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Review

Sugammadex for our little ones: a brief narrative review

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Sugammadex, the first noncompetitive antagonist developed for the reversal of neuromuscular blockade (NMB), is one of the few drugs that has revolutionized anesthetic practice. However, sugammadex use was only recently approved for children aged 2 to 17 years, and it remains unapproved for children under 2. Although the precision and reliability of reversal of NMB with sugammadex are of great benefit in pediatric anesthesia, several important questions remain regarding its use in our youngest patients. In this brief narrative review, we aim to provide an overview of the key considerations and potential challenges that anesthesiologists often face when using sugammadex in pediatric patients.

Keywords: Bradycardia; Hypersensitivity; Neostigmine; Neuromuscular blocking agents; Newborn infant; Pediatrics; Sugammadex.

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INTRODUCTION

Sugammadex, the first noncompetitive antagonist developed for the reversal of neuromuscular blockade (NMB) [1], is one of the few drugs that has revolutionized anesthetic practice. Because of its rapid and predictable action in reversing NMB, it is now preferred over traditional acetylcholinesterase inhibitors. While effective, acetylcholinesterase inhibitors have a slower onset and are associated with a wide range of side effects, including bradycardia, increased secretions, and the need for concomitant anticholinergic drugs to mitigate these effects [2]. While sugammadex was approved for adults in the United States in 2015, its use in children (2 to 17 years) was not approved until 2021. Although the precision and reliability of NMB reversal by sugammadex are of great benefit in pediatric anesthesia, several important questions remain regarding the use of sugammadex in young patients.

A recent meta-analysis suggesting the superiority of sugammadex over acetylcholinesterase inhibitors also highlighted the need for additional high-quality randomized trials owing to the general low quality and heterogeneity of previous studies [3]. Therefore, there is a need to further explore and understand the use of sugammadex in children. For example, the pharmacokinetics and pharmacodynamics of sugammadex in pediatric patients can differ significantly from those in adults, necessitating age-specific considerations of dosing and administration. The long-term safety and efficacy of sugammadex in the pediatric population also require further research.

In this brief narrative review, our aim is to address several practical concerns that anesthesiologists often face when using sugammadex in pediatric patients, drawing from the existing literature to provide a comprehensive overview of key considerations and potential challenges. Our focus is not on comparing the efficacy of sugammadex and acetyl-

cholinesterase inhibitors, as this has been extensively reviewed elsewhere [3,4]. Instead, we focus on particular issues that anesthesiologists often face when using sugammadex in pediatric anesthesia.

THE RECOMMENDED DOSAGE OF SUGAMMADEX FOR CHILDREN

Although the risk of overdosing with sugammadex remains unclear [5], underdosing poses a definite risk because of the possibility of residual blockade. Therefore, the dosage should be adjusted according to the degree of NMB using appropriate NMB monitoring techniques.

In adults, the recommended dose of sugammadex is 2–16 mg/kg. The routine reversal dose is 4 mg/kg when the post-tetanic count (PTC) is 1–2 or there are no twitch responses to train-of-four (TOF) stimulation (deep block), and 2 mg/kg when there is reappearance of the second twitch (T2) in response to TOF stimulation (moderate block). A dose of 16 mg/kg is used for immediate reversal of rocuronium-induced NMB [6]. In pediatric patients, the recommended routine reversal dose is the same as that in adults. However, measuring the degree of NMB itself can be challenging in young pediatric patients, making it more difficult to select the appropriate reversal dose. In cases of accidental large doses of rocuronium, the administration of additional rocuronium just before the end of surgery, or continuous rocuronium infusion, insufficient sugammadex dosing without NMB monitoring can lead to residual blockade and subsequent respiratory complications. Therefore, careful selection of the sugammadex dosage is essential.

In a recent randomized clinical trial using NMB monitoring, the authors showed that in pediatric patients aged 2–17 years, there was no difference in recovery time (1.3, 0.9 and 0.6 min, respectively) and dose-dependent side effects between different dosages of sugammadex (2, 4, and 8 mg/kg) when administered at a TOF count of 2 [7]. These results suggest that a dose of 2 mg/kg should be sufficient in situations where NMB monitoring can be employed. However, caution is warranted when NMB monitoring cannot be employed, as residual block or recurarization has been frequently documented and the use of higher doses may be considered. We address this issue in more detail below.

NEUROMUSCULAR BLOCKADE

Although formal research on immediate reversal in pediatric patients is limited, several successful cases have been documented. For example, Wooszczuk-Gbicka et al. [8] reported a 10-month-old infant who had difficulty ventilating with a mask after receiving 0.1 mg/kg of vecuronium but returned to spontaneous ventilation after the administration of an 8 mg/kg dose of sugammadex. Similarly, Wakimoto et al. [9] described a newborn weighing 1.77 kg at 34 weeks of gestation who experienced ventilation difficulties after administration of 1 mg/kg of rocuronium and subsequently resumed spontaneous breathing after receiving 8 mg/kg of sugammadex. The patients successfully returned to spontaneous ventilation within 25 s and 1–2 min, respectively. Recently, Ji et al. [10] reported that in patients aged 2–7 years who received 1 mg/kg rocuronium, effective reversal was achieved within 3 min following the administration of 8 mg/kg sugammadex at the moment of intense NMB (PTC of 0) without adverse events. In a "cannot ventilate, cannot intubate" situation in a pediatric patient, sugammadex use may be considered, though with caution [11].

RESIDUAL BLOCK/RECURARIZATION

In pediatric patients, owing to their smaller capacity compared to adults, the presence of residual blockade or recurarization can be extremely dangerous and life-threatening [12]. Even in adults, 0.2% of patients experience recurrence of NMB despite the use of the recommended dose, and this incidence can increase to 4.62% when doses lower than the recommended amount are administered. Therefore, careful consideration is necessary when selecting the appropriate dose.

Most research findings suggest that sugammadex can be used safely in pediatric patients; however, previous reports have frequently documented cases of residual blockade or recurarization in these children. These incidents have been associated with the prolonged use of neuromuscular blocking agents (NMBAs) [13] or administration of lower than the recommended doses of sugammadex [14]. However, recurrence of NMB, even when using recommended doses, can occur due to the redistribution of NMBAs or potential interactions with other medications [15]. Cases have been documented in which difficulties in reversal were encountered despite using doses greater than 4 mg/kg, and in-

stances of recurarization occurred as late as 52 min after surgery [16]. Cates et al. [17] also suggested that younger age and lower body weight are associated with an increased risk of residual weakness. Therefore, meticulous monitoring up to one hour after surgery should be considered in pediatric patients despite the use of the recommended doses. This is especially true in pediatric patients who receive vecuronium, as the affinity for sugammadex is 3.1 times lower than that for rocuronium [18].

POTENTIAL SIDE EFFECTS OF SUGAMMADEX IN PEDIATRIC PATIENTS

Most studies indicate that sugammadex is well tolerated in children, with adverse effects that are usually mild and self-limiting, such as nausea/vomiting and pain. However, studies also suggest the importance of maintaining awareness, particularly regarding the signs of allergic reactions, bradycardia, and laryngospasm.

Hypersensitivity and anaphylaxis

The main cause of delay in FDA approval in adults was concern regarding hypersensitivity reactions. Allergic reactions can range from mild skin rash and urticaria to bronchospasm, and in rare cases, anaphylactic shock that requires resuscitation. Data from a randomized clinical trial estimated that the incidence of allergic reactions was approximately 0.3% in healthy adult volunteers, generally treated with antihistamines and corticosteroids, and no subject required epinephrine [19]. In this study, there was no clear evidence that repeated administration of sugammadex increased the incidence or severity of hypersensitivity events, and the incidence of dose-related anaphylaxis remained unclear.

Although the incidence has not been established in pediatric patients, a recent systemic review [20] reported the association of sugammadex-induced perioperative anaphylaxis in all age groups with an incidence between 0.02 and 0.04% in observational studies [21,22]. According to a systematic review encompassing all age groups by Tsur et al. [23], a total of 15 hypersensitivity events were documented, 11 of which met the criteria for anaphylaxis. All patients included in this review experienced events within 4 min, similar to another study that reported the onset time to be less than 5 min [24]. Thus, close observation for at least 5 minutes post-administration is essential, as timely diagnosis and treatment during this period can improve prognosis. Unfortunately, recent case reports have also reported the occurrence of adverse events up to 30 min after surgery, emphasizing the need for caution up to 1 h after surgery, particularly in pediatric patients [25].

Bradycardia

The incidence of bradycardia is lower with sugammadex than with neostigmine [3,26]. Although most reports suggest that sugammadex-induced bradycardia is relatively short and requires little or no special intervention, even in patients with congenital heart disease [27,28], a few studies have also reported severe bradycardia. Bhavani [29] reported two compelling cases of bradycardia progressing to severe bradycardia and asystole following administration of sugammadex at doses of approximately 2–4 mg/kg in adult patients. Fortunately, both patients achieved rapid and complete recovery after appropriate resuscitation, with no reported residual complications [29]. Cases of cardiac arrest due to bradycardia in children are rare, and only two cases have been reported to date. The first case involved a 10-year-old child with heart disease who experienced profound bradycardia requiring chest compressions for approximately 10-15 seconds after sugammadex administration [30]. Another recently reported case involved a 10-min bradycardia-induced cardiac arrest after sugammadex administration in an 8-month-old child with complex congenital heart disease [31]. Additionally, it remains unclear whether bradycardia occurs in a dose-dependent manner in pediatric patients. However, previous observational studies have indicated no relationship between bradycardia and sugammadex dosage used in children [27,32].

Laryngospasm

Laryngospasm is a common respiratory complication during pediatric anesthesia and can be life threatening in some cases. Although the available data are limited, there have been reports of laryngospasm occurring after reversal of NMB with sugammadex. McGuire and Dalton reported seven cases of transient laryngospasm, attributing these occurrences to a rapid increase in upper airway tone induced by the administration of sugammadex. In their report, only one patient experienced desaturation (90%), whereas the others recovered spontaneously without significant oxygen desaturation [33]. The severity of the re-

ported cases varies widely. Some of these cases involved transient desaturation that resolved with continuous positive airway pressure (CPAP) or 100% oxygen supplementation [33-35]. However, more severe outcomes have also been reported, including negative pressure pulmonary edema [36-38] and cyanosis accompanied by bradycardia [39] resulting from laryngospasm. Notably, one documented case described the use of succinylcholine to relieve laryngospasm after sugammadex administration [40]. Recently, Wu et al. [39] reported a case of sugammadex-induced laryngospasm in an awake, non-intubated patient. These findings emphasize the need for caution when administering additional doses of sugammadex to conscious patients, including those in post-anesthesia care units (PACUs).

Although the optimal timing of sugammadex administration remains unclear, Kang et al. [41] retrospectively explored the relationship between the timing of sugammadex administration and the occurrence of laryngospasm in intubated patients recovering from general anesthesia. Their findings indicated that the incidence of laryngospasm significantly decreased in patients who received sugammadex when the end-tidal inhalation anesthetic gas concentration was below 0.3 minimum alveolar concentration (MAC-awake) compared with those who received sugammadex at levels above 0.3 MAC [41]. Furthermore, another study involving patients who underwent general anesthesia with supraglottic airway devices (SADs) also reported a lower incidence of laryngospasm when sugammadex was administered after the patients had regained consciousness [42].

Reports on pediatric patients are even more limited. However, a recent prospective study observed the angle of the vocal cords before and after sugammadex administration in pediatric patients undergoing general anesthesia with SADs. The study speculated that sugammadex-induced laryngospasm might result from the differential recovery of laryngeal muscles, with the adductor muscles recovering faster than the abductor muscles after sugammadex administration, unlike in spontaneous recovery [43]. Additionally, the study reported that a higher fentanyl effect-site concentration prior to sugammadex administration prevents laryngeal narrowing and suggested that sugammadex should be administered under deep anesthesia to ensure the complete reversal of NMB in small children with SADs [44].

Given these findings, it is crucial to be aware of the potential for laryngospasm when using sugammadex. Further studies, including those involving pediatric patients, are needed to clarify the mechanisms and determine the optimal timing for safe administration.

Interaction with oral contraceptives

Theoretically, additional caution is necessary in pediatric patients taking hormonal oral contraceptives, as sugammadex may also bind to substances with structurally similar features and/or strong binding affinities. Pharmacokinetic modeling suggests that the administration of sugammadex at a dose of 4 mg/kg may result in an interaction between sugammadex and endogenous progesterone, potentially reducing the levels by 34% in patients using hormonal contraception. This interaction could be equivalent to missing a single dose of an oral contraceptive pill. Therefore, both manufacturers and professional organizations recommend counseling patients to use additional non-hormonal contraception after receiving sugammadex. However, there is a lack of robust clinical evidence to support or refute the significant interactions between sugammadex and oral contraceptives [45]. A recent prospective observational study did not find significant hormonal changes that would threaten contraceptive efficacy in women using hormonal contraception after receiving sugammadex [46]. The study also reported that this interaction may not be clinically significant but could potentially offer some protection against ovulation.

SUGAMMADEX IN CHILDREN UNDER THE AGE OF 2 YEARS

Neonates and infants under 2 years of age are particularly sensitive to NMBAs owing to underdeveloped neuromuscular junctions and immature clearance systems. This can prolong the effects of the drugs and increase the risk of residual NMB after surgery [47,48]. Furthermore, their immature respiratory systems render them more susceptible to complications from residual paralysis such as respiratory failure. Therefore, precise dosing and use of sugammadex, which provides more complete reversal, might be beneficial [49].

While currently approved for children aged 2 years and older, emerging data support the use of sugammadex in patients under 2 years (Table 1). A recent retrospective cross-sectional observational study found that anesthesiologists may prefer to use sugammadex in children under the

Table 1. Summary of Available Literature On the Use of Sugammadex in Neonates and Infants

Study (reference)	Patient information	Sugammadax dose	Study information
Franz et al. (2019) [51]	Case series (n = 331) of under 2-year-old infants (ASA I-V)	2 mg/kg of sugammadex used, n = 223 4 mg/kg of sugammadex used, n = 98 16 mg/kg of sugammadex used, n = 10	Average time between end of surgery and out of OR. : 19.6 min (neostigmine group) vs. 19.4 min (sugammadex group) Average time between last dose of NMBA and reverse agent administration. : 84 min (neostigmine group) vs. 103 min (sugammadexa group) No adverse effects attributed to sugammadex. Only 13 cases used TOF stimulation.
Wakimoto et al. (2018) [9]	Case report of a 34-week-old neonate (1.77 kg)	8 mg/kg of sugammadex used. 1 mg/kg of rocuronium used at induction.	Spontaneous ventilation regained within 1–2 min after sugammadex administration.
Efune et al. (2020) [52]	Case report of a 2-week-old preterm neonate (0.85 kg)	16 mg/kg of sugammadex used. 10 min after 1.2 mg/kg rocunium administration at induction.	Resumed spontaneous ventilation within a few seconds after sugammadex administration.
Carlos et al. (2016) [54]	Case report of a 3-day-old neonate (2.98 kg)	4 mg/kg of sugammadex used; PTC 1 at the time of administration. 75 min after 0.9 mg/kg rocuronium administration.	90 s until TOF ratio of 0.9.
Ozmete et al. (2016) [57]	Case report of an 11-day-old term neonate	3 mg/kg (2 mg/kg + additional 1 mg/kg) of sugammadex used; completion of procedure. 0.6 mg/kg of rocuronium at the start of procedure.	Onset of reversal was not presented. Extubated without any complication.
Cárdenas and González (2013) [53]	Case report of a 20-day-old neonate (2.65 kg) Case report of a 34-week-old neonate (3.2 kg)	12 mg of sugammadex used; end of surgery TOF 4 3 mg of rocuronium used at induction. 6 mg of sugammadex used; after extuabation. Total 2.6 mg of rocuronium used (1.8 mg at induction + 0.4 mg x 2 (20 min, 70 min). Extubation done at the end of the procedure (90 min) TOF T4/T1 ratio < 25%	T4/T1 100% after 2 min. T4/T1 100% after 2 min.
Sarı et al. (2013) [55]	Retrospective study of infant (28 days–23 months, n = 24), children (2–11 years, n = 16), adolescent (11–17 years, n = 6) (ASA I-II)	Sugammadex dose was not presented. 0.6 mg/kg of rocuronium used.	Mean extubation time. : 56.5 (infant group), 84.5 (child group) and 77.4 (adolescent group) s. No side effects specific to this infant group were reported.
Alonso et al. (2014) [56]	Neonates; 1 day (n = 8, mean weight 2.8 kg), 1–7 days (n = 15, mean weight 2.4 kg)	Fixed dose of 4.0 mg/kg of sugammadex used; at the end of surgery : NMB monitoring showed profound NMB in all patients. Total 1.6 mg (1 day group)/1.4 mg (1–7 day group) of rocuronium used.	TOF ratio recovered to 0.9 within a few minutes. Mean recovery time: 1.4 min (1-day group), 1.2 min (1–7 day group). Residual curarization or re-curarization was not observed. Adverse events and changes in vital signs were not observed.
Lang et al. (2022) [3]	Meta-analysis of 0–18 year-old children (ASA I–III)	2–4 mg/kg of sugammadex used. (only 1 study using a sugammadex dose of 0.5 mg, 1 mg, 2 mg, or 4 mg) 0.6 mg/kg Rocuronium used. NMB monitoring used.	Satisfactory and rapid NMB reversal with low incidences of adverse events. : Shorter duration from administration of reversal agents to TOF ratio > 0.9. : Shorter interval from reversal from NMBA to extubation. : Less incidence of PONV, bradycardia, dry mouth.

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Table 1. Continued

Study (reference)	Patient information	Sugammadax dose	Study information
Benigni et al. (2013) [59]	34 children; 2 months to 8 years (5–28 kg) (ASA I–III)	Fixed dose of 4 mg/kg of sugammadex used; at the end of the procedure : All children still had a deep NMB (PTC 2) 0.6 mg/kg Rocuronium used at induction.	All achieved TOFr > 0.9 after sugammadex administration. : Recovery time,104 s. Successfully recovery without notable side effects.
Saber et al. (2021) [60]	Randomized trial of age < 2 years with congenital heart diseases; n = 25 (ASA I–III)	Fixed dose of 4 mg/kg sugammadex used when T2 reappeared. 0.6 mg/kg Rocuronium used at induction (0.2 mg/kg rocuronium every 20 min).	Recovery time (T2 ~TOF 90% achieved) was significantly shorter with sugammadex. : 1.61 min (sugammadex group) vs. 9.23 min (neostigmine group). No significant postoperative complications.

ASA: American Society of Anesthesiologists physical status, OR: operating room, TOF: train-of-four, PTC: post-tetanic count, NMB: neuromuscular blockade, NMBA: neuromuscular blocking agent, PONV: postoperative nausea and vomiting.

age of 2 years [50]. Although its safety and efficacy in this age group have not been conclusively established, the limited data do not show any unique side effects of sugammadex in infants and neonates compared to those in older children. Franz et al. [51] reported the use of sugammadex in 331 patients under two years of age, including 53 neonates, with the youngest patient being two days old. The doses of sugammadex used were 2 mg/kg in 223 infants, 4 mg/kg in 98 infants, and 16 mg/kg in 10 infants. No adverse effects were observed in any of the patients [51]. Other studies have reported similar results in neonates and infants with no adverse effects of sugammadex (2–16 mg/kg) [9,52-57]. One of these case reports included the successful use of sugammadex in a preterm infant weighing 850 g [52]. The infant received 1.2 mg/kg of rocuronium and experienced ventilation difficulties. The infant recovered spontaneous ventilation after receiving 16 mg/kg sugammadex. A recent meta-analysis, although stating the need for additional studies, also demonstrated rapid recovery without any significant increase in adverse effects when using sugammadex (2 or 4 mg/kg) in neonates and infants [3].

Compared with older children, the optimal dose required for neonates and infants has not been clearly established. One prospective trial enrolled infants aged 28 days to 23 months to receive one of four doses of sugammadex (0.5, 1, 2, or 4 mg/kg) but did not specify whether dosing differed from the older pediatric groups [58]. Another study reported rapid recovery without significant side effects when using a fixed dose of 4 mg/kg sugammadex to reverse deep NMB in 34 children aged 2 months to 8 years [59]. A recent randomized clinical trial conducted in pediatric patients under 2 years of age with congenital heart diseases also reported similar results [60].

Based on the limited data, it is possible that the use of doses previously approved for older pediatric patients may also be appropriate for neonates and infants. However, additional research is still needed on sugammadex dosing and safety profile, specifically in this youngest age group.

PEDIATRIC PATIENTS WITH NEUROMUSCULAR DISORDERS OR CONGENITAL HEART DISEASES

Recent evidence also supports the use of sugammadex in infants and children with neuromuscular disorders (NMDs) or congenital heart disease.

Patients with neuromuscular disorders

In patients with NMDs, the use of NMBAs can present significant risks, including prolonged residual neuromuscular block and respiratory complications. These patients often demonstrate heightened sensitivity or unpredictable responses to NMBAs, which can extend the effects of the drug and elevate the risk of postoperative respiratory failure due to weakened respiratory muscles [61,62].

The general principle of anesthesia for patients with NMDs is to use NMBAs only when absolutely necessary. Nevertheless, NMBAs are frequently required to maintain airway safety, prevent involuntary movements, and create optimal surgical conditions [61,63,64]. Thus, rather than limiting the use of NMBAs in such patients, the focus should be on effectively reversing the NMB. Since succinylcholine should be avoided owing to the potential risks in

these patients, non-depolarizing NMBAs such as rocuronium and vecuronium are preferred. Sugammadex, with its rapid and complete reversal profile, may be a suitable choice for patients with NMDs [62,65]. Previous studies have demonstrated its successful use in adult patients with NMDs [66,67], and similar results are emerging in pediatric populations.

Successful reversal of NMB has been reported in two patients aged 11 and 9 years with Duchenne muscular dystrophy under NMB monitoring [68,69]. At the end of surgery, NMB monitoring showed deep NMB, and the patients received 2 mg/kg and 4 mg/kg of sugammadex, respectively. Both patients recovered from anesthesia without complications. In another case report, a 12-year-old patient with myasthenia gravis achieved reversal within 120 s of receiving 2 mg/kg sugammadex [70]. Additionally, a 7-year-old patient with Ullrich's disease successfully recovered from deep NMB following administration of 4 mg/kg sugammadex [71].

In all of the above cases, patients fully recovered without adverse effects after receiving 2–4 mg/kg sugammadex with NMB monitoring. This finding suggests that a standard dose of 2–4 mg/kg sugammadex may be acceptable for pediatric patients with NMDs. However, determining the optimal dose for this population remains challenging. In a 14-month-old patient with congenital myotonic dystrophy type 1 (MD 1) who received 0.8 mg/kg of rocuronium, NMB persisted for 57 minutes without spontaneous recovery of neuromuscular function (TOF count of 0). Initially, 5 mg/kg sugammadex was administered; however, effective reversal was only achieved after the administration of an additional 5 mg/kg dose [72]. Therefore, sugammadex doses in pediatric patients with NMDs should be carefully adjusted. Additionally, quantitative NMB monitoring is strongly recommended to ensure complete reversal and adequate postoperative monitoring, despite the use of sugammadex [62,65].

Patients with congenital heart diseases

A recent review on the use of sugammadex in pediatric patients with congenital cardiovascular diseases reported a 20% incidence of bradycardia after administration, with no cases requiring additional treatment [32]. A randomized controlled study demonstrated the benefits of 4 mg/kg sugammadex for fast-track surgery in children undergoing cardiac surgery, noting shorter extubation times and reduced postoperative atelectasis compared to neostigmine [73]. Another randomized study also reported rapid and effective reversal without side effects using a 4 mg/kg sugammadex dose in infants with congenital heart disease. In this study, the hemodynamic profile was superior in the sugammadex group than in the neostigmine group [60]. These findings indicate that sugammadex offers a valuable option for fast-track anesthesia and surgery in this population, potentially reducing complications and hospital stays and underscoring the need for individualized anesthetic management.

Similar to neonates and infants, although there is no explicit dose recommendation for children with congenital diseases, evidence suggests that a standard dose of 2–4 mg/kg sugammadex may be effective in this population with appropriate monitoring. However, as mentioned above, although extremely rare, circulatory collapse can occur in patients with congenital heart disease [30,31]. Thus, individualized dosing and careful monitoring are required, as there may be variability in the response in patients with congenital diseases or other comorbidities.

CONCLUSION

Drawing a definitive conclusion on the use of sugammadex in pediatric patients is challenging owing to the wide age spectrum. Although approved for patients over 2 years of age, anesthesiologists must be aware of the potential risks of sugammadex in young patients. Importantly, despite not being approved, recent studies have indicated that the efficacy and safety of sugammadex are not significantly different in neonates and infants. However, most studies on safety and efficacy in this age group are retrospective, case-based, or observational, and have inherent limitations. Therefore, further prospective studies are crucial to establish the safety and efficacy of sugammadex.

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CONFLICTS OF INTEREST

No potential conflict of interest relevant to this article was reported.

DATA AVAILABILITY STATEMENT

The datasets generated during and/or analyzed during the current study are available from the corresponding author on reasonable request.

AUTHOR CONTRIBUTIONS

Writing - original draft: Soomin Lee, Woosuk Chung. Writing - review & editing: Soomin Lee, Woosuk Chung. Conceptualization: Soomin Lee, Woosuk Chung. Methodology: Soomin Lee, Woosuk Chung. Visualization: Soomin Lee, Woosuk Chung. Investigation: Soomin Lee. Supervision: Woosuk Chung. Validation: Soomin Lee, Woosuk Chung.

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