The effect of postoperative positive end-expiratory pressure on postoperative bleeding after off-pump coronary artery bypass grafting

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Abstract

Introduction: To compare postoperative prophylactic use of two positive end-expiratory pressure (PEEP) levels in order to prevent postoperative bleeding in patients undergoing off-pump coronary artery bypass grafting (CABG) surgery.

Material and methods: Sixty patients undergoing an elective off-pump CABG operation were included in this prospective, nonrandomized clinical trial. Patients were divided into two groups as receiving either 5 cm H_2O (group 1) or 8 cm H_2O PEEP (group 2) after the operation until being extubated. Chest tube outputs, use of blood products and other fluids, postoperative hemoglobin levels, accumulation of pleural and pericardial fluid after the removal of chest tubes, and duration of hospital stay were recorded and compared.

Results: Low- and high-pressure PEEP groups did not differ with regard to postoperative chest tube outputs, amounts of transfusions and crystalloid/colloid infusion requirements, or postoperative hemoglobin levels. However, low-pressure PEEP application was associated with significantly higher pleural (92 ±37 ml vs. 69 ±29 ml, $p = 0.03$) and pericardial fluid (17 ±5 ml vs. 14 ±6 ml, $p = 0.04$) accumulation. On the other hand, high-pressure PEEP application was associated with significantly longer duration of hospitalization (6.25 ±1.21 days vs. 5.25 ±0.91 days, $p = 0.03$).

Conclusions: Prophylactic administration of postoperative PEEP levels of 8 cm H_2O, although safe, does not seem to reduce chest-tube output or transfusion requirements in off-pump CABG when compared to the lower level of PEEP. Further studies with larger sample sizes are warranted to confirm the benefits and identify ideal levels of PEEP administration in this group of patients.

Key words: off-pump coronary artery bypass grafting, positive end-expiratory pressure, bleeding, pleural effusion, pericardial effusion.

Introduction

One of the main goals immediately after cardiac surgery is to reduce transfusion of blood and blood products depending on postoperative

bleeding. Postoperative chest-tube output has been reported to be a risk factor for the need of blood products after open-heart surgery [1]. Red blood cell (RBC) transfusions are related to immunosuppressive effects such as hypersensitivity reactions, reducing life expectancy, and may cause spread of infectious diseases [2–6]. In addition, RBC transfusions may cause microcirculatory problems, and may be less efficient in sufficient oxygen loading and carrying due to the reductions in 2,3-DPG concentrations in stored blood [7, 8]. Hébert *et al*. [9], in their multicenter, randomized, controlled trial of transfusion requirements in critically ill patients, found that a restrictive control strategy of RBC transfusions is effective and preferred over a liberal transfusion strategy.

Various methods have been reported to reduce transfusion requirements in cardiac surgery [10], including the postoperative use of positive end-expiratory pressure (PEEP) in patients on positive-pressure ventilation [11]. Positive end-expiratory pressure increases end-expiratory airway pressure and some indications for PEEP are refractory hypoxemia such as acute respiratory distress syndrome and decreased functional residual capacity [8, 12, 13]. Although PEEP levels as high as 15 cm of H_2O have been used to control thoracic and mediastinal drainage [1, 11, 14–17], prophylactic use of PEEP after off-pump coronary artery bypass grafting (CABG) surgery has not been thoroughly investigated. In our routine practice, we use a PEEP level of 5 cm H_2O in patients after CABG at the intensive care unit during mechanical ventilation. However, increased PEEP levels may further prevent bleeding from internal thoracic artery beds by the tamponade effect [1, 16, 17].

In this prospective clinical trial, we aimed to compare the benefits and risks associated with the prophylactic use of two different PEEP levels, 8 cm H_2O vs. 5 cm H_2O, in patients undergoing off-pump CABG surgery.

Material and methods

Patients

Sixty patients (age range: 40–70 years) undergoing elective off-pump CABG surgery at our institution were included in this prospective clinical trial. All operations were performed between March 2006 and August 2010 by the same surgery team. The study protocol was approved by the local ethics committee and informed consent was obtained from all patients prior to study entry after explaining the procedure and study protocol in detail.

Exclusion criteria were as follows: a preoperative, operative or postoperative mean arterial pressure (MAP) less than 60 mm Hg and lasting more than 30 min, intra-aortic balloon pump use; need for early heparin therapy, extubation in the operating theatre, PEEP use for refractory hypoxemia, higher than stage II chronic obstructive pulmonary disease, uncontrolled hyperglycemia, dialysis-dependent chronic renal failure, emergency off-pump CABG cases, patients not tolerating PEEP as assessed during the operation.

Anesthesia management

All recent cardiac medications except digoxin and diuretics were continued until the morning of surgery. For premedication, midazolam 0.05 mg/kg was injected intramuscularly an hour before the surgery. In the operating room, electrocardiography (ECG) leads DII and V5 were monitored. The radial artery was cannulated on the non-dominant arm for continuous monitoring of arterial blood pressure and blood gas analyses and a right or left jugular venous catheter was inserted for continuous central venous pressure (CVP) monitoring. A standard anesthesia technique was used for all patients. Anesthesia was induced with 0.1–0.15 mg/kg of midazolam, 3 µg/kg of fentanyl, and 0.8 mg/kg of rocuronium and maintained with 0.5–1.5 vol% of sevoflurane and continuous intravenous fentanyl infusion at a rate of 0.05–0.1 µg/kg/min and rocuronium as needed according to the train-of-four (TOF-WATCH S, Organon, Dublin, Ireland) score. Ventilation was controlled with an oxygen-air mixture (FiO_2 0.5–0.6) to maintain end-tidal CO_2 ($ETCO_2$) at 35 mm Hg. Isosorbide dinitrate 0.5–1 µg/kg/min was started after anesthesia induction. Patients were also monitored by transesophageal echocardiography (TEE, SonoSite MicroMaxx Bothell, WA, USA). The temperature of the operating room was kept above 24°C and all the fluids were warmed to prevent hypothermia. A warm humidifier was connected to the breathing circuit. Patients were also warmed with a warm water blanket. After median sternotomy, an adequate amount of fluid (5–10 ml/kg) was given and a head-down position was assumed during anastomoses. In case of hypotension, norepinephrine was given to maintain the mean arterial pressure above 60 mm Hg. A suction type tissue stabilizer (Octopus Tissue Stabilizer System, Medtronic Inc., Minneapolis, MN, USA) was applied for anastomosis. An intracoronary endoluminal shunt (1–1.5 mm) was used during left anterior descending coronary (LAD) and proximal right coronary artery (RCA) anastomoses [18].

Intensive care unit management

Postoperatively, arterial blood pressure, CVP, ECG, $ETCO_2$, oxygen saturation (SpO_2), arterial and mixed venous blood gases were monitored in the

intensive care unit (ICU). Cardiac status and mediastinal fluid collections were also controlled with transthoracic echocardiography (TTE). All the patients were transferred to the ICU while still intubated. Until extubation, patients were sedated with propofol perfusion at a rate of 1–2 mg/kg/h, targeting Ramsay Sedation Scale scores of 4 to 5 [19]. Patients were administered crystalloid (Ringer's solution or normal saline) or colloid (gelatin polysuccinate 4%w/v) to keep the mean arterial pressure between 60 mm Hg and 80 mm Hg, CVP at 6–12 cm H_2O, and urine output at 0.5–2 ml/kg/h. Packed red blood cells were transfused when the hemoglobin level was less than 8 g/dl. An autotransfusion system (autoLog Autotransfusion System, Medtronic, USA) was used in 14 patients and 12 patients from 5 cm H_2O and 8 cm H_2O PEEP groups, respectively. Weaning from mechanical ventilation and extubation took place 4 h after the operation.

Study groups and details of positive end-expiratory pressure application

Consecutive patients were recruited and tested for toleration of PEEP at the operating theatre. After the completion of anastomoses and removal of the aortic side clamp, first 5 cm H_2O than 8 cm H_2O PEEP was applied to see if any compression occurs over the grafts. Patients who did not tolerate PEEP at all were excluded from the study. Patients who tolerated 8 cm H_2O PEEP were assigned to the high-pressure PEEP group (n = 30) and the patients who tolerated only 5 cm H_2O PEEP but not 8 cm H_2O PEEP were included in the low-pressure PEEP group (n = 30). Then PEEP was discontinued until the completion of the operation. Beginning from the completion of the operation, the low-pressure group received 5 cm H_2O PEEP and the high-pressure group received 8 cm H_2O PEEP until extubation for about 4 h. All patients were placed on synchronized intermittent mandatory ventilation (SIMV) and added pressure support (PS), and received a tidal volume of 6–8 ml/kg of weight and a respiratory rate of 12–20/min [20] to keep $PaCO_2$ at 35 mm Hg, mixed venous oxygen saturation (SvO_2) at 65%, and pH at 7.4. Pressure support was 13–16 cm H_2O with peak inspiratory pressure (PIP) 40 cm H_2O or less [21, 22]. In the high-pressure PEEP group, PEEP was first decreased to 5 cm H_2O and then discontinued before extubation.

Data collection

Demographic and clinical data were obtained for all patients. Standard intraoperative and postoperative parameters were recorded to facilitate comparisons between groups. Cumulative chest-tube outputs and hemoglobin concentrations were recorded immediately after the operation, at 2, 4, 6, 8, 12, and 24 h postoperatively, and at the time of chest-tube removal. The amounts of transfused blood product and infused intravenous fluids were noted. The primary outcome was the mean chest-tube output in the groups and the secondary outcome was the cumulative amount of transfusions and crystalloid/colloid infusions. The frequency and severity of adverse events related to PEEP were also noted. After the removal of the chest tube, pleural fluid volume was assessed using ultrasonography by a radiologist blinded to the groups and pericardial fluid volume was assessed by a blinded cardiologist using transthoracic echocardiography. Patients were followed during the hospital stay and called for a follow-up visit 15 days after discharge.

Statistical analysis

Statistical analysis was performed with the computer program Statistical Package for the Social Sciences (SPSS) 12.0 (SPSS Inc. Chicago, Illinois) for Windows by a professional statistician. Data were expressed as mean ± standard deviation. Definitive statistical evaluations were expressed as mean, standard deviation, median, minimum and maximum, for numerical variables, and as numbers and percentages for categorical variables. The difference between the groups with regards to categorical variables was determined by the Pearson χ^2 and Fisher exact tests. For other variables, the difference between two groups was determined by the independent sample t-test in the case of normally distributed data, whereas the Mann-Whitney U-test was used for analysis of non-normally distributed data for independent groups. Variations were assessed during the preoperative and postoperative periods using the Friedman test. The relationship between numerical variables was assessed using Pearson and Spearman correlation analysis. All univariate comparisons were performed using Student's t test in cases where the data were normally distributed. All longitudinal comparisons were performed using repeated measures analysis of variance (RM-ANOVA). A p value less than 0.05 was considered statistically significant.

Results

Both groups included 30 patients. In the low pressure PEEP group there were 12 male and 18 female patients, whereas in the high pressure group the male/female ratio was 19/11. Mean age of the patients in group 1 was 60.2 ±10.7 years and in group 2 was 65.4 ±12.1 years. Weight ranges were 79.75 ±11.6 kg and 77.3 ±10.8 kg in group 1 and 2,

respectively. There were 7 patients with chronic obstructive pulmonary disease in group 1 and 4 patients in group 2. Diabetes mellitus was present in 8 patients and 9 patients were hypertensive in the low pressure group and the respective values were 8 and 11 patients in the high pressure group. There was peripheral arterial disease in 2 patients in group 1 and in 1 patient in group 2; additionally 1 patient experienced transient ischemic attacks in the high pressure group. Two patients had chronic renal failure in group 1 and 5 patients had the disease in group 2. Cardiac status estimated with ejection fraction values was 47 ±13% and 44 ±14% in low pressure and high pressure groups, respectively.

Blood studies revealed hemoglobin values of 11.0 ±1.9 mg/dl in group 1 and 15.85 ±3.9 mg/dl in group 2 in the preoperative period. Clotting studies indicated platelet count of 278.1 ±114.5 K/µl and 262.6 ±91.0 K/µl, prothrombin time of 14.7 ±3.1 s and 15.85 ±3.9 s and activated partial thromboplastin time of 35.1 ±11.2 s and 36.8 ±12.6 s in group 1 and group 2, respectively.

Preoperative demographic features of the two groups such as age, sex, weight, ejection fraction, prothrombin time, activated partial thromboplastin time, hemoglobin concentration (Hb) and platelet count (Plt) were similar, and additional disease did not significantly differ between the two groups. Patient demographics are presented in Table I. Frequencies of the co-morbidity factors were also similar.

The intraoperative variables are summarized in Table II. Mean number of bypassed vessels was 2 ±0.7 in group 1 vs. 2.3 ±0.8 in group 2. During the operation, depending on the weight of the patients, 88 ±43 mg and 91 ±39 mg of heparin were administered to achieve 184 ±22 s and 195 ±23 s activated clotting time in group 1 and 2, which were neutralized by 93 ±43 mg and 96 ±40 mg of protamine sulfate, respectively. Patients received autotransfusion of 244 ±185 ml and 203 ±194 ml of blood during the operation. Intraoperatively, 3 patients required low dose dopamine support in group 1 and 1 patient required inotropic support in group 2. The intraoperative values of the patients did not differ significantly between the two groups.

After the operation, in group 1 and group 2, the measured values of duration of mechanical ventilation (4.2 ±0.9 h vs. 3.9 ±1.6 h), the 6th h values of prothrombin time (16.2 ±4.3 s vs. 14.9 ±2.4 s), activated partial thromboplastin time (43.7 ±18.2 s vs. 49.8 ±17.4 s), platelet count (345.2 ±98.8 K/µl vs. 319.9 ±114.5 K/µl), mean arterial pressure (70.2 ±14.2 mm Hg vs. 64.3 ±10.7 mm Hg), and cardiac indices (2.8 ±0.7 l/min/m^2 vs. 2.5 ±1.1 l/min/m^2) of the two groups were not significant-

Table I. Preoperative characteristics

Variable	Low-pressure PEEP group (5 cm H_2O)	High-pressure PEEP group (8 cm H_2O)	Value of *p*
Number of patients	30	30	–
Age [years]	60.2 ±10.7	65.4 ±12.1	0.15
Gender, *n* (M/F)	12/18	19/11	0.12
Weight [kg]	79.75 ±11.6	77.3 ±10.8	0.49
EF (%)	47 ±13	44 ±14	0.57
PT [s]	14.7 ±3.1	15.85 ±3.9	0.31
aPTT [s]	35.1 ±11.2	36.8 ±12.6	0.66
Hb [mg/dl]	11.0 ±1.9	11.4 ±2.1	0.56
Platelet count [K/µl]	278.1 ±114.5	262.6 ±91.0	0.64
COPD, *n*	7	4	0.50
Diabetes, *n*	8	11	0.57
Hypertension, *n*	9	12	0.58
PAD, *n*	2	1	1
TIA, *n*	0	1	1
CRF, *n*	2	5	0.42

Unless otherwise stated, data are presented as mean ± standard deviation. COPD – chronic obstructive pulmonary disease, PAD – peripheral artery disease, TIA – transient ischemic attack, EF – ejection fraction, CRF – chronic renal failure not dependent on dialysis, PT – prothrombin time, aPTT – activated partial thromboplastin time

Table II. Intraoperative characteristics

Variable	Low-pressure PEEP group (5 cm H_2O)	High-pressure PEEP group (8 cm H_2O)	Value of *p*
Amount of autotransfusion (range) [ml]	244 ±185 (0–600)	203 ±194 (0–550)	0.51
Heparin administered [mg]	88 ±43	91 ±39	0.83
Protamine administered [mg]	93 ±43	96 ±40	0.8
Activated clotting time [s]*	184 ±22	195 ±23	0.37
Number of bypassed vessels	2 ±0.7	2.3 ±0.8	0.3
Time needed for distal anastomoses [min]	40 ±16	34 ±11	0.16
Duration of aortic side clamping [min]	28 ±9	26 ±6	0.35
Inotropic use, *n*	3	1	
Arrhythmia (VF, AF), *n*	2	3	
ST changes ≥ 2 mm, *n*	3	5	

**Immediately after the operation. Unless otherwise stated, data are presented as mean ± standard deviation*

ly different when the low PEEP group was compared with the high PEEP group.

Outcome measures

Groups did not differ with regard to the cumulative amount of chest tube drainage at 6 h (303 ±161 ml in group 1 vs. 295 ±41 ml in group 2, $p = 0.84$), at 24 h (449 ±129 ml in group 1 vs. 473 ±184 ml in group 2, $p = 0.80$), or at the time when the chest tubes were removed (522 ±182 ml in group 1 vs. 494 ±171 ml in group 2, $p = 0.60$) (Table III). Postoperatively, groups received similar amounts of packed RBC transfusions (1.05 ±1.11 U vs. 0.84 ±1.17 U for low- and high-pressure PEEP groups respectively, $p = 0.58$), and similar amounts of crystalloid (2.39 ±0.65 l vs. 2.16 ±0.59 l, $p = 0.27$) and gelatin (673 ±127 ml vs. 596 ±113 ml, $p = 0.06$) were administered to the groups. Postoperative hemoglobin concentrations assessed immediately after the operation (9.99 ±1.97 g/dl vs. 9.65 ±1.54 g/dl, $p = 0.65$), at 6 h (9.5 ±1.64 g/l vs. 9.3 ±1.13g/dl, $p = 0.68$), and at 24 h (9.15 ±1.14 g/dl vs. 8.95 ±0.89 g/dl, $p = 0.54$) were also similar between the two groups.

Low-pressure PEEP application was associated with significantly higher amounts of total pleural (92 ±37 ml vs. 69 ±29 ml, $p = 0.03$) and total pericardial effusion (17 ±5 vs. 14 ±6, $p = 0.04$) in group 1. On the other hand, duration of hospitalization was longer for patients in group 2 when compared with group 1.

Morbidity and mortality data

None of the patients required reoperation for bleeding. One patient in the high pressure group had a cerebrovascular accident leading to monoparesis of the left upper extremity. There was one death in the low pressure group, which was not related to the PEEP use. This patient died due to myocardial infarction in the early postoperative period resulting in low cardiac output without any signs of increased chest-tube output or any evidence of pericardial effusion or tamponade. Myocardial infarction did not develop in any

Table III. Outcome variables

Variable	Low-pressure PEEP group (5 cm H_2O)	High-pressure PEEP group (8 cm H_2O)	Value of *p*
Activated clotting time [s]	116 ±21	124 ±19	0.23
Drainage at 6 h [ml]	303 ±161	295 ±41	0.84
Drainage at 24 h [ml]	449 ±129	473 ±184	0.8
Total drainage [ml]	522 ±182	494 ±171	0.6
Total pleural effusion [ml]	92 ±37	69 ±29	0.03
Total pericardial effusion [ml]	17 ±5	14 ±6	0.04
Duration of hospital stay [days]	5.25 ±0.91	6.25 ±1.21	0.03

of the other patients and new-onset renal failure was not observed.

Discussion

Postoperative bleeding has certain mortality and morbidity after off-pump CABG surgery. A chest-tube system allows drainage and provides a window to outside of the thorax and enables the monitoring of bleeding. Strategies have been devised in the preoperative, intraoperative, and postoperative periods to reduce bleeding, including the use of PEEP, which has been used for decades as an adjunct to ventilator therapy to improve oxygenation [1, 14, 16, 17]. The main aim and benefits of the PEEP ventilation mode are to improve pulmonary functions, and increase arterial and peripheral tissue oxygenation [23]. The mechanism includes lung recruitment and increasing the alveolar surface area during inspiration while keeping expiration [24]. Positive end-expiratory pressure application is quite a safe procedure; however, major complications related to PEEP may be accounted such as alveolar over-distention, lung injury, hypoxemia, hypercapnia, pneumothorax and decreased cardiac output by decreasing preload due to diminished venous return and decreased coronary blood flow [12, 13, 25–29].

Other than being as a ventilator therapy, another application of PEEP has been bleeding control after thoracic surgery. Various PEEP values have been instituted for this purpose [1, 12, 14, 15, 17]. In order to control postoperative bleeding, the literature includes studies with PEEP values as high as 15 cm H_2O [1, 12], ranging from 0 to 15 cm H_2O [1, 14–17] (Table IV). However, due to the aforementioned cardiac and pulmonary consequences of high PEEP levels, it may sometimes be hazardous [12, 13, 25–29]. In the current study, we aimed at lower PEEP levels when compared to the other studies in the literature [1, 10, 14–17], especially the PEEP level of 15 cm H_2O, which led to detrimental cardiac effects in the series of Ilabaca *et al.* [1]. To the best of our knowledge, a PEEP value of 8 cm H_2O has not been evaluated in the literature for the control of postoperative bleeding before. Moreover, such a maneuver with PEEP values of 5 cm H_2O and 8 cm H_2O in the current study after off-pump CABG is also unique.

After on-pump open heart surgery the use of PEEP has been evaluated in many studies from different aspects. Marvel *et al.* [30] in their prospective study evaluated the effect of PEEP (0, 5, and 10 cm H_2O) on the severity of impaired oxygen transfer and radiological evidence of atelectasis after CABG. Their study showed that routine PEEP did not alter the arterial hypoxemia or radiological appearance of atelectasis [30]. Positive end-expiratory pressure has also been used to manage non-surgical bleeding in patients undergoing on-pump CABG. Ilabaca *et al.* [1] found a decrease in chest-tube output with PEEP use (10 cm H_2O or greater) in patients whose drainage was at least 200 ml/h. Also they observed up to 73% of patients requiring no reoperation [1] (Table I).

In our study, the cumulative chest tube outputs of the two groups were similar postoperatively, both early after the operation and at the time of drain removal. Although higher levels of PEEP may be expected to reduce postoperative bleeding by a mechanical tamponade effect on the thoracic wall [1], this was not supported by the findings of our study. Furthermore, no statistically significant difference was found in hemoglobin levels postoperatively between the 5 cm H_2O PEEP group and the 8 cm H_2O PEEP group. Thus, the findings of this study suggest that postoperative bleeding is not affected by increased PEEP levels. Additionally, our results are consistent with the previous findings of Murphy *et al.* [14], Zurick *et al.* [15], and Collier *et al.* [17], but not with Ilabaca *et al.* [1] (Table I).

In our study we found a significant difference between the two groups with regard to the amounts of pleural and pericardial effusions assessed after the removal of the drains, with significantly higher amounts in the 5 cm H_2O PEEP group. However, the total amounts were clinically insignificant in both groups. Early respiratory physiotherapy has been shown to reduce pleural and pericardial effusion [31]; thus, such effusions might have been reduced by increased daily sessions of physiotherapy involving incentive spirom-

Table IV. Literature review

Author	PEEP value [cm H_2O]	Duration [h]	Result
Ilabaca *et al.*, 1980	10–15	5–10	Bleeding control: 73%
Zurick *et al.*, 1982	0–10	8–24	No effect
Murphy *et al.*, 1983	0–10	1–8	No effect
Collier *et al.*, 2002	5–10	6–24	No effect
Current study	5–8	0–4	No effect

etry, deep breathing exercises, coughing and early ambulation [25, 29].

Although increasing levels of PEEP may be expected to necessitate more fluid administration due to a decrease in venous return and in mixed venous oxygen saturation [8, 12, 13, 25, 32], both groups received similar amounts of crystalloid fluids and packed red cells in our study. Similarly, groups did not differ significantly with regard to the amount of gelatin that they received during the postoperative period, although increased intrathoracic pressure induced by higher PEEP levels may potentially necessitate additional gelatin administration. On the other hand, no definitive evidence exists whether increased or decreased amounts of crystalloid or colloid solutions administered in the postoperative period to patients undergoing CABG affect the outcome. In contrast, patients receiving 8 cm H_2O PEEP stayed significantly longer at hospital than the patients who received 5 cm H_2O PEEP. However, this did not seem to be associated with increased morbidity, but it is definitely associated with increased costs without providing any benefits in terms of bleeding control.

It is important to note that this study suffered due to an important limitation. The relatively small sample size (n = 60) could have led to type II errors because of low statistical power. Future research on prophylactic PEEP use after off-pump CABG surgery with a larger sample could address this issue. However, this trial was stopped early because it was clear to the researchers that the management did not enhance the care.

In conclusion, this study demonstrates that prophylactic administration of postoperative PEEP levels of 8 cm H_2O, although safe, does not seem to reduce chest-tube output or transfusion requirements in patients after off-pump CABG when compared to the lower PEEP level, i.e. 5 cm H_2O. Although high PEEP levels were associated with lower accumulation of pleural and pericardial fluids, the amount was not clinically significant in either group. In addition, high-pressure PEEP was associated with longer duration of hospitalization, which meant increased health care costs. Thus, the findings of this study do not support the prophylactic use of 8 cm H_2O PEEP after off-pump CABG surgery to reduce the amount of postoperative bleeding; rather, 5 cm H_2O PEEP would be sufficient if prophylactic PEEP is to be administered. Further studies with larger sample sizes are warranted to confirm the benefits and identify ideal levels of PEEP administration in this particular group of patients.

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