International Journal of Health Systems and Medical Sciences
ISSN: 2833-7433
Volume 03 Number 02 (2024)
Impact Factor: 10.87
SJIF (2023): 3.656

www.inter-publishing.com

Article

Comparing the Effects of Different Flow Rate of Fresh Gas on Patient Hemodynamic Stability and Depth of Anesthesia

Wisam Adnan Mahmood[1], Saief Ali Raheel[2], Saif Khalid Salsal[3]

1. M.B.Ch.B. , F.A.B.M.S., Senior Specialist in Anesthesia and Intensive Care, Al-Yarmouk Teaching Hospital, Baghdad, Iraq
2. M.B.Ch.B, D.A.I., Specialist in Anesthesia and Intensive Care, Al-Yarmouk Teaching Hospital, Baghdad, Iraq
3. M.B.Ch.B , F.I.B.M.S., Senior Specialist in Anaesthesia and Intensive Care, Al-Yarmouk Teaching Hospital, Baghdad, Iraq

Abstract: More general anaesthesia with lower fresh gas flow rates is needed to reduce environmental contamination and treatment costs. Reducing or eliminating fresh gas administration improves patient care by keeping the highest anaesthesia safety and quality standards and reducing emissions. The increasing use of low fresh gas flow rates addresses environmental concerns and ensures excellent anaesthesia patient outcomes. This study examined how the unique low-flow anaesthesia regimen affected hemodynamic stability throughout medical procedures. One hundred consecutive people were used for this experiment. A group of patients received two litres per minute of high flow anaesthesia (HFA) while another received one litre per minute of low flow (LFA). Surgery took up to two hours for each research subject. The bispectral index (BIS), heart rate (HR), blood pressure, end-tidal carbon dioxide levels, haemoglobin oxygen saturation (SaO_2), and inhalational anaesthetic agent concentrations like isoflurane, nitrous oxide (N_2O), and oxygen (O_2) were closely monitored and recorded during the procedures. The two groups had significantly different heart rates, SaO_2 levels, and systolic and diastolic blood pressure. The two groups' BIS scores were similar, showing that low-flow anaesthesia patients were not more alert during surgery. In addition, the high-flow and low-flow anaesthesia groups had statistically significant differences in end-tidal anaesthetic concentrations at 5, 10, 15, and 60 minutes and after surgery. To conclude, low-flow and high-flow rate general anaesthesia approaches maintain hemodynamic stability and provide the optimum anaesthesia for patients. The current study stresses the importance of continuously monitoring and controlling anaesthesia administration methods to optimise patient outcomes and procedural safety. This study adds to the knowledge of anaesthetic methods and their influence on clinical management and patient care in healthcare.

Keywords: flow rate, hemodynamic stability, anaesthetic methods

Citation: Mahmood, W. A., Raheel, S. A., & Salsal, S. K. Comparing the Effects of Different Flow Rate of Fresh Gas on Patient Hemodynamic Stability and Depth of Anesthesia. International Journal of Health Systems and Medical Sciences 2024, 3(2), 125-131.

Received: 8th April 2024
Revised: 15th April 2024
Accepted: 22nd April 2024
Published: 29th April 2024

1. Introduction

The benefits of low flow anaesthesia and its improved availability to modern treatments and monitoring technology have boosted interest in its clinical use. Benefits of low-flow anaesthesia have garnered attention. These include being cost-effective, lowering pollution, and reducing patient heat and moisture loss. Rebreathing exhaled gases has been crucial to anaesthetic delivery system advancement from open drop ether administration to semi-closed and closed breathing systems. Anaesthesia equipment, precision vaporizers, anaesthetic gas analyzer monitors, and innovative volatile agents have helped low gas flow treatments become more popular. Modern anesthesiologists must use available resources and execute low-flow anaesthesia due to the substantial environmental impacts of anaesthetic gas emissions [1]. LFA is becoming increasingly important in healthcare settings as environmental concerns grow. Lack of a broadly accepted definition for low flow anaesthesia underlines the need to create and improve this approach with fresh clinical understanding and technology. Since LFA definition is so complicated, the anaesthesia community must continue to research and collaborate to produce widely accepted principles and methods for its effective implementation. The complex features of low flow anaesthesia underline the necessity for continual training for anaesthesia practitioners to provide safe and effective patient care. Low-flow anaesthesia (LFA) is not well-defined in medicine. Low-flow anaesthesia uses fresh gas (FG) flow below the patient's alveolar breathing. In "low-flow anaesthesia" inhalation, at least 50% of the gaseous components are recycled during the inspiratory phase. After removing the carbon dioxide from exhaled gas, some is recycled back to the patient. Anaesthetic technology allows this rebreathing treatment with fresh gas flow (FGF) rates as low as 1 litre per minute or lower. Safety features in anaesthesia equipment and precise gas monitoring capabilities have considerably reduced the technical obstacles to low-flow anaesthesia, removing any earlier objections to its widespread usage. Modern anaesthetic workstations have $ETCO_2$, FiO_2, and inhalational anaesthetic monitoring hardware. These technologies streamline low-flow anaesthetic operations. Reliable recommendations that eliminate difficult mathematical computations make low-flow anaesthesia safe and effective in medical contexts, boosting its practicality [2]. Monitoring the Bispectral Index (BIS) helps assess tiredness and anaesthesia. Several investigations have shown that BIS monitoring reduces intraoperative awareness episodes, improving patient safety [3]. The BIS index objectively measures anaesthetics' CNS sedative and hypnotic effects. Ninety As previously mentioned, this quantitative parameter provides crucial sedative data. Medical professionals can better administer anaesthesia and keep patients safe with this information. BIS monitoring helps doctors adjust anaesthetic dosages more accurately, reducing the danger of over- or under-sedation and improving patient outcomes. The BIS index for objective sedation assessment is a major advance in anaesthesia treatment. Quality patient care depends on this index. The study aimed to determine how a novel Low Flow Anaesthesia (LFA) regimen affected hemodynamic stability preservation in two-hour operations.

2. Materials and Methods

The Al-Yarmouk Teaching Hospital in Iraq conducted a study from April 2020 to March 2022. 100 patients were sampled for the study. Before the study began, all ethics committee clearances were received, and participants gave informed consent. Two groups of fifty patients each got low-flow or standard-flow anaesthesia. Both groups were selected using inclusion criteria. According to the American Society of Anesthesiologists (ASA), patients had to be 18–65 years old, class I or II, and scheduled for a two-hour elective procedure. The study excluded pregnant women, obese people, and emergency patients. This study examined surgeries lasting up to two hours. Neurosurgery for disc hernia was performed alongside plastic surgeries such Dupuytren's contracture, tendon surgeries, augmentation, and gynecomastia. In the first group, two liters per minute were utilised to induce and maintain anaesthesia. However, the second group received low-flow anaesthesia. After induction, pre-oxygenation, hypnotic and narcotic drugs, muscle relaxants, and endotracheal intubation were used to induce low-flow anaesthesia. The patient was given a strong fresh gas flow after being connected up to the equipment to start anaesthesia. This flow reduced throughout the study. From 4-6 liters per minute, gas flow was maintained until anaesthesia and isoflurane end-tidal concentrations were reached. The preparation time was calculated by reducing the flow rate and injecting each gas at 4-5 liters per minute for 6-8 minutes. After the first step, 30% oxygen and 65% nitrous oxide were maintained. The isoflurane vaporizer was set at 2.5% until the expiratory concentration was reached, resulting in a MAC of 0.8. After ten minutes, an adult patient used 1.0 liter of petrol per minute, down from 600 milliliters per minute. To maintain inspiratory oxygen concentration, reducing fresh gas flow to 30% would have required increasing oxygen concentration to 50%. The decrease in flow rate also reduced isoflurane administration. Adjusting the vaporizer to 3.0% would have preserved the initial anaesthetic medication concentration of 0.8 times MAC. Each patient's Bispectral Index (BIS), heart rate, blood pressure, arterial oxygen saturation (SaO_2), and end-tidal carbon dioxide concentration ($ETCO_2$) were continually measured. The above parameters were captured throughout the procedure. These included pre-induction, mask ventilation, intubation, immediate post-intubation, incision, 30 minutes after incision, completion of procedure, before extubation, and when the patient recovered consciousness. Exhaled isoflurane, nitrous oxide (N_2O), and oxygen (O_2) concentrations were measured at 5, 10, 15, and 60 minutes and after surgery. All statistical analyses used a 5% significance level ($P < 0.05$). Results are presented using descriptive statistics like mean and standard deviation. A t-test was used to evaluate if two groups had statistically significant mean differences.

3. Results

Systolic pressure measurements differ greatly between those with high-flow anesthesia (HFA) and those with low-flow anesthesia. In Table 1, five measurements taken during the incision operation and nine taken after the patient awakens were examined to determine this conclusion.

The second round of data showed statistically significant differences in diastolic pressure measurements between the (HFA) group and the low-flow anesthesia group. The patient was on mask breathing during these measurements. Table 2 shows differences in measurements from the fifth (incision) to the tenth (patient waking).

Table 3 demonstrates a statistically significant difference in SaO_2 values between the first evaluation (before induction) and the fifth through ninth tests between the HFA and LFA cohorts. Table 4 reveals a statistically significant difference in heart rate data between the initial HFA and LFA groups at the fifth and eighth assessments before extubation.

Table 1. Readings of systolic pressure (mmHg)

Time	Mean		P value
	Group 1(LFA)	Group 2(HFA)	
1	119.30	121.80	.510
2	110.45	112.96	.516
3	108.50	115.70	.087
4	110.90	112.80	.980
5	99.8	104.34	.001*
6	93.20	103.20	.000*
7	95.40	106.50	.000*
8	99.70	112.380	.000*
9	112.90	122.70	.001*
10	119.10	126.30	.072

* denotes statistically significant variations.

Table 2. Readings of diastolic pressure (mmHg)

Time	Mean		P value
	Group 1 (LFA)	Group 2(HFA)	
1	72.640 ±	72.40	.928

2	70.320	72.46	.402
3	70.08	72.80	.291
4	67.820	72.96	.062
5	59.380	64.50	.022*
6	60.640	64.74	.056
7	60.86	64.56	.071
8	62.76	67.12	.029*
9	68.30	72.76	.051
10	72.90	74.87	.294

* denotes statistically significant variations.

Table 3. SaO_2 readings (%)

Time	**Mean**		**P value**
	Group 1 (HFA)	Group 2 (LFA)	
1	80.40	80.16	.928
2	78.62	80.76	.402
3	78.086	80.68	.291
4	75.04	80.360	.062
5	67.48	72.600	.022*
6	68.08	72.340	.056
7	68.46	72.160	.071
8	70.46	75.42	.029*
9	76.00	80.76	.051
10	80.00	82.58	.294

*indicates statistically significant variations.

Table 4. Readings of Heart rate

Time	**Mean**		**P value**
	Group 1 (HFA)	Group 2 (LFA)	
1	82.20	82.36 ± 11.370	.928
2	80.42	82.96	.402
3	80.48	82.88	.291
4	77.42	82.16	.062
5	69.28	74.80	.022*
6	70.44	75.14	.056
7	70.26	73.36	.071
8	73.26	77.12	.029*
9	75.00	82.96	.051
10	84.58	82.08	.294

*indicates statistically significant variations

The statistical finding above underlines the need of considering how anaesthetic practices affect patient outcomes, especially heart rate variability and consciousness risk.

Our study aimed to assess the effects of HFA and LFA on anaesthesia depth and hemodynamic stability. We measured end tidal nitrous oxide in the high flow group five minutes after surgery and until it was finished. Our observations ranged from 38% to 59%. In contrast, the low flow group had concentrations from 38% to 56%. The oxygen concentration levels were throughout surgery, demonstrating that both groups' expired oxygen ranged between 33% and 40%. Both groups maintained 25–35 mm Hg carbon dioxide levels at tide's end.

4. Discussion

Modern rebreathing apparatuses enable LFA at one liter per minute or less, according to our study. Studies have shown that clinical symptoms alone cannot accurately assess anaesthesia [4], [5]. According to objective and precise criteria, subjective symptoms alone cannot determine the right level of anaesthesia. Anaesthesia depth assessment is subjective and imprecise because to a lack of reliable measurements and monitoring methods. Thus subjective assessments to decide whether a deeper anaesthetic is appropriate may misjudge the patient's condition.

BIS analysis is a non-invasive method that directly measures how hypnotic and sedative medications influence the brain, the organ they treat. Bispectral analysis uses an electroencephalogram (EEG) of the frontal brain region, which maintains hypnotic levels. Current methods use electroencephalography data and meticulously examine it. The bispectral index (BIS), which ranges from 1 to 100, is calculated using complicated methods. Its numerical representation roughly matches consciousness and anaesthesia. Drugs administered intravenously or inhaled are assessed for hypnotic effects. Monitoring allows doctors to precisely modify anaesthetic dosage based on patient sedation, speeding anaesthesia recovery. Numerous investigations have examined comparable effects with various medicinal interventions [6], [7]. Russell discovered a slight connection between BIS value and patient responsiveness during surgery [8]. BIS monitoring's effects on three general anaesthesia patients were the focus of our investigation. By thoroughly analysing and analysing the data, we hoped to add to the body of information on BIS analysis's clinical efficacy.

Anaesthesia Bispectral Index (BIS) readings are usually 68–72. Treatment with an intravenous anaesthetic can modify this range. Six participants had BIS values between 20 and 30 before intubation. These readings improved significantly after intubation, as expected. This study demonstrated a statistically significant difference in systolic blood pressure measurements between HFA and LFA groups at various time periods. These intervals include incision, 30 minutes after incision, procedure finish, pre-extubation, and patient awakening. The HFA and LFA groups also have different diastolic blood pressure readings from the incision to the patient's wake-up and during the second evaluation (when the patient is receiving mask ventilation). At the pre-induction evaluation and between the initial and awakening exams, the HFA and LFA groups may have significantly different oxygen saturation (SaO_2) levels. The HFA and LFA groups have different heart rates in the fifth and eighth evaluations (pre-extubation), highlighting the different effects of anaesthesia on physiological components during medical procedures. A detailed investigation by Kupisiak et al. found similar trends in heart rate, arterial blood pressure, oxygen saturation, and end-tidal carbon dioxide ($ETCO_2$) between HFA and LFA groups [3]. The study's statistical analysis showed no significant differences, advancing perioperative care and anesthesiology.

Patients with hypertension were more prevalent in the low-flow cohort. Patients with hypertension before surgery continued their antihypertensive medications. Two patients developed hypotension during surgery, which was rapidly treated with IV fluids. Chatrath et al. (2016) found that setting the anaesthesia level using BIS monitoring or providing propofol can control the hemodynamic response to a surgical stimulus [9]. By adjusting isoflurane end-tidal concentration, the acute hemodynamic response to the surgical stimulation was regulated quickly and properly regardless of FGF rates. Isoflurane's short time constant, which measures how long it takes for fresh gas mixture changes to match anaesthetic system gas composition changes, may affect its efficacy. The time constant must be established to understand how quickly gas concentration changes can effect the patient's physiological reaction during anaesthesia [9].

At 5, 10, 15, 60, and the conclusion of the procedure, statistically significant differences in end-tidal volatile anaesthetic concentrations, especially isoflurane, were found across groups. Both main and secondary evaluations showed increased isoflurane levels in the low flow group. Better flow and greater concentration in the first ten minutes of treatment explain this. After reducing the flow rate to 1 liter per minute, concentrations dropped but remained above 1%. This study found that low-flow anaesthesia is stable and long-lasting. Since there were no significant differences in average blood pressure across groups, the statistical differences in systolic and diastolic blood pressure were considered meaningless in a therapeutic environment. Heart rate measurements were consistent across patients, demonstrating hemodynamic stability and high end-tidal isoflurane values. In contrast, the high flow group measured the tide's end nitrous oxide content from five minutes till completion. Concentration was 38%–59%. The low flow group had 38%–56% concentrations. Two groups had expired oxygen levels between 33% and 40% throughout surgery, which was continuously measured. Notably, concentration never dropped below 30%. Modern inhaled anaesthetics, oxygen, and air can reduce the risks of moderate anaesthesia produced by a decline in inspired gas concentration. However, it is important to distinguish between monitoring anaesthesia and awareness of it. Any anaesthetic device needs objective monitors like BIS and entropy for precise monitoring. Modern anaesthesia technology, especially low-flow anaesthesia, must monitor inhalational medicine end-tidal concentration. Awareness under low-flow anaesthesia needs more study. This would allow us to compare low and high flow anaesthesia in this clinical scenario and determine its frequency.

5. Conclusion

Hemodynamic stability in patients is preserved during general anaesthesia administration when both low-flow and high-flow rates are used. With their high degree of adaptability, the previously outlined solutions can be successfully included into the perioperative care of surgical patients having procedures lasting up to two hours. But it is imperative to stress how important it is to address safety issues and remain mindful of the potential for intraoperative consciousness while performing the surgical procedure.

REFERENCES

[1] J. D. Sherman and S. Ryan, “Ecological responsibility in anesthesia practice,” *Int Anesthesiol Clin*, 2010, [Online]. Available: https://journals.lww.com/anesthesiaclinics/FullText/2010/04830/Ecological_Responsibility_in_Anesthesia_Practice.11.aspx

[2] J. A. Baum and A. R. Aitkenhead, “Low-flow anaesthesia,” *Anaesthesia*, 1995, doi: 10.1111/j.1365-2044.1995.tb06189.x.

[3] J. Kupisiak, R. Goch, W. Polenceusz, R. Szyca, and ..., “Bispectral index and cerebral oximetry in low-flow and high-flow rate anaesthesia during laparoscopic cholecystectomy–a randomized controlled trial,” *Videosurgery and Other …*, 2011, [Online]. Available: https://www.termedia.pl/Bispectral-index-and-cerebral-oximetry-in-low-flow-and-high-flow-rate-anaesthesia-during-laparoscopic-cholecystectomy-a-randomized-controlled-trial,42,17852,0,1.html

[4] A. E. Ibrahim, J. K. Taraday, and E. D. Kharasch, "Bispectral index monitoring during sedation with sevoflurane, midazolam, and propofol," *The Journal of the American …*, 2001, [Online]. Available: https://pubs.asahq.org/anesthesiology/article-abstract/95/5/1151/39213

[5] C. Kerssens, J. Klein, A. van der Woerd, and ..., "Auditory information processing during adequate propofol anesthesia monitored by electroencephalogram bispectral index," *Anesthesia & …*, 2001, [Online]. Available: https://journals.lww.com/anesthesia-analgesia/fulltext/2001/05000/Auditory_Information_Processing_During_Adequate.24.aspx

[6] K. J. Chin and S. W. Yeo, "ABIS guided study of isoflurane requirements for adequate depth of anaesthesia in cesarean section ," *Anaesthesia*, vol. 59, p. 1064, 2004.

[7] D. Skaja, M. Graff, Z. Karwacki, and ..., "BIS monitoring during volatile anaesthesia for lumbar laminotomy," *Anestezjologia …*, 2006, [Online]. Available: https://www.czytelniamedyczna.pl/268,monitorowanie-indeksu-bispektralnego-w-celu-optymalnego-doboru-wziewnego-srodka.html

[8] I. F. Russell, "The ability of bispectral index to detect intra-operative wakefulness during total intravenous anaesthesia compared with the isolated forearm technique," *Anaesthesia*, 2013, doi: 10.1111/anae.12177.

[9] V. Chatrath, R. Khetarpal, D. Bansal, and ..., "Sevoflurane in low-flow anesthesia using 'equilibration point,'" *Anesthesia Essays and …*, 2016, [Online]. Available: https://journals.lww.com/anar/fulltext/2016/10020/sevoflurane_in_low_flow_anesthesia_using.23.aspx

[10] J. F. Nunn, "Contrai of Vapor Concentrations. ln Low Flow and Closed System Anesthesia," *Eds JA Aldrete, ll J. Lowe and RW Virtue. Grune …*, 1979.

[11] M. Willingham, A. Ben Abdallah, and ..., "Association between intraoperative electroencephalographic suppression and postoperative mortality," *British journal of …*, 2014, [Online]. Available: https://academic.oup.com/bja/article-abstract/113/6/1001/249736

[12] P. S. Myles, K. Leslie, M. T. Chan, A. Forbes, P. J. Peyton, and ..., "ANZCA Trials Group for the ENIGMA-II investigators. The safety of addition of nitrous oxide to general anaesthesia in at-risk patients having major non …," *Lancet*, 2014.

[13] L. Kearse, "The bispectral index correlates with sedation/hypnosis and recall: comparison using multiple agents," *Anesthesiology*, 1995, [Online]. Available: https://cir.nii.ac.jp/crid/1573950399670527616

[14] A. B. Baker, "Back to basics—a simplified non-mathematical approach to low flow techniques in anaesthesia," *Anaesth Intensive Care*, 1994, doi: 10.1177/0310057X9402200413.

[15] P. A. March and W. W. Muir, "Bispectral analysis of the electroencephalogram: a review of its development and use in anesthesia," *Vet Anaesth Analg*, 2005, [Online]. Available: https://www.sciencedirect.com/science/article/pii/S1467298716309394

[16] P. S. Sebel, T. A. Bowdle, M. M. Ghoneim, and ..., "The incidence of awareness during anesthesia: a multicenter United States study," *Anesthesia & …*, 2004, [Online]. Available: https://journals.lww.com/anesthesia-analgesia/fulltext/2004/09000/The_Incidence_of_Awareness_During_Anesthesia__A.36.aspx

[17] R. J. Pollard, J. P. Coyle, R. L. Gilbert, and ..., "Intraoperative awareness in a regional medical system: a review of 3 years' data," *The Journal of the …*, 2007, [Online]. Available: https://pubs.asahq.org/anesthesiology/article-abstract/106/2/269/8015