

CORRESPONDENCE

Respiratory benefits of deep neuromuscular block during laparoscopic surgery in a patient with end-stage lung disease

Editor—Anaesthetic management of patients with end-stage lung disease undergoing surgery is challenging, and certain aspects have not been well clarified.^{1 2} Specifically, it is not clear how changing the level of neuromuscular block (NMB) affects the respiratory system during laparoscopic surgical procedures. We, therefore, report our experience with a 24-yr-old woman (weight, 60 kg; height, 168 cm) undergoing laparoscopic appendectomy. The patient had α -1 antitrypsin deficiency (AATD), which led to emphysema. She also suffered from respiratory infections (bronchiectasis) and recurrent pneumothorax. The last pneumothorax occurred 1 month before surgery and was treated by tube drainage and pleurodesis. The patient received non-invasive ventilation while waiting for a lung transplant because of the end-stage lung disease. Preoperative arterial blood analysis showed pH 7.35, partial pressure of oxygen (P_{aO_2}) 8.2 kPa, partial pressure of carbon dioxide (P_{aCO_2}) 5.9 kPa, and P_{aO_2} (mm Hg)/fraction of inspired oxygen (F_{iO_2}) 220.

Anaesthesia was induced with fentanyl 3 μ g kg⁻¹, propofol 3 mg kg⁻¹, and rocuronium 1 mg kg⁻¹. Tracheal intubation was easily performed. The patient's lungs were ventilated with a 35/65 oxygen/air mixture delivered in the pressure-regulated volume control mode (FLOW-i[®] Ventilator, MAQUET Medical System, Italy). During pressure-regulated volume control, the FLOW-i[®] ventilator adjusts the inspiratory pressure control to the lowest possible level to guarantee delivery of the preset tidal volume, in accordance with the mechanical properties of airways, lungs, and thorax. Ventilation was first set at inspiratory tidal volume 6 ml kg⁻¹, respiratory rate 10 bpm, inspiratory-to-expiratory ratio 1:2, and PEEP 3 cm H₂O. Ventilation was adjusted to achieve a better respiratory pattern (Table 1). Because of a high risk of barotrauma, recruitment manoeuvres were not performed. The automatic gas control of the ventilator allowed minimal flow anaesthesia (0.3 litre min⁻¹).

Anaesthesia was maintained with desflurane (end-tidal concentration 5.2%, corresponding to a minimum alveolar concentration of 0.9) and remifentanyl 0.1–0.15 μ g kg⁻¹ min⁻¹ to ensure a BIS value of 35. Neuromuscular monitoring of the adductor pollicis muscle was conducted by acceleromyography (TOF-Watch[®] SX, Organon Teknik, Ireland). Stabilization, calibration, and baseline responses were recorded at the time of anaesthesia induction before rocuronium administration, and neuromuscular monitoring continued until the train-of-four (TOF) ratio returned to ≥ 1.0 . NMB was maintained with boluses of rocuronium after the intubating dose (total dose 90 mg).

Laparoscopic surgery started after abdominal insufflation of carbon dioxide (carboperitoneum). The intra-abdominal

pressure was 1.3 kPa, which allowed an adequate surgical view. The respiratory pattern during laparoscopy varied according to the level of NMB (Table 1). Cardiovascular parameters were stable throughout the surgical procedure. After an uneventful surgery, remifentanyl was discontinued. Ondansetron 4 mg and ketoprofen 100 mg were given for postoperative nausea/vomiting and pain prophylaxis. Sugammadex 4 mg kg⁻¹ was administered to reverse the deep rocuronium-induced NMB. Complete NMB reversal [from 5 post-tetanic counts (PTCs) to a TOF ratio of 1.12] was achieved in 80 s. Desflurane was then discontinued, the patient awakened, and the tracheal tube was removed 6 min later. The patient did not have pain, postoperative nausea/vomiting, or signs of respiratory failure or residual NMB in the post-anaesthesia care unit. The patient was discharged to the surgical ward 2 h later.

AATD is an under-recognized genetic condition that affects approximately one in 2000 to one in 5000 individuals.³ α -1 antitrypsin, which is produced mainly in the liver, protects the lung against proteolytic damage (i.e. from neutrophil elastase);³ therefore, individuals with AATD are predisposed to bronchiectasis and early-onset emphysema.³ Panacinar emphysema is often seen with AATD,³ but panacinar and centrilobular emphysema may coexist.^{3 4} Although lung compliance is generally increased with panacinar emphysema,^{3 4} it may be unexpectedly decreased with a predominantly centrilobular type.⁴ In end-stage lung disease, hypoxaemia and hypercapnia may be present,^{3 4} increasing the risk of perioperative respiratory complications.^{5 6} Carboperitoneum in laparoscopic surgery increases intra-abdominal pressure and pushes the diaphragm upwards, thereby increasing peak airway pressure and decreasing both lung and chest wall compliance.^{7 8} Conversely, reducing intra-abdominal pressure decreases airway pressure and improves respiratory system compliance.⁸ Deepening the level of NMB may be also useful, because it increases muscle relaxation and reduces chest wall stiffening.⁸ PTC monitoring can be used to determine the degree of relaxation in muscles of the thorax and abdomen, including the diaphragm, which is the most resistant to NMB.⁹ PTC ≤ 5 indicates adequate NMB, even for the diaphragm.⁹ Compared with moderate or shallow NMB, deep NMB with a low insufflation pressure during carboperitoneum facilitates lung recruitment and gas exchange, decreases inflammatory mediator release, respiratory system elastance, and lung hyperinflation,^{8 10} reduces cardiac dysfunction,⁷ improves the quality of surgical conditions,¹¹ and decreases postoperative pain intensity, incidence of shoulder pain, and analgesic consumption.¹² Sugammadex can be used to reverse deep rocuronium-induced NMB at the end of surgery.^{7 11} In patients with lung disease, reversal of rocuronium-induced NMB with sugammadex was shown to be safe, quick, and effective.^{5 6}

Table 1 Intraoperative ventilation parameters and arterial blood gas analysis in a patient with end-stage lung disease due to AATD undergoing laparoscopic surgery. BMV, beginning of mechanical ventilation performed in pressure-regulated volume control (PRVC) mode; EMV, end of mechanical ventilation performed in PRVC mode; BCP, beginning of carboperitoneum; ECP, end of carboperitoneum; P_{peak} , peak pressure; P_{plateau} , plateau pressure; PEEP, positive end-expiratory pressure; V_t , tidal volume; RR, respiratory rate (bpm); $I:E$ ratio, inspiratory time:expiratory time ratio; E , elastance; C_{stat} , static compliance; C_{dyn} , dynamic compliance; T_c , time constant (expiration); $F_{\text{I}_{\text{O}_2}}$, fraction of inspired oxygen; $P_{\text{a}_{\text{O}_2}}$, partial pressure of oxygen; Sa_{O_2} , arterial oxygen saturation; IAP, intra-abdominal pressure during CP; NMB, neuromuscular block; PTC, post-tetanic count. The MAQUET FLOW-i® anaesthesia ventilator automatically displays some measured parameters, but other parameters (i.e. P_{plateau} , E , C_{stat} , T_c , total PEEP) require a 5 s inspiratory hold, 5 s expiratory hold, or both

	BMV	10 min	20 min	BCP	10 min	20 min	30 min	40 min	50 min	60 min	ECP	EMV
RR (bpm)	10	10	10	10	10	10	10	10	10	10	10	10
V_t (ml kg^{-1})	6	7	8	8	8	8	8	8	8	8	8	8
$I:E$ ratio	1:2	1:2	1:2	1:2	1:2	1:2	1:2	1:2	1:2	1:2	1:2	1:2
P_{peak} (cm H_2O)	18	19	21	24	24	24	24	23	24	24	19	20
P_{plateau} (cm H_2O)	16	17	19	21	22	21	21	21	22	21	17	18
PEEP (cm H_2O)	3	3	5	5	5	5	5	5	5	5	5	5
E (cm H_2O litre $^{-1}$)	42	34	26	49	51	49	44	41	36	33	22	22
C_{stat} (ml cm H_2O^{-1})	24	29	39	21	19	21	23	25	28	30	45	45
C_{dyn} (ml cm H_2O^{-1})	22	30	35	18	18	19	21	22	26	28	39	39
T_c (s)	0.48	0.52	0.61	0.41	0.39	0.4	0.44	0.47	0.52	0.58	0.79	0.89
$F_{\text{I}_{\text{O}_2}}$	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35
pH	7.35	7.38	7.4	7.39	7.38	7.39	7.39	7.4	7.4	7.4	7.41	7.41
$P_{\text{a}_{\text{O}_2}}$ (kPa)	13.1	15.1	15.7	14.3	13.8	14.5	14.9	16.4	18.1	18.8	19.7	19.8
$P_{\text{a}_{\text{CO}_2}}$ (kPa)	5.7	5.4	5.2	5.4	5.5	5.4	5.3	5.3	5.1	5.1	5	5
Sa_{O_2} (%)	97.2	98.2	98.5	98.1	97.7	97.9	98.1	98.6	98.8	99	99	99.1
$P_{\text{a}_{\text{O}_2}}$ (mm Hg)/ $F_{\text{I}_{\text{O}_2}}$	282	325	337	308	297	308	320	351	388	402	422	423
IAP (mm Hg)	0	0	0	10	10	10	10	10	10	10	0	0
NMB level (PTC)	0	1	3	5	8	0	1	2	4	1	3	5

In conclusion, deep NMB improves respiratory patterns and should be recommended in high-risk respiratory patients undergoing laparoscopic surgery.

Declaration of interest

M.C. has received payments for lectures from Merck Sharp & Dohme (MSD), Italy.

M. Carron

Padova, Italy

E-mail: michele.carron@unipd.it

- Hillier J, Gillbe C. Anaesthesia for lung volume reduction surgery. *Anaesthesia* 2003; **58**: 1210–9
- Grichnik KP, Hill SE. The perioperative management of patients with severe emphysema. *J Cardiothorac Vasc Anesth* 2003; **17**: 364–87
- Stoller JK, Aboussouan LS. A review of α_1 -antitrypsin deficiency. *Am J Respir Crit Care Med* 2012; **185**: 246–59
- Saetta M, Kim WD, Izquierdo JL, Ghezzi H, Cosio MG. Extent of centrilobular and panacinar emphysema in smokers' lungs: pathological and mechanical implications. *Eur Respir J* 1994; **7**: 664–71
- Porter MV, Paleologos MS. The use of rocuronium in a patient with cystic fibrosis and end-stage lung disease made safe by sugammadex reversal. *Anaesth Intensive Care* 2011; **39**: 299–302
- Amao R, Zornow MH, Cowan RM, Cheng DC, Morte JB, Allard MW. Use of sugammadex in patients with a history of pulmonary disease. *J Clin Anesth* 2012; **24**: 289–97
- Carron M, Gasparetto M, Vindigni V, Foletto M. Laparoscopic surgery in a morbidly obese, high-risk cardiac patient: the benefits of deep neuromuscular block and sugammadex. *Br J Anaesth* 2014; **113**: 186–7
- Valenza F, Chevillard G, Fossali T, Salice V, Pizzocri M, Gattinoni L. Management of mechanical ventilation during laparoscopic surgery. *Best Pract Res Clin Anaesthesiol* 2010; **24**: 227–41
- El-Orbany MI, Joseph NJ, Salem MR. The relationship of post-tetanic count and train-of-four responses during recovery from intense cisatracurium-induced neuromuscular blockade. *Anesth Analg* 2003; **97**: 80–4
- Greenberg SB, Vender J. The use of neuromuscular blocking agents in the ICU: where are we now? *Crit Care Med* 2013; **41**: 1332–44
- Martini CH, Boon M, Bevers RF, Aarts LP, Dahan A. Evaluation of surgical conditions during laparoscopic surgery in patients with moderate vs deep neuromuscular block. *Br J Anaesth* 2014; **112**: 498–505
- Gurusamy KS, Samraj K, Davidson BR. Low pressure versus standard pressure pneumoperitoneum in laparoscopic cholecystectomy. *Cochrane Database Syst Rev* 2009; **15**: CD006930

doi:10.1093/bja/aeu419