoperative setting and leads to various postoperative pulmonary complications (PPCs). Residual NMB impairs the patient's ability to properly maintain their airway, which leads to PPCs, including respiratory failure, atelectasis, and pneumonia (Moon et al., 2020). Around 5% of non-cardiac surgeries result in a major PPC; these complications increase mortality rates and cost hospital systems around $100,000 per occurrence (Kheterpal et al., 2020).

Patients undergoing thoracic surgery are a population at risk for developing PPCs due to residual NMB from the deep levels of paralysis achieved throughout the surgery. A recent meta-analysis of 14 randomized controlled trials, including 1478 adult patients, concluded that Sugammadex NMB reversal was associated with fewer PPCs than Neostigmine (Wang et al., 2021). Another study, specifically focusing on thoracic surgery patients, concluded that residual NMB was more significant in patients who received Neostigmine than Sugammadex (Murphy et al., 2020). This scholarly project aims to develop an optimal reversal strategy to decrease residual NMB and PPCs in patients undergoing thoracic surgery.

Background

Many surgical procedures with general anesthesia require paralytics to elicit muscle paralysis, including thoracic surgery cases. Patients undergoing thoracic surgery are at high risk for complications associated with residual NMB. Thoracic surgery patients are at higher risk for incomplete NMB recovery than other surgery types due to the deep levels of paralysis required to keep the diaphragm motionless for surgical manipulation (Murphy et al., 2020). Patients undergoing thoracic surgery often have decreased respiratory reserve and pulmonary comorbidities, resulting in amplified sensitivity to residual NMB and increased occurrence of PPCs (Moon et al., 2020). Furthermore, postoperative pain around the thoracic cavity will impact the respiration quality of these patients and exacerbate any adverse side effects resulting from residual paralysis. The increased risk of residual NMB in the thoracic surgery population necessitates the complete and rapid reversal of paralytic agents.

Neostigmine

Anesthesia providers traditionally have used Neostigmine as the reversal of NMB. Neostigmine reverses NMB, but evidence suggests it is less than optimal in efficacy, especially in reducing deep levels of neuromuscular blockade (Wang et al., 2021). Neostigmine has a ceiling effect, meaning the maximum dose is 50 micrograms/kilogram (μg/kg); greater doses may induce a cholinergic crisis, potentiating the NMB and weakening the patient (Bohringer & Liu, 2019). This ceiling effect limits the depth of NMB that patients can be effectively reversed from with Neostigmine. Also, Neostigmine requires co-administration of an anticholinergic, such as glycopyrrolate, to minimize the muscarinic side effects of Neostigmine, which include bradycardia, bronchoconstriction, and hypersalivation (Yu et al., 2023). Furthermore, Neostigmine use has resulted in incomplete or slow NMB reversal, nausea and vomiting, and physiological changes in lung and heart function (Hristovska et al., 2017). Residual NMB associated with Neostigmine use may significantly contribute to the development of PPCs in thoracic surgery patients. Li et al. (2021) state that residual NMB causes various physiologic effects, such as impaired pharyngeal function, impaired hypoxic ventilatory drive, and decreased functional residual capacity. These physiologic effects lead to various PPCs, including aspiration, pneumonia, and reintubation (Moon et al., 2020).

Sugammadex

Sugammadex, launched in 2008 and approved by the FDA in 2015, is an alternative reversal agent to Neostigmine (Ledowski et al., 2021; Li et al., 2021). Sugammadex, unlike

Neostigmine, can reverse paralysis regardless of the depth of NMB within ≤ 2.2 minutes (Yu et al., 2021; Krause et al., 2019). Bohringer & Liu (2019) state that because Sugammadex does not have a ceiling effect like Neostigmine, it can reverse even very deep levels of NMB. Sugammadex reversal is more rapid, reliable, and associated with lower rates of residual NMB than Neostigmine (Li et al., 2021). Additionally, because of its mechanism of action, muscarinic side effects like bradycardia and hypersalivation are rare with Sugammadex administration compared to Neostigmine (Krause et al., 2019).

Significance of the Problem Related to Anesthesia

Anesthesia providers should make it a priority to prevent patient complications stemming from the care provided. Part of safe and effective anesthesia practice is the administration of NMBAs to elicit muscle paralysis for the surgeon to conduct the operation. Although the effects of these paralytics are reversed with agents such as Neostigmine, the risk of residual NMB exists (Wang et al., 2021). This residual paralysis may result in the anesthesia provider's patient exhibiting decreased functional residual capacity, impaired upper airway patency, and respiratory insufficiency (Liu et al., 2023). These impairments place patients at risk for various PPCs, including pneumonia, atelectasis, and hypoxemia, directly impacting patient mortality and morbidity (Togioka et al., 2020; Yılmaz & Özçelik, 2022).

The use of Sugammadex has been limited at many institutions due to the higher costs compared to Neostigmine (Murphy et al., 2020). While Sugammadex costs $102 (200 mg/2ml vial), Neostigmine with Glycopyrrolate costs $13.5 (5mg/5 ml syringe of Neostigmine with 0.2 mg/ml vial of glycopyrrolate) (Wachtendorf et al., 2023). However, drug costs are only one part of overall hospital costs. A comprehensive understanding of complications associated with each reversal agent must be analyzed to better understand financial outcomes.

When a patient has a PPC, it has substantial financial implications. Of the 300 million surgeries performed worldwide yearly, 5% result in a significant PPC costing $100,000 per occurrence (Kheterpal et al., 2020). Litigation costs from a single PPC occurrence can cost hospital systems amounts far greater than the initial price differences between Sugammadex and Neostigmine. Besides the high costs of each PPC, prolonged NMB reversal leads to extended operating room (OR) time. Any increase in OR time costs approximately $37 per minute (Childers & Maggard-Gibbons, 2018). Prolonged reversals increase surgery costs and may limit the number of daily surgeries with repeated prolonged reversals. While finances are important, the primary goal of healthcare should be patient care. Therefore, optimal reversal strategies must be analyzed and implemented, particularly in vulnerable patient populations such as individuals undergoing thoracic surgery.

Patient outcomes should be the priority when deciding whether to use Sugammadex versus Neostigmine to reverse NMB. When considering costs, it is imperative to consider clinical outcomes in the calculation. As mentioned, a PPC occurrence can result in enormous costs far exceeding the initial price differences between Sugammadex and Neostigmine. With a comprehensive understanding of all related clinical outcomes and costs associated with either Sugammadex or Neostigmine use, anesthesia providers can deliver the safest patient care, and hospital systems can make decisions that will positively influence profits and patient outcomes.

Problem Statement

A population at high risk for residual NMB is patients undergoing thoracic surgery. Thoracic surgical patients are at a higher risk than other surgical cases due to various preoperative variables and deeper levels of neuromuscular blockade required to ensure diaphragm immobilization during the operation (Murphy et al., 2020). Furthermore, research states that PPCs are prevalent in thoracic surgery patients (Yang et al., 2022). Therefore, optimal reversal must be analyzed and incorporated into clinical practice to decrease residual NMB and PPCs in patients undergoing thoracic surgery.

While all surgical patients undergoing procedures requiring muscle paralysis would benefit from Sugammadex use over Neostigmine, this analysis will focus on thoracic surgery patients. Optimal NMB reversal is critical in thoracic surgery patients, as residual NMB is associated with PPCs (Yang et al., 2022). Although mounting evidence points to the benefits of Sugammadex use over Neostigmine, the influence of Sugammadex on postoperative outcomes, especially PPCs, has been controversial (Yu et al., 2021). Until recently, clinical studies comparing Neostigmine versus Sugammadex use affecting PPCs have provided inconsistent results. Some studies showed a reduced risk of PPCs with Sugammadex, while others did not show statistically significant differences (Wang et al., 2021). In conclusion, optimal NMB reversal is critical in patients undergoing thoracic surgery to reduce PPCs in this vulnerable patient population. This project will identify the most up-to-date, evidence-based practice (EBP) research outlining optimal NMB reversal in adult patients undergoing thoracic surgery.

PICOT

The components of a PICO question are patient population (P), the clinical intervention of interest (I), comparison intervention (C), and outcome or consequences (O) (Moran et al., 2019). The author developed a project PICOT question based on these components. In adult surgical patients undergoing thoracic surgery (P), does the use of Sugammadex for reversal of non-depolarizing neuromuscular blockers (I), compared to Neostigmine (C), affect postoperative pulmonary complications including respiratory failure, pneumonia, and atelectasis (O).

Project Objectives

The Doctor of Nursing Practice scholar will use the perspective of an anesthesia department Chief CNRA to develop EBP recommendations to improve NMB reversal involving two reversal agents, Sugammadex and Neostigmine, in patients undergoing thoracic surgery. This final scholarly project will include a plan for implementation and evaluation as a blueprint for quality improvement. The objectives for this scholarly project are the following:

1. Synthesize evidence from the most recent EBP literature on reversing non-depolarizing NMBAs with either Sugammadex or Neostigmine.
2. Develop EBP recommendations for reversing non-depolarizing NMBAs with Sugammadex versus Neostigmine in patients undergoing thoracic surgery.
3. Develop a comprehensive plan to implement, monitor, and modify the EBP recommendation of utilizing Sugammadex instead of Neostigmine to reverse NMB in patients undergoing thoracic surgery.

Literature Review

The lack of recommendations for using Sugammadex versus Neostigmine in patients undergoing thoracic surgery led the author to conduct a systematic literature search. The author thoroughly investigated the literature in May 2023. This analysis discusses how the author conducted the literature search, selected relevant articles, and correlated themes throughout the selected sources.

Literature Search

Databases in the search were PubMed, Cumulative Index to Nursing and Allied Health Literature Plus with Full Text (CINAHL), and the Otterbein University library database, which contains multiple databases, including MEDLINE and Health Course. The author developed search terms based on the PICO question. The search included the Boolean search phrase "(*thoracic* OR *lung* OR *intrathoracic)* AND (*Sugammadex* OR *Bridion)* AND (*Neostigmine)* AND (*postoperative pulmonary complications* OR *residual neuromuscular blockade)"* on each database. The author filtered results on the databases to exclude articles over five years old, articles without full text, or articles with irrelevant topics. PubMed initially yielded 19 results, and 11 after filters were applied. CINAHL yielded an initial 24 results and 14 after the application of filters. The discovered articles presented evidence of the problem, provided research on the effects of using Sugammadex versus Neostigmine, and offered insight for creating EBP recommendations.

Literature Results

The literature search discussed above resulted in the selection of eight studies comprised of various designs and corresponding levels of evidence. Of the included studies, three were systematic reviews and meta-analyses, the highest level of evidence. Wang et al. (2021) conducted a meta-analysis of randomized controlled trials (RCTs) to compare the effects of Sugammadex administration versus Neostigmine on PPCs after reversal of NMB. The researchers state that this was the first systematic review and meta-analysis of RCTs on the topic. The analysis included 14 RTCs of 1478 patients undergoing various surgeries, including thoracoscopic lung cancer resection. The primary outcome was overall PPCs, while the secondary outcomes were specific categories of PPCs, including atelectasis, postoperative respiratory failure, respiratory infection, pneumothorax, and pleural effusions. Another systematic review and meta-analysis by Yang et al. (2022) was not limited to RCTs. Instead, the included seven studies consisted of one prospective cohort study, three retrospective cohorts, and three RCTs. As with the previous study, the primary outcome investigated PPCs relating to

Sugammadex versus Neostigmine use, although PPCs were defined as prolonged air leak, atelectasis, postoperative chest radiographic abnormalities, and residual neuromuscular blockade during tracheal extubation and post-anesthesia care unit (PACU) admission (Yang et al. 2022). Unlike Wang et al. (2021), which consisted of various surgery types, this meta-analysis focused on one type of surgery, lung surgery. The third systematic review and meta-analysis was the most recent article in this literature analysis, Liu et al. (2023) included 21 studies consisting of 11 observational studies and 10 RCTs. The study included various types of surgery, including four studies specifically involving thoracic surgery patients. Like the first two studies, the primary outcome was PPCs relating to Sugammadex versus Neostigmine use, although PPCs were defined as desaturation episodes, pneumonia, atelectasis, and reintubation rates. Similar to Wang et al. (2021), a significant strength of this article is that it was the first systematic review and meta-analysis collecting all available clinical trial data on the topic.

Besides systematic reviews and meta-analysis, the literature search led to the discovery of three randomized, double-blinded studies. Yu et. (2022) conducted a randomized, double-blind prospective study to investigate the incidence of PPCs in patients undergoing lung cancer resection when using Sugammadex versus Neostigmine to reverse NMB. The study was conducted on 100 patients in a major university hospital analyzed from January to April 2021. The primary outcomes were occurrences of PPCs and speed of NMB reversal. Secondary outcomes included specific PPCs associated with residual neuromuscular blockade (pneumonia, pleural effusion, atelectasis) and other pulmonary complications (pneumothorax). Moon et al. (2020) conducted another randomized, double-blind clinical trial on 92 patients at Parkland Hospital in Dallas, Texas. The researchers aimed to determine if using Sugammadex versus Neostigmine to reverse NMB results in lower rates of postoperative hypoxic episodes and quicker reversal times in patients undergoing thoracic surgery. Lee et al. (2021) conducted the third randomized, double-blind prospective study to assess Sugammadex versus Neostigmine use on the incidence of PPCs in patients undergoing video-assisted thoracoscopic lobectomy surgery. The primary outcome of PPCs included pneumonia, prolonged air leak, desaturation, atelectasis, and reintubation rates. No statistically significant difference was found in postoperative pulmonary complications in the Sugammadex and Neostigmine groups. These results may be due to the small sample size. The authors state that more large-scale studies should be conducted on the topic.

The final two studies in this analysis include one nonrandomized controlled trial and one observational matched cohort study, with three and four levels of evidence, respectively. Murphy et al. (2020) conducted the nonrandomized controlled trial of 200 patients at NorthShore University Health System in Illinois to determine the incidence of postoperative residual NMB after thoracoscopic surgery in which patients were paralyzed and reversed with Neostigmine versus Sugammadex. Secondary outcomes included adverse respiratory events, including postoperative hypoxemia episodes and occurrences of airway obstruction. Kheterpal et al. (2020) conducted the observational matched cohort study on 45,712 patients from twelve U.S. multicenter hospitals from January 2014 to August 2018. The researcher's goal was to analyze whether the choice of NMB reversal agent, Sugammadex versus Neostigmine, is associated with lower rates of PPCs. The researchers of this study defined PPCs as respiratory failure and pneumonia.

Reversal Speed and Residual Neuromuscular Blockade

Medications all have differences in the timing of onset, and reversal agents are no different. This timing is critical with reversal agents like Sugammadex and Neostigmine as they are reversing a patient from a state of paralysis. Also, incomplete reversal, known as residual NMB, can result in adverse patient outcomes. This data is essential as residual NMB is associated with incidences of PPCs (Yang et al., 2022).

The literature review includes two studies presenting data on the reversal speed associated with Sugammadex and Neostigmine use. The researchers assessed this data utilizing a peripheral nerve stimulator using the train-of-four (TOF) function. Sugammadex reversal was faster than Neostigmine in patients undergoing thoracic surgery (Yu et al., 2022; Moon et al., 2020). Yu et al. (2022) found that the average time to achieve TOF ≥ 0.9 was 164.5 ± 27.7 seconds with Sugammadex and 562.9 ± 59.7 seconds with Neostigmine. Moon et al. (2020) found time to achieve TOF ≥ 0.9 to be 10 minutes in the Sugammadex group and 40 minutes in the Neostigmine group.

The literature review includes two other studies presenting residual NMB findings. Patients undergoing thoracic surgery show lower rates of residual NMB at both tracheal extubation and PACU admission when reversed with Sugammadex versus Neostigmine (Murphy et al., 2020; Yang et al., 2022). Murphy et al. (2020) found that residual NMB (TOF < 0.9) was significantly lower in the Sugammadex group than in the Neostigmine group at both tracheal extubation (6% versus 80%, respectively) and PACU admission (1% versus 61%, respectively). As residual NMB is a source for various PPCs, reducing incidences of this residual paralysis will positively impact patient outcomes by decreasing associated PPCs.

Postoperative Pulmonary Complications

As no standardized definition of PPCs exists, each study described above integrated various complications in assessing overall PPC findings. While specific PPCs will be discussed in subsequent sections, the results of this literature review were largely unanimous when describing overall PPCs. In patients undergoing thoracic surgery, Sugammadex administration for reversal of NMB results in fewer PPCs compared with Neostigmine (Wang et al., 2021; Yang et al., 2022; Liu et al., 2023; Yu et al., 2022; Kheterpal et al., 2020). This finding stands regardless of the patient's body mass index (BMI) (Yang et al., 2022). In multivariable analysis, Kheterpal et al. (2020) concluded that patients administered Sugammadex had a 30% reduced risk of PPCs compared to the Neostigmine group. Yu et al. (2022) found that 42% of patients administered Neostigmine exhibited a PPC, while this number was only 20% in the Sugammadex group.

While Wang et al. (2021) found that Sugammadex administration for reversal of NMB was associated with less risk of developing PPCs than Neostigmine, the researchers note that the result is mainly driven by data on respiratory failure. While all 14 RCTs in the meta-analysis showed lower rates of postoperative respiratory failure, data on postoperative respiratory infection, atelectasis, and pneumothorax were only backed by one to three studies each (Wang et al., 2021). The other studies in this literature analysis do not report overall PPC data driven by one specific complication.

Respiratory Failure

The most common subcategory of PPCs throughout the studies is respiratory failure. Of the included studies, five sources concluded that NMB reversal with Sugammadex decreased rates of respiratory failure, compared with Neostigmine administration (Wang et al., 2021; Yang et al., 2022; Liu et al., 2023; Kheterpal et al., 2020; Moon et al., 2020). Wang et al. (2021) defined respiratory failure as Pa02 < 60 mmHg on room air, Pa02:Fi02 ratio < 300 mmHg, or arterial oxyhemoglobin < 90% requiring oxygen. All three meta-analysis studies showed decreased rates of respiratory failure with Sugammadex administration versus Neostigmine

(Wang et al., 2021; Yang et al., 2022, Liu et al., 2023). Kheterpal et al. (2020) defined respiratory failure as needing supplemental oxygen to maintain oxygen saturation > 90%. In multivariable analysis, the researchers concluded that patients have a 55% reduced risk of respiratory failure when administered Sugammadex versus Neostigmine (Kheterpal et al., 2020). Moon et al. (2020) defined respiratory failure as SpO2 < 94% on ≤ 2 L/min of oxygen, or < 98% on ≥ 2 L/min of oxygen, or postoperative SpO2 5% less than preoperative values lasting > 1 min. The researchers found that 54% of the Neostigmine group had at least one hypoxic episode versus 41% in the Sugammadex group.

The literature analysis includes two studies that concluded with slightly different results. Murphy et al. (2020) assessed hypoxic episodes as a secondary outcome. The researchers defined hypoxemic events as moderate, Sp02 95%-91%, and severe, ≤ 90%, both on room air. Although patients in the Neostigmine group had higher percentages of moderate hypoxemia than the Sugammadex group (47% versus 31%) and severe hypoxemia (13% versus 4%), the differences were not statistically significant in the researchers' calculations. In the analysis by Liu et al. (2023), desaturation events were comparable between the Sugammadex and Neostigmine groups at 43.2% versus 45%, respectively. The authors state that further research, preferably from RCTs, is needed to verify the findings.

Pneumonia

Another common subcategory of PPCs in the included studies is pneumonia. Incidences of pneumonia were reduced with Sugammadex administration after reversal of NMB, compared to Neostigmine. (Yang et al., 2022; Liu et al., 2023; Yu et al., 2022; Kheterpal et al., 2020). Liu et al. (2023) found that rates of pneumonia after NMB reversal with Sugammadex were 1.37%, compared to 2.45% with Neostigmine. However, the authors state that rates of aspiration pneumonia were comparable between the two groups (both 0.14%). Yu et al. (2022) found that 14% of the Sugammadex group developed pneumonia versus 30% in the Neostigmine group. Yu et al. (2022) believe that the significant differences between the occurrence rates of these two studies are due to population differences. Patients undergoing thoracic surgery are at higher risk of incomplete NMB recovery than other types of surgery due to various preoperative variables and deeper levels of neuromuscular blockade required to ensure the diaphragm does not move during the operation, leading to various PPCs (Yang et al., 2022). Liu et al. (2023) is a meta-analysis with only four of 21 studies involving thoracic surgery, while Yu et al. (2022) is a single-center study of all patients undergoing thoracic surgery. Lastly, in multivariable analysis, Kheterpal et al. (2020) found that patients administered Sugammadex had a 47% reduced risk of pneumonia compared to the Neostigmine group. This finding is significant as this is the most extensive study in this analysis.

Atelectasis

Atelectasis is another PPC subcategory in several studies. Residual NMB after the reversal of paralysis often produces laryngeal weakness and atelectasis, leading to reintubation in PACU recovery rooms (Bohringer & Liu, 2019). Several studies concluded that rates of atelectasis are decreased with Sugammadex versus Neostigmine administration (Liu et al., 2023; Yu et al., 2022; Yang et al., 2022). Liu et al. (2023) found that patients in the Sugammadex group had lower atelectasis rates than the Neostigmine group (24.6% versus 30.4%) by pooling results from four RCTs and three observational studies. Yu et al. (2022) found that only 8% of patients who received Sugammadex developed atelectasis versus 28% who received Neostigmine. Yang et al. (2022) conducted a subgroup meta-analysis from January 2000 to March 2022 for overall PPCs assessing the results with and without atelectasis data. The authors conclude that Sugammadex use for reversal of NMB in lung surgeries results in fewer PPCs assessed with or without atelectasis, compared to Neostigmine.

Literature Summary

While each study in this literature synthesis and analysis defined PPCs differently with specific subcategories, the overall finding of decreased PPCs with Sugammadex administration is evident. The identified correlations throughout the subcategories highlight the specific PPCs that may be avoided with Sugammadex administration. In this analysis, information describing reversal speed and incidences of residual NMB emphasizes the source of various PPCs. It is clear that in patients undergoing thoracic surgery, utilizing Sugammadex for reversal of NMB, compared to Neostigmine, improves patient outcomes by reducing incidences of PPCs.

Project Framework

An EBP framework helps bring direction to project development. Choosing an EBP model provides a standardized approach for researchers to follow appropriate procedures to investigate, appraise, and synthesize evidence when contemplating a change or improvement in systems, processes, and practice (Dang et al., 2022). In addition, a standardized approach is conducive to implementing the best clinical and administrative practices, identifying improvement of various cost components, aiding in outcomes improvement, and ensuring the success of the EBP initiative (Dang et al., 2022).

The Johns Hopkins Evidence-based Practice Model for Nursing and Healthcare Professionals (JHEBP) is the framework applied to this final DNP scholarly project. The author received permission to use the JHEBP model and tools (Appendix A). An EBP framework guides research and eventual translation into practice (Melnyk & Fineout-Overholt, 2019). The JHEBP model is a framework used in interprofessional collaborative practice and consists of three major components: inquiry, best practice, and learning (Dang et al., 2022). Additionally, within the model is the PET management guide to develop best practices and clinical improvements. The PET management guide consists of a three-phase approach which includes developing a practice question, synthesizing the best up-to-date evidence, and translating this evidence into best practice (Dang et al., 2022). The JHEBP components and phases continuously flow throughout the work within interprofessional teams (Appendix B). The three phases of PET management guide consist of 20 steps (Appendix C).

Practice

The first phase of the PET management guide involves the development of a practice question. This first phase includes appointing a leader and recruiting an interprofessional team. The DNP scholar will lead the plan implementation. The recruited team includes leadership from the academic faculty, anesthesia department, pharmacy, billing, information technology (IT), and quality improvement (QI). Quarterly meetings are conducted between the team leader and all stakeholders to review progress and objectives. Next, the researcher clarifies and describes the problem. Sugammadex and Neostigmine reverse NMB from paralytic agents such as vecuronium and rocuronium (Yu et al., 2023). Traditionally, Neostigmine has been used to reverse NMB, but the recovery speed is unpredictable, residual NMB may be present, and side effects such as bradycardia, hypersalivation, and bronchoconstriction may occur (Liu et al., 2023). Sugammadex, a reversal agent approved by the FDA within the last decade, is an alternative to Neostigmine which provides faster reversal, reduces the incidence of residual NMB, and produces less bradycardia and bronchoconstriction (Li et al., 2021). Hospital guidelines lack clear direction to guide anesthesia providers in choosing specific reversal agents for certain populations. Furthermore, hospital policies often restrict providers from using Sugammadex due to its high cost (Kheterpal et al., 2020). The first phase of PET management also entails the DNP scholar developing the EBP question and refining this question throughout the project. The final PICO question: in adult surgical patients undergoing thoracic surgery (P), does the use of Sugammadex for reversal of non-depolarizing neuromuscular blockers (I), compared to Neostigmine (C), affect postoperative pulmonary complications and residual neuromuscular blockade (O)? Sixth, the DNP scholar outlines the need for the EBP project. Patient outcomes will be improved in patients undergoing thoracic surgery when reversed with Sugammadex. Additionally, the cost savings from fewer PPCs might outweigh the initial high cost of Sugammadex. The final step in phase one is identifying the stakeholders. The DNP scholar identified hospital administrators, anesthesia providers, nursing staff, pharmacy, billing, and quality improvement as relevant stakeholders for the project.

Evidence

The second phase of the PET management guide involves synthesizing the best up-to-date evidence. This second phase starts with conducting an internal and external search for evidence. The researcher collects internal evidence by reviewing clinical practice guidelines and QI data on PPCs in patients undergoing thoracic surgery. The researcher collects external evidence through a comprehensive literature search which is synthesized (Appendix D). The articles include a meta-analysis, a meta-analysis of RCTs, an observational matched cohort study, a nonrandomized controlled trial, and several randomized, double-blind studies. The articles were then appraised for the quality and level of the evidence and findings summarized. The included studies are all level I-III except for one level IV study. From the critical appraisal of evidence, EBP recommendations were developed for practice change.

Translation

Phase three of the PET management guide focuses on translating gathered EBP into clinical practice. First, the DNP scholar presents recommendations to project stakeholders regarding using Sugammadex versus Neostigmine in patients undergoing thoracic surgery. Second, the DNP scholar will create a detailed action plan to guide this EBP recommendation. Once implemented, outcomes assessment is necessary to evaluate progress, report results to key stakeholders, and identify the next steps relating to the maintenance of the project. Once the team completes these steps, disseminating the findings will educate others in anesthesia practice.

Design & Method Plan

Recommendation

The project's design and method plan encompass the third phase of the PET management guide within the JHEBP model: translating evidence into best practice. The project's recommendation is based on literature showing that in patients undergoing thoracic surgery, utilizing Sugammadex for reversal of NMB, compared to Neostigmine, improves patient outcomes by reducing PPCs (Wang et al., 2021; Yang et al., 2022; Liu et al., 2023; Yu et al., 2022; Kheterpal et al., 2020). Many diagnoses could qualify as a PPC, but for the purposes of this project, respiratory failure, pneumonia, and atelectasis will be the focus.

Setting

The setting of this project's initiative is designed for an urban level-one trauma center in the Midwest United States.

Population

The population includes all adult patients undergoing thoracic surgery, except for two exceptions. First, Sugammadex will be avoided in patients with a known allergy to the medications. Second, Sugammadex will be avoided in patients with reduced renal function, specifically patients with a creatinine clearance of less than 30 ml/min. The FDA does not recommend using Sugammadex in patients with a creatinine clearance of less than 30 ml/min due to the risk of prolonged residual neuromuscular blockade and potential anaphylactic reactions (Oh & Lim, 2023).

Action Plan

Phase three of the PET management guide entails creating an action plan and securing support and resources to implement the said plan. This action plan consists of anesthesia providers administering Sugammadex to all adult patients undergoing thoracic surgery at the urban level-one trauma hospital. Although this will be standard practice for the initiative, there are exceptions that include allergy and renal function contraindications described in the population section.

In conclusion, this project's design and method plan encompasses the third phase of the PET management guide, translating evidence into best practice. First, recommendations are tailored around a specific practice setting. An action plan is created, and resources are secured. The action plan is implemented, and outcomes are evaluated. These outcomes are reported to stakeholders, and "next steps" are identified regarding QI adjustments to the initiative. The final step is disseminating project outcomes to educate other anesthesia providers.

Implementation Plan

The scholarly author designed a plan to implement an EBP project surrounding recommendations for Neostigmine versus Sugammadex use in patients undergoing thoracic surgery. The implementation plan requires the creation of an organizational infrastructure comprised of individuals from various departments within the Midwest level-one trauma center.

The team leader will inform the recruited team of the project initiative, procedures, and goals. The recruited team will include individuals from the following departments: surgery, anesthesia, IT, QI, and pharmacy. The interprofessional team members will work cohesively to implement the project EBP recommendations thoroughly and efficiently.

First, the project team leader must apply and gain approval to conduct the project initiative through the Institutional Review Board (IRB). Next, the project team leader must collaborate with the Chief CRNA and anesthesiologists to gain approval for the project initiative and discuss potential start dates. Once approval is granted, the team leader must meet with the manager of the pharmacy department. The purpose of this meeting is to inform the pharmacy staff of the project initiative to anticipate the increased use of Sugammadex by anesthesia staff. The project team leader will discuss the initiative's start date with the pharmacy manager to give the department sufficient time to order more Sugammadex stock.

After project approval is granted, the project team leader must connect with the QI department manager to acquire retrospective quantitative data on PPCs in patients who underwent thoracic surgery in the past year. PPCs will include postoperative respiratory failure, atelectasis, and pneumonia. The specific data points that must be collected for each thoracic surgery case throughout the last year are the following: which reversal agent was used, oxygen desaturation occurrences from the time of extubation to PACU discharge (Sp02 $\leq$ 90%), occurrences of reintubations in the OR or PACU, occurrences of atelectasis within 72 hours of extubation (diagnosed with chest radiographic images), and diagnoses of pneumonia within 72 hours post-operation. The project team leader and the QI department will analyze and organize the data. This retrospective quantitative data will be a baseline for comparing project initiative progress and outcomes.

Next, the project team leader and Chief CRNA will compose and send an email to all anesthesia providers informing them of the project initiative. This email will include a an informational poster about the initiative. Although this poster will contain detailed EBP information behind the reasons for the project rollout, the message to anesthesia providers should be clear about using Sugammadex for NMB reversal in thoracic cases unless contraindicated. Besides the informational email, daily shift huddles and weekly staff meetings should remind anesthesia staff of the project initiative. Regarding turnover, as new staff join the anesthesia team, the Chief CRNA will send the previously composed informational email to the new team member and verbally educate them on the EBP protocol.

Next, the project team lead will meet with an IT department representative to create a "pop-up" alert within the electronic medical record system. The IT department will program this alert to be triggered during thoracic surgeries to remind the anesthesia provider to use Sugammadex for NMB reversal unless contraindicated due to a known Sugammadex allergy or a patient creatinine clearance of less than 30 ml/min. If at least one of these contraindications is present, the anesthesia provider will use Neostigmine for NMB reversal.

Throughout the project implementation, the project team leader will focus on maintaining compliance with the project initiative, answering any specific staff questions regarding the initiative, and assessing progress. Compliance will be assessed by randomized chart audits and interpersonal communication during weekly staff meetings. Additionally, quarterly outcomes will be assessed. The QI department will be asked to gather this quarterly retrospective data for the project team leader to gauge the initiative's success by comparing these figures to baseline data. Upon completion of the initiative, a final retrospective chart audit will be completed by the QI department. These figures will be organized and compared with the baseline numbers to assess the initiative's impact on PPCs. These findings will be shared with all stakeholders of the project. If the project initiative fails to display a reduction in PPCs after implementation, the recommendations will be discontinued, and the anesthesia provider's preference of NMB reversal agent will be encouraged. If the project initiative shows a reduction in PPCs, the hospital may adopt the recommendations as the standard of care at the medical center.

Timeline

The projected timeline for the implementation of the developed recommendations is 15 months. The first three months of the project will be the preparation phase. During this time, the project team leader will gain approval from the Chief CRNA and anesthesiologists. The team leader will also schedule in-person meetings with the pharmacy, QI, and IT departments. The three-month preparation time frame will give the pharmacy department sufficient time to order more Sugammadex stock, if necessary. This time frame should also be appropriate for the QI department to gather, organize, and present all the requested retrospective quantitative baseline data. This data will be presented to stakeholders. Additionally, three months should be adequate time for the IT department to create the "pop-up" alert in the electronic medical record system *Epic*. Once the interprofessional meetings are completed, the Chief CRNA and project team leader will compose the informational email and send it to the anesthesia staff with a tentative start date. Until the "go-live" date, the project team leader will answer any questions the anesthesia staff may have during weekly staff meetings.

After the three-month preparation phase, the "go-live" phase will last 12 months. After the initial rollout, the project team leader will conduct monthly randomized chart audits to monitor compliance. Additionally, quarterly progress assessments will be conducted by comparing progress data to baseline figures. At the one-year mark after the "go-live" date, the final retrospective chart audit will be completed by the QI department. The project team leader will compare these figures to the baseline data to measure the initiative's success. At this time, the project initiative is complete. The project team leader will disseminate outcome findings to project stakeholders. If the project initiative shows reductions in PPCs, the stakeholders can adopt the recommendations as the standard of care at the medical center.

Budget

The budget of this project is based on expenses for the preparation and implementation of the recommendations. The meetings between the project team leader and interprofessional team members will occur during regular working hours, not adding to the overall project expenses. The weekly staff meetings will also occur during regular working hours. Any additional project time spent by the project team leader will be endured by that individual, not adding to overall expenses. Therefore, the main expense for this project is additional Sugammadex stock.

Sugammadex is an expensive medication, but it is the only expense. The cost of a single-dose 200mg/2 mL vial and 500mg/5 mL vial of Sugammadex is $99.74 and $182.70, respectively (Jiang et al., 2021). The required quantity of Sugammadex is estimated. All adult patients undergoing thoracic surgery will be included in the sample for the project initiative. Through analysis of daily OR schedules at a Midwest level-one trauma center, the author of this project has estimated that an average of twenty thoracic surgery cases are completed weekly, amounting to 80 per month. Additionally, two trauma cases involving thoracic surgery are expected every weekend. These additional trauma cases amount to an additional eight monthly cases, bringing the overall monthly count to 88 thoracic cases. Thus, the conclusion is that a safe number of Sugammadex stock available monthly is 100 vials. The 100 vials will be divided into 70 vials of 200mg and 30 vials of 500mg. This amount brings the first month's cost of

Sugammadex to $12,463. The hospital already has existing Sugammadex stock. Therefore, the initial meeting between the project team leader and the pharmacy department should discuss these figures. After the start of the “go-live” date, the pharmacy department can place monthly orders based on the surplus or deficit of the medication.

Outcomes & Analysis Plan

Outcome Measurement

The primary outcome that will be monitored is the occurrence of PPCs. The outcome of PPCs is divided into four subgroups: postoperative hypoxic episodes, respiratory failure requiring re-intubation, pneumonia, and atelectasis. Occurrences of hypoxic episodes will be monitored quantitatively by any Sp02 readings ≤ 90% on room air or supplemental oxygen, extubation to PACU discharge. Respiratory failure requiring re-intubation will be defined as any incidences of tracheal re-intubation after initial extubation to PACU discharge. Occurrences of atelectasis or pneumonia will be counted if diagnosed by x-ray within 72 hours of extubation.

The data points of the outcomes described above will be analyzed and presented quarterly by the QI department throughout the 12-month implementation phase. The exact number of patients in the sample will be determined by the number of adult thoracic surgeries during the 12-month time frame, although the author estimates about 88 monthly cases. The project team leader will also conduct monthly randomized chart audits to monitor adherence to the initiative. A final data collection will be conducted at the end of the 12-month implementation phase. This final data will be compared to the baseline retrospective quantitative data to assess overall findings.

Data Interpretation

If the recommendations are successful, a finding of reduced PPCs will be noted. While all four subgroups of PPCs will be analyzed and tracked individually, the information gathered will be united to present overall PPC findings. If there is at least a 5% reduction in hypoxic episodes, re-intubation rates, or occurrences of pneumonia or atelectasis after the initiative, the findings will support a successful EBP model. In the final outcomes report, the verdict on overall PPC findings will be presented first, with information on each subgroup of PPCs presented subsequently.

Barriers

Potential research barriers exist regarding the implementation of this initiative. One potential barrier is a supply shortage of Sugammadex stock. The pharmacy may inform the project team leader that there is a national drug shortage or that supply lines are backed up due to external forces outside the organization. In this case, the project should be placed on hold until sufficient Sugammadex stock is available to ensure full compliance with the initiative throughout the duration of data collection. Another barrier may be time-consuming bureaucracy. Although time frames have been allotted for the preparation phase of the initiative, extensions may occur if the involved departments meet resistance to the allocated preparation time frames from management.

Limitations

A primary limitation may be the anesthesia staff's lack of compliance with the recommendation. The final outcomes data should be analyzed along with compliance data. A lack of compliance with the initiative could skew the outcomes data to appear as if the recommendations have failed. Therefore, the outcome data must be analyzed for compliance before comparison with the initial baseline retrospective data. Another limitation may be a small sample size throughout implementation due to a factor such as an extended leave of absence by the thoracic surgeon. A small sample size may not adequately reflect the hospital's standard thoracic surgery population and produce skewed findings.

Future Direction

Implementation of this project initiative will provide evidence of the effectiveness of utilizing Sugammadex versus Neostigmine in patients undergoing thoracic surgery on occurrences of PPCs. Once implemented, project outcomes and any potential QI adjustments made throughout the project implementation will be disseminated to key stakeholders. After this, the initiative has the potential to become the standard of care at the participating hospital. In the future, this project's recommendations, comprehensive implementation plan, and outcome analysis plan may be used at any facility that performs thoracic surgeries.

Dissemination

The last part of phase three of the JHEBP PET management guide includes disseminating findings. The author developed a poster with a comprehensive overview of the EBP project, including a literature synthesis, action plan, and data monitoring. The dissemination will include a meeting with the project team leader, key stakeholders, anesthesia staff, and scholarly peers. The project team leader will present background information along with an overview of why the topic is important, an overview of the literature review with an outline of the most recent EBP recommendation, and a plan for implementation and monitoring of the initiative. In addition to this meeting, the poster will be displayed in a high-traffic area in the hospital to provide education about the initiative.

Conclusion

The extensive literature search in this DNP scholarly project confirmed that patients undergoing thoracic surgery are at higher risk for residual NMB and subsequent PPC complications such as respiratory failure, atelectasis, and pneumonia. A literature synthesis concluded that NMB reversal with Sugammadex, instead of Neostigmine, reduces the incidence of PPCs in patients undergoing thoracic surgery. Although Sugammadex is more expensive than Neostigmine, the high cost of a single PPC can be avoided by using Sugammadex in this patient population. In the future, utilizing Sugammadex for NMB reversal in thoracic surgery cases has the potential to become the standard of care. Doing so will decrease residual NMB and subsequent PPCs such as respiratory failure, pneumonia, and atelectasis.

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Appendix A

JOHNS HOPKINS EBP MODEL AND TOOLS-PERMISSION

Johns Hopkins Nursing
Center for Evidence-Based Practice

Thank you for your submission.
We are happy to give you permission to use the Johns Hopkins Evidence-Based Practice model and tools to adhere to our legal terms noted below.
No further permission for use is necessary.

You may not modify the model or the tools without written approval from Johns Hopkins.
All references to source forms should include "© 2022 Johns Hopkins Health System/Johns Hopkins School of Nursing."
The tools may not be used for commercial purposes without special permission.
If interested in commercial use or discussing changes to the tool, please email ijhn@jhmi.edu.

Available Downloads:

2022 JHEBP Tools- English version

2022 JHEBP Tools- Spanish version

2022 JHEBP Tools- Chinese version

2022 JHEBP Tools- Portuguese version

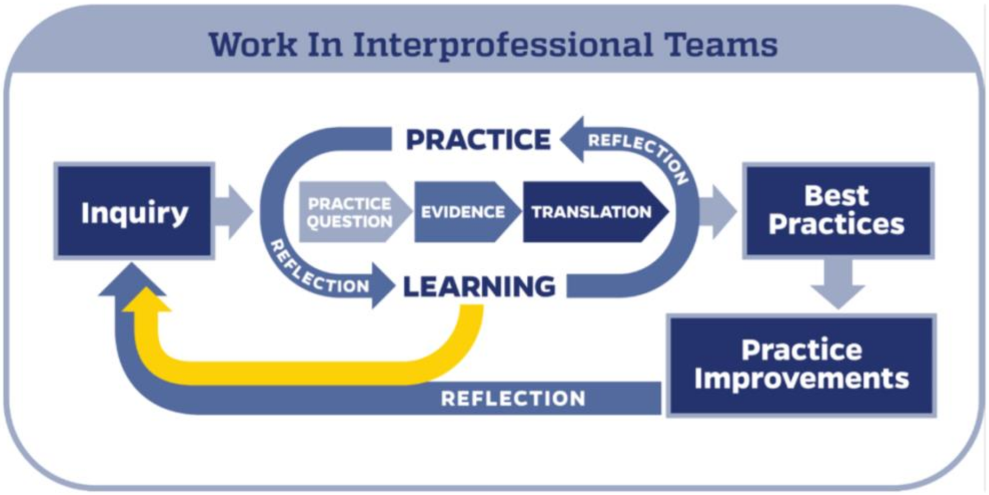
Would you like to join us? *Group rates are available, email ijhn@jhmi.edu to inquire.*

EBP Boot Camp: We are offering a 5-day intensive Boot Camp where you will learn and master the entire EBP process from beginning to end. Take advantage of our retreat-type setting to focus on your project, collaborate with peers, and get expertise and assistance from our faculty. ***COMING in 2024!***

EBP Skill Build: This 3-day virtual workshop gives you a front-row seat to our EBP training and provides every participant with the guidance and support they need to get their EBP projects started.

Appendix B

Johns Hopkins Evidence-Based Practice Model



Note. © 2022 Johns Hopkins Health System/Johns Hopkins School of Nursing

Appendix C

EBP Work Plan

Initial EBP question:

EBP team leader(s):

EBP team members:

Goal completion date:

	Steps	Month								
		1	2	3	4	5	6	7	8	9
Practice Question & Project Planning	1. Recruit interprofessional team									
	2. Determine responsibility for project leadership									
	3. Schedule team meetings									
	4. Clarify & describe the problem (App. B)									
	5. Develop & refine the EBP question (App. B)									
	6. Determine the need for an EBP project									
	7. Identify stakeholders (App. C)									
Evidence	8. Conduct internal & external search for evidence									
	9. Appraise the level & quality of each piece of evidence (Apps. E/F)									
	10. Summarize the individual evidence (App. G)									
	11. Synthesize findings (App. H)									
	12. Develop best evidence recommendations (App. H)									
Translation	13. Identify practice setting–specific recommendations (App. I)									
	14. Create action plan (App. I)									
	15. Secure support & resources to implement action plan									
	16. Implement action plan									
	17. If change is implemented, evaluate outcomes to determine if improvements have been made									
	18. Report results to stakeholders (App. C)									
	19. Identify next steps									
	20. Disseminate findings (App. J)									

Appendix D

Evidence Review Worksheet								
APA Citation: Wang, J.-F., Zhao, Z.-Z., Jiang, Z.-Y., Liu, H.-X., & Deng, X.-M. (2021). Influence of sugammadex versus neostigmine for neuromuscular block reversal on the incidence of postoperative pulmonary complications: A meta-analysis of randomized controlled trials. Perioperative Medicine, 10(1). https://doi.org/10.1186/s13741-021-00203-6								
Conceptual Framework or Model	***Design or Method***	***Sample & Setting***	***Major Variables Studied & their Definitions, if any***	***Outcome Measurement(s)***	***Data Analysis***	***Findings***	***Level of Evidence***	***Quality of Evidence: Critical Worth to Practice***
To determine the influence of Sugammadex vs. Neostigmine on postoperative pulmonary complications (PPC) by performing a meta-analysis of randomized controlled trials (RCT)	Meta-analysis of RTCs	14 RTCs consisting of 1478 patients undergoing various surgeries, including thoracoscopic lung cancer resection. Inclusion criteria were adults undergoing surgeries with general anesthesia and neuromuscular blockade, Sugammadex as intervention and Neostigmine as a control, outcomes consisting of PPCs (as defined in	**Independent variables:** **IV1=** Sugammadex administration (0.0625 – 4 mg/kg) **IV2=** Neostigmine administration (0.005 mg/kg – 0.085 mg/kg) **Dependent variables:** Primary outcome was the incidence of overall PPCs. Secondary outcomes were specific categories of PPCs, including atelectasis, postoperative respiratory failure, respiratory infection,	Two authors independently completed the literature search, data extraction, and quality evaluation. RCT quality was assessed by the Cochrane Collaboration Risk of Bias Tool.	The incidence of PPC was calculated with odds ratio and 95% confidence interval. Cochrane's Q test detected heterogeneity (significant heterogeneity $p < 0.10$). $I2 > 50$ also indicated significant heterogeneity. The random effects model was used to pool analysis. Sensitivity analysis by the omission of one study at a time analyzed stability of the meta-analysis.	Sugammadex showed lower risk of postoperative pulmonary complications (mainly due to lower rates of postoperative respiratory failure). Sugammadex was not shown to decrease rates of respiratory infection, atelectasis, or pneumothorax compared with neostigmine	I	**Strengths:** First systematic review and meta-analysis of RCTs to discover if using Sugammadex correlated with a lower risk of PPCs compared with Neostigmine **Limitations:** Clinical heterogeneity could exist relating to variations in patient characteristics, types of surgery, and Sugammadex and Neostigmine regiments. Conclusion data of Sugammadex being superior regarding overall PPCs is mainly driven by data of

		accordance with multiple previous studies generally including respiratory failure, respiratory infection, atelectasis, pneumothorax, pleural effusion, etc.) Exclusion criteria included studies with children, studies not analyzing PPCs, and not RCTs.	pneumothorax, pleural effusion, etc.)		The Egger's regression asymmetry test tested for publication bias by visual observation of the funnel plots. P < 0.05 indicated statistical significance. Statistical analysis were completed with The RevMan (version 5.1) and Stata software (version 12.0).			postoperative respiratory failure, the other types of PPCs was backed by only 1-3 studies each.

Annotated Bibliography

This meta-analysis of randomized controlled trials (RCTs) analyzed the rates of postoperative pulmonary complications (PPCs) in surgical patients who were administered Sugammadex versus Neostigmine for reversal of neuromuscular blockade (NMB). The meta-analysis consisted of 14 RCTs consisting of 1478 patients undergoing various surgeries, including thoracoscopic lung cancer resection. The primary outcome was PPCs while the secondary outcomes were specific categories of PPCs which included atelectasis, postoperative respiratory failure, respiratory infection, pneumothorax, and pleural effusions.

Thematic Analysis

1. Sugammadex administration for reversal of NMB is associated with less risk of developing PPCs than Neostigmine.
2. Patients reversed from NMB with Sugammadex have lower risk of developing postoperative respiratory failure compared with reversal with Neostigmine.
3. Sugammadex administration is not correlated with lower rates of postoperative infection, atelectasis, or pneumothorax compared with Neostigmine administration.

APA Citation: Yang, J.-L., Chen, K.-B., Shen, M.-L., Hsu, W.-T., Lai, Y.-W., & Hsu, C.-M. (2022). Sugammadex for reversing neuromuscular blockages after lung surgery: A systematic review and meta-analysis. Medicine, 101(39), e30876. https://doi.org/10.1097/md.0000000000030876								
Conceptual Framework or Model	***Design or Method***	***Sample & Setting***	***Major Variables Studied & their Definitions, if any***	***Outcome Measurement(s)***	***Data Analysis***	***Findings***	***Level of Evidence***	***Quality of Evidence: Critical Worth to Practice***
To determine if the use of Sugammadex is correlated with a lower risk of postoperative pulmonary complications (PPC) and other improved outcomes in patients undergoing lung surgeries.	Systematic review and meta-analysis	7 studies (3 randomized controlled trials, 3 retrospective cohorts, and 1 prospective cohort) totaling 905 patients undergoing lung surgery. 453 patients receiving sugammadex and 452 patients receiving a control (Neostigmine or another cholinesterase inhibitor). The included studies were all conducted between 2017 and 2021.	**Independent variables:** **IV1=** Patients receiving Sugammadex **IV2=** Patients receiving control (Patients received neostigmine in 4 studies, and Pyridostigmine in 3 studies) **Dependent variables:** PPCs including prolonged air leaks, pneumonia, atelectasis, postoperative hypoxic episodes, early postoperative chest radiographic abnormalities, and residual neuromuscular blockade during tracheal extubation and	Two authors independently assessed the methodological quality of all included studies using the modified Jadad scale. This modified scale evaluates randomization, blinding, withdrawals, dropouts, inclusion criteria, exclusion criteria, adverse events, and statistical analysis. Articles were scored 0-8, with higher scores meaning higher quality of the trial.	Meta-analysis and statistical analysis were performed using Review Manager 5 software (version 5.4). A pairwise meta-analysis by inverse variance random-effect model was carried out because differences in types of surgery and outcome definitions could cause inter-study heterogeneity. Calculations of standard mean differences and 95% confidence intervals were performed. The researchers assessed heterogeneity by I2 statistics	Results showed statistically significant fewer PPCs occurrences in the Sugammadex group. Subgroup analysis revealed that Sugammadex group had less PPCs analyzed with and without atelectasis. Also, the subgroup analysis revealed Sugammadex group had lower rates of PPCs with high and low BMIs. No statistically significant difference in LOS, PACU	I	**Strengths:** Study focused on lung surgery and analyzed PPCs. Subgroup analysis was completed for non-atelectasis and atelectasis. Also, another subgroup analysis analyzed whether BMI affected the treatment effect. Modified Jadad scores indicated moderate to high-quality study results, and sensitivity analysis excluded retrospective studies. **Limitations:** All included studies were heterogeneous in types of lung surgery, and different ranges of lung resections may affect

			PACU admission. Secondary outcomes were hospital length of stay, extubation time after surgery, length of PACU stay, and duration of chest tube insertion		(> 50% considered high) and related P value (< 0.05 statistically significant). Subgroup meta-analysis was carried out for PPCs with and without atelectasis, and body mass index (BMI). Sensitivity analysis was also conducted by excluding retrospective studies.	stay, chest tube duration No statistically significant difference in hospital length of stay, PACU stay, chest tube duration. Four studies that assessed extubation time after surgery showed Sugammadex group with shorter times.		outcomes. Surgical complications like massive intraoperative blood loss were not included in analysis, which could also affect outcomes. Also, risk factors for PPCs were not included, like smoking and chronic obstructive pulmonary disease. Lastly, the study did not investigate some side effects of the reversal agents like postoperative nausea, vomiting, and bradycardia.

Annotated Bibliography

This systematic review and meta-analysis investigated whether Sugammadex use for reversal of neuromuscular blockade (NMB) correlated with lower rates of postoperative pulmonary complications (PPCs) and improved outcomes in lung surgeries compare with Neostigmine. The meta-analysis included three randomized controlled trials, three retrospective cohorts, and one prospective cohort study. The primary outcome of PPCs included prolonged air leaks, pneumonia, atelectasis, postoperative hypoxic episodes, early postoperative chest radiographical abnormalities, and residual NMB during tracheal extubation and PACU admission. The secondary outcomes included hospital length of stay, extubation time after surgery, length of PACU stay, and duration of chest tube insertion.

Thematic Analysis

1. Sugammadex administration for reversal of NMB results in fewer incidences of PPCs than reversal with Neostigmine after lung surgeries.
2. Sugammadex use for reversal of NMB in lung surgeries results in less PPCs assessed with or without atelectasis, compared with Neostigmine.
3. Sugammadex reversal of NMB results in fewer PPCs than Neostigmine in both high and low body mass index (BMI) groups undergoing lung surgeries.

APA Citation: Liu, H.-M., Yu, H., Zuo, Y.-D., & Liang, P. (2023). Postoperative pulmonary complications after sugammadex reversal of neuromuscular blockade: A systematic review and meta-analysis with trial sequential analysis. BMC Anesthesiology, 23(1). https://doi.org/10.1186/s12871-023-02094-0								
Conceptual Framework or Model	***Design or Method***	***Sample & Setting***	***Major Variables Studied & their Definitions, if any***	***Outcome Measurement(s)***	***Data Analysis***	***Findings***	***Level of Evidence***	***Quality of Evidence: Critical Worth to Practice***
To determine if the use of Sugammadex for neuromuscular block reversal results in lower risk of postoperative pulmonary compilations (PPCs) compared with Neostigmine.	Systematic review and meta-analysis	21 studies, including 10 randomized controlled trials (RTCs) and 11 observational studies, were included. Inclusion criteria were 1) RTCs and observational studies 2) adults > 18 years 3) Intervention of Sugammadex administration 4) Control of Neostigmine administration 5) Outcomes to include at least one type of PPC. Four studies specifically involved thoracic surgery, and the others involved various types of surgery including major abdominal,	**Independent variables:** **IV1=** Patients receiving Sugammadex (doses ranging from 1.5 to 4 mg/kg) **IV2=** Patients receiving Neostigmine (doses ranging from 0.02-0.07 mg/kg) **Dependent variables:** PPCs including desaturation episodes, pneumonia, atelectasis, and reintubation rates.	The 1395 potentially eligible studies were screened by two independent investigators for compliance with selection criteria. RCT quality was assessed by the Cochrane Collaboration Risk of Bias Tool. Observational study quality were evaluated by the Newcastle-Ottawa Scale.	All statistical data analysis was completed with computer software including Review Manager Version 5.4. Risk ratio with 95% confidence intervals were completed for outcomes using the random effects model. I2 statistics assessed study heterogeneity. Subgroup analysis and sensitivity analysis according to study type (RCT and observational studies) was carried out to analyze	Patients administered Sugammadex had statistically significant lower risk of pneumonia, atelectasis, and reintubation than patients administered Neostigmine. Rates of desaturation were comparable between Sugammadex and Neostigmine groups.	I	**Strengths:** First systematic review and meta-analysis collecting all available clinical trial data to discover if using Sugammadex correlated with a lower risk of PPCs compared with Neostigmine **Limitations:** First, findings ranked very low to low across outcomes according to the GRADE system; this is attributed to the high risk of bias and inclusion of observational study design. Second, some studies poorly defined pulmonary outcomes with some including them as secondary

		laparoscopic cholecystectomy, and robotic surgery with the da Vinci robot. Three studies were multi-centered while the remaining 18 were single center studies. Exclusion criteria included pediatric population, not in English, other meta-analysis, and case reports.			sources of heterogeneity. Trial sequential analysis was performed on outcomes using TSA software. Statistical significance was considered with P value < 0.05.			outcomes. Third, the sample size of RTCs was limited and results may be largely influenced by the observational studies. Fourth, included studies comprised of various surgery types, drug dosages, and definitions of PPC. Fifth, neuromuscular monitoring by train-of four (TOF) through a nerve stimulator is recommended when using paralytics to decrease PPCs; 17 of the 21 studies utilized this method. The studies who did not may have had increased incidence of PPC, obfuscating the results.

Annotated Bibliography
This systematic review and meta-analysis aimed to investigate the effect of Sugammadex administration for reversal of neuromuscular blockade (NMB) on incidences of postoperative pulmonary complications (PPCs) compared with Neostigmine administration. The meta-analysis included 21 studies consisting of 10 randomized controlled trials and 11 observational studies. The primary outcome of PPCs included desaturation episodes, pneumonia, atelectasis, and reintubation rates.

Thematic Analysis **1.** Sugammadex administration for reversal of NMB is more effective at reducing incidences of PPCs than Neostigmine. **2.** Reversal of NMB with Sugammadex results in lower rates of pneumonia, atelectasis, postoperative non-invasive ventilation, and reintubation rates compared with Neostigmine.

APA Citation:
Yu, Y., Wang, H., Bao, Q., Zhang, T., Chen, B., & Ding, J. (2022). Sugammadex versus neostigmine for neuromuscular block reversal and postoperative pulmonary complications in patients undergoing resection of lung cancer. Journal of Cardiothoracic and Vascular Anesthesia, 36(9), 3626–3633. https://doi.org/10.1053/j.jvca.2022.03.033

Conceptual Framework or Model	***Design or Method***	***Sample & Setting***	***Major Variables Studied & their Definitions, if any***	***Outcome Measurement(s)***	***Data Analysis***	***Findings***	***Level of Evidence***	***Quality of Evidence: Critical Worth to Practice***
To determine the effect that Sugammadex and Neostigmine have on postoperative pulmonary complications (PPC) and neuromuscular block reversal in patients undergoing lung cancer resection.	Randomized, double-blind prospective study	The sample consisted of 100 patients undergoing elective radical resection of lung cancer at a single major urban teaching and university hospital from January 2021 to April 2021. Patients were randomly allocated to either the Sugammadex group (n=50) or the Neostigmine group (n=50). Inclusion criteria were individuals ≥ 18 years old, patients willing to undergo bronchial	**Independent variables:** **IV1=** Sugammadex 2mg/kg of actual body weight and rounded off to 10mg. **IV2=** Neostigmine 0.05 mg/kg of actual body weight (max 5 mg) with 0.02 mg/kg atropine **Dependent variables:** Occurrences of any PPC and time to achieve 90% of train-of-four (TOF). Secondary outcomes were	Neuromuscular blockade was quantitatively assessed using TOF with a nerve stimulator by an independent anesthesiologist who did not take part in the study. Pulmonary function tests, blood gases, noninvasive ventilation, reintubation, oxygen weaning, time for postoperative drainage to reach < 200ml, removal time of postoperative	Statistical analysis was completed by IBM SPSS 20.0 Statistical Analysis Software. The Shapiro-Wilk test analyzed normality of continuous variables. Means ± standard deviation and independent t tests were obtained from data. X2 test compared categorical variables. Odds ratio	Occurrences of PPC in Sugammadex group was lower than Neostigmine group (20% vs 42%). Sugammadex recovery to TOF ≥ 0.9 164.5 ± 27.7 seconds vs neostigmine 562.9 ± 59.7 seconds. Secondary outcomes showed 2 Sugammadex patients and 3 Neostigmine patients	II	**Strengths:** Randomized, double-blinded study. Uniform surgery type of lung lobectomy through video-assisted thoracic surgery. **Limitations:** Small sample size and single hospital.

		intubation with general anesthesia, stable vital signs, ASA score I-III, and subjects receiving steroidal nondepolarizing muscle relaxants rocuronium or vecuronium. Exclusion criteria were abnormal heart, liver, or kidney function, ASA IV-VI, patients with contraindications to neuromuscular blockade, allergies to Sugammadex or Neostigmine, and patients lost to follow-up.	readmission rates 30 days post discharge, specific PPC associated with residual neuromuscular block (pneumonia, pleural effusion, atelectasis), and other pulmonary complication (pneumothorax). PPCs were based on radiological observations defined in the European Perioperative Clinical Outcome guidelines.	thoracic drainage tube, and extubation time after Sugammadex or Neostigmine administration was documented by hospital staff.	with 95% confidence intervals were completed. P < 0.05 was statistically significant.	readmitted to the hospital 30 days post discharge. Pneumonia, pleural effusion, atelectasis, and pneumothorax rates were 2.14, 2.5, 3.5, and 2.75-fold lower in the Sugammadex group, respectively.		

Annotated Bibliography

This double-blind, randomized, prospective study aimed to investigate the incidence of postoperative pulmonary complications (PPCs) in patients undergoing lung cancer resection when using Sugammadex versus Neostigmine for reversal of rocuronium-induced neuromuscular blockade (NMB). The study included 100 patients from a single major university hospital from January 2021 to April 2021. Of the 100 patients, 50 were assigned to receive Sugammadex and 50 to receive Neostigmine with atropine. The primary outcomes measured were occurrences of PPCs and time to achieve 90% of train-of-four (TOF) by a nerve stimulator. Secondary outcomes were readmission rates 30 days post discharge, specific PPCs associated with residual neuromuscular blockade (pneumonia, pleural effusion, atelectasis), and other pulmonary complication (pneumothorax).

Thematic Analysis

1. Reversal of rocuronium-induced NMB is faster with Sugammadex administration compared to Neostigmine.
2. In patients undergoing lung cancer resection, Sugammadex administration could result in fewer PPCs associated with residual NMB compared with Neostigmine.
3. Using Sugammadex, compared with Neostigmine, could result in reduced rates of pneumonia, pleural effusions, atelectasis, and pneumothorax.

APA Citation:
Kheterpal, S., Vaughn, M. T., Dubovoy, T. Z., Shah, N. J., Bash, L. D., Colquhoun, D. A., Shanks, A. M., Mathis, M. R., Soto, R. G., Bardia, A., Bartels, K., McCormick, P. J., Schonberger, R. B., & Saager, L. (2020). Sugammadex versus neostigmine for reversal of neuromuscular blockade and postoperative pulmonary complications (stronger). Anesthesiology, 132(6), 1371–1381. https://doi.org/10.1097/aln.0000000000003256

Conceptual Framework or Model	***Design or Method***	***Sample & Setting***	***Major Variables Studied & their Definitions, if any***	***Outcome Measurement(s)***	***Data Analysis***	***Findings***	***Level of Evidence***	***Quality of Evidence: Critical Worth to Practice***
To determine if the choice of neuromuscular blockade reversal, Sugammadex vs Neostigmine, is associated with lower rates of major postoperative pulmonary complications (PPC) in patients undergoing noncardiac inpatient surgery	Observational matched cohort study	Sample size included 45,712 adult patients (≥ 18) undergoing elective noncardiac surgery in twelve multicenter perioperative outcome group hospitals. Patients undergoing tracheal intubation with general anesthesia, receiving a nondepolarizing neuromuscular blocking agent (rocuronium or vecuronium) by bolus or infusion, and a reversal agent (Sugammadex or Neostigmine) were eligible	**Independent variables:** **IV1=** Sugammadex administration prior to extubation **IV2=** Neostigmine administration prior to extubation **Dependent variables:** PPC related to residual neuromuscular defined as: 1) pneumonia, 2) respiratory failure, or 3) other major pulmonary complications (including pneumonitis; pneumothorax, or iatrogenic pulmonary embolism).	A database programmer matched each Sugammadex case to exactly one Neostigmine case	Continuous data were shown by medians and interquartile ranges. Outcomes were presented by frequencies and percentages for every matched group. Odds ratio with 95% confidence interval were completed. All statistical analysis was completed using SAS Analytics Software.	Multivariable analysis revealed that patients who received Sugammadex had a 30% reduced risk of PPC, 47% reduced risk of pneumonia, and 55% reduced risk of respiratory failure, compared to Neostigmine.	IV	**Strengths:** Large sample size. **Limitations:** Inherent limitation exists due to the observational nature of the study. This may warrant a prospective, pragmatic controlled trial.

		for matching (22,856 Sugammadex patients were matched with 22,856 Neostigmine patients). Exclusion criteria included ages less than 18, outpatient procedures, emergency transplant surgery, intubation prior to OR arrival, ASA V or VI, moribund or brain dead organ procurement patients, renal failure, Sugammadex used in combination with Neostigmine, Sugammadex or Neostigmine use with redosing or neuromuscular blocking agent.	Pulmonary complications with unclear relationship to residual neuromuscular blockade were not included (atelectasis, pulmonary edema, etc.)					

Annotated Bibliography
This multicenter observational matched cohort study aimed to analyze whether the choice of neuromuscular block (NMB) reversal agent, Sugammadex versus Neostigmine, is associated with lower rates of major postoperative pulmonary complications (PPCs). The sample size included 45,712 patients from twelve U.S. Multicenter Outcome Group Hospitals from January 2014 to August 2018. PPCs related to residual NMB were defined as: 1) pneumonia, 2) respiratory

failure, or 3) other major pulmonary complications including pneumonitis, pneumothorax, or iatrogenic pulmonary embolism. PPCs with unclear relationship to residual NMB, such as atelectasis and pulmonary edema, were not included.

Thematic Analysis
1. Sugammadex use for reversal of NMB is associated with statistically significant lower rates of major PPCs compared with Neostigmine.
2. Patients reversed from NMB with Sugammadex results in lower rates of pneumonia and respiratory failure compared with reversal with Neostigmine.

APA Citation:
Murphy, G. S., Avram, M. J., Greenberg, S. B., Bilimoria, S., Benson, J., Maher, C. E., Teister, K. J., & Szokol, J. W. (2020). Neuromuscular and clinical recovery in thoracic surgical patients reversed with neostigmine or sugammadex. Anesthesia & Analgesia, 133(2), 435–444. https://doi.org/10.1213/ane.0000000000005294

Conceptual Framework or Model	***Design or Method***	***Sample & Setting***	***Major Variables Studied & their Definitions, if any***	***Outcome Measurement(s)***	***Data Analysis***	***Findings***	***Level of Evidence***	***Quality of Evidence: Critical Worth to Practice***
To determine the incidence of postoperative residual neuromuscular blockade (NMB) in patients receiving Sugammadex vs Neostigmine	Nonrandomized controlled trial	200 ASA I-III patients undergoing thoracoscopic surgical procedures were included. Patients either received Sugammadex (n=100) or Neostigmine (n=100). Exclusion criteria were open thoracic procedures, patients with allergies to Sugammadex or	**Independent variables:** **IV1=** Sugammadex 4 mg/kg **IV2=** Neostigmine 0.07 mg/kg **Dependent variables:** Residual neuromuscular blockade, defined as train-of-four (TOF) ratio < 0.9. Other outcomes included adverse respiratory	Residual neuromuscular blockade (defined as TOF ratio < 0.9) was performed by a nerve stimulator. Two electrodes were placed over the ulnar nerve before induction of anesthesia. The negative electrode was placed near the wrist, and the positive electrode was 3 cm proximally. TOF ratios were	Data is presented as means ± standard deviation. Data reported as median were analyzed with the Mann-Whitney U test, and data reported as % were compared using Pearson's X2 test. Mean, median, and	The percentage of residual neuromuscular blockade was lower in the Sugammadex group than in the Neostigmine group at tracheal extubation (80% vs. 6%) and PACU admission (61% vs. 1%). No statistically significant difference in	III	**Strengths:** The study was limited to one surgery type (thoracoscopic). Consistent dosages of reversal agents were administered. **Limitations:** Relatively small sample size, healthcare participants were not blinded to group assignments resulting in

		Neostigmine, esophagectomies, drugs used that interfere with neuromuscular transmission, succinylcholine used for rapid sequence intubation, renal insufficiency or failure, liver disease, or existing neuromuscular disease. The setting was a single medical center, NorthShore University Health System in Evanston, Illinois.	events including postoperative hypoxemia episodes and occurrences of airway obstruction.	manually recorded by a research assistant. Postoperative hypoxemia episodes were analyzed by Sp02 values recorded by a Phillis IntelliVue monitor (Sp02 95%-91%: moderate, $\leq$ 90%: severe). PACU nurses noted lowest Sp02 values and episodes of airway obstruction.	proportion differences were reported at 99% confidence intervals using Hodges-Lehmann estimator. P < 0.01 was criterion for rejection of null hypothesis.	adverse airway events was observed.		potential observer bias.

Annotated Bibliography

This nonrandomized controlled trail aimed to investigate incidence of postoperative residual neuromuscular blockade (NMB) in thoracic surgery patients paralyzed with rocuronium or vecuronium and reversed with Neostigmine versus Sugammadex. The study was conducted at NorthShore University Health System in Illinois and consisted of 200 adult patients undergoing thoracic surgery. Fifty patients were reversed with Sugammadex and 50 with Neostigmine. The primary outcome of residual NMB was defined as a train-of-four (TOF) ratio < 0.9. Secondary outcomes included adverse respiratory events including postoperative hypoxemia episodes and occurrences of airway obstruction.

Thematic Analysis

1. Patients undergoing thoracic surgery show lower rates of residual NMB at both tracheal extubation and PACU admission when reversed with Sugammadex versus Neostigmine.
2. Patients reversed from NMB with Sugammadex were rarely observed exhibiting postoperative muscle weakness.
3. No statistically significant differences were noted in the rates of hypoxemic episodes or occurrences of airway obstruction in patients administered Sugammadex versus Neostigmine.

APA Citation:
Moon, T. S., Reznik, S., Pak, T., Jan, K., Pruszynski, J., Kim, A., Smith, K. M., Lu, R., Chen, J., Gasanova, I., Fox, P. E., & Ogunnaike, B. (2020). Sugammadex versus neostigmine for reversal of rocuronium-induced neuromuscular blockade: A randomized, double-blinded study of thoracic surgical patients evaluating hypoxic episodes in the early postoperative period. Journal of Clinical Anesthesia, 64, 109804. https://doi.org/10.1016/j.jclinane.2020.109804

Conceptual Framework or Model	***Design or Method***	***Sample & Setting***	***Major Variables Studied & their Definitions, if any***	***Outcome Measurement(s)***	***Data Analysis***	***Findings***	***Level of Evidence***	***Quality of Evidence: Critical Worth to Practice***
To determine if neuromuscular block reversal with Sugammadex vs. Neostigmine affects the number of postoperative hypoxic episodes and how long it takes to reach neuromuscular recovery with each reversal agent.	Randomized, double-blinded, two-arm clinical trial	92 patients undergoing thoracic surgery were included. Inclusion criteria were adults (≥ 18), ASA II-IV, and thoracic surgery necessitating single lung ventilation. Exclusion criteria included allergy to the intervention drugs, patients with neuromuscular disease, pre-existing muscle weakness, pregnancy, renal or hepatic impairments, and patients with difficult	**Independent variables:** **IV1=** Sugammadex 2 mg/kg **IV2=** Neostigmine 0.05 mg/kg with Glycopyrrolate 0.008 mg/kg **Dependent variables:** Hypoxic episodes (defined as $SpO_2 < 94\%$ on ≤ 2 L/min of oxygen, or < 98% on ≥ 2 L/min of oxygen, or postoperative SpO_2 5% less than preoperative values lasting ≥ 1 min) in the first 90 min postoperatively and time to achieve neuromuscular recovery (defined	Hypoxia was measured with a pulse oximeter and neuromuscular monitoring was completed using a peripheral nerve stimulator (TOF-Watch® SX) with TOF measurements completed at 2, 5, 10, and 15 minutes after each reversal agent administration. All data was recorded by a trained research assistant.	The median number of hypoxic episodes was calculated in both the Sugammadex and Neostigmine groups. The mean times of neuromuscular recovery were calculated for both groups.	Subjects reversed with neostigmine had medial of 1 hypoxic episode, sugammadex group had 0 hypoxic episodes. Neuromuscular recovery to TOF ≥ 0.9 in the Sugammadex group was 10 minutes compared to 40 minutes in the Neostigmine group.	II	**Strengths:** Randomized, double-blinded, with standardized anesthetic protocol. The study focused on a specific patient population, thoracic surgery patients undergoing single-lung ventilation. **Limitations:** Relatively small sample size. Single center study design.

		airways. Patients were randomly assigned to receive Sugammadex (n=44) or Neostigmine (n=48). The study was conducted in an operating room and post-anesthesia care unit at a single center, Parkland Hospital in Dallas, TX.	as a train-of-four [TOF] $\geq$ 0.9) with each reversal agent.					

Annotated Bibliography

This randomized, double-blind study aimed to determine if using Sugammadex versus Neostigmine for reversal of rocuronium-induced neuromuscular blockade (NMB) results in lower rates of postoperative hypoxic episodes and quicker reversal times in patients undergoing thoracic surgery. The sample size consisted of 92 patients at Parkland Hospital of Dallas, TX. The researchers analyzed the outcome of hypoxic episodes by postoperative pulse oximetry readings and the outcome of reversal times by train-of-four readings through a peripheral nerve stimulator.

Thematic Analysis

1. In patients undergoing thoracic surgery, patients reversed from NMB with Sugammadex results in decreased number of postoperative hypoxic episodes compared with reversal by Neostigmine.

2. Administrating Sugammadex results in faster reversal of NMB compared with Neostigmine.

APA Citation:
Lee, T., Jeong, S., Jeong, J., Kim, J., & Choi, S. (2021). Comparison of postoperative pulmonary complications between sugammadex and neostigmine in lung cancer patients undergoing video-assisted thoracoscopic lobectomy: A prospective double-blinded randomized trial. Anesthesia and Pain Medicine, 16(1), 60–67. https://doi.org/10.17085/apm.20056

Conceptual Framework or Model	***Design or Method***	***Sample & Setting***	***Major Variables Studied & their Definitions, if any***	***Outcome Measurement(s)***	***Data Analysis***	***Findings***	***Level of Evidence***	***Quality of Evidence: Critical Worth to Practice***
To determine the influence of Sugammadex vs. Neostigmine on the incidence of postoperative pulmonary complications (PPCs), duration of hospital stay, and rates of Intensive Care Unit (ICU) admission.	Randomized, double-blind prospective study	102 patients undergoing video-assisted thoracoscopic lobectomy randomly assigned to a Sugammadex group (n=51) or neostigmine group (n=51) were initially included in this study. Inclusion criteria included ASA I-III, and > 18 years of age. Cases changed to open conversion were excluded. 9 exclusions were made due to open conversion resulting in 46 final patients in Sugammadex group and 47 in	**Independent variables:** **IV1=** Sugammadex 2 mg/kg **IV2=** Neostigmine 0.05 mg/kg (max 5 mg) with atropine 0.02 mg/kg **Dependent variables:** Incidence of PPCs (pneumonia, prolonged air leak, desaturation, atelectasis, or reintubation) duration of hospital stay, and ICU admission rates.	Reintubation rates were analyzed from progress and discharge records. Desaturation was analyzed with a pulse oximeter with readings < 95%. Pneumonia and atelectasis rates were recorded based on radiographical images obtained postoperatively. Prolonged air leak was recorded if noted on day 6 after surgery.	Data is presented as means ± standard deviation, percentage of patients, or medians. The chi-square test or Fisher's exact test analyzed categorical variables. The Students t-test examined continuous variables. P values < 0.05 were statistically significant. Statistical data was analyzed using SPSS software (version 26).	No statistically significant difference in postoperative pulmonary complications, duration of hospital stays, or ICU admission rates. These results may be due to the small sample size. The authors state that more large-scale studies should be conducted on the topic.	II	**Strengths:** Randomized, double-blinded study. Consistent drug dosages. Uniform surgery type of lung lobectomy through video-assisted thoracic surgery. **Limitations:** Relatively small sample size. Single center hospital

		Neostigmine group. The study was conducted between April 2018 and May 2020 at a single center hospital.						

Annotated Bibliography

This randomized, double-blind, prospective study compared Sugammadex versus Neostigmine administration for reversal of neuromuscular blockade (NMB) on the incidence of postoperative pulmonary complications (PPCs), duration of hospital stays, and rates of Intensive Care Unit (ICU) admissions. The study consisted of 102 patients at a single center hospital conducted between April 2018 and May 2020. The primary outcome of PPCs included pneumonia, prolonged air leak, desaturation, atelectasis, and reintubation rates. Secondary outcomes were duration of hospital stay and ICU admission rates.

Thematic Analysis

1. No statistically significant difference exists between Sugammadex versus Neostigmine administration for reversal of NMB on rates of PPCs.
2. Sugammadex administration does not correlate with shorter duration of hospital stays or ICU admission rates compared with Neostigmine administration.