A comparative study on some cardiopulmonary effects, anesthesia quality, and recovery time of isoflurane vs. propofol in domestic pigeons (*Columba livia domesticus*)

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Abstract:

BACKGROUND: It is commonly acknowledged that the most safe and method of choice anesthesia in birds is inhalation anesthesia but in some clinical situations, such as tracheal resection, injectable anesthetic agents are the only choice of surgeons regardless of whether or not an anesthesia machine is available. **OBJECTIVES:** This study aimed to compare the quality of anesthesia and recovery time of isoflurane and propofol in domestic pigeons. **METHODS:** Twenty pigeons (Columba livia domesticus), weighing 302.5±37.95g (Mean ± SD) were randomly allocated to two groups of ten. One group was anesthetized by isoflurane (Iso-group), and the anesthesia lasted for 30 minutes. The other group received 14 mg/kg of propofol (1%) at constant rate (CRI) through basilica (wing) vein catheter to induce anesthesia (Pro-group). 1.33 mg/kg per min of propofol was infused to keep pigeons anesthetized for 30 minutes, using an injection pump. Temperature, heart rate, respiratory rate, and percentage of oxygen saturation of hemoglobin (SpO2%) were recorded in all three phases including before induction of anesthesia, during anesthesia at minutes 1, 3, 5, 10, 15, 20, 25 and 30, and after recovery time in both groups. **RESULTS:** Anesthesia caused significant effects on respiratory rate, heart rate, and SpO2% ($p \leq 0.05$). Recovery times in both groups were significantly different (longer in propofol group). **CONCLUSIONS:** Our findings revealed that the pigeons anesthetized with isoflurane have a soft and fast anesthesia; however, the pigeons were anesthetized with propofol, had a rough induction that was not uniform for all pigeons. Isoflurane showed that it is safer than propofol to anesthetize pigeons.

Introduction

Domestic pigeons have been used for thousands of years to carry brief written messages, racing, pigeon shows, kept as an avian pet, and as food for protein supply (Blechman, 2006 ; Vriends and Erskine, 2005). Pigeons are very delicate birds and any mishandling can lead to immediate shock and death (Durrani et al., 2008). Sometimes, pigeons are presented at veterinary clinics under critical conditions such as tumors removal, orthopedic surgeries, or suturing wounds in which surgeons need to perform general anesthesia for a safe and pain-

less surgery. Wild birds require anesthesia not only for surgical interventions but also during diagnostic procedures (Muller et al., 2011). Currently, inhalation anesthesia by isoflurane or more recently synthesized sevoflurane is the method most usually used. The inhalation anesthesia ensures a short induction time, a short recovery, minimal depression of cardiopulmonary function and limited organ toxicity. However, surgeons may be exposed to anesthetic gases when surgical procedures expose the coelomic cavity or respiratory tract (Langlois et al., 2003). For these procedures and some clinical situations (such as surgeries on the beak, oropharynx, and trachea) when intubation is not possible, alternative anesthetic methods are needed (Muller et al., 2011).

There are many injectable anesthetic agents e.g. alpha-2-adrenoceptor agonists (detomidine, xylazine), pentothal sodium, ketamine, and diazepam (Durrani et al., 2008). Most injectable anesthetics are inexpensive and rapid acting; however, whenever given intramuscularly, induction and recovery periods may take a long time accompanied by excitations, inadequate muscle relaxation, and depression of the cardiovascular system (Muller et al., 2011). Propofol is a non-barbiturate isopropyl phenol, ultra short acting intravenous anesthetic agent commonly used in human and veterinary anesthesia (Smith et al., 1994). Recent studies in avian species suggest that propofol may be a useful injectable agent for induction and maintenance of anesthesia (Mama et al., 1996; Machin and Caulkett, 1998 ; Kilic N and Pasa, 2009). The advantages of propofol use include rapid induction, short duration of action, and quick recovery. Propofol induction and maintenance in a barn owl and in wild turkeys resulted in minimal impairment of cardiopulmonary function and also in smooth, rapid, and unremarkable recoveries (Mama et al., 1996; Schumacher et al., 1997). Propofol is usually used for anesthetic induction or as the main drug to maintain anesthesia when inhalational anesthesia is not available. The purpose of this study was the comparative evaluation of the cardiopulmonary and anesthetic effects of either isoflurane or propofol in domestic pigeons.

Materials and Methods

Twenty domestic pigeons (Columba livia domesticus), weighing 302.5±37.95g (Mean ± SD) were anesthetized with either isoflurane or propofol. All pigeons were kept in the same conditions from 24 hours before the study began.

The first group anesthetized with isoflurane (Iso-group n=10) without any pre-anesthetic drugs. Anesthesia was induced with 5% isoflurane in 500ml/min oxygen administered by face mask (Small Animal Anesthesia Ventilator, Model 3000, Matrx®, USA). Immediately following induction, all birds were intubated with an uncuffed 3.0-mm endotracheal tube. Anesthesia was maintained for 30 minutes with isoflurane. The average concentration of isoflurane during anesthesia was 2% in 500ml/min oxygen.

The second group of the pigeons (Pro-group n=10), which did not take any pre-anesthetic drugs, received propofol intravenously. Either basilic vein was catheterized (24 gauge). The anesthesia was induced with propofol (Pofol, Dongkook, Korea, 1%) 14 mg/kg IV over one minute and maintained for 30 minutes by constant rate infusion (1.33 mg/kg per min) via a syringe pump (Syringe pump SP-510, JMS Co., Japan). An uncuffed endotracheal tube was placed in the trachea for supplemental oxygen delivery (500 ml/min).

Induction time was defined as the elapsed time from administration of isoflurane or propofol to losing the righting reflex. Body temperature was monitored through cloaca by a digital thermometer. Heart rate was recorded by pulse oximeter (Capnograph and Digital Pulse Oximeter, V90041, Surgivet®, Smiths

Medical ASD, Inc, USA) and electrocardiograph.

Standard limb leads electrocardiogram was recorded (Lopez Murcia et al., 2005). The respiratory rate was easily determined by watching abdomen and chest movements. Peripheral capillary oxygen saturation (SpO2) was monitored by pulse oximeter device placing. The probe was positioned over the gastrocnemius and tibialis cranialis muscles. All criteria were recorded at three separate phases including before induction of anesthesia, during anesthesia at minutes 1, 3, 5, 10, 15, 20, 25, and 30, and after recovery. Recovery time was defined as the time from discontinuation of anesthesia until the time when the bird was standing. During anesthesia period palpebral, corneal and pain reflex to toe pinch were checked to evaluate the anesthesia depth.

To compare the two groups' recorded parameters during the study period, the "Independent samples T-test" was used, and to investigate changes in these parameters between the different measurements in each group the "Repeated measure ANOVA test" was used. P value equal or less than 0.05 was considered significant.

Results

Anesthesia caused significant effects on respiratory rate, heart rate, and %SPO2 ($p \leq 0.05$). The recovery times were significantly different.

Isoflurane study: Induction with isoflurane was rapid (119±55 sec; Mean ± SD). Intubation was easily performed. Temperature reduced throughout the anesthetic span and decreased significantly after 30 minutes (37.0±1.1˚C; Mean ± SD) when compared with the results obtained before induction (41.8 ± 0.5˚C; Mean ± SD) of anesthesia (Table 1). The respiratory rate decreased significantly 1 minute after induction (22.8±11.3 breaths/min; Mean ± SD); when compared to pre-induction phase (59.6±34 breaths/min) and thereafter remained constant (Table 2). Heart rate decreased significantly at minute 5 (155.80±25 bpm; Mean ± SD), compared to values obtained before induction (243.30±5.03 bpm; Mean ± SD). Pigeons of Iso-group showed bradycardia (Table 3). No significant differences in SpO2 values were seen over the time. The values remained around 95% (Table 4). Recovery time was 7.4±2.45 (Mean ± SD) minutes and recoveries were smooth and uneventful.

Propofol study: Propofol induction was not rapid (375±123 sec; Mean ± SD) and intubation was difficult in four birds because of the light plane of anesthesia. The temperature decreased significantly after 30 minutes (38.3 ±1˚C; Mean ± SD) of anesthesia and thereafter when compared with the result obtained before induction (42.1 ±0.37˚C; Mean ± SD) of anesthesia (Table 1). There was a significant decrease in respiratory rate at minute 1 (48.9 ± 18 breaths/min) and minute 15 (38.8 ± 13 breaths/min; Mean ± SD) of anesthesia when compared with the respiratory rate recorded before induction (66.9 ± 11 breaths/min; Mean ± SD) (Table 2). A significant increase in heart rate was shown at minute 1 (413.10±66.22 bpm; Mean ± SD) when compared with value obtained exactly before induction (242.7±10.58 bpm; Mean ± SD). Pigeons of Pro-group showed tachycardia. Steady continuous increase in heart rate after minute 1 was observed (Table 3). The SpO2 values decreased significantly at minute 10 (87% ±3.8%; Mean ± SD) and remained significantly low for the rest of the anesthetic span (Table 4). Recovery times were 32.7±8.8 (Mean ± SD) minutes and recoveries were smooth and uneventful.

Isoflurane versus propofol: There was a significant decrease in temperature with both isoflurane and propofol; however, only at minutes 25 and 30 after induction, greater decreases in body temperature were observed in the Iso-group in comparison with Pro-group ($p \leq 0.05$) (Table 1). Respiratory rates in Iso-group were

Table 1. Temperature changes in both groups. (*)Significant if p≤0.05.

Time (Minute)	Temperatures (˚C) Mean±SD		p value(*)
	Iso-group	Pro-group	
Before induction	41.86±0.51	42.12±0.37	0.215
1	41.41±0.65	41.09±0.89	0.376
5	40.32±0.86	40.33±0.87	0.980
10	39.35±0.72	39.74±0.88	0.315
15	38.76±0.72	39.12±1.02	0.378
20	38.25±0.68	38.79±1.00	0.180
25	37.57±0.77	38.55±0.99	0.025
30	36.99±1.14	38.30±1.03	0.015
After recovery	41.86±0.77	39.84±0.68	0.511

Table 2. Respiratory rate changes in both groups. (*)Significant if p≤0.05.

Time (Minute)	Respiratory rate (beats/minute) Mean±SD		p value(*)
	Iso-group	Pro-group	
Before induction	59.6±34.7	66.9±11.13	0.669
1	22.8±11.39	48.90±18.14	0.002
5	22.20±10.54	49.40±22.47	0.003
10	22.88±8.93	42.60±15.69	0.004
15	21.70±9.44	31.80±13.34	0.004
20	20.00±8.34	35.90±10.70	0.002
25	20.44±9.02	36.90±9.51	0.001
30	20.80±8.72	39.10±13.30	0.002
After recovery	30.66±10.40	46.20±14.05	0.014

Table 3. Heart rate changes in both groups. (*)Significant if p≤0.05.

Time (Minute)	Heart rate (beats/minute) Mean±SD		p value(*)
	Iso-group	Pro-group	
Before induction	243.30±5.03	242.7±10.58	0.874
1	173.11±15.90	413.10±66.22	0.00
5	155.80±25.70	398.33±66.33	0.00
10	157.22±23.83	399.00±46.65	0.00
15	166.80±15.41	383.20±30.20	0.00
20	178.80±42.65	357.60±37.48	0.00
25	189.33±41.18	358.30±41.02	0.00
30	189.40±41.07	362.00±31.64	0.00

significantly lower than Pro-group (p≤0.05) (Table 2) all over the experiment. Comparison between isoflurane and propofol anesthesia revealed significant differences in heart rates throughout the anesthetic event. The heart rates were significantly higher in Pro-group than in Iso-group at any given time (Table 3). The SpO2 values were significantly higher in Iso-group than in Pro-group during experiment (Table 4). Four out of 10 birds anesthetized with propofol retained their palpebral reflexes, flapped their wings, or reacted to toe pinch at one or more recordings during maintenance of anesthesia. Recovery times with propofol anesthesia were significantly longer when compared with isoflurane; 7.40±2.45 vs 32.70±8.85 (Minutes Mean±SD), for Iso-group and Pro-group respectively.

Discussion

The main indication for using an anesthetic drug is reducing the patient's level of consciousness for surgery to the extent that the senses (especially pain) do not work. Another reason for using an anesthetic drug in birds is to produce chemical restraint while radiography, endoscopy, or some other non-painful procedure is carried out. There are several inhalation anesthetics or injectable agents suitable for the purpose. Isoflurane is the anesthetic of choice for the avian patient. Induction may be achieved by face mask on 5% concentration, being turned down to 1.25-2% for maintenance, preferably delivered via an uncuffed endotracheal tube. When inhalation anesthetic agents are unavailable, a variety of injectable agents have been used in avian species with variable success (Langlois et al., 2003).

This is the first study that the effects of propofol and isoflurane anesthesia was assessed on physiological variables such as changes in body temperature, respiratory rate, heart rate, and %SPO2 in pigeons. Anesthesia with isoflurane and propofol has been studied in various species and according to species differences there were differences in the outcomes of anesthesia. In this study, to compare

Table 4. SpO2 changes in both groups. (*)Significant if p≤0.05.

Time (Minute)	SpO2 (%) Mean±SD		p value(*)
	Iso-group	Pro-group	
1	95.50±2.91	90.20±4.51	0.007
5	96.30±2.40	89.20±4.82	0.001
10	95.60±2.50	87.20±3.82	0.000
15	95.90±2.23	87.10±4.88	0.000
20	95.60±2.71	86.30±5.27	0.000
25	95.22±2.94	85.80±5.60	0.000
30	94.60±4.92	85.60±5.86	0.002

two method of anesthesia, two groups of pigeons were anesthetized with propofol and isoflurane. It was shown that pigeons of Iso-group had a smooth and rapid induction just like Pekin ducks (Goelz et al., 1990), chickens (Lukasikr et al., 1997), Hispaniolan Amazons (Langlois et al., 2003), and turkeys (Schumacher et al., 1997). Inhalational anesthetics also have variable effects among birds. Isoflurane anesthesia was associated with significant respiratory depression and minimal alteration of cardiovascular function in ducks (Ludders et al., 1990), sand hill (Ludders et al., 1989), and Hispaniolan Amazon parrots (Langlois et al., 2003) whereas a significant increase in heart rate and decrease in respiratory rate have been reported in Pekin ducks (Goelz et al., 1990). Similar to the response to isoflurane in galahs (Jaensch et al., 1999), respiratory and cardiac function was significantly depressed in the pigeons of present study. Pulse oximetry has been reported to be helpful to trace the trend of oxygenation in avian species (Schumacher et al., 1997 and Schmitt et al., 1998); however, values reported in this study are not absolute; because pulse oximeter machine was calibrated on the basis of the small animal oxygen-hemoglobin dissociation curve. No significant change in SpO2% value was observed over the time in the pigeons (minute 1=95.50±2.91, minute 30=94.60±4.92).

There is a marked variability in effective doses for injectable anesthetic agents between and within avian species. The induction doses of propofol used in this study were extrapolated from previous reports in pigeons with Fitzgerald and Cooper in 1990. Induction with 14 mg/kg of propofol was not rapid and (Smith et al., 1994). Birds were agitated. Moreover (Muller et al., 2011), pigeons retained palpebral reflexes, flapped their wings, or reacted to toe pinch one or more times during propofol infusion. The maintenance dose of this study provided only a light plane of anesthesia by comparison, induction was achieved in Hispaniolan Amazon parrots (Langlois et al., 2003), mallard ducks (Machin and Caulkett, 1998), wild turkeys (Schumacher et al., 1997), chickens (Lukasikr et al., 1997), and canvasback ducks (Machin and Caulkett, 1999) with 5 mg/kg, 10 mg/kg, 5 mg/kg, 4.5-9.7 mg/kg, and 15 mg/kg, respectively. A light plane of anesthesia was also achieved in the chickens and canvasback ducks (Lukasikr et al., 1997; Machin and Caulkett, 1999).

Temperature decreased significantly 1 minute after induction of pigeons with propofol and more with isoflurane when compared with values obtained before induction. This is consistent with studies involving propofol anesthesia in ostriches (Langan et al., 2000) and mallard ducks (Machin and Caulkett, 1998; Machin and Caulkett, 1999) and isoflurane anesthesia in mallard ducks (Machin and Caulkett, 1999). Temperature diminution during propofol anesthesia was more than isoflurane anesthesia (at time30 in Iso-group= 37, Pro-group=38.3).

A significant increase in heart rate was observed immediately 1 minute after induction of pigeons with propofol when compared with values obtained before induction. Although Mallard ducks (Machin and Caulkett, 1998), ostriches(Langan et al., 2000), Hispaniolan Amazon parrots (Langlois et al., 2003) and wild turkeys (Schumacher et al., 1997) exhibited a bradycardia immediately after induction, chickens(Lukasikr et al., 1997) had an increase in HR following propofol administration. This observation suggests that cardiovas-

cular responses may differ among birds.

Respiratory rate decreased significantly 1 minute and 10 to 15 minutes after propofol injection; however, apnea was not observed. In humans, apnea may occur for more than 30 seconds following induction in up to 83% of patients (Gold et al., 1987). Apnea was not observed in chickens (Lukasikr et al., 1997) and Hispaniolan Amazon parrots (Langlois et al., 2003) anesthetized with 4.5-9.7 and 5 mg/kg, respectively of propofol; however, apnea was observed in ostriches (Langan et al., 2000), mallard ducks (Machin and Caulkett, 1998), wild turkeys (Schumacher et al., 1997) and canvasback ducks (Machin and Caulkett, 1999) when anesthesia was induced by 3, 10, 5 and 15 mg/kg propofol, respectively.

The SpO2 values decreased significantly 5 minutes after induction with propofol and remained significantly decreased, with values below 89%. The SpO2 values with isoflurane were higher, but not significantly more different than with propofol at any given time. This outcome is consistent with studies involving wild turkeys (Schumacher et al., 1997), Hispaniolan Amazon parrots(Langlois et al., 2003), Ostriches (Langan et al., 2000), and mallard ducks (Machin and Caulkett, 1998). Delivery of isoflurane most likely accounted for the higher SpO2 values in the first anesthetic protocol compared with the values during propofol infusion.

Propofol caused pronounced respiratory depression in pigeons and canvasback ducks (Machin and Caulkett, 1999) and thus was considered to have a narrow margin of safety. To prevent hypoxemia associated with propofol in avian, supplementation of oxygen either by endotracheal intubation or placement of an air sac tube has been recommended (Schumacher et al., 1997; Machin and Caulkett, 1998; Machin and Caulkett, 1999) and in this study, supplemental oxygen was provided during propofol infusion.

In the pigeons, propofol recovery times (32.70 ± 8.8 min) were prolonged when compared with isoflurane (7.40 ± 2.45 min).. This finding differs from the use of propofol in mallard ducks (Machin and Caulkett, 1998) and chickens (Lukasikr et al., 1997) where recoveries were rapid. Prolonged recoveries following propofol anesthesia have been reported in great horned owls and red-tailed hawks (Hawkins et al., 2003). Finally, pharmacodynamics studies of propofol in avian species especially in pigeons have not been reported and metabolism of propofol may differ from mammals (Smith et al., 1994) or among avian species. Inadvance administration of analgesics (e.g. opioids) may reduce the dose of propofol required to induce and maintain anesthesia, and may improve the quality of recovery (Langlois et al., 2003). In conclusion, propofol is an effective agent for induction and maintenance of anesthesia in many avian species (Langlois et al., 2003). One of the major disadvantages of propofol in birds, especially in small birds, is the necessity of administering the drug intravenously which may be difficult or impractical in these patients. Hypothermia was associated with propofol administration in this study; therefore, application of external heat source(s) may reduce the occurrence of significant body temperature loss (Lierz and Korbel , 2012). Constant rate infusion of propofol requires close monitoring of the anesthetic depth. It can be concluded that in a pigeon, anesthesia protocol without use of any pre-anesthetic medications, using propofol (as a single drug) is not safe and secure in comparison to use of isoflurane alone. After all, for pigeons, isoflurane seems to be a better choice for anesthesia.

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