J Vet Clin 29(6) : 447-454 (2012)

Journal of Veterinary Clinics
www.ksvc.or.kr

Effects of Propofol and Remifentanil Combination Anesthesia on Intraocular Pressure and Hemodynamic Parameters in Dogs

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(Accepted: December 11, 2012)

Abstract : The objective of this study was to determine the effect of propofol and remifentanil combination on hemodynamics and intraocular pressure (IOP), and to compare with those of isoflurane in beagle dogs. Fourteen clinically healthy beagle dogs were divided randomly into 2 groups and each group was consisted with 7 dogs. Anesthetic agents were propofol (0.2 mg/kg/min) plus remifentanil (0.5 μg/kg/min, 1% solution in standard saline) in one group (group PRP) and 3% isoflurane in the other group (group ISF). Anesthesia was maintained for 90 min in the both groups. IOP, blood pressure, heart rate and blood gas values (pH, $PaCO_2$, PaO_2, SaO_2, tCO_2, HCO_3^-) were recorded at 5, 10, 15, 30, 45, 60, 75 and 90 min in the both groups. IOP values in both eyes were significantly decreased in group PRP compared with those in group ISF. but there were no significant differences between two eyes in each group. Systolic, diastolic and mean blood pressures were significantly decreased in group PRP within the normal range. There were no differences between groups in all blood gas parameters. In this study, propofol and remifentanil combination could provide stable IOP and blood pressure compared with isoflurane.

Key words **:** IOP, blood pressure, remifentanil, propofol, dog.

Introduction

Variable ophthalmic surgeries can be processed with simple local anesthesia in human, even at complicate procedure like phacoemulsification (21,40,41), but general anesthesia is practically essential for restraint in veterinary medicine. Because anesthetic agents may alter the intraocular pressure (IOP) during anesthesia, one of the most important things to be regarded during anesthesia for ophthalmic surgery is to provide adequate control of IOP. Because, patients could have potential glaucoma or other ophthalmic problems, normal or mildly decreased IOP should be maintained during non-ophthalmic surgery as well as ophthalmic surgery (31,35).

The high IOP during anesthesia could make the patient with glaucoma worse, compromise postoperative visual function and impair the intraoperative conditions. It may also cause an expulsion of intraocular contents with transient or permanent damage to the eye. Eventually, raise of IOP worsen the prognosis after surgery. Open eye surgeries, such as removal of foreign body, penetrating keratoplasty, cataract extraction, and iridectomy need especial concern about changes of IOP. Therefore, clinicians should choose the anesthetic regime that could minimize the variations in IOP and, especially, prevent high IOP or IOP spike (19,30).

IOP is altered mainly by aqueous humor production and outflow, and other factors including changes in the choroidal blood volume, central venous pressure and extraocular muscle tone (15,20,32). Many previous studies tempted to examine the relation of IOP between anesthetic agents. Although precise mechanisms are unclear, most of anesthetic agents reduce IOP by increasing of the aqueous humor outflow, relaxing extraocular muscle tone and depressing diencephalic function, except ketamine (3,12,17). Isoflurane, same as other inhalants, is known to decrease IOP by suppressing formation of aquaeous humour and promoting outflow (31).

Propofol is generally used as inducing and maintaining anesthesia in veterinary medicine because it provides smooth induction, rapid onset, fast clearance, short duration of action and rapid recovery (14,34,37). Because propofol has minimal analgestic effect, it has been concurrently administrated with proper analgestic agent, such as alfentanil or remifentanil (5,33).

Remifentanil is a potent μ-opioid receptor agonist and phenylpiperidine opioid that has ultra-short acting properties. It has been known that propofol and remifentanil have synergistic effect to each other (6,23,27,39). Remifentanil is distinguished with other opioids by the extraordinary metabolism. Alfentanil, fentanyl and sufentanil metabolized by liver and excreted by kidney. However, remifentanil metabolized by ester hydrolysis which is wide spread in the body, and it makes remifentanil independent on hepatic and renal functions (5,11,38,39).

Remifentanil could reduce IOP and prevent hemodynamic stress response associated with laryngoscopy and intubation, even in patients who coughed or moved in response to intu-

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bation in human (16). Similarly with remifentanil, a previous study suggested that propofol makes IOP decrease by increasing trabecular outflow and decreasing production of aqueous humor from the cilliary body in human (30), while no alterations were reported by Batista *et al*. (4).

Coughing, nausea and vomiting could make IOP steeply increase by influencing in intrathoracic and intraabdominal pressure. As propofol has antiemetic effects, incidence of postoperative nausea and vomiting (PONV) is lower than inhalant anesthetic agents. Opioids could increase the frequency of PONV, but combination of propofol and remifentanil has minimal PONV because remifentanil is an ultra-short acting opioid (10,28).

Propofol and remifentanil combination could induce mild hypotensive anesthesia. Deliberate hypotension is reported to be useful to provide stable blood pressure, to minimize hemorrhage during operation and to improve operating conditions for the surgeon (8,9). In the dog with patent ductus arteriosus, the combination of propofol and remifentanil was used for stable hemodynamics, excellent intraoperative condition and smooth recovery (26).

Recently, some veterinary reports suggested that inhalant agent, such as desflurane and sevoflurane, could increase IOP mildly within normal range, contrasted to previous studies (1,2). Furthermore, there was no published study about the correlation between IOP and anesthesia with combination of propofol and remifentanil in veterinary medicine.

The objective of this study was to determine the effect of propofol and remifentanil combination on IOP and hemodynamic parameters in beagle dogs and to compare with that of isoflurane.

Materials and Methods

Animals

The protocol was approved by the Kyungpook National University Animal Ethics Committee (KNU 2012- 46). Fourteen clinically healthy beagle dogs were used and divided randomly into 2 groups (group PRP and group ISF). The age of dogs was 2.4 ± 0.3 years, body weight was 8.4 ± 1.7 kg and body condition scores were between 4~5.

All dogs used in this study were normal in ophthalmic examinations consisted of Schirmer tear test, fluorescein staining examination, applanation tonometry and indirect ophthalmoscopy test. Blood cell count and chemistry examination were also performed to select clinically healthy dogs.

Procedures

Dogs fasted for at least 12 hr before anesthesia. One day before experiment, an arterial catheter (Pediatric jugular catheterization set®, Arrow international, Inc., USA) was inserted into the right femoral artery under anesthesia with propofol (Provive 1%®, Claris Lifesciences Ltd., India) and isoflurane (Ifran®, Hana Pharm. Co. Ltd., Korea). Anesthesia was induced with a bolus of 5 mg/kg propofol given slowly over 1 min and maintained with 1.9% isoflurane. The incision site was locally anesthetized with subcutaneously injection of 2% lidocaine. A catheter tip was inserted into the femoral artery about 5 cm forwarded to the aorta, and the catheter, through a tunnel under the subcutis, was exited on the median sacral crest. It filled with saline diluted heparin (50 IU/ml) to prevent occlusion of the arterial catheter. The arterial catheter was flushed with saline diluted heparin two times a day. It was used for measuring arterial blood pressure and heart rate, and collection of arterial blood samples.

At least 1 hr before each experiment, the dogs were placed in experimental room for enough acclimation. The arterial catheter was connected to a polygraph (Model 7P1, Grass Instrument Co., USA). After measuring of baseline values in setting position, a 22 gauge intravenous catheter was inserted in the cephalic vein.

Each parameter was measured at 5, 10, 15, 30, 45, 60, 75, and 90 min. Ten min before induction, acepromazine (Sedaject®, Samu median, Korea, 0.05 mg/kg, IV) was injected for premedication in group PRP. All dogs were injected with atracurium (0.1 mg/kg) concurrently at the beginning of induction for facilitating IOP measurement. Propofol (5 mg/kg) was administrated intravenously for 1 min for the induction of anesthesia in both groups.

In group PRP, propofol (0.2 mg/kg/min) and remifentanil (UltivaTM®, GlaxoSmithKline, Italy, 0.5 μg/kg/min, 1% solution in standard saline) was intravenously infused by using two syringe pumps just after induction.

In group ISF, isoflurane was initially given by 3% and, when anesthetic state was stable, it reduced by 1.9%. Same volume of normal saline as that of propofol and remifentanil in group PRP was constantly injected.

During anesthesia, in both groups, intermittent positive ventilation with 100% oxygen (15 to 20 ml/kg/min) was applied to maintain SpO_2 and end-tidal CO_2 to 95~100% and 35~45 mmHg, respectively. The inspiratory pressure of ventilator did not exceed 15 mmHg, and inspiration/expiration ratio was 1:2.

Dogs were positioned in right lateral recumbency. Proparacaine hydrochloride (Alcain®, Alcon-Couvreur, Belgium) were applied to the cornea 1min before measuring IOP with applanationtonometry. Temperature of the dog was maintained in normal range from 37.5ºC to 39.0ºC by using circulating warm water blanket.

Evaluation parameters

IOP

IOP was measured with an applanation tonometer (Tonopen®XL, Medtronic Solan, USA) at the central cornea. The tonometer was calibrated before each measurement and mean IOP was automatically calculated by the tonometer.

Hemodynamic measurement

Heart rate and systolic/diastolic arterial pressure were measured with the polygraph. Heart rate values were recorded at a

speed of 25 mm/sec and were calculated from the mean of 10 seconds. Systolic arterial blood pressure (SAP) and diastolic arterial blood pressure (DAP) were recorded at a speed of 50 mm/min and calculated from the mean of 1 min records. Mean arterial blood pressure (MAP) was calculated based on systolic and diastolic pressure.

Blood gas parameters

pH, $PaCO_2$, PaO_2, SaO_2, tCO_2 and HCO_3^- were measured with an portable blood gas analyzer (i-STAT® Analyzer MN300, i-STAT Co. Ltd, USA) and test cartridges (i-STAT® G3+ cartridge, Abbott Point of Care Inc., USA). The analysis was carried out immediately after blood sampling. The arterial blood sample was collected by 0.3 ml though the arterial catheter and catheter was flushed with 0.3 ml heparinized saline after each blood sampling.

Statistical analyses

Values were presented as mean ± standard deviation. Statistical analyses were performed with IBM SPSS Statistics Version 19 (IBM SPSS Inc, Chicago, IL, USA). The differences between groups were statistically analyzed by repeated measure analysis of variance (ANOVA). Paired *t*-test was performed to analyze differences between baseline and other values within groups. Statistical differences were compared between group PRP and ISF at each periods using the independent *t*-test.

Results

IOP

In IOP, there was significant difference between groups ($F[1,12] = 66.51$, $p < 0.001$). The results are shown in Fig. 1 and 2. The values of IOP in the right eye between group PRP and group ISF were significantly different at independent *t*-test throughout anesthesia ($p < 0.05$).

Right eye's (OD [oculus dexter]) IOP of group PRP were decreased compared to baseline at 10 to 75 min, and that of group ISF were increased at 30 to 90 min (Fig 1). Left eye's (OS [Oculus Sinister]) IOP showed significant difference between group PRP and ISF ($F[1,12] = 108.19$, $p < 0.001$). Significant differences also appeared between groups in entire anesthetic state. Significant differences were found between

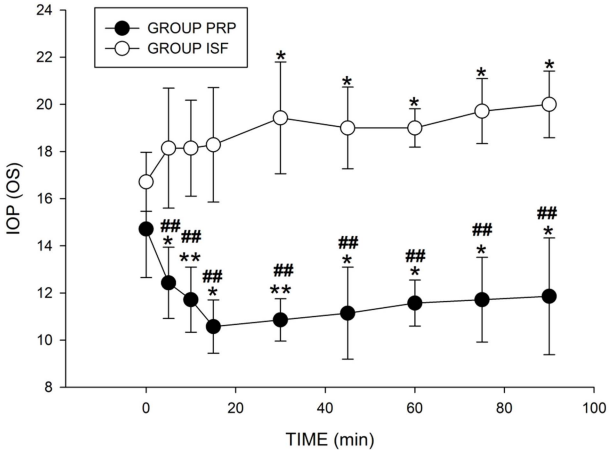

Fig 2. IOP of left eyes in dogs anesthetized with isoflurane or propofol and remifentanil combination. Group PRP: Group anesthetized with propofol and remifentanil combination; Group ISF: Group anesthetized with isoflurane. Data are expressed as mean ± SD. *,**; significantly different from baseline ($p < 0.05$, $p < 0.001$, respectively). #,##; significantly different between groups ($p < 0.05$, $p < 0.001$, respectively).

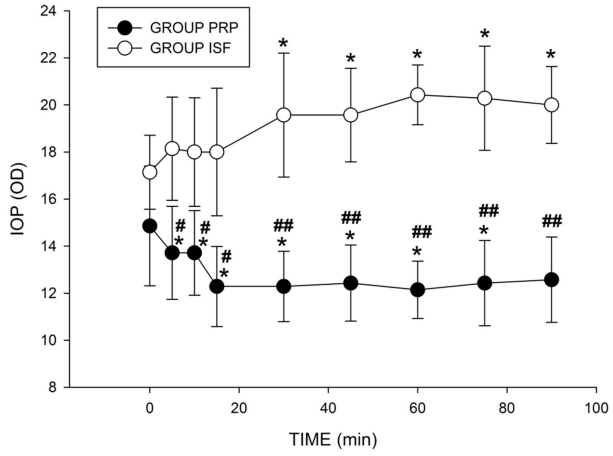

Fig 1. IOP of right eyes in dogs anesthetized with isoflurane or propofol and remifentanil combination. Group PRP: Group anesthetized with propofol and remifentanil combination; Group ISF: Group anesthetized with isoflurane. Data are expressed as mean ± SD. *; significantly different from baseline ($p < 0.05$). #,##; significantly different between groups ($p < 0.05$, $p < 0.001$, respectively).

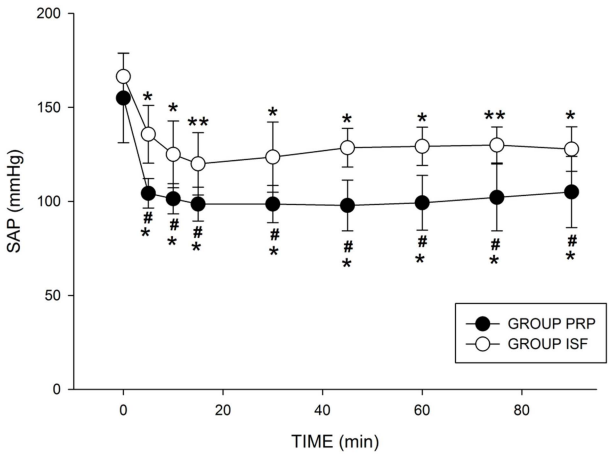

Fig 3. Systolic arterial blood pressure in dogs anesthetized with isoflurane or propofol and remifentanil combination. Group PRP: Group anesthetized with propofol and remifentanil combination; Group ISF: Group anesthetized with isoflurane. Data are expressed as mean ± SD. *,**; significantly different from baseline ($p < 0.05$, $p < 0.001$, respectively). #; significantly different between groups ($p < 0.05$).

baseline and other measuring time in group PRP and ISF at 5 to 90 min and 30 to 90 min, respectively (Fig 2).

The mean IOP values of OS were lower than those of OD, but there were no significant statistical differences.

Hemodynamic parameters

In systolic arterial blood pressure, there was significant difference between groups ($F[1,12] = 20.49$, $p = 0.001$).

Comparing with group ISF, significant decreases in group PRP were observed ($p < 0.05$) and, comparing with baseline, SAP was decreased after anesthesia in both groups ($p < 0.05$, Fig 3).

According to repeated measure analysis, DAP values in group PRP showed significantly decrease compared with group ISF ($F[1,12] = 38.84$, $p < 0.001$, Fig 4). In comparison with group ISF, Independent *t*-test revealed that there were significant decreases in group PRP ($p < 0.05$). Statistically meaningful decreases within groups were also observed ($p < 0.05$).

MAP were significantly decreased in group PRP compared with group ISF ($F[1,12] = 45.57$, $p < 0.001$). All values were decrease in both groups after anesthesia ($p < 0.05$). In all groups, independent *t*-test showed significant decrease in all time point besides at baseline (Fig 5).

Heart rates were significantly decreased in group PRP compared with group ISF ($F[1,12] = 47.88$, $p < 0.001$). In group ISF, the values of heart rates were increased during entire anesthesia compared with baseline. In group PRP, significantly decreased heart rates were observed after 30 min (Fig 6).

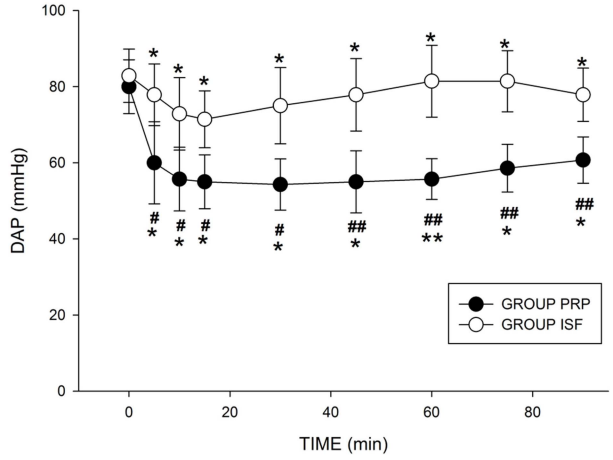

Fig 4. Diastolic arterial blood pressure in dogs anesthetized with isoflurane or propofol and remifentanil combination. Group PRP: Group anesthetized with propofol and remifentanil combination; Group ISF: Group anesthetized with isoflurane. Data are expressed as mean ± SD. *,**; significantly different from baseline ($p < 0.05$, $p < 0.001$, respectively). #,##; significantly different between groups ($p < 0.05$, $p < 0.001$, respectively).

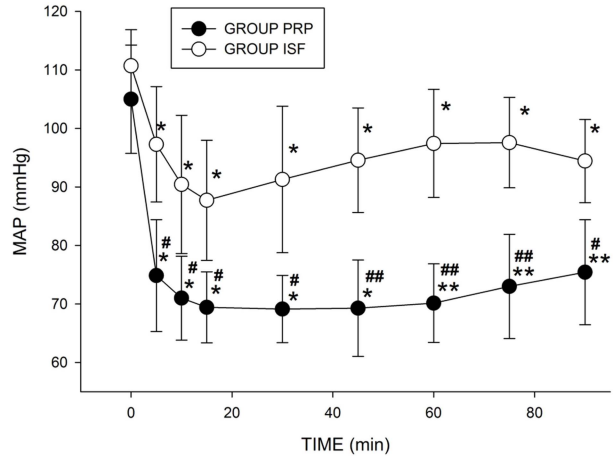

Fig 5. Mean arterial blood pressure in dogs anesthetized with isoflurane or propofol and remifentanil combination. Group PRP: Group anesthetized with propofol and remifentanil combination; Group ISF: Group anesthetized with isoflurane. Data are expressed as mean ± SD. *,**; significantly different from baseline ($p < 0.05$, $p < 0.001$, respectively). #,##; significantly different between groups ($p < 0.05$, $p < 0.001$, respectively).

Blood gas analyses

pH

There was no significant difference between groups. Mean pH during anesthesia was 7.395 and 7.366 in group PRP and group ISF, respectively. During anesthesia, ranges of pH were 7.321 to 7.475 in group PRP and 7.283 to 7.422 in group ISF (Fig 7).

$PaCO_2$

In anesthetic period, mean values of $PaCO_2$ were 39.9 in group PRP and 41.9 in group ISF. No significant difference was observed between groups. $PaCO_2$ did not over 50 mmHg in all measuring times (Fig 8).

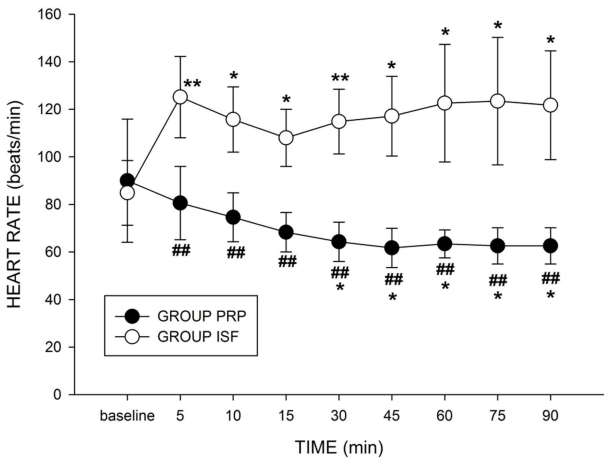

Fig 6. Heart rates in dogs anesthetized with isoflurane or propofol and remifentanil combination. Group PRP: Group anesthetized with propofol and remifentanil combination; Group ISF: Group anesthetized with isoflurane. Data are expressed as mean ± SD. *,**; significantly different from baseline ($p < 0.05$, $p < 0.001$, respectively). ##; significantly different between groups ($p < 0.001$).

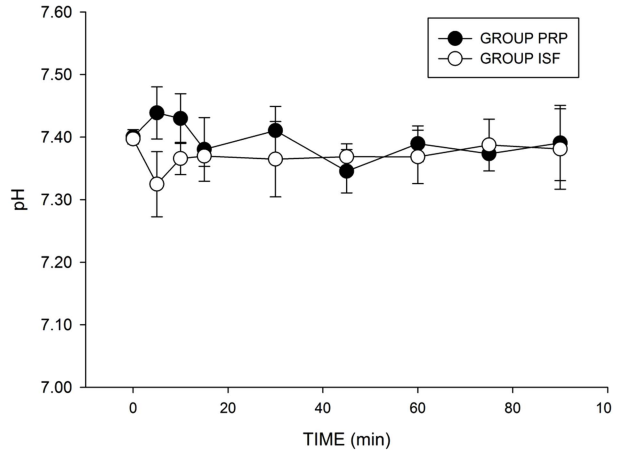

Fig 7. Blood pH in dogs anesthetized with isoflurane or propofol and remifentanil combination. Group PRP: Group anesthetized with propofol and remifentanil combination; Group ISF: Group anesthetized with isoflurane. Data are expressed as mean ± SD.

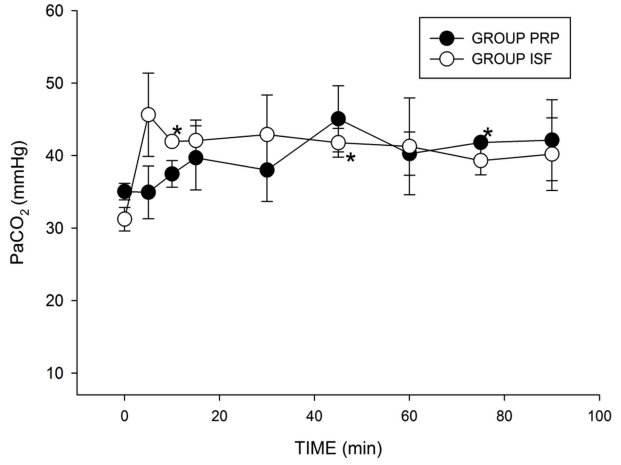

Fig 8. $PaCO_2$ in dogs anesthetized with isoflurane or propofol and remifentanil combination. Group PRP: Group anesthetized with propofol and remifentanil combination; Group ISF: Group anesthetized with isoflurane. Data are expressed as mean ± SD. *; significantly different from baseline ($p < 0.05$).

PaO_2

Mean PaO_2 during anesthesia was 564 and 589 in group PRP and group ISF, respectively. The range PaO_2 was 477 to 613 and 542 to 636 in group PRP and group ISF, respectively. There was no significant difference between groups (Fig 9).

SaO_2

There was no significant difference between groups. After anesthesia, SaO_2 in all measuring time in both groups were maintained as 100% (Fig 10).

tCO_2

No significant difference was observed between groups (Fig 11). During anesthesia, mean values of tCO_2 were 25.3

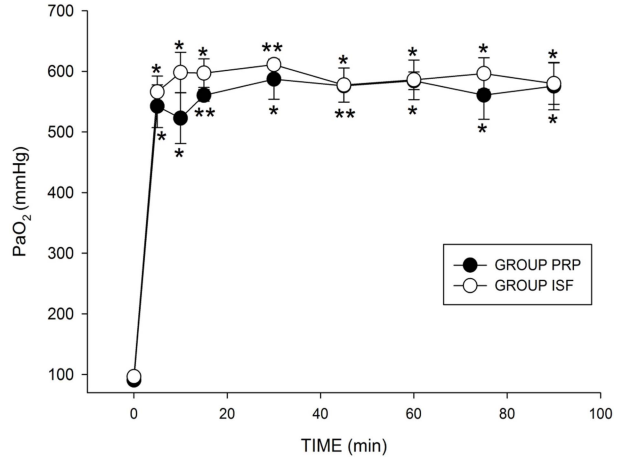

Fig 9. PaO_2 in dogs anesthetized with isoflurane or propofol and remifentanil combination. Group PRP: Group anesthetized with propofol and remifentanil combination; Group ISF: Group anesthetized with isoflurane. Data are expressed as mean ± SD. *, **; significantly different from baseline ($p < 0.05$, $p < 0.001$, respectively).

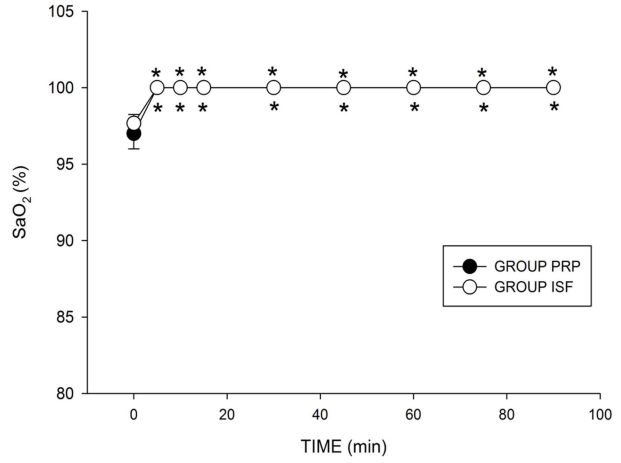

Fig 10. SaO_2 in dogs anesthetized with isoflurane or propofol and remifentanil combination. Group PRP: Group anesthetized with propofol and remifentanil combination; Group ISF: Group anesthetized with isoflurane. Data are expressed as mean ± SD. *; significantly different from baseline ($p < 0.05$).

and 25.1 in group PRP and ISF, respectively.

HCO_3^-

Mean values of HCO_3^- during anesthesia were 25.3 in group PRP and 25.1 in group ISF. No significant difference was observed between groups (Fig 12).

Discussion

Propofol solely provide unsatisfactory analgesia, therefore, it requires combination of proper analgesic drug and, until now, remifentanil seems to be the most adequate agent. However, because hypoventilation is inevitable side effect of

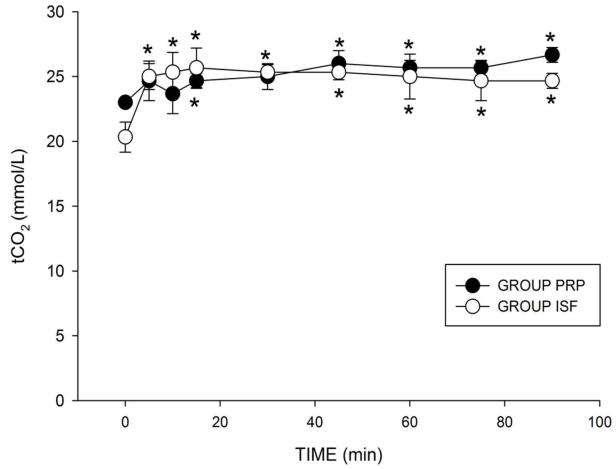

Fig 11. tCO_2 in dogs anesthetized with isoflurane or propofol and remifentanil combination. Group PRP: Group anesthetized with propofol and remifentanil combination; Group ISF: Group anesthetized with isoflurane. Data are expressed as mean ± SD. *; significantly different from baseline ($p < 0.05$).

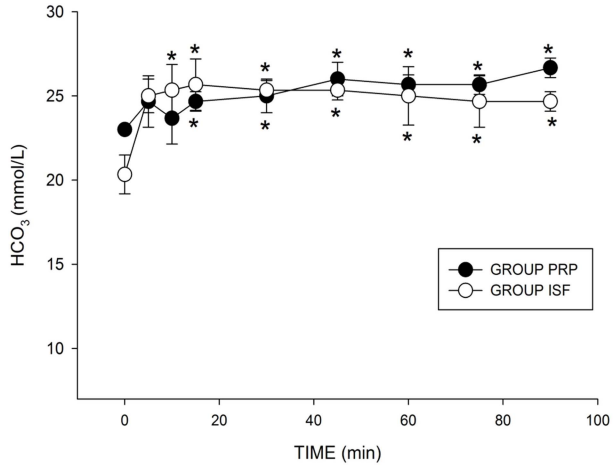

Fig 12. HCO_3^- in dogs anesthetized with isoflurane or propofol and remifentanil combination. Group PRP: Group anesthetized with propofol and remifentanil combination; Group ISF: Group anesthetized with isoflurane. Data are expressed as mean ± SD. *; significantly different from baseline ($p < 0.05$).

this regime, intermittent positive pressure ventilation is essential in total intravenous anesthesia with propofol and remifentanil (24). Because increased CO_2 tension could prevent decreasing IOP effect of propofol, the control of CO_2 tension was considered to be necessary (4).

During anesthesia, blood pressure of group PRP was lower than that of group ISF in entire anesthetized period but blood pressures were stable in both groups within normal range.

It was known that mild hypotensive anesthesia rarely caused the side effect, such as postoperative vision loss, and most studies showed no decrease cerebral blood flow while hypotensive anesthesia. Although the use of deliberative hypotensive anesthesia needs cautions, it is known as safe, typically (25,29).

In this study, blood pressures were mildly decreased within the normal range, but proper titrations of each agent could make deliberative hypotensive anesthesia and it could be utilized in handling of blood rich tissue, such as the choroidal plexus, retina and iris.

In blood gas analyses, there were no significant differences between groups in all measured parameters such as pH, $PaCO_2$, PaO_2, SaO_2, tCO_2 and HCO_3^-. $PaCO_2$ were maintained below 50 mmHg in both group. During anesthesia, SaO_2 were maintained as 100% and PaO_2 were over 450 in both groups.

Dogs were positioned in right lateral recumbency and, although mean values were a little higher in right eyes, there were no statistically differences between the right and left eyes.

The acepromazine, propofol and remifentanil concentrations used in this study were based on a previous published literature (13), but atracurium was premedicated to facilitate IOP measurement and mechanical ventilation. It is reported that atracurium could remain eye position centrally by relaxing surround muscles, and the effect of atracurium on cardiovascular system and IOP were minimal during anesthesia (22).

In this experiment, isoflurane induced the increase of IOP after 30 min in both eyes. Although the results in this study contradict some previous studies describing the reduction of IOP by volatile agent, increase of IOP was also suggested in dogs anesthetized with sevoflurane and desflurane (1,2). IOP, in spite of increase, was maintained within the normal range throughout total anesthetic period.

According to the literatures, propofol has some contradictory effects in dogs. Propofol decreased IOP during general anesthetic state (7) but induction with propofol could induce moderate and transient increase IOP (18,19). In addition, endotracheal tube insertion causes steep increase of IOP by the hemodynamic response and coughing in human. But remifentanil and atracurium is expected to alleviate or prevent increase of IOP (16,36).

It is well known that the combination of propofol and remifentanil effectively reduces IOP in human (32) but, because some anesthetic agents have different effects between human and dogs, obvious correlations of IOP with propofol in dogs should be defined.

In the situation that mild increase in IOP might be deleterious to the eyes, combination of propofol and remifentanil could be concerned as an alternative anesthetic method.

In this study, combination of propofol and remifentanil could provide stable and effectively reduced IOP and blood pressure compared with isoflurane.

Acknowledgement

This research was supported by Kyungpook National University Research Fund, 2011

References

1. Almeida DE, Rezende ML, Nunes N, Laus JL. Evaluation of intraocular pressure in association with cardiovascular parameters in normocapnic dogs anesthetized with sevoflurane and desflurane. Vet Ophthalmol 2004; 7: 265-269.
2. Almeida DE, Nishimori CT, Oria AP, Paula DP, Nunes N, Laus JL. Effects of nitrous oxide on IOP and pupillary diameter in dogs anesthetized with varying concentrations of desflurane. Vet Ophthalmol 2008; 11: 170-176.
3. Aroni F, Iacovidou N, Dontas I, Pourzitaki C, Xanthos T. Pharmacological aspects and potential new clinical applications of ketamine: reevaluation of an old drug. J Clin Pharmacol 2009; 49: 957-964.
4. Batista CM, Laus JL, Nunes N, Patto Dos Santos PS, Costa JL. Evaluation of intraocular and partial CO_2 pressure in dogs anesthetized with propofol. Vet Ophthalmol 2000; 3: 17-19.
5. Beers R, Camporesi E. Remifentanil update: clinical science and utility. CNS Drugs 2004; 18: 1085-1104.
6. Beier SL, de Araujo Aguiar AJ, Vianna PT, Mattoso CR, Massone F. Effect of remifentanil on requirements for propofol administered by use of a target-controlled infusion system for maintaining anesthesia in dogs. Am J Vet Res 2009; 70: 703-709.
7. Biricik HS, Sindak N, Ceylan C, Hayat A. A comparison of the effects of propofol and thiopental on intraocular pressure in dogs. J Anim Vet Adv 2010; 9: 1160-1163.
8. Degoute CS, Ray MJ, Gueugniaud PY, Dubreuil C. Remifentanil induces consistent and sustained controlled hypotension in children during middle ear surgery. Can J Anaesth 2003; 50: 270-276.
9. Degoute CS, Ray MJ, Manchon M, Dubreuil C, Banssillon V. Remifentanil and controlled hypotension; comparison with nitroprusside or esmolol during tympanoplasty. Can J Anaesth 2001; 48: 20-27.
10. Dershwitz M, Michalowski P, Chang Y, Rosow CE, Conlay LA. Postoperative nausea and vomiting after total intravenous anesthesia with propofol and remifentanil or alfentanil: how important is the opioid? J Clin Anesth 2002; 14: 275-278.
11. Egan TD. Pharmacokinetics and pharmacodynamics of remifentanil: an update in the year 2000. Curr Opin Anaesthiol 2000; 13: 449-455.
12. Ghaffari MS, Rezaei MA, Mirani AH, Khorami N. The effects of ketamine-midazolam anesthesia on intraocular pressure in clinically normal dogs. Vet Ophthalmol 2010; 13: 91-93.
13. Gimenes AM, de Araujo Aguiar AJ, Perri SH, de Paula Nogueira G. Effect of intravenous propofol and remifentanil on heart rate, blood pressure and nociceptive response in acepromazine premedicated dogs. Vet Anaesth Analg 2011; 38: 54-62.
14. Glowaski MM, Wetmore LA. Propofol: application in veterinary sedation and anesthesia. Clin Tech Small Anim Pract 1999; 14: 1-9.
15. Göbel K, Rüfer F, Erb C. Physiology of aqueous humor formation, diurnal fluctuation of intraocular pressure and its significance for glaucoma. Klin Monbl Augenheilkd 2011; 228: 104-108.
16. Hanna SF, Ahmad F, Pappas ALS, Mikat-Stevens M, Jellish WS, Kleinman B, Avramov MN: The effect of propofol/remifentanil rapid-induction technique without muscle relaxants on intraocular pressure. J Clin Anesth 2010; 22: 437-442.
17. Hofmeister EH, Mosunic CB, Torres BT, Ralph AG, Moore PA, Read MR. Effects of ketamine, diazepam, and their combination on intraocular pressures in clinically normal dogs. Am J Vet Res 2006; 67: 1136-1139.
18. Hofmeister EH, Williams CO, Braun C, Moore PA. Propofol versus thiopental: effects on peri-induction intraocular pressures in normal dogs. Vet Anaesth Analg 2008; 35: 275-281.
19. Hofmeister EH, Weinstein WL, Burger D, Brainard BM, Accola PJ, Moore PA. Effects of graded doses of propofol for anesthesia induction on cardiovascular parameters and intraocular pressures in normal dogs. Vet Anaesth Analg 2009; 36: 442-448.
20. Llobet A, Gasull X, Gual A. Understanding trabecular meshwork physiology: a key to the control of intraocular pressure? News Physiol Sci 2003; 18: 205-209.
21. Malik A, Fletcher EC, Chong V, Dasan J. Local anesthesia for cataract surgery. J Cataract Refract Surg 2010; 36: 133-152.
22. McMurphy RM, Davidson HJ, Hodgson DS. Effects of atracurium on intraocular pressure, eye position, and blood pressure in eucapnic and hypocapnic isoflurane-anesthetized dogs. Am J Vet Res 2004; 65: 179-182.
23. Mertens MJ, Olofsen E, Engbers FH, Burm AG, Bovill JG, Vuyk J. Propofol reduces perioperative remifentanil requirements in a synergistic manner: response surface modeling of perioperative remifentanil-propofol interactions. Anesthesiology 2003; 99: 347-359.
24. Moerman AT, Struys MM, Vereecke HE, Herregods LL, De Vos MM, Mortier EP. Remifentanil used to supplement propofol does not improve quality of sedation during spontaneous respiration. J Clin Anesth 2004; 16: 237-243.
25. Moss E. Cerebral blood flow during induced hypotension. Br J Anaesth 1995; 74: 635-637.
26. Musk GC, Flaherty DA. Target-controlled infusion of propofol combined with variable rate infusion of remifentanil for anaesthesia of a dog with patent ductus arteriosus. Vet Anaesth Analg 2007; 34: 359-364.
27. Nieuwenhuijs DJ, Olofsen E, Romberg RR, Sarton E, Ward D, Engbers F, Vuyk J, Mooren R, Teppema LJ, Dahan A. Response surface modeling of remifentanil-propofol interaction on cardiorespiratory control and bispectral index. Anesthesiology 2003; 98: 312-322.
28. Rama-Maceiras P, Ferreira TA, Molins N, Sanduende Y, Bautista AP, Rey T. Less postoperative nausea and vomiting after propofol + remifentanil versus propofol + fentanyl anaesthesia during plastic surgery. Acta Anaesthesiol Scand 2005; 49: 305-311.
29. Roth S. Perioperative visual loss: what do we know, what can we do? Br J Anaesth 2009; 103 Suppl 1: i31-40.
30. Sator-Katzenschlager S, Deusch E, Dolezal S, Michalek-Sauberer A, Grubmuller R, Heinze G, Wedrich A. Sevoflurane and propofol decrease intraocular pressure equally during non-ophthalmic surgery and recovery. Br J Anaesth 2002; 89: 764-766.
31. Sator S, Wildling E, Schabernig C, Akramian J, Zulus E, Winkler M. Desflurane maintains intraocular pressure at an equivalent level to isoflurane and propofol during unstressed non-ophthalmic surgery. Br J Anaesth 1998; 80: 243-244.
32. Schäfer R, Klett J, Auffarth G, Polarz H, Völcker HE, Martin

E, Böttiger BW. Intraocular pressure more reduced during anesthesia with propofol than with sevoflurane: both combined with remifentanil. Acta Anaesthesiol Scand 2002; 46: 703-706.
33. Servin FS. Remifentanil: an update. Curr Opin Anaesthesiol 2003; 16: 367-372.
34. Smith I, White PF, Nathanson M, and Gouldson R. Propofol. An update on its clinical use. Anesthesiology 1994; 81: 1005-1043.
35. Tiefenthaler W, Gabl M, Teuchner B, Benzer A. Intraocular pressure during lumbar disc surgery in the knee-elbow position. Anaesthesia 2005; 60: 878-881.
36. Vinik HR. Intraocular pressure changes during rapid sequence induction and intubation: a comparison of rocuronium, atracurium, and succinylcholine. J Clin Anesth 1999; 11: 95-100.
37. Visser K, Hassink EA, Bonsel GJ, Moen J, Kalkman CJ. Randomized controlled trial of total intravenous anesthesia with propofol versus inhalation anesthesia with isoflurane-nitrous oxide: postoperative nausea with vomiting and economic analysis. Anesthesiology 2001; 95: 616-626.
38. Vuyk J, Mertens MJ, Olofsen E, Burm AG, Bovill JG. Propofol anesthesia and rational opioid selection: determination of optimal EC50-EC95 propofol-opioid concentrations that assure adequate anesthesia and a rapid return of consciousness. Anesthesiology 1997; 87: 1549-1562.
39. Vuyk J. Pharmacokinetic and pharmacodynamic interactions between opioids and propofol. J Clin Anesth 1997; 9: S23-S26.
40. Weindler J, Weindler M, Ruprecht KW. Local anesthesia in ophthalmic surgery. Ophthalmologe 2004; 101: 847-864.
41. Woo JH, Au Eong KG, Kumar CM. Conscious sedation during ophthalmic surgery under local anesthesia. Minerva Anestesiol 2009; 75: 211-219.

개에서 Propofol/Remifentanil 병용마취 후 안압 및 혈역학 변화

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요 약 : 본 실험에서는 propofol과 remifentanil 병용 마취법 사용 시 안압 및 혈액학적 변화를 측정하고 isoflurane 마취 결과와 비교하였다. 건강한 14마리의 비글견을 7마리씩 2군 (PRP군, ISF군)으로 나누었으며 PRP군은 마취 도입 10분 전에 acepromazine (0.05 mg/kg, IV)으로 전마취제 투여하고 atracurium 0.1 mg/kg 투여 후, propofol (5 mg/kg, IV)으로 마취 유도하였다. 마취 유지에는 propofol (0.2 mg/kg/min)과 remifentanil (0.5 μg/kg/min)을 사용하였다. ISF군에서는 propofol (5~7 mg/kg, IV)로 마취를 유도하고, isoflurane 흡입마취법으로 마취를 유지하였다. 초기 isoflurane 농도를 3%으로 유지하다가 마취가 안정된 후 1.9%로 낮추어 유지 하였다. 모든 군에서 간헐적인 100% 양압 호흡을 사용해 CO_2는 38에서 45 mmHg사이를 유지하고 SpO_2는 95에서 100사이를 유지하였다. 총 마취 시간은 90분이었으며 안압, 혈압, 심박수를 각각 5, 10, 15, 30, 45, 60, 75, 90에 측정을 하였다. 실험 결과 propofol과 remifentanil 병용마취법이 isoflurane 흡입마취법 보다 안정적으로 안압과 혈압을 낮출 수 있었다.

주요어 : IOP, blood pressure, remifentanil, propofol, 개