2018 SSAT PLENARY PRESENTATION

Effect of Perioperative High Oxygen Concentration on Postoperative SSI in Elective Colorectal Surgery—A Randomized Controlled Trial

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Abstract

Background This study was carried out to investigate the effect of perioperative high oxygen concentration on surgical site infection (SSI) in patients undergoing elective colorectal surgery.

Methods This was a single-center, prospective, parallel arm, double-blind, superiority randomized controlled trial. All patients more than 18 years of age undergoing elective colorectal surgery were included as per the inclusion criteria. Patients were randomized at the time of induction of anesthesia into high concentration and standard concentration oxygen group based on the concentration of oxygen. Incidence of SSI, day of the detection of SSI, grade of SSI, incidence of anastomotic leak, postoperative day of return of bowel functions, day of starting oral feeds, day of ambulation, and length of hospitalization were studied in both the groups.

Results A total of 94 patients were included in the study, 47 patients each in high concentration oxygen group and standard concentration oxygen group respectively. The SSI rates were comparable between the two groups [55.3% (95% CI—4.012–69.83) vs. 40.4% (95% CI—26.37–55.73); $p = 0.215$]. There was no significant difference found with respect to mean day of detection of SSI [4.5(IQR—3.0–7.5) vs. 6.0 (IQR—3.0–9.0; $p = 0.602$], postoperative day of return of bowel functions (2.20 ± 0.542 vs. 2.13 ± 0.582; $p = 0.540$), oral feeds (3.62 ± 0.945 vs. 3.46 ± 1.048; $p = 0.544$), ambulation (4.17 ± 0.868 vs. 4.17 ± 1.270; $p = 0.987$), and the length of hospitalization [15(IQR—10–19) vs. 15(IQR—10.75–18.25); $p = 0.862$] between the two groups.

Conclusion There was no significant difference in the rate of SSI with the use of perioperative high oxygen concentration in patients undergoing elective colorectal surgery.

Keywords SSI · Non-rebreathing mask · Colon surgery · Rectal surgery · Perioperative period

Introduction

Surgical site infection (SSI) is a leading health care problem, following both elective and emergency operations. It is associated with a prolonged hospital stay, increased morbidity, and mortality. Colorectal operations are more vulnerable to SSI because of the presence of a high bacterial load in colon and rectum, construction of stoma, and elderly patients. Most of the SSIs are due to microbial contamination of the surgical site by patient's own gut flora. All the surgical wounds get contaminated to some extent depending on the intraoperative spillage of bowel contents, but the development of SSI depends on host defenses. The most critical period for the development of SSI is first few hours of the contamination.[1]

Even with the better understanding of the factors that influence wound healing, the wound infection rate following colorectal surgery remains significantly high ranging from 5 to 30%.[2] Factors which have been proven to reduce SSI include antimicrobial prophylaxis, maintenance of perioperative normothermia, avoidance of hyperglycemia, proper surgical techniques, and adequate pain relief postoperatively.[3–5] But even with the standardized implication of these measures, SSI continues to be a severe economic and clinical concern. Studies evaluating the unapparent factors involved in the wound infection are required to reduce the morbidity of the SSI.

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Perioperative high concentration oxygen has recently gained interest due to its potential role in reducing the SSI. It is postulated that low tissue oxygen can reduce the oxidative bactericidal activity of neutrophils and also affect collagen synthesis, epithelial regeneration, and neovascularization. With the use of high oxygen concentration during the perioperative period, tissue oxygen concentration can be increased and thus the oxygen-mediated bactericidal activity by reactive oxygen species (superoxide anion etc.).[6] The superoxide anion gets converted into hydrogen peroxide, which forms hypochlorous acid after combining with a chloride ion; the reaction being catalyzed by myeloperoxidase enzyme. Hypochlorous acid is responsible for the bactericidal action.[7]

The effect of perioperative high oxygen concentration has been evaluated in few studies with inconsistent results. Grief et al. and others reported reduction of 54%, 41%, and 39% in the rate of SSI respectively.[1,8,9] However, another report found doubling of incidence of SSI.[7] Meyhoff et al. observed no significant difference in rate of SSI with high concentration oxygen.[10] Thus, well-conducted randomized controlled trials are required to ascertain the role of high concentration oxygen in reducing SSI in elective colorectal surgery.

Hence, this study was carried out to assess the effect of perioperative high oxygen concentration on postoperative SSI in patients undergoing elective colorectal surgery.

Materials and Methods

Study Design

The study was conducted as a single-center, parallel arm, double-blinded, prospective, superiority randomized controlled trial, in a tertiary care center in South India over a period of 2 years. The study was approved by the Institute Ethics Committee (IEC) and has been performed in accordance with the ethical standards laid down in an appropriate version of the Declaration of Helsinki (as revised in Brazil 2013). Written informed consent was taken from all the participants before the commencement of the study, after explaining the nature of the study, methodology, and risks involved in the study; patients were given full freedom to withdraw at any point of time during the study. Information regarding all participants of the study was kept confidential. The study was registered at www.ctri.gov.in (CTRI no.: CTRI/2017/09/009726).

Patient Enrollment

The study included all patients aged $\geq$ 18 years as per inclusion criteria who underwent elective colorectal surgery under general anesthesia in the Department of Surgery. Patients undergoing minor colorectal procedures including polypectomy, where the expected duration of surgery was less than 1 h;

emergency colorectal surgeries for bowel obstruction; and patients with recent h/o fever, patient with known immunological dysfunction (on steroids, decompensated liver disease, HIV, etc.); evidence of infection (TLC < 2500 or > 12,000); severe malnutrition (albumin < 2.5 g %); significant comorbidities (unfit for general anesthesia); and respiratory illness (COPD, asthma, etc.); were excluded from the study.

Randomization

Participants were randomly assigned in 1:1 ratio to receive either high concentration or standard concentration of perioperative oxygen supplementation. Stratified permuted block randomization was done using a computer program with randomly selected block sizes of 4 and 6. Stratification was done based on a preoperative plan for stoma vs. no stoma. Allocation concealment was ensured by serially numbered opaque sealed envelope (SNOSE) technique. The operating surgeon including the principal investigator and the patients were blinded by using an opaque cover to the oxygen delivery unit which was handled by the anesthesia team involved in the operative procedure.

Study Procedure

Preoperatively, the risk of infection was assessed using the scoring system of Centers for Disease Control and Prevention (Study on the Efficacy of Nosocomial Infection Control—SENIC) and the National Nosocomial Infection Surveillance System (NNISS) scoring system before the randomization.[5]

Patients were allocated to one of the study groups after induction and endotracheal intubation. Intraoperatively, a high concentration of oxygen (80% oxygen + 20% nitrous oxide) and standard concentration oxygen (33% oxygen + 66% nitrous oxide) were given through the endotracheal tube with constant fresh gas flow rate in both the groups. The fractional inspired and expired gas concentrations were measured by gas analyzer in the anesthesia workstation. When the patients were ready for extubation, 100% oxygen was administered through the endotracheal tube in both the groups and continued until 5 min after extubation. Five minutes following extubation, high concentration oxygen supplementation was maintained and given through non-rebreathing Venturi face mask in high concentration oxygen group patients for 6 h. Standard oxygen group patients received oxygen supplementation through the standard Venturi face mask. The oxygen flow rates were adjusted according to the group designated required oxygen concentration. Subsequently, patients in both groups were allowed to breathe ambient air unless additional oxygen was required to maintain an oxyhemoglobin saturation of more than 92%.

The patients were aggressively hydrated during and after surgery. A crystalloid solution was administered intravenously at a rate of 15 ml per kg per hour throughout surgery. Blood

loss was replaced with a crystalloid solution in a solution-to-blood ratio of 4:1 or a colloid solution in a solution-to-blood ratio of 2:1. Fluids were administered at a rate of 3.5 ml per kg per hour for the first 24 h after surgery and at a rate of 2 ml per kg per hour for the subsequent 24 h. Packed red blood cells were administered if necessary. No antibiotic or antiseptic irrigation of the wound or peritoneal cavity was done. Standard wound closure methods were followed. The intraoperative core temperature was maintained at 36 °C with the use of a warmer and intravenous fluid warming.

Arterial blood gas analysis was done to measure the PaO_2 at the time of induction, 2 h and 6 h after the initiation of high concentration of oxygen. Bowel preparation was done using polyethylene glycol. Antibiotic prophylaxis was given using intravenous antibiotics—ceftriaxone and metronidazole.

For all patients, the wound was inspected after 48 h for any evidence of infection. In those with clinical evidence of infection, the dressing was changed daily. The wound was assessed daily according to ASEPSIS criteria.[11] A score of more than 20 indicated the presence of SSI. SSI was defined as per CDC guidelines; wound swabs were taken and appropriate antibiotics were given depending on the wound swab culture.

Outcome Measures

The primary endpoint was the incidence of SSI postoperatively (according to the CDC criteria up to 30 days).[12] The secondary endpoints included day of detection of SSI, grade of SSI (superficial incisional, deep incisional, organ/space), the incidence and rate of anastomotic leak and day of detection of leak, the day of return of bowel sound, the day of patient ambulation, and the length of hospitalization (LOH) in days.

Data Collection Statistical Analysis

Data was collected on a specified proforma prepared by the investigators. Baseline demographic parameters, such as age, gender, body mass index (BMI), and comorbidities, were recorded. Outcome variables were also recorded by the investigators.

SSI, the primary outcome alone was used for power analysis. With an expected reduction in the SSI by 15% (25% vs. 10%)[9] in the study group, considering the alpha error of 5% and power of 80%, the sample size of 50 in each group (total = 100) was calculated using OPENEPI® software. The infection rate between the two groups was 24.4% vs. 14.9% in high oxygen and standard oxygen concentration group respectively.[9]

Statistical analysis was done using SPSS 19.0 software for windows. The difference in the proportion of SSI between two groups was tested using chi-square test. Differences in the anastomotic leak (yes/no) between two groups were tested using chi-square test. Duration for the return of bowel function, the day of ambulation and LOH were compared between two groups using independent t test or Mann-Whitney U test.

Categorical variables like tumor stage, gender, respiratory disease, FiO2, SENIC, and NNISS score, etc. were assessed for association with SSI using chi-square test. Continuous variables like BMI, age, preoperative hemoglobin, preoperative blood sugar, etc. were assessed for association with SSI using independent t test or Mann-Whitney U test. To determine the independent factors leading to SSI, multivariate logistic regression analysis was used.

Results

In the present study, 136 patients were assessed for eligibility and 94 patients were included based on the inclusion criteria. These patients were randomized into two groups—47 patients in both high concentration oxygen group and standard concentration oxygen group. The schematic representation of the study as per the CONSORT 2010 (Consolidated Standards of Reporting Trials) flow diagram is shown in Fig. 1. There was no mortality or loss to follow-up in the present the study.

The distribution of mean age (57.02 ± 12.94 years in high oxygen concentration group and 53.36 ± 14.45 years in standard oxygen concentration group; $p = 0.199$), ASA grade, and comorbidities were comparable in both the groups. There was no significant difference between the nutritional status of patients in both the groups: BMI was 21.47 ± 1.45 kg/m^2 in high oxygen concentration group and 21.23 ± 1.59 kg/m^2 in standard oxygen concentration group; ($p = 0.459$). The history of smoking was comparable between the two groups. History of smoking was present in 25.5% patients in high oxygen concentration group and 27.6% patients in the standard oxygen concentration group; ($p = 0.815$). There was no difference in the preoperative risk of developing SSI calculated by SENIC and NNISS score between the two groups. There was no significant difference in the preoperative hemoglobin and blood sugar between the two groups (Table 1).

The mean duration of surgery was comparable in both the groups. There was no significant difference in the type of anastomosis between the two groups. Of the total number of anastomosis created in the high oxygen concentration group, 43.3% were ileocolic, 23.3% were colocolic, and 33.3% were colorectal anastomosis. While, in the standard concentration oxygen group 30.7% were ileocolic, 7.7% were ileorectal, 11.5% were colocolic, and 50% were colorectal anastomosis; ($p = 0.178$). When the overall proportions of the patients who underwent surgery either with anastomosis or without anastomosis (stoma) were assessed, it was observed that 53.2% patients in high concentration oxygen group and 36.2% patients in standard oxygen concentration group had the colon as the site of surgery, while 46.8% patients in high concentration

Fig. 1 CONSORT diagram for the study
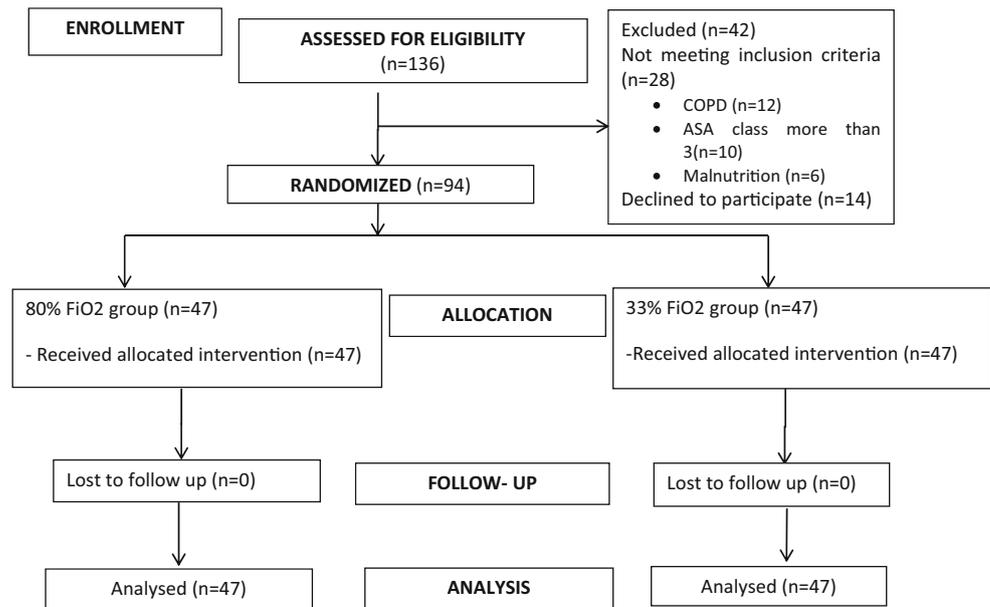
oxygen group and 63.8% patients in standard concentration oxygen group had rectum as the site of surgery. However, there was no significant difference between the two groups ($p = 0.097$). Stoma creation rates were comparable between the groups. The rates were 36.2% vs. 31.9% in the high concentration and standard concentration oxygen group respectively, ($p = 0.663$). However, there were six patients in the standard concentration oxygen group for whom neither an anastomosis nor a stoma was done. Four patients found to have an unresectable tumor and were sent for chemotherapy for downstaging. One of the patients was assessed for possibility of low anterior resection, but the procedure was abandoned as patient was not willing for a permanent stoma after the abdominoperineal resection. One patient had rectal prolapse for which mesh repair was done (Table 2).

The overall wound infection rate was 55.3% (95% CI—40.12–69.83) in high concentration oxygen group and 40.4% (95% CI—26.37–55.73) in standard concentration oxygen group, but the difference was not statistically significant ($p = 0.215$) (Table 3).

Both the groups were comparable in the distribution of grade of SSI. The proportions of superficial, deep, and organ/space SSI were 69.2%, 23%, and 7.6% in the high oxygen concentration group and 68.4%, 15.8%, and 15.8% in the standard oxygen concentration group; ($p = 0.625$). The median day of detection of SSI [4.5 (IQR—3.0–7.5) days in high oxygen concentration group and 6.0 (IQR—3.0–9.0) days in standard oxygen concentration group; $p = 0.602$], the postoperative day of return of bowel functions [2.20 ± 0.542 days in high oxygen concentration group and 2.13 ± 0.582 days in standard oxygen concentration group; $p = 0.540$], the postoperative day of oral feeds [3.62 ± 0.945 days in high oxygen concentration group and 3.46 ± 1.048 days in

standard oxygen concentration group; $p = 0.544$], the postoperative day of ambulation [4.17 ± 0.868 days in high oxygen concentration group and 4.17 ± 1.270 days in standard oxygen concentration group; $p = 0.987$] and the LOH [15 (IQR—10–19) days in high oxygen concentration group and 15 (IQR—10.75–18.25) days in standard oxygen concentration group; $p = 0.862$], were comparable between the two groups (Table 4).

One patient in high concentration oxygen group and two patients in standard concentration oxygen group had an anastomotic leak. Anastomotic leak occurred on postoperative day (POD) 7 in the high concentration oxygen group patient and POD 6 and 7 in the standard concentration oxygen group patients.

Discussion

In the present study, it was found that there is no evidence to suggest that the routine use of perioperative high oxygen concentration in patients undergoing elective colorectal surgery could cause a reduction in the incidence of SSI. There was no significant difference in the grade of SSI, day of return of bowel sound, day of patient ambulation, and LOH with use of perioperative high concentration oxygen.

The results in the present study were consistent with results observed by Meyhoff et al. (PROXI trial) and others.[10,13–15] Meyhoff observed no significant difference in the rate of SSI with the use of high oxygen concentration in patients undergoing acute or elective abdominal surgery. However, the major limitations of these trials were the inclusion of non-homogenous population,[10,13,14] usage of high concentration oxygen only during intraoperative period,[13] and low statistical

Table 1 Comparison of demographic and clinicopathological characteristics between high oxygen concentration group and standard oxygen concentration group

Patient characteristics	High oxygen concentration group ($n = 47$)	Standard oxygen concentration group ($n = 47$)	p value
Age (in years)	57.02 ± 12.94	53.36 ± 14.45	0.199
Gender			
Male:female	28:19	30:17	0.671
BMI (kg/m^2)[*]	21.47 ± 1.45	21.23 ± 1.59	0.459
Smoker—no. (%)	12 (25.5)	13 (27.6)	0.815
ASA score[$]—no. (%)			0.834
I	0	0	
II	27 (57.4)	28 (59.6)	
III	20 (42.5)	19 (40.4)	
Hemoglobin (g/dl)	10.4 ± 1.4	10.4 ± 1.6	0.997
Sugar (mg/dl)	105.62 ± 28.28	109.71 ± 31.70	0.510
Comorbidities[#]—no. (%)			
DM	7 (14.9)	5 (10.6)	0.536
HTN	8 (17.0)	8 (17.0)	1.000
Others (CAD, CKD, hypothyroidism)	1 (2.1)	3 (6.4)	0.257
Diagnosis—no. (%)			
Carcinoma	41 (87.2)	43 (91.5)	0.694
Others	6 (12.8)	3 (8.5)	
SENIC score—no. (%)			
1	4 (8.5)	2 (4.2)	0.640
2	38 (80.8)	41 (87.2)	
3	5 (10.6)	4 (8.5)	
NNISS score—no. (%)			0.244
0	1 (2.1)	0	
1	21 (44.7)	28 (59.6)	
2	25 (53.2)	19 (40.4)	

Plus–minus values are means ± SD

[*] *BMI* body mass index

[$] *ASA* American Society of Anesthesiologists, *NNISS* National Nosocomial Infections Surveillance System, *SENIC* Study on the Efficacy of Nosocomial Infection Control

[#] *DM* diabetes mellitus, *HTN* hypertension, *CAD* coronary artery disease, *CKD* chronic kidney disease

power.[15] The present study included a homogenous population of patients undergoing elective colorectal surgery. In a meta-analysis done by Brar et al., five high quality trials (Jadad score more than 3) which studied the effect of perioperative high oxygen concentration in patients undergoing colorectal surgery and which defined SSI as outcome parameter were included. The incidence of SSI in the study and control group was 11 and 15.6% respectively, with a combined OR of 0.69 (95% CI, 0.43–1.10; $P = 0.12$) using random-effects model. There was no beneficial effect of perioperative high oxygen concentration supplementation in reducing SSIs in patients undergoing colorectal surgery.[16]

The superiority of perioperative high concentration oxygen in colorectal surgery has been demonstrated in few studies.[1,8,9] Meta-analysis done by Chura et al. and others confirmed the beneficial effects of high oxygen concentration in colorectal surgery.[17–22] Greif et al. conducted the first randomized controlled trial to study the effect of perioperative high oxygen concentration in elective colorectal surgery. They concluded that the rate of SSI was reduced by 54% with the use of supplemental oxygen during colorectal surgery and 2 h postoperatively. Only culture positive wounds were included as SSI by the authors. The other limitation of this study was that there was no comparison of distribution of comorbidities such as diabetes, etc.[8] While in the other study, there were more number of female and higher BMI patients in the study group and distribution of diabetic patients was not considered.[9] In contrast to these studies, Pryor et al. observed doubling of SSI rate with the use of supplemental oxygen. The authors believed that the oxidative killing by the neutrophils may have

Table 2 Comparison of intraoperative characteristics between high oxygen concentration group and standard oxygen concentration group

Intraoperative characteristics	High oxygen concentration group ($n = 47$)	Standard oxygen concentration group ($n = 47*$)	p value
Mean duration of surgery (in minutes)	233.51 ± 87.65	207.66 ± 103.53	0.195
Site of surgery			0.097
Colon	25 (53.2)	17 (36.2)	
Rectum	22 (46.8)	30 (63.8)	
Stoma	17 (36.2)	15 (31.9)	0.663
Type of anastomosis ($n = 56$)			0.178
Ileocolic	13 (43.3)	8 (30.7)	
Ileorectal	0	2 (7.7)	
Colocolic	7 (23.3)	3 (11.5)	
Colorectal	10 (33.3)	13 (50.0)	
Stage of tumor ($n = 80$)			0.248
I	7 (17.9)	5 (12.1)	
II	11 (28.2)	15 (36.9)	
III	19 (53.8)	18 (43.9)	
IV	0	3 (7.3)	

Plus–minus values are means ± SD

*In six patients due to various reasons mentioned in the text anastomosis or a stoma was not done

some deleterious effects. Reactive oxygen species can be detrimental to DNA, proteins and phagocytic property of macrophages. It can promote cellular death by necrosis or apoptosis. Moreover, bacteria can adapt to the new environment by the process of gene mutation. Thus, the eventual effect of supplemental oxygen in vivo cannot be adequately measured. However, the study was criticized for being underpowered, non-homogenous population, and biased determination of wound infection with retrospective charts.[7,9]

In the present study, although a trend of a higher SSI was seen in the high oxygen concentration group (55.3%) than standard oxygen group (40.4%), the difference was not statistically significant. The reason for this trend can be the higher rectal surgeries and inclusion of higher proportion malignancy patients compared to other studies. In general, rectal surgery is more commonly associated with SSI than colonic surgery because of preoperative radiation, the location of anastomosis near the anal verge and hence more bacterial contamination, and the presence of stoma in most of the rectal surgeries.[23,24] Konishi et al. demonstrated an increased rate of SSI in patients with rectal surgery when compared to the colon surgery.[24] In the present study,

53.19% patients in high oxygen concentration group and 36.17% patients in the standard oxygen concentration group had the colon as the site of surgery, while 46.80% patients in high oxygen concentration group and 63.82% patients in standard oxygen concentration group had rectum as the site of surgery. However, there was no difference in the distribution of site of surgery between both the groups. When compared to the present study, Greif et al. (71% vs. 29% in high oxygen concentration group and 63% vs. 37% in standard oxygen concentration group) had more number of colon surgeries in both the groups as compared to the rectal surgeries.[8] The presence of stoma is an independent risk factor for SSI. In the present study, though the stratification was done based on stoma, a relatively high number of stoma done in our study might be responsible for overall high infection rate observed. Malignancy leads to a state of catabolism and immune suppression; hence, most of the malignancy patients are at risk of poor wound healing and SSI. 87.2% patients in high oxygen concentration group and 91.5% patients in the standard oxygen concentration group in the present study compared to study by Greif (22% vs. 26%)[8] had malignancy as the primary diagnosis.

Table 3 Comparison of primary outcome parameter between high oxygen concentration group and standard oxygen concentration group

Outcome parameter	High oxygen concentration group ($n = 47$)	Standard oxygen concentration group ($n = 47$)	p value
Number of patients with SSI	26	19	0.215
% (95% CI)	55.3 (40.12–69.83)	40.4 (26.37–55.73)	

SSI surgical site infection, *CI* confidence interval

Table 4 Comparison of secondary outcome parameters between high oxygen concentration group and standard oxygen concentration group

Outcome parameters	High oxygen concentration group ($n = 47$)	Standard oxygen concentration group ($n = 47$)	p value
Grade of SSI			0.625
Superficial	18 (69.2)	13 (68.4)	
Deep	6 (23)	3 (15.8)	
Organ/space	2 (7.6)	3 (15.8)	
Median day of detection of SSI (IQR)	4.5 (3.0–7.25)	6.0 (3.0–9.0)	0.602
Day of return of bowel sounds	2.20 ± 0.542	2.13 ± 0.582	0.540
Day of oral feeds	3.62 ± 0.945	3.46 ± 1.048	0.544
Day of ambulation	4.17 ± 0.868	4.17 ± 1.270	0.987
Length of hospitalization, median (IQR)	15.0 (10.0–19.0)	15.0 (10.75–18.25)	0.862

Plus–minus values are means ± SD

IQR interquartile range

SSI can be superficial, deep, or organ/space type. The grade of SSI can be an indirect measure of wound contamination in the preoperative, intraoperative, and postoperative period, with gross contamination resulting in deep and organ/space infections while minimal contamination leading to superficial infection. Most of the SSIs in the present study were superficial type in both the groups. However, the distribution of grade of SSI was similar in both the groups (superficial: 69.2% vs. 68.4%; deep—23% vs. 15.8%; organ/space—7.6% vs. 15.8%). Pryor et al. did not report any statistical difference in the distribution of grade of SSI between the two groups.[7] Schietroma et al. observed significantly more number of deep infections in the standard oxygen concentration group.[1] In the present study, the concentration of supplemental oxygen did not affect the rate and grade of SSI. As discussed above, the tissue factors may vary in different patients of a homogenous population, which might have resulted in the difference in the grade of SSI that was observed in the present study.

Three patients in the present study had an anastomotic leak, one in high oxygen concentration group and two in standard oxygen concentration group. However, the incidence of anastomotic leak in the present study was low and inadequate to draw any conclusions.

The ultimate goal of reducing the incidence of SSI is to reduce the LOH and cost. In general, patients with SSI will have an increased duration of hospital stay. Greif et al. observed increased LOH in standard oxygen concentration group compared to high oxygen concentration group. Pryor et al. reported higher LOH in high oxygen concentration group. These results reflected the fact that the presence of SSI increases the LOH. In the present study, there was no significant difference in the distribution of LOH between the two groups.[7,8]

The inclusion of non-homogenous population, use of different criteria for defining SSI, unbalanced perioperative factors, such as perioperative hypothermia and adequate fluid resuscitation are some other reasons for the inconsistent results with the use of perioperative supplemental oxygen across the literature.[1,7,8] One should not assume that high concentration oxygen is always beneficial. The tissue factors which determine beneficial or harmful effects of the oxygen tension can vary among different patients in a population. Hence, the authors suggest further studies to identify the other factors in anesthetic and surgical management associated with SSI.

The present study is not without limitations of its own. The baseline rate of surgical site infection in our population was more than the previous studies. Greif et al. defined surgical site infection only when the cultures were positive,[8] while the diagnostic method used in our study was CDC criteria, which might have affected our results.

Conclusion

There was no significant difference in the rate of SSI with the use of perioperative high oxygen concentration therapy in patients undergoing elective colorectal surgery. There was no difference in grade of SSI, the incidence of anastomotic leak, the return of bowel function, the day of ambulation, and the LOH in high oxygen concentration group as compared to the standard oxygen concentration group. The present study does not recommend the use of perioperative high concentration oxygen to reduce SSI in patients undergoing elective colorectal surgery.

Compliance with Ethical Standards

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