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# Comparison of Haemodynamics and Recovery Characteristics of Sevoflurane versus Desflurane in Adult Patients Undergoing Elective Surgeries under General Endotracheal Anaesthesia

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**Abstract**

Introduction: Management of haemodynamic stability and early recovery is the most important part of a standard balanced anaesthesia technique. The aim of this study is to prospectively compare the haemodynamics and recovery characteristics of sevoflurane with that of desflurane in general anaesthesia

Methods: Sixty ASA (American Society of Anaesthesiologists) physical status class I and II patients aged between 18-60 years admitted as inpatients, undergoing elective surgeries lasting for less than two hours under general anaesthesia were randomly assigned to receive Desflurane or Sevoflurane as maintenance agents. Anaesthesia was induced with Inj. propofol 2 mg/kg IV, and maintained with either desflurane 3%-6% (n = 30) or sevoflurane l%-2% (n = 30) with 50% nitrous oxide in oxygen. Intraoperative analgesia and neuromuscular block was achieved using fentanyl 1mcg/kg and vecuronium, respectively. The inhalational anaesthetics were titrated to achieve an adequate clinical depth of anaesthesia and to maintain mean arterial pressure (MAP) within 20% of the preinduction baseline values. Heart rate (HR), Systolic Blood Pressure (SBP), Diastolic Blood Pressure (DBP) and Mean arterial pressure (MAP) were recorded preoperatively, at induction and then at regular intervals. After extubation, early recovery was recorded by time to verbalise and orientation to time and place. In post-anaesthesia care unit, intermediate recovery was assessed by modified Aldrete Score.

Results: The intraoperative haemodynamic characteristics were comparable with both sevoflurane and desflurane. The early and intermediate recovery time was shorter after maintenance of anaesthesia with desflurane compared with sevoflurane.

**Keywords**: Desflurane, haemodynamics, recovery, Sevoflurane.

**INTRODUCTION:**

General anaesthesia is a dynamic balance between the level of hypnosis, analgesia, and stimulation. This single discovery facilitated the development of modern surgery and spawned the specialty of anaesthesiology .[1]

Inhaled volatile anaesthetics remain the most widely used drugs for maintenance of general anesthesia because of their predictable intraoperative and recovery characteristics .[2]

One of the major factors that determine speed of recovery from anaesthesia is the choice of anaesthetic technique. An ideal general anaesthetic, should provide smooth and rapid induction, optimal operating conditions, and rapid recovery with minimal side effects like nausea, vomiting [3] .Inhaled anaesthetics allow rapid emergence from anaesthesia because of easy titrability with inherent neuromuscular blocking effects that make them more suitable for ambulatory anaesthesia1. The availability of less soluble inhalation anaesthetics such as sevoflurane and desflurane made us rethink about the selection of volatile anaesthetics for patients undergoing general anaesthesia . Given the low blood: gas partition coefficient of sevoflurane [0.63] and desflurane [0.42], faster emergence from anaesthesia is expected compared to traditional inhalation anaesthetics like halothane [3].

Both Desflurane and Sevoflurane provide cardiovascular stability at one minimum alveolar concentration (1 MAC) . Since, Desflurane has low blood: gas partition coefficient, it is required to know if the emergence is faster with Desflurane when compared to Sevoflurane [3].

The purpose of this prospective randomized study was to assess and compare the intraoperative haemodynamics, maintenance and recovery characteristics after anaesthesia with Desflurane and Sevoflurane in adult patients undergoing elective sugeries under general anaesthesia .The primary objective was to assess the peroperative haemodynamics and recovery status and the secondary objective was to observe for postoperative side effects like nausea, vomiting, drowsiness, respiratory tract complications like persistent cough.

**Material and Methods:**

A randomized, prospective, clinical study of 60 adult patients undergoing elective surgeries under general anaesthesia, was carried out .The study was conducted after taking the approval of institutional ethical committee .Written informed consent was taken from the patients before including any patient in the study.

Inclusion criteria are patients in the age group of18-60 years belonging to ASA physical status I/II undergoing elective surgical procedures under general anaesthesia lasting less than 2 hours. The study excluded patients with severe cardiopulmonary disease, severe hepatic or renal dysfunction, endocrinal disturbances, neurological or psychiatric disorders, history of drug allergy or abuse, patients on CNS depressant drugs, pregnant or lactating women,patients who have undergone recent anaesthesia (within previous 7 days), patients with Body mass index (BMI) of >30 kg/m2

All the patients underwent a preanaesthetic evaluation which consisted of detailed history regarding present complaints, past medical history, history of previous surgeries or anaesthesia, physical examination and routine investigations including complete haemogram, urine examination, blood urea, serum creatinine, random blood sugar, X-ray chest PA view and electrocardiogram. Other relevant investigations such as 2D echo were done if indicated in that particular case.

All patients were kept nil by mouth for a minimum of 6 hours for solids and 2 hours for clear liquids before taking them for surgery. They were premedicated with Tab. Ranitidine 150mg and Tab .Alprazolam 0.5mg orally on the night before surgery.

On the morning of the surgery, anaesthesia machine and monitors were checked. Emergency drugs tray was kept ready. After wheeling in the patient into the operation theatre, patients were monitored for baseline heart rate, systolic blood pressure, diastolic blood pressure, mean arterial pressure, ECG (lead II) and oxygen saturation using multiparameter Philips monitor. An 18 G I.V. canula was secured and an infusion of Ringer Lactate was started at a rate of 10ml/kg body weight.

All patients were premedicated with Inj.Fentanyl 1mcg/kg IV, Inj. Ondansetron 0.1mg/kg IV, Inj.Midazolam 0.01mg/kg IV.

Patients were randomized using shuffled opaque sealed envelope technique into two groups of 30 each as follows :
**Group S:** Anaesthesia was induced with Inj.Propofol and maintained with 66% nitrous oxide ($N_2O$) in 33% oxygen ($O_2$) and Sevoflurane
**Group D:** Anaesthesia was induced with Inj .Propofol and maintained with 66% $N_2O$ in 33% $O_2$ and Desflurane.
Preoxygenation was done with 100% $O_2$ for 3 min using closed circuit. Patient was induced with Inj. Propofol 2 mg/kg IV till loss of eyelash reflex .After confirming adequate mask ventilation, Inj. Vecuronium bromide- 0.1 mg/kg IV was given and ventilated with 66 % $N_2O$ and 33% $O_2$ .
Laryngoscopy & Intubation was done with appropriate size, cuffed portex endotracheal tube. Closed circuit was connected to endotracheal tube and bilateral equal air entry was confirmed and endotracheal tube was secured. Anaesthesia was maintained with $O_2$ : $N_2O$ (50:50) at 2 L/min + Sevoflurane 2% or Desflurane 6% as per the group the patient was assigned to using Drager Fabius plus machine compatible with Sevoflurane and Desflurane vapourizers. Dial concentration was adjusted to control mean arterial pressure (MAP) and heart rate (HR) within 20% range of the preoperative values. Ventilation was controlled using closed circle absorber system and end tidal carbon dioxide was maintained between 35-45 mm Hg using volume control mode of ventilation. Incremental doses of muscle relaxant, Inj.Vecuronium Bromide were given in doses of - 0.025 mg/kg IV. Intraoperative fluids were given as per the need of the patient.
At the end of surgery, after the last skin suture was placed, $N_2O$ and volatile agent were discontinued, patient was ventilated with 100% oxygen with fresh gas flow of eight liters/min. till patient established spontaneous respiration. Reversal of residual neuromuscular block was done with Inj. Neostigmine 0.05mg/kg IV and Inj. Glycopyrrolate 0.01 mcg/kg IV.
Patients were extubated once they fulfilled the extubation criteria and were hemodynamically stable. Early recovery characteristics assessed. Patients were then shifted to post-anaesthesia care unit (PACU).
Heart rate, Systolic blood pressure, Diastolic blood pressure and $SpO_2$ to be recorded before induction, after induction, every 5 min for initial 15 min and every 15 min till the end of surgery and then postoperatively every 5 min till the modified Aldrete score was greater than 9.
Early recovery was assessed by :

1) Time taken for response to verbal command ( time taken from discontinuation of the inhalational agent to the patient's response to verbal commands )
2) Time taken for spontaneous eye opening ( time taken from discontinuation of the inhalational agent to spontaneous eye opening )
3) Time taken to squeeze fingers and lift limb (time taken from discontinuation of the inhalational agent to squeeze fingers and lift limb )
4) Extubation time (from the time of administering reversal agent to removal of endotracheal tube)

After extubation , orientation was assessed by-Time taken to state name, place of stay and date of birth ( i.e, from the time of extubation to the time patient states name, place of stay and date of birth ). The duration of surgery ( defined in this study as the time period from incision to the application of last skin suture ) and the duration of anaesthesia ( from the time of induction to discontinuation of the inhalational agent ) were also noted down .
In the post - anaesthesia care unit (PACU )intermediate recovery was assessed by the modified Aldrete score every 5 min. till the score became greater than 9 [ time taken to achieve modified Aldrete score of >9 is defined in this study as the time when patient was shifted to PACU till he/she reaches modified Aldrete score of > 9]

**STATISTICAL ANALYSIS**

The sample size was calculated for the primary outcome parameters with a power of $(1- \beta) = 0.9$ and a significance level of $\alpha= 0.05$, considering a difference of 4 min. as relevant, a minimum of 28 patients was required. Considering the possible dropouts in each group, a total of 30 patients were taken in each group for the study. All statistical analysis was performed using SPSS package (version 20) software for windows .Student's t-test was applied to test the statistical significance between the Desflurane and the Sevoflurane groups for hemodynamic variables and early recovery characteristics. Mann-Whitney U-test was used for modified Aldrete scoring. P value <0.05 were considered statistically significant and <0.001 was taken as highly significant.

**RESULTS**

Sixty patients were recruited for the study. Thirty patients were allocated in each group. There was no premature study withdrawal due to failure of surgery to proceed as planned or the development of complications hindering the assessment of study variables. Patient characteristics as well as duration of anaesthesia and surgery were comparable in both the groups.

There was no statistical difference in the intraoperative HR(Table 1 and Graph 1) and mean arterial blood pressure (Table 2 and Graph 2 ) between the groups.
The time from administration of reversal agent to response to painful stimuli, to eye opening, to verbal commands and spontaneous eye opening were significantly shorter in patients administered desflurane than in patients given sevoflurane. For a given duration of anaesthesia, emergence from anaesthesia was significantly faster in desflurane compared to sevoflurane group.(Table 3 and Graph 3)
Patients given desflurane achieved Modified Aldrete Score of 9 (Table 4 and Graph 4 )significantly faster than patients given Desflurane . There was no difference in both the groups as far as the incidence of postoperative complications was concerned (Table 5)

**TABLE 1 : Changes In The Heart Rate Intra-Operatively**

| **GROUP** | | | | | | | | | **P value** |
|---|---|---|---|---|---|---|---|---|---|
| | **Desflurane** | | | | **Sevoflurane** | | | | |
| **HR** | Mean | SE | 95% ***CI | | Mean | SE | 95%*** CI | | |
| | | | *LB | **UB | | | *LB | **UB | |
| Baseline | 92.000 | 7.502 | 68.126 | 115.874 | 75.500 | 9.188 | 46.260 | 104.740 | 0.258 |
| 5 min | 84.667 | 7.247 | 61.604 | 107.730 | 68.000 | 8.876 | 39.754 | 96.246 | 0.242 |
| 10 min | 82.000 | 6.055 | 62.729 | 101.271 | 65.000 | 7.416 | 41.398 | 88.602 | 0.174 |
| 15 min | 87.667 | 5.861 | 69.014 | 106.319 | 68.500 | 7.178 | 45.655 | 91.345 | 0.130 |
| 30 min | 84.000 | 5.583 | 66.233 | 101.767 | 65.500 | 6.837 | 43.740 | 87.260 | 0.127 |
| 45 min | 82.000 | 6.394 | 61.650 | 102.350 | 66.000 | 7.832 | 41.076 | 90.924 | 0.212 |
| 60 min | 78.333 | 6.792 | 56.719 | 99.948 | 62.500 | 8.318 | 36.027 | 88.973 | 0.237 |
| 90 min | 79.333 | 6.474 | 58.731 | 99.935 | 61.500 | 7.928 | 36.268 | 86.732 | 0.180 |

**TABLE 2 : CHANGES IN THE MEAN ARTERIAL PRESSURE INTR OPERATIVELY**

| **GROUP** | | | | | | | | | **P value** |
|---|---|---|---|---|---|---|---|---|---|
| **MAP** | **Desflurane** | | | | **Sevoflurane** | | | | |
| | Mean | SE | 95%*** CI | | Mean | SE | 95%*** CI | | |
| | | | *LB | **UB | | | *LB | **UB | |
| Baseline | 91.500 | 11.059 | 60.794 | 122.206 | 111.000 | 15.640 | 67.575 | 154.425 | 0.366 |

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| 5 min | 88.500 | 4.815 | 75.130 | 101.870 | 75.000 | 6.810 | 56.093 | 93.907 | 0.181 |
| 10 min | 85.000 | 2.921 | 76.890 | 93.110 | 76.500 | 4.131 | 65.031 | 87.969 | 0.168 |
| 15 min | 97.000 | 3.147 | 88.261 | 105.739 | 74.500 | 4.451 | 62.142 | 86.858 | 0.015 |
| 30 min | 120.750 | 25.699 | 49.397 | 192.103 | 69.500 | 36.344 | -31.408 | 170.408 | 0.314 |
| 45 min | 114.750 | 24.704 | 46.160 | 183.340 | 94.000 | 34.937 | -3.001 | 191.001 | 0.653 |
| 60 min | 88.750 | 15.734 | 45.066 | 132.434 | 137.000 | 22.251 | 75.222 | 198.778 | 0.151 |
| 90 min | 90.250 | 3.975 | 79.215 | 101.285 | 88.000 | 5.621 | 72.394 | 103.606 | 0.760 |

**GRAPH 2 : TREND IN CHANGES IN THE MEAN ARTERIAL PRESSURE INTRA-OPERATIVELY**

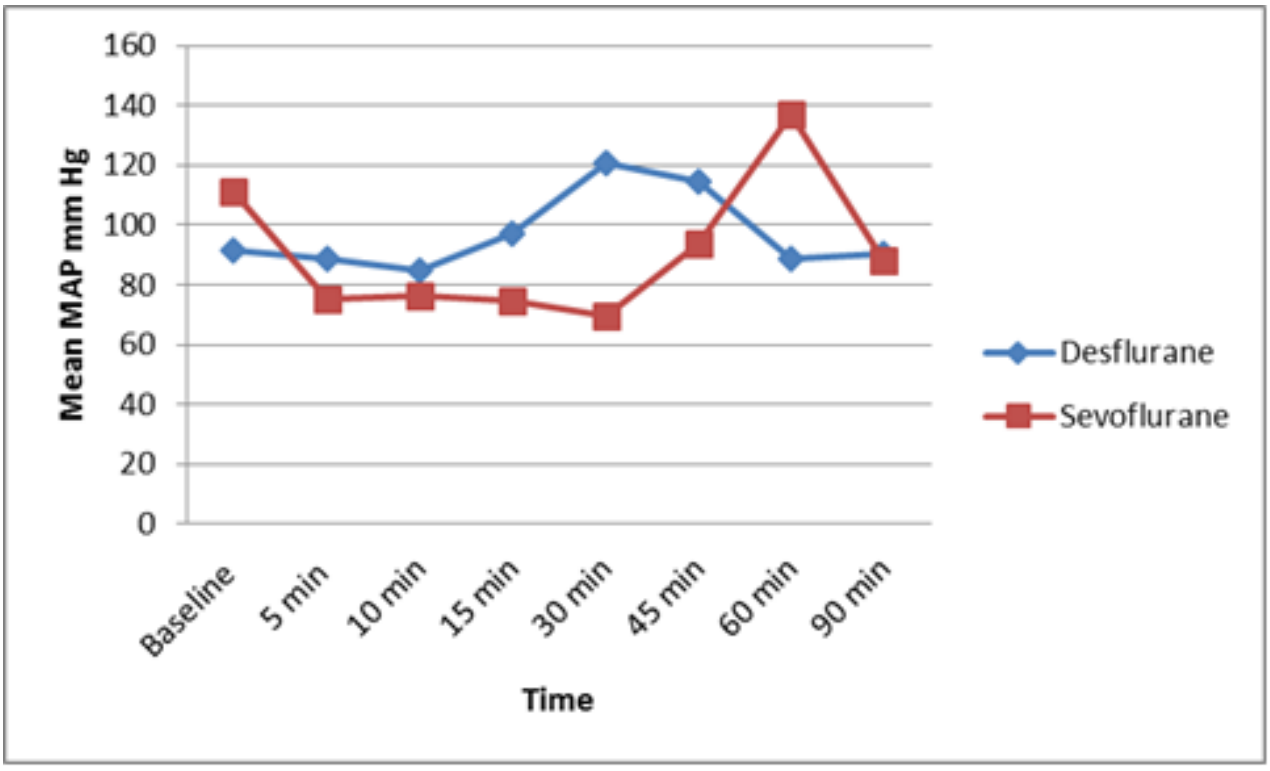


**TABLE 3 : EARLY RECOVERY PROFILES**

| EARLY RECOVERY PROFILES | GROUP | | | | |
|---|---|---|---|---|---|
| | Desflurane | | Sevoflurane | | |
| | Mean | SD | Mean | SD | P value |
| Time taken for response to verbal commands | 4.7 | .5 | 6.7 | .5 | <0.0001* |
| Time taken for spontaneous eye opening | 5.0 | .6 | 7.7 | .5 | <0.0001* |

| | | | | | |
|---|---|---|---|---|---|
| Time taken to squeeze fingers and lift limb | 5.6 | .6 | 8.9 | .6 | <0.0001* |
| Extubation time | 7.1 | .8 | 10.4 | .5 | <0.0001* |
| Time taken to state place, name | 8 | 1 | 11 | 1 | <0.0001* |
| **MAS>9** | 8.59 | 1.02 | 12.40 | .45 | <0.001* |

**TABLE 5: Adverse Effects**

| **Adverse Effects** | **Group D** | **Group S** | **P value** |
|---|---|---|---|
| **Nausea** | 5 (21.7%) | 3 (13%) | >0.05 |
| **Vomiting** | 2 (8.7%) | 4 (17.4%) | >0.05 |
| **Drowsiness** | 0 | 0 | >0.05 |
| **Cough** | 4 (17.4%) | 3 (13%) | >0.05 |

**DISCUSSION**.

In our study, there was no statistical difference with respect to age, gender, weight, ASA physical status, duration of surgery and duration of anaesthesia.

Regarding the haemodynamic parameters, the changes in the mean heart rate, systolic blood pressure and diastolic pressure were within ±20% of the baseline values in both the groups. The cardiovascular stability during the maintenance period and the lack of any difference between the two groups in our study was predictable, since the study was designed to maintain mean arterial pressure (MAP) within 20% of the baseline values by varying the inspired concentration of the volatile anaesthetic agents. Similar findings were observed in the studies conducted by Ravi Jindal et al in 2011 [4], Amandeep Kaur et al in 2013 [5] and Michael H. Nathanson et al in 1995 [3].

We found in our study that there was a statistically highly significant difference between Desflurane and Sevoflurane groups regarding all the parameters in the recovery profile with patients in group D having shorter recovery time compared to patients in group S.

In our study, we switched off the volatile agent at the application of last skin suture. The time to extubation was consistently less in the Desflurane group similar to the findings of a study conducted by Nathanson et al [3] who observed that in healthy, unpremedicated women undergoing laparoscopic sterilization procedures, use of Desflurane led to a more rapid emergence and significantly shorter time to extubation compared to Sevoflurane. Dupont J et al [6] did a study where they observed emergence and recovery from anaesthesia during pulmonary surgeries using one-lung ventilation. In this study, emergence was twice as fast with Desflurane, than with Sevoflurane or Isoflurane and the time to extubation was significantly lesser with Desflurane which compares with our study.

In our study, we observed that the patients in Group D, consistently opened their eyes to verbal command faster than the patients in Group S .Also, as compared to the patients in Group S, the patients in Group D were able to verbalise faster . Similar to the observations in our study, Jindal R et al [4] commented that the time to eye opening to verbal commands and spontaneous eye opening were significantly shorter in patients who were administered Desflurane than in patients who were given Sevoflurane when maintenance and recovery characteristics were studied. The recovery timings were shorter when compared to the observations in our study as the definition of the timing was taken from time of administration of reversal agent.

Kaur A et al [5] were able to corroborate the same findings in a study conducted in morbidly obese patients undergoing bariatric surgery where the time to respond to painful stimuli, obey verbal commands and spontaneous

eye opening was shorter in the Desflurane group. Though patients in this study were morbidly obese, recovery was earlier when compared to our study as they used bispectral index (BIS) as an indicator of adequate anaesthesia and the dial concentrations of the volatile agents was adjusted using BIS during maintenance. Hence the difference.
In our study, the patients who received Desflurane had significantly higher mean modified Aldrete score at 5min.and 10min. After extubation, the patients were monitored and observed until they achieved a modified Aldrete score of ≥ 9. Analysis of the recovery profiles revealed that the patients who were enrolled in the group that received Desflurane achieved a modified Aldrete score of ≥ 9 faster when compared to the patients in the Sevoflurane group . These results were comparable to the study done by Jindal et al, who documented that the mean time required for achievement of a modified Aldrete score of >9 was significantly lesser in the Desflurane group when compared to the Sevoflurane group.

Very few patients in our study had complications associated with the inhalational agents during the recovery [8 out of 60 patients had nausea; 6 patients had vomiting and 7 out of 60 patients had cough] in our study. It was seen that more patients in the Desflurane group had complications as compared to those in the Sevoflurane group. However, this number was not statistically significant.

**LIMITATIONS OF THE STUDY**

Our study findings are however, limited by the number of patients that were a part of the study and the nonavailability of monitors of depth of anaesthesia such as Bispectral Index (BIS) and Entropy at our institute. Our study was designed only to observe the intraoperative haemodynamics and early and intermediate recovery profiles presented by the use of Desflurane and Sevoflurane. Hence, no comments regarding the late recovery period, including the psychomotor and qualitative recovery can be made. We are also unable to comment on whether or not faster recovery from anaesthesia as demonstrated by the use of Desflurane would translate into early discharge from the hospital and prove economically beneficially to the patient in terms of decreased length of hospital stay. We did not study the total volume of desflurane used and did not compare the cost effectiveness of desflurane and sevoflurane. Probably, the cost would be on the higher side for the use of desflurane. We also could not monitor the end tidal concentrations of the maintenance agents as we did not have respiratory gas analyser.

**CONCLUSION**

Desflurane or Sevoflurane administration has no negative effects on the intraoperative as well as the early postoperative haemodynamic parameters and provide cardiovascular stability when titrated to maintain within 20% of the baseline values. Desflurane as the inhalational agent ensures faster recovery in the early postoperative period as evident from significant decrease in the time required for extubation and the time required to achieve a modified Aldrete score of ≥ 9 when compared to patients receiving Sevoflurane.The patients receiving Desflurane opened their eyes and verbalised sooner. It was also not associated with any significant adverse effects.Thus, Desflurane administration in patients undergoing surgeries under general anaesthesia was associated with stable intraoperative haemodynamics and faster early and intermediate recovery.

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