Inhalant anesthetics are widely used to maintain anesthesia in cats. These drugs have been shown to cause dose-dependent cardiovascular and respiratory depression in many species. Compared to dogs, cats appear to be more sensitive to the depressant effects of inhalant anesthetics. At similar anesthetic concentrations, cats are indeed more hypotensive, and have lower cardiac index than dogs. Moderate to severe hypotension is commonly observed during anesthesia in clinical feline patients.

Balanced anesthesia relies on the concurrent administration of several drugs, in an attempt to decrease the dose of each drug, and therefore their toxicity. Balanced anesthesia is often advocated to decrease the requirements for inhalant anesthetics, and thereby their adverse cardiovascular and/or respiratory effects. Traditionally, opioids have been used in combination with inhalant anesthetics to provide balanced anesthesia. High dose opioid techniques are commonly used in people and dogs. In cats, however, the benefits are much more limited. Although maximal MAC reduction is reported to be >70% in dogs and >80% in people, that effect is only about 35% in cats. Moreover, high dose opioid techniques in cats result in sympathetic activation, which may be detrimental in some cases.

Other drugs have been reported to decrease the requirements for inhalant anesthetics and are therefore potential candidates for balanced anesthesia. These include alpha-2 agonists, nitrous oxide, ketamine, and lidocaine. Lidocaine has been reported to decrease the MAC of inhalant anesthetics in people, rats, dogs and ponies. In cats, lidocaine is commonly used for local anesthesia. Moreover, it is sometimes used for the treatment of ventricular arrhythmias. However, lidocaine has the reputation to be particularly toxic in cats, especially when administered intravenously. Tilley and Weitz wrote that “the use of lidocaine as an antiarrhythmic drug has been shown to be extremely dangerous in the cat”. A search of the literature does not suggest any particular sensitivity of cats to the toxic effects of lidocaine. Several toxicity studies were actually conducted in cats, and did not show a difference in the toxic dose of lidocaine between cats and other species.

Based on the findings that lidocaine decreases the requirements for inhalant anesthetics, and that even though anecdotal evidence suggests that cats may be sensitive to lidocaine toxicity, no scientific evidence of that alleged sensitivity could be found, we undertook a study to examine the potential of intravenous lidocaine infusions for balanced anesthesia and analgesia in cats.

In the first phase of the study, we determined the pharmacokinetics of lidocaine in awake cats and cats anesthetized with isoflurane. We also determined the MAC of isoflurane in each cat. Isoflurane anesthesia significantly altered the disposition of lidocaine in cats. Compared to awake cats, the volume of distribution of the central compartment, the volume of distribution at steady-state, the clearance and the elimination half-life were significantly decreased in cats anesthetized with isoflurane.

In the second phase of the study, we examined the effects of 6 plasma lidocaine concentrations on the MAC of isoflurane. Plasma concentration was selected rather than dose, because it was assumed to correlate better with the effect. We studied 1, 3, 5, 7, 9, and 11 µg/mL. Although a target-controlled infusion system was used to rapidly reach and maintain these plasma concentrations, according to our pharmacokinetic model, these would correspond to a loading dose and constant rate infusion of 0.3 mg/kg and 23 µg/kg/min, 0.9 mg/kg and 69 µg/kg/min, 1.5 mg/kg and 115 µg/kg/min, 2.2 mg/kg and 161 µg/kg/min, 2.8 mg/kg and 207 µg/kg/min, and 3.4 mg/kg and 252 µg/kg/min, to achieve 1, 3, 5, 7, 9, and 11 µg/mL, respectively. At these plasma concentrations, we found that lidocaine dose-dependently and linearly decreased the MAC of isoflurane by -6 to 59%. The effect appeared to be clinically significant at all concentrations except 1 µg/mL. Based on these results, lidocaine appeared to be a potential candidate for balanced anesthesia in cats, when administered at plasma concentrations between 3 and 11 µg/mL. No side-effects were observed during this study; EEG was continuously monitored (since central nervous toxicity should be one of the first stages of toxicity and that seizure activity may not be apparent in anesthetized animals) and seizure activity was not observed at any of the plasma lidocaine concentrations.

Since balanced anesthetic techniques are often used to improve cardiovascular function, in the third phase of this study, we examined whether isoflurane combined to lidocaine would produce less cardiovascular depression than an equipotent dose of
isoflurane alone (i.e. the concentration of isoflurane was reduced when the concentration of lidocaine was increased, according to the results of the second phase of the study). In this phase, we studied the effects of lidocaine at 0, 3, 5, 7, 9, and 11 µg/mL in cats receiving isoflurane concentrations to reach the equivalent of 1.25 MAC. Heart rate, cardiac index, stroke index, right ventricular stroke work index, total protein concentration, mixed-venous PO$_2$ and hemoglobin oxygen saturation, arterial and mixed-venous bicarbonate concentrations, and oxygen delivery were significantly lower during lidocaine administration than when no lidocaine was administered. Mean arterial pressure, central venous pressure, pulmonary artery pressure, systemic and pulmonary vascular resistance indices, PCV, arterial and mixed-venous hemoglobin concentrations, lactate concentration, arterial oxygen concentration, and oxygen extraction ratio were significantly higher during administration of lidocaine than when no lidocaine was administered. These effects were dose-dependent, and statistically significant at plasma concentrations higher than 7 µg/mL. Moreover, no clinically beneficial cardiovascular effects were seen at concentrations lower than 7 µg/mL. In summary, although lidocaine administration in isoflurane anesthetized cats results in an increase in blood pressure, overall, it produces more cardiovascular depression than an equipotent dose of isoflurane alone, and is therefore not recommended for balanced anesthesia in cats. Lidocaine at moderate plasma concentrations can result in severe cardiovascular depression, as seen in one cat in this study when infusing lidocaine to reach 7 µg/mL, requiring the discontinuation of lidocaine and isoflurane, as well as the initiation of supportive measures.

The fourth and final phase of this study examined the analgesic effect of lidocaine administered intravenously in awake cats. For this experiment, a thermal threshold model was used, because it is an objective measurement of analgesia that has been validated in cats. Target plasma lidocaine concentrations of 0, 0.5, 1, 2, 5, and 8 µg/mL were studied, and compared to the administration of an equivalent volume of isotonic saline. Thermal threshold did not change over time in the control group, and was not significantly different from control at any of the plasma lidocaine concentrations. In conclusion, we could not demonstrate a significant effect of lidocaine on thermal pain in cats. Whether lidocaine affects other pain modalities and higher concentrations of lidocaine would increase thermal threshold remains to be elucidated.

References


