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Original Article

Identification of Various Perioperative Risk Factors Responsible for Development of Postoperative Hypoxaemia

Ashutosh Kaushal[1], Puneet Goyal[2], Sanjay Dhiraaj[2], Aarti Agarwal[2], Prabhat Kumar Singh[2]

[1]*Department of Neuro Anaesthesiology, CN Centre, All India Institute of Medical Sciences, New Delhi, India*

[2]*Department of Anaesthesiology and Intensive Care, Sanjay Gandhi Post Graduate Institute of Medical Sciences, Lucknow, India*

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ORCID IDs of the authors: **A.K. 0000-0001-8552-7861; P.G. 0000-0003-0015-618X; S.D. 0000-0001-7591-3013; A.A. 0000-0003-4899-1918; P.K.S. 0000-0003-1888-4679**

Abstract

Objective: Identification of risk factors that might be responsible for postoperative hypoxaemia, in view of changing profile of surgical patients and better but more complex perioperative care nowadays.

Methods: We conducted a prospective observational study that included patients aged 18-65 years, who underwent elective surgery and required general anaesthesia. Oxygen saturation was monitored before the induction in operating room and continued 72 hours post-surgery. Patients were maintained on room air if SpO_2 remained >94%. If SpO_2 was between 90% and 94%, then patients were provided oxygen therapy via face mask (flow rate at 5-6 litre min^{-1}). If SpO_2 was between 89%-85% despite oxygen therapy with face mask, the Bilevel Positive Airway Pressure (BiPAP) was applied. If SpO_2 was <85% despite therapy with face mask, or if patient was unable to maintain SpO_2>90% on BiPAP, then patient was intubated, and ventilatory support was provided.

Results: Out of 452 patients, 61 developed SpO_2 ≤94% requiring oxygen therapy (13.5%). Oxygen therapy by face mask was required in 51 patients, BiPAP in 8 and ventilatory support with endotracheal intubation in 2. Age, body mass index (BMI), smoking status, presence of preoperative respiratory disease, SPO_2 (on room air) at baseline and immediately after the transfer to the post-anaesthesia care unit (PACU) were independently associated with postoperative oxygen therapy.

Conclusion: The risk of postoperative hypoxaemia was highest in patients aged 51–65 years, BMI higher than 30, current and former smokers, pre-existing respiratory disease, chronic obstructive pulmonary disease, patients with 96% oxygen saturation or less at baseline or after shifting to PACU. The type of surgical incision, duration of surgery and dose of opioids administered were not independent risk factors.

Keywords: Postoperative hypoxaemia, oxygen therapy, respiratory complications, risk factors for perioperative hypoxaemia

Introduction

Hypoxaemia in postoperative period is an important complication, and its incidence has been quoted as high as 55% in literature from the 1990s (1), which decreased to 28% by 2012 (2). Hypoxaemia can have potential deleterious effects, such as cardiovascular morbidities (3, 4), mental confusion (5), delirium (6) and postoperative wound complications (7). The high incidence of hypoxaemia in post-anaesthesia care units (PACUs) is the reason behind the routine administration of oxygen in the immediate postoperative period (8). However, hypoxaemic episodes can be seen even with oxygen administration (9). Oxygen therapy might not be needed in about two-thirds of patients immediately after surgery (10), and the routine use of supplemental oxygen might not prevent hypoxaemic episodes (1). Postoperative hypoxaemia may develop due to both surgical factors (e.g. duration of surgery, site of incision etc) as well as patient related risk factors (like obesity and pre-existing respiratory illness) (11, 12). The presence of these factors helps to identify patients prone to postoperative hypoxaemia. Such patients require close monitoring for development of hypoxaemia, as well as oxygen therapy in postoperative period.

The profile of surgical patients is changing nowadays, as an increasing number of patients are presenting with advanced age and multiple comorbidities. Surgical procedures are becoming more complex yet with better equipment and technology. Anaesthetic and perioperative management techniques have improved with better monitoring standards, the use of shorter-acting drugs with less respiratory depression and better perioperative pain management. These developments have the po-

Address for Correspondence: Puneet Goyal E-mail: princeofcoma@yahoo.co.uk

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tential to modify the risk factors, which might be responsible for development of postoperative hypoxaemia.

Hence, this observational study was to evaluate the incidence of postoperative hypoxaemia in current surgical population in a tertiary care centre, as well as to find out various risk factors responsible for development of postoperative hypoxaemia. This may help to improve patient safety and reduce the cost by a sensible use of oxygen therapy.

Methods

This prospective observational study was conducted after obtaining an approval from the institute's ethics committee and written informed consent from all the patients. The sample size was calculated to find the incidence of postoperative hypoxaemia with the assumption that 5% of patients would develop postoperative hypoxaemia (oxygen saturation ≤94%) and would require oxygen therapy. For statistically significant result (power 95% and α 0.05), the sample size was calculated to be 400, using Fischer's exact test. Patients aged 18–65 years of either gender posted for elective open or laparoscopic abdominal surgery that would require general anaesthesia with endotracheal intubation were included in the study. Patients requiring emergency surgery, minor procedures, neurosurgery or thoracic surgeries, patients with preoperative cardiac disease, as well as patients shifted to postoperative care unit without extubation on ventilatory support, were excluded from the study. A total of 490 consecutive patients were enrolled, out of which 38 were shifted to PACU without extubation, and hence were excluded from the study. In addition to demographic data, smoking history (current smoker and former smoker) (13) and patients' preoperative respiratory status were noted. After a routine pre-anaesthetic examination, all patients were premedicated with lorazepam (1–2 mg, tablet) and ranitidine (150 mg, tablet), on the night prior to surgery and on the morning of surgery, as per our institute's protocol. On the arrival to operating room, baseline oxygen saturation on room air was recorded with the help of pulse oximeter (Beijing Choice Electronic Tech. Co. Ltd MD300C). Intravenous (i.v.) access was achieved with peripheral venous cannula after infiltrating skin with 2% lignocaine. Monitoring consisted of 5-lead electrocardiography, plethysmography, non-invasive blood pressure (automated oscillometric method), temperature, end tidal CO_2 and neuromuscular monitoring. Routine anaesthesia protocol was followed at the discretion of the attending anaesthesiologist to manage the patient intra-operatively. Following pre-oxygenation with 100% oxygen, anaesthesia was induced with i.v. midazolam (0.05 mg kg^{-1}), fentanyl (2-5 mcg kg^{-1}) and sleep dose of thiopentone sodium (3-5 mg kg^{-1}). Endotracheal intubation was facilitated with vecuronium bromide (0.1 mg kg^{-1}). Following intubation, patients were ventilated with volume control mode. Ventilatory parameters were set to tidal volume of 8-10 mL kg^{-1} and respiratory rate of 10-12/minute so as to adjust minute volume to maintain $EtCO_2$ at 35±5 mmHg. Anaesthesia was maintained with oxygen, air, isoflurane and intermittent dose of vecuronium, fentanyl or morphine. Reversal of anaesthesia was done with neostigmine at 0.06 mg kg^{-1} and glycopyrrolate at 0.01 mg kg^{-1} intravenously, and patients were extubated when the train of four ratio was >0.9. Nasopharyngeal temperature, a surrogate marker of core temperature, was monitored. Intraoperative temperature was maintained between 34°C and 36°C. A decision to extubate was made at the start of surgical closure; if temperature of the patient was ≤34°C, then the patient was not extubated, but electively ventilated in the PACU till rewarming, hence excluded from the study. If the temperature was >34°C, all measures of rewarming were continued to reach the target temperature of ≥36°C before extubation.

Paracetamol 1 gm intravenously was administered at time of closure of surgical wound and thereafter every 8 hours. Patients with epidural catheter were administered a combination of bupivacaine and fentanyl for postoperative pain relief. All other patients were given intravenous patient-controlled analgesia with fentanyl. Type of the surgery, duration of surgery and incision site were recorded. Oxygen saturation was noted following extubation on room air, and if it persisted above 94%, no oxygen therapy was administered. The intensity of postoperative pain was measured on the arrival in recovery room using a 10-cm Visual Analogue Scale (VAS) (0=no pain, 10=most severe pain).

Patients were again assessed on arrival to PACU by monitoring oxygen saturation in semi-recumbent position on room air for up to 5 minutes after shifting to the PACU.

It is important to understand here that all those patients whose SpO_2 values were ≤94% on room air were labelled as having postoperative hypoxaemia and were supplemented with oxygen therapy (face mask, BiPAP or ventilatory support after endotracheal intubation). Thus, in our study, both these terms, namely *postoperative hypoxaemia* and *requirement of postoperative oxygen therapy*, have been used synonymously.

Patients were maintained on room air if SpO_2 remained >94%. If SpO_2 was between 90% and 94%, then patients were provided oxygen therapy via face mask (flow rate at 5-6 liter min^{-1}). If SpO_2 was still at <90% (85%-89%) despite oxygen therapy with face mask, the BiPAP was applied. If SpO_2 was <85% despite therapy with face mask, or if patient was unable to maintain SpO_2>90% on BiPAP, then patient was intubated, and ventilatory support was provided. Correlation of postoperative hypoxaemia (need for postoperative oxygen therapy) with various perioperative risk factors such as age, sex, BMI, respiratory diseases such as COPD, asthma, Old Koch's, Upper respiratory tract infection (URTI), smoking status (non-smoker, current smoker, remote smoker), types of surgery/incision site, duration of surgery/anaesthesia, temperature, type and total dose of opioids administered, and intensity of postoperative pain was examined. The Statistical Package for Social Science Version 20 was used for statistical analysis. Statistical technique of chi-squared, Binary Logistic Regression Analysis and two-proportion Z-test were used for data analysis. P≤0.05 was considered statistically significant.

Results

Demographic data and preoperative characteristics of patients in study cohort are shown in Table 1. A total of 490 patients were enrolled in the study, out of which 38 patients were shifted to PACU on ventilator without extubation, hence excluded from further analysis. Data of 452 patients were included in the analysis. Patients were distributed according to their oxygen saturation on room air at baseline, as well as after admission to PACU following surgery (Table 2).

Table 1. Demographic data and preoperative characteristics of patients

	Groups	Number of patients (%)
Age (years)	18–35	129 (28.54)
	36–50	156 (34.51)
	51–65	167 (36.95)
Gender	Male	265 (58.63)
	Female	187 (41.37)
BMI (kg m^{-2})	<18.5	38 (8.41)
	18.5–24.9	288 (63.72)
	25–29.9	104 (23)
	30–34.9	22 (4.87)
Smoking status	Non-smoker	343 (75.88)
	Smoker	78 (17.26)
	Remote smoker	31 (6.86)
Respiratory diseases	No preoperative respiratory diseases	325 (71.90)
	URTI	9 (1.99)
	Asthma	32 (7.08)
	Old Koch's	37 (8.19)
	COPD	49 (10.84)
Surgery type /Incision site	Laparoscopic	28 (6.19)
	Pan abdominal	30 (6.64)
	Subcostal	154 (34.07)
	Lower abdominal	108 (23.90)
	Upper abdominal	132 (29.20)
Duration of surgery (hours)	0–3	3 (0.66)
	3–6	236 (52.21)
	6–11	213 (47.12)

BMI: body mass index; COPD: chronic obstructive pulmonary disease; Old Koch's: previous pulmonary tuberculosis; URTI: upper respiratory tract infection

Out of 452 patients, 61 developed postoperative hypoxaemia (SpO_2 ≤94%) requiring oxygen therapy (overall incidence 13.5%). Out of 61 patients who developed postoperative hypoxaemia, 51 required oxygen therapy by face mask, 8 needed BiPAP and 2 required ventilatory support with endotracheal intubation. Out of 61 patients who required oxygen therapy, 60 patients needed it in the first 2 hours after extubation (98.36%) (Table 3).

We analysed association of various risk factors with the requirement of postoperative oxygen therapy using chi-squared test (Table 4). Age, BMI, smoking status, presence of preoperative respiratory disease, type of surgery and incision site, oxygen saturation on room air at baseline, as well as immediately after shifting to PACU had statistically significant association with requirement of postoperative oxygen therapy, where gender, duration of surgery, type of opioid and total dose of opioid administered did not have any significant association with development of postoperative hypoxaemia.

Binary logistic regression analysis was performed to find out risk factors which might have an independent association with the requirement of postoperative oxygen therapy. Risk factors which had a significant association with postoperative hypoxaemia on chi-squared test were included in logistic regression analysis. Iterative maximum likelihood estimation method was used for logistic regression analysis. Age, BMI, smoking status, presence of preoperative respiratory disease, SpO_2 (on room air) at baseline and SpO_2 (on room air) immediately after shifting to PACU were independently associ-

Table 2. Patients distribution according to their oxygen saturation on room air at baseline, as well as after admission to PACU following surgery

Risk factors	Value of SpO_2	Numbers of patients (%)
SpO_2 (room air) at baseline	100%	96 (21.24)
	99%	139 (30.75)
	98%	136 (30.09)
	97%	60 (13.27)
	96%	20 (4.42)
	95%	1 (0.22)
SpO_2(room air) immediately after admission to PACU	100%	40 (8.85)
	99%	101 (22.34)
	98%	159 (35.18)
	97%	109 (24.12)
	96%	37 (8.19)
	95%	5 (1.10)
	94%	1 (0.22)

PACU: post-anaesthesia care unit

ated with the requirement of postoperative oxygen therapy, whereas incision site did not have any independent association (Table 5).

After identifying various risk factors which had independent association with requirement of postoperative oxygen therapy, we performed subgroup analysis of various risk factors to know the incidence of postoperative hypoxaemia in different subgroups (Table 6).

To identify the most significant subgroup for a particular risk factor which might have highest association with development of postoperative hypoxaemia, two-proportions Z-test was performed.

Table 3. Patients requiring oxygen therapy on time scale after shifting to PACU

Time	Number of patients requiring oxygen therapy (%)
1st hr after shifting to PACU	55 (90.16)
2nd hr after shifting to PACU	5 (8.20)
3rd hr after shifting to PACU	0 (0)
4th hr after shifting to PACU	0 (0)
1st postoperative day	1 (1.64)
2nd postoperative day	0 (0)
3rd postoperative day	0 (0)

PACU: post-anaesthesia care unit

Table 4. Association of risk factors with requirement of postoperative oxygen therapy

Risk factors	Chi-Squared Test		
	Value	df	p
Age	29.73	2	<0.001*
Gender	3.039	1	0.081
BMI	35.45	3	<0.001*
Smoking status	57.433	2	<0.001*
Respiratory disease	81.125	4	<0.001*
Incision site	3.734	4	<0.001*
Duration of surgery	14.238	8	0.076
Type of opioid	0.089	1	0.765
Total dose of opioid	1.27	6	0.973
SPO_2 (on room air) at baseline	168.574	5	<0.001*
SPO_2 (on room air) immediately after admission to PACU	137.120	6	<0.001*

* p≤0.05: statistically significant, df: degrees of freedom; PACU: post-anaesthesia care unit

Less than 2% patients aged 18-35 years developed postoperative hypoxaemia, patients aged 36-50 years had 12.8% incidence of postoperative hypoxaemia, and patients aged 51–65 years had 23.35% incidence of postoperative hypoxaemia (Table 6). The difference between all three subgroups was statistically significant, but patients in the age group 51-65 years had the highest risk for the development of postoperative hypoxaemia (Z value 5.38, p<0.01, two-proportions Z-test).

It is also evident from Table 6 that the risk of postoperative hypoxaemia increases with higher BMI, and patients with BMI over 30 are at the highest risk of postoperative hypoxaemia, although the risk starts rising significantly in patients with BMI higher than 25, and the difference between patients having BMI 25-29.9 and BMI 30-34.5 is statistically insignificant. Smokers had a significantly higher incidence for development of postoperative hypoxaemia as compared to non-smokers (37.17% vs. 6.70%). Former smokers also had a significantly higher incidence (29.03%) of postoperative hypoxaemia as compared to non-smokers (Z value 4.25, p<0.01, two-proportions Z-test). Patients with pre-existing respiratory disease had a significantly higher incidence of postoperative hypoxaemia as compared to patient having no respiratory disease (Table 4). Among all types of pre-existing respiratory diseases, COPD patients had the highest risk for development of postoperative hypoxaemia, followed by patients with old pulmonary tuberculosis and then with pre-existing bronchial asthma (Table 6). The number of patients with URTI was very limited, and surprisingly none of them required postoperative oxygen therapy. Patients having baseline SpO_2 96% had 95% incidence of development of postoperative hypoxaemia, whereas patients

Table 5. Risk factors independently associated with development of postoperative hypoxaemia (requirement of postoperative oxygen therapy) based on result of binary logistic regression analysis

Risk factors	Binary Logistic Regression Analysis			
	Logistic regression coefficient	SE of regression coefficient	p	Odds ratio
Age	0.076	0.014	<0.001*	1.079
Body mass index	0.210	0.039	<0.001*	1.234
Smoking status	0.684	0.133	<0.001*	1.982
Respiratory disease	0.609	0.093	<0.001*	1.839
Incision site	−0.014	0.120	0.909	0.986
SpO_2 (on room air) at baseline	−1.639	0.197	<0.001*	0.194
SPO_2 (on room air) immediately after admissionto PACU	−1.770	0.217	<0.001*	0.170

* p≤0.05: statistically significant, SE: standard error; PACU: post-anaesthesia care unit

Table 6. Incidence of postoperative hypoxaemia in subgroups of various risk factors

Various risk factors	Subgroups	Patients without need of postoperative oxygen therapy / total patients in that subgroup	Total number of patients requiring O_2 by any method (a+b+c)	Number of patients requiring postoperative oxygen therapy		
				By face mask (a)	By BiPAP (b)	By ventilator (c)
Age (years)	18–35	127 / 129 (98.45%)	2 (1.55%)	2 (100%)	0	0
	36–50	136 / 156 (87.18%)	20 (12.82%)	16 (80%)	3 (15%)	1 (5%)
	51–65	128 / 167 (76.65%)	39 (23.35%)	33 (84.6%)	5 (12.8%)	1 (2.6%)
BMI (kg m^{-2})	<18.5	33 / 38 (86.84%)	5 (13.16%)	4 (80%)	1 (20%)	0
	18.5–24.9	267 / 288 (92.71%)	21 (7.29%)	19 (90.48 %)	1 (4.76%)	1 (4.76%)
	25–29.9	78 / 104 (75%)	26 (25%)	23 (88.46%)	3 (11.54%)	0
	30–34.9	13 / 22 (59.1%)	9 (40.9%)	5 (55.56%)	3 (33.33%)	1 (11.11%)
Smoking status	Non-smoker	320 / 343 (93.29%)	23 (6.71%)	22 (95.65%)	1 (4.35%)	0
	Smoker	49 / 78 (62.82%)	29 (37.18%)	23 (79.31%)	5 (17.24%)	1 (3.45%)
	Remote smoker	22 / 31 (70.97%)	9 (29.03%)	6 (66.67%)	2 (22.22%)	1 (11.11%)
Preoperative respiratory disease	No respiratory disease	307 / 325 (94.46%)	18 (5.54%)	17 (94.44%)	0	1 (5.56%)
	URTI	9 / 9 (100%)	0	0	0	0
	Asthma	25 / 32 (78.12%)	7 (21.88%)	6 (85.71%)	1 (14.29%)	0
	Old Koch's	23 / 37 (62.16%)	14 (37.84%)	11 (78.57%)	3 (21.43%)	0
	COPD	27 / 49 (55.1%)	22 (44.9%)	17 (77.27%)	4 (18.18%)	1 (4.55%)
SpO_2 (on room air)at baseline	100%	95 / 96 (98.96%)	1 (1.04%)	1 (100%)	0	0
	99%	133 / 139 (95.68%)	6 (4.32%)	4 (66.67%)	2 (33.33%)	0
	98%	123 / 136 (90.44%)	13 (9.56%)	13 (100%)	0	0
	97%	39 / 60 (65%)	21 (35%)	18 (85.71%)	2 (9.52%)	1 (4.76%)
	96%	1 / 20 (5%)	19 (95%)	14 (73.68%)	4 (21.05%)	1 (5.26%)
	95%	0 / 1 (0%)	1 (100%)	1 (100%)	0	0
SpO_2 (room air) immediately after admission to PACU	100%	40 / 40 (100%)	0	0	0	0
	99%	101 / 101 (100%)	0	0	0	0
	98%	153 / 159 (96.23%)	6 (3.77%)	5 (83.33%)	0	1 (16.67%)
	97%	79 / 109 (72.48%)	30 (27.52%)	25 (83.33%)	5 (16.67%)	0
	96%	18 / 37 (48.65%)	19 (51.35%)	17 (89.47%)	2 (10.53%)	0
	95%	0 / 5 (0%)	5 (100%)	4 (80%)	1 (20%)	0
	94%	0 / 1 (0%)	1 (100%)	0	0	1 (100%)

BMI: body mass index; COPD: chronic obstructive pulmonary disease; Old Koch's: previous Pulmonary tuberculosis; PACU: post-anaesthesia care unit; URTI: upper respiratory tract infection

having baseline SpO_2 97% had 35% incidence of developing of postoperative hypoxaemia (Table 6), and this difference was found to be statistically significant (Z value 4.65, $p<0.01$, two-proportions Z-test); hence patients with baseline oxygen saturation ≤96% were the most vulnerable subgroup with regard to postoperative oxygen therapy. Patients having SPO2 of 95% at room air after shifting to PACU had 100% incidence of development of postoperative hypoxaemia, whereas patients with SpO_2 of 96% had 51.35% incidence of developing postoperative hypoxaemia (Table 6). This difference was found to be statistically significant (Z value 2.06, $p<0.05$, two-proportions Z-test). Thus, patients having 96% oxygen saturation or less after being transferred to PACU were the most vulnerable subgroup with regard to postoperative oxygen therapy.

Discussion

The incidence of postoperative hypoxaemia in our study has been estimated to be 13.5%, which is remarkably lower than the incidence reported earlier (1, 2). This probably reflects an overall improved perioperative care and elimination of certain factors (described above) in the present.

We analysed the association of postoperative hypoxaemia with SpO_2 on room air at baseline as well as SpO_2 on room air just after transferring to PACU. We think that these two values are most important because the preoperative oxygen saturation represents the respiratory status of a patient preoperatively, whereas all the factors influencing respiratory parameter intraoperative such as type and duration of surgery, general anaesthesia and drugs influence the oxygen saturation immediately after extubation. This is why the association between postoperative hypoxaemia with oxygen saturation was analysed at these two time points.

Age has been found to have significant and independent association with higher risk of developing postoperative hypoxaemia and other postoperative respiratory complications in various studies, with variable age limits (55–70 years) having significantly higher risk (12, 14-17). Filho et al. (11) studied 204 patients admitted to PACU after surgery and found that patients older than 55 had a significantly higher incidence of postoperative hypoxaemia, which is similar to findings in our study. However, one study also showed that postoperative hypoxaemia did not correlate significantly with age (18).

In our study, we found that patients with BMI ranging between 25 and 29.9 kg m^{-2} had 25% incidence of postoperative hypoxaemia as compared to only 7.3% incidence of postoperative hypoxaemia in patients with BMI between 18.5 and 24.9 kg m^{-2}. The incidence of postoperative hypoxaemia was even greater in patients with BMI between 30 and 34.5 kg m^{-2}, where it reached to almost 40%.

In literature, obesity has been quoted as one of the major risk factors for postoperative hypoxaemia. Some studies found that the incidence of postoperative hypoxaemia increases if patients had BMI ranging from 25 to 27 kg m^{-2} following abdominal surgery (16, 19), while others found that it increases with a marked increase in BMI (20). We found a higher incidence of postoperative hypoxaemia in patients with BMI higher than 25 and the risk is highest in patients having BMI over 30 kg/m^2. Billard et al. (15) found that BMI was independently associated with early postoperative hypoxaemia.

One interesting finding in our study was that patients with BMI less than 18.5 kg/m^2 had an increased incidence of postoperative hypoxaemia (13.15%) as compared to patients with normal BMI (7.3%), nearly doubling the incidence of postoperative hypoxaemia in this subset of patients. The probable reasons for this finding could be malnourishment or a chronic illness in these patients, leading to reduced pulmonary reserve, and thereby increasing the risk of postoperative hypoxaemia.

Various studies in literature have found smoking to be one of the major and most important risk factor for postoperative hypoxaemia. Most of the studies have identified current smokers to have an increased risk (14, 16, 21-23), whereas our study demonstrated that not only current smokers, but also remote smokers have an increased risk for development of postoperative hypoxaemia, which highlights the fact that remote smokers are equally prone to develop postoperative hypoxaemia as smokers.

The presence of preoperative respiratory diseases (COPD, asthma and old pulmonary tuberculosis) have been quoted as one of the major risk factors for postoperative pulmonary complications in various studies, with COPD patients having the highest risk of developing postoperative hypoxaemia and other respiratory complications, which is similar to the findings in our study (14, 24-27). An interesting finding in our study was that adult patients with URTI did not have an increased incidence of postoperative hypoxaemia, although the number of such patients was limited.

Siriussawakul et al. (19) conducted a study in 206 patients not expected to receive supplemental oxygen postoperatively who were undergoing upper abdominal surgery in a tertiary care university hospital. They concluded that obesity, a sub-costal incision and neuraxial opioid administration are risk factors for oxygen desaturation.

We observed a peculiar phenomenon in our study which was that when baseline oxygen saturation on room air starts falling below 97%, the requirement of postoperative oxygen therapy starts rising. Oxygen therapy is required in 95% patients with baseline oxygen saturation of 96%, whereas most of the studies in literature have found an increased risk in patients with baseline oxygen saturation of 95% or less (11, 28). In a study by Billard et al. (15), it was found that the baseline preoperative SpO_2 was significantly associated with postoperative hypoxaemia.

We also found that SPO_2 at room air immediately after arriving to PACU can be significantly associated with the requirement of oxygen therapy, with an increased risk in patients having SPO_2 less than or equal to 96%. We could not find any study in literature that examined this association.

One of the limitations of our study is that it could not analyse the effect of hypothermia and postoperative pain on the development of postoperative hypoxaemia. All active and passive warming methods were employed to maintain temperature of ≥36°C intra-operatively, as long as possible. Despite all the measures, 23 patients undergoing major abdominal surgery and/or requiring massive transfusion could not be maintained in normothermic range during surgery. Eleven patients with temperature >34°C at the start of surgical closure of abdomen could be warmed to ≥36°C till the completion of surgical closure, and they were extubated. Whereas 12 patients having temperature ≤34°C before the start of surgical closure were not extubated and ventilated in PACU till full rewarming, they became part of those 38 patients who were excluded from the analysis.

Patients received a multimodal analgesia in the intraoperative and postoperative period as per our institute's acute pain service protocol, and most of the patients were nearly pain free in postoperative period; hence it was not possible to evaluate the effect of postoperative pain on postoperative hypoxaemia. In other words, this finding reflects an emerging trend of improved perioperative care in terms of better pain control.

Conclusion

Our study emphasises the fact that advanced age, obesity, smoking and the presence of a preoperative respiratory disease, especially COPD, increase the need of postoperative oxygen therapy.

Anaesthesiologists should be cautious in patients whose preoperative baseline oxygen saturation on room air is below 97%, as well as in those who have room air oxygen saturation below 96% after shifting to PACU, as these are the most vulnerable patients who would require the postoperative oxygen therapy.

The type and an extent of surgical incision, duration of surgery, as well as type and dose of opioids administered were not found to be independent risk factors for development of postoperative hypoxaemia unlike reported in literature earlier (23-29). This may be due to improved anaesthetic and perioperative management in terms of better monitoring and improved pain control with drugs and techniques causing reduced respiratory depression, because of which these factors were not found to play a role in the development of pulmonary complications. Further studies may be needed to confirm this trend.

Ethics Committee Approval: Ethics committee approval was received for this study from the ethics committee of Sanjay Gandhi Post Graduate Institute of Medical Sciences.

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