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Evaluation of biphasic positive airway pressure [BIPAP] versus control mode, SIMV and CPAP in post anesthetic patients receiving elective post-operative ventilation

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Abstract

Context: Prolonged mechanical ventilation and intensive care unit (ICU) stay increases morbidity and mortality.

Objective: To evaluate the effects of biphasic positive airway pressure versus continuous mandatory ventilation (CMV), synchronized intermittent mandatory ventilation (SIMV) and continuous positive airway pressure (CPAP) in patients receiving elective post operative ventilation

Methods and Material: 40 patients of age group 20 yrs and older of American society of anesthesiologists (ASA) physical status 1 - 3 who underwent elective abdominal surgery under general anesthesia were divided into 2 groups, group B(n=20) comprised of patients who were put on BIPAP mode and group C(n=20) who were put on CMV, SIMV, CPAP mode. Outcomes measured were ratio of arterial oxygen partial pressure to fractional inspired oxygen (PaO2/FiO2), duration of mechanical ventilation, sedation requirement, and hemodynamic instability. Patients were put on ventilator and ventilated according to protocol.

Results: The duration of mechanical ventilation was significantly reduced [p – 0.005] in group B [6.8±2.8 hours] than group C [9.9±3.6 hours]. Sedation requirement with midazolam was significantly reduced [p – 0.0001] in group B (4±2.71 mg) than group C (8.05±2.45 mg). There was no difference with respect to PaO2/FiO2 ratio and hemodynamic stability between both the groups.

Conclusions: BIPAP as compared to CMV, SIMV and CPAP mode reduces the duration of mechanical ventilation and sedation requirement which in turn reduces morbidity. Pulmonary gas exchange was similar between the two groups.

Keywords: Biphasic intermittent positive airway pressure, Pulmonary ventilation, Postoperative period.

Introduction

Conventional ventilatory support has a mode to start with and needs a switch over to another for stepping down from the ventilatory support. Time cycled mandatory breaths in Biphasic Positive Airway Pressure (BIPAP) allow spontaneous breathing at any phase of ventilatory cycle.(1) Since it allows transition from controlled to any level of assisted mechanical ventilation, BIPAP seems to be a suitable mode for the patient throughout the period of mechanical ventilation.(2) This study was undertaken to evaluate the effects of BIPAP as a single ventilatory mode to initiate and step down versus continuous mandatory ventilation (CMV), synchronized intermittent mandatory ventilation (SIMV) and continuous positive airway pressure (CPAP) in patients receiving elective post-operative ventilation.

Subjects and Methods

After institutional ethical committee clearance and obtaining consent, 40 patients of age group 20 yrs and older of American society of anesthesiologists (ASA) physical status 1-3 who underwent elective transhiatal esophagectomy and Whipple's procedure under general anesthesia were selected and the patients were randomly allocated into two groups by computer generated random allocation before mechanical ventilation in Post anesthetic care unit (PACU). SAVINA ventilator (Dräger, Germany) was used in all the patients. Group B (n=20) comprised of patients who were put on BIPAP mode and group C(n=20) who were put on continuous mandatory ventilation (CMV), synchronized intermittent mandatory ventilation (SIMV) and continuous positive airway pressure (CPAP) mode. An independent researcher allocated interventions through sequentially numbered sealed envelopes marked according to the allocation schedule generated by computer. Acute physiology and chronic health evaluation (APACHE) II severity score was done in all patients. In both the groups, an intensivist unrelated to the study managed mechanical ventilation. Patients with neuromuscular disorders, cervical cord injuries, severe cardiovascular, hepatic and renal disease were excluded from the study. Primary outcomes measured were duration of mechanical ventilation and ratio of arterial oxygen partial pressure to fractional inspired oxygen (PaO2/FiO2) ratio. Secondary outcomes measured were hemodynamic instability and sedation requirement. Postoperative pain relief was given with epidural analgesia and the insertion point of epidural needle was between T10 - T11 and catheter was kept 5 cm inside the epidural space. Continuous epidural infusion of 0.125 % bupivacaine with 2 µg/ml of fentanyl was given at a rate of 5 - 8 ml/hr to achieve a visual analogue score (VAS) of ≤ 4/10 in both the groups. Sedation scoring was done by Observer assessment of alertness and sedation scale (OAA/S)[3] which is as follows:

5- Responds readily to name spoken in normal tone
4- Lethargic response to name in normal tone

3- Responds only after name is called loudly, repeatedly
2- Responds only after mild prodding or shaking
1- Does not respond to mild shaking

Hemodynamic instability was defined as reduction in mean arterial pressure or systolic blood pressure by more than 20 % from the baseline. Patient was put on mechanical ventilation and stepped down according to the protocol given below.

Group C ventilation protocol was started with either CMV or SIMV-volume control. The tidal volume was set at 10 ml/kg, respiratory rate of 12/min, inspiratory time to expiratory time ratio (I:E) was kept at 1:2 and the inspired oxygen concentration(FiO2) was tapered down to achieve the lowest level at which oxygen saturation (SpO2) >92% could be achieved. A positive end expiratory pressure (PEEP) of 5 cm H2O and pressure support (PS) of 15 cm H2O was added. When the patient was arousable and had spontaneous breaths, a spontaneous breath trial (SBT) was done. If the patient tolerated SBT well and there was no hemodynamic instability, then a T-piece trial was done. If the patient tolerated T piece trial for more than one hour and met the extubation criteria, then extubation was done.

Group B ventilation protocol was started by keeping pressure control of 20 cm H2O, Inspiratory positive airway pressure (IPAP) of 10 cm H2O, Expiratory positive airway pressure (EPAP) of 5 cm H2O, respiratory rate of 12/min, inspiratory time to expiratory time ratio (I:E) ratio of 1:2 and the inspired oxygen concentration (FiO2) was adjusted gradually to the lowest level at which SpO2 >92% could be achieved. The IPAP and EPAP were increased in increments of 2 cm H2O to reduce the work of breathing and to improve oxygenation respectively. When the patient was arousable and had spontaneous breaths, the pressure control was decreased in decrements of 5 to 6 cm H2O, the IPAP was decreased in decrements of 2 cm H2O until it was equal to EPAP and the EPAP was decreased in decrements of 2 till 5 cm of H2O.When IPAP was equal to EPAP, spontaneous breath trial was done. If the patient tolerated SBT well and there was no hemodynamic instability, then a T-piece trial was done. If the patient tolerated T piece trial for more than one hour and met the extubation criteria, then extubation was done.

Sedation was given with intravenous midazolam 2 mg when OAAS score was ≥ 4 and midazolam was given in increments of 2 mg till OAAS ≤ 3.Extubation criteria followed were (i) alert patient (ii) adequate spontaneous ventilation (iii) SpO_2>92% on $FIO_2$of ≤ 60%, (iv) End tidal carbon dioxide ($EtCO_2$) <45 mm Hg (v) stable haemodynamics (vi) normothermia. Power analysis was calculated using G* Power(version 3.1.9.2, United states) and through preliminary study of 10 patients, mean duration of ventilation was calculated as 6.2 hours in group B and 10.4 hours in group C. The total sample size was calculated as 40 from an effect size of 0.3 to have a power of 80% to detect 30% difference with respect to the primary outcome (Duration of mechanical ventilation) between the two groups with an accepted type I error of 0.05 and type II error of 0.20.

Analysis was done using SPSS version 15.0 and students t- test was applied for interpretation of results and a P value of <0.05 was considered statistically significant. All the outcome measures are expressed as mean and standard deviation. Duration of mechanical ventilation and PaO2/FiO2 ratio were compared using student's t-test and sedation requirement was compared using student's t-test and hemodynamic instability was compared using Fisher's exact test.

Results

The two groups were comparable with respect to age, sex, weight, height, preoperative hemoglobin, intraoperative blood loss, duration of surgery, visual analogue score(VAS), type of surgery [Table 1] and severity caused by the surgical condition and systemic illness in terms of APACHE II score [Table 2]. The serum electrolytes (sodium and potassium) and general nutritional status was comparable in both the groups. The intraoperative period was uneventful in all the patients in both the groups. The results are summarized in Table 2. The mean duration of ventilation in group B (6.8±2.8 hours) was less than in group C (9.9±3.6 hours) with statistical difference (p – 0.005) shown in Fig. 1. PaO2/FiO2 ratio in group B (427.5±47.5) was comparable with group C (410.5±36.3). Sedation requirement with midazolam was significantly reduced (p – 0.0001) in group B (4±2.71 mg) compared to group C (8.05±2.45 mg) shown in Fig. 2. There was no incidence of hemodynamic instability in both the groups.

Table 1: Patient and operative Demographic data

Variables	Group B(n=20)	Group C(n=20)
Age (years)	49.3±13.58	48.7±13.8
Male	14	12
Female	6	8
Height (cm)	161.4±9.3	156.75±9.7
Weight(kg)	60.3±8.02	57.85±11.2
Hemoglobin(g/dl)	11.75±0.96	11.65±1.1
Duration of surgery(min)	269.5±40.9	289±25.3
VAS score	3±0.61	3±0.71
Blood loss(ml)	426±57.5	443±53
Type of surgery		
THE	10	9
Whipple's	10	11

THE – transhiatal oesophagectomy

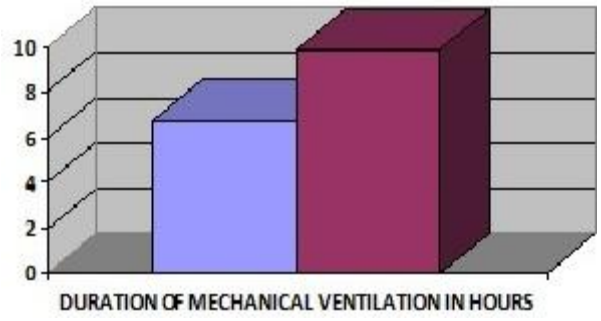

Fig. 1: Duration of Mechanical Ventilation

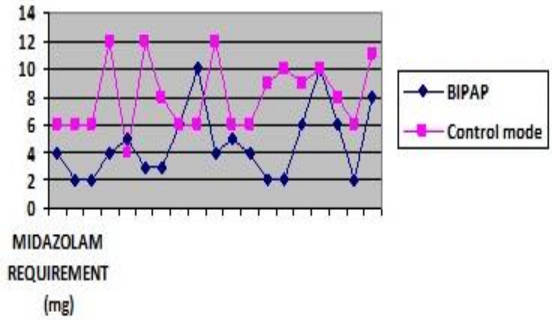

Fig. 2: Sedation Requirement

Table 2: Outcome measures

Variables	Group B(n=20)	Group C(n=20)	P value	Significance
APACHE 2 score	2.4±1.02	2.12±0.98	0.12	NS
PaO2/FiO2 ratio	427.5±47.5	410.5±36.3	0.21	NS
Duration of ventilation(hrs)	6.8±2.8	9.9±3.6	0.005	S
Midazolam requirement(mg)	4±2.71	8.05±2.45	0.0001	S
Hemodynamic instability	0	0	1.0	NS

S- significant, NS – not significant. P<0.05 is taken to be significant

Discussion

Biphasic Positive Airway Pressure (BIPAP) was first described by Baum and colleagues,[1] who described this newer mode as a combination of pressure controlled ventilation with spontaneous breathing in a system allowing time cycled mandatory breaths and unrestricted spontaneous breathing at any phase of the ventilatory cycle. BIPAP uses the same principle as Airway pressure-release ventilation (APRV) which was first described by Stock and coworkers,[4] as a mode of ventilation in which spontaneous breaths are at elevated baseline (CPAP) and intermittently released to facilitate expiration.

In our study, the mean duration of ventilation in group B (6.8±2.8 hours) was less than in group C (9.9±3.6 hours). These results were similar to the study done by rathgeber and colleagues[5] in which they did a prospective analysis in 596 patients who were ventilated after cardiac surgery and they reported a significant reduction in the mean duration of mechanical ventilation with BIPAP group (10.1 hours) compared with SIMV (14.7 hours) and CMV (13.2 hours).

Studies have shown that BIPAP increases transpulmonary pressure due to a reduction in pleural pressure which in turn causes recruitment of collapsed alveoli especially in juxtadiaphragmatic lung regions.[6,7] In a model of Acute lung injury (ALI) done by Gama de Abreu and coworkers,[8,9] they compared distribution of pulmonary aeration with BIPAP and PSV and they reported that BIPAP with spontaneous breathing improves oxygenation and reduces venous admixture compared with controlled ventilation. In our study, mean PaO2/FiO2 ratio in group B (427.5±47.5) was comparable to group C (410.5±36.3) which differs from the results of previous studies. One possible explanation is that Gama de Abreu and coworkers conducted the study in animal models with lung injury, other studies[10,11] similar to our study was conducted in patients with acute respiratory distress syndrome. The patients in our study group consisted of patients without respiratory disease and their admission to PACU was primarily for postoperative mechanical ventilation.

The mean midazolam requirement was reduced in group B (4±2.71 mg) compared to group C (8.05±2.45 mg). These results were similar to the study done by Rathgeber and coworkers who reported that the mean midazolam requirement in BIPAP group (4.3 mg) was lower than CMV group (8.8 mg).[5] Putensen and colleagues reported a reduced requirement of sedation in patients with patients ventilated with BIPAP compared with control mode ventilation due to maintenance of spontaneous breathing during BIPAP.[12]

There was no incidence of hemodynamic instability in both the groups. These results are similar to the results of previous studies.[10,13] Intermittent positive pressure ventilation reduces venous return due to increase in intrathoracic pressure.[14] Rasanen and colleagues[15] reported that there was no reduction in cardiac output or tissue perfusion while switching from CPAP to BIPAP although control mode ventilation caused reduction in stroke volume and tissue perfusion. Studies have shown that since BIPAP maintains spontaneous breathing, there is a decrease in intrathoracic pressure which in turn promotes venous

return to the patient hence increasing cardiac output and delivery of oxygen DO2. It was found that right end diastolic volume and cardiac index was elevated when the patient was in BIPAP indicating its cardiovascular stability.[10,16]

There are few limitations in this study. First, is the design of the study since it is difficult to blind a ventilator study. Second, is the variability in the timing of initiation of spontaneous breath trial due to individual variation by intensivists involved in this study although this variation may be little since they were blinded to the study and ventilator management was done based on institutional protocol.

In comparison with other similar studies which was done in patients with ARDS, our study population consisted of patients who came to PACU for elective postoperative ventilation. Very few studies have been done in patients who came for elective postoperative ventilation.[5]

Our findings implicate that BIPAP can be used for patients coming to ICU for elective postoperative ventilation. Since it reduces the duration of mechanical ventilation and sedation, it can be used for postoperative patients without respiratory disease in the context of current literature evidence. Similar studies of large sample size in different population are required to validate the results of this study.

Conclusion

BIPAP reduces the duration of mechanical ventilation and sedation requirement which in turn reduces morbidity.

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