Postoperative care of cardiac surgery patients: A protocolized approach towards enhanced recovery versus the conventional approach

Moustafa Ibrahim Abd EL-Aal Halwag[a], Mahar Ahmed Doghiem[b], Moustafa Abdelaziz Moustafa[b] and Hossam Ossama Ahmed Sorour[c]

[a]Assistant Lecturer of Anaesthesia and Surgical Intensive Care, Department of Anaesthesia and Surgical Intensive Care, Faculty of Medicine, Alexandria University, Alexandria, Egypt; [b]Professor of Anaesthesia and Surgical Intensive Care, Faculty of Medicine, Alexandria University, Alexandria, Egypt; [c]Lecturer of Anaesthesia and Surgical Intensive Care, Faculty of Medicine, Alexandria University, Alexandria, Egypt

ABSTRACT

Background: Patients post-cardiac surgery face multiple challenges, but poorly controlled pain and atelectasis remain major issues that can prolong their recovery journey. The aim of this study was to compare two protocols of postoperative care in cardiac surgery: An enhanced recovery program consisting of high flow nasal oxygen therapy together with pectointercostal block, versus conventional postoperative care.

Patients and Methods: Fifty adult participants above the age of 18, of either sex scheduled for cardiac surgery who required the utilization of cardiopulmonary bypass and median sternotomy approach, were included in the study. The participants were divided into ERAS Care group, where they received ultrasound-guided pectointercostal fascial plane block with subcutaneous local anaesthesia infiltration around the mediastinal drains and were extubated onto high flow nasal oxygen therapy (HFNO), and a Conventional (CONV) care group, where participants received fentanyl IV bolus dose followed by fentanyl IV infusion that was continued till the end of day zero and were extubated onto 6 L/min simple facemask.

Results: Participants in the ERAS group had shorter ICU stay, lower numeric pain rating scale scores, less need for rescue analgesia, better oxygenation and lung aeration scores, better patient satisfaction, and less late pulmonary complications on discharge radiological screening. However, gastrointestinal complications and hospital stay were compared in both groups.

Conclusion: ERAS care protocol in cardiac surgery patients led to shorter ICU ventilation periods, shorter ICU stay, better patient satisfaction and pain control, better oxygenation and lung aeration and less atelectasis on discharge radiology.

1. Introduction

Enhanced Recovery after Surgery (ERAS) is a multimodal, trans-disciplinary care initiative to promote the recovery of surgical patients throughout their perioperative journey [1].

The main aims of such program are to reduce complications, shorten the period of hospital stay, reduce costs and eventually speed up the patient return to his preoperative daily routine [2,3].

Cardiac surgery patients experience a great deal of challenges when it comes to the postoperative period unrelated to their cardiac performance such as respiratory, gastrointestinal and renal problems, which can be exaggerated by prolonged opioid intake, ineffective pain control and late mobilization, which will add to the problem of their advanced age and comorbid conditions, all of which will eventually increase the overall morbidity, mortality and eventually hospital stay [4].

Traditionally, conventional oxygenation methods were used to correct hypoxemia but they were always experienced by the limitation of patient's intolerance to the application system and the limitation of oxygen flow to 15 l/min, which may fail to cover the minute ventilation of patients in respiratory failure and eventually inhaled flow is mixed with air from the atmosphere dropping the fraction of inspired oxygen [5]. In addition, oxygen is not always delivered under optimal conditions regarding temperature and humidity [5].

High flow nasal oxygen therapy carries the benefit of reducing the dilution of the administered oxygen [6,7], dead space washout [7–9], the generation of continuous positive airway pressure (CPAP) [10–13] and improving mucociliary transport courtesy of the active humidification and heating of the administered gas [14,15].

Utilization of regional blocks in cardiac surgery have been shown to provide improved post-operative pain control and decreased opiate requirements with less possible complications [16–18].

The aim of the present study was to compare two protocols of postoperative care: An enhanced recovery program consisted of high flow nasal oxygen therapy together with pectointercostal block versus conventional

postoperative care, in cardiac surgery patients. **Primary outcome**: To compare regarding the length of ICU stay, **Secondary outcome**: To study the effect on the postoperative course regarding pain intensity, postoperative opioid consumption, systemic criteria of enhanced recovery such as the early postoperative respiratory course and gastrointestinal complications and the late postoperative pulmonary complications.

2. Patients and methods

After approval of the Ethical Committee of Faculty of Medicine, Alexandria University, and having an informed written consent from patients included in the study, 50 adult patients above the age of 18 undergoing elective cardiac surgery who required the utilization of cardiopulmonary bypass and median sternotomy approach were randomly allocated into two groups using closed envelope method.

The patients were excluded if they had a nasal septal defect, or any form of facial deformity, showed signs of delirium, re-operated for mediastinal collection or bleeding, failed to fulfill extubation criteria 36 h postoperatively, had a body mass index above 45 kg/m^2, or had postoperative severe recurrent ventricular arrhythmias, low cardiac output state requiring high doses of inotropes and/or intra-aortic balloon pump support or a LVEF <30% at time of preoperative screening, had preoperative severe gastrointestinal illness that greatly affect motility, or had a history of alcohol, narcotic or illicit drug abuse.

Induction was carried out with 5 mg Midazolam, 3–5 µg/kg Fentanyl, 1.2 mg /kg Rocuronium, and Sevoflurane. 1–3 µg/kg of fentanyl was used again at skin incision, before and after cardiopulmonary bypass.

Extubation was achieved when patients met prescribed protocolised extubation criteria.

In the ERAS Care group, patients received ultrasound-guided pectointercostal fascial plane block using 20 ml of Bupivacaine 0.25% with 4 mg Dexamethasone on each side of the sternum. Additional 10 ml of Bupivacaine 0.25% was injected subcutaneously around the mediastinal drains [19].

The patients were extubated onto HFNO with initial settings of FiO$_2$ 0.6 and gas flow of 60 L/min. Starting from day 1 postoperatively, patients were weaned off the HFNO [20].

In CONV care group, patients received 1 µg/kg of IV fentanyl bolus dose, followed by fentanyl IV infusion, which was started at 0.5 µg/kg/h and continued till the end of day zero.

Once patients were extubated, oxygen was delivered at 6 L/min via a simple facemask.

The need to escalate the respiratory support was defined as respiratory rate above 30 breaths per minute, severe dyspnea or oxygen saturation below 92%.

In the conventional care group, escalation was to HFNC, NIPPV (non-invasive positive pressure ventilation) or intermittent positive-pressure ventilation (IPPV), while in the ERAS care group, escalation was to NIPPV or IPPV, and the decision was individualized for each patient based on his clinical condition [21].

The patients in both groups received 5 mg IV Nalbuphine as a rescue analgesia every 3 h if their numeric pain rating scale score was more than 5 or in the case of break through pain.

Each patient was evaluated according to the duration of mechanical ventilation postoperatively, duration of ICU stay, duration of hospital stay.

Pain intensity was assessed using the Numeric pain rating scales (NPRS) scores in an 8-hinterval post extubation till the end of day 1' with reviewing the need of rescue nalbuphine shoots on days zero and 1 [22].

Hypoxic index was calculated in the first 48 h postextubation, and the mean data were collected every 12 h [23].

Lung aeration was assessed on day 1 using modified radiological atelectasis score from a plain posteroanterior chest radiology [24], where each lobe (including the lingula) was scored 0–3, where Normal was scored zero, Plate or minor infiltrate was scored 1, Moderate atelectasis was scored 2 and Total atelectasis was scored 3 [24].

Lung aeration was assessed on day 2 using the Modified lung ultrasound score, where each hemithorax is divided into three compartments by the anterior and posterior axillary lines and then into upper and lower ones, where normal aeration was scored no points, moderate loss of aeration with multiple well-defined B-lines was scored 1 point, severe loss of aeration with multiple coalescent B-lines was scored 2 points and lung consolidation was scored 3 points [25].

A mean respiratory rate was calculated at 12 h interval in 48 h post-extubation.

Patient comfort was assessed at 1 and 8 h postextubation using a modified Borg scale where 0 meant no dyspnea to 10 that meant maximal dyspnea [4].

The need to escalate respiratory support and the Gastrointestinal complications were assessed for their presence or absence as well as late pulmonary complications, which was diagnosed by chest radiology on day 7 post-operative or on discharge.

3. Statistical analysis of the data [26]

Data were fed to the computer and analyzed using IBM SPSS software package version 20.0. (Armonk, NY: IBM Corp) [27]. Qualitative data were described using number and percent. The Kolmogorov-Smirnov test was used to verify the normality of distribution Quantitative data were described using range (minimum and maximum), mean, standard deviation and median. Significance of the obtained results was judged at the 5% level.

4. Results

53 participants were enrolled in the study, 3 of which were soon excluded due to failure of follow up. The remaining 50 participants were randomly allocated into two equal groups using the closed envelope method (Figure 1).

The Department of Statistics, Medical Research Institute, University of Alexandria approved the sample size to be sufficient.

Participants in both groups were comparable regarding age, gender and BMI.

Regarding the duration of mechanical ventilation postoperatively, it seems to be statistically shorter in the ERAS care group (p valve =0.002) (Figure 2).

Regarding the duration of ICU stay, participants in the ERAS care group had a shorter stay (P value =0.003), however both groups were comparable regarding the duration of hospital stay.
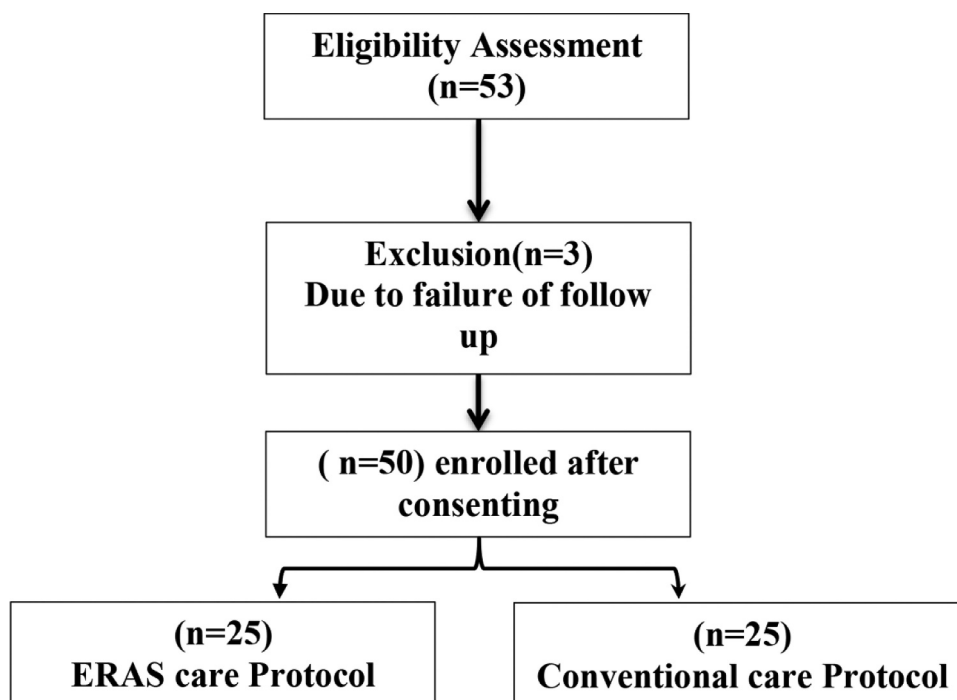
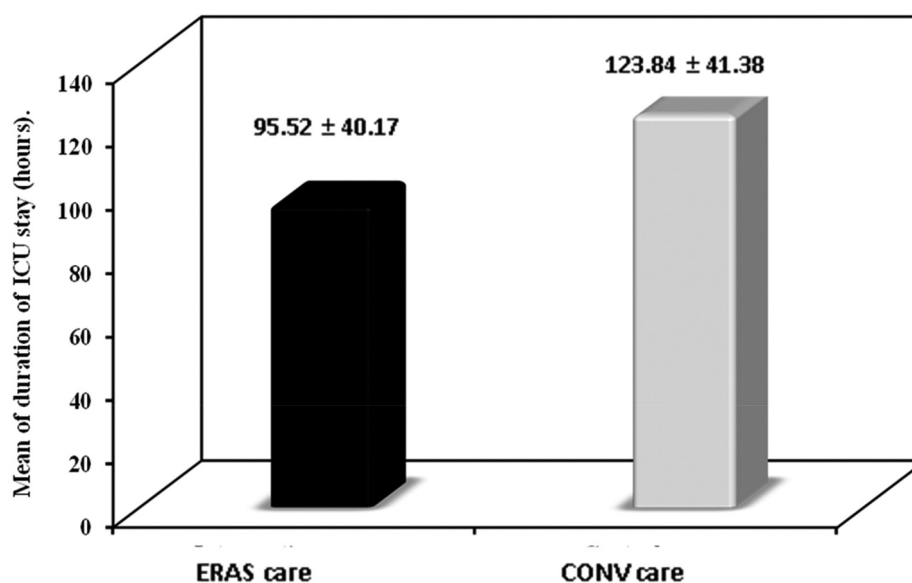

Figure 1. Study flow chart.

Figure 2. Comparison between the two studied groups according to duration of ICU stay.

Participants in the CONV care group showed statistically higher scores regarding numeric pain rating scales throughout all readings (P value <0.001 in all readings) and 72% of its participants needed nalbuphine recuse shoots, compared to 32% in the ERAS group. (Figure 3)

Regarding the hypoxic index, the first mean index calculated 12 h postextubation was compared in both groups, however, further readings were all statistically higher in the ERAS care group (P value = 0.033, 0.008 and 0.001).

Both the modified radiological atelectasis score and the modified lung ultrasound score were statistically significantly higher among the CONV. care group participants when compared with the ERAS care group (P value =0.005 and <0.001, respectively) (Table 1).

Only the mean respiratory rate calculated on the 2nd 24 h post-extubation was statistically significantly higher in the CONV care group (P value = 0.004 and 0.002) while other mean readings calculated in the first 24 h postextubation were comparable.

Regarding the patients comfort that was assessed using the modified Borg score, both readings were statistically significantly higher among the CONV. Care group participants. (p value =0.007, <0.001) (Figure 4)

The need for escalation of the respiratory support was statistically significantly higher in the CONV Care group (P value =0.009) with 56% of the participants needed such escalation compared with only 20% in the ERAS care group. (Table 2)

The incidence of gastrointestinal complication in the post-operative journey was comparable in both groups, however, the ERAS group showed statistically significantly less abnormal findings on the radiological screening done before discharge (p value = 0.015) with only 16% of the participants having such findings compared to 48% in the other group.

5. Discussion

The postoperative course in cardiac surgery is filled with multiple challenges that if left unattended, the journey would indeed be a long and a complicated one.

The ERAS-based protocol led to an earlier extubation when compared to the conventional care protocol.

In accordance with the present study, Rahman et al [28], in their study concluded that parasternal wound infiltration with long acting local anaesthetic Bupivacaine facilitated early extubation.
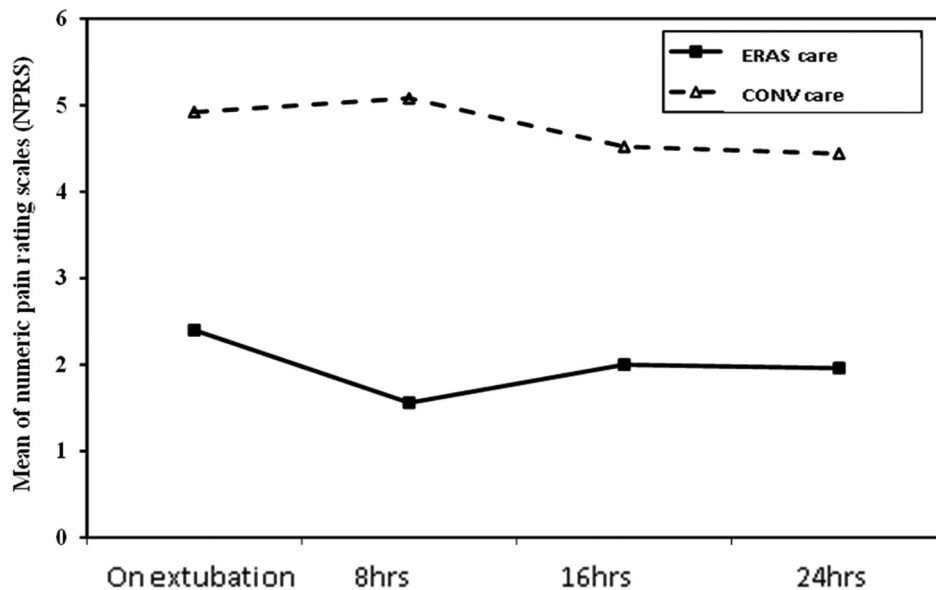

Figure 3. Comparison between the two studied groups according to Numeric pain rating scales (NPRS).
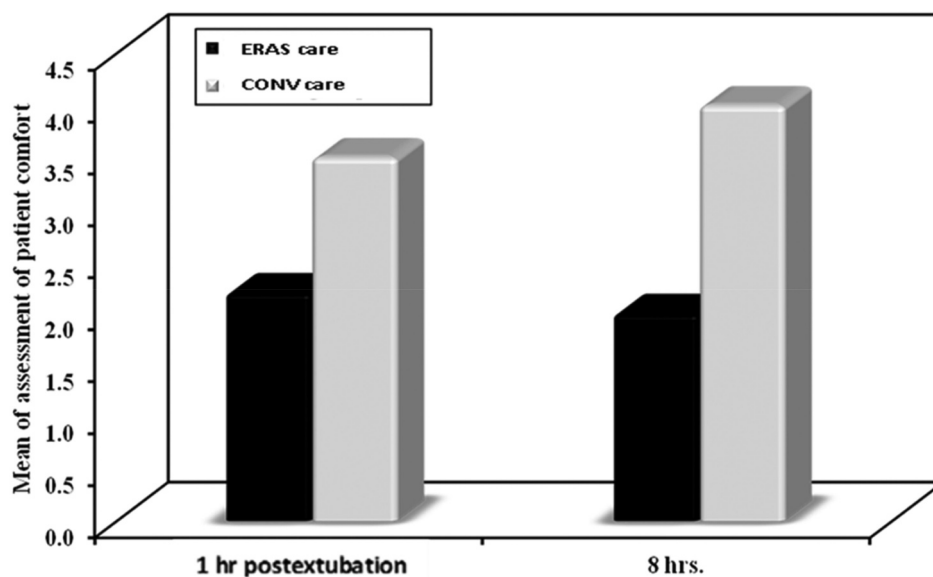
Table 1. Comparison between the two studied groups according to modified radiological atelectasis score and modified lung ultrasound score.

	ERAS care group (n = 25)	CONV care group (n = 25)	U	p
Modified radiological atelectasis score				
Mean ± SD.	3.16 ± 3.39	5.36 ± 2.98	170.50*	0.005*
Median (Min. – Max.)	3.0 (0.0– 15.0)	5.0 (1.0– 12.0)		
Modified lung ultrasound score				
Mean ± SD.	9.68 ± 6.14	16.04 ± 4.45	108.0*	<0.001*
Median (Min. – Max.)	8.0 (4.0– 27.0)	16.0 (9.0– 24.0)		

SD: **Standard deviationU: Mann Whitney test**
p: p value for comparing between the two studied groups
*: Statistically significant at p ≤ 0.05

Figure 4. Comparison between the two studied groups according to assessment of patient comfort.

Table 2. Comparison between the two studied groups according to assessment of the need to escalate respiratory support.

Assessment of the need to escalate respiratory support	ERAS care group (n = 25)		CONV care group (n = 25)		χ^2	p
	No.	%	No.	%		
Absence	20	80.0	11	44.0	6.876*	0.009*
Present	5	20.0	14	56.0		

χ^2: Chi square test
p: p value for comparing between the two studied groups
*: Statistically significant at p ≤ 0.05

Also, Saeidi et al [29], in their study noted that parasternal single injection of bupivacaine in early postoperative period can facilitate earlier ventilator weaning and tracheal extubation.

ICU stay was significantly shorter among the ERAS care group participants in comparison with the CONV care group with a P value of 0.003. However, the duration of hospital stay was comparable in both groups.

Zhang et al [30], in their study concluded that pectointercostal block led to shorter ICU stay in accordance with the present study but in contrary with it, they concluded that it also led to shorter hospital stay. The same results were noted by Abdelmaboud [31] in his study.

Such discrepancy in the findings between the present study and the two previously mentioned studies regarding the duration of hospital stay may be caused by the fact that the decision of home discharge in our centre was purely a surgical one, and that patients were kept in the hospital for multiple reasons like waiting for a scheduled follow up echo or for wound and CRP follow up.

The numeric pain rating scale scores were dramatically significantly lower in the ERAS care group with a p value of <0.001 in all readings when compared to the other group with less participants needed rescue doses of nalbuphine in that group versus the CONV care group participants.

This concurs with Rahman et al [28], as in their study, the mean visual analogue scale was significantly (P < 0.001) lower in the Bupivacaine group with zero requirement of rescue pain medication, compared to 53.3% of the participants in the Placebo group needing rescue pain medication.

In addition, Zhang et al [30] noted similar findings among their intervention group participants with lower Numerical Rating Scale (NRS) pain scores at 24 h after the operation both at rest and during coughing when compared to their control group.

Oxygenation (hypoxic index) was found to be significantly better in the ERAS care group participants in all readings except for that calculated 12 hours postextubation.

This does not concur with work done by Rahman et al [28], and Saeidi et al [29], who noted improved oxygenation in the intervention group participants in all of their readings.

Non-concurring finding was also revealed by Vourc'h et al [32], who compared HFNO with a Hudson non-rebreathing face mask in 90 cardiac surgery patients, where the HFNO group showed higher PaO_2/FiO_2 (by 22–26%) at 6 and 24 h postextubation.

On the other hand Theologou et al [33], in their study, comparing High Flow Oxygen Therapy versus Conventional Oxygen Therapy post-cardiac surgery, concluded that there was no statistically significant difference in the hypoxic index between different groups. They explained such finding by the incidence of participants switching from conventional oxygen therapy group to the high flow nasal cannula groups.

In the present study, participants in the ERAS care group showed better lung aeration proved by lower scores in modified radiological atelectasis score and modified lung ultrasound score.

In accordance with the present study, Lee et al [34] in their study concluded that the preventive use of HFNC after surgery improved the lung ultrasound score compared to conventional oxygen therapy in infants and small children.

However, in contrast to the present study, Du et al [35], in their study, concluded that there was no significant difference in radiological atelectasis score between the HFNC group participants and the control ones.

The respiratory rate was comparable in both groups in the first 24 h and significantly lower among the ERAS group participants over the next 24 h.

In contrary to the present study, Vourc'h et al [32], in their study, noted a statistically lower respiratory rate (by 14%) at 24 h in the high flow nasal cannula group,

Such discrepancy might be explained by the fact that in the present study, respiratory complications usually develop later on day 1 were long-term uncontrolled pain and unaddressed atelectasis start to show their effect on respiratory rate.

Participants showed better satisfaction and comfort as measured by the modified Borg score in the ERAS care group.

This concurs with the studies done by Vourc'h et al [32], and Maggiore et al [36], where they both reported improvement in patients' comfort among participants in the HFNC groups,

In the present study, roughly three times the number of participants in the CONV care group required escalation of the respiratory support compared to the ERAS care ones.

This concurs with Vourc'h et al [32] and Maggiore et al [36], who both noted a less frequent need for NIV or reintubation in the HFNC group, with no differences in ICU mortality.

However, in contrast to the present study, Theologou et al [33], in their study, demonstrated no statistically significant difference between both the intervention and control group.

In the present study, participants in the ERAS care group showed better lung aeration proved by lower scores in modified radiological atelectasis score and modified lung ultrasound score.

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In the present study, gastrointestinal complication was comparable in both groups.

This concurs with the study of Chen et al [37], regarding ultrasound-guided regional anaesthesia for postoperative median sternotomy pain.

In the present study, participants in the CONV care group showed more findings in the predischarge radiological screening. Atelectasis was by far the most common finding.

This did not concur with Du et al [35], in their study, they concluded that HFNC had no difference in improving atelectasis.

However it concurs with Lee et al [34], in their study, they concluded that the preventive use of HFNC after surgery reduces postoperative atelectasis compared to conventional oxygen therapy in infants and small children.

This study had its limitations including the single-centre design and the relatively small sample size of participants, not taking into account the possibility of break through pain with coughing or mobilization, and the lack of escalation in pain management other than nalbuphine intravenously.

In conclusion, ERAS protocol in cardiac surgery patients led to shorter ICU ventilation period, shorter ICU stay, better patient satisfaction and pain control, better oxygenation and lung aeration and less atelectasis on discharge radiological.

Abbreviations

ERAS: Enhanced recovery after surgery, CONV: Conventional, HFNO: High flow nasal Oxygen therapy, IV: Intravenous, ICU: Intensive care unit, CPAP: Continues positive airway pressure, LVEF: Left ventricular ejection fraction, Fio_2: Fraction inspired oxygen, NIPPV: Noninvasive positive pressure ventilation, IPPV: Intermittent positive pressure ventilation, NPRS: Numeric pain rating scales, BMI: Body mass index, CRP: C-Reactive protein, Pao_2: Partial pressure of oxygen, NIV: Noninvasive ventilation, HFNC: High flow nasal cannula.

Disclosure statement

No potential conflict of interest was reported by the author(s).

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