ejpmr, 2021,8(4), 633-638

SJIF Impact Factor 6.222

EUROPEAN JOURNAL OF PHARMACEUTICAL AND MEDICAL RESEARCH

www.ejpmr.com

Research Article

ISSN 2394-3211

EJPMR

ASSESSMENT OF THE HEMODYNAMIC AND RESPIRATORY EFFECTS OF LOW FLOW GENERAL ANESTHESIA IN LAPAROSCOPIC CHOLECYSTECTOMY SURGERY

Dr. AKM Faizul Hoque*[1], Dr. Ashfaqul Islam[2], Dr. Dabasis Kumar[3], Dr. Farida Khan[4], Dr. Jeevan Pacchad[5], Dr. Ranjan Kumar Nath[6]

[1]Associate Professor, Anaesthesia Analgesia and ICU, BSMMU, Shahbag, Dhaka, Bangladesh.
[2]Medical Officer, Anaesthesia Analgesia and ICU, BSMMU, Shahbag, Dhaka, Bangladesh.
[3]Assistant Registrar (Anaesthesiology), Nitor, Sher-E-Bangla Nagar, Dhaka, Bangladesh.
[4]Consultant, Gyane and obstetrics, Central Police Hospital, Dhaka, Bangladesh.
[5]Consultant Anaesthesia, Anaesthesia and Pain, Lifeline Medical Institute of Science and Research, Dhaka, Bangladesh.
[6]Professor, Dept. of Anaesthesia, Chattogram Medical College, Chattogram, Bangladesh.

***Corresponding Author: Dr. AKM Faizul Hoque**

Associate Professor, Anaesthesia Analgesia and ICU, BSMMU, Shahbag, Dhaka, Bangladesh.

Article Received on 20/02/2021 **Article Revised on 10/03/2021** **Article Accepted on 30/03/2021**

ABSTRACT

Low flow anesthesia technique was first introduced by by Foldes in 1952 now it is going popularity across the globe due to availability of modern anesthetic machine, pollution free and economical. This study was designed to find any difference between high flow and low general anesthesia using halothane as an anesthetic during laparoscopic cholecystectomy in adult. Observe and compare the hemodynamic and respiratory effects under high flow general anesthesia and low flow general anesthesia in laparoscopic cholecystectomy. **Materials and Method:** a prospective randomized single-blind comparative study total 68 patients of 25 - 40 years old ASA I/ II scheduled for laparoscopic cholecystectomy enrolled. The patients were randomly allocated into two equal groups by an online based software generated randomization divided the patients into two equal group assigned; high flow general anesthesia (6L/minute, group A n=17) and Low flow general anesthesia (3L/minutes, group A n=17) technique. A standardized checking of anesthetic machine fitted with a leak-proof circle breathing system with CO_2 absorber and absorbent and calibration of vaporizer were carried before induction for every cases. During surgery heart rate, blood pressure percentage of hemoglobin saturated with oxygen (SpO_2) and end tidal carbon dioxide ($EtCO_2$) were carefully recorded. ABG analysis was done after intubation and immediate before extubation. Recovery time after extubation were also recorded. **Conclusions:** There were no difference between high-flow anesthesia and low -flow halothane anesthesia technique on the hemodynamics, oxygen saturation and ETCO2 level. pulmonary functions are comparable to high-flow halothane anesthesia in patients undergoing laparoscopic cholecystectomy.

KEYWORDS: SpO_2, $EtCO_2$.

INTRODUCTION

Low flow anaesthesia may be defined as an anaesthetic technique that using fresh gas flow less than the alveolar ventilation.[1]

Low-flow anaesthesia is an inhalation anaesthetic technique in which the rebreathing fraction at least amounts to 50%, and rest of the exhaled gas mixture and recycled to the patient in the next breath after removal of CO_2.[2 – 4] The modern anaesthetic machines comprising gas analyzers with precision vaporizers with more potent volatile agents encouraging low flow general anesthesia.[5]

During normal tidal ventilation only 5% (200 - 250 ml. min) of oxygen is consumed by the body[6] and the remaining part of gas mixture returned to the circuit unchanged that can be reused in the next breath via a circle breathing system with CO2 absorber. Therefore, supplementing consumed part can safely be achieved by adding fresh gas flow rate 2 L min-' or less using leak-proof rebreathing circle system.

Low flow anesthesia technique improves the flow dynamics of the inhaled air preserves heat and moisture loss thereby maintaining respiratory mucociliary function leading to reduction of the risk of pulmonary inflammation. volutrauma and postoperative atelectasis. The reduced flow reduces the risk of inhalational anesthetic related organ impairment.[3, 7-9]

There are several possible disadvantages resulting from the inappropriate use of low-flow anesthesia include hypercapnia hypoxia, excessive or insufficient concentrations of volatile agents, and the accumulation of potentially toxic gases.[8,5] The modern anaesthetic machines comprising gas analyzers and precision vaporizers with more potent volatile agents encouraging low flow general anesthesia.[10] Low flow general anesthesia results in a decrease in anesthetic consumption, atmospheric pollution, and cost.[11]

Laparoscopic cholecystectomy has "minimal" impact upon patient: smaller incisions, early ambulation, less postoperative discomfort and less compromised postoperative respiratory and gastro-intestinal functions and shorter hospital stays, an earlier return to work and less morbidity and mortality.[12-16]

Insufflation of the peritoneal cavity with co2 at the rate of 1-2L/minute and maintaining 12-14 mm Hg intra-peritoneal pressure and displace diaphragm upward. This distension increases intrathoracic pressure, and the alveoli are collapsed. During the laparoscopy, the direct effects of the additional positive end-expiratory pressure cause a hemodynamic imbalance. The increased intra-abdominal pressure (IAP) caused by pneumoperitoneum may impair venous return and thus cardiac output. The reverse Trendelenburg position decreases the venous return in anesthetized patients.[17]

There is no study on low flow anesthesia of „Bangladeshi‟ population. who are different in physical status, life styles, and food habits and usually halothane anaesthesia may have variation on the hemodynamic and respiratory effects during low flow general anaesthesia. This study was conducted to determine the hemodynamic and respiratory effects of low flow general anesthesia and high flow general anesthesia using halothane during laparoscopic cholecystectomy.

METHODS

It was a prospective randomized single-blind comparative study conducted after obtaining approval from the Institutional Review Board (IRB) of BSMMU and informed written consent from each patient; 68 patients aged between 25 to 40 years suffering from cholecystitis, BMI ranging from 18.5 to 24.9 Kg/m2 and belong to American Society of Anesthesiologist (ASA) Physical status group I and II and who were selected for laparoscopic cholecystectomy were enrolled for the study.

The patients were randomly allocated into two equal groups by an online based software generated randomization technique. Group A‟ (high flow general anesthesia group) had received high flow general anesthesia and" Group B‟ (low flow general anesthesia group) received low flow general anesthesia".

All the anesthesia were carried out by using a properly checked anesthetic machine fitted with a leak-proof circle breathing system with fully functioning absorber and absorbent and properly calibrated vaporizer for every cases.

Both groups general anesthesia were induced by 1.5 μg/kg fentanyl and 1.5–2 mg/kg propofol and intubation facilitated by 2 mg/kg suxamethonium chloride. Vecuronium bromide was given when patient's spontaneous respiration restarted.

Patients of group A were ventilated with high fresh gas flow rate (equal to minute volume comprising 50% O_2 and 50% N_2O) all along the surgery. On the other hand, patients of group B, breathing circuit primed with high fresh gas flow (equal to minute volume) for first 10 minutes then set to 2 L min-'. After dressing, high flow O2 were given to avoid delayed emergence.

During surgery patients‟ hemodynamics (heart rate, blood pressure), percentage of hemoglobin saturated with oxygen (SpO_2) and end tidal carbon dioxide ($EtCO_2$) were carefully recorded every 03 minutes interval up to the reversal from anesthesia. ABG analysis was done to replace gas analyzer after intubation and immediate before extubation.

Statistical analysis

Statistical analyses were carried out by using the Statistical Package for Social Sciences version 23.0 for Windows (SPSS Inc., Chicago, Illinois, USA). A descriptive analysis was performed for all data. The mean values were calculated for continuous variables. The quantitative observations were indicated by frequencies and percentages. Fisher exact test was used to analyze the categorical variables. Student t-test was used for continuous variables like hemodynamic respiratory and SPO2. Student t-test was also used for age and BMI. Chi-square test was used to analyze the recovery time. P value < 0.05 considered as statistically significant.

RESULTS

A prospective randomized comparative study total sixty-eight (68) patients underwent laparoscopic cholecystectomy; allocated in two equal high flow general anesthesia (Group A) or for low flow general anesthesia (Group B) randomly.

Table I: Demography of patients in two studied groups.

Characteristics	Group A (n = 34) Mean ±SD	Group B (n = 34) Mean ±SD	P value
Age in years	36.79 ± 5.00	35.32 ± 5.52	0.254
Sex Male/Female	41.2/58.8	23.5/76.5	0.120
Weight	56.91 ± 6.55	53.00 ± 5.98	0.120
Height	157.76 ± 8.24	156.55 ± 5.21	0.474
BMI	22.28 ± 1.53	21.53 ± 1.48	0.046
ASA			0.324
I	18 (52.9%)	22 (64.7%)	
II	16 (47.1%)	12 (35.3%)	
Occupational status Service/Business/Others	26.5/11.8/61.8	8.8/14.7/76.5	0.162

Data were analyzed using fisher exact test and student 't 'test. Values are expressed as Mean ± SD absolute number; within parenthesis are percentages over row total and percentage (as appropriate). P value < 0.05 considered as significant.

Table II: Comparison of heart rate (HR) in the studied groups.

Heart rate	Group A (n = 34)	Group B (n = 34)	P value
Baseline	80.82 ± 8.98	79.08 ± 10.57	0.469
After intubation	81.11 ± 8.9	80.94 ± 11.64	0.944
3 min	77.88 ± 9.13	76.23 ± 10.80	0.500
9 min	75.23 ± 9.39	74.02 ± 10.49	0.619
15 min	73.85 ± 9.94	72.52 ± 10.11	0.588
21 min	72.82 ± 10.45	71.20 ± 10.43	0.525
27 min	73.55 ± 10.41	71.47 ± 10.76	0.419
33 min	72.39 ± 10.04	71.78 ± 9.62	0.803
39 min	76.63 ± 9.31	72.02 ± 9.55	0.518
45 min	79.25 ± 16.25	72.61 ± 10.31	0.115
51 min	75.81 ± 9.50	76.62 ± 10.29	0.86
57 min	79.66 ± 4.72	82.66 ± 16.16	0.773

Before initiation of induction, just after intubation and 3 minutes after then every 6 minutes interval heart rate changes were recorded unto extubation.

Table II shows mean ±SD heart rate between in group A and B at baseline, 21 minutes, 39 minutes and 57 minutes were (80.82 ±8.98, 79.08 ±10.57; p=0.469), (72.82 ± 10.45, 71.20 ± 10.43; p=0.525) (76.63 ± 9.31,72.02 ± 9.55; p=0.518) and (79.66 ±4.72, 82.66 ± 16.16, P= 0.773) respectively; There were no significant difference between two groups regarding heart rate (P > 0.05) changes between the technique.

Table III: Comparison of systolic blood pressure (SBP) and diastolic blood pressure (DBP) and mean arterial blood pressure (MAP) in the studied groups.

	Systolic blood pressure in mm of HG			Diastolic blood pressure in mm of HG			Mean arterial blood pressure in mm of HG		
Time interval	Group A	Group B	P value	Group A	Group B	P value	Group A	Group B	P value
Baseline	133.88 ± 9.36	132.20 ± 8.29	0.437	84.82 ± 5.37	84.64 ± 5.42	0.893	100.82 ± 6.06	100.11 ± 5.84	0.626
After intubation	133.55 ± 8.84	132.55 ± 7.90	0.615	86.67 ± 4.97	85.26 ± 6.37	0.312	101.91 ± 5.66	100.70 ± 6.32	0.411
3 min	129.24 ± 8.74	129.20 ± 8.78	0.989	84.32 ± 5.26	82.52 ± 7.07	0.238	98.91 ± 5.91	97.79 ± 6.98	0.479
9 min	127.94 ± 10.38	127.91 ± 10.25	0.991	83.32 ± 6.55	81.70 ± 7.22	0.337	97.76 ± 7.34	96.88 ± 7.88	0.634
15 min	128.44 ± 10.37	127.58 ± 10.16	0.733	83.17 ± 7.23	81.94 ± 6.79	0.471	97.70 ± 7.91	96.82 ± 7.35	0.275
21 min	127.44 ± 10.25	127.05 ± 9.65	0.875	82.70 ± 6.47		0.388	97.14 ± 7.03	96.32 ± 7.19	0.635
27 min	127.82 ±	127.17 ±	0.782	82.91 ±	81.35 ±	0.291	97.61 ±	96.23 ±	0.397

	9.94	9.29		6.55	5.47		7.04	6.29	
33 min	128.18 ± 8.64	127.15 ± 9.32	0.643	82.12 ± 6.37	82.50 ± 5.35	0.309	93.75 ± 16.01	95.69 ± 6.00	0.517
39 min	127.78 ± 10.06	128.06 ± 8.81	0.910	82.41 ± 5.97	82.13 ± 5.20	0.852	93.72 ± 17.02	96.86 ± 5.37	0.348
45 min	130.13 ± 8.72	130.00 ± 7.81	0.659	84.86 ± 6.01	81.90 ± 7.12	0.146	99.74 ± 5.13	97.85 ± 6.95	0.383
51 min	129.72 ± 8.27	132.22 ± 5.93	0.458	83.72 ± 4.94	82.77 ± 3.52	0.635	98.72 ± 5.36	96.44 ± 4.85	0.904
57 min	122.66 ± 10.78	133.66 ± 7.50	0.221	81.33 ± 2.30	86.66 ± 5.77	0.212	94.66 ± 3.51	102.33 ± 6.35	0.141

Table IV: Comparison of SpO_2 in the studied groups.

SpO_2	Group A (n = 34)	Group B (n = 34)	P value
Baseline	99.88 ± 0.32	99.97 ± 0.17	0.168
After intubation	99.94 ± 0.23	99.79 ± 0.33	0.400
3 min	99.79 ± 0.41	99.82 ± 0.45	0.781
9 min	99.70 ± 0.46	99.58 ± 0.55	0.347
15 min	99.61 ± 0.60	99.61 ± 0.69	1.000
21 min	99.76 ± 0.49	99.70 ± 052	0.636
27 min	99.50 ± 0.66	99.52 ± 0.78	0.868
33 min	99.79 ± 0.47	99.69 ± 0.91	0.617
39 min	99.86 ± 0.35	99.75 ± 0.57	0.413
45 min	99.79 ± 0.41	99.42 ± 1.20	0.173
51 min	99.91 ± 0.28	99.75 ± 0.46	0.332
57 min	100.0 ± 0.0	99.88 ± 0.32	0.437

Data were analyzed using student ‘t ’test. Values are expressed as Mean ±SD.

The SpO2 values of the patients in both groups were measured over different time periods and compared, it was found that there was no significant difference between after intubation (P=0.400), at 21th ((P=0.636), 33rd ((P=0.617) and 45th (0.173) 57th((P=0.437), minutes and not statistically significant ($p < 0.05$).

Table V: Comparison of P^H PaO_2 and PaCO2 in the studied groups.

	Group A (n = 34)	Group B (n = 34)	P value
P^H			
After intubation	7.47 ± 0.05	7.48 ± 0.05	0.772
During dressing	7.45 ± 0.06	7.46 ± 0.07	0.488
PaO_2			
After intubation	167.52 ± 33.55	167.35 ± 44.43	0.985
During dressing	184.26 ± 60.13	179.79 ± 47.44	0.735
$PaCO_2$			
After intubation	34.81 ± 5.50	34.76 ± 5.51	0.970
During dressing	35.74 ± 7.91	34.58 ± 7.21	0.529

Data were analyzed using student ‘t ’test. Values are expressed as Mean ±SD.

Table shows the $EtCO_2$ at baseline, after intubation, at 3 minutes then every 6 minutes unto 57 minutes ETCO2 were recorded between the group which were statistical insignificant (P=1.000, p=1.000, p=0.570, p=0.640, p=0.330, p=0.426, p=0.417 p=0.236) as their values >.05.

There was no significant difference between two groups $EtCO_2$ ($P > 0.05$). The pH in the studied groups, mean ± SD after intubation (7.47 ±0.05 in A and 7.48 ±0.05 in B, P= 0.772) and during dressing (7.45 ±0.06 in A and 7.46 ±0.07 in B; P=0.488). were statistically not significant between two group ($P > 0.05$). For PaO_2 mean ±SD after intubation (167.52 ± 33.55 167.35 ± 44.43; P= 0.985) in A and group B 184.26 ± 60.13, 179.79 ± 47.44; P=0.735) was P >.05 and statistically insignificant. For $PaCO_2$ mean ±SD after intubation was (34.81 ± 5.50 in A 34.76 ± 5.51 in B; P= 0.970) and during dressing (35.74 ± 7.91, 34.58 ± 7.21; P=0.529) was P >.05 and statistically into significant.

Table VI: Comparison of recovery time in the studied groups.

Recovery time	Group A (n = 34)	Group B (n = 34)	P value
Within 40 min	7 (20.5%)	8 (23.5%)	0.457
Within 40 to 60 min	27 (79.5%)	26 (76.5%)	

In terms of recovery time; 7 (20.5%) patients of group A and 8 (23.5%) patients of group B were recovered from anesthesia within 40 minutes. Whereas, 27 (79.5%) patients of group A and 26 (76.5%) patients of group B were recovered from anesthesia within 40 to 60 minutes. The statistical differences between the groups were insignificant ($P > 0.05$), which indicates low flow general anesthesia had no effect on recovery process.

DISCUSSION

Laparoscopic cholecystectomy is conventionally done with high flow general anesthesia to ensure optimum oxygenation, ventilation and hemodynamics taking an account on pneumoperitonium and patient position; although it can be performed with low flow general anesthesia.

This prospective randomized single-blind comparative study showed the demographic characteristics of high flow general anesthesia and low flow general anesthesia that were statistically similar in context of age, sex, weight, height, BMI ($p > 0.05$); unpaired student's t test was done for age, weight, height, BMI and fisher exact test was done for sex, occupation and ASA status.

Unpredictable uptake anesthetic gases and longtime constant prevent rapid change of anesthetic plan and controlling of hemdynamonymic may be challenging.[18]

The current study had found no variation of heart rate (HR), systolic blood pressure (SBP), diastolic blood pressure (DBP) and mean arterial pressure (MAP) and pulmonary function test between low flow and high flow general anesthesia. Similar results were also found in a study to assess hemodynamic response to low flow sevoflurane general anesthesia (LFA) and O_2 as carrier gas.[19,20]

There are many potential risk of hypoxic mixture, hypercarbia, circulation of unwanted substances i.e., alcohol, carbon monoxide; contamination with toxic gases may reduce oxygen. Leaks in the breathing circuit and sampling from expired gases reduces total volume resulting retention of carbon dioxide as well percentage of oxygen during low flow anesthesia.[3, 21 – 23]

This study observed and recorded SPO2 and ETCO2 over time during general anesthesia With halothane and O2 and N2O as carrier gas at different flow rates and were found insignificant statistical difference ($P > 0.05$). A recent study on low flow anesthesia and choice of volatile anesthetic matched similar result.[24]

To review the merits and demerits of low flow anesthesia, in terms of cost benefit ratio[25], had showed gas analyzer was optimal monitoring reflect magnitude of changes in PaO2, PCO2 and PH in the blood therefore no necessity of additional ABG analysis. Despite extreme solubility of halothane, at low flow anesthesia it maintains constant concentration in the anesthetic gas mixture delivered to the patient. The inhaled anaesthetic consumption influenced by the FGF (L/min), delivered gas concentration (%) of gas delivered, duration of the anaesthetic Low flow anesthesia technique saves volatile agents /halothane lost is minimum by limiting venting of expired gas.[26]

Aiming to assess the performance of different flow rates of gas mixtures in terms of hemodynamic state, gas exchange parameters and recovery time and safety ground during low flow general anaesthesia,[26,27] had done a study and found that – limiting flow rate of gas mixture enhance minimal wastage of volatile anaesthetics and environmental pollution without compromising the hemodynamics and recovery process. In this study we found that the difference in hemodynamic and respiratory parameters between the high flow general anesthesia and the low flow general anesthesia were statistically insignificant ($p > 0.05$).

This study suggests that, the low flow general anesthesia can be performed safely with a properly calibrated and functioning ventilator fitted with leak proof closed circuit breathing system, calibrated vaporizer and functioning CO_2 absorber and absorbents. Present study showed that, the high flow and low flow general anesthesia is equally effective in laparoscopic cholecystectomy.

CONCLUSION

Low flow general anesthesia preserves hemodynamic and pulmonary function without impairing recovery from anesthesia, economical and safer for the patient, theatre personnel and environment. However, low flow anesthesia needs constant monitoring of O2 and CO2 in the gas mixture. It is recommended to practice low flow anesthesia wherever leak proof functional circle breathing system and calibrated vaporizer is available.

REFERENCES

1. Baker AB. Back to basics – A simplified non-mathematical approach to low flow techniques in anaesthesia. Anaesth Intensive Care, 1994; 22: 394-5.
2. Baum JA, Aitkenhead AR. Low-flow anaesthesia. Anaesthesia, 1995; 50 Suppl 10: 37-44.
3. Geoffrey Nunn (2008), Low flow anesthesia, Continuing Education in Anaesthesia, Critical Care & Pain, BJA, 8: 1-4.
4. Suttner, S. and Boldt, J. (2000), Low flow anesthesia Does it have Potential Pharmacoeconomic

Consequences?, Pharmacoeconomics, 17(6): 585-590.
5. Coca, 4.D. S., Coca, D. and Billings, S.A. (2005), An Adaptive GPC Approach to Low-Flow Anaesthesia, 16th Triennial World Congress, Prague, Czech Republic, IFAC, 7-12.
6. Upadya Madhusudan, Saneesh P J Year : 2018 | Volume: 62 | Issue Number: 3 | Page: 166-172 2018, Vecil et al., 2008).
7. Hönemann, C., Hagemann, O., & Doll, D. (2013). Inhalational anaesthesia with low fresh gas flow. Indian journal of anaesthesia, 57(4): 345–350. Protective Ventilation in the OR
8. Clinical Benefits of Low- and Minimal- Flow Anaesthesia https://doi.org/10.4103/0019-5049.118569), https://www.draeger.com/Library/Content/low-flow-and-minimalflow-wp-999-en.pdf
9. Meakin, G. H. (2003), Time constant or half time of a breathing system?, Anesthesia, 58: 386-387. DOI: 10.1046/j.1365-2044.2003.03095_5.x
10. Aldrete, J. A., Cubillos, P. and Sherrill D., (1981), Humidity and Temperature Changes during Low and closed system anesthesia, Acta anaesth. scand., 25: 312-314.
11. Vecil, M., Di Stefano, C., Zorzi, F., Saltarini, M. and De Monte, A. (2008), Low flow, minimal flow and closed circuit system inhalational anesthesia in modern clinical practice, SIGNA VITAE, 3 Suppl 1: S, 33 – 36.
12. Sivaci, R., Orman, A., Yilmazer, M., Yilmaz, S., Ellidokuz, H. and Polat, C. (2005), The Effect of Low-Flow Sevoflurane and Desflurane on Pulmonary Mechanics During Laparoscopic, Journal Of Laparoendoscopic & Advanced Surgical Techniques, 15(2): 125-129.
13. McLaughlin, J.G., Scheeres, D.E., Dean, R.J. et al. The adverse hemodynamic effects of laparoscopic cholecystectomy. Surg Endosc, 1995; 9: 121–124. https://doi.org/10.1007/BF00191950 Cunningham, Anthony J. (1998), Anesthetic Implications of Laparoscopic Surgery, Yale Journal Of Biology And Medicine, 71: 551-578.
14. Tripathi, D. C., Shah, K. S., Dubey, S. R., Doshi, S. M., & Raval, P. V. (2011). Hemodynamic stress response during laparoscopic cholecystectomy: Effect of two different doses of intravenous clonidine premedication. Journal of anaesthesiology, clinical pharmacology, 27(4): 475–480. https://doi.org/10.4103/0970-9185.86586
15. Suzanne Odeberg-Wernerman, Laparoscopic surgery – effects on circulatory and respiratory physiology: an overview, European Journal of Surgery, November 2000; 166 Supplement_12: 4–11, https://doi.org/10.1080/110241500750056454
16. F. Valenza, G. Chevallard, T. Fossali, V. Salice, M. Pizzocri, and L. Gattinoni, "Management of mechanical ventilation during laparoscopic surgery," Best Practice & Research: Clinical Anaesthesiology, 2010; 24(2): 227–241.
17. Hirvonen, E. A., Poikolainen, E. A., Pa¨a¨kko¨nen, M. E. and Nuutinen, L. S. (2000), The adverse hemodynamic effects of anesthesia, head-up tilt, and carbon dioxide pneumoperitoneum during laparoscopic cholecystectomy, Surg Endosc, 14: 272–277, DOI: 10.1007/s004640000038
18. S. Ahanatha Pillai, Low Flow Anaesthesia Technique The merits and demerits http://www.isakanyakumari.com/doc
19. Debre, Ö., Sarıtaş, A. and Şentürk, Y. (2014), Influence of sevoflurane on hemodynamic parameters, JCEI / Journal of Clinical and Experimental Investigations, 5(1): 12-17.
20. Doger, C., Kahveci, K., Ornek, D., But, A., Aksoy, M., Gokcinar, D., & Katar, D. (2016). Effects of Low-Flow Sevoflurane Anesthesia on Pulmonary Functions in Patients Undergoing Laparoscopic Abdominal Surgery. BioMed research international, 2016, 3068467. https://doi.org/10.1155/2016/3068467
21. Geoffrey Nunn, BA (Hons) FRCA, Low-flow anaesthesia, Continuing Education in Anaesthesia Critical Care & Pain, February 2008; 8(1): 1–4, https://doi.org/10.1093/bjaceaccp/mkm052
22. Bilgi, Murat; Goksu, Sitki; Mizrak, Ayse; Cevik, Cengiz; Gul, Rauf; Koruk, Senem; Sahin, Levent Comparison of the effects of low-flow and high-flow inhalational anaesthesia with nitrous oxide and desflurane on mucociliary activity and pulmonary function tests, European Journal of Anaesthesiology: April 2011; 28(4): 279-283. doi: 10.1097/EJA.0b013e3283414cb7
23. Kılıç Y. A Reminder to Anesthesiologists: Low-Flow Anesthesia. J Clin Anal Med, 2016; 7(suppl 2): 183-5.
24. Carter, L. A., Oyewole, M., Bates, E., & Sherratt, K. (2019). Promoting low-flow anaesthesia and volatile anaesthetic agent choice. BMJ open quality, 8(3): e000479. https://doi.org/10.1136/bmjoq-2018-000479
25. Kulandayan, S., Lily, Ng. and Kamarudin, D. (2002), Comparison Of The Efficacy Of Two Low Fresh Gas Flow Techniques In Low Flow Anaesthesia, The Internet Journal of Anesthesiology, 7(1): 1-6, https://ispub.com/IJA/7/1/9457
26. J. F. Coetzee1* and L. J. Stewart2) Fresh gas flow is not the only determinant of volatile agent consumption: a multi-centre study of low-flow anaesthesia British Journal of Anaesthesia, 2002; 88(1): 46-55.
27. Kepekçi, A. B., Omaygenç, D. Ö., Karaca, İ. O., Telli, S., Yücepur, S. and Özenç, E. (2019), Even Lower is Possıble: Impact of Flow Rate on Safety Issues in Low Flow Anaesthesia, Medical Journal of Bakırköy, 15(1): 15-23. DOI: 10.4274 BTDMJB.galenos.2017.20171005064643