The effect of lidocaine on regional blood flows and cardiac output in the non-stressed and the stressed foetal lamb

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Lidocaine has been used in obstetrical anaesthesia for many years but there are still concerns about possible adverse effects of this drug on the foetus in utero. To examine in greater detail the effects of lidocaine in the foetus, the following two-part study was done.

In Part A, seven pregnant ewes were surgically prepared with maternal and foetal arterial and venous catheters. After recovery from surgery lidocaine was infused intravenously, initially into the ewe and then into both ewe and foetus. Blood lidocaine concentrations were monitored and foetal regional blood flows were determined by the radioactive microsphere method.

In Part B, 14 ewes were prepared as in Part A with the addition of an inflatable loop around the umbilical cord. During each study the loop was inflated to partially compress the cord and produce foetal acidosis. In all animals this cord compression was maintained for 30 minutes. In seven animals a lidocaine infusion was given, to examine the effect of lidocaine in the acidotic foetus. Organ blood flows were measured and cardiac outputs calculated.

The normal foetuses in Part A showed no change in

organ blood flow or cardiac output with arterial lidocaine concentrations of $1.5\text{--}3.4\text{ mg}\cdot\text{ml}^{-1}$. In the acidotic foetuses, lidocaine concentrations of $1.4\text{--}1.5\text{ mg}\cdot\text{ml}^{-1}$ produced a tachycardia and an increase in cerebral blood flow compared to the control acidotic foetuses. There were no other significant changes.

We conclude that arterial lidocaine concentrations of less than $3.5\text{ mg}\cdot\text{ml}^{-1}$ do not produce significant alterations in organ blood flow in normal foetal lambs. A lidocaine concentration of $1.5\text{ mg}\cdot\text{ml}^{-1}$ does not produce significant deterioration in acidotic foetuses.

Lidocaine is used in obstetrical anaesthesia for epidural, spinal, paracervical, and pudendal blocks, as well as local infiltration for episiotomies.¹⁻⁴ With the exception of spinal anaesthesia, lidocaine has been measured in cord blood and the newborn following the use of these blocks.¹ Clinical studies^{2,3} have shown that the presence of lidocaine in the newborn does not reduce APGAR scores if lidocaine blood concentrations are less than $3.5\text{ }\mu\text{g}\cdot\text{ml}^{-1}$.

Prior to delivery however, lidocaine has been incriminated in reducing beat to beat variability in foetal heart rate tracings and in increasing the incidence of late decelerations.^{5,6} These observations have been made in patients who were usually not clinically hypotensive, so explaining the changes in the foetal heart rate as being due to maternal hypotension is not always possible. The mechanism by which lidocaine itself might produce these changes is unclear.

Another cause for concern has been some of the neurobehavioural studies which suggest that in the

Key words

ANAESTHETICS, LOCAL: lidocaine; BRAIN: cerebral blood flow, asphyxiation; PREGNANCY: foetus.

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Supported by Medical Research Council Grant no. MA-6735.

newborn lidocaine decreases muscle tone and produces "floppy" babies.⁷

A third concern about using lidocaine, or other amide local anaesthetic agents, is the effect on the stressed infant *in utero* who may be acidotic.⁸ These foetuses may "trap" lidocaine because a greater proportion of the weak base local anaesthetic becomes ionized in the acidotic foetus so that transfer back across the placenta is reduced.⁹ The circulating levels of lidocaine in the acidotic foetus may be higher than in the normal foetus and could contribute to neonatal depression at birth.

Because of the above concerns we designed the following two-part study to examine the effect of lidocaine on the foetus. In the first part the effects of clinically relevant levels of lidocaine in the foetus with normal acid-base status were studied. In the second part the foetuses were stressed by partial cord occlusion to produce acidosis and hypercarbia prior to being exposed to lidocaine.

Methods

Part A

Seven pregnant ewes of 125–135 days gestation (term 150 days) were surgically prepared as follows: under halothane in oxygen anaesthesia with controlled ventilation, indwelling catheters were placed in the maternal femoral artery and vein through a groin incision. The uterus was exposed through a midline abdominal incision and a small hysterotomy was made. A fetal hind limb was withdrawn and indwelling catheters were placed in the femoral artery and vein. Then the foetal forelimb was exposed and an indwelling catheter was placed in the axillary artery. All incisions were closed and the catheters tunnelled subcutaneously and enclosed in a protective pocket. All animals were allowed to recover for 48–72 hours before a study.

Each pregnant ewe was studied while standing quietly in an experimental cart. No animal was accepted for study unless the foetal arterial PO_2 was greater than 15 torr and pH greater than 7.30. Each experiment began with a control period of 30 minutes to ensure stability of the preparation. Maternal and foetal mean arterial blood pressure (MABP) and pulse rate were recorded continuously on a Hewlett-Packard multichannel recorder. Blood samples (0.6 cc) were drawn at 15-minute intervals

during the study from the maternal femoral artery and foetal axillary artery for blood gas analysis.

At the end of the control period lidocaine was infused into the maternal femoral vein for 90 minutes. For the first 15 minutes the infusion rate was $0.25 \text{ mg} \cdot \text{kg}^{-1} \cdot \text{min}^{-1}$. For the remainder of the study the infusion rate was $0.15 \text{ mg} \cdot \text{kg}^{-1} \cdot \text{min}^{-1}$. This regimen has been previously shown to produce stable maternal arterial blood lidocaine concentrations of $2\text{--}4 \mu\text{g} \cdot \text{ml}^{-1}$.^{10,11} After 60 minutes a lidocaine infusion was begun into the foetal femoral vein at a rate of $0.5 \text{ mg} \cdot \text{kg}^{-1} \cdot \text{min}^{-1}$ while the maternal infusion was continued. Maternal and foetal arterial blood (2 ml per sample) was drawn at 15-minute intervals and analysed for lidocaine by gas liquid chromatography.¹² These blood volumes were replaced with normal saline in the foetus.

To measure organ blood flow and calculate cardiac output in the foetus, radioactive microspheres (Ce^{141} , Cr^{51} , or Sr^{85}) were injected at the end of the control period, after one hour of infusion of lidocaine into the ewe at $0.15 \text{ mg} \cdot \text{kg}^{-1} \cdot \text{min}^{-1}$, and finally after 30 minutes of lidocaine infusion into both ewe and foetus when the lidocaine concentration in the foetus was calculated to be twice that of the preceding microsphere injection.

The labelled microspheres (diameter 10 microns) were injected into the foetal femoral vein over 60 seconds and blood was withdrawn from the foetal axillary and femoral arteries at a rate of 2 ml per minute for three minutes. The radioactive counts from these samples were used as reference counts to calculate blood flow to organs above and below the ductus arteriosus.¹³

At the end of each study the ewe and foetus were killed by an injection of thiopentone and KCl. The foetus and placenta were removed and dissected. All foetal organs (except the lungs) were weighed, ground, and ashed. The ashed samples were placed in counting vials and the radioactive counts obtained were compared to the reference counts to obtain the blood flow to each organ. The counts for all organs were combined to calculate the cardiac output for the foetus. This method slightly underestimates total cardiac output as there is no reference sample for the lungs and they were not included.

Maternal and foetal MABP, pulse rate, blood gases, microsphere counts, and lidocaine levels were analysed by one-way analysis of variance to

TABLE I Maternal and foetal arterial lidocaine levels in (Part A) during infusion of lidocaine intravenously to the mother combined with infusion to the foetus beginning at 60 minutes ($n = 7$) (Mean $\pm$ SEM)

	15 min	30 min	45 min	60 min	75 min	90 min
Maternal $\mu\text{g}\cdot\text{ml}^{-1}$	1.93 $\pm .31$	1.89 $\pm .25$	2.14 $\pm .15$	2.47 $\pm .20$	2.77 $\pm .38$	3.17 $\pm .57$
Foetal $\mu\text{g}\cdot\text{ml}^{-1}$	1.30 $\pm .55$	1.02 $\pm .18$	1.54 $\pm .23$	1.49 $\pm .16$	3.49* $\pm .66$	3.36* $\pm .37$
FA/MA ratio	0.67	0.54	0.72	0.60	1.26	1.06

* $p < 0.05$ significantly different from the 60-minute value.

detect significant differences during the study. A paired "t" test was applied to detect within group differences when appropriate.

Part B

Fourteen pregnant ewes of 125–135 days gestation were anaesthetized with halothane in oxygen with controlled ventilation. Indwelling catheters were placed in the maternal femoral artery and vein, the foetal femoral artery and vein and the axillary artery. An inflatable loop was loosely secured around the umbilical cord. All incisions were closed and the catheters tunnelled subcutaneously and enclosed in a protective pocket. All animals were allowed to recover for 48–72 hours before study.

The ewes were divided into two groups. The first group did not receive lidocaine and was thus the control group. The second group received an infusion of lidocaine during the experiment. Both groups were studied with the animal standing quietly in an experimental cart.

Control group ($n = 7$): Each experiment began with a control period of 30 minutes to ensure stability of the preparation. Maternal and foetal MABP and heart rate were measured continuously on a Hewlett-Packard multi-channel recorder. Blood was drawn from the maternal femoral artery and the foetal axillary artery for blood gas analysis at 15 and 30 minutes. No animal was included for study if foetal pH was less than 7.35 or foetal PO_2 less than 15 torr.

At the end of the control period the loop around the umbilical cord was slowly inflated with air to produce compression of the umbilical vessels. The volume of air was steadily increased until foetal arterial pH declined to a range of 7.10–7.15. This

process required 60–90 minutes. Foetal arterial pH was measured at five- to ten-minute intervals. Once the pH was 7.10–7.15 the volume of air required to inflate the loop was then held constant for 30 minutes.

To measure organ blood flow and calculate cardiac output in the foetus, radioactive microspheres were injected just before inflation of the loop, when the foetal pH was in the 7.10–7.15 range, and after the inflation of the loop had been maintained for 30 minutes. The microsphere technique is described in Part A.

Lidocaine group ($n = 7$): In this group, after a 30-minute control period, umbilical cord compression was produced and maintained in the same way as for the control group. When foetal arterial pH was 7.10–7.15 lidocaine was infused into the maternal femoral vein for 30 minutes. Initially the infusion rate was $0.25 \text{ mg}\cdot\text{kg}^{-1}\cdot\text{min}^{-1}$ for 15 minutes and then the rate was reduced to $0.15 \text{ mg}\cdot\text{kg}^{-1}\cdot\text{min}^{-1}$ for 15 minutes. Blood was withdrawn from the maternal femoral artery and the foetal axillary artery at 15, 20, 25, and 30 minutes for measurement of plasma lidocaine concentrations.

Microsphere injections were made into the foetus at the end of the control period, when foetal arterial pH was 7.10–7.15, and after the infusion of lidocaine into the ewe for 30 minutes.

The animals in both groups were killed with an injection of thiopentone and KCl at the end of the experiment. The foetus and placenta were removed and weighed. The foetal organs were prepared and counted in the same way as for Study A.

Maternal and foetal MABP, heart rate, and blood gas data were analysed for within group differences by one-way analysis of variance. Between group

TABLE II Foetal mean arterial blood pressure (MABP), pulse rate, and blood gas data at control and during infusion of lidocaine intravenously (Part A) ($n = 7$) (Mean $\pm$ SEM)

Foetal	Control	30 min	60 min	90 min
MABP (mm Hg)	50.4 ± 2.3	49.6 ± 2.5	47.6 ± 1.9	49.3 ± 2.2
Pulse rate (beats/min)	158.0 ± 4.7	175.0 ± 5.9	168.0 ± 7.3	162.0 ± 3.7
PO ₂ (mm Hg)	18.0 ± 1.1	18.0 ± 1.1	16.0 ± 1.5	16.0 ± 1.6
PCO ₂ (mm Hg)	34.0 ± 1.1	35.0 ± 1.6	34.0 ± 2.1	36.0 ± 1.2
pH	7.38 ± 0.01	7.36 ± 0.01	7.37 ± 0.02	7.37 ± 0.05
BE	-3.8 ± 0.6	-3.2 ± 1.1	-3.4 ± 1.2	-2.6 ± 0.7

*No values significantly different from control.

TABLE III Foetal regional blood flows and calculated cardiac output during control period, after 60 minutes of lidocaine infusion to the ewe, and after 30 minutes of infusion to both ewe and foetus ($n = 7$) (Mean $\pm$ SEM)

Blood flow $\text{ml} \cdot \text{g}^{-1} \cdot \text{min}^{-1}$	Control	60 min	90 min
Brain	1.15 $\pm .11$	1.25 $\pm .20$	1.36 $\pm .23$
Heart	1.52 $\pm .39$	1.53 $\pm .42$	1.89 $\pm .46$
Musculo-skeletal system	0.39 $\pm .03$	0.38 $\pm .05$	0.56 $\pm .16$
Placenta	0.83 $\pm .12$	0.76 $\pm .08$	0.71 $\pm .09$
Calculated cardiac output $\text{ml}^{-1} \cdot \text{min}$	3689 ± 22.3	3525 ± 34.7	4098 ± 75.6
Fetal lidocaine level ($\mu\text{g} \cdot \text{ml}^{-1}$)	0	1.49 $\pm .16$	3.36 $\pm .37$

comparisons were made by an unpaired "t" test corrected for multiple comparison. The microsphere data were analysed similarly.

Results

Part A

Maternal and foetal arterial lidocaine concentrations

are shown in Table I. After infusion of lidocaine ($0.25 \text{ mg} \cdot \text{kg}^{-1} \cdot \text{min}^{-1}$) into the ewe for 15 minutes the maternal concentration was $1.93 \mu\text{g} \cdot \text{ml}^{-1}$. From that point onward the lidocaine infusion rate was maintained at $0.15 \text{ mg} \cdot \text{kg}^{-1} \cdot \text{min}^{-1}$ in the ewe. There were no significant changes in the maternal arterial lidocaine concentration during the remainder of the study.

In the foetus, at 15 minutes, the arterial lidocaine concentration was $1.30 \mu\text{g} \cdot \text{ml}^{-1}$. There was no significant change in this concentration until the lidocaine infusion to the foetus was begun. At 75 and 90 minutes the arterial lidocaine concentrations in the foetus were approximately double those of the preceding 60 minutes.

During this study there were no significant changes in maternal or foetal MABP, pulse rate, or arterial blood gases. The foetal values are shown in Table II.

The blood flow results are shown in Table III. There were no significant changes from control in organ blood flow or calculated cardiac output with lidocaine levels of 1.49 ± 0.16 or $3.36 \pm 0.37 \mu\text{g} \cdot \text{ml}^{-1}$ in the foetal arterial blood.

Part B

In both control and lidocaine groups there were no significant changes in any maternal variables. In the lidocaine group maternal arterial lidocaine concentrations ranged from 2.10 to $2.84 \mu\text{g} \cdot \text{ml}^{-1}$ (Table IV). There were no significant differences between samples. In the acidotic foetus arterial lidocaine concentrations ranged from 1.26 to $1.50 \mu\text{g} \cdot \text{ml}^{-1}$. There were no significant differences between any of the values. In one foetus there were technical problems with the microsphere injection so this foetus is not included in the data analysis.

TABLE IV Maternal and foetal arterial lidocaine levels (Part B) during infusion of lidocaine intravenously to the ewe after production of acidosis in the foetus ($n = 6$) (Mean $\pm$ SEM)

	15 min	20 min	25 min	30 min
Maternal $\mu\text{g} \cdot \text{ml}^{-1}$	2.72 $\pm .13$	2.36 $\pm .25$	2.84 $\pm .38$	2.10 $\pm .18$
Foetal $\mu\text{g} \cdot \text{ml}^{-1}$	1.43 $\pm .24$	1.33 $\pm .17$	1.26 $\pm .17$	1.50 $\pm .25$
FA/MA ratio	0.53	0.56	0.44	0.71

FIGURE 1 Foetal mean arterial blood pressure during asphyxia and asphyxia plus lidocaine (mean $\pm$ SEM). A significant increase in MABP occurs with partial cord occlusion. Infusion of lidocaine did not affect foetal MABP. * $p < 0.05$ significantly different from control.

FIGURE 2 Foetal heart rate during asphyxia and asphyxia plus lidocaine (mean $\pm$ SEM). The bradycardia occurring with partial cord occlusion was abolished by the lidocaine infusion. * $p < 0.05$ significantly different from control period. † $p < 0.05$ significantly different from asphyxia-control group.

In both the control group and the lidocaine group, inflation of the umbilical loop produced significant foetal bradycardia and hypertension (Figures 1, 2). In the control group there was no further significant change in these variables over 30 minutes. In the lidocaine group the infusion of lidocaine into the ewe resulted in a significant increase in foetal heart rate back to control values by 15 minutes but blood pressure remained unchanged (Figure 2). There were no significant changes in pH, PCO_2 , or PO_2 between the two groups in the 30 minutes of cord compression (Figures 3, 4, 5). The pH in both groups declined from a mean of 7.08 ± 0.02 to 7.00 ± 0.06 during the 30 minutes (Figure 3).

FIGURE 3 Foetal pH with asphyxia and during infusion of lidocaine (mean $\pm$ SEM). Partial cord occlusion in both groups produced a decrease in foetal pH to 7.10–7.15 by 90 minutes. The pH declined to 7.00 over the next 30 minutes in both groups. * $p < 0.05$ significantly different from control period.

FIGURE 4 Foetal PCO_2 during asphyxia and asphyxia plus lidocaine (mean $\pm$ SEM). Foetal PCO_2 increases significantly from the control period in both groups during cord occlusion. There is no difference between the two groups. * $p < 0.05$ significantly different from control period.

Analysis of the microsphere data demonstrated a significant increase in cerebral blood flow in both groups with cord compression and acidosis (Table V, Fig. 6). There was also a significant decrease in blood flow to the musculo-skeletal system and the placenta. Cardiac output was also significantly decreased. In the lidocaine group, after 30 minutes, there was an additional significant increase in cerebral blood flow compared to the control group (Figure 6) but no change in the other organ blood flows or cardiac output.

TABLE V Foetal regional blood flows and calculated cardiac output in the control group and the lidocaine group prior to cord compression, after production of acidosis, and after 30 minutes of acidosis ($n = 7$) (Mean $\pm$ SEM)

Blood flow $\text{ml} \cdot \text{g}^{-1} \cdot \text{min}^{-1}$	Pre-acidosis		Acidosis: pH 7.08		30 min acidosis pH 7.00	
	Control $N = 7$	Lidocaine $N = 6$	Control	Lidocaine	Control	Lidocaine
Brain	1.50 $\pm .32$	1.86 $\pm .24$	2.86* $\pm .42$	3.68* $\pm .33$	2.29* $\pm .56$	5.96† ± 1.4
Heart	1.96 $\pm .26$	2.05 $\pm .41$	1.68 $\pm .24$	1.91 $\pm .48$	1.76 $\pm .09$	2.30 $\pm .47$
Musculo-skeletal	0.36 $\pm .03$	0.18 $\pm .07$	0.16* $\pm .04$	0.12* $\pm .05$	0.13* $\pm .04$	0.07* $\pm .08$
Placenta	1.10 $\pm .17$	0.84 $\pm .11$	0.17* $\pm .10$	0.18* $\pm .03$	0.14* $\pm .05$	0.18* $\pm .16$
Calculated cardiac output $\text{ml}^{-1} \cdot \text{min}$	1258 ± 93.3	1230 ± 127.0	655* ± 94.1	598* $\pm .81$	561* ± 60.0	635* ± 195.4
Foetal lidocaine level ($\mu\text{g} \cdot \text{ml}^{-1}$)						1.50 $\pm .25$

*Significantly different from control value.

†Significant difference between groups (control and lidocaine).

FIGURE 5 Foetal PO_2 during asphyxia and asphyxia plus lidocaine (mean $\pm$ SEM).

Discussion

In this two-part study we have examined the effects of clinically relevant lidocaine concentrations on the cardiovascular system of the foetal lamb. In Part A we measured cerebral blood flow and cardiac output with lidocaine levels of $1.49\text{--}3.36 \mu\text{g} \cdot \text{ml}^{-1}$. There were no significant alterations in either of these variables to account for the clinical observation of changes in foetal heart rate variability and decelerations occurring with epidural anaesthesia. The explanation for the clinical observation is still

FIGURE 6 Cerebral blood flow during asphyxia and asphyxia plus lidocaine (mean $\pm$ SEM).* $p < 0.05$ significantly different from control period.† $p < 0.05$ significant difference between control group and lidocaine group.

not clear. There may be other changes, such as alterations in uterine blood flow with epidural anaesthesia, which cannot be detected clinically and it may be factors such as this, rather than the lidocaine concentrations in the fetal blood, which produces changes in the foetal heart rate. In our study, infusing lidocaine intravenously does not, of course, produce the sympathetic blockade which occurs with epidural anaesthesia.^{14,15}

In Part B, the effect of lidocaine on the acidotic foetus was examined. Umbilical cord compression is a frequently recognized clinical event. In the clinical situation this is detected by the presence of variable decelerations in the foetal heart rate.¹⁶ In our model we are able to produce this foetal bradycardia for up to 30 minutes.

Partial cord compression leads to foetal acidosis and hypercarbia by two mechanisms. There is, first of all, a sharp reduction in return of blood from the placenta to the foetus. This produces hypovolemia. Peripheral vasoconstriction occurs and foetal blood pressure rises. The decrease in the heart rate may be a response to the increase in blood pressure. Secondly, with time, the decreased foetal blood volume cannot supply the metabolic demands of the foetus and hypercarbia and acidosis results. In our study foetal pH declined from a normal value of 7.35 to 7.10–7.15 in 60–90 minutes. During this time arterial PCO₂ also rose but PO₂ did not change. The maintenance of a normal PO₂ does not guarantee a normal O₂ content, however. With acidosis the oxyhaemoglobin dissociation curve shifts to the right. In a study by Johnson *et al.*,¹⁷ where oxygen saturation was measured, the production of foetal acidosis by partial cord compression did result in a decrease in O₂ saturation and thus O₂ content. Experiments by Parer *et al.*,¹⁸ have suggested that the stressed foetus also decreased its oxygen consumption by converting to anaerobic metabolism. This may also contribute to a stable PO₂. In our model of severe cord compression asphyxia as well as acidosis and hypercarbia likely occur despite a PO₂ in the normal range.

Infusion of lidocaine into the pregnant ewe once the foetus was acidotic resulted in arterial blood lidocaine concentrations in the foetus that were not significantly different from those in the non-acidotic foetal lambs in Part A. Compression of the umbilical cord does not interfere with circulation in the placenta so transfer of lidocaine to foetal blood from maternal should not be impaired. During the 30 minutes of lidocaine infusion the concentrations of lidocaine did not increase in the foetus as might be expected from the ion-trapping phenomenon demonstrated in other studies in the foetal lamb.⁹ If the experiment had continued for a longer time the blood concentrations may have increased. An alternate explanation is that the lidocaine may have been taken up by acidotic foetal tissues and trapped there.

The effect of lidocaine in the acidotic foetus was limited to an increase in foetal heart rate and an increase in cerebral blood flow with no significant change in blood pressure or blood gases. Lidocaine may abolish the reflex bradycardia seen with cord compression by interfering with impulses from the baroreceptors in the aorta and carotid arteries or may have suppressed the reflex at the level of the brainstem.

Cerebral blood flow in the lidocaine group was significantly increased over that in the control animals despite similar pH and PCO₂ in both groups. A direct vasodilating effect of lidocaine on cerebral vessels could account for the increased flow. No other explanation was obvious from this study. Whether this has clinical relevance remains to be determined.

Comparing the acidotic foetuses exposed to lidocaine with the control acidotic group demonstrated fewer changes than seen with exposure of acidotic foetuses to general anaesthetic agents. In our studies with general anaesthesia halothane, thiopentone, and nitrous oxide abolished foetal bradycardia and also reduced foetal blood pressure.¹⁹ With lidocaine only the foetal bradycardia was abolished. The increased cerebral blood flow seen with lidocaine was not demonstrated in the acidotic foetuses exposed to general anaesthesia. While it is difficult to extrapolate to the clinical situation, a recent study by Marx suggested that in situations of foetal distress regional anaesthesia resulted in better outcomes for the neonate than general anaesthesia.²⁰ Our findings in the animal model support that view.

In conclusion, we were not able to demonstrate any changes in the normal foetus in heart rate, blood pressure, or regional blood flow with foetal lidocaine blood concentrations up to 3.5 µg·ml⁻¹. The explanation for the clinical finding of changes in foetal heart rate remains to be determined.

Exposure of the acidotic foetus to lidocaine concentrations up to 1.5 µg·ml⁻¹ did not result in deterioration of acid-base status or MABP compared to a control group but did result in an increase in foetal heart rate and cerebral blood flow.

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Résumé

La lidocaine a été utilisée dans l'anesthésie obstétricale pour plusieurs années, actuellement cependant on se demande sur la possibilité des effets néfastes de cette drogue sur le fœtus in utero. Afin d'examiner en grand détail les effets de la lidocaine sur le fœtus, l'étude présente en deux parties a été effectuée.

Pour la partie A, sept brebis gravides ont été chirurgicalement préparées avec des cathéters artériels et veineux maternel et fœtal. Après rétablissement de la chirurgie la lidocaine a été perfusée par voie intraveineuse initialement chez la brebis puis chez la brebis et le fœtus. Les concentrations plasmatiques de lidocaine ont été étudiées et les flots sanguins régionaux fœtaux ont été déterminés par la méthode de microsphère radioactifs.

Pour la partie B, 14 brebis ont été préparées comme pour la partie A avec l'addition d'une boucle gonflable autour du cordon ombilicale. Lors de chaque étude la boucle était gonflée afin de comprimer partiellement le cordon ombilicale et produire une acidose fœtale. Chez tous les animaux cette compression de la corde était maintenue pour 30 minutes. Chez sept animaux la perfusion de lidocaine a été donnée afin de démontrer les effets de la lidocaine chez le fœtus acidotique. Les flots sanguins dans les différents oranges ont été mesurés et les débits cardiaques calculés.

Les fœtus normaux dans la partie A n'ont pas démontré aucun changement dans les flots sanguins régionaux ni le débit cardiaque avec des concentration de lidocaine artérielle de 1.5–3.4 $\mu\text{g}\cdot\text{ml}^{-1}$. Chez le fœtus acidotique, les concentrations de lidocaine de 1.4–1.5 $\mu\text{g}\cdot\text{ml}^{-1}$ ont produit une tachycardie et une diminution du flot sanguin cérébral comparativement au contrôle du fœtus acidotique. Il n'y avait aucun autre changement significatif.

On conclut que les concentration de lidocaine artérielle de moins de 3.5 $\mu\text{g}\cdot\text{ml}^{-1}$ ne produisent aucune alteration significative dans les flots sanguins régionaux chez le fœtus d'une brebis normale. Les concentrations de lidocaine de 1.5 $\mu\text{g}\cdot\text{ml}^{-1}$ ne produisent aucune détérioration significative chez les fœtus acidotiques.