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The comparison of the effects of bispectral index controlled minimal, low and high flow desfluran anesthesia on hemodynamics and recovery in patients undergoing lower abdominal surgery

Alt abdominal cerrahi geçirecek olgularda bispektral indeks kontrollü minimal, düşük ve yüksek akımlı desfluran anestezisinin hemodinami ve derlenme üzerine etkilerinin karşılaştırılması

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SUMMARY

Objective: Low flow anesthesia is an inhalation anesthesia technique applied through a semi-closed rebreathing system in which the rate of rebreathing is at least 50%. When modern rebreathing systems are used, low anesthesia could be uttered if the speed of gas flow is decreased below 2 L/min.
Method: In the present study, the comparison between minimal flow, low flow and high flow anesthesia practices of the effects of BIS controlled desfluran anesthesia on hemodynamic and costs has been aimed. Of the cases randomized divided into three groups within first 10 minutes after the anesthesia induction in all cases, in group Y, fresh gas flow in anesthesia maintenance was kept at 4.0 L/min; in group D, the flow speed was decreased to 1 L/min after the 10th minute; in group M, it was decreased to 0,5 L/min; anesthesia maintenance with desfluran (4-6%) was continued in all three groups.
Results: In the comparison between the three groups received high, low and minimal flow, no significant differences had been noticed in heart rate, average arterial pressures, oxygen saturation and end-tidal carbon dioxide values in all three groups. The recovery was found to be earlier in low flow and minimal flow groups ($p<0.05$). Significant decrease in volatile anesthetic consumption and costs was observed in low flow and minimal flow groups ($p<0.05$).
Conclusions: Low and high flow desfluran anesthesia application provided sufficient anesthesia depth, hemodynamic stability and respiration parameters during intraoperative period as well as had positive effects on postoperative recovery under sufficient conditions.
Keywords: Desfluran, BIS, low flow anesthesia, minimal flow anesthesia

ÖZET

Amaç: Düşük akımlı anestezi, yarı kapalı yeniden solutmalı bir sistemle uygulanan ve yeniden solutma oranının en az %50 olduğu anestezisi tekniğidir. Modern yeniden solutmalı sistemler kullanıldığında, taze gaz akım hızı 2 L/dk'nın altına indirilirse düşük akımlı anesteziden söz edilebilir.

Yöntem: Bu çalışmada BIS kontrolünde uygulanan desfluran anestezisinin hemodinami ve maliyet üzerindeki etkilerinin minimal akımlı, düşük akımlı ve yüksek akımlı anestezi uygulamaları arasında karşılaştırılması amaçlandı. Randomize olarak üç gruba ayrılan olgulardan Grup Y'de anestezi idamesinde taze gaz akımı 4.0 L/dk olarak devam edildi, Grup D'de 10. dakikadan sonra akım hızı 1 L/dk'ya indirildi, Grup M'de ise 10. dakikadan sonra 0.5 L/dk'ya indirildi ve her üç grupta da desfluran (%4-6) ile anestezi idamesine devam edildi.

Bulgular: Yüksek, düşük ve minimal akım uygulanan üç grup arasında yapılan karşılaştırmada, her üç grupta da; kalp atım hızı, ortalama arteriyel basınçlar, oksijen saturasyonu, end-tidal karbondioksit değerlerinde anlamlı bir farklılık saptanmadı. Düşük akımlı ve minimal akımlı grupta derlenmenin daha erken olduğu belirlendi ($p<0.05$). Düşük akım ve minimal akım gruplarında volatil anestezik tüketimi ve maliyet açısından önemli azalma sağlandı ($p<0.05$).

Sonuç: İntraoperatif süreçte, yeterli anestezi derinliği, hemodinamik stabilite ve respirasyon parametrelerini sağlayan düşük ve yüksek akımlı desfluran anestezisinin, yeterli koşullar altında postoperatif iyileşme üzerine pozitif etkileri vardır.

Anahtar sözcükler: Desfluran, bispektral indeks, düşük akımlı anestezi, minimal akımlı anestezi

INTRODUCTION

Low flow anesthesia technique could be applied through a semi-closed rebreathing system in which the rate of rebreathing is at least 50%. When the novel rebreathing systems are used, low flow anesthesia could be mentioned if the fresh gas flow rate was under 2L/min. Virtue in 1974 introduced an anaesthia method called "minimal flow anesthesia" in which the fresh gas flow was decreased to 0.5 ml/min.

Bispectral index is an unquestionable method showing the hypnotic effects of anesthetic and sedative agents in brain as well as the measurement of anesthetic depth derived from the amplitude and frequency measurements of EEG (1). When the flow rate was reduced in low flow anesthesia, the realization risk in a possible gas consuming insufficiency could be disappeared by using BIS (2). The present study aimed to compare the effects of minimal, low and high fresh gas flow anesthesia applications along with the BIS controlled, standard and trustable desfluran anesthesia on hemodynamics and recovery in cases undergoing lower abdominal surgery

MATERIALS AND METHODS

The present study was performed in Anesthesiology and Reanimation Department between October 2010 and February 2011 along with the Ethic Committee permission from Abant İzzet Baysal University, Faculty of Medicine Education and Research Hospital (Date: 22.09.2010, Number:37) and all patients signed an informed consent form for participation in the study. Sixty cases between the ages of 18-65 from ASA I-II risk group undergoing lower abdominal surgery with the anticipated surgery time of 120 mins under the general anesthesia were included in this prospective and simple random sampled study. The heartbeat rates (HBR), average arterial pressures (AAP), SpO^2 (%) and $ETCO^2$ values, Desfluran consumption throughout the surgery and Aldrete Recovery Scale (ARS) values were aimed to be measured in the present study. The statistical analyses were done using SPSS 12.0 program. Data were presented as mean-standard deviation, median (25% - 75%), minimum-maximum and n(%). One way Anova Test in the comparison of dual independent groups and Repetitious Measurements' Variance Analysis Test in the comparison of three or more repetitious measurements for dependent groups were used. Data for ASA, gender, perioperative and postoperative side effects were compared by Chi Square Test or Fisher's Exact Chi Square Tests were applied. $P<0.05$ was regarded as the level of significance.

Anesthesia Application

5-7 mL/kg/h serum physiologic infusion was given to the patients through an 18-20 Giv canul from the dorsal side of the hand. 2 mg/kg propofol (%1) was given for anesthesia induction and intravenous 0.6 mg/kg rokuronyum (10 mg/mL) was administered for muscle relaxation. Following the sufficient muscle relaxation, mechanical ventilation was done after the endotracheal intubation in which the $ETCO_2$ level was between 30-40 mmHg, tidal volume was 8mL/kg and the number of respiration was 12 respiration/min.

Patients were divided into three groups (n=20) randomly according to the used agent:

Group I (Group Y): High flow anesthesia application group, desluran (4 L/min) in ***O_2+N_2O*** (n=20)

Group II (Group D): Low flow anesthesia application group, desfluran (1 L/min) in ***O_2+N_2O*** (n=20).

Group III (Group M): Minimal flow anesthesia application group, desluran (0.5 L/min) in ***O_2+N_2O*** (n=20).

Anesthesia perpetuation with 4 L/min and desfluran (4-6%) was started in all patients during the first 10 minutes. While fresh gas flow in Group Y remained 4 L/min, it was reduced to 1 L/min in Group D and to 0.5 L/min in Group M after ten minutes of anesthesia with desfluran (4-6%).

Patients were extubated when the BIS value reached to 80%. Following the extubation of all cases, they were followed up in revival room for 30 mins in order to the evaluation of possible side effects and improvement. Patients with ≥9 Aldret Revival Score (ARS) were sent to service. Cost estimation for anesthesia period during preoperative observation in both patient groups was estimated and their mean values was taken using Dion Formula (50-53).

Dion Formula (94):

C=P x F x T x M / 2412 x d

P= Vapourizater concentration (%)

F= Fresh Gas Flow (L/min)

T= Time (min)

M= Molecular weight (g)

d= Density (g/mL)

C= Used Volatile Anesthetic Agent (mL)

RESULTS

There were no statistically significant difference between the groups when the demographical data of cases included in the present study as well as the operation and anesthesia times were compared**.**

HBR and AAP values of patients are given in Table 1. Analysis of variance results demonstrated that there were no statistically significant difference between the groups in respect of time when the HBR and AAP values were compared in patients undergoing operation (Table 1).

Table 1: HBR values (beat/min) [Mean±SD(min-max)] and AAP values (mmHg) [Mean±SD(min-max)]

	HBR			AAP		
Time	Group Y (n=20)	Group D (n=20)	Group M (n=20)	Group Y (n=20)	Group D (n=20)	Group M (n=20)
0. min	93.00 ± 19.41 (63-147)	96.35 ± 18.89 (71-136)	90.90 ± 11.26 (65-117)	102,35 ± 22,24 (68-139)	97,85 ± 15,53 (76-135)	104,60 ± 22,80 (80-178)
30. min	82,70 ± 15,15 (66-111)	82,50 ± 11,26 (77-105)	84,00 ± 11,97 (70-113)	100,25 ± 13,47 (78-123)	101,15 ± 15,15 (78-131)	106,85 ± 14,98 (83-129)
60. min	85,80 ± 16,30 (61-113)	79,80 ± 12,69 (57-112)	84,50 ± 11,60 (67-117)	102,45 ± 13,35 (76-130)	101,10 ± 17,46 (63-136)	106,60 ± 21,27 (67-144)
90. min	78,77 ± 17,65 (60-113)	78,85 ± 6,82 (66-84)	85,00 ± 11,09 (70-100)	96,88 ± 13,46 (71-113)	94,57 ± 19,94 (63-126)	102,80 ± 22,53 (78-133)
120.min	62,50 ± 6,36 (58-67)	79,00 ± 5,47 (73-86)	95,00 ± 18,38(82-108)	91,50 ± 17,67 (79-104)	86,75 ± 20,36 (65-111)	94,50 ± 19,09 (81-108)

* $p < 0.05$

Table 2 shows SpO_2 and $ETCO_2$ values of patients during the operation. The analysis of variance results showed no statistically significant difference between the groups when the SpO_2 and $ETCO_2$ values were compared (Table 2).

Table 2: SpO_2(%) and $ETCO_2$ (mm Hg) values [Mean±SD(min-max)]

	SpO2			ETCO2		
Time (min)	Group Y(n=20)	Group D(n=20)	Group M(n=20)	Group Y(n=20)	Group D(n=20)	Group M(n=20)
0	99.20 ± 0.55 (98-100)	99.15 ± 0.60 (98-100)	99.20 ± 0.65 (98-100)	31,85 ± 3,23 (27-41)	31,00 ± 2,07 (28-35)	30,65 ± 1,66 (27-33)
30	99.05 ± 0.55 (98-100)	99.10 ± 0.40 (98-100)	99.20 ± 0.55 (97-100)	32,20 ± 2,39 (28-39)	31,90 ± 3,12 (28-42)	34,65 ± 3,91 (29-41)*
60	99.31 ± 0.67 (97-100)	99.56 ± 0.75 (97-100)	99.46 ± 0.61 (96-100)	32,80 ± 2,85 (30-40)	33,95 ± 4,07 (30-46)	35,80 ± 4,85 (30-47)
90	99.34 ± 0.71 (98-100)	99.20 ± 0.55 (98-100)	99.14 ± 0.39 (97-100)	32,88 ± 4,62 (29-44)	35,14 ± 5,33 (30-45)	37,00 ± 3,46 (34-42)
120	99.05 ± 0.55 (97-100)	99.26 ± 0.49 (97-100)	99.20 ± 0.56 (96-100)	32,50 ± 2,12 (31-34)	34,50 ± 3,10 (30-37)	38,50 ± 3,53 (36-41)

* $p < 0.05$

Table 3 demonstrates post-op ADS values of patients following the operation. The analysis of variance results showed no statistically significant difference between the groups (Table 3).

Table 3: Post-op ADS values [Mean±SD(min-max)]

Time	Group Y (n=20)	Group D (n=20)	Group M (n=20)
1.min	7,05 ± 0,99 (6-9)	7,1 ± 1,3 (5-9)	7,35 ± 0,79 (5-8)*
5. min	7,95 ± 0,82 (7-10)	8,15 ± 0,98 (7-10)	8,50 ± 0,82 (7-10)*
15. min	8,10 ± 0,49 (7-10)	8,90 ± 0,30 (7-10)	9,15 ± 0,44 (8-10)*
30. min	9,4 ± 0,57 (9-10)	9,6 ± 0,46 (9-10)	9,95 ± 0,22 (9-10)

* $p < 0.05$

Table 3 shows the total cost of desfluran used for patients. The analysis of variance showed statistically significant difference between the groups Y and D, groups Y and M as well as groups D and M (Table 3).

DISCUSSION

The low flow anesthesia could be described as a technique that at least 50% of gas mixture returns to the lungs following the CO_2 absorption (2). Economic concerns, environmental factors, developments in monitorization technology, the come out of new and expensive inhalation anesthetics increased the interest to the anesthesia application that using the low flow anesthesia techniques. Desfluran, sevofluran and isofluran could be used as volatile anesthetic agent in low flow anesthesia applications (3, 6). The major risks in this technique could be described as hypoxia, the low and high dose usage of volatile anesthetics, hypercapny and the potential accumulation of toxic trace gases (2).

Işık and co-workers (4) applied low flow anesthesia technique with desfluran and sevofluran on pediatric patients that caused no disruption in hepatic and renal functions and on stable hemodynamics.

Yıldırım and co-workers (5) found no statistically significant difference between the groups that used low and high flow anesthesia by sevofluran, desfluran and isofluran throughout the preoperative and postoperative three days when compared heartbeat rates, blood pressures, kidney function tests, liver function tests and cardiac enzymes as well as postoperative recovery and nausea-vomiting. In addition, they suggested that desfluran and sevofluran could be preferred as volatile anesthetic in low flow anesthesia application because of their early recovery effects.

According to Bennet and co-workers (6), desfluran could be preferred for the fast control in especially hypertensive patients’ operation procedure because of their labile hemodynamics.

Even the low flow anesthesia was preferred during the operation, high flow anesthesia must be used for a while at the beginning. In the present study, high flow anesthesia was used for the first 10 mins in the low flow anesthesia group patients. The most important reason for the preference of desfluran as the inhalation agent in the present study was its physicochemical distinctions resulting from its low resolution rate in blood.

Lee *et al* (7), used desfluran and isofluran in 500 ml/min minimal flow and demonstrated that the isofluran concentration proceeded to decrease during the operation while desfluran showed improvement following a slight decrease at the beginning they also postulated that desfluran caused no clinical problems even at low flows.

Baum *et al* (2) used desfluran at minimal and low flows and suggested that the operation could be resumed without changing the vapourisator calibration, on the other hand there would be a 1-2 % enhancement in fresh gas concentration in minimal flow. The vapourisator calibrations were not changed in all groups in the present study, however, a slight decrease was detected in fresh gas concentrations in low and minimal flow groups therefore vapourisator calibration was not changed since it did not affect the anesthesia depth.

The agent choice used for the cost finding might cause cost differences. Since the desfluran synthesis is more expensive and it is 5 times inefficient than isofluran it could be suggested that the desfluran usage is irrelevant. However, each milliliter liquid desfluran gives 8% more vapor than a milliliter isofluran. This causes the desfluran effectiveness decreases to 3 times. It has also been suggested that desfluran had pharmacodynamic and economic advantages as well as its perfect anesthesia control (8).

In the present study, the comparison of gas consumption rates between the groups revealed that decrease in O_2, N_2O and desfluran consumption in Group Y is statistically significant ($p<0.05$) when compared to the Group M and Group D. Similarly, the decrease in O_2, N_2O and desfluran consumption in Group D was statistically significant ($p<0.05$) when compared to the Group M.

It is well known that the BIS application during the operation is a considerably efficient monitorization method against the intraoperative awareness risk. In addition, finding out the anesthesia depth through the cerebral monitorization could decrease the postoperative care consumption related to the early recovery as well could decrease the intravenous and volatile anesthetics consumption (9).

Weiskopf and co-workers (10) investigated the hemodynamic effects of 0.83, 1.24 and 1.66 MAC desfluran anesthesia in noncardiac surgery cases under the high flow desfluran anesthesia. They suggested that while the heartbeat rate remained unchanged under the 0.83 MAC desfluran, evident **tachycardia** was observed over 1 MAC desfluran concentrations. Gormley *et al* 11 suggested that the use of over 6% vapourizator calibrations caused temporary (1-4 min) sympathetic activity, heartbeat rate and blood pressure increase. On the other hand, Daniel and co-workers (12) indicated that 1.5 mcg/kg fentanyl and desfluran given during the induction could prevent the adrenergic response against the surgical incision. The present study found no sympathetic activity findings and no increase in heartbeat rate in all cases during the induction period under 1 mcg/kg fentanyl and under 1 MAC desfluran anesthesia.(13)

In conclusion, low and high flow desfluran anesthesia application provided sufficient anesthesia depth, hemodynamic stability and respiration parameters during intraoperative period as well as had positive effects on postoperative recovery under sufficient conditions. In addition, minimal and low flow desfluran anesthesia application decreases the anesthetic gas consumption thus the cost of anesthesia in contrast to the high flow application.

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