In summary, this meta-analysis suggests that the PVI could be an accurate predictor of fluid responsiveness in children under mechanical ventilation in the operating theatre. In the future, this non-invasive haemodynamic monitoring tool could be incorporated into an intraoperative fluid management algorithm in the paediatric population. However, given the low number of studies and participants and the heterogeneity among studies in terms of sensitivity, additional studies are required to confirm our findings before recommending the PVI for routine assessment of fluid responsiveness in children.

**Declaration of interest**
None declared.

**References**

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**Improved postoperative oxygenation after antagonism of moderate neuromuscular block with sugammadex versus neostigmine after extubation in ‘blinded’ conditions**

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Editor—Neuromuscular blocking agents are routinely used during general anaesthesia to optimize intubation and improve surgical conditions. For example, we recently showed that a deep neuromuscular block (NMB) improves the quality of the surgical field in retroperitoneal laparoscopic surgery.¹ The persistence of some level of NMB (residual relaxation defined by a train-of-four (TOF) ratio <0.9) during and after extubation is an independent risk factor for postoperative pulmonary complications, with hypoxaemia as most the frequent event.²⁻³ In order to assess whether the practice of NMB antagonism has an effect on residual NMB and oxygenation levels in the postanaesthesia care unit (PACU), we conducted a multicentre, double-blind, randomized controlled trial (with acronym NEUROPA) comparing the effect of antagonism of a moderate NMB (TOF one to two twitches) with sugammadex 2 mg kg⁻¹ vs neostigmine 2.5 mg on oxygen saturation (SpO₂) values in the PACU. The use of neostigmine 1–2.5 mg is currently the standard of practice in the two hospitals where this study was conducted (Leiden University Medical Center, Leiden and HagaZiekenhuis, The Hague, The Netherlands). In order to obtain an indication of the oxygenation status of the patients in the PACU without the confounding effects of supplemental oxygen, the application of an oxygen mask was not allowed unless SpO₂ was <94%. The study was registered (ClinicalTrials.gov NCT02243943), approved by the local ethics committees, and all patients gave written informed consent before participation. All patients received total i.v. anaesthesia (propofol, sufentanil, and rocuronium); the level of NMB was kept at one to two twitches in the TOF. After antagonism, the attending anaesthetist was blinded to the TOF monitor, and extubation was based on clinical grounds (head lift, hand grip, open eyes, tongue protrusion, etc.).

One hundred patients were randomized, with 50 patients in each group. The attending anaesthetist decided that after antagonism, eight patients required one additional neostigmine dose of 1 mg; three others received a dose of sugammadex after their initial neostigmine dose. None of the patients who initially received sugammadex required additional treatment. The mean T4/T1 TOF ratio (95% confidence interval) at extubation was 0.74 (0.71–0.83) in the neostigmine group vs 0.99 (0.98–1.00) in the sugammadex group (P < 0.0001). Thirty-five (70%) patients treated with neostigmine had a TOF ratio <0.9 upon extubation vs two (4%) of the patients treated with sugammadex. The lowest SpO₂ in the PACU was 93.3 (91.9–94.7)% in the neostigmine group vs 96.8 (96.1–97.4)% in the sugammadex group (P < 0.0001). Figure 1 shows the individual lowest saturation value in the PACU vs TOF ratio at extubation. In the sugammadex group, 90% of the patients were in the upper right quadrant of the graph (TOF ratio >0.9 combined with lowest saturation ≥94%) vs 16% of patients treated with neostigmine. In the PACU, no significant differences in sedation and pain scores were observed. No adverse events occurred. Low SpO₂ values are not uncommon in the PACU and are related to multiple factors, including the residual effects of opioids and anaesthetics, type of surgery, patient characteristics,
underlying disease, use of recruitment manoeuvres, and the fractional inspired O₂ during anaesthesia and recovery. As these factors were either evenly distributed between the two treatment groups or tightly controlled according to protocol, we hold the intervention (sugammadex vs neostigmine) responsible for the large difference in \( \text{SpO}_2 \) distribution in the PACU. Our findings indicate that the choice of NMB antagonistic agent has a significant effect on postoperative recovery. The difference between treatments was, however, relatively small (3.5%) because we administered supplemental oxygen when \( \text{SpO}_2 \) decreased below 94%. Evidently, this was done to prevent any harm to the patient. The use of supplemental oxygen and the relatively low neostigmine dose is standard of practice in most hospitals in Europe. It is possible that higher neostigmine doses might have improved \( \text{SpO}_2 \) values in the PACU. However, it is our experience that higher neostigmine doses come at the expense of uncomfortable cholinergic side-effects, such as nausea, vomiting, abdominal cramps, and blurred vision.

In conclusion, we show that the selection of antagonistic agent has a significant effect on postoperative respiratory conditions. Our data confirm the need for monitoring of neuromuscular function upon extubation.

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