

Clinical evaluation of general anaesthesia in pigeons using a combination of ketamine and diazepam

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This study was undertaken to investigate the clinical effects of ketamine, diazepam and a ketamine and diazepam combination in the general anaesthesia of pigeons. Thirty-two pigeons of both sexes with body weights ranging from 280 g to 300 g were allocated randomly to four groups comprising eight birds each. Group D received a 0.5 mL mixture of diazepam (0.2 mg/kg) and normal saline, group K a 0.5 mL mixture of ketamine 5% (30 mg/kg) and normal saline, group D, group KD a 0.5 mL mixture of ketamine 5% (10 mg/kg), diazepam (0.2 mg/kg) and normal saline, whilst group C (control) received 0.5 mL of normal saline only. Each mixture was administered intramuscularly.

Under standard operating room conditions, general anaesthesia was not observed in group C (normal saline alone). In group D, sedation and muscle relaxation without complete loss of consciousness was observed. Induction time of anaesthesia in group KD was significantly quicker than group K ($p < 0.05$). Duration of anaesthesia in group KD was significantly longer than group K ($p < 0.05$). Recovery took longer in group KD in comparison with group K, but the difference was not statistically significant ($p > 0.05$). The birds in group KD were calm and sedated, with good muscle relaxation, whilst in group K the birds were excited and showed a drop in body temperature.

According to the results of this study, the combination of low dose ketamine hydrochloride (HCL) and diazepam overcame the adverse effects of ketamine alone. This combination produced a more rapid induction of anaesthesia, as well as an increase in anaesthesia duration, with good muscle relaxation and a smooth and slow recovery. Use of a combination of ketamine HCL given at 10 mg/kg and diazepam given at 0.2 mg/kg for anaesthesia in pigeons is therefore recommended.

Introduction

Avian anaesthetic and surgical techniques have progressed greatly in the last decade. The choice of anaesthesia and route of administration is often as important as the surgical procedure itself.¹ General anaesthesia in various avian species may be produced by administration of either inhalation or injectable agents.^{2,3} Injectable anaesthetics and sedatives can be administered intramuscularly, intravenously or intraosseously.⁴ Inhalation of anaesthesia is preferred for birds but requires expensive equipment. The use of an injectable agent in comparison with an inhalation agent has the advantage of increased speed of anaesthesia induction, the need for minimal equipment and a low cost.^{2,3,5}

Several injectable drugs are used in birds. These include barbiturates, chloral hydrate, phenothiazine derivatives, alpha-2 adrenergic agonists, ketamine and propofol.^{6,7,8} Pigeons are very sensitive birds and any mismanagement in a crisis can lead to immediate shock and death. Pigeons are often referred to a hospital in a critical condition and these birds require safe anaesthesia and painless surgery. In these situations, careful selection of the safest possible anaesthetic agent is very important.^{9,10}

Ketamine is a dissociative anaesthetic agent which can be used for the induction of general anaesthesia in many species by either the intravenous, intramuscular or intraosseous route.^{1,5,6} However, ketamine is rarely used as the sole sedative agent in birds. According to Athar et al.², ketamine has a wide safety margin in birds and as much as 10 times the therapeutic dose is normally required before symptoms of toxicity appear. For respiratory depression that may result from ketamine, supportive ventilation and administration of doxapram can be applied.

When ketamine is used as the sole anaesthetic agent, it produces poor muscle relaxation, muscle tremors, myotonic contractions, opisthotonos, persistent pain reflexes and stormy recoveries.^{11,12,13} Therefore, it is most often combined with other agents (alpha-2 adrenergic agonists, diazepam or azaperone), depending on the species involved.^{10,14,15} A combination of

ketamine and benzodiazepines (diazepam and midazolam) or ketamine and alpha-2 adrenergic agonists are commonly used for general anaesthesia in pigeons.^{9,10,15,16} Diazepam has potent muscle relaxant and anticonvulsant properties and has been used in a wide range of wild and domestic animals and birds.^{15,16,17} When used together, diazepam and ketamine have a synergistic effect, resulting in a smooth recovery and better muscle relaxation.^{11,18} Their efficacy is enhanced whilst minimising their unwanted adverse effects.

The purpose of this study was to compare the effects (time to onset of anaesthesia, duration of anaesthesia, duration of recovery, response to external stimuli, muscular relaxation, palpebral and pedal reflexes, and cloacal temperature) of diazepam and ketamine in pigeons when administered intramuscularly alone or combined.

Materials and methods

Birds

Thirty-two healthy adult pigeons of both sexes (9 males and 23 females) with body weights ranging from 280 g to 300 g were used in the study. All the pigeons were from the same flock and their ages were between 1 and 2 years. All the birds were acclimatised in a quiet room for 2 weeks. They were fed a wheat-based diet similar to their previous diet and had free access to water and food, except for a period of 1 h prior to drug administration. This minimised the chances of vomiting. Before the commencement of the study, the birds were found to be in good health, based on physical examinations.

Trial procedure

The pigeons were allocated randomly to four equal groups of eight birds each. The groups were differentiated as follows: in group D, diazepam was administered at a dose of 0.2 mg/kg, in group K, ketamine 5% was administered at a dose of 30 mg/kg, in group KD, a ketamine (5%) and diazepam combination was administered at a dose of 10 mg/kg and 0.2 mg/kg, respectively, whilst in group C (control), a 0.5 mL dose of normal saline was given per bird.

All medications were administered intramuscularly into the deep pectoral muscle using an insulin syringe. The medications in groups D, K and KD were diluted with normal saline to make a final volume of 0.5 mL.

Post-treatment monitoring

After drug administration, each bird was placed in sternal recumbency in separate cages, so that each bird could be observed individually and external stimulation was kept to a minimum.

The clinical parameters for each pigeon were as follows:

- The severity of opisthotonos was scored on a scale of 0–4: lack of opisthotonos was scored as 0 and those with severest opisthotonos were scored as 4.

- Onset of anaesthesia: Time interval (in minutes) from administration through the stages of anaesthesia to loss of consciousness.
- Duration of anaesthesia: Time interval (in minutes) from loss of consciousness to reappearance of sensation.
- Eyelids: scored as - for closed, + for half-opened and ++ for opened.
- Duration of recovery: Time interval (in minutes) from the return of reflexes to complete consciousness.
- The severity of excitability, such as wing flapping and ataxia was scored from 0 to 1. No excitability was scored as 0 and the birds showing most excitability were scored as 1.
- Muscle relaxation was tested in the muscles of the neck, wings and legs. The ease with which the wings of the birds could be pulled, their hind limbs could be flexed and the neck could be extended was recorded as the degree of muscle relaxation. It was graded on a scale of 0.0–3.0, where 0.0 represented weak relaxation. Birds given this score showed closed wings and stiff limbs. A score of 1.5 represented moderate relaxation where there was mild resistance to extension of the neck, opening of the wings and flexing of the limbs, whilst a score of 3.0 represented excellent relaxation where the birds showed a flaccid neck, no resistance to opening of the wings and flexing of limbs.
- Pedal reflex was evaluated by using a towel clamp forceps. The presence and strength of the reflex was scored based on a scale of 0–4, with 0 being a weak reflex and 4 being a strong reflex.
- Palpebral reflexes were tested by touching the eyelids with a sterile cotton tip swab. Lack or presence of the reflexes were scored as - or +, respectively.
- Cloacal temperature was measured before anaesthesia and again 10 min after induction of anaesthesia. A digital thermometer was used.

Statistical analysis

Opisthotonos, onset of anaesthesia, duration of anaesthesia and duration of recovery were compared using an independent *t*-test. The Kruskal-Wallis test was used to compare the mean scores amongst the different groups. Cloacal temperature was analysed by one-way ANOVA and Duncan's multiple-range test. All statements of significance were based on the 0.05 level of probability.

Ethical considerations

The Institutional Animal Care and Use Committee approved the protocol for this project, under the following project number 671.

Results

No anaesthesia or opisthotonos was observed in groups C and D. Diazepam alone produced better muscle relaxation than ketamine alone, but the muscle relaxation was not as good as with the ketamine and diazepam combination. Opisthotonos in the ketamine and diazepam combination

TABLE 1: Rate of opisthotonos and time taken in minutes for onset of anaesthesia, duration of anaesthesia and recovery period in pigeons treated with ketamine only and a ketamine and diazepam combination.

Groups	Opisthotonos	Onset of anaesthesia	Duration of anaesthesia	Recovery period	Excitement
K	3.50 ± 0.21	4.50 ± 0.41 ^a	8.13 ± 1.41 ^a	19.25 ± 2.69	0.90 ± 0.05 ^a
KD	3.80 ± 0.35	1.50 ± 0.23 ^b	14.10 ± 1.48 ^b	23.12 ± 2.85	0.20 ± 0.04 ^b

K, pigeons treated with ketamine; KD, pigeons treated with a ketamine and diazepam combination.

^{a,b}, Mean presented in column with different superscripts differing significantly ($p < 0.05$).

was more severe than with ketamine alone, but the difference was not statistically significant ($p > 0.05$) (Table 1). The onset of anaesthesia after injection was significantly quicker with the ketamine and diazepam combination (1.50 min ± 0.23 min) than with ketamine alone (4.50 min ± 0.41 min) ($p < 0.05$) (Table 1). The duration of anaesthesia in the KD group (14.10 min ± 1.48 min) was significantly higher than group K, where ketamine was used alone (8.13 min ± 1.41 min) ($p < 0.05$) (Table 1). Recovery from anaesthesia took longer with the ketamine and diazepam combination (23.12 min ± 2.85 min) compared with ketamine alone (19.25 min ± 2.69 min), but the difference was not statistically significant ($p > 0.05$) (Table 1). The excitability during the recovery was significantly less in group KD as compared with group K ($p < 0.05$). The pigeons that were treated with diazepam alone were calm and sedated during recovery (Table 1).

Muscle relaxation following the administration of the ketamine and diazepam combination was twice as pronounced than with diazepam alone ($p < 0.05$). Muscle relaxation was not observed in groups K and C (Figure 1). The pigeons' pedal reflexes were significantly weaker in groups K and KD when compared with groups C and D ($p < 0.05$). This reflex was markedly weaker with the ketamine and diazepam combination than with ketamine alone (Figure 2).

There were significant differences in eyelid status between group KD and groups C, D and K ($p < 0.05$). The eyelids of pigeons treated with the ketamine and diazepam combination were completely closed. With ketamine alone, the pigeons' eyes were completely open during anaesthesia (Table 2). There were no significant differences in the palpebral reflexes in the different groups and these were present in all the groups (Table 2). The cloacal temperature was 41.30 °C ± 0.72 °C before medication. When measured 10 min after drug administration in groups K and D, the cloacal temperature was recorded to have decreased significantly ($p < 0.05$). However, in pigeons from group KD, the cloacal temperature remained within the initial range, measuring at 40.93 °C ± 0.86 °C (Table 2).

Discussion

The dose and anaesthetic response of ketamine varies across different bird species.¹³ The recommended dosage of ketamine is approximately 10 mg/kg – 60 mg/kg, given intramuscularly or intravenously. Larger birds (greater than 1000 g) require a lower dose per kilogram (10 mg/kg). The recommended intramuscular and/or intravenous dosage of diazepam in birds is 0.2 mg/kg – 1 mg/kg.¹¹ In this study,

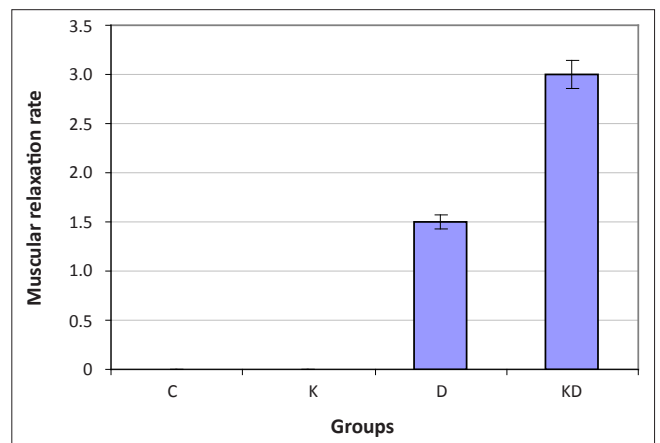
TABLE 2: The status of eyelids, response of palpebral reflex and cloacal temperature in pigeons of different groups.

Groups	Eyelids	Palpebral reflex	Cloacal temperature (°C)
C	++	+	41.30 ± 0.72 ^a
K	++	+	39.17 ± 0.59 ^b
D	++	+	38.52 ± .04 ^b
KD	-	+	40.93 ± 0.86 ^a

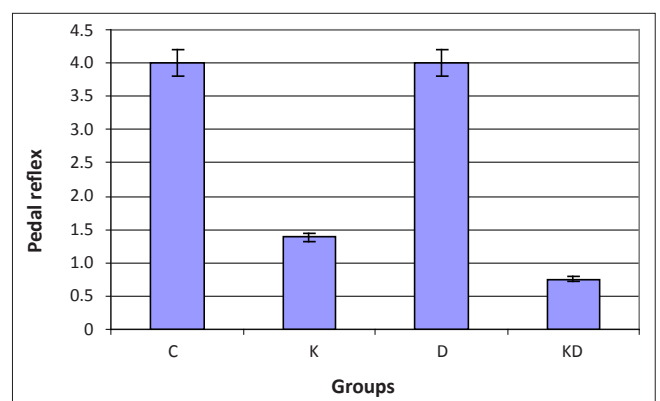
C, pigeons treated with saline; K, pigeons treated with ketamine; D, pigeons treated with diazepam; KD, pigeons treated with a ketamine and diazepam combination.

++, eyelids opened; -, eyelids closed; +, palpebral reflex present.

^{a,b}, Mean presented in column with different superscripts differing significantly ($p < 0.05$).



C, saline; K, ketamine; D, diazepam; KD, ketamine and diazepam combination.

FIGURE 1: The comparison of muscular relaxation across the groups of pigeons treated with normal saline, ketamine, diazepam, and a ketamine and diazepam combination, where a score of 0.0 represents weak relaxation, 1.5 represents moderate relaxation and 3.0 represents excellent relaxation.

C, saline; K, ketamine; D, diazepam; KD, ketamine and diazepam combination.

FIGURE 2: The comparison of pedal reflex across the groups of pigeons treated with normal saline, ketamine, diazepam, and a ketamine and diazepam combination, where a score of 0.0 represents a weak reflex and 4.0 represents a strong reflex.

the dosage of ketamine was about half the normal dose used in pigeons.^{9,10,15} There are very few articles in the current literature on the ideal intramuscular dosage of the diazepam and ketamine combination in pigeons. For this reason a low dosage of ketamine and diazepam was used.

A ketamine and diazepam combination produced a fast and smooth induction of anaesthesia, whilst a dosage of ketamine alone produced a slow and smooth anaesthesia. The duration of anaesthesia with a ketamine and diazepam combination ($14.10 \text{ min} \pm 1.48 \text{ min}$) obtained in this study was longer than the $8.13 \text{ min} \pm 1.41 \text{ min}$ obtained with ketamine alone. Diazepam is distributed widely throughout the body after administration and, being fat soluble, it can be deposited into muscle and fat tissue.¹⁹ The diazepam that was absorbed by the fat and muscle tissue is then released slowly into the system, resulting in a longer duration of anaesthesia than with ketamine alone. Paul-Murphy et al.²⁰ reported that the average surgical time needed for most perching bird species was 15 min. Therefore, the increase in anaesthesia duration through this combination provides enough time for most surgical procedures.

In the present study, the recovery was smooth but slow in the pigeons anaesthetised with the ketamine and diazepam combination. This observation is similar to those reported by Lumeij and Deenik¹⁵ and Varner et al.¹⁸ In the ketamine-treated pigeons, recovery was stormy. These birds showed severe convulsions and wing flapping. This was also found by Atalan et al.¹⁴, who reported that the stormy recovery is caused by the dissociative characteristics of ketamine anaesthesia. With the ketamine and diazepam combination, the reduction of side effects during the recovery could be the result of the low dose of ketamine used in this group, as compared with ketamine alone (used at a higher dosage), as well as the simultaneous administration of sedatives such as diazepam.

In this study, muscle relaxation was significantly more pronounced in the ketamine and diazepam combination than with diazepam alone ($p < 0.05$). Improvement of muscular relaxation in this combination was associated with the muscle relaxant properties of diazepam.^{15,18,19} Poor muscle relaxation was found when ketamine was used alone.^{13,14} The presence of palpebral reflex in the ketamine-treated pigeons was reported previously by many studies^{9,10} and was also observed in our study. In the present study, the cloacal temperature 10 min after anaesthetic administration dropped to $39.17^\circ\text{C} \pm 0.59^\circ\text{C}$ in the ketamine group. Yet, it remained at $40.93^\circ\text{C} \pm 0.86^\circ\text{C}$ in pigeons treated with the ketamine and diazepam combination.

The present study showed that intramuscular injection of the diazepam and normal saline mixture could not induce anaesthesia, but sedation and muscle relaxation were observed. Normal saline alone produced no sedation, muscle relaxation or anaesthesia. Solution volume alone therefore plays no role. This finding correlates with previous investigations.^{15,18}

Conclusion

The combination of ketamine HCL given at 10 mg/kg and diazepam given at 0.2 mg/kg provides more ideal conditions for the veterinary surgeon. This is, to a large extent, thanks to the sedation and the prolongation of the anaesthetic effect produced by diazepam. The ketamine and diazepam

combination produced more a rapid induction of anaesthesia, an increase in the duration of anaesthesia, as well as smooth recovery and more muscle relaxation without any adverse effects. It can therefore be considered an important tool for the light anaesthesia of pigeons.

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Competing interests

The authors declare that they have no financial or personal relationship(s) which may have inappropriately influenced them in writing this paper.

Authors' contributions

The authors made equal contributions to the experimental project design and acquisition of data.

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