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Research Article

Effect of low tidal volume during general anesthesia for urological procedures on lung functions

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KEYWORDS

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Abstract *Background:* Postoperative lung function impairment is common after surgery specially in the lateral decubitus position. Evidence suggests that if we use low tidal volume during mechanical ventilation this may limit post-operative lung injury. We compared post-operative lung functions in patients put in the lateral position when ventilated with low vs. high tidal volumes.

Methods: This prospective open label clinical trial was performed on 104 patients ASA I&II scheduled for elective urological operations done in the right or left lateral position expected to last more than 2 hours. Patients were divided into two groups: group L ventilated with 5–7 ml/kg tidal volume, with positive end expiratory pressure (PEEP) 10 cm H_2O and recruitment maneuver (RM) and group H ventilated with 10–12 ml/kg tidal volume with zero-end expiratory pressure and no recruitment maneuver. Pulmonary functions were measured pre-operatively and 6, 12, 24 hours after extubation.

Results: Better pulmonary functions were found in the first post-operative six hours in the low tidal volume group and significant difference was found in all parameters. FVC and FEV1/FVC were significantly higher in the low tidal volume group ($P = 0.000$) after 12 hours of extubation. After 24 hours we found significant difference in the predicted FEV1 and FVC and FEV1/FVC ratio ($P = 0.000$) being higher in the low tidal volume group.

Conclusion: In comparison with conventional mechanical ventilation using high tidal volume with zero PEEP and no RM: a lung protective strategy using low tidal volume with 5–10 cm H_2O PEEP and RM did improved lung functions in the first post-operative 24 hours. The overall postoperative follow up did not show significant difference between the two groups.

1. Introduction

The tidal volume is considered the main determinant of ventilation settings during general anesthesia. It is the key factor in volume controlled mechanical ventilation. Recently, the trend to use lower tidal volume during mechanical ventilation is expanding rapidly to decrease lung injury. Postoperative

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pulmonary complications, especially postoperative respiratory failure, are important causes of peri-operative morbidity and mortality [1–4]. Patients who are on mechanical ventilation during surgery experience varying degrees of postoperative lung function impairment, including decreased forced vital capacity (FVC) and forced expiratory volume in one second (FEV 1) which is reflected on the patient's outcome [5]. This is because risk factors for postoperative lung function impairment are many and the list includes the following: the duration, site, and technique of surgery [6,7]. After induction of general anesthesia atelectasis develops within minutes and is a direct source of intra-operative gas exchange abnormalities. These areas of atelectasis can be functionally restored in part by lung recruitment maneuver followed by a substantial level of PEEP, which has been demonstrated to improve intra-operative oxygenation [8]. High tidal volumes (10–15 ml/kg) over-distends non-atelectatic alveoli, in particular in nondependent lung areas. During surgery this may stress the non-atelectatic lung regions, triggering local inflammation [8,9]. The beneficial effects of lower tidal volumes in patients who are on short-term mechanical ventilation have been demonstrated in many studies [10,11]. These studies discussed these effects on patients lying supine. Alterations in distribution of pulmonary ventilation and perfusion are known to occur with change in position especially the lateral and prone positions [12] which is the *aim of this study* that is to evaluate the effect of low tidal volume on lung functions during mechanical ventilation for general anesthesia while patients lying in the lateral position.

2. Methods

This prospective, randomized, open label, clinical trial was performed in the department of anesthesia of Qena University Hospital, South Valley University along the year 2013. The trial was *registered prospectively* at the Australian & New Zealand clinical trial registry with the number ACTRN12614000100695. Written informed *consent* was taken from every patient included in the study. *Ethical* committee approval for this study was provided by the Ethics Committee of Qena faculty of medicine. (Chairperson Prof. Ahmad Abolyosr). Patients scheduled for elective non-laparoscopic urological operations under general anesthesia in *the left or right lateral* position (kidney position) expected to last $\geqslant$2 hours. Age of the patients ranged from 18 to 65 years with normal respiratory, hepatic, and cardiac functions and hemodynamically stable. We excluded patients with body mass index more than 30. We also excluded patients with history of chronic obstructive lung disease, asthma or sleep disorders, heavy smokers (more than 2 packs/day), previous lung surgery, or acute lung injury and lastly those patients with history of neuromuscular diseases or on medications that affect their respiratory system (see Figs. 1 and 2).

2.1. Assigning patients

Patients eligible for the study (104 patients) were randomly allocated into the two study groups as 52 patients per group using random allocation software (windows software, version 1.0, May 2004). The allocation ratio is 1:1, and the group identification paper was put in a sealed and opaque envelops to hide allocation.

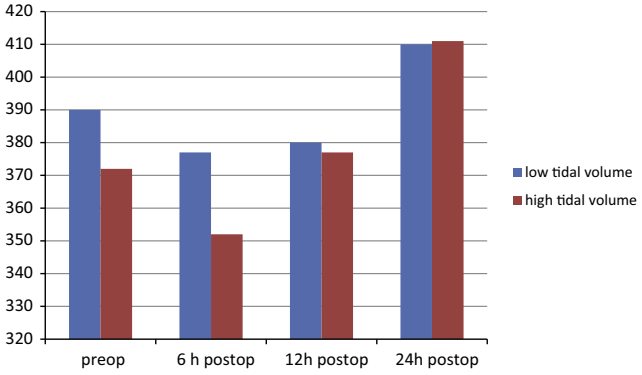

Figure 1 PaO_2/FiO_2 data are expressed as mean ± SD. *P* value is significant at preoperative and 6 hours postoperative time points.

2.2. Anesthesia

Before induction of general anesthesia and for the purpose of perioperative pain relief epidural catheter was inserted at the lumber 2–3 level whenever not contraindicated, otherwise systemic opioids in the form of repeated doses of 1–2 ug/kg fentanyl I.V. were used for pain relief. 34 patients were subjected for epidural catheter insertion. 16 patients were in the group of low tidal volume and 18 patients were in the group of high tidal volume. They received 10 ml lidocaine 2% and 10 ml bupivacaine 0.5% before induction of anesthesia. Postoperatively: 5 ml lidocaine 2% plus 50:100 ug fentanyl was administered through the catheter in repeated doses as guided by pain assessment score specially before spirometry. The rest of patients (70 patients) received systemic fentanyl. The major contraindication for epidural block was patient refusal. Induction and maintenance of general anesthesia were done by the same drugs in all patients in both groups. We used propofol (1%) in a dose of 2 mg/kg preceded by fentanyl 1–2 ug/kg I.V. Tracheal intubation was facilitated by using rocuronium 0.4–0.8 mg/kg I.V. Anesthesia was maintained by sevoflurane in oxygen (FiO_2 = 0.4) during the whole anesthesia period. Patients were monitored during anesthesia for heart rate, ECG, noninvasive blood pressure, pulse oximetry, end tidal carbon dioxide level (Nihon kohden, Japan). An arterial catheter was inserted in the radial artery near the wrist joint for arterial sample withdrawal for blood gas analysis, also a central venous line was inserted in the right or left internal jugular vein in all patients. We followed a conservative fluid infusion of 12–15 ml/kg/h during the operative time to ensure sufficient fluid replacement.

2.3. Positioning

After induction of general anesthesia and assuring that monitoring and venous lines are fixed in position: patients were turned to one side: right or left according to the planned side of surgery. After raising the kidney rest proper position of the head, shoulders, and the endotracheal tube was checked after turning the patient to one side.