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A study on the effect of intraoperative continuous positive airway pressure (CPAP) on the postoperative pulmonary function in overweight patients undergoing lower limb, lower abdominal or vaginal surgeries under spinal anesthesia

Abstract

Introduction: Spinal anaesthesia, supine position and higher BMI are risk factors for pulmonary atelectasis. NIV, PEEP and CPAP are employed in ICU's to treat atelectasis postoperatively. However, we wanted to investigate whether CPAP was protective against atelectasis when used intraoperatively, in high risk patients.

Material and methods: This study was a randomized controlled trial. Overweight patients, who were to undergo surgeries under spinal anesthesia were included in the study. After informed consent, 126 patients underwent preoperative pulmonary function tests (PFT: FEV_1, FVC, PEFR). Following the onset of spinal anaesthesia patients were randomised into group E (n = 63, received CPAP) and control group, group C (n =63, received nil intervention). Postoperative PFT was done at 20 minutes, 1 hour, 2 hours and 3 hours after surgery. Patients were followed up till discharge for pulmonary complications.

Results: We observed significant reduction in pulmonary function (FEV_1, FVC and PEFR) postoperatively compared to baseline. CPAP group had better pulmonary function when compared to control group, the difference being significant 20 minutes after the surgery($p < 0.05$). No postoperative pulmonary complication was reported among the 126 patients studied.

Conclusion: Intraoperative use of CPAP in overweight patients undergoing surgeries under spinal anaesthesia could be beneficial in improving pulmonary function in the immediate post-operative period.

Key words: intraoperative CPAP, spinal anesthesia, overweight, pulmonary function

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Introduction

Postoperative pulmonary complication (PPC) is a recognised event. Incidence of postoperative atelectasis is 20–69% and that of postoperative pneumonia is 9 to 40% [1]. The duration of hospital admission, morbidity and mortality increase significantly in patients with respiratory dysfunction. Age ≥ 60 years, body mass index (BMI) ≥ 27, history of cancer, impaired cognitive function in the preoperative setting, upper abdominal, or both upper/lower abdominal incision site and positive smoking history within the past 8 weeks are the identified predictors [2] of development of postoperative pulmonary dysfunction.

Overweight and obese individuals have higher intraabdominal pressure which can lead to basal atelectasis [3, 4]. Increased chest wall stiffness causes higher respiratory elastance in patients with obesity [5]. Atelectasis which worsens during general anaesthesia and do not disappear after surgery is documented in obese patients.

Supine position during surgery causes cephalad movement [6] of the diaphragm and reduction in cross-sectional area of the thorax. Relative pooling of blood in the thorax during

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supine position reduces the pulmonary volume.

For a wide range of lower limb, abdominal, vaginal and inguinal surgeries, general as well as spinal anaesthesia are equally feasible. Atelectasis during both general and spinal anaesthesia are well documented [7].

The application of positive end-expiratory pressure (PEEP) is effective against atelectasis in general anaesthesia [8]. In spontaneously breathing awake patients, PEEP can be provided using EzPAP® [9, 10]. Overweight patients in supine position under spinal anaesthesia are definitely a high-risk group of development of postoperative atelectasis.

The aim of our study was to assess whether administering EzPAP® intraoperatively to overweight patients improved their pulmonary function postoperatively, compared to controls, after surgeries under spinal anaesthesia.

Materials and methods

This study was an open-label randomised control trial undertaken in the Department of Anaesthesiology and Critical Care, Jawaharlal Institute of Postgraduate Medical Education and Research (JIPMER) between January 2015 and May 2016. A total of 126 American Society of Anaesthesiology (ASA) Class 1 and 2 patients in the age group of 18 to 60 years with BMI between 25 to 30 undergoing elective lower limb, inguinal or vaginal procedures under spinal anaesthesia were included in the study after approval from the institute ethics committee, Clinical Trial Registry of India (CTRI), registration and written informed consent from participants. Patients who were claustrophobic, pregnant, having cardiorespiratory diseases causing poor effort tolerance were excluded from the study. Inability to comprehend the application of EzPAP® was also an exclusion criterion.

During preoperative assessment, the procedure was explained and the use of a PFT machine was demonstrated to all participants. All the patients received standard premedication as per institute protocol which included famotidine 20 mg and diazepam 5 mg at night followed by 20 mg famotidine, 5 mg diazepam and 10 mg metoclopramide in the morning unless otherwise specified.

In the operation theatre, in supine position, standard ASA monitors were attached. They included ECG, pulse oximetry and Non-Invasive Blood Pressure monitoring. Baseline pulmonary function test (PFT) was done using a handheld spirometer (190513 MIR Spirobank G). A nose clip was used during the spirometry, which was performed by the anaesthesiologist assigned to the case. Forced expiratory volume in the first second (FEV_1), forced vital capacity (FVC) and PEFR were noted down. Each time spirometry was repeated three times in supine position and the best of the three results was taken as per the European Respiratory Society guidelines [11].

Spinal anaesthesia was administered with hyperbaric bupivacaine and block height was documented. After the onset of spinal anaesthesia, the anaesthesia resident assigned to the operating table opened a sealed opaque envelope. The envelope contained a random number which was computer-generated by block randomisation. The block sizes were 4, 6 and 8, and the original generated list contained 130 numbers. The list was created and sealed with the help of an independent anaesthesiologist, unrelated to the study.

PEEP was provided during the study by the anaesthesiologist assigned to the case using a device called EzPAP® (PORTEX® EzPAP® Positive Airway Pressure System, manufactured by Smiths Medical). It is an FDA approved device, for treatment and prevention of atelectasis and mobilisation of endobronchial secretions. The device consists of a mouthpiece, an air inlet, pressure port with a cap, gas inlet port with tubing and a manometer. Once EzPAP® is connected to the oxygen flow meter from the wall port, the patient has to breathe in through the mouth piece. Oxygen flow is then adjusted to generate a PEEP of 10 cm H_2O (9), which is measured by the manometer. Airflow to the convex parts of the PEEP valve causes it to attach and adhere due to coanda effect, generating PEEP. A nose clip is not a part of the device and was not used during the study. EzPAP® was administered throughout the duration of the surgery. Fixed CPAP of 10 cm H_2O was used for better comparability, as per protocol.

Intraoperatively, the group E (n = 63) received EzPAP® and the control group, group C (n = 63) received oxygen by face mask at a flow rate of 6 L/min.

Throughout the surgery, at 5 minutes intervals, noninvasive blood pressure, ECG and SpO_2 were documented.

Postoperatively, PFT was repeated in supine position using the same spirometer, as before, at 20 minutes, 1 hour, 2 hours and 3 hours after the end of surgery. This was done after assessing the visual analogue scale (VAS) score for pain. PFT was measured only when VAS score was less than 2 to remove the confounding effect of pain on PFT. Rescue analgesics (paracetamol and

ketorolac) were used to ensure adequate analgesia whenever VAS score was > 2. Postoperative nausea and vomiting were documented. Patients were followed up clinically till discharge for postoperative pulmonary complications.

Postoperative pulmonary complication was defined as the development of pneumonia any time before discharge. Diagnosis was based on the presence of new onset of cough with expectoration, fever (temperature > 38.3°C), leucocytosis (total leucocyte count > 20,000/μL) or leucopenia (total leucocyte count < 4000/μL) and radiological infiltrates.

Sample size calculation and statistical analysis were done by using SPSS version 13.0 software. Sample size calculation was based on a similar study [7] which documented reduction in FEV_1, FVC and PEFR following spinal anaesthesia. Distribution of data was tested using one-sample Kolmogorov Smirnov test. Categorical data were expressed as frequency and percentages and were compared by using chi-square test or Fischer's exact test. The data on age, anthropometric parameters, level of pain and pulmonary function parameters were expressed as mean with standard deviation or median with range and were compared with the help of independent student t test/Mann-Whitney U test/one-way analysis of variance or Kruskall-Wallis test based on the distribution of data and the number of groups. Spinal block height was expressed as median with interquartile range and analysed using the Mann-Whitney U test. The statistical significance of the longitudinal changes in FEV1, FVC and PEFR in each group was calculated by one-way repeated measures of ANOVA. The longitudinal changes over time between the groups were analysed using two-way repeated measures of ANOVA. Post hoc analysis of ANOVA results was performed using the Tukey Test in SPSS software. Statistical analysis was carried out at 5% level of significance and 80% power, and p value < 0.05 was considered as significant.

Results

A total of 150 patients were assessed for eligibility. 4 individuals did not fit into inclusion criteria, 10 persons opted not to participate in the study and 10 patients had failed spinal anaesthesia. Finally, 126 subjects were included in the study. 63 patients were randomly allotted to the test group and control group. Consort Diagram is represented as Figure 1. Demographic characteristics are represented in Table 1.

The duration of surgery was found to be significantly different (P < 0.01) between the

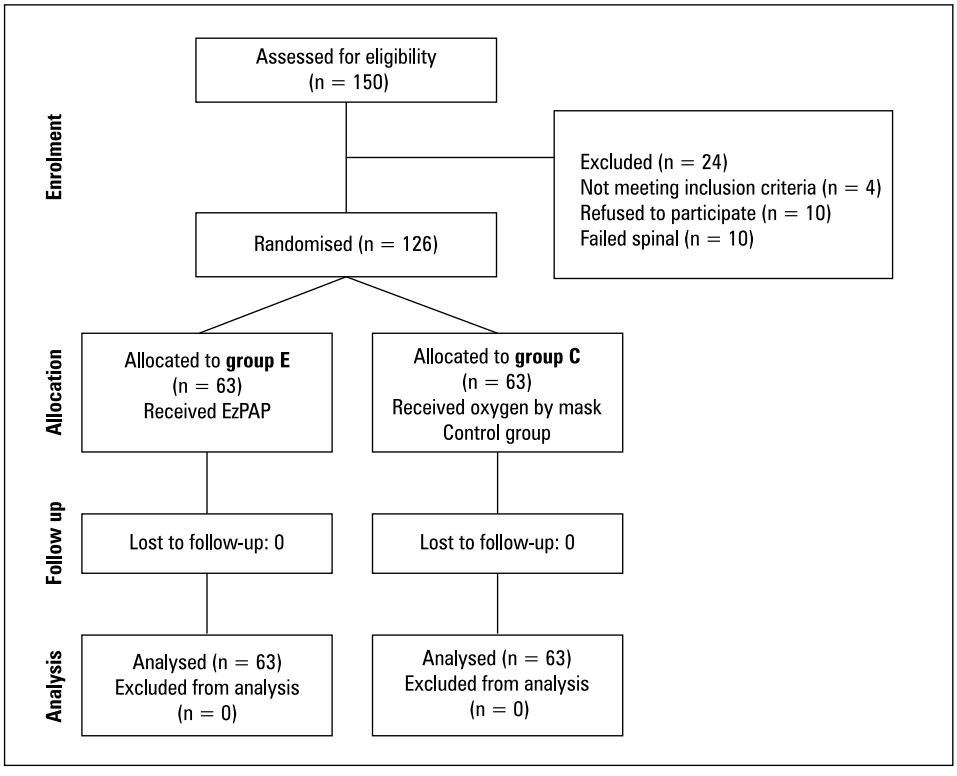

Figure 1. Consort diagram

Table 1. Distribution of age, sex, body mass index (BMI) and duration of surgery between the two groups

Parameter	E group	C group	P value
Age (Years — mean ± SD)	39.7 ± 9.01	38.06 ± 9.1	0.29
Sex (male:female %)	39.7 ± 60.3	42.9 ± 57.1	0.717
Duration of surgery (hours — mean ± SD)	1.81 ± 0.76	1.46 ± 0.69	0.007
BMI (Kg/m^2 — mean ± SD)	26.63 ± 1.11	26.34 ± 1.03	0.124

Table 2. Comparison of FEV_1, FVC, PEFR between the groups at different time points

	FEV_1*			FVC*			PEFR*		
Time point	**Group E**	**Group C**	**P value**	**Group E**	**Group C**	**P value**	**Group E**	**Group C**	**P value**
Baseline	3.3 ± 0.41	3.3 ± 0.4	0.8	3.97 ± 0.48	4.05 ± 0.52	0.39	500 ± 75.9	505 ± 85.1	0.71
20 minutes	3 ± 0.4	2.82 ± 0.4	0.01*	3.68 ± 0.46	3.5 ± 0.51	0.046*	468 ± 70	440 ± 78.2	0.035*
1 hour	3.1 ± 0.38	2.97 ± 0.39	0.18	3.75 ± 0.48	3.67 ± 0.5	0.38	475 ± 71.2	458 ± 77	0.2
2 hours	3.1 ± 0.38	3.11 ± 0.4	0.8	3.82 ± 0.48	3.82 ± 0.5	0.98	485 ± 71.98	476 ± 80.4	0.51
3 hours	3.2 ± 0.38	3.21 ± 0.4	0.98	3.9 ± 0.5	3.9 ± 0.5	0.94	492 ± 72.55	488 ± 82.3	0.76

*All results in mean ± SD (L). FEV_1 — forced expiratory volume in the first second; FVC — forced vital capacity; PEFR — peak expiratory flow rate

two groups with the EzPAP® group (group E) undergoing surgeries for a longer duration. End operative block height among the group E was comparable to the group C (P = 0.633). Mean end operative block height was T8 (T8–T10) in both the groups.

22.2% of patients in each group required analgesia before doing PFT postoperatively. Either paracetamol (19/28–67.85%) or ketorolac (9/28–32.15%) was used as analgesic. None of the patients had postoperative nausea or vomiting.

FEV_1, FVC and PEFR were found to be significantly better among the group E compared to the group C, 20 minutes after surgery ($p < 0.05$). Baseline PFT parameters and those at 1 hour, 2 hours and 3 hours after surgery were comparable between the groups (Table 2, Figures 2–4).

None of the patients in either group had SpO_2 values <95% at any point of time. SpO_2 trend in either group during the first hour of surgery is represented in Figure 5. The distribution of the type of surgery is illustrated in Figure 6.

There is a significant fall in FEV_1, FVC and PEFR after spinal anaesthesia and surgery, measured at the end of 20 minutes, 1 hour, 2 hours and 3 hours postoperatively when compared to baseline in the E group as well as C group (Table 3, 4). None of the patients developed postoperative pulmonary complications till discharge.

Discussion

Overweight patients have higher chances of atelectasis and postoperative complications compared to normal weight patients [12]. Spinal anaesthesia and supine position are also independent risk factors for reduction in pulmonary function. Positive end expiratory pressure improves pulmonary function by lung expansion in patients undergoing surgeries under general anaesthesia. Given the current data by World Health Organization (WHO), nearly 40% of the adult population in the world is overweight. We wanted to address the effects of spinal anaesthesia and potential results of PEEP on the pulmonary function of overweight patients [13] undergoing surgeries.

We recruited 126 overweight patients (BMI 25–30 kg/m^2) who underwent lower limb, vaginal or inguinal surgeries under spinal anaesthesia. Meira *et al.* [14] and Sternberg *et al.* [7] have documented atelectasis in overweight patients undergoing surgeries under spinal anaesthesia. But the application of EzPAP® in overweight patients to prevent atelectasis is not well studied.

Both groups of patients were comparable in terms of distribution of age (group E *vs* group C: 39.7 ± 9.01 years' *vs* 38.06 ± 9.01 years; $p > 0.05$), sex (M:F group E *vs* group C: 39.7 ± 60.3 *vs* 42.9 ±

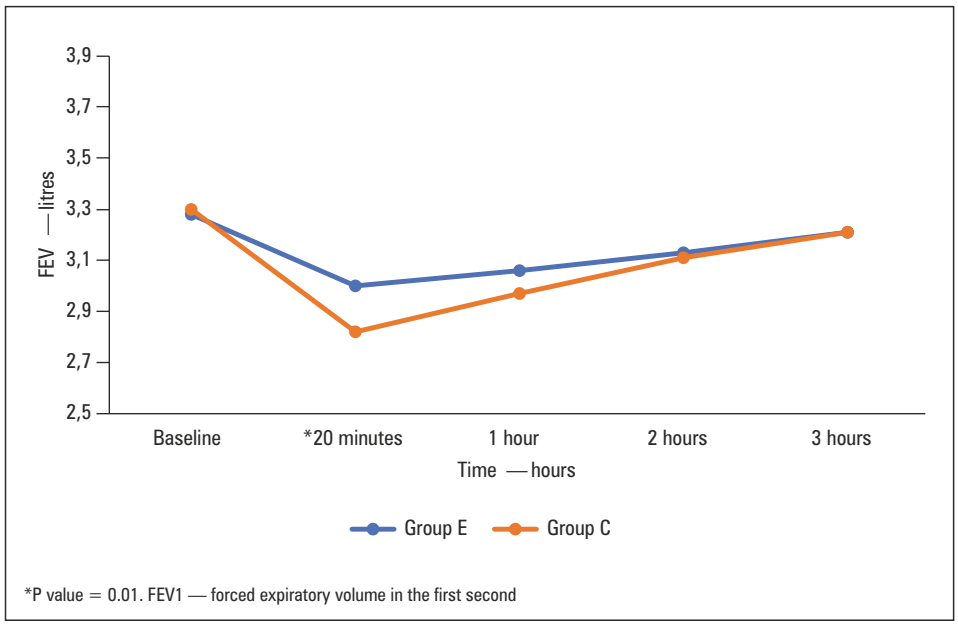

Figure 2. Comparison of FEV_1 (L) between group E and group C at different time points

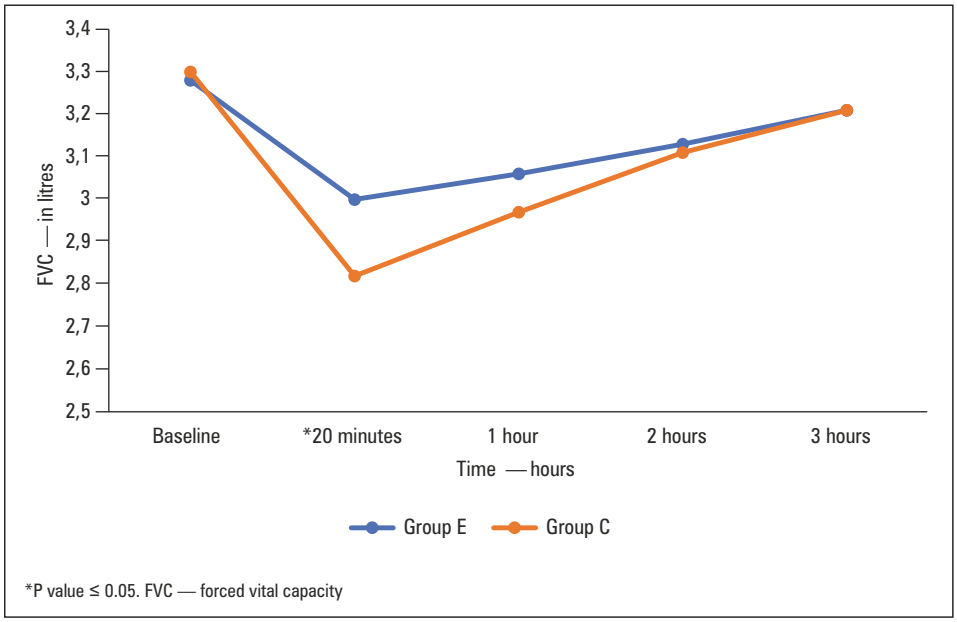

Figure 3. Comparison of FVC between group E and group C at different time points

57.1; $p > 0.05$) and BMI (group E *vs* group C 26.63 ± 1.11 *vs* 26.34 ± 1.03; $p > 0.05$). BMI in both groups were only marginally higher than that of normal as our study focused strictly on overweight patients.

The test group had a significantly longer duration of surgery (1.81 ± 0.76 hours) compared to the control group (1.46 ± 0.69 hours; $p < .05$). A possible explanation is that setting up EzPAP® and ensuring the patient compliance and comfort during the procedure might have caused the delay. However, end operative block height in the test group as well as the control group was T8 (T8–T10) with a p value of 0.63, which indicates that irrespective of the duration of surgery, end operative block heights were comparable.

All patients were pain-free throughout the surgery and did not require intraoperative analgesics. Patients belonging to both groups were haemodynamically stable throughout the surgery.

All PFT measurements including baseline measurement were done in supine position to en-

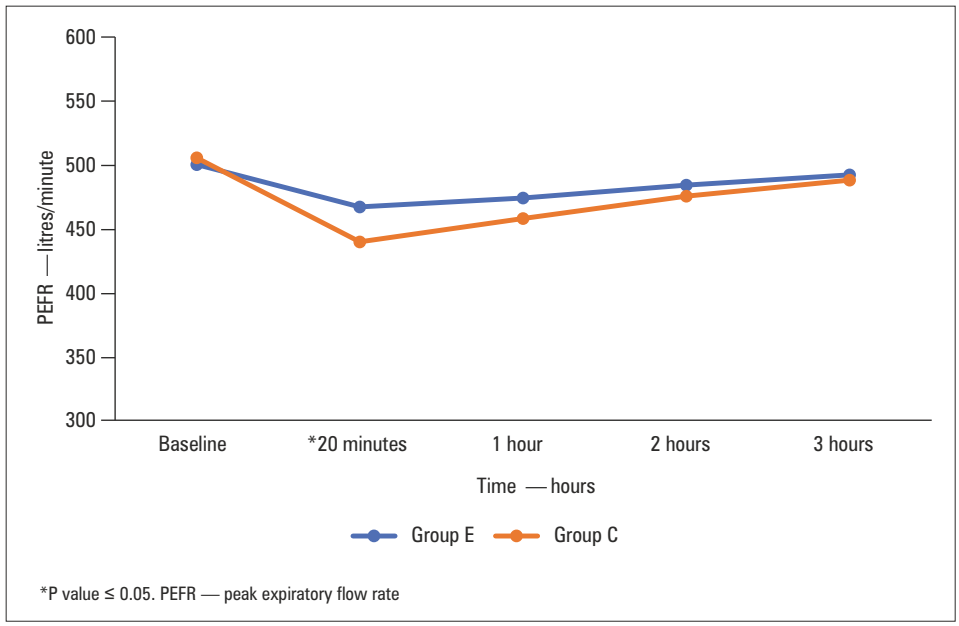

Figure 4. Comparison of PEFR between group E and group C at different time points

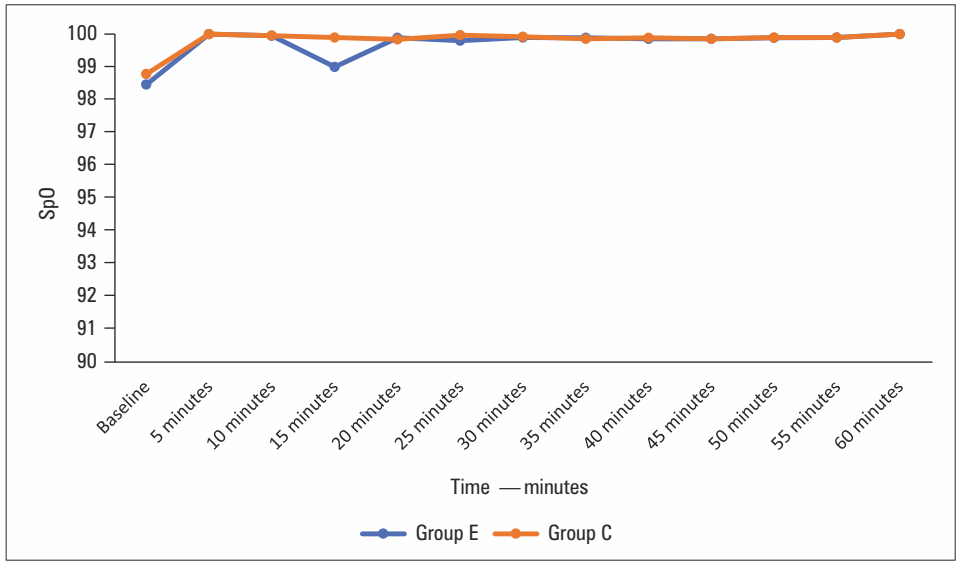

Figure 5. Variation of SpO_2 with time in group E and group C during surgery

sure uniformity. Both groups had significant fall in PFT, i.e. FEV_1, FVC and PEFR when compared to baseline at 20 minutes, 1 hour, 2 hours and 3 hours after the surgery. This is in accordance with previous studies which have documented reduction in pulmonary function after spinal anaesthesia [7, 11, 14].

FEV1 , FVC and PEFR declined in both groups over time, though the difference was significant only at 20 minutes. However, PFT values declined less in the group E, which could be attributed to better lung expansion in in this group. Another study in cardiology ICU setting [15] has demonstrated similar findings in a group of postoperative cardiac surgery patients receiving CPAP, though they were receiving CPAP for a significantly longer duration.

A limitation we felt during the study was the lack of PaO2 measurements for comparison. However, this aspect was considered and decided against during the planning stage as we felt it was unethical to take arterial prick samples from awake ASA1 and 2 patients when it did not directly benefit them in terms of management. Furthermore, FRC couldn't be assessed as it was unsafe to mobilise immediate postoperative patient to PFT lab for getting the FRC done. The patients

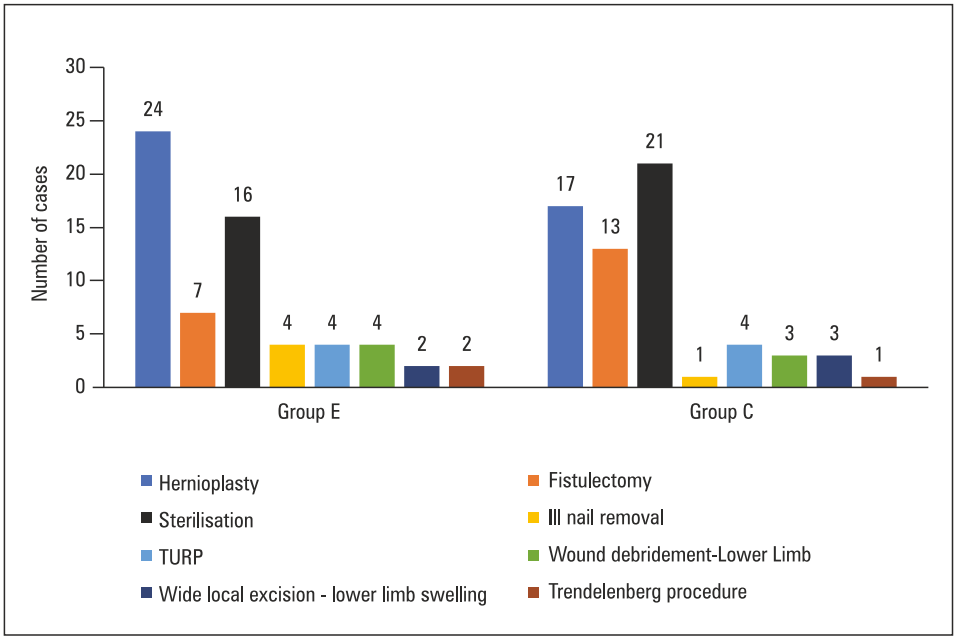

Figure 6. The distribution of the type of surgery

Table 3. Comparison of FEV_1, FVC, PEFR at different time points when compared to baseline in group E

Baseline	Time points	FEV_1 — mean with SD (L)	P value
FEV_1* 3.28 ± 0.412	20 minutes	3 ± 0.4	< 0.001*
	1 hour	3.06 ± 0.38	< 0.001*
	2 hours	3.13 ± 0.38	< 0.001*
	3 hours	3.21 ± 0.38	0.01*
FVC* 3.97 ± 0.48	20 minutes	3.68 ± 0.46	< 0.001*
	1 hour	3.75 ± 0.48	< 0.001*
	2 hours	3.82 ± 0.48	< 0.001*
	3 hours	3.9 ± 0.5	0.021*
PEFR* 500.16 ± 75.85	20 minutes	467.92 ± 70	< 0.001*
	1 hour	474.94 ± 71.2	< 0.001*
	2 hours	484.52 ± 71.98	< 0.001*
	3 hours	492.16 ± 72.55	0.01*

*All results in mean ± SD (L). FEV_1 — forced expiratory volume in the first second; FVC — forced vital capacity; PEFR — peak expiratory flow rate

were not evaluated by lung ultrasound for atelectasis due to lack of availability of a dedicated ultrasound machine for the study. Similarly, they were not assessed for obstructive sleep apnoea by polysomnography due to practical difficulties of high caseload in the sleep lab and unavailability of the same for 126 patients. As we included only overweight patients belonging to ASA 1 and 2 in the study, the results might not be generalisable to morbidly obese or elderly patients with multiple comorbidities. Postoperative pulmonary complications might not have developed in our study population probably because our study was limited to overweight patients without significant comorbidities.

Conclusions

Intraoperative use of EzPAP® in overweight patients undergoing surgeries under spinal anaesthesia may improve pulmonary function in the immediate postoperative period. However, further studies are needed to evaluate the impact it has on arterial PaO2 as well as FRC. Furthermore,

Table 4. Comparison of FEV_1, FVC and PEFR at different time points when compared to baseline in group C

Baseline (L)	Time points	FVC — mean with SD (L)	P value
FEV_1* 3.3 ± 0.44	20 minutes	2.82 ± 0.4	< 0.001*
	1 hour	2.97 ± 0.39	< 0.001*
	2 hours	3.11 ± 0.4	< 0.001*
	3 hours	3.21 ± 0.4	0.01*
FVC* 4.05 ± 0.52	20 minutes	3.5 ± 0.51	< 0.001*
	1 hour	3.67 ± 0.5	< 0.001*
	2 hours	3.82 ± 0.5	< 0.001*
	3 hours	3.9 ± 0.5	< 0.001*
PEFR* 505.4 ± 85.14	20 minutes	439.67 ± 78.17	< 0.001*
	1 hour	457.86 ± 77	< 0.001*
	2 hours	475.48 ± 80.4	< 0.001*
	3 hours	487.97 ± 82.27	< 0.001*

*All results in mean ± SD (L). FEV_1 — forced expiratory volume in the first second; FVC — forced vital capacity; PEFR — peak expiratory flow rate

combined intraoperative and postoperative use of EzPAP® in the same subset of patients might sustain the improvement in lung function and needs to be evaluated.

Author's contribution

HB, CR and MM designed the study. Technical input related to spirometry and PFT was given by MR. MM collected the data, analysed and wrote the paper, which was reviewed by HB.

Conflict of interest

None declared.

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