



## Comparison of ventricular repolarization parameters including Tp-e, Tp-e/QTc, JTc and JTd during low-flow and high-flow desflurane anesthesia in gynecologic laparoscopic surgery

Berna Kaya Uğur<sup>1</sup>, Murat Sucu<sup>2</sup>, Gülseren Karsli<sup>3</sup>, Fatma Yılmaz Coşkun<sup>2</sup>,  
Veysel İ. Düzen<sup>2</sup>, Mete G. Uğur<sup>4</sup>

1 Gaziantep University, Faculty of Medicine, Department of Anesthesiology and Reanimation, Gaziantep, Turkey

2 Gaziantep University, Faculty of Medicine, Department of Cardiology, Gaziantep, Turkey

3 Gaziantep Cengiz Gökçek Maternity and Children's Hospital, Department of Anesthesiology and Reanimation, Gaziantep, Turkey

4 Gaziantep University, Faculty of Medicine, Department of Obstetrics and Gynecology, Gaziantep, Turkey

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### Abstract

**Objectives:** Low-flow anesthesia (LFA) gained reasonable popularity as it provides many advantages including physiological, ecological, economical issues. Desflurane is a preferable anesthetic in low-flow anesthesia practice however, the relation between QTc, QTd, and QTcd prolongation and management of anesthesia with desflurane has been previously demonstrated. We aimed to compare the effects of low-flow (LFA) and high-flow (HFA) desflurane anesthesia on hemodynamic changes and ventricular repolarization markers in gynecologic laparoscopy.

**Methods:** 58 patients were randomized into group L (LFA, n=30) and group H (HFA, n=28). ECG was recorded before anesthesia and 60th minute of anesthesia in both groups.

**Results:** JTc-0 values were lower than JTc-1 values within both group L and H (p=0.001 for both groups). JTcd-0 and JTd-1 values were lower than JTcd-1 within group H (p=0.042 and 0.002, respectively). QTc-0 values were lower than QTc-1 within both group L and group H (p=0.001 and 0.002, respectively). QTcd-0 values were lower than QTcd-1 within group H (p=0.021). QTd-0 values were lower than QTd-1 within-group H (p=0.026). Tpe-0 and Tpe-1 values were lower in group L (p=0.001 and 0.002 respectively). Also, JTc-0 values were lower than JTc-1 values within both group L and H (p=0.021 and 0.027, respectively). Tpe/QTc-1 ratio was significantly lower in group L (p= 0.010). The difference between Tpe/QTc-0 and Tpe/QTc-1 ratios within group H was significant (p=0.028).

**Conclusion:** Our study showed that there was no significant difference between LFA and HFA in terms of ECG repolarization markers, which may predict the possibility of torsadogenity.

**Keywords:** Low-flow anesthesia; desflurane; ECG; arrhythmia; ventricular repolarization; QT; JT; Tpe

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**Correspondence / Yazışma Adresi:** Berna Kaya Ugur, Gaziantep University, Faculty of Medicine, Department of Anesthesiology and Reanimation, Gaziantep, Turkey e-mail: bernakayaugur@hotmail.com

## Jinekolojik Laparoskopik Cerrahide Düşük ve Yüksek Akımlı Desfluran Anestezisinin Tp-e, Tpe/QTc, JTc ve JTd gibi ventriküler repolarizasyon parametrelerine etkisinin karşılaştırılması

### Öz

**Amaçlar:** Düşük akımlı anestezi (DAA) fizyolojik, ekolojik, ekonomik konular dahil olmak üzere birçok avantajları nedeniyle son yıllarda popülerlik kazanmıştır. Desfluran, DAA uygulamasında tercih edilen bir anestezi türüdür, ancak desfluran ile anestezide QTc, QTd ve QTcd uzaması daha önceki çalışmalarda gösterilmişti. Çalışmamızda jinekolojik laparoskopide düşük akımlı ve yüksek akımlı (HFA) desfluran anestezisinin hemodinamik değişiklikler ve ventriküler repolarizasyon belirteçleri üzerindeki etkilerini karşılaştırmayı amaçladık.

**Yöntemler:** 58 hasta grup L (LFA, n = 30) ve grup H (HFA, n = 28) olarak randomize edildi. Her iki grupta da anestezi öncesi ve 60. dakika anestezi EKG çekildi.

**Bulgular:** JTc-0 değerleri hem grup L hem de H içinde JTc-1 değerlerinden düşüktü (her iki grup için p = 0,001). Grup H içinde JTcd-0 ve JTd-1 değerleri JTcd-1'den düşüktü (sırasıyla p = 0.042 ve 0.002). QTc-0 değerleri hem grup L hem de grup H'de QTc-1'den düşüktü (sırasıyla p = 0.001 ve 0.002). Grup H içinde QTcd-0 değerleri QTcd-1'den daha düşüktü (p = 0.021). QTd-0 değerleri, grup H içinde QTd-1'den düşüktü (p = 0.026). Grup L'de Tpe-0 ve Tpe-1 değerleri daha düşüktü (sırasıyla p = 0,001 ve 0,002). Ayrıca, hem L hem de H grubunda JTc-0 değerleri JTc-1 değerlerinden daha düşüktü (sırasıyla p = 0.021 ve 0.027). Grup L'de Tpe / QTc-1 oranı anlamlı olarak daha düşüktü (p = 0,010). Grup H içinde Tpe / QTc-0 ve Tpe / QTc-1 oranları arasındaki fark anlamlıydı (p = 0,028).

**Sonuç:** Çalışmamızda, DAA ve YAA arasında EKG repolarizasyon belirteçleri ve torsadojenite riski arasında anlamlı bir fark olmadığı sonucuna varıldı.

**Anahtar kelimeler:** Düşük akım anestezi; desfluran; EKG; aritmi; ventriküler repolarizasyon; QT; JT; Tpe.

### INTRODUCTION

In the era of minimally invasive medicine, combining a minimally invasive procedure with an ecological, physiological, and economical friendly anesthetic method makes more sense in modern anesthesia practice. However the chosen anesthetic method also must be also patient friendly and safe.

Low-flow anesthesia (LFA) gained a reasonable popularity as it provides many advantages including ecological issues, reduction of air pollution of operating room, decreased costs and prevention of airway desiccation.

Desflurane is relatively less soluble among the inhaled anesthetic agents and has advantageous pharmacologic characteristics and fast metabolism. These features make desflurane preferable in low-flow anesthesia practice<sup>1,2</sup>.

Ventricular repolarization (VR) is a complex electrical phenomenon and comprises an important step in cardiac electrical activity<sup>3-5</sup>. Markers of ventricular repolarization (VR) including QT interval (QT), corrected QT

interval (QTc) intervals, QT dispersion (QTd), T peak to end (Tp-e), Tp-e/QTc, corrected JT interval (JTc) and JT dispersion (JTd) may help forecast arrhythmic events of ventricles and even sudden death. In previous studies, the relation between QTc<sup>6,7</sup>, QTd, and QTcd prolongation and management of anesthesia with desflurane has been demonstrated<sup>8</sup>.

The aim of this study is to compare the effects of LFA and HFA with desflurane on hemodynamic changes and ventricular repolarization parameters including QTc, QTd, QTcd, JTc, JTd, Tp-e, and Tp-e/QTc during gynecologic laparoscopic surgery.

### METHODS

Sixty consecutive patients scheduled for diagnostic or operative laparoscopy combined with hysteroscopy for infertility with ASA I-II physical status were prospectively enrolled in the study between May 1st 2015 and January 1st 2016. Approval of the Faculty Ethical Committee and informed consents (verbal and written) were obtained (2015/189). We

excluded patients less than 18 years of age or taking antiarrhythmic drugs or beta-blockers or patients with any cardiovascular disease or electrolyte imbalance from the content of the study.

Echocardiography and electrocardiogram (ECG) were performed on all patients in order to rule out any cardiovascular disease before enrollment. Routine monitoring parameters, namely, ECG, heart rate (HR), non-invasive blood pressure (NIBP), oxygen saturation (SpO<sub>2</sub>), end-tidal CO<sub>2</sub> (EtCO<sub>2</sub>) and gas monitoring were performed for all the patients. Demographic data of the participants' age, body mass index (BMI, kg/m<sup>2</sup>), ASA physical status, operation and anesthesia time (minutes) were recorded. In order to avoid CO<sub>2</sub> accumulation with desflurane, CO<sub>2</sub> absorbent canisters (KNG SORB, KNG Medical, İzmir, Turkey) were refilled everyday. Randomization of the patients into two groups as group L (Low-flow desflurane anesthesia, n=30) and group H (High-flow desflurane anesthesia, n=30) was achieved with computer-generated random numbers. Pre-oxygenation was applied with 100% oxygen (O<sub>2</sub>) at 6 L/min for 3 min in all patients. ECG recordings (twelve leads) were performed before and 60 minutes after anesthetic induction in all patients. All patients were given intravenous (IV) fentanyl citrate (Talinat, Vem ilaç, İstanbul, Turkey), 2 µg/kg and propofol (Propofol, Fresenius Kabi, İstanbul, Turkey) 2-3 mg/kg followed by IV rocuronium bromide Rocuronium (Esmeron; MSD Pharma Hungary, Budapest, Hungary) 0.5 mg/kg for endotracheal intubation. Anesthesia was maintained by administration of %6-8 MAC desflurane (Suprane®, Baxter Healthcare, Deerfield, IL, USA). Intermittent positive pressure ventilation was initiated with a tidal volume of 7 ml/kg, rate of 12/min with O<sub>2</sub> and air in a ratio 40:60 with an FGF of 6 L/min to maintain EtCO<sub>2</sub> values between 35-45 mmHg after endotracheal intubation.

The inspired and expired gas concentrations were measured each minute for the first 10 minutes to achieve steady state. Then total gas flow was reduced to 0.5 L/min with 50% O<sub>2</sub>-air mixture in group L.

The surgery was performed in routine gynecologic position (low lithotomy). We inserted a primary umbilical 12-mm trocar (for 10-mm laparoscope) and ipsilateral two 5-mm trocars for surgery. Surgeons decreased the pressure of pneumoperitoneum down to 12 mmHg after the insertion of all trocars. The degree of Trendelenburg position was less than 20° was used in both groups but 0° was preferred for hysteroscopy.

Conventional 12 lead ECG recordings at 25mm/s paper speed and 10mm/mV amplitude was used. Mean results were calculated from three consecutive cardiac cycles and parameters were determined in all 12 leads when possible. Any lead with a wave amplitude <1.5mm was excluded from analysis. A blinded cardiologist assessed ECG recordings manually. HR [baseline (HR-0), 60th minute (HR-1)], MAP (baseline and at the 60th minute), QTc [baseline (QTc-0), 60th minute (QTc-1)], QTd [baseline (QTd-0), 60th minute (QTd-1)], JTc [baseline (JTc-0), 60th minute (JTc-1)], JTd [baseline (JTd-0), 60th minute (JTd-1)], Tpe [baseline (Tpe-0), 60th minute (Tpe-1)] and Tpe/QTc [baseline (Tpe/QTc-0), 60th minute (Tpe/QTc-1)] of patients in both groups were measured. The QT intervals were measured manually from the onset of QRS complex to the end of the T wave (defined as the intersection of isoelectric line and the tangent of the maximal downward limb of the T wave). The QT interval was corrected for heart rate using the Bazett formula. QTd was defined as the difference between the maximum and minimum average of QT interval. The JTc interval was calculated by subtracting the QRS duration from the QTc interval. JTd was defined as the difference between the maximum and minimum average

of JT interval. The Tpe interval was measured from the peak of the T wave to the end of the T wave. When U waves were present, the end of the T wave was defined as the nadir of curve between the T and U waves. Tp-e/QTc interval ratios (Tp-e divided by a QTc) were also calculated as index of repolarization.

Then endotracheal intubation and mechanical ventilation with tidal volume of 8ml/kg, ventilation frequency of 12 breaths/min, inspiration-expiration ratio of 1:2, oxygen flow rate of 2 L/min were performed, and the airway pressure, PETCO2, and SpO2 were maintained between 12-18 cmH2O, 35-45 mmHg, and 98-100% respectively. Any arrhythmic event of the patients was recorded through the study period.

The normality of distribution of continuous variables was analyzed by Shapiro-Wilk test. Student t test (for normal data) and Mann-Whitney U test (for non-normal data) were used for comparison of two independent groups and Wilcoxon tests were used to compare numerical variables measured at two different time points. This is a pilot study regarding the hypothesis, therefore we did not perform a power analysis. SPSS for Windows version 22.0 was utilized for statistical analysis and the difference was accepted as significant when the p value was below 0.05.

### RESULTS

Two patients in group H were excluded because of significant artifacts in the ECG recordings leading to unreliable readings and 58 patients were available for final analysis. No significant difference was revealed in terms of age, BMI, operation time, anesthesia time, laparoscopic surgery type, and ASA status between the groups (Table 1).

Hemodynamic parameters of patients during anesthesia were compared between the two groups. No significant difference was revealed in terms of MAP, SpO2 and HR values between

the study groups at each observation period (Table 2).

**Table I:** Age, BMI, operation time, anesthesia time and ASA physical status of the patients.

Variables	Group L (n=30)	Group H (n=28)	p*
Age	38,93 ± 11,42	40,71 ± 8,95	0.513
BMI	27,05 ± 5	28,86 ± 5,65	0.206
Operation time (min)	92,17 ± 18,08	97,68 ± 33,87	0.814
Anesthesia time (min)	105 ± 18,89	111,79 ± 33,67	0.963
Diagnostic	11	10	0.940
Operative	19	18	
ASA status			0.849
	I 10(33.3)	10(35.7)	
	II 30(66.7)	28(64.3)	

\*Significant at p<0.05.

**Table II:** Comparison of mean arterial pressure (MAP), SpO2 values between the groups.

Variables	Group L (n=30)	Group H (n=28)	p
SpO <sub>2</sub> (%)			
Before induction	98,27 ± 1,66	98,14 ± 1,56	0,610
60 <sup>th</sup> minute	98,87 ± 1,78	98,68 ± 2,31	0,736
Mean arterial pressure			
Before induction	98,37 ± 18,17	94,54 ± 21,92	0,862
60 <sup>th</sup> minute	87,07 ± 12,88	90,32 ± 19,06	0,895
Heart rate			
Before induction	85,07 ± 15,33	89,11 ± 13,96	0,338
60 <sup>th</sup> minute	73,7 ± 11,52	78,04 ± 14,83	0,311

\*Significant at p<0.05.

The heart rate, JTc, JTcd, JTd, QTc, QTcd, QTd, Tpe, and Tpe/QTc ratio values of groups depending on ECG readings are presented in table 3 and 4.

**Table III:** Heart rate, JT, JTc, JTcd and JTd values of groups.

Variables	Group L (n=30)	Group H (n=28)	p
HR-0	78.73 ± 9.99	77.5 ± 17.13	0.383
HR-1	74.77 ± 10.95	77.86 ± 19.29	0.864
	p=0.072	p=0.801	
JTc-0	310.87 ± 20.69	317.50 ± 34.08	0.183
JTc-1	336.33 ± 16.62	341.18 ± 29.18	0.697
	p=0.001*	p=0.001*	
JTcd-0	24.87 ± 17.58	19.96 ± 8.54	0.450
JTcd-1	24.2 ± 13.31	23.32 ± 7.56	0.932
	p=0.823	p=0.042*	
JTd-0	22.73 ± 16.07	16.43 ± 6.47	0.259
JTd-1	22 ± 12.08	21.14 ± 6.85	0.856
	p=0.818	p=0.002*	

\*Significant at 0.05 levels. HR: Heart rate

**Table IV:** QTc, QTcd, QTd, Tpe, and Tpe/QTc ratio values of groups.

Variables	Group L (n=30 )	Group H (n=28 )	p
QTc-0	400.43 ± 23.77	413.61 ± 47.75	0.088
QTc-1	432.43 ± 25.78	439.75 ± 24.6	0.331
	p=0.001*	p=0.002*	
QTcd-0	23.23 ± 15.17	22 ± 11	0.646
QTcd-1	29.37 ± 17.02	27.39 ± 10.28	0.396
	p=0.143	p=0.021*	
QTd-0	20.33 ± 13.51	18.89 ± 9.02	0.740
QTd-1	26.33 ± 15.81	24.21 ± 10.12	0.405
	p=0.097	p=0.026*	
Tpe-0	77.7 ± 15.79	84.14 ± 9.02	0.07
Tpe-1	88.67 ± 20.84	101.07 ± 11.73	0.002*
	p=0.021*	p=0.001*	
Tpe/QTc-0	0.19 ± 0.04	0.21 ± 0.03	0.109
Tpe/QTc-1	0.21 ± 0.05	0.23 ± 0.03	0.010*
	p=0.274	p=0.028	

\*Significant at 0.05 levels.

No significant change both between and within the groups in terms of heart rate according to ECG was revealed.

The difference between the groups regarding JTc-0 and JTc-1 values was not significant (p=0.183 and 0.697, respectively). JTc-0 values were significantly lower than JTc-1 values within both group L and H (p=0.001 for both groups).

There was no significant difference between the groups and within group L in terms of JTcd-0 and JTcd-1 values. But JTcd-0 values were significantly lower than JTcd-1 within group H (p=0.042).

There was no significant difference between the groups and within group L in terms of JTd-0 and JTd-1 values. But JTd-0 values were significantly lower than JTd-1 within group H (p=0.002).

There was no significant difference between the groups in terms of QTc-0 and QTc-1 values. QTc-0 values were significantly lower than QTc-1 within both group L and group H (p=0.001 and 0.002, respectively).

There was no significant difference between the groups and within group L in terms of QTcd-0 and QTcd-1 values. But QTcd-0 values were significantly lower than QTcd-1 within group H (p=0.021).

There was no significant difference between the groups and within group L in terms of QTd-0 and QTd-1 values. But QTd-0 values were significantly lower than QTd-1 within group H (p=0.026).

Tpe-0 and Tpe-1 values were significantly lower in group L (p=0.001 and 0.002 respectively). Also JTc-0 values were significantly lower than JTc-1 values within both group L and H (p=0.021 and 0.027, respectively).

The difference between the groups regarding Tpe/QTc-0 ratio was not significant (p=0.109). Tpe/QTc-1 ratio was significantly lower in group L (p= 0.010). There was no significant

difference between Tpe/QTc-0 and Tpe/QTc-1 ratios within group L ( $p=0.274$ ), but there was a significant difference between these ratios within group H ( $p=0.028$ ).

## DISCUSSION

Low-flow and minimal-flow anesthesia use in routine clinical anesthetic practice did not gain wide popularity, although studies concerning low-flow anesthesia are increasing. High-flow anesthesia is still preferred by many anesthesiologists depending on the long clinical experience, prevention of possible hazards including arrhythmias, hypoxia, CO accumulation, and awareness.

During general anesthesia and endotracheal intubation, the respiratory tract behaves as a large heat and moisture exchanger. Because of the by-pass effect of endotracheal intubation, the upper airway of the patient cannot heat and moisture the cold and dry gas that absorbs the heat and moisture of the patient. For maintaining the body temperature and decreasing the loss of humidity, warmed and moistened anesthetic gas has to be applied<sup>9</sup>.

In routine general anesthesia practice, an anesthetic circle breathing system preserves moisture and heat by rebreathing of exhaled gas that contains water and heat of expirium gas of the patient and releasing of water vapor and heat from CO<sub>2</sub> absorbent, which creates an exothermic reaction<sup>10</sup>.

A viewpoint of advantages regarding LFA may be the positive physiological effects of LFA on the respiratory tract as we have previously suggested.

Special patient groups with a limited physiologic capacity of pulmonary and/or cardiac reserves are more prone to such airway temperature and humidity alterations<sup>11</sup>.

VR is one of the most important contributors of complex electrical occurrences that constitute a critical step in electrical activity of the heart. VR

is defined as the time between the onset of the QRS wave complex and the end of the T wave in ECG. Any change in cardiac electrical activity may lay the groundwork to mortal arrhythmias by means of producing various alterations in repolarization<sup>12</sup>.

Anesthetics used in clinical practice may have various effects on the ECG parameters. Many volatile anesthetics such as sevoflurane, isoflurane, and desflurane are known to prolong QT interval<sup>13</sup>.

Sympathetic activation caused by desflurane, activates renin-angiotensin-aldosterone system and increases vasopressin and catecholamine concentration<sup>14</sup>.

In healthy volunteers, desflurane at 1.0-1.5 MAC has been shown to cause significant sympathetic excitation and results in hypertension and tachycardia<sup>15</sup>. These sympathetic activations exerted by desflurane causes hemodynamic changes that have effects on cardiac electrophysiology<sup>16</sup>.

There is a strong correlation with the prolongation of QTc and ventricular arrhythmia<sup>17</sup>. In the present study, there was a prolongation of QTc in both groups between baseline and the 1st hour ECG recordings, which is more remarked in group H. These prolongations in QTc theoretically make the patients more prone to ventricular arrhythmias.

Another perspective is that our study population is homogeneously composed of healthy women. This eliminates potential bias regarding gender, because QT prolongation after such medications, and TdP-type arrhythmias are observed more in women compared with men. Also, this constitutes the logic of our hypothesis to test the effect of two different desflurane anesthesia methods on ventricular repolarization parameters in such a population with relatively more risk of arrhythmia<sup>18,19</sup>.

Fortunately, there was no occurrence of arrhythmia in both groups in our study. LFA has some potential physiological advantages and has less physiological burden on the patient as it protects the airway from the non-physiologic effect of HFA. Although mean QTc interval was longer in HFA group, the difference in QTc interval between the two groups at the 1st hour ECGs was not significant.

Transmural dispersion of repolarization can be measured by a relatively novel parameter T<sub>peak</sub> to T<sub>end</sub> (T<sub>pe</sub>)<sup>3</sup>.

The risk for life-threatening ventricular arrhythmias and sudden death in patients with a normal QTc can be calculated upon some parameters but T<sub>pe</sub> interval has better predictive performance<sup>4</sup>. Any prolongation in T<sub>pe</sub> interval effects the excitation and conduction, and induces TdP. In the study of Liu et al. the effect of desflurane on T<sub>pe</sub> interval in three groups with different MAC values at the same FGF rates was investigated and no significantly different prolongation was reported<sup>20</sup>. The authors concluded that desflurane does not have an effect on ventricular transmural dispersion. But in our study, we found contradicting results. T<sub>pe</sub> interval is prolonged in both groups between baseline and the 1st hour. According to the results of our study desflurane prolongs T<sub>pe</sub> interval at the same MAC and at different FGF rates. The T<sub>pe</sub> prolongation at the first hour is significantly longer in HFA compared with LFA. This finding also raises concerns regarding potential arrhythmogenic effect with HFA.

The ratio of T<sub>pe</sub>/QT is the ratio of relative to total ventricular refractory period. The higher the ratios the higher proportion of the relative refractory period, so the higher probability of cardiac electrical re-entry<sup>20</sup>. The ratio of T<sub>pe</sub>/QT helps us to predict ventricular arrhythmia risk without the effect of HR20 and this why we preferred the T<sub>pe</sub>/QTc ratio, as QTc is more reliable than QT. In our study T<sub>pe</sub>/QTc

ratio at the first hour is higher in Group H compared to group L. The reason for the higher T<sub>pe</sub>/QTc ratio in HFA may be the physiological burden of the HFA. Also in the LFA group, one hour of low FGF rates may help protect the heat and moisture of the inspired air and makes the airway environment close to normal physiology as previously discussed.

JT interval, another repolarization parameter that involves both depolarization and repolarization periods, has better performance than QT intervals in representing specific repolarization time particularly in patients with prolonged QRS duration<sup>5</sup>. Desflurane has been shown to prolong ventricular repolarization parameters and the findings of our study are similar with the literature Jtc, Jtcd, and Jtd was prolonged in group H, but only Jtc was prolonged in group L<sup>21</sup>.

These findings may support that HFA can have a disadvantage, however no patient in both study groups had clinically relevant arrhythmias. But also it should be considered that the patient population in this current study consisted of healthy and young patients. In order to evaluate the possible deleterious effects of HFA with desflurane in vulnerable and risky populations, further large-scaled studies in special patient groups are needed.

Our study may be criticized that there may be confounding effects of laryngoscopy and intubation through sympathetic stimulation on ECG parameters. In order to homogenize the interference of sympathetic stimulation and tracheal intubation, we included the ECG recordings at 1st hour.

Also another confounding factor in our study was to choose propofol as the induction agent. We applied propofol for induction of anesthesia and to attenuate the sympathetic stimulation of laryngoscopy in both study groups. And besides, we applied 2 µg/kg of intravenous fentanyl to contribute to propofol. Fentanyl has no effect on

the duration of repolarization at clinical doses in patients without cardiac pathology<sup>22,23</sup>.

However no significant effect of propofol on the duration of QTc in adults without cardiac pathology has been suggested in most of the studies<sup>19,24,25</sup>.

Experimental studies also concluded the clinical results suggesting that propofol has no effect on QTc interval<sup>26</sup>.

Furthermore some studies found that propofol may even shorten the QT and QTc intervals<sup>25,27</sup> and this effect may reverse the QTc prolongation originated by sevoflurane<sup>28</sup>.

According to these studies we may suggest that propofol may have no effect or attenuate the effect of sympathetic stimulation caused by laryngoscopy and concurrently sympathetic stimulation caused by desflurane. The significant prolongation of QTc in both groups even after propofol may depict the effect of desflurane.

Since the day John Snow noted that a significant amount of anesthetic gas was found in expired air from the patients unchanged in the early 1850s, it is one of the major problems of anesthesia providers to decrease the pollution of exhaled anesthetic gases. During routine anesthetic practice, an excessive amount of anesthetic gas emission to the atmosphere causes environmental pollution.

Most commonly used volatile anesthetics, namely, sevoflurane, desflurane, and isoflurane are very slightly metabolized in vivo<sup>29</sup> and are scavenged to atmosphere as medical wastes with no or little degradation. They have the potential to behave like greenhouse gas as they have a long half-life in the atmosphere ranging between 1.4 and 21.4 years<sup>30</sup>. Thus, choosing lower FGFs as possible would help reduce the environmental impact of anesthetics because of minimal volatile agent consumption.

A possible cause of avoidance of LFA in clinical practice may be safety concerns. Our study showed that there was no significant difference between LFA and HFA regarding ECG repolarization markers, which may predict the possibility of torsadogenity. In light of our results, it is prudent not to hesitate for safety concerns of arrhythmogenic potential of low flow desflurane anesthesia. As studies concerning the safety of LFA increase, the avoidance behavior of anesthesia providers on preferring LFA may decrease and may contribute to the preference of this rather environment-friendly anesthetic method. There is an evident need for larger scaled further studies with other patient groups.

**Ethics Committee Approval:** Approval of the Faculty Ethical Committee and informed consents (verbal and written) were obtained (2015/189).

**Declaration of Conflicting Interests:** The authors declare that they have no conflict of interest.

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