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Original Research Article

Comparative Assessment of the Characteristics Features of Desflurane with Isoflurane under Low Flow Anaesthesia using Equilibration time: Prospective Trial

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Abstract

Aim: to compare characteristics of Desflurane with Isoflurane under low flow anaesthesia using equilibration time. **Material and Methods:** This prospective observational study was done in the Department of Anaesthesiology, Government Medical College, Bettiah (West Champaran) Bihar, India, for 1 year. 120 healthy patients of either sex scheduled for routine surgeries, American Society of Anesthesiologists (ASA) physical status I and II, age 20–65 years, and hemoglobin more than 10 g/dL were include in this study. Patients were randomly allocated to two groups. Group I received desflurane as the inhalational anesthetic agent with minimal flow anesthesia (n=60). Group II received isoflurane as anesthetic agent with minimal flow anesthesia (n=60). **Results:** Out of 120 adult patients were randomly divided into two groups of 60 patients each. There was no significant clinical and statistical difference in hemodynamic parameters in between the two groups. Mean of time taken for equilibration of the volatile anesthetic agent in the desflurane group was 5.77 ± 1.58 min and in the isoflurane group was 16.98±8.95 min, and the difference was statistically significant (P <0.001). Mean end-tidal volatile anaesthetic partial pressure (MFe) was calculated at 5, 20, 60, and 120 min intervals, i.e. in wash-in period (5, 20 min) and steady state (60 and 120 min). At 5, 20, 60, and 120 min, mean end-tidal concentrations (in kPa) of desflurane were not changed much and were 4.59 ± 0.77, 4.68 ± 0.57, 4.47 ± 0.63 and 4.09 ± 0.65, respectively. In the isoflurane group, variation was significant over time and were 0.82 ± 0.15, 0.95 ± 0.13, 0.69 ± 0.22 and 0.67 ± 0.17 at 5, 20, 60 and 120 min intervals, respectively. The nitrous oxide concentration tended to fall over time. It ranged between 40.70 ±4.85 and 63.10 ± 4.80 vol.%. The oxygen level varied between a minimum of 34.11 ± 3.12% and a maximum of 47.22 ± 4.33%. In both the groups, end-tidal to inspired nitrous oxide ratio was found to be 0.82 ± 0.15 in 5 min duration and 0.92 ± 0.07 by 12 min. **Conclusion:** with availability of agents like desflurane we can use minimal flow anaesthesia more efficiently, with less drift in anaesthetic gases and a clear-headed recovery and minimum operating room pollution.

Keywords: Desflurane, Isoflurane, Anaesthesia

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Introduction

Advantages of low-flow anaesthesia (LFA) are many, and thus LFA is frequently used in clinical practice[1]. As the anaesthetic gases are diluted with rebreathing in LFA, there is a discrepancy between the inspired and dialed anaesthetic agent concentrations, and therefore some anaesthetists prefer higher fresh gas flow (FGF). Time taken to reach end-tidal anaesthetic agent concentration to provide sufficient anaesthetic depth is known as the wash-in time, which should not last too long to achieve LFA because the effect of intravenous (IV) agents wears off with time.[1] Inhaled volatile anaesthetics remain the most widely used drugs for maintenance of general anaesthesia because of their ease of administration and predictable intraoperative and recovery characteristics. Management of hemodynamic stability and early recovery is the most important part of a standardized balanced technique. Given the low blood–gas partition coefficients of isoflurane (1.4) and desflurane (0.42), a more rapid emergence from anaesthesia is expected compared with traditional inhalation anesthetics[2] Isoflurane is an inhalational anaesthetic whose low solubility (blood–gas partition coefficient equals 1.4) enables a rapid induction of and recovery from anaesthesia. The mild pungency of isoflurane may limit the rate of induction, although excessive salivation or tracheobronchial secretions do not appear to be stimulated. The level of anaesthesia may be altered rapidly with isoflurane. Pharyngeal and laryngeal reflexes are readily and easily obtunded[3]. Desflurane (2,2,2-trifl uoro-1-fl uoroethyldifluoromethyl ether) is a highly fluorinated methyl ethyl ether used for maintenance of general anaesthesia. It is gradually replacing isoflurane for use in humans. It has the most rapid onset and off set of the volatile anaesthetic drugs used for general anaesthesia because of its low solubility in blood[4]. There are a number of reports that desflurane achieves adequate alveolar concentration faster than agents with comparatively lesser blood gas solubility like isoflurane, thus requiring lesser duration of high FGF and causing less environmental pollution[5]. The aim of the present study was to comparing characteristics of Desflurane with Isoflurane under low flow anaesthesia using equilibration time.

Material and methods

This prospective observational study was done the Department of Anaesthesiology, Government Medical College, Bettiah (West Champaran) Bihar, India, for 1 year, after taking the approval of the protocol review committee and institutional ethics committee.120 healthy patients of either sex scheduled for routine surgeries were include in this study.

Inclusion criteria

American Society of Anaesthesiologists (ASA) physical status I and II, age 20–65 years, and hemoglobin more than 10 g/dL.

Exclusion criteria

Patients with cardiac diseases, lung disorders, pregnancy and patients undergoing laparoscopic surgery.

Patients were randomly allocated to two groups. Group I received desflurane as the inhalational anaesthetic agent with minimal flow anaesthesia (n=60). Group II received isoflurane as anaesthetic agent with minimal flow anaesthesia (n=60). An Aestiva anaesthesia workstation (Datex Ohmeda, Madison, USA) was used in all patients. A special connector for return of sampling gas back to the breathing circuit was used (one end of this connector was attached to the exhaust port of the respiratory gas monitor and the other end was attached to the expiratory limb of the breathing circuit). Patients were preoxygenated with 100% oxygen. Anaesthesia was induced by administering intravenous (IV) fentanyl 2mcg/kg, propofol 3 mg/kg, and atracurium 0.5 mg/kg. Lungs were hand ventilated with help of a facemask using FGF of oxygen 6

L/min for 3 min. Intermittent boluses of propofol 20 mg IV were given. Boluses of propofol 20mg were used thus at 1 min intervals (without nitrous oxide and inhalational agent) after induction of anaesthesia. Trachea was intubated 3 min after administration of atracurium. The patient was connected to the anaesthesia machine with a Y-piece connector of the breathing circuit. A high FGF mixture of 6 L/min (oxygen 2 L/min and nitrous oxide 4 L/min) was delivered initially with a volatile inhalational anaesthetic agent after tracheal intubation. The volatile inhalational anaesthetic agent was set at 1.3 times the agent minimum alveolar concentration (MAC), i.e. 1.5% for isoflurane or 8% for desflurane. Once the ratio of expired (Fe) to inspired (Fi) volatile inhalational agent concentration (isoflurane/desflurane) became 0.8, high FGF was reduced to the minimal FGF mixture, i.e. 300 mL/min of oxygen and 200 mL/min of nitrous oxide. The point when the ratio of Fe to Fi inhalational agent concentration became 0.8 (uptake of the volatile inhalational anaesthetic agent reaches: 80% – Fe/ Fi = 0.8) was defined as the "equilibration point" of the inhalational anaesthetic agent. During maintenance phase of anaesthesia, a minimum inspired oxygen concentration (FiO2) of 0.3 was maintained in the minimal FGF mixture. The vaporizer dial setting was changed, if needed, after flow reduction to maintain MAC of 1 or more as required depending on the type of surgery but keeping the FGF constant. Top-up doses of atracurium 0.1 mg/kg IV were given every 15 min and morphine 0.15 mg/ kg IV was given at time of incision. Diclofenac 1 mg/kg IV, in 100 mL normal saline, was given to all patients as a part of the multimodal approach to analgesia. The inhalational anaesthetic vaporizer was switched off after the end of the surgery. The neuromuscular block was reversed with neostigmine 0.5 mg/kg and glycopyrolate 0.01 mg/kg IV administered 20 min of the last dose of relaxant or if the patient started spontaneously breathing. Thereafter, nitrous oxide was stopped and only oxygen 6 L/min was given. The trachea was extubated once extubation criteria were met, and the patient transferred to the postoperative recovery room. Before discharging the patient from the recovery room, the patient was interviewed for intraoperative awareness. "Recovery time" was defined from the time of discontinuation of the inhalational anaesthetic agent (vaporizer switched off) to the time the patient opened his/her eyes on verbal command while recovering from anaesthesia. During recovery, patient recovery characteristics were defined by a recovery score (1 = No response to painful stimuli; 2 = Drowsy but arousal by verbal command; and 3 = Awake and responding to command at extubation).[6] The following parameters were recorded: hemodynamic characteristics (mean change in the heart rate, systolic, diastolic and mean blood pressure, oxygen saturation, nasopharyngeal temperature); mean equilibration time of the volatile inhalational agent (mean was taken at 5, 10, 15, 30 min, and thereafter at 30 min interval till the time of extubation); mean end-tidal volatile anaesthetic partial pressure; recovery time and score; and any critical event if occurred and measures taken to tackle the problem.

Results

120 adult patients were studied. The groups were randomly divided into two groups of 60 patients each. The two groups were comparable with respect to age, weight, height, and body mass index. There was no significant clinical and statistical difference in hemodynamic parameters in between the two groups. (Table 1)

Table 1: Demographic characteristics of patients who received minimal flow anaesthesia with desflurane or isoflurane as inhalational anaesthetic agent

Demographic Profile	Group I, Desflurane	Group II, Isoflurane	P value
Age (years, mean ± SD)	39.26 ± 13.09	38.12 ± 12.98	0.88
Body weight (kg, mean ± SD)	66.07 ± 13.06	73.12 ± 13.98	0.051
Height (m, mean ± SD)	1.56 ± 0.19	1.60 ± 0.29	0.17
BMI (kg/m2, mean ± SD)	25.98 ± 3.45	28.26 ± 4.26	0.15

Table 2: Mean of "equilibration time" of volatile anaesthetic agent

Mean equilibration time	Group 1 Desflurane (n = 60)	Group 2 Isoflurane (n =60)	P value
	5.77 ± 1.58 min	16.98±8.95 min	< 0.001)

Mean of time taken for equilibration of the volatile anesthetic agent in the desflurane group was 5.77 ± 1.58 min and in the isoflurane group was 16.98±8.95 min, and the difference was statistically significant (P <0.001) [table.2].

Table 3: Mean end-tidal volatile anesthetic partial pressure (MFe)

Time (min)	Group 1 Desflurane (n = 60)	Group 2 Isoflurane (n =60)	P value
5	4.59 ± 0.77	0.82 ± 0.15	0.00
20	4.68 ± 0.57	0.95 ± 0.13	0.00
60	4.47 ± 0.63	0.69 ± 0.22	0.00
120 P value	4.09 ± 0.65 0.066	0.67 ± 0.17 0.001	0.00

Mean end-tidal volatile anaesthetic partial pressure (MFe) was calculated at 5, 20, 60, and 120 min intervals, i.e. in wash-in period (5, 20 min) and steady state (60 and 120 min). At 5, 20, 60, and 120 min, mean end-tidal concentrations (in kPa) of desflurane were not changed much and were 4.59 ± 0.77, 4.68 ± 0.57, 4.47 ± 0.63 and 4.09 ± 0.65, respectively. In the isoflurane group, variation was significant over time and were 0.82 ± 0.15, 0.95 ± 0.13, 0.69 ± 0.22 and 0.67 ± 0.17 at 5, 20, 60 and 120 min intervals, respectively. Changes in measured values were statistically significant between the two groups and within the isoflurane group. The changes were, however, not statistically significant within the desflurane group [table 3], i.e. there were less drift in mean end-tidal concentration in this group. We could maintain breathing gas concentration throughout, and no patient had hypoxia any time during anesthesia. The nitrous oxide concentration tended to fall over time. It ranged between 40.70 ±4.85 and 63.10 ± 4.80 vol.%. The oxygen level varied between a minimum of 34.11 ± 3.12% and a maximum of 47.22 ± 4.33%. At no point of time, the concentration fell below 30%. There was an initial rise in the oxygen level but drifted down later.

Table 4: Recovery time (min)

	Group I, Desflurane	Group II, Isoflurane	P value
Mean ± SD of recovery time (min)	5.39 ± 2.65	8.25 ± 3.42	0.004

Table 5: Recovery score

Recovery score	Group I, Desflurane	Group II, Isoflurane	P value
2	8	40	0.000
3	52	20	

Uptake of nitrous oxide was 80% and above by the time equilibration of any of the agents occurred. In both the groups, end-tidal to inspired nitrous oxide ratio was found to be 0.82 ± 0.15 in 5 min duration and 0.92 ± 0.07 by 12 min. Nitrous oxide concentration also fell over the time, and it was difficult to maintain nitrous oxide at 68%. It ranged between 40.70 ±4.85 and 63.10 ± 4.80. In long duration, minimal flow anaesthesia nitrous oxide end-tidal concentration found to be <50%.

At 80% uptake point of nitrous oxide, uptake of only desflurane was found to be nearly 80% at that time. At 5 min interval, the Fe/Fi volatile anaesthetic agent ratio of desflurane was calculated to be 0.82 ± 0.13 while that of isoflurane 0.64 ± 0.16 and the difference found was statistically significant. By 20 min, the Fe/Fi ratio of desflurane increased to 0.97 ± 0.04 while that of isoflurane was 0.81 ± 0.11.

After the changeover to minimal flows, the frequency of change of dial setting or the number of times dial setting that was changed to achieve the abovementioned goal was not statistically different in the two groups. It was 2.72 ± 1.83 times in the desflurane group and 2.42 ± 1.53 times in the isoflurane group.

Recovery of patients from anaesthesia was quicker in the desflurane group, and patients were more alert than those of the isoflurane group. Patients recovered in nearly 5.39 ± 2.65 min in the desflurane group while 8.25 ± 3.42 min in the isoflurane group (P = 0.004) [Tables 4 and 5]. Patients had a clear-headed recovery in the desflurane group: 52 patients out of 60 were alert and awake and 8 were drowsy but arousable. In the isoflurane group: 40 patients out of 60 were drowsy but arousable and 20 patients were alert and awake. The difference between the two groups was statistically and clinically significant. No patient had awareness.

Discussion

Modern but expensive inhalational anaesthetics such as desflurane and sevoflurane can be used safely and effectively in low-flow technique. We aimed to compare equilibration time, changing the gas composition and haemodynamic changes during LFA with desflurane and sevoflurane. We used ‘equilibration time’ to change-over from high-to-low flows. During LFA we maintained age-specific 1 MAC of inhalational agent with 50% N_2O as the carrier gas. Minimal flow anaesthesia is safe today because of availability of advanced gas monitoring. However, a leak proof machine, gas monitoring, and capnography are essential for conduct of a minimal flow technique[7-9].

We aimed to compare desflurane and isoflurane in minimal flow anaesthesia. Use of mask ventilation with high FGF can lead to the loss of inhalational agent, defeating the purpose of minimal flow and making it difficult to monitor the level of inhalational agent used during this period. To prevent this, boluses of propofol were

used at 1 min intervals after the initial induction as recommended[10]. This method is an effective alternative to the use of inhalational agent at this period of time.

Equilibration time is an effective parameter for change over from high flow to minimal flows. Time of equilibration between Fi and Fe agent concentrations is defined as the time to reach a Fe/Fi ratio of 80%[7,10,11]. This ratio is an effective change-over point and helps in effective denitrogenation and maintenance of the constant level of desflurane and isoflurane after the change over from high FGF to minimal FGF anesthesia[10]. Equilibration time with desflurane was found to be shorter than isoflurane, and we could reduce the FGF earlier in the desflurane group as compared to the isoflurane group. Similar findings were obtained by others[10]. In the earlier studies, change over from high to low FGF was done after 10–20 min, as recommended by Baum[10,12,13].

In minimal flow anaesthesia, nitrous oxide usually shows an increasing trend while oxygen shows a decreasing trend because nitrous oxide is neither consumed nor metabolized, but oxygen is consumed by the body. Higher flow of oxygen in relation to nitrous oxide is recommended, to prevent undesirable fall in inspired oxygen concentration especially in long duration surgeries. Higher flow of oxygen in relation to nitrous oxide is recommended in first 30–45 min after the start of minimal flow as the nitrous oxide uptake continuously declines and the gas tends to accumulate within the breathing system. In our study, the fall in the level of end-tidal concentration of nitrous oxide was possibly due to maintenance of the FGF flow ratio as per the study protocol end MAC is a useful measure because it mirrors brain partial pressure, allows comparisons of potency between agents. Around 1.3 MAC of any of volatile anaesthetic has been found to prevent movement in about 95% of patients (an approximation of ED95). We did not use any depth of anaesthesia monitoring but maintained 1MAC or more asked the patient for any history of awareness before discharging from the recovery room. No patient had any awareness. Change in hemodynamics can occur during surgery because of changes in the surgical stimulus level. Hemodynamics can be maintained by regulating the depth of anaesthesia (maintaining an adequate MAC/end-tidal concentration) or by the use of rescue medications such as propofol, esmolol etc[14].

The dial setting of volatile anaesthetic agent concentration in our study was changed only to maintain adequate MAC. The high FGF, delivered initially, quickly achieved the desired concentration. At minimal flows, the dial was set higher as it takes longer to achieve the desired concentration. At both low and high FGF rates, the acute hemodynamic response to surgical stimulus was more efficiently treated by increasing the end-tidal concentration of desflurane concentration than isoflurane. Armavov et al. could easily control an increase in mean arterial blood pressure by changing the desflurane dial setting even at lower FGF (1 L/min)[14].

The effects of anaesthetic duration on kinetics and recovery characteristics of desflurane and sevoflurane were studied. Awakening to response to command and orientation was found to be almost twice as rapid after anaesthesia with desflurane[15]. We found a more rapid wake-up with desflurane than isoflurane. In the desflurane group, patients had a clear- headed recovery. Coetzee and Stewart used a wash-in period of 10 min at high FGF, which was less than the usually recommended 15–20 min for minimal flow[16]. They concluded that even for the most soluble drug-like halothane, a 10 min wash-in period was sufficient and said that for desflurane, a shorter wash-in period will suffice with even greater cost saving. Consumption of soluble agents (such as

enflurane and isoflurane) only partially depends on FGF[11].

Conclusion

We concluded that, with availability of agents like desflurane we can use minimal flow anesthesia more efficiently, with less drift in anesthetic gases and a clear-headed recovery and minimum operating room pollution.

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