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Original Contribution

Intermittent reinflation is safe to maintain oxygenation without alteration of extravascular lung water during one-lung ventilation☆

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Abstract

Study Objective: To investigate whether a maneuver for repeated cycles of collapse and reexpansion of the operative lung, termed "intermittent reinflation" (IR), to counter hypoxemia during one-lung ventilation (OLV), results in a time-dependent alteration of extravascular lung water.

Design: Prospective, randomized clinical study.

Setting: Operating room and postsurgical intensive care unit of a university hospital.

Patients: 36 ASA physical status 1 and 2 patients undergoing elective, video-assisted thoracic surgery for lung tumors.

Interventions: Patients were randomly assigned to two groups. Group C consisted of 18 patients whose nondependent lung was kept collapsed during OLV, while Group IR included 18 patients with IR that consisted of 4 separate, 10-second manual inflations and 5-second openings within one minute at intervals of 20 minutes during OLV.

Measurements: Perioperative parameters included transcutaneous oxygen saturation (SpO_2), hemodynamic data, extravascular lung water index (EVLWI), pulmonary vascular permeability index (PVPI) as determined by the single-indicator transpulmonary thermodilution technique, and partial pressure of arterial oxygen/inspired oxygen fraction (PaO_2/FIO_2) ratio.

Main Results: Group IR had significantly higher SpO_2 at 20 minutes after commencement of OLV (98.9% vs 96.3%, $P = 0.029$) and average SpO_2 throughout OLV (98.7% vs 97.0%, $P = 0.020$). Hemodynamic data, EVLWI, PVPI, and PaO_2/FIO_2 ratio did not differ between the groups, and there were no differences between groups in postoperative morbidity or hospital stay.

Conclusions: Intermittent reinflation had a beneficial effect on oxygenation during OLV, without any significant effects on EVLW or postoperative outcomes.

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1. Introduction

One-lung ventilation (OLV) is an established procedure performed during lung resection to prevent blood vessel injury and facilitate surgical procedures. Hypoxemia is the most important problem encountered during OLV [1,2]. To counter this major concern, a maneuver to expand the collapsed lung, known as "intermittent reinflation" (IR), performed to improve oxygenation at regular intervals of 10-15 minutes, has been recommended [3-5].

Lung injury after lung resection is associated with significant morbidity and mortality [6]. This type of injury generally follows a clinically and histopathologically indistinguishable course from acute lung injury (ALI) or acute respiratory distress syndrome (ARDS) [7], and is related to mechanical forces exerted during OLV [8]. Similar to ALI and ARDS, a recent experiment has demonstrated a potential reduction of lung injury due to OLV using a protective ventilatory strategy with low tidal volume (V_T) in perioperative patients with normal lungs [9]. Shear forces secondary to repeated collapse and reopening of alveolar units can result in lung injury, known as atelectrauma [10]. However, there are no reports of repeated IR during OLV or the relationship of IR to lung injury after lung resection. Lung injury induced by IR repeatedly applied during surgical resection was investigated.

Extravascular lung water (EVLW) is not only an indicator of prognosis and severity of ALI and ARDS [11-13], it is also a useful parameter to assess perioperative respiratory conditions in patients with no preexisting lung injury [9,14]. Thus, it may be useful to quantify the inflammatory process of lung injury, which may increase vascular permeability, resulting in accumulation of fluid and development of pulmonary edema [7]. A continuous cardiac output monitor (PiCCO; Pulsion Medical Systems, Munich, Germany) was recently introduced to measure EVLW using a single-indicator thermodilution method [15]. In this prospective clinical study, a time-dependent alteration of EVLW was evaluated with the PiCCO monitor.

2. Materials and methods

2.1. Study population

The study protocol was approved by the Ethics Committee of Hiroshima University (IRB No. 266), and all patients provided written, informed consent before enrollment. This study was registered at www.umin.ac.jp/ctr/index.htm (UMIN000008759). Eligible patients met the following criteria: 1) 80 years of age or under, 2) ASA physical status 1 or 2, and 3) scheduled for elective, video-assisted thoracic surgery for lung tumors requiring OLV lasting more than 120 minutes (Table 1). Exclusion criteria included decompensated cardiac (New York Heart Association > class II) or pulmonary disease [vital capacity (VC) <

Table 1 Patient characteristics and intraoperative values

Demographic variables	Group IR (n = 18)	Group C (n = 18)	*P* -value
Age (yrs)	63 ± 9	65 ± 8	0.57
Gender (m/f)	15 / 3	11 / 7	0.14
Weight (kg)	64 ± 8	63 ± 12	0.85
Height (cm)	165 ± 7	161 ± 8	0.22
ASA physical status (1 / 2) (n)	0 / 18	1 / 17	0.32
Preop VC (% predicted)	108 ± 13	109 ± 13	0.85
Preop FEV_1/FVC ratio (%)	73 ± 9	74 ± 9	0.61
Right-sided thoracotomy (n)	7	9	
Left-sided thoracotomy (n)	9	8	0.45
Bilateral thoracotomy (n)	2	1	
Segments resected (n)	3 ± 1	4 ± 1	0.09
Surgery duration (min)	310 ± 107	317 ± 102	0.85
OLV duration (min)	253 ± 88	269 ± 90	0.60
Intraop blood loss (mL)	193 ± 172	236 ± 206	0.50
Intraop urine output (mL)	756 ± 373	940 ± 662	0.31
Intraop fluid administration (mL)	3456 ± 756	3411 ± 1092	0.89
Hydroxyethyl starch (0 mL/500 mL/1000 mL) (n)	16 / 1 / 1	15 / 3 / 0	0.69
Intraop transfusion (n)	0	0	1.00
Sequential intermittent reinflation (n)	12 ± 4	3 ± 1	<0.001

Values are means ± SD, unless otherwise noted.
Group IR patients underwent intermittent reinflation, Group C patients served as controls. Preop = preoperative, VC = vital capacity, FEV_1 = forced expiratory volume in 1 second, FVC = forced vital capacity, OLV = one-lung ventilation, intraop = intraoperative.