

A randomized prospective study comparing characteristics of Desflurane with Isoflurane under low flow anaesthesia using equilibration time

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Abstract

Introduction: Equilibration point of an inhalational agent is the transition point when ratio of expired (Fe) to inspired (Fi) concentration of inhalational anaesthetic agent (Fe/Fi) reaches 0.8 or when uptake of volatile agent reaches 80%. It helps in reducing the duration of initial high gas flows before switching over to low flows.

Aim: To compare Desflurane with Isoflurane for equilibration time, intraoperative hemodynamic parameters and post extubation recovery parameters.

Materials and Methods: Depending on the volatile anesthetic agent being used patients were randomly allocated into two groups. Group I ($n=25$) received Desflurane and Group II ($n=25$) received Isoflurane as inhalational anesthetic agent. In all patients low flow anaesthesia was given after achieving equilibration time and that time was noted. Other parameters measured were intraoperative heart rate, mean blood pressure, mean EtN₂O, mean EtFe (End tidal volatile anesthetic agent concentration), recovery parameters (recovery time, recovery score and vitals) and any complications if any.

Statistics: Analysis was performed on SPSS (Statistical package for social sciences) version 17.0 Statistical Analysis Software.

Result: The equilibration point for group I was achieved in 2.18 ± 0.84 min and for group II was achieved in 10.08 ± 2.36 min and this difference was statistically significant. The intraoperative heart rate and MAP did not differ significantly ($p>0.05$) between the two groups at all time periods. On comparing, post extubation vitals i.e. HR (8.1%) and recovery time (69.9%) they were found significantly ($p<0.05$ or $p<0.001$) different and higher in Group II as compared to Group I. Further, the recovery score (i.e. awake and responding to command at extubation) was found significantly ($p<0.05$) higher (36.0%) in Group I as compared to Group II.

Conclusion: Desflurane use results in shorter equilibrium time and earlier reduction of FGF with early and better recovery than Isoflurane.

Keywords: Desflurane, Isoflurane, Low flow Anaesthesia, Equilibration time.

Introduction

Low flow anaesthesia is an inhalation anaesthetic technique which is carried out via a rebreathing system where fresh gas flow rate is kept significantly lower than the minute volume (0.5-1 L/min).¹ In low flow anaesthesia 50% of the exhaled gas volume is led back to the patient after carbon dioxide absorption in the next inspiration. It improves climatization of the anaesthetic gases and decreases nitrous oxide consumption, which is one among the greenhouse gases and also an important factor causing ozone destruction. So by performing low flow anaesthesia a significant reduction in anaesthesia gas emissions can be achieved and their adverse impact on environment can be decreased too. And it has also been observed that use of low flow anaesthesia decreases anaesthetic gas consumption with significant cost savings.²⁻⁴ Despite this we usually practice high flow anaesthesia because of lack of proper infrastructure. Now with modernization and availability of newer machines for anaesthesia, low flow anaesthesia is possible, which is the need of hour.

Before switching to low flow an adequate alveolar concentration of anesthetic gases and oxygen should be achieved. Recent studies^{5,6} have termed this switchover point as the "equilibration point" of the inhalational agent. It is a point when ratio of expired (Fe) to inspired (Fi) concentration

of inhalational anaesthetic agent (Fe/Fi) reaches 0.8 or when uptake of volatile agent reaches 80%. Desflurane has very low solubility in blood and body tissues and has approximately one-fifth the potency of isoflurane. It facilitates the control of low-flow anaesthesia and reduces the duration of temporary high-flow phases to rapidly adjust the circuit gas concentrations.⁷ As very few studies have been done to find out the equilibration time of newer anaesthetic agent Desflurane, so in our study we have compared Desflurane with Isoflurane for their equilibration time and compared their efficacy as an anaesthetic agent under low flow anaesthesia. The primary aim of the study was to compare equilibration time for switch over to low flow between Desflurane and Isoflurane and secondary aims of the study were to compare intraoperative heart rate, mean blood pressure, mean EtN₂O, mean EtFe (End tidal volatile anesthetic agent concentration), post extubation recovery parameters (recovery time, recovery score and vitals); and any complications if occurred between Desflurane and Sevoflurane under low flow anaesthesia.

Materials and Methods

After approval from ethical committee and obtaining written informed consent from all patients, this randomized prospective single blind study was done in elective operation

theatres of a tertiary care center in Lucknow. A total of 50 patients of either sex of age group 20-60yrs, ASA I & II, Hb>10g/dl were chosen. Patients with cardiac diseases, respiratory disorders, obesity (BMI>30kg/m²), pregnancy and alcoholism were excluded. A routine pre-anesthetic checkup was done for all patients who were posted for elective surgery to be done under general anesthesia. No pre-anesthetic medication was given to any of the patient. Patients were allocated into two groups as per computer generated sequence of randomization. Group I (n =25) received Desflurane and Group II (n=25) received Isoflurane as anesthetic agent with low flow anaesthesia.

The "Dräger Primus" anesthesia workstation was used in all the patients in which the fresh gas control worked precisely, the flow meter tubes were calibrated and graduated in the low flow range. The leakage rate of the rebreathing systems did not exceed 100 mL/min. Patients were pre-oxygenated with 100% oxygen and given i.v. Fentanyl 2µg/kg. Induction was achieved by injecting Propofol (1.5mg/kg) and Vecuronium (0.1mg/kg) intravenously and bag and mask ventilation was continued with Oxygen @ 6L/min. Intubation was done 3.5mins after giving Vecuronium i.v. Just before intubation Propofol bolus (0.5mg/kg i.v.) was given. After confirmation of intubation by capnography patients were taken on volume controlled ventilation with O₂ and N₂O (50:50) maintaining total fresh gas flow @ 6L/min. Vaporizer was switched on with the goal of maintaining 1.3 MAC of the particular inhalational anaesthetic agent i.e. 1.5% for Isoflurane and 8% for Desflurane. Patients were switched to low flow i.e. total fresh gas flow of 1L/min with both O₂ and N₂O @ 0.5L/min when expired to inspired concentration of volatile anaesthetic agent became 0.8 (equilibration time). When we achieved the low flow anaesthesia MAC of inhalational agent was maintained at 0.8 MAC (i.e. 1% for Isoflurane and 5% for Desflurane) by adjusting the dial flow. Minimum oxygen concentration through out the conduct of anaesthesia was maintained at least 50% and if SpO₂ fell below this oxygen flow was increased by 10% (100ml/min) with reduction of N₂O at the same rate. Total fresh gas flow was kept constant i.e. 1L/min. Anaesthesia was maintained by giving top-up doses of Vecuronium (0.02mg/kg i.v.) at every 30 minutes and Fentanyl (1.0 mcg/kg i.v.) every hourly. Paracetamol 1gm (i.v.) was given to all patients 30 minutes before completion of surgery. After the completion of surgery inhalational vaporizer was switched off and when the patient started breathing spontaneously nitrous oxide was also switched off. Oxygen was increased to 6 L/min. Neostigmine 0.05 mg/kg i.v. and glycopyrolate 0.01 mg/kg i.v. were given intravenously to reverse the neuromuscular blockade and once the patients fulfilled the extubation criteria they were extubated. All the patients were transferred to the recovery room.

"Recovery time" was defined from the time of discontinuation of the inhalational agent to time the patient opened his/her eyes on verbal command while recovering

from anesthesia. During recovery, patient's 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).

In this study we recorded mean equilibration time, mean EtN₂O, mean EtFe (End tidal volatile anesthetic agent concentration), mean EtN₂O, hemodynamic parameters (heart rate, mean blood pressure), recovery parameters (recovery time, recovery score and vitals) and any complication.

We summarized data as Mean ± SD (standard deviation). Student's t test was used to compare two independent groups were compared by. Chi-square (χ^2) test was used to compare discrete (categorical) groups. A two-tailed p value less than 0.05 (p<0.05) was considered statistically significant. Analysis were performed on SPSS (Statistical package for social sciences) version 17.0 Statistical Analysis Software.

Results

A total of 50 patients requiring general anesthesia fulfilling inclusion criteria and giving their informed consent were randomly divided into two groups and received either Desflurane (Group I) or Isoflurane (Group II) with low flow anaesthesia. The baseline demographic characteristics of two groups were comparable (Table 1). The equilibration point for group I was achieved in 2.18 ± 0.84 min and for group II was achieved in 10.08 ± 2.36 . This difference was found to be highly significant p<0.001.

The intraoperative mean EtFe (End tidal volatile anesthetic agent concentration) did not differ significantly from baseline in group I. But in Group II, it differs and lowers significantly from 0.25 to 1.45 hr. (Fig. 1). The intraoperative mean end-tidal nitrous oxide concentration showed almost similar and decreasing trend over the time in both the groups and there was no statistically significant difference between two groups at all time periods. (Fig. 2)

The intraoperative mean HR showed decreasing trend over the time in both groups but slightly higher (0.05-1.30hr) in Group II. For each period (time), the intraoperative H.R did not differ significantly (p>0.05) between the two groups at all periods. Similarly, the intraoperative mean M.A.P also showed similar trend between the two groups over the time except it remain slightly lower at most of periods in Group II than Group I but the difference between two was not statistically significant. (Fig. 3 & 4). On comparing, post extubation vitals viz. HR (8.1%) and recovery time (69.9%) were found significantly (p<0.05 or p<0.001) different and higher in Group II as compared to Group I. Further, the recovery score (i.e. awake and responding to command at extubation) was found significantly (p<0.05) higher (36.0%) in Group I as compared to Group II. However, MAP, SPO₂ and critical event did not differ (p>0.05) between the two groups i.e. found to be statistically the same (Table 2).

Table 1: Demographic characteristics of two groups

Demographic characteristics	Group I (n=25)	Group II (n=25)	t/ χ^2 value	p value
Age (yrs)	38.12 ± 7.46	41.00 ± 6.35	1.47	0.148 [#]
Sex: Mean (%)				
Female	16 (64%)	16 (64%)	0.00	1.000 [#]
Male	9 (36%)	9 (36%)		
BMI (kg/m ²)	22.17 ± 0.84	22.09 ± 0.77	0.35	0.728 [#]
Hb (gm%)	12.38 ± 0.96	11.98 ± 0.90	1.52	0.135 [#]
Type of Surgery				
LC	12 (48%)	15 (60%)	1.78	0.879 [#]
WLE+MND	5 (20%)	4 (16%)		
RC	3 (12%)	3 (12%)		
MRM	2 (8%)	2 (8%)		
FP	2 (8%)	1 (4%)		
DLP	1 (4%)	0 (0%)		
Duration of Surgery	2.60 ± 0.66	2.22 ± 0.56	2.19	0.3 [#]

LC: LAP cholecystectomy, **RC:** Radical Cholecystectomy, **MRM:** Modified Radical Mastectomy, **FP:** Frey’s Procedure, **DLP:** Diagnostic Laprotomy with Proceed
[#] P value > .05 = Non Significant

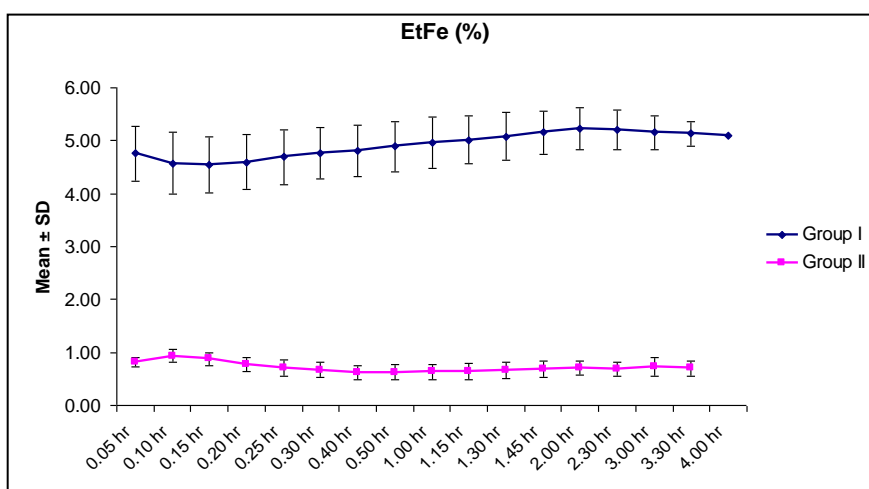


Fig. 1: Intraoperative End tidal volatile anesthetic agent {EtFe (%)} concentration of two groups over the time

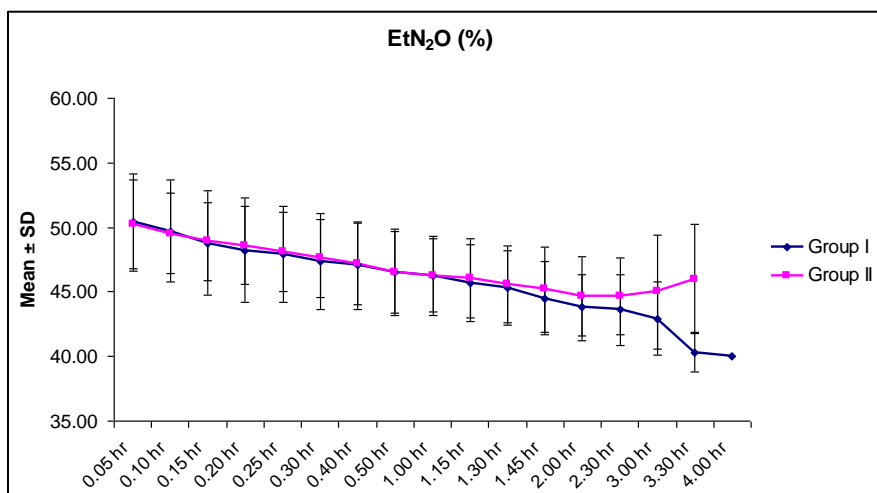


Fig. 2: Intraoperative EtN₂O of two groups over the time

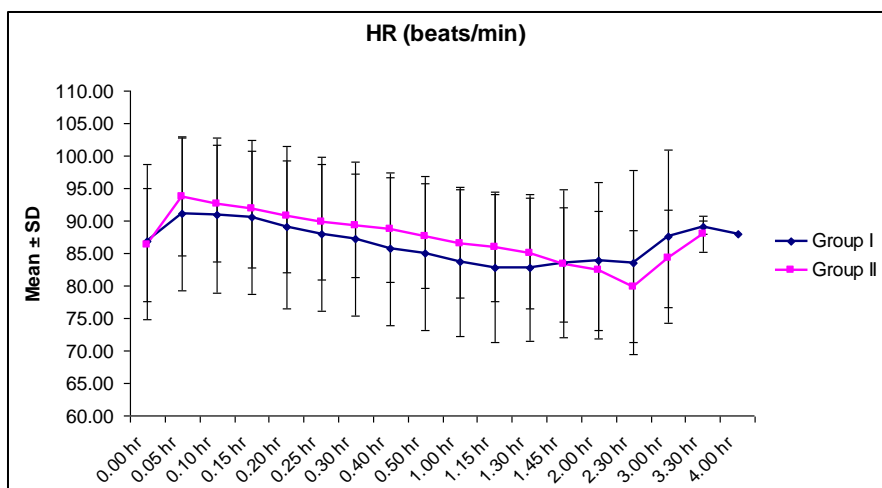


Fig. 3: Intraoperative HR of two groups over the time

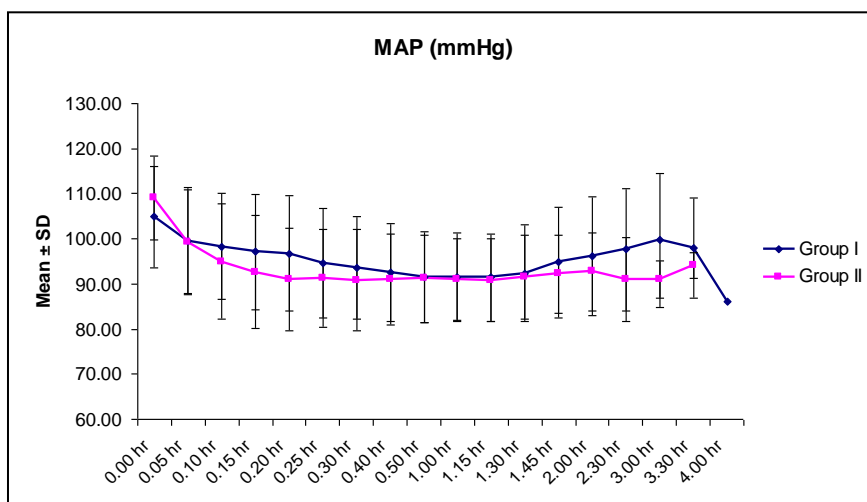


Fig. 4: Intraoperative MAP of two groups over the time

Table 2: Post extubation vitals and parameters (Mean ± SD) of two groups

Post extubation vitals/ parameters	Group I (n=25) (%)	Group II (n=25) (%)	t/ χ^2 value	p value
HR (beats/min)	87.80 ± 11.34	95.52 ± 9.44	2.62	0.012*
MAP (mmHg)	96.92 ± 13.98	96.52 ± 9.05	0.12	0.905#
SPO2 (%)	99.28 ± 0.79	98.88 ± 1.20	1.39	0.171#
Recovery time (min)	4.46 ± 0.99	14.84 ± 2.75	17.77	<0.001*
Recovery score:				
1. No response to painful stimuli.	0	0		
2. Drowsy but arousal by verbal command.	7 (28.0)	16 (64.0)	6.52	0.011*
3. Awake and responding to command at extubation.	18 (72.0)	9 (36.0)		
Clinical event:				
No	25 (100.0)	22 (88.0)	3.19	0.074#
Yes (nausea/vomiting)	0 (0.0)	3 (12.0)		

P value > .05 = Non Significant

* P value < .05 = Significant

Discussion

With the availability of modern anaesthesia machines having carbon dioxide absorption units and advance gas monitoring now it is safe to perform economical and low-flow anaesthesia.⁸ Some previous studies have observed that equilibration time can be taken as effective parameter at which high flows can be change over to low flows.^{5,6} It is defined as time at which expired to inspired concentration of volatile anaesthetic agent became 80% and it has been observed that at this point the uptake of volatile agent start decreasing so the flows can be reduced at that time.^{9,10} In our study we have compared Desflurane with Isoflurane to find out their equilibration time for efficient use of low flow anaesthesia as primary objective. The secondary aims were to compare heart rate, mean blood pressure, mean EtN₂O, mean EtFe (End tidal volatile anesthetic agent concentration), and recovery parameters between Desflurane and Isoflurane in patients undergoing low flow anaesthesia.

In our study we have observed that equilibration time was achieved earlier in Desflurane group (2.18 min) as compared to Isoflurane group (10.08min). Similar findings were observed by other authors.^{10,11} Nel MR et¹¹ have done a study in which they compared Isoflurane, Sevoflurane and Desflurane and observed their mean equilibration times were 19.7 ± 6.5 min, 8.2 ± 2.1 min and 3.8 ± 0.7 min, respectively and difference was statistically significant. Lee et al¹⁰ compared Desflurane and Isoflurane and observed that mean equilibration times was 5 min for Desflurane and 19 min for Isoflurane, and this difference was statistically significant. A study conducted by Chatrath V et al⁵ comparing Sevoflurane and Isoflurane and they observed that mean equilibration time were 8.22 ± 1.060 min and 17.24 ± 10.2 min, respectively and difference was statistically significant ($P < 0.001$). In our study equilibration time was achieved earlier in both groups in comparison to previous studies. In group I it was 2.18 ± 0.84 min and for group II it was 10.08 ± 2.36 min.

Regarding mean end-tidal concentrations of inhalational agents we observed that in Group I, it showed an increasing trend after the initiation of low flow anaesthesia and values was higher significantly ($p < 0.05$) from 1.45 to 2.00 hr as compared to baseline (0.05hr). In contrast, in Group II, it showed a decreasing trend and values was lower significantly ($p < 0.05$ or $p < 0.01$) from 0.25 to 1.45hr from baseline. Similarly Nel MR et al¹⁰ and Mallik T et al⁶ also observed the same. The reason behind the decreasing trends in Isoflurane may be its higher blood solubility and greater uptake than that delivered by low flow anaesthesia. Lee et al¹⁰ observed that after reducing the flow expired concentration of both Desflurane and Isoflurane decreased. In Isoflurane group it continued to decrease throughout the anaesthesia but in Desflurane group it initially decrease followed by slow recovery. Similarly in a study conducted by Hargasser S et al¹² the target concentration was attained sooner with Desflurane than with Isoflurane during the first 30 minutes of high-flow administration, then after the reduction of inflow to 1 l/min inhalational agents concentration had to be

increased to maintain inspired concentration and end-tidal target concentrations for the more soluble anaesthetics (Isoflurane) but not for Desflurane.

In both the groups of our study, end-tidal nitrous oxide concentration showed almost similar and decreasing trend between the two groups over the time except at the end when it was lower in Group I than Group II (1.15-3.30 hr). A minimum inspired oxygen concentration (FiO₂) of 0.5 was maintained during the conduct of low flow anaesthesia. Mallik T et al⁶ and Chatrath V et al⁵ have also observed the similar trends in their studies.

On comparing hemodynamic parameters, the intraoperative mean heart rate and MAP did not differ significantly ($p > 0.05$) between the two groups at different periods. They showed similar and decreasing trend over the time with slightly higher heart rate initially in Group II (Isoflurane) than Group I (Desflurane). In a study conducted by Shoukry AA et al¹³ in which they compared the Desflurane and Isoflurane for hemodynamics in patients undergoing pelvic and abdominal operations they observed that in desflurane group there were better intraoperative hemodynamic parameters in comparison to isoflurane group.

In our study we observed that recovery time was less, and recovery parameters were better with Desflurane. Recovery time for Desflurane was 4.46 ± 0.99 min and for Isoflurane was 14.84 ± 2.75 min in our study after average duration of surgery of 3hrs. Various studies showed similar results. Study conducted by Malik T et al⁶ in which they compared Isoflurane with Desflurane under minimal flow anaesthesia and observed that with Desflurane recovery of patients was quicker and they were more alert. Bennett JA et al¹⁴ compared Desflurane-nitrous oxide (N₂O) with Isoflurane-N₂O in elderly patients for hemodynamics, emergence and recovery characteristics and concluded that Desflurane resulted in a more rapid recovery and shorter PACU (post-anaesthesia care unit) stay. Thus on comparison result of this study matches with our study. Ghouri AF et al¹⁵ compared the emergence and recovery characteristics of outpatients receiving either Desflurane or Isoflurane with nitrous oxide for the maintenance of general anaesthesia. They concluded that Desflurane might offer clinical advantage over Isoflurane when administered for maintenance of anaesthesia in situations where rapid emergence and recovery of cognitive function are important. Similarly Juvin P et al¹⁶ also discovered early recovery with Desflurane as compared to Propofol and Isoflurane. On comparing the recovery score in our study we observed that in Desflurane group, 72% patients were awake and responding to command at extubation (recovery score=3) and 28% patients were drowsy but aroused by verbal command (recovery score=2). On the other hand in Isoflurane group 36% patients had recovery score of 3 and 64% patients had recovery score of 2. None of the patients in either group had recovery score of 1 i.e. "no response to painful stimuli". Postoperative complications were comparable in both the groups.

Conclusion

In our study we have observed that Desflurane use results in shorter equilibrium time and earlier reduction of FGF to low flows with early and better recovery in postoperative period than Isoflurane. So the newer anaesthetic agent like Desflurane can be used safely with low flow anaesthesia using equilibration time.

Conflict of Interest: None.

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