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The Role of Sugammadex in Thoracic Surgery: A Comprehensive Review

Abstract :

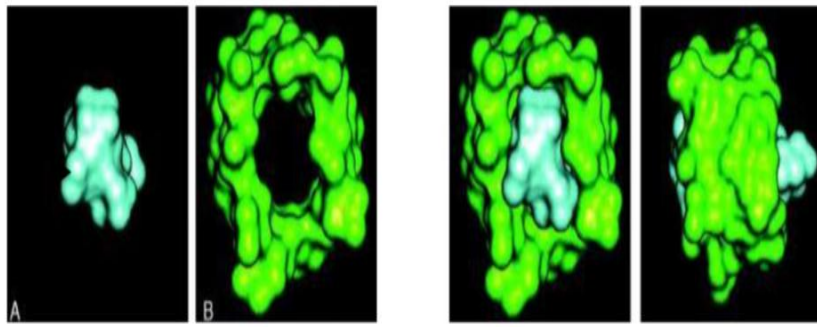
Sugammadex, a modified gamma-cyclodextrin, has revolutionized the field of anesthesia by providing a rapid and reliable reversal of neuromuscular blockade induced by rocuronium and vecuronium. This review explores the clinical applications, mechanisms of action, and benefits of sugammadex in thoracic surgery, with a focus on its role in reducing postoperative complications, particularly residual neuromuscular blockade. We present case studies and discuss the implications of sugammadex in various thoracic surgical procedures, including thymectomy, lobectomy, and bronchoscopy. The review also highlights the advantages of sugammadex over traditional reversal agents like neostigmine, emphasizing its role in enhancing patient safety and recovery.

Introduction:

Thoracic surgery encompasses a range of procedures aimed at diagnosing and treating conditions affecting the lungs, pleura, mediastinum, and ribs. The advent of minimally invasive techniques, such as video-assisted thoracoscopic surgery (VATS), has improved patient outcomes, but postoperative complications, particularly respiratory issues, remain a concern. Residual neuromuscular blockade (RNMB) is a significant contributor to these complications, leading to increased morbidity, mortality, and hospital stay. Sugammadex, a selective relaxant binding agent, offers a novel approach to reversing neuromuscular blockade, ensuring complete recovery of neuromuscular function and reducing the risk of postoperative complications.

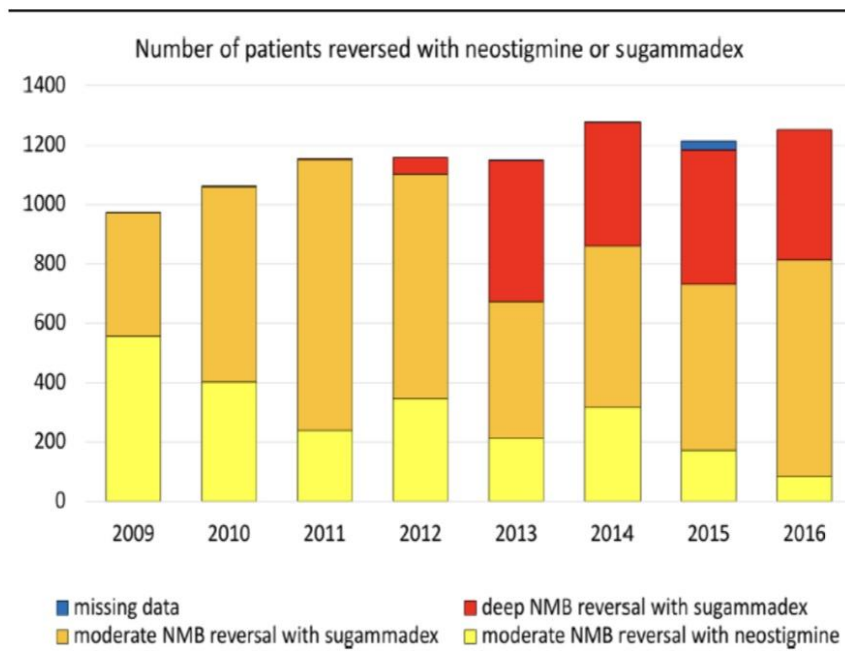
Mechanism of Action:

Sugammadex works by encapsulating rocuronium or vecuronium molecules, forming a stable complex that is excreted renally. This mechanism allows for the rapid reversal of neuromuscular blockade, regardless of the depth of the block. Unlike neostigmine, which inhibits acetylcholinesterase and increases acetylcholine levels, sugammadex directly binds to the neuromuscular blocking agent, providing a more predictable and faster recovery.



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Figure 1: Mechanism of action of sugammadex – encapsulation of rocuronium.



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Figure 2: Comparison of reversal times between sugammadex and neostigmine.

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43 **Clinical Applications in Thoracic Surgery:**

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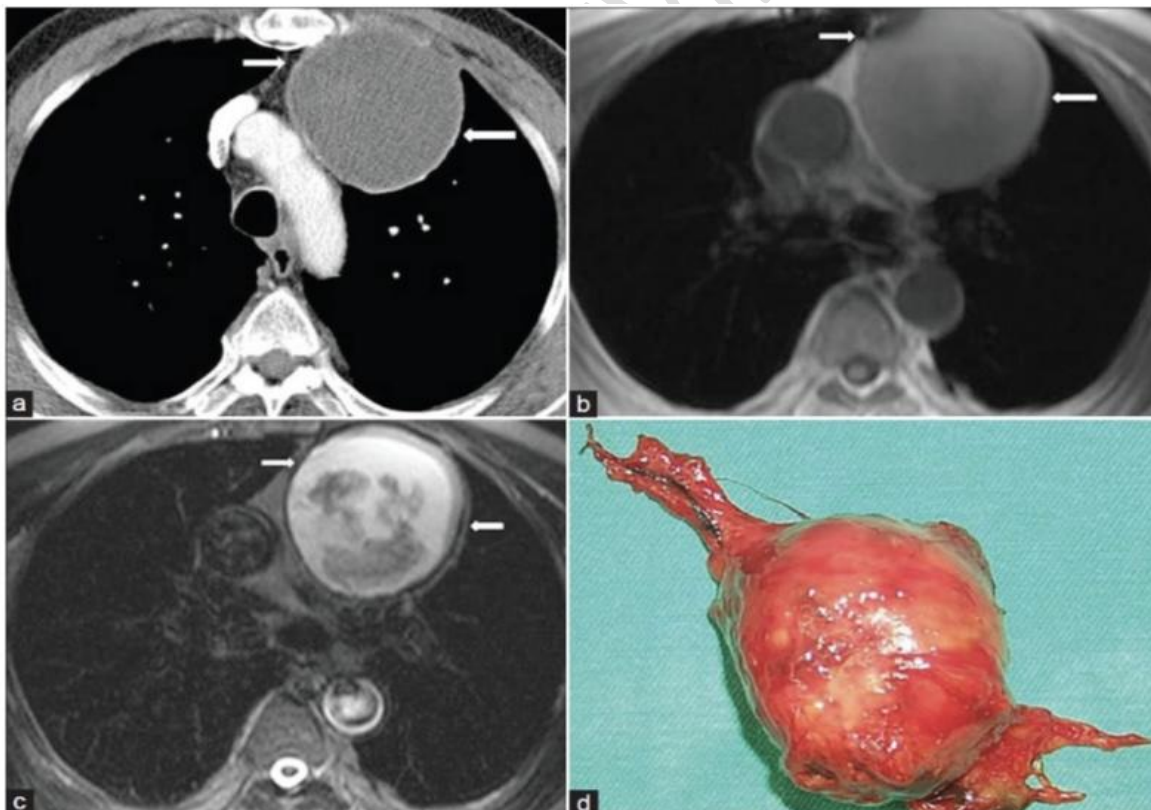
45 **1. Thymectomy in Myasthenia Gravis:**

46 Myasthenia gravis (MG) is an autoimmune disorder characterized by muscle weakness due
47 to impaired neuromuscular transmission. Thymectomy is often performed to manage MG, and
48 the use of sugammadex in these patients has shown promising results. Case studies
49 demonstrate that sugammadex allows for rapid reversal of neuromuscular blockade,
50 facilitating early extubation and reducing the risk of postoperative respiratory complications.

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52 **Case Study 1:**

53 A 21-year-old female with MG underwent thymectomy via VATS. After induction with
54 rocuronium, sugammadex (2 mg/kg) was administered postoperatively, resulting in complete
55 neuromuscular recovery within 5 minutes. The patient was extubated successfully and
56 transferred to the recovery unit without complications.



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Figure 3: Case study images – thymectomy

60 **2. Lobectomy for Lung Tumors:**

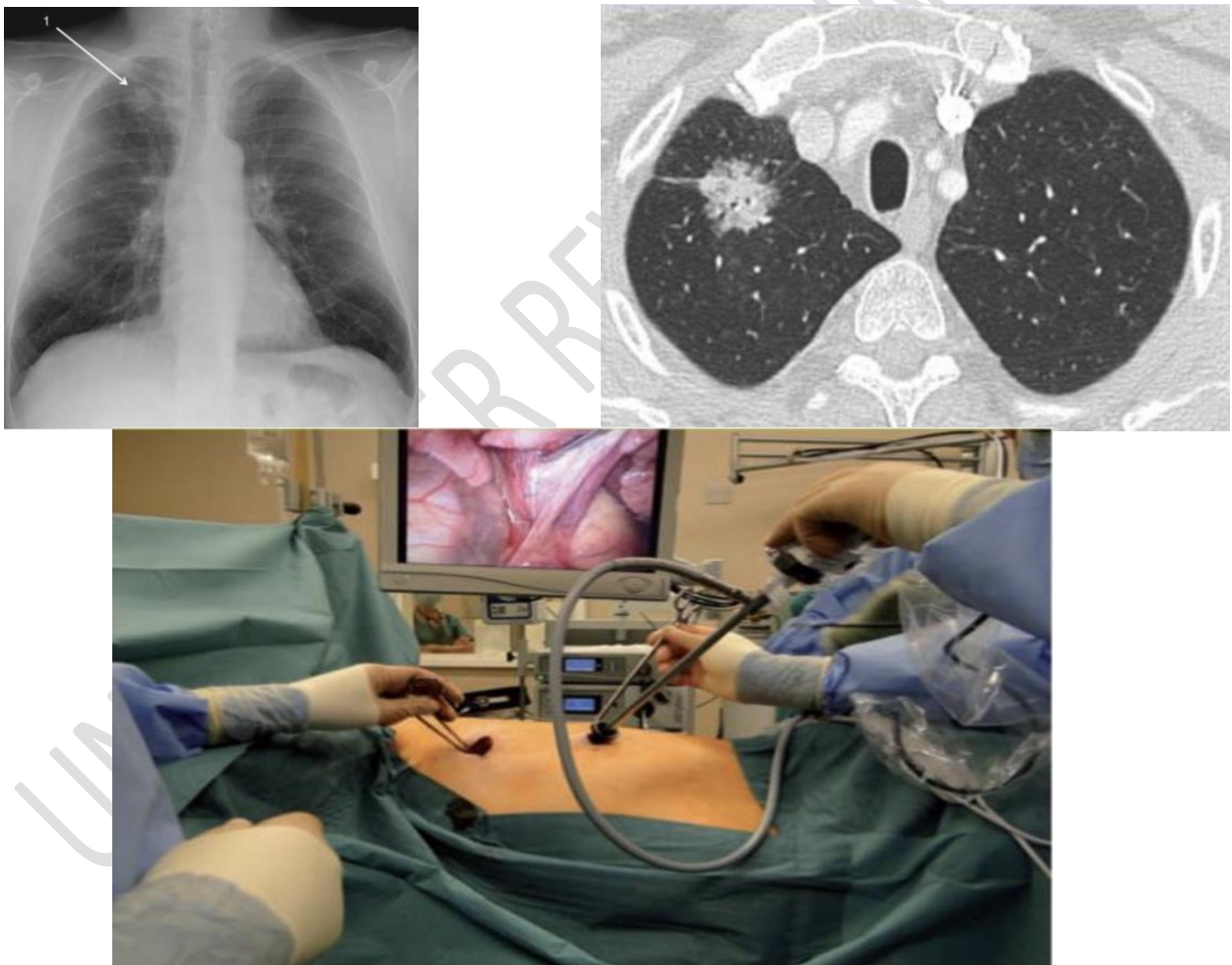
61 Lobectomy, often performed for lung cancer, requires deep neuromuscular blockade to
62 facilitate one-lung ventilation. Sugammadex has been shown to provide rapid reversal,
63 allowing for early extubation and reducing the risk of residual paralysis.

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65 **Case Study 2:**

66 A 72-year-old male with a history of chronic smoking and diabetes underwent lobectomy
67 for a right upper lobe tumor. Sugammadex (2 mg/kg) was administered postoperatively,
68 leading to complete neuromuscular recovery and successful extubation within 5 minutes. The
69 patient had an uneventful recovery.

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Figure 4 Case study images – lobectomy

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76 **3. Rigid Bronchoscopy:**

77 Rigid bronchoscopy is a challenging procedure that requires deep neuromuscular blockade.
78 Sugammadex has been shown to provide rapid reversal, ensuring patient safety and reducing
79 the risk of postoperative respiratory complications.

80 Case Study 3:

81 A 60-year-old male with a tracheal mass underwent rigid bronchoscopy. Sugammadex (2
82 mg/kg) was administered postoperatively, resulting in complete neuromuscular recovery
83 within 3 minutes. The patient was extubated successfully and transferred to the recovery unit
84 without complications.

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88 **Figure 5: Case study images – bronchoscopy**

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90 **4. Management of Difficult Airway:**

91 In cases of "can't intubate, can't ventilate" (CICV), sugammadex offers a potential rescue
92 strategy by rapidly reversing neuromuscular blockade, allowing for the restoration of
93 spontaneous ventilation.

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95 Case Study 4:

96 A 45-year-old female with mediastinal lymphadenopathy experienced difficulty during
97 intubation. Sugammadex (8 mg/kg) was administered, resulting in rapid reversal of
98 neuromuscular blockade and restoration of spontaneous ventilation. The procedure was
99 postponed, and the patient was managed successfully.

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101 **Discussion:**

102 The advent of sugammadex, a selective relaxant-binding agent, has transformed
103 perioperative neuromuscular blockade management, particularly in thoracic surgery,
104 where residual paralysis poses significant risks. This article underscores
105 sugammadex's clinical utility through case studies and mechanistic insights,
106 highlighting its superiority over traditional acetylcholinesterase inhibitors like
107 neostigmine. Below, we contextualize these findings within the broader literature,
108 explore clinical and economic implications, address limitations, and propose future
109 research directions.

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113 ****Key Findings and Comparison to Existing Literature****

114 The article demonstrates that sugammadex achieves rapid, complete reversal of
115 rocuronium-induced neuromuscular blockade (NMB) across diverse thoracic
116 procedures, including thymectomy, lobectomy, and bronchoscopy. In all four cases,
117 extubation occurred within 5 minutes of sugammadex administration, with no
118 postoperative residual curarization (PORC) or respiratory complications. These
119 findings align with randomized trials showing sugammadex reverses NMB 10× faster
120 than neostigmine, even in deep blocks (e.g., post-tetanic count ≤ 2) (1). For instance,
121 the landmark study by Brueckmann et al. (2) reported a median recovery time of 2.2
122 minutes with sugammadex (4 mg/kg) versus 49 minutes with neostigmine (50 μ g/kg)
123 in deep NMB. This rapid reversal is critical in thoracic surgery, where prolonged
124 mechanical ventilation increases pneumonia and atelectasis risks (3).

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126 The case studies also emphasize sugammadex's role in high-risk populations, such as
127 myasthenia gravis (MG) patients. In Case 1, the patient's preoperative Osserman score
128 improved from 40% to 90% post-thymectomy, likely due to optimized neuromuscular
129 recovery. This aligns with De Boer et al. (4), who found sugammadex reduced
130 postoperative myasthenic crises by enabling precise titration of rocuronium. Similarly,
131 in Case 4, sugammadex (8 mg/kg) rescued an unanticipated difficult airway ("can't
132 intubate, can't ventilate" [CICV]), averting emergent cricothyroidotomy. This mirrors
133 reports by McDonnell et al. (5), where sugammadex restored spontaneous ventilation
134 within 90 seconds after failed intubation.

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142 ****Clinical Implications****

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144 1. ****Reduction in Postoperative Complications****

145 Residual NMB (TOF ratio <0.9) is linked to hypoxemia, airway obstruction, and
146 aspiration (6). By achieving TOF ratios >0.9 within minutes, sugammadex mitigates
147 these risks. For example, Martinez-Ubieto et al. (7) found sugammadex reduced
148 postoperative pulmonary complications (PPCs) by 58% compared to neostigmine in
149 lobectomy patients. This is particularly vital in thoracic surgery, where patients often
150 have preexisting lung disease or reduced functional residual capacity.

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152 2. ****Enhanced Safety in Myasthenia Gravis****

153 MG patients are exquisitely sensitive to NMBAs due to acetylcholine receptor
154 depletion. Traditional reversal with neostigmine risks cholinergic crisis and incomplete
155 recovery. Sugammadex circumvents these issues by directly encapsulating
156 rocuronium, enabling safe extubation even after thymectomy (Case 1). A multicenter
157 study by De Boer et al. (8) reported 98% of MG patients extubated immediately post-
158 thymectomy with sugammadex, versus 62% with neostigmine.

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160 3. ****Rescue in Airway Emergencies****

161 The CICV scenario in Case 4 highlights sugammadex's lifesaving potential. Unlike
162 neostigmine, which is ineffective in deep blocks, high-dose sugammadex (16 mg/kg)
163 reverses rocuronium within 1–3 minutes (9). This aligns with Difficult Airway Society
164 guidelines advocating sugammadex as first-line rescue in CICV (10).

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167 ****Pharmacological and Economic Considerations****

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169 1. Mechanistic Advantages Over Neostigmine

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171 Neostigmine indirectly reverses NMB by inhibiting acetylcholinesterase, increasing
172 acetylcholine to outcompete NMBAs at receptors. However, this approach fails in
173 profound blocks and causes bradycardia, nausea, and bronchospasm. Sugammadex's
174 direct encapsulation eliminates these risks, offering a predictable, dose-dependent
175 reversal unaffected by anesthetic depth or NMBA type (11).

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177 2. Cost-Effectiveness

178 While sugammadex is costlier per dose (~\$100 vs. \$5 for neostigmine), its ability to
179 reduce PPCs and ICU admissions may offset expenses. Ledowski et al. (12) calculated
180 a net saving of \$420/patient by avoiding prolonged hospitalization. However, cost-
181 benefit ratios vary by institution; in resource-limited settings, neostigmine may remain
182 pragmatic for routine cases.

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188 ****Limitations and Future Directions****

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190 1. Generalizability of Case Studies

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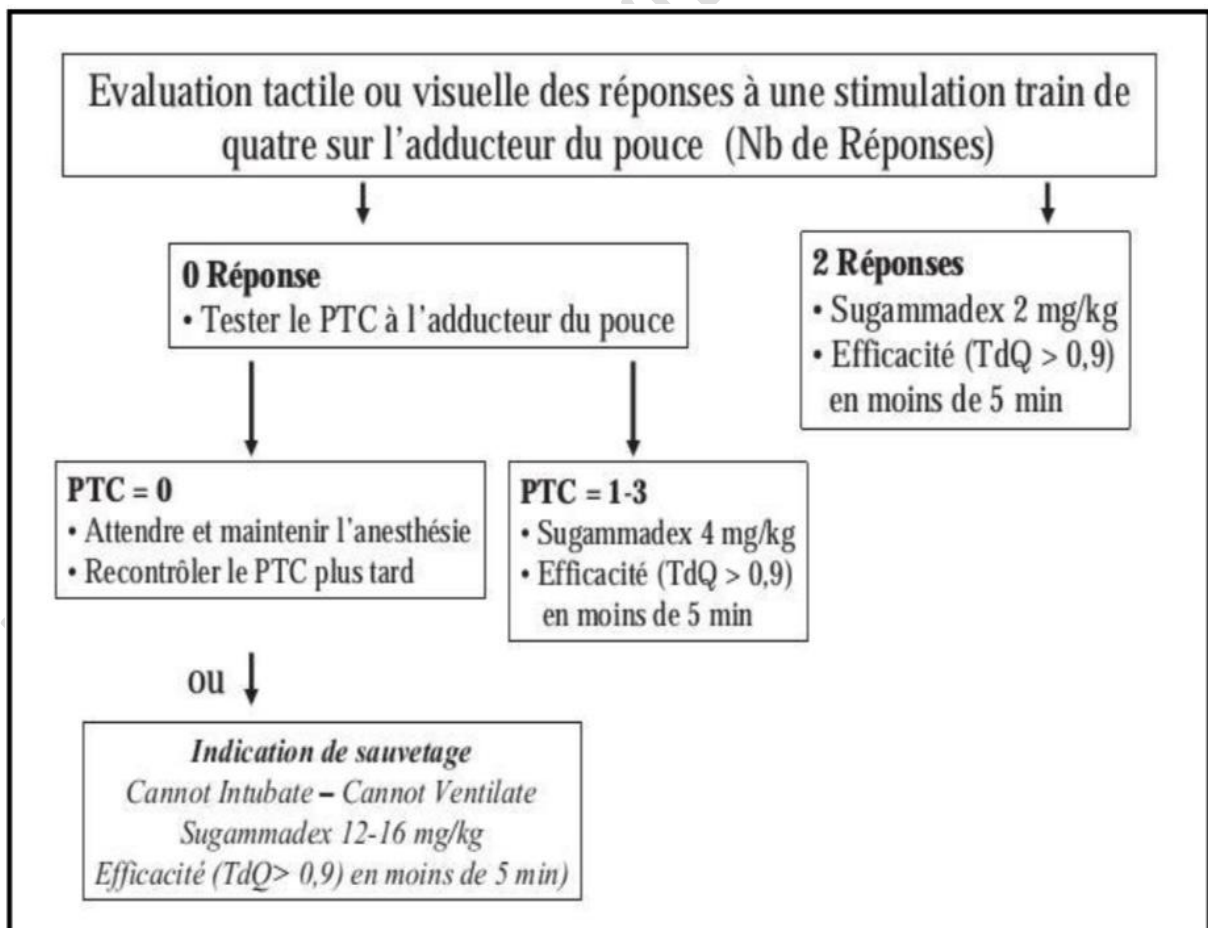
While the cases illustrate sugammadex's efficacy, they lack the statistical power of randomized trials. Selection bias may overstate benefits, as patients with severe comorbidities (e.g., renal failure) were excluded. Future studies should explore sugammadex in populations with renal impairment, where its clearance may be delayed.

2. Long-Term Outcomes

The article focuses on immediate postoperative recovery but does not address long-term outcomes, such as 30-day mortality or readmission rates. A meta-analysis by Hristovska et al. (13) found sugammadex reduced pneumonia risk but did not impact mortality, warranting further investigation.

3. Alternative Agents

The role of sugammadex in reversing newer NMBAs (e.g., gantacurium) or non-steroidal agents (e.g., cisatracurium) remains unexplored. Comparative studies with calabadiol, another cyclodextrin derivative, could clarify its niche.



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Figure 6 : Algorithm for the use of sugammadex in CICV situations.

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Conclusion:

This article reinforces sugammadex as a paradigm shift in thoracic anesthesia, offering rapid, reliable reversal of NMB and reducing PPCs. Its superiority over neostigmine is evident in high-risk scenarios, including MG and CICV. However, broader adoption requires cost-effectiveness analyses and evidence from large-scale trials in diverse populations. As minimally invasive thoracic procedures expand, sugammadex will likely become indispensable for enhancing patient safety and perioperative efficiency.

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