

nonnormalized TOF ratio of 1.0 or greater as an acceptable criterion to exclude a residual NMB.<sup>2</sup> Also, we calculated the normalized TOF ratios at recovery, which were around 1.0, as well. Normalization (dividing TOF fade ratios at recovery with those before administration of rocuronium) was necessary because control TOF ratios with acceleromyography often exceeded unity, biasing the results of recovery.<sup>3</sup> For instance, when the TOF ratio recovers to 1.0, but the control TOF ratio is 1.18, the normalized TOF ratio will be 0.84 (1.0/1.18), which is insufficient. There is general agreement that a normalized TOF ratio of 0.9 or greater is required to exclude clinically significant residual paralysis.<sup>2,3</sup> Furthermore, the changes of single-twitch height should also be measured during neuromuscular monitoring and should exceed a value of 90% of control for neuromuscular recovery to be considered as acceptable.<sup>4</sup> However, to date the majority of investigations have not described the changes of T1 single twitches. Considering all these factors, we do agree with Dr. Carron's suggestion that there is place for improvement of the current practice of neuromuscular monitoring and research.

Second, Dr. Carron estimates that 1.0 mg/kg of sugammadex is not as safe as 2.0 mg/kg in reversing a threshold TOF count 4 residual NMB and therefore suggests the administration of 2.0 mg/kg in this situation. There is no evidence for this suggestion. We have demonstrated that 1.0 mg/kg like 2.0 mg/kg of sugammadex effectively reverses rocuronium-induced NMB when administered at the reappearance of four twitches during TOF stimulation.<sup>1</sup> Recurrent muscle paralysis did not occur in our patients. Dr. Carron argues that the safety margin of neuromuscular transmission (70 to 75% of postsynaptic acetylcholine receptors) cannot be liberated from the rocuronium molecules when lower than 2.0 mg/kg sugammadex is administered. This assumption, although attractive, is not supported by any evidence. It is logical that at a TOF count 4 level of block fewer rocuronium molecules are present at the neuromuscular synapse than at a TOF count 2 level of block, where 2.0 mg/kg of sugammadex is the recommended dose. Because the encapsulation of rocuronium by sugammadex is a one-to-one molecular interaction,<sup>5</sup> one may hypothesize that the shallower the depth of block the fewer sugammadex molecules are necessary to encapsulate all of the free rocuronium molecules and to relieve the pre- and postsynaptic acetylcholine receptors. Our results support this assumption. However, a caveat is in order: unless the amount of sugammadex is sufficient for the encapsulation of almost all rocuronium molecules, agents that decrease acetylcholine release at the motor nerve terminal (*i.e.*, magnesium or aminoglycoside antibiotics) may cause recurarization. It may therefore be prudent not to give inadequately low doses of sugammadex (0.25 or 0.5 mg/kg) in patients who had received these agents. Quantifying the proportion of receptor occupancy after recommended and lower doses of sugammadex requires further research.

We estimate that adequate use of low doses of sugammadex is safe and may contribute to its widespread use by reducing the expenses of the treatment.

### Competing Interests

The authors declare no competing interests.

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## Influence of Body Mass Index and Epidural Anesthesia on Lung Function

### To the Editor:

I read with interest the report by Severgnini *et al.*<sup>1</sup> in which they describe that the protective mechanical ventilation improves postoperative pulmonary function in patients undergoing open abdominal surgery with general anesthesia. However, we wish to raise two concerns which may undermine the clinical validity of the authors' conclusions.

First, the authors state that the exclusion criteria included patients with body mass index greater than 40 kg/m<sup>2</sup>. It means that the inclusion criteria included patients with body mass index 40 kg/m<sup>2</sup> or less, and obese patients (mildly obese: body mass index 25–30; obese: body mass index >30) were also included in this study. Obesity is a risk factor for perioperative pulmonary complications as the pathophysiological changes induced by obesity may jeopardize respiratory function and contribute to pulmonary morbidity, such as hypoxemia, hypercapnia, and atelectasis.<sup>2</sup> In addition, obesity is an important risk factor for perioperative impairment of spirometric

measurements in patients undergoing laparotomy.<sup>3</sup> There is a significant negative correlation between perioperative spirometric tests and obesity. The reduction in postoperative lung volumes was significantly greater in obese patients than in normal-weight patients. Also, surgery with general anesthesia may reduce lung volumes and this effect may be greater in the obese patients.<sup>4</sup> So, we think the authors should give the information about the proportion of the obese patients in the two groups.

Second, the authors state that most patients underwent epidural anesthesia at the T8 to T12 level before general anesthesia and received continuous analgesia after surgery. High thoracic perioperative epidural anesthesia was shown to decrease spirometric measurements by blocking intercostal muscle innervation.<sup>5</sup> Even if low concentrations of local anesthetics are used, the sensory levels of epidural anesthesia extending from approximately T4 to L1 are likely to be accompanied by some degree of muscle paralysis.<sup>6</sup> It is more likely to block the muscles of the abdominal wall (innervation T6–L1). Even a subtle decrease in abdominal muscle tone will affect dynamic parameters. To avoid the influence of the epidural anesthesia on spirometric measurements, we think it is necessary to perform a pulmonary functional test after the epidural anesthesia. Or else, the authors should give the information about the epidural anesthesia including the dose of the local anesthetics, the direction of the epidural catheter, and the plane of the epidural anesthesia.

### Competing Interests

The authors declare no competing interests.

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## Association between Intraoperative Ventilation Strategies and Postoperative Pulmonary Outcomes in Surgical Patients

### To the Editor:

In a small-sample, randomized, clinical trial comparing standard and protective ventilation strategies in patients with normal lung function undergoing elective laparotomy, Severgnini *et al.*<sup>1</sup> showed that a protective ventilation strategy during surgery improved the postoperative respiratory function and reduced the clinical signs of postoperative pulmonary infection. Other than strict inclusion and exclusion criteria of patients, the authors should also be applauded for trying to control most of preoperative and intraoperative risk factors that may affect the postoperative respiratory function and pulmonary complications, such as age, body mass index, American Society of Anesthesiologists classification, history of smoking, type of surgery, anesthetic protocol, antibiotic prophylaxis, blood transfusion, intraoperative complications, uses of postoperative analgesia and physiotherapy, and many more.<sup>2,3</sup> However, to differentiate the effect of one factor on postoperative pulmonary outcomes, all of the other factors have to be standardized. In this study, several important issues were not addressed.

First, perioperative hemoglobin levels are not included in data analysis. Preoperative anemia is common among surgical patients. In a previous study including 227,425 noncardiac surgery patients, 69,229 patients (30.4%) have preoperative anemia, of whom 57,870 (83.6%) are mild anemic and 11,359 (16.4%) are moderate-to-severe anemic.<sup>4</sup> It has been shown that preoperative anemia is independently associated with the postoperative pulmonary complications.<sup>5</sup> Furthermore, low preoperative and postoperative hemoglobin levels are associated with increased perioperative mortality, increased postoperative pneumonia, and increased hospital length of stay.<sup>6</sup>

Second, there was no mention of serum albumin level. A low serum albumin level has been shown to be an important predictor of pulmonary complications after major noncardiac surgery.<sup>7</sup> According to the guideline of the American College of Physicians on risk assessment for and strategies to reduce perioperative pulmonary complications for patients undergoing noncardiothoracic surgery, serum albumin should be measured in all patients who are clinically suspected of having hypoalbuminemia and in those with one or more risk factors of postoperative pulmonary complications.<sup>2</sup>

Third, the authors did not describe use of nasogastric tubes although 63 to 71.4% of the study population underwent gastrointestinal surgery. A meta-analysis examined evidence from studies regarding selective and routine use of nasogastric tube for gastrointestinal decompression after elective laparotomy and showed that patients receiving selective use of nasogastric tube had a significantly decreased incidence of postoperative pneumonia and atelectasis.<sup>8</sup>