Smoking Cessation Can Reduce the Incidence of Postoperative Hypoxemia After On-Pump Coronary Artery Bypass Grafting Surgery

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Objectives: **To determine whether smoking cessation can reduce the incidence of postoperative hypoxemia (POH) after on-pump coronary artery bypass grafting (CABG) surgery.**

Design: **Prospective, single-center, observational study.**

Setting: **Single-center university teaching hospital.**

Participants: **The study comprised 300 patients undergoing on-pump CABG surgery who met the inclusion criteria. Patients were divided into the following 3 groups according to smoking status: sustained quitters (n = 132)—smoking cessation for more than 1 month and less than 1 year; quitters (n = 95)—smoking cessation for more than 1 week and less than 1 month; and smokers (n = 73)—smoking at least 1 cigarette per day for at least 1 year.**

Interventions: **None.**

Measurements and Main Results: **The primary outcome was the incidence of POH after on-pump CABG surgery. Secondary outcomes included length of postoperative mechanical ventilation and intensive care unit stay between the POH group and non-POH group. There were significant decreases of POH incidence in the sustained quitters and quitters compared with the smokers both after intensive care unit (ICU) admission and 24 hours after surgery (18.2%, 18.9%, *v* 32.9%; p = 0.036 and 9.8%, 10.5%, *v* 26%; p = 0.003, respectively), and there was no significant difference in POH incidence between the sustained quitters and quitters. The length of postoperative mechanical ventilation was longer in smokers than in sustained quitters and quitters (15.9 ± 6.1 h *v* 11.9 ± 5.3 h and 13.0 ± 5.8 h, respectively; p < 0.05), but there were no significant differences in the length of ICU stay among the 3 groups (54.2 ± 7.5 h *v* 55.1 ± 7.5 h and 53.7 ± 6.6 h, respectively; p = 0.333).**

Conclusions: **Smoking cessation can reduce POH after on-pump CABG surgery, and it also can shorten the length of postoperative mechanical ventilation.**

KEY WORDS: smoking cessation, postoperative hypoxemia, coronary artery bypass grafting

ON-PUMP CORONARY ARTERY BYPASS GRAFTING (CABG) surgery still is used in coronary heart disease treatment.[1] Postoperative hypoxemia (POH) often is detectable in patients after cardiac surgery with cardiopulmonary bypass (CPB)[2] and is characterized by a decrease in arterial oxygen partial pressure. The incidence of POH after on-pump cardiac surgery is between 27% and 42.6%.[3,4] POH can result in prolonged postoperative mechanical ventilation and intensive care unit (ICU) stay and therefore apparently increases medical costs.[7]

An estimated 28.1% of adults in China were smokers in 2010.[8] Smoking is a risk factor for hypoxemia after on-pump cardiac surgery[9]; smoking also can aggravate the pulmonary function of patients with chronic obstructive pulmonary disease (COPD)[10] and is a risk factor for acute lung injury after esophagectomy.[11] Smoking cessation can improve the health-related quality of life. It can increase the oxygen saturation and improve the spirometry of COPD patients,[12] and it also can improve decreased pulmonary function resulting from other pulmonary diseases.[13,14]

This study is being published to address the lack of information about the effect of smoking cessation on the incidence of POH after on-pump cardiac surgery; no other such study has been published in the literature. This study examined the relationship between smoking cessation and POH after on-pump CABG surgery to determine whether smoking cessation was beneficial for decreasing the incidence of POH after on-pump CABG and to evaluate whether smoking cessation shortened the length of postoperative mechanical ventilation and ICU stay.

METHODS

This was a prospective, single-center, observational study. Written informed consent was obtained from the patients for publication. Male patients who underwent on-pump CABG surgery at a university teaching hospital from January 1, 2013, to December 31, 2015, were enrolled in the study. The inclusion criteria were male sex, age 18 to 70 years, patients who were scheduled for on-pump CABG surgery for coronary artery disease, and ex-smoker or current smoking history. Exclusion criteria were left ventricular ejection fraction (LVEF) <50%, COPD, preoperative pulmonary congestion, preoperative respiratory failure, preoperative heart failure, and surgery other than CABG. Rejection criteria were the need for any forms of positive airway pressure ventilation during surgery and/or the first postoperative day, the need for intra-aortic balloon pump, death during surgery or ICU stay, and additional surgeries performed during ICU stay due to any reasons (Fig 1).

The authors obtained information regarding patients' smoking history through questionnaires before their surgery. Patients were divided into the following 3 groups according to smoking status: sustained quitters (n = 132, 44%)—smoking cessation for more than 1 month and less than 1 year; quitters (n = 95, 32%)—smoking cessation for more than 1 week and less than 1 month; and smokers (n = 73, 24%)—smoking at least 1 cigarette per day for at least 1 year. The data were collected by

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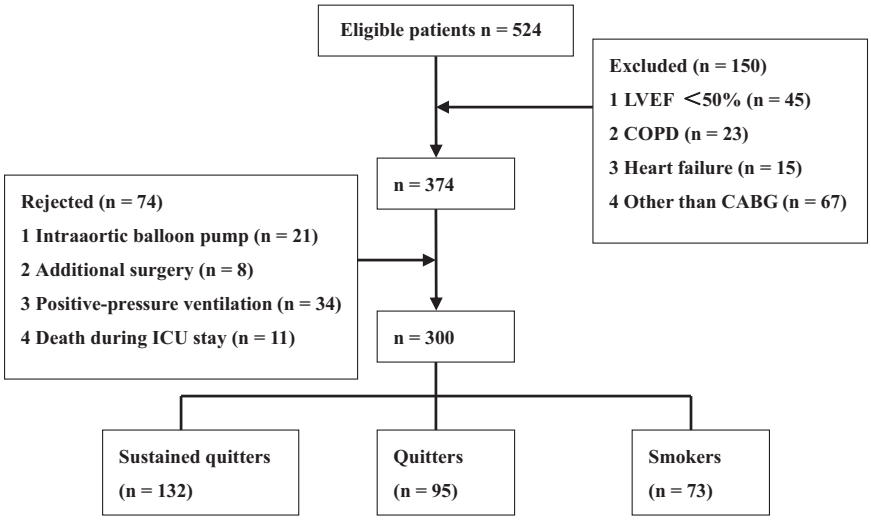

Fig 1. Flow diagram of patients' enrollment. CABG, coronary artery bypass grafting; COPD, chronic obstructive pulmonary disease; ICU, intensive care unit; LVEF, left ventricular ejection fraction.

an independent data collector who was not involved in routine care (see Fig 1).

Preoperative premedication and anesthesia were standard. All patients received clonazepam orally (2 mg) 1 hour before surgery. General anesthesia was induced with sufentanil, etomidate, and rocuronium and maintained with continuous infusion of propofol, remifentanil, and rocuronium. Electrocardiography, pulse oximetry, invasive arterial blood pressure, central venous pressure, and end-tidal carbon dioxide tension were used to monitor the patients. The cardiac output and stroke volume were monitored using the Vigileo monitor (Edwards Lifesciences, Irvine, CA) through an arterial catheter. Patients were ventilated mechanically with the volume control mode at a tidal volume of 8 mL/kg, a respiratory rate of 8 to 15 cycles/minute, and an inspiratory:expiratory ratio of 1:2 to maintain the arterial partial pressure of carbon dioxide value between 35 and 45 mmHg. The inspiratory oxygen fraction (F_IO_2) was set at 0.6.

CPB was performed using an extracorporeal circuit and a membrane oxygenator. The surgery was performed under parallel circulation on a beating heart. Mechanical ventilation was suspended during CPB. Vasoactive drugs were infused to facilitate CPB weaning according to the attending anesthesiologist, and mechanical ventilation was resumed at the end of CPB, followed by an alveolar recruitment maneuver.

After surgery, the patients, under anesthesia were transferred to the ICU. The mechanical ventilation parameters were the same as during the surgery. Patients' airways were extubated as soon as they could breathe spontaneously with a spontaneous tidal volume >6 mL/kg, an arterial partial pressure of oxygen (PaO_2) >70 mmHg at F_IO_2 of 0.4, and stable vital signs. After extubation of the airway, oxygen was administered by mask that delivered a known oxygen concentration. Postoperative pain was controlled using a morphine bolus whenever necessary.

The arterial blood gas analysis was performed before anesthesia induction, after intubation, after CPB weaning, at ICU admission, and 24 hours after surgery, in which PaO_2 was measured and the oxygenation index (PaO_2/F_IO_2) was calculated (Table 1). According to the current Berlin definition,[15] hypoxemia was determined when PaO_2/F_IO_2 was ≤300; the POH was recorded (Table 2) as were the length of postoperative mechanical ventilation and length of ICU stay (Table 3).

Continuous variables were described as mean ± standard deviation, and categoric variables were described as numbers and percentages. Statistical analysis was performed using SPSS, Version 18.0, statistical software (SPSS Inc, Chicago, IL). Statistical significance among sustained quitters, quitters, and smokers was determined using 1-way analysis of variance for continuous variables and the chi-square test for categoric

Table 1. The Oxygenation Index in the 3 Groups Before, During, and After Surgery

Oxygenation Index	Sustained Quitters (n = 132)	Quitters (n = 95)	Smokers (n = 73)	p Value
Before anesthesia induction	426.6 ± 44.9	422.1 ± 45.0	432.6 ± 44.2	0.320
After intubation	427.1 ± 44.9	422.2 ± 43.5	431.6 ± 43.1	0.386
After CPB weaning	380.9 ± 71.9	368.1 ± 73.3	351.0 ± 84.1*	0.025
At ICU admission	383.8 ± 67.6	373.3 ± 69.9	356.9 ± 79.7*	0.037
24 h after surgery	400.6 ± 55.5	395.4 ± 55.9	379.5 ± 70.2	0.051

NOTE. Value is mean ± standard deviation for continuous variables.
Abbreviations: CPB, cardiopulmonary bypass; ICU, intensive care unit.
*Compared with sustained quitters, $p < 0.05$.