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Recruitment of lung volume during surgery neither affects the postoperative spirometry nor the risk of hypoxaemia after laparoscopic gastric bypass in morbidly obese patients: a randomized controlled study

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Editor's key points

- General anaesthesia causes a reduction in functional residual capacity (FRC) that can last several days.
- Obese patients can suffer more profound changes than non-obese patients.
- Recruitment manoeuvres reverse the reduction in FRC during the intraoperative phase.
- The current study investigated whether this improvement persists into the postoperative phase in obese patients.

Background. Intraoperative recruitment manoeuvres (RMs) combined with PEEP reverse the decrease in functional residual capacity (FRC) associated with anaesthesia and improve intraoperative oxygenation. Whether these benefits persist after operation remains unknown. We tested the hypothesis that intraoperative RMs associated with PEEP improve postoperative spirometry including FRC and reduce the incidence of postoperative hypoxaemia in morbidly obese (MO) patients undergoing laparoscopic gastric bypass.

Methods. After IRB approval and informed consent, 50 MO patients undergoing laparoscopic gastric bypass under volume-controlled ventilation (tidal volume 6 ml kg^{-1} of IBW) were randomly ventilated with either 10 cm H_2O PEEP or with 10 cm H_2O PEEP and one RM carried out after induction of pneumoperitoneum, and another after exsufflation. Anaesthesia and analgesia were standardized. Spirometry was assessed before operation and 24 h after surgery. Postoperative oxygenation and the apnoea–hypopnoea index (AHI) were recorded during the first postoperative night.

Results. Age, BMI, and STOP BANG score were similar in both groups. FRC decrease after surgery was minimal [0.15 (0.14) litre in control and 0.38 (0.19) litre in the RM group] and similar between the groups (P=0.35). FVC, FEV_1, mean Sp_{O_2}, percentage of time spent with Sp_{O_2} below 90%, and AHI did not differ significantly between the groups.

Conclusions. This study demonstrates that when added to a protective mechanical ventilation combining low tidal volume and high PEEP, two RMs do not improve postoperative lung function including FRC, arterial oxygenation, and the incidence of obstructive apnoea in MO patients after laparoscopic upper abdominal surgery.

Clinical trial registration. EudraCT 2011-000999-33.

Keywords: anaesthesia; functional residual capacity; obesity; pulmonary ventilation

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General anaesthesia decreases functional residual capacity (FRC) and causes atelectasis.[1 2] After upper abdominal surgery, FRC remains decreased in the immediate postoperative period and then recovers slowly over several days.[3 4] Upper abdominal surgery is also associated with reductions in forced vital capacity (FVC) and forced expiratory volume after 1 s (FEV_1). However, the alteration in FRC is more clinically relevant since it can result in small airway closure and ventilation–perfusion mismatch, potentially leading to postoperative hypoxaemia and respiratory complications.[5]

Morbidly obese (MO) patients undergoing abdominal surgery under general anaesthesia develop more perioperative atelectasis than healthy subjects.[6] The decrease in lung volume secondary to obesity also favours velopharyngeal collapsibility, particularly in the case of pre-existing sleep-disordered breathing, a prevalent disorder in MO patients.[7] Further reduction in FRC such as after upper abdominal surgery[3 4] could therefore worsen episodes of upper airway obstruction in the case of sleep apnoea syndrome. Taken together, these perioperative pathophysiological ventilatory changes explain that MO patients

experience frequent episodes of postoperative hypoxaemia[8] and seem to be at increased risk of postoperative pulmonary complications.[9]

Different strategies have been proposed to reduce atelectasis: induction of anaesthesia in the head-up position without[10] or with a continuous positive airway pressure (CPAP)[11 12] and use of intraoperative PEEP.[13] However, the alveolar recruitment manoeuvre (RM) seems the most effective technique to reverse atelectasis.[13 14] In MO patients undergoing laparoscopic surgery, recruitment of lung volume during surgery improves intraoperative respiratory mechanics and oxygenation.[13 15 16] However, whether these benefits persist into the postoperative period is unknown.

We investigated the effect of an intraoperative alveolar recruitment strategy on postoperative FRC, and also on oxygenation and the incidence of obstructive apnoea during the first postoperative night in MO patients undergoing laparoscopic gastric bypass.

Methods

After approval by the Institutional Ethics Committee of Centre Hospitalier Universitaire de Liege (Liege, Belgium ; ref 2001-59: and registered with EudraCT 2011-000999-33), 50 consenting MO (BMI >35 kg m^{-2}) ASA physical status II–III patients were included in this randomized double-blind controlled study (see Fig. 1 for CONSORT trial profile). All patients had a laparoscopic gastric bypass performed in the morning between December 2011 and May 2012. Exclusion criteria were: age <18 and >65, preoperative diagnosis of obstructive sleep apnoea (OSA) syndrome using polysomnography (our policy is to use CPAP or BiPAP after operation in these patients), a history of pneumothorax or right heart failure, or surgery scheduled on Friday since the spirometry laboratory is closed on Saturday. Patients were withdrawn from the study and replaced in the case of protocol violation and if intraoperative RM were necessary because of pulse oximetry below 90%.

Randomization and blinding

Patients were assigned to one of the two groups using a reproducible set of computer-generated random numbers: the RM group and the control group without RM. Investigators involved in recording postoperative parameters and patients were blinded to treatment allocation.

Anaesthesia

Anaesthesia was standardized in all patients. Patients were orally premedicated with alprazolam 0.5 mg, ranitidine 150 mg, and domperidone 10 mg 1 h before surgery. When in the operating theatre, patients were given a 300 μg clonidine i.v. infusion over 10 min together with an i.v. infusion of 500 ml of Volulyte®, a balanced hydroxyethyl starch solution (Fresenius Kabi AG, Bad Homburg, Germany) to improve haemodynamic tolerance of head-up position, pneumoperitoneum, and RMs when used.[17] Anaesthesia was induced i.v. using 10 μg sufentanil, 100 mg lidocaine, propofol 2 mg kg^{-1} of IBW+40% of weight excess. Tracheal intubation was facilitated with succinylcholine 1 mg kg^{-1} of actual body weight. Anaesthesia was maintained with desflurane in an air:oxygen mixture with an $F_{I_{O_2}}$ of 0.8. After recovery from succinylcholine, muscle relaxation was maintained with rocuronium 0.6 mg kg^{-1} of IBW followed by a continuous infusion of rocuronium started at 7 μg kg^{-1} h^{-1} of IBW+40% of weight excess and titrated to keep a train of four of 0 until the end of the surgical procedure. At the end of surgery, neuromuscular block was antagonized using sugammadex 4 mg kg^{-1} of IBW+40% of weight excess. A continuous i.v. infusion of Plasmalyte®, a crystalloid solution (Baxter® SA, Lessines, Belgium), was administered at a rate of 4 ml kg^{-1} h^{-1} of IBW intraoperatively.

Ventilation

Ventilation was standardized in all patients. Before induction, preoxygenation and denitrogenation were obtained by vital capacity manoeuvres with an $F_{I_{O_2}}$ of 1.0 and using a 10 cm H_2O CPAP until the $F_{E_{O_2}}$ becomes >0.9 in patients in ramp position. After tracheal intubation, lungs were ventilated using volume-controlled ventilation with a tidal volume of 6 ml kg^{-1} of ideal body weight [IBW; IBW was calculated as the height (in cm) minus 100 in men and minus 105 in women] using an Aisys ventilator (GE Healthcare, Diegem, Belgium). The respiratory rate was adapted to maintain a $P_{E'_{CO_2}}$ between 4.7 and 6 kPa and a 10 cm H_2O PEEP was applied in all patients. In patients assigned to the RM group, two RMs consisting of maintaining the airway pressure at 40 mm Hg during 40 s[15] were performed, one 5 min after creation of the pneumoperitoneum (14 cm H_2O) and one 5 min after its exsufflation. At the end of surgery and after reversal of muscle relaxation, patients were allowed to awaken from anaesthesia in the head-up position breathing a mixture of air:oxygen with an $F_{I_{O_2}}$ of 0.8. After emergence from anaesthesia, patients were placed in their bed 30° upright and given oxygen via a non-rebreathing facemask with reservoir bag in the recovery room. Non-invasive positive pressure ventilation was not used after operation.

Postoperative analgesia

Patients received parecoxib 80 mg i.v. in the absence of contra-indication after the induction of anaesthesia. Paracetamol 2 g (Paracetamol, Fresenius Kabi AG) and tramadol 100 mg (Contramal®, Grunenthal, Sint-Stevens, Woluwe, Belgium) were administered i.v. 30–60 min before the end of surgery. Piritramide, a synthetic opioid (Janssen Pharmaceutica, Beerse, Belgium), was titrated in the recovery room to provide a pain score inferior to 3 on a 0–10 verbal scale. When in the ward, patients received paracetamol i.v. 1 g every 6 h and a continuous i.v. infusion of 400 mg tramadol over 24 h.

Measurements

The primary endpoint of this study was the change in FRC at postoperative day 1. FRC was measured at the time of preoperative assessment and at postoperative day 1 by closed-circuit helium dilution (FRC_{He}) and whole body plethysmography (FRC_{Pleth}) (Vmax™ Autobox, Carefusion Corporation, Torrey