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Effect of Posture on Postoperative Oxygen Saturation in Patients Undergoing Upper Abdominal Surgery under General Anaesthesia: It Matters

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Abstract

Context: Incidence of postoperative pulmonary complications is between 30-50% in patients undergoing abdominal surgery. Addressing pain at surgical site and improving respiratory mechanics , to reduce postoperative hypoxia have a key role in mitigating hospital stay and costs. *Aims:* To observe the changes in lung function tests and effect of different postures on postoperative oxygen saturations in patients undergoing upper abdominal surgery on the first, fourth and seventh postoperative days and to compare the respective pain scores. *Settings and Design:* Prospective observational study. *Methods and Material*: The study was done on 40 patients undergoing upper abdominal surgeries under general anaesthesia. Peripheral oxygen saturations (SpO_2) was measured using pulse oximeter and lung function tests using Medispiror preoperatively and on postoperative day 1, 4 and 7. The SpO2 was measured in supine, sitting and standing positions. The FVC, FEV1 and PEFR was measured in the sitting position on all 4 days. Pain was recorded using Numeric Rating Scales. *Statistical analysis used*: The Statistical software namely SPSS 18.0, and R environment ver. 3.2.2 were used for the analysis of the data and Microsoft word and Excel have been used to generate graphs, tables. *Results:* The improvement in oxygen saturation from supine (mean 95.95±1.77) to sitting (97.98±1.37) on the first postoperative was statistically significant with a p value of <0.001. Reductions in FVC from the preoperative (mean 2.35+0.48) value to the first post operative day (mean 1.29+0.39) was statistically significant with a p value of < 0.001. The FVC , PEFR and FEV1 were not at preoperative values even on the 7th postoperative day with a significant p value < 0.001 *Conclusions*: Postoperative oxygen saturations improve statistically in the sitting and standing position after upper abdominal surgery as compared to supine position. Simple maneuvers like change in position from supine to sitting and mobilization in the early postoperative period can improve the oxygen saturation and lung functions significantly and help in reducing lung atelectasis and resulting postoperative pulmonary complications.

Keywords: Anaesthesia General; Postoperative Period; Posture; Oxygen.

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Introduction

The postoperative period is one of rapidly changing pulmonary pathophysiology. The predominant pulmonary complication in the late postoperative period is hypoxaemia which can be attributable to micro atelectasis, pneumonia, thromboembolism and occurs in up to 40% of the patients [5].

Functional residual capacity (FRC) decreases in the supine compared to that in sitting position . [4]. Small postoperative measures like propped up position, spirometry, mobilisation and breathing exercises can not only reduce the hypoxemia, but also help in early ambulation decreasing pulmonary morbidity and need for prolonged hospital stay.

As hypoxaemia is a pathogenic factor in postoperative organ dysfunction and since many

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postoperative patients stay in the supine position after major abdominal operations, we decided to study the effect of posture on oxygen saturations in the postoperative period and compare the pulmonary function tests both before and after surgery [10,19].

Aim

To observe

1. The effect of supine, sitting and standing postures on postoperative oxygen saturations in patients undergoing upper abdominal surgery on the first, fourth and seventh postoperative days.
2. Changes in lung function tests from the preoperative to the first, fourth and seventh postoperative days measured in the sitting position.
3. To study the pain scores on the first, fourth and seventh postoperative days.

Material and Methods

Forty (40) patients undergoing upper abdominal surgeries under general anaesthesia were selected for the study. Inclusion criteria was American Society of Anaesthesiologists (ASA) grade 1– 2 patients, in the age group of 18-60 years, of either sex were randomly selected for the study. All patients were examined, kept fasting overnight after 10:00pm and received Tab. Alprazolam 0.5mg orally and Tab. Rantidine 150 mg as premedication on the night before surgery.

All patients were tested preoperatively for peripheral oxygen saturations (SpO2) using pulse oximeter in the supine, sitting and standing position after attaining the position for 5 minutes. Forced vital capacity (FVC), forced expiratory volume in 1second (FEV1), and peak expiratory flow rate (PEFR) were done using a Medispiror preoperatively, for base line values.

Patients with ASA Grade 3- 4 and those with pulmonary, neurological or cardiac dysfunction, obese patients with BMI >30 were excluded from the study.

On the day of surgery all patients were premedicated with injection fentanyl 2mcg/kg. A standardised general anaesthesia was induced with injection Propofol 2mg/kg and intubation was carried out with intubating dose of vecuronium (0.1mg/kg), patients were maintained on a mixture of isoflurane (0.4-1.2%) with oxygen nitrous combination (40:60). Before extubation injection Paracetamol 1gm and injection Tramadol 100mg intravenously were given for analgesia. Patients were extubated after reversal of neuromuscular blockade with injection neostigmine 0.05mg/kg and glycopyrolate 0.4 mg. Intraoperatively ECG, NIBP, SpO_2, $EtCO_2$, temperature and urine output monitoring was initiated in the operation theatre.

Postoperatively the peripheral arterial oxygen saturation was measured with pulse oximeter (Criticare), with the patient in supine, sitting in bed and standing positions. All the patients had rested for 30 minutes in bed and received injection Diclofenac 75mg intravenously, one hour prior to any measurement. Measurements were performed uniformly in the afternoon both preoperatively and on the 1st, 4th and 7th day after surgery. Forced vital capacity (FVC), forced expiratory volume in 1second (FEV1) and peak expiratory flow rate (PEFR) was measured using Medispiror, a standard portable computerised lung function monitor by taking the best of three readings to be able to meet the criteria of the European Respiratory Society (ERS). Each day pain scores were recorded and scored using Numeric Rating Scales (NRS), where no pain equaled 0 and the intolerable worst pain equaled 10, while the patient was in supine , sitting and standing positions. All the data was collected and descriptive and inferential statistical analysis was carried out. Results on continuous measurements were presented on Mean± SD (Min-Max) and results on categorical measurements were presented in number (%). Significance was assessed at 5 % level of significance. Student t test (two tailed, dependent) was used to find the significance of study parameters on continuous scale within each group

Results

All the patients were well matched in height and weight. The median age was 40 yrs, height 150 cm and weight 42kg. Median duration of surgery was 90 minutes.

There was significant decrease in the oxygen saturation on the first and fourth postoperative days in the supine position (p value < 0.001 and 0.001 respectively) which came near normal on the seventh postoperative day as seen in Table 1.

Preoperatively the oxygen saturations was comparable in all three positions for all the patients and there was no difference statistically or physiologically.

On the first postoperative day, the patients were mobilised from supine (mean saturation 95.95±1.77) to sitting (97.38±1.53) and standing (97.98±1.37) positions. The increase in saturation was significant statistically (p value <0.001). The patients reported feeling more comfortable after the position was changed with assistance (Table 2).

Even on the 4th postoperative day the improvement in saturation was significant on achieving the sitting position from the supine position (97.15±1.55 vs 98.20±0.99). After making the patient stand with support after a few minutes the oxygen saturation improved statistically (97.15±1.55 vs 98.43±1.03 , p value<0.001) relative to the supine position,but was not significantly different to that in sitting position (p value= 0.083+) (Table 2).

Though on the 7th postoperative day the patients were more comfortable and breathing well clinically, the increase in SpO_2 was still significant statistically in the sitting and standing positions when compared to supine position (p value<0.001), but were not clinically significant.

On comparing the lung functions the forced vital capacity (FVC) showed a significant decrease on the first postoperative day (1.29±0.39 vs 2.35±0.48) from the preoperative values. There was about 50% fall in the FVC, which could be due to incisional pain, diaphragmatic splinting and atelectasis. Even on the 4th and 7th POD, the FVC was significantly decreased (1.64±0.42 and 2.04±0.37) as compared to the preoperative value (Table 3).

Table 1: Peripheral Oxygen Saturation (SpO_2) Supine in the preoperative and postoperative day 1,4,7

SpO2 in Supine position	Min-Max	Mean ± SD	difference	t value	P value
Preoperative	96.0-98.0	98.13±0.85	-	-	-
Day 1	91.00-98.00	95.95±1.77	2.175	7.600	<0.001**
Day 4	92.00-99.00	97.15±1.55	0.975	3.561	0.001**
Day 7	94.00-99.00	97.85±1.05	0.275	1.263	0.214

Table 2: Mean values of oxygen Saturations in the supine, sitting and standing positions on the first fourth and seventh postoperative days

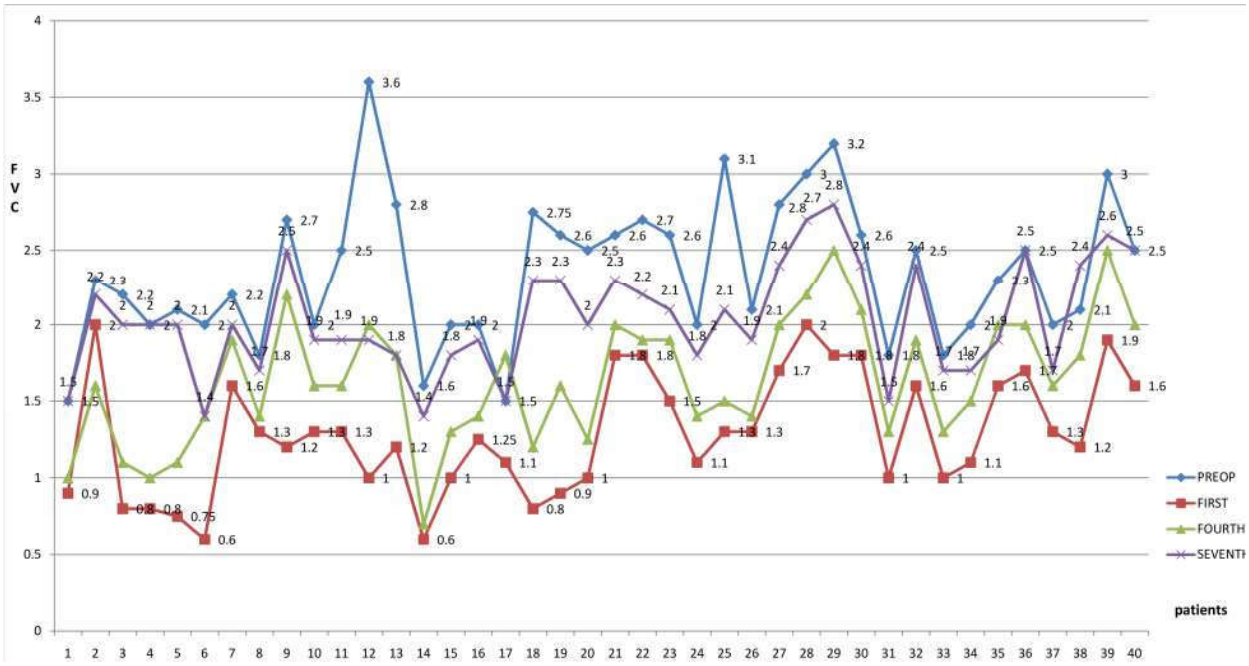
Oxygen Saturations on POD(Postoperative day)	Supine	Sitting	Standing	difference Supine vs Sitting	difference Supine vs Standing	difference Sitting vs Standing	P value Supine vs Sitting	P value Supine vs Standing	P value Sitting vs Standing
Pre-Operative	98.13±0.85	98.17±0.82	98.20±0.82	0.050	0.075	0.025	0.323	0.183	0.570
1st POD	95.95±1.77	97.38±1.53	97.98±1.37	0.425	2.025	0.600	<0.001**	<0.001**	0.003**
4th POD	97.15±1.55	98.20±0.99	98.43±1.03	1.050	1.275	0.225	<0.001**	<0.001**	0.083+
7th POD	97.85±1.05	98.53±0.60	98.70±0.56	0.675	0.850	0.175	<0.001**	<0.001**	0.018*

Table 3: Mean values of forced vital capacity (FVC)

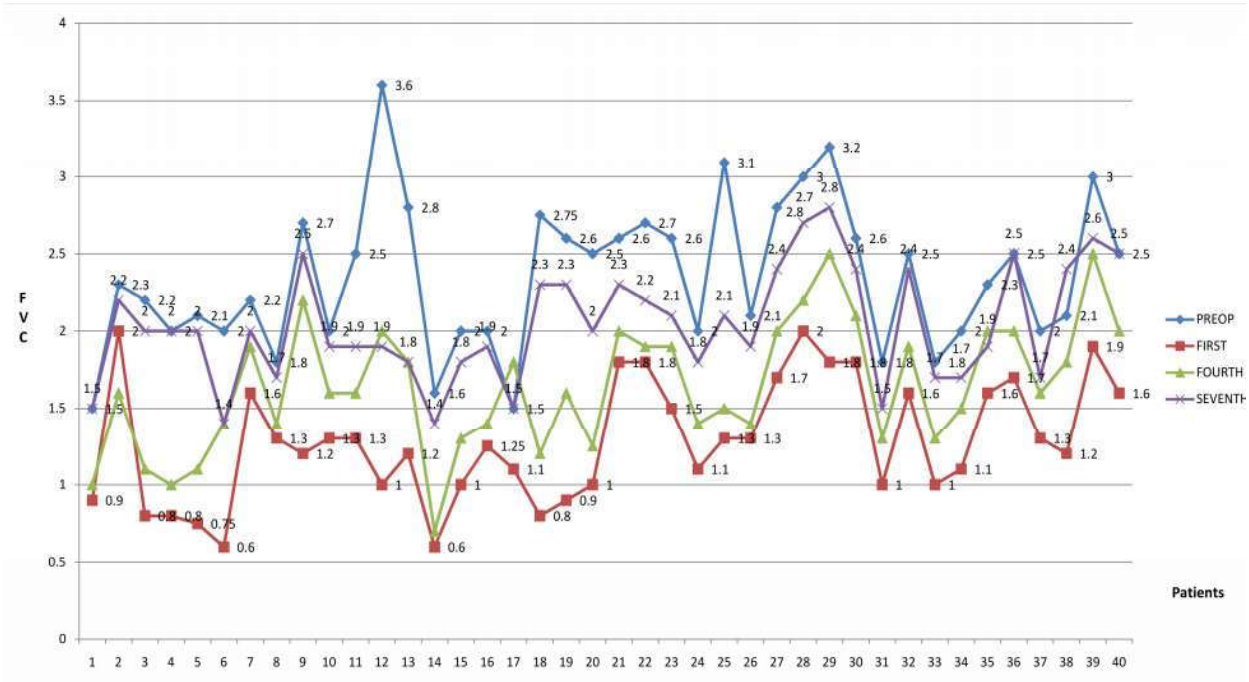
FVC	Min-Max	Mean ± SD	difference	t value	P value
Preop	1.50-3.60	2.35±0.48	-	-	-
1st POD	0.60-2.00	1.29±0.39	1.059	14.712	<0.001**
4th POD	0.70-2.50	1.64±0.42	0.703	11.902	<0.001**
7th POD	1.40-2.80	2.04±0.37	0.306	5.721	<0.001**

Table 4: Mean Values of Forced Expiratory Volume in 1 second (FEV_1)

FEV1	Min-Max	Mean ± SD	difference	t value	P value
Preop	1.25-3.00	2.02±0.49	-	-	-
1st POD	0.50-2.10	1.16±0.43	0.858	12.965	<0.001**
4th POD	0.60-2.50	1.48±0.43	0.536	8.947	<0.001**
7th POD	1.00-2.70	1.79±0.42	0.224	4.202	<0.001**



Graph 1: Measured FVC (Forced Vital Capacity) of Patients on all 4 Days

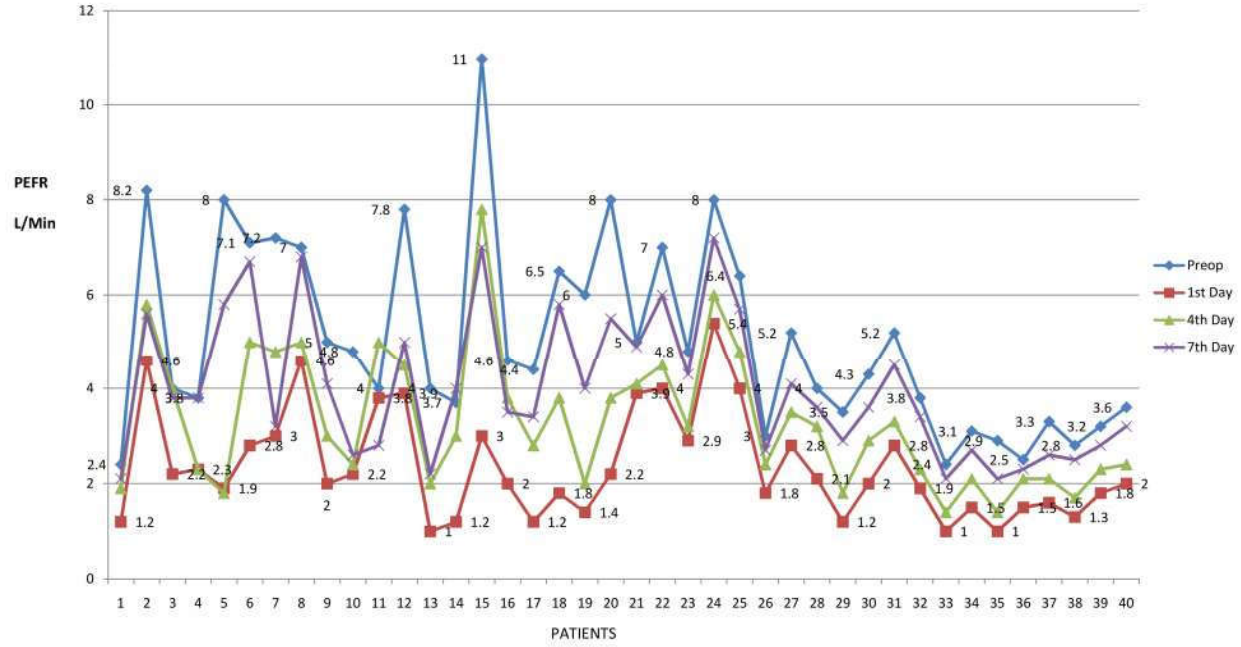


Graph 2: Measured FEV_1 of Patients on All 4 Days

Graph 1 shows the FVC values of all the patients in the preoperative period and on the first, fourth and seventh postoperative days.

There was significant reduction in the FEV_1, on the 1st postoperative day (2.02±0.49 vs 1.16±0.43) from the preoperative values and the trend continued on the 4th and 7th postoperative days. The significant decreases in the pulmonary function following surgery persisted beyond one week after surgery (Table 4). The changes in FEV_1 of all the patients is depicted in the Graph 2.

There was significant reduction in the PEFR on the 1st postoperative day (5.04±2.03 vs 2.37±1.13) from the preoperative values and the trend continued on the 4th and 7th postoperative days ($p<0.001$) (Table 5).



Graph 3: Measured PEFR Values of patients on all 4 days

Table 5: Mean Peak Expiratory Flow Rates (PEFR) Values

PEFR	Min-Max	Mean ± SD	difference	t value	P value
Preop	2.40-11.00	5.04±2.03	-	-	-
1st POD	1.00-5.40	2.37±1.13	2.668	10.843	<0.001**
4th POD	1.40-7.80	3.30±1.45	1.738	8.807	<0.001**
7th POD	2.10-7.20	4.02±1.50	1.015	6.252	<0.001**

Table 6: Pain scores (NRS) on the First, fourth, and Seventh Post operative days in the supine, sitting and standing positions

Pain	Supine	Sitting	Standing	Supine vs Sitting	Supine vs Standing	Sitting vs Standing
1st Post operative Day	5.98±1.35	6.08±1.05	6.45±1.01	<0.001**	0.007**	0.400
4th Postoperative Day	2.90±0.63	2.78±0.58	2.85±0.62	0.486	0.058+	0.412
7th Post operative Day	2.15±0.48	2.00±0.23	1.98±0.16	0.032*	0.018*	0.323

The significant decreases in the pulmonary function following surgery persisted beyond one week after surgery.Graph 3 depicts the changes in PEFR from the preoperative values to the reduced postoperative values.

Pain as assessed by Numeric Rating scores (NRS) was maximum on the first post operative day with a mean score of 5.98±1.35, which increased significantly on mobilization (p<0.001) to sitting (6.08±1.05) and standing (6.45±1.01) position. However, by the fourth postoperative day pain had subsided to an average of 2.15 and there was no significant increase with change in position. On 7th postoperative day, changes in pain on mobilization were statistically significant but not clinically relevant (2.15±0.48 vs 1.98±0.16) (Table 6).

Discussion

The incidence of post operative pulmonary complications (PPC) ranges from less than 1% to 23 % in major surgeries with 30-50% occurring after abdominal surgeries [20]. Mortality is increased in both the immediate short term and the long term, especially in patients developing secondary respiratory

problems. Many studies using continuous monitoring have shown severe and prolonged periods of hypoxaemia which occur immediately after surgery and continue episodically for several days [21].

After general anaesthesia the reduction in Functional Residual Capacity (FRC) of 15-20% is seen on induction of the patient, irrespective of whether patient receives any muscle relaxation [15].

Reduction in FRC along with ventilation perfusion mismatch due to abnormal regional distribution of ventilation and reduced cardiac output further aggravate the pulmonary dysfunction in apparently healthy individuals. Evidence implicates the occurrence of perioperative atelectasis as a key element in the progression to PPCs. Its presence appears to be a universal finding in PPCs arising from a diverse array of intrinsic and extrinsic contributing factors.

After upper abdominal surgery FRC usually reaches its lowest value 1-2 days after surgery, before slowly returning to normal values after 5-7 days. Appropriate technologies now include computed tomography, MRI, electric impedance tomography, ultrasonography and, most recently, intravital microscopy , for detecting atelectasis [1,7] . With the implementation of these methods, it has been shown that 90% of patients undergoing general anaesthesia demonstrate atelectasis in the most dependent parts of the lung [7,18].

It has been further shown that anaesthesia induced atelectasis triggers a cascade of pathophysiological events that may culminate in diffuse alveolar damage, respiratory failure and, in extreme cases, death [9,10,22].

Diaphragmatic dysfunction plays a critical role in progression to PPC. This is especially true in patients undergoing upper abdominal and thoracic surgeries. For reasons unclear, significant post-anaesthesia impairment of diaphragmatic contraction often persists for up to a week after surgery in some patients [24] Increased expiratory muscle activity also occurs commonly both during anaesthesia and post-operatively. Such an activity produces a rapid decrease in end-expiratory lung volume. Combined with reduced FRC, these mechanisms intensify the severity of atelectasis.

In the immediate postoperative period hypoxia is common, and several factors influence this including the residual effects of anaesthesia, effect of narcotics, as well as impairment of ventilatory response to hypercapnia and hypoxia. Since these would be confounding factors this period was not included in the study and first fourth and seventh days in postoperative period were examined to assess the late postoperative changes in oxygenation.

Patients undergoing abdominal surgery lose a great deal of inspiratory and expiratory reserve volume during the first post-operative days, with a 40% reduction in FRC, total lung capacity and forced expired volume in 1 s persisting for at least 1 week post-operatively [24]. In our study the reduction in FVC and FEV 1 were nearly 50% of the preoperative values, on the first postoperative day, and even after one week had not returned to the preoperative values.

Post-operative pain control is critical to PPC prevention. Pain contributes to diminishing the lung volumes and restricts the expansion of the lung by impairing the ability to perform deep inspirations and cough effectively [9].

We did not compare the requirement for postoperative analgesia/opioids, because Gunaydin and colleagues showed that FVC and FEV1 did not change, not even for constant opioid administration in alert patients [12]. This is also confirmed by results reported by others, who found no difference in postoperative lung function after desflurane/remifentanil anaesthesia or desflurane/sufentanil anaesthesia, provided that spirometry was performed at a similar VAS score after administration of various morphine doses [6]. We have measured the lung function tests in the sitting position, in all patients, approximately an hour after receiving Diclofenac 75 mg and in the afternoon.

In our study the lowest recorded saturation was 91%, in the supine position, on the first postoperative day, which would be on the cusp of the oxygen dissociation curve beyond which the drop would be acute. Arterial blood gas analysis is the gold standard to evaluate the oxygenation of a patient while pulse oximetry is an indirect measure .The correlation of the two even in critically ill patients is maintained and SpO_2 of > 90% correlated to a PaO_2 of >60 mmHg in most cases . Beyond this saturation the PaO_2 will be on "slippery slope" as small reductions in PaO2 is accompanied by disproportionately large reductions in oxygen saturation and content and therefore in oxygen delivery to the tissues [11]. This critical level would be avoided by the sitting up posture as found in a previous study by the improvement in FRC of 0.6-0.8 l on changing of position and improvement in saturations that we have found [13]. A review article has also concluded that postoperatively change of position to sitting or standing is of major importance in the interpretation of postoperative pulmonary outcomes [16].

Kehlet et al. have also found that following major abdominal surgeries, hypoxemia can occur till five days after surgery with superimposed episodes at night [14]. Further research on healthy patients evaluating the oxygen saturation concluded that best saturation was in the sitting upright position, while the lowest saturation was in the supine position, though all the values were within the normal range (94%-98%) [3].

Even in the ICU patients on mechanical ventilation with head of bed elevation of atleast 30 degrees significantly increased global and regional end expiratory lung volumes [23]. So far there is corroborative evidence suggesting that lung function tests and saturations improve in the sitting and standing positions relative to the supine position in the perioperative period.

In another recent study the recumbent position of patient under general anaesthesia, which is the norm, itself was found to be a major factor for perioperative hypoxia and perioperative pulmonary aspiration which can add to the PPC's [8].

Remarkably despite the significant reduction in FEV_1 and FVC and the significant changes of saturations from the supine to the sitting position, the drop in saturations never fell beyond 90% in our study group, reflecting on the big reserve of oxygen the body has. Also that the tests we are doing are not sensitive to the pathology which inevitably exists in the lung as evidenced by the nearly 50% reduction in pulmonary function tests.

A small crosssectional descriptive study has shown that despite growing evidence, more than 80% patients in the postoperative ward were maintained in the supine position [17].

The postoperative period is a critical period and small measures can make a significant difference to the outcome cannot be stressed enough. Acronym "ICOUGH"standing for -I for Incentive spirometry, C-for Cough and deep breath, O-for Oral care. U-for Understanding patient education, G-for Get out of bed and H-for Head of Bed elevation also underline the importance of all the other measures which do not cost money, but play a critical role in improving outcomes, and are neglected due to various reasons [2].

The lacunae in our study was that blinding was not done and functional residual capacity could not be measured, where the correlation between improvement of FRC to the improved saturations would have strengthened the hypothesis.

Conclusion

Cumulative effect of general anaesthesia, diaphragmatic dysfunction and pain leads to appreciable drop in FRC and significant drop in oxygen saturations in the post operative period. Simple manoeuvre like a change in position from supine to sitting in the early postoperative period can improve the oxygen saturation and lung functions significantly and help in reducing lung atelectasis and resulting postoperative pulmonary complications.

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