



Journal of Medical Sciences

ISSN 1682-4474

science
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JMS (ISSN 1682-4474) is an International, peer-reviewed scientific journal that publishes original article in experimental & clinical medicine and related disciplines such as molecular biology, biochemistry, genetics, biophysics, bio-and medical technology. JMS is issued eight times per year on paper and in electronic format.

For further information about this article or if you need reprints, please contact:

Dr. Daniel Mota-Rojas
Department of Animal Production
and Agriculture Research Area,
Ecodesarrollo de la Producción
Animal,
Universidad Autónoma
Metropolitana-Xochimilco,
Calzada del Hueso 1100. Villa
Quietud. Coyoacan,
México D. F. CP: 04960, México

Effect of Different Doses of Oxytocin at Delivery on Suffering and Survival of Newborn Pigs

¹Daniel Mota-Rojas, ²Dina Villanueva-García, ¹María Alonso-Spilsbury, ³Marcelino Becerril-Herrera, ¹Ramiro Ramírez-Necoechea, ¹Miguel González-Lozano and ⁴Ma. Elena Trujillo Ortega

The objective of the present study was to compare various doses of intramuscular administration of oxytocin and its effects on the dynamics of the uterus and level of neonatal asphyxia in periparturient Yorkshire-Landrace sows. Two hundred females were randomly assigned to 4 groups of 50 for each treatment. They were given oxytocin in 3 different doses and criteria was made after the birth of the first piglet. There was a high mortality rate during birth in groups G₂ and G₃ that were treated with high and medium doses of oxytocin, respectively, in comparison with the control and low dosage groups (G₁ and G₄). There was a significant increase ($p < 0.01$) in number and intensity of contractions during birth of the groups treated with a high and medium doses of oxytocin as compared to the groups that received a low dose of oxytocin and the control group. The former groups had a higher rate of intra-uterine suffering ($p < 0.01$), measured by the delayed variable deceleration in cardiac frequencies in the fetus. The neonatal piglets with acute fetal suffering that survived prenatal asphyxia with mild meconium staining on the skin, had hyperglycemia; as compared to the piglets with severe staining characterized by the presence of hypoglycemia. The use of low dosage oxytocin helped avoid deceleration in cardiac frequencies in the fetus, rupture of the umbilical cord and meconium staining; in addition it did not reduce the fetal mortality rate, but increased the viability of the neonate.

Key words: Neonatal, oxytocin, uterine contraction, asphyxia, sow, delivery

¹Departamento de Producción Agrícola y Animal. Universidad Autónoma Metropolitana-Xochimilco, Calz. Del Hueso 1100, Col. Villa Quietud, México, DF 04960, México

²División de Neonatología. Hospital Infantil de México Federico Gómez. México DF., Dr. Márquez No.162 Col. Doctores, Delegación Cuauhtemoc, C.P. 06720 México, DF

³EIAH-Benemérita Universidad Autónoma de Puebla, Domicilio conocido, San Juan Acateno. Municipio Teziutlán, Puebla

⁴Departamento de Producción Animal: Cerdos. FMVZ. Universidad Nacional Autónoma de México, 04510, México, DF

INTRODUCTION

Oxytocin is one of the most frequently used hormones in modern obstetrics and its prudent use has broadened in-practice. However, when it is used inadequately, it can be associated with uterus hyperstimulation and ruptured uterus as well as fetal death (Shyken and Petrie, 1995; Domínguez *et al.*, 1999; Phaneuf *et al.*, 2000). Today there are many controversies regarding its use during pregnancy (Blanks and Thornton, 2003). There is no medical veterinary literature regarding treatment using oxytocin during pregnancy indicating dosage and time of application that will not compromise the life of the neonatal piglets (Straw *et al.*, 2000; Mota *et al.*, 2002a; Alonso-Spilsbury *et al.*, 2004).

Oxytocin has been used to control the mortality rate in the birth of piglets in Mexico as in other parts of the world (Sprecher *et al.*, 1974; Pejsak, 1984). Recent studies have shown that oxytocin effectively reduces the farrowing duration, but reduction of the birth mortality rate has been difficult to prove (Pejsak, 1984; Mota *et al.*, 2002a).

The objective of high dosages of oxytocin (pharmacological dosages) is to induce strong uterine contractions that abbreviate labor during birth (Shyken and Petrie, 1995) and it has advantages in women experiencing non effective spontaneous birth or without maximal number of labor pains (Satin *et al.*, 1992a). However, this procedure has its disadvantages, since deceleration in fetal cardiac frequencies and fetal suffering has been recorded.

Another treatment using oxytocin in human birth is an intravenous low dosage, (pharmacological dosages) used to avoid hyperstimulation of the uterus and fetal suffering; it is also used as a way to simulate an endogenous release normal physiological pulse pattern (Cummiskey *et al.*, 1989; Shyken and Petrie, 1995).

Studies carried out by Straw *et al.* (2000), indicate that oxytocin was the drug most used in 31,940 pigs on 250 farms in the United States of America. Of the 250 pig farms, 82.8% used the hormone and they used it in various dosages, from 5 UI to 240 UI per pig, applying it in one or two doses. For which it has been concluded in this study that protocols for oxytocin treatment of pregnant pigs do not exist and that the same are not adequate. Recently, Mota *et al.* (2002a) demonstrated that oxytocin used during farrowing in crated white breed pigs, caused asphyxia and neonatal death. The authors coincide with Straw *et al.* (2000) and conclude that studies are needed to evaluate oxytocin dosages, the objective being to find the optimum dosage that would accelerate labor during birth without compromising the live of the

neonates (Alonso-Spilsbury *et al.*, 2005). Electronic monitoring of the fetus helped record the uterus and fetus response after applying the uterotonic (James *et al.*, 2001; Mota *et al.*, 2005a). The objective of this study was to compare various dosages of oxytocin in peri-parturient pigs, applied intramuscularly after the birth of the first piglet, that promotes contraction of the uterus without compromising the vitality of the neonate.

MATERIALS AND METHODS

Experiments and number of animals: Two hundred Yorkshire-Landrace hybrid sows close to the farrowing were used. The pigs were placed in individual pens measuring between 4 and 6 m², 4 days prior to giving birth, they remained there for a period of 28 days, including the time of birth up till weaning. The corrals had a cement floor, asbestos tile roof and a one square meter wooden microclimate for the piglets. Observation began 48 h before the estimated time of birth. Farrowings were synchronized with prostaglandins (Lutalyse®, Pharmacia and Upjohn, Mexico), the pigs were injected intramuscularly 36 h previous to the estimated time of birth.

Sows were randomly assigned to 4 groups of fifty for each of the treatments. Oxytocin (Oxipar® de Laboratorios Anchor S. A. de C. V. Guadalajara, Mexico) was administered intramuscularly in 3 dosages and the criterion applied was used immediately after the first born in the litter, as recommended by various laboratories. Group 1 was treated with injectable water (control), group 2 was injected with 1 UI 6 kg live weight oxytocin (high dosage), group 3, 1 UI 9 kg L. W. (medium dosage) and group 4, 1 UI 12 kg L. W. (low dosage).

The study was carried out at an intensive production commercial pig farm located in Central Mexico between November 2003 and February 2004.

Fetal control: During birth the fetal cardiac frequency (FCF) and intensity and frequency of the myometrium contractions measured in mm of Hg by way of digital electronic cardiotocograph (Fetal Monitor Medical Systems Inc. Co. USA) used previously (Mota *et al.*, 2005a) were monitored from the expulsion of the first to the last piglet. Before placing the two transducers on the abdomen of the pig they were spread with abundant obstetric gel (Farmacéuticos Altamirano de México S.A. de C.V., Mexico D.F.), the uterus transducer was placed close to the base of the abdomen area and the fetal transducer was placed at the best possible focal point for the auscultation of the FCF.

It is important to point out that sows over six parities or any pregnant pig with more than 28 mm of backfat determined by ultrasound, were excluded from the study, they were excluded because it was notably difficult to identify an auscultation focus point in order to evaluate the FCF. The following criteria was used in the FCF evaluation: bradycardia was diagnosed when the FCF was less than 110 beats per minute and tachycardia, when the FCF basal was more than 160 beats per min. Delayed decelerations of the FCF called dips II were also identified, in order to corroborate the degree of asphyxia the fetus experimented in the uterus. In humans, the umbilical or variable deceleration dips II are attributed to the transitory oscillation of the umbilical vessels in the contracted uterus. When the oscillation is brief and less than 40 sec, it only produces a stimulation reflected in the vagus, but if the oscillation is more than 40 sec, fetal hypoxia will occur. This is why “dips II” are considered as a sign of acute fetal suffering (AFS) (Vispo *et al.*, 2002). Dips II are considered unfavorable if they occur for longer than 60 sec with diminished FCF under 80 beats per minute (Schwarcz *et al.*, 1995; Ruoti, 2000; Mota *et al.*, 2005a).

In order to detect these unfavorable dips II, the FCF was auscultated before, during and immediately after the myometrium contraction, being careful to observe coincidence with the peak of contraction. Control of myometrium activity is fundamental during the fetal expulsion phase, since it is well known that an increase in uterus contractions diminish the blood flow to the uterus and the gaseous exchange through the placenta (Tucker and Haut, 1990). This control included: the intensity, frequency and duration of myometrium contraction.

The active period of oxytocin starts when myometrium contraction patterns change, an activity that is only modified during the time the product is active. The intensity and frequency of the contractions increase and immediately after the same is finished, the intensity of the contractions return to their normal pattern (Mota *et al.*, 2005a).

Variable response in the different experiments: Birth traits monitored were: total duration of expulsion of the

piglets, interval between expulsion of piglets, number of parity and litter size.

The backfat was recorded at the P2 point (tenth thoracic vertebra), using ultra sound equipment (Renco Preg-Alert® Minneapolis, MN. USA).

At birth the live and stillborn (SB) piglets were counted. The number of piglets born with meconium stains on the skin were evaluated and the severity of stains were classified. The Randall (1972), variable neonatal scale modified by Zaleski and Hacker (1993) (Table 1) was also used. The umbilical cords were classified as normal, this means adhered and ruptured.

The cardiac frequency of the newborn piglets were measured with a stethoscope immediately after expulsion. Breathing latency was measured from the time of birth of the piglet up until apnea ended. Respiratory frequency was evaluated by observing thoracic movements in the newborn piglets.

Type of death classification: In order to classify the mortality of the peri-natal piglets, they were divided into either a Type I or Type II classification, the criteria was followed as described elsewhere (Randall, 1972; Sprecher *et al.*, 1974; Svendsen *et al.*, 1986; Mota *et al.*, 2002a, 2002b). In this study we were particularly interested in intra-partum stillbirths, since these are the deaths due to asphyxia.

The records for live and stillborn piglets with evidence of fetal suffering were recorded with the following information: order of birth at expulsion, sex, weight, condition of the umbilical cord and condition at expulsion.

Perinatal asphyxia classification level: The piglets with meconium stains on the skin were classified on a scale based on the apparent concentration of meconium (Mota *et al.*, 2002b; Mota-Rojas *et al.*, 2006). The level of stains were: mild (any indication of meconium, even a small amount and covering no more than 20% of the body of the neonatal), moderate (meconium staining of the skin covering from 21 to 60% of the body) and severe (meconium staining of the skin covering more than 60% of the body).

Table 1: Neonatal vitality score

Traits	Score		
	0	1	2
Cardiac frequency	<110 min	Between 121 and 160	>161 min
Latency to first breathing	More than 1 min	Between 16 sec and 1 min	Before 15 sec
Colour	Pale	Cyanotic	Pink
Latency to first standing on feet	>5 min	1 and 5 min	<1 min
Meconium staining of skin	Severe	Moderate	Mild

Modified of Zaleski and Hacker (1993)

Classification of Acute Fetal Suffering (AFS) was considered when piglets suffered asphyxia in the uterus and survived and at birth had all the following indicators: some level of meconium staining of the skin, hyperglycemia (more than 1100 mg L) or hypoglycemia (less than 550 mg L) (Polin and Spitzer, 2003), severe damage to the umbilical cord (oedema, congestion or hemorrhage) and metabolic acidosis reflected by a pH under 7.2.

The pH in the umbilical cords blood was analyzed with a digital potentiometer, model KS-701 24003 with a CH701 (Coprovet S.A. de C.V., Zapopan Jalisco) electrode for all newborns.

Body temperature was taken within the first minute of the neonate's birth, which was taken instantaneously (1 sec) with an otal thermometer (ThermoScan Braun®).

In order to measure the level of plasmatic glucose in the newborns, a drop of blood was taken from the umbilical cord of the neonates within the first minute of life and measured with a digital glucose-meter (BioSensor Optium MediSense®).

Statistical analysis: The results are presented as averages and standard errors. In order to evaluate the effects of treatment of fetal indicators in the uterus and after birth, the one way ANOVA test was used, followed by the Tukey test by way of a General Linear Model SAS (1990). In order to evaluate the effect of the various dosages on the number of piglets born with stained skin according to the neonatal viability qualification scale, the χ^2 test was used. In order to establish the level of correlation between variables the Pearson test was used. The effect of the parity number on the different treatments was evaluated with the one way analysis of variance.

RESULTS

In Table 2 the uterus control and the electronic fetal control indicators are shown. High and medium dosages had significantly higher ($p<0.01$) number of neonatal fetal suffering interpreted by means of the dips II.

There was a significant increase ($p<0.01$) in the number of uterus contractions during birth in the groups

treated with high and medium dosages of oxytocin, compared with the groups that received a low dosage and the control group.

The intensity of the contractions was significantly more ($p<0.01$) in the groups treated with oxytocin, compared with the control (Fig. 1). The intensity of the contractions increased with augmentation in the dosage of oxytocin, with a significant difference ($p<0.01$) between the groups treated. The duration of contractions diminished when the dosage of oxytocin was reduced.

The correlation between the reduction of ruptured umbilical cords when the intensity of contraction was reduced was $r = 0.57$ ($p<0.05$).

The average action of oxytocin was maintained uniform and there were no differences with the dosages applied. The productive traits are shown in Table 3. The analysis shows a larger number of deaths during farrowing in groups G_2 and G_3 that were treated with high and medium dosages of oxytocin, respectively, in comparison to the group treated with a low dosage and the control group (G_4 and G_1 , respectively). Among the groups treated with oxytocin, the larger number

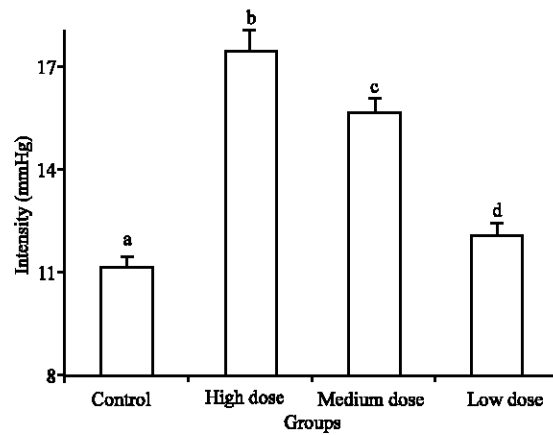


Fig. 1: Uterine contraction intensity in mm Hg measured through a tococardiograph (mean±standard error). ^{a,b}Different letter(s) among bars indicate significant differences ($p<0.01$) among groups, ANOVA test

Table 2: Variables of the intra-uterine fetal control evaluated through the use of a fetal an uterus transducer (media±EE)

	G ₁ Control n = 50	G ₂ High oxytocin dose n = 50	G ₃ Médium oxytocin dose n = 50	G ₄ Low oxytocin dose n = 50
Uterine traits				
Number of uterine contractions	39.16±0.88a	54.28±2.44b	58.46±1.06b	42.76±1.37a
Duration of the uterine contraction (sec)	9.70±0.39a	14.56±0.6b	15.82±0.58b	12.0±0.58c
Dips II	0.23±0.06a	0.92±0.17b	0.72±0.46b	0.46±0.25ca
Timing action (min)	0.0±0a	27.34±0.55b	26.82±0.65b	27.76±0.72b

^{a,b} Different letter(s) express significant differences ($p<0.01$) among groups, ANOVA test. High dosage: 1 UI 6 kg L. W.; medium dosage 1 UI 9 kg L.W; low dosage 1 UI 12 kg L.W.

Table 3: Birth traits: litter size, stillborns, duration of expulsion and inter-birth interval (mean±SE)

Birth traits	G ₁ Control n = 50	G ₂ High oxytocin dose n = 50	G ₃ Medium oxytocin dose n = 50	G ₄ Low oxytocin dose n = 50
Litter size	10.11±0.19a	10.46±0.23a	10.34±0.21a	10.5±0.18a
Born alive pigs	9.38±0.16a	9.64±0.17a	9.32±0.13a	9.76±0.17a
Duration of expulsion (min)	195.68±3.06a	131.36±3.33b	159.8±11.2b	164.36±6.22c
Inter-birth interval (min)	19.68±0.44a	12.82±0.38b	15.66±1.10b	16.1±0.74c
Intra-partum stillbirths	0.48±0.08a	0.68±0.11a	0.78±0.15a	0.48±0.1a
Intra-partum stillbirths with broken umbilical cord	0.34±0.04a	0.54±0.35bc	0.64±0.37c	0.24±0.07a

^{a,b} Different letter(s) express significant differences (p<0.01) among groups, ANOVA test. High dosage: 1 UI 6 kg L. W.; medium dosage 1 UI 9 kg L.W; low dosage 1 UI 12 kg L.W.

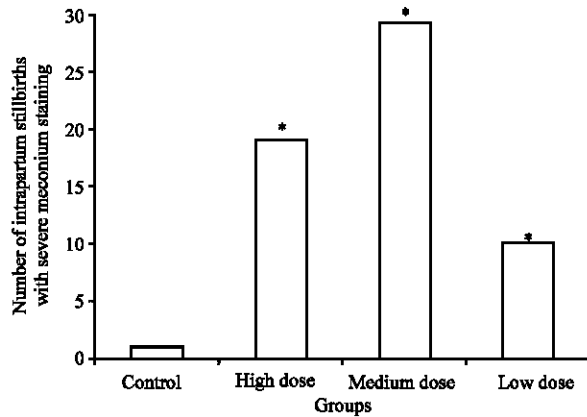


Fig. 2: Number of intra-partum deaths with severe meconium staining in skin. A postmortem examination was carried out to distinguish from antepartum deaths and confirm asphyxia. *Significant differences (p<0.05) with respect to the control group, χ^2 test

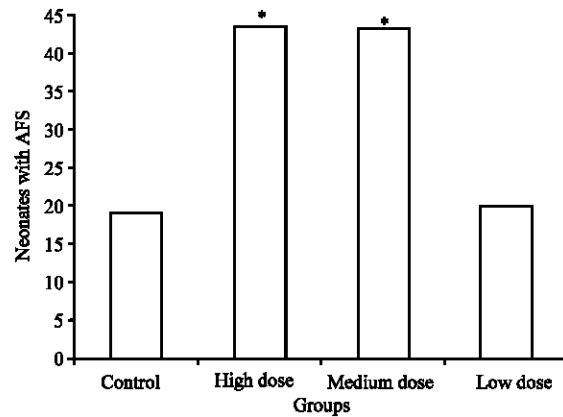


Fig. 3: Number of neonates with acute fetal suffering (AFS). These were those neonates that were through a process of asphyxia in uterus and survived and at birth showed some degree of meconium staining, hyperglycemia (>1100 mg L) or hypoglycemia (<550 mg L), severe umbilical cord damage (edema, congestion or hemorrhage) and metabolic acidosis (pH<7.2). *Significant differences (p<0.05) with respect to the control group, χ^2 test

of intrapartum stillbirth was present in the group treated with a high dosage.

Regarding the duration of expulsion of the piglets, the expulsion time significantly increased when oxytocin dosages decreased (p<0.01) (Table 3).

The expulsion interval between piglets was lesser (p<0.01) in the groups treated with high and medium dosages of oxytocin, compared to the control group.

The number of piglets born alive and the size of the litter had no significant differences (p>0.05) comparing the various dosages of oxytocin administered to the pigs.

The total number of stillbirths per group was 24, 34, 39 and 24; for groups 1, 2, 3 and 4, respectively.

In Fig. 2 the lesser number of IPS (p<0.05) with severe meconium staining of the skin is observed in the group treated with a low dosage of oxytocin.

The level of correlation of the number of IPS with ruptured umbilical cord, with intense uterus contractions (r = 0.56, p<0.05) was observed in the group treated with a high dosage.

The total number of piglets born live was 1,905, of which 6.56% (125 neonates) were born with meconium staining of the skin and 93.43% (1,780 neonates) had no staining, independent of the dosage applied.

The number of neonates with acute fetal suffering was significantly less (p<0.05) in the control group and the group treated with low dosages of oxytocin in comparison to the groups treated with high and medium dosages (Fig. 3).

There was a dramatically increase in the neonates with AFS (p<0.05) showing bradycardia (qualification = 0) in the groups treated with high and medium dosages of oxytocin (G₂ = 31 and G₃ = 28), compared to the groups with low dosage and the control (G₄ = 9 and G₁ = 1).

The number of neonates with AFS that took more than 5 min to stand on their feet were 2, 26, 30 and 9 for

Table 4: Number and percentage of neonates with signs of acute fetal suffering, on a grading scale indicated by color of snout

Snout color grading	G ₁ Control n = 50	G ₂ High oxytocin dose n = 50	G ₃ Medium oxytocin dose n = 50	G ₄ Low oxytocin dose n = 50
Pale	2 (10.5%)	12(27.9%)*	24(52.1%)*	5(25%)
Cyanotic (1)	4 (21%)	25(58.1%)*	16(34.7%)*	9(45%)
Pink (2)	13(68.4%)	6(13.9%)	6(13%)	6(30%)

* Significant statistical differences ($p < 0.05$) in χ^2 test, compared to the control group. High dosage: 1 UI 6 kg L. W.; medium dosage 1 UI 9 kg L.W; low dosage 1 UI 12 kg L.W.

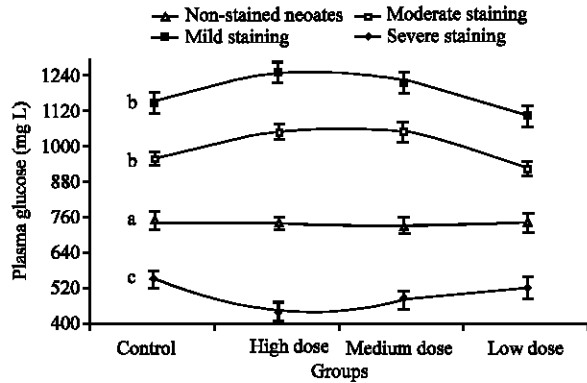


Fig. 4: Plasma glucose levels in meconium stained and non-stained neonates, which showed acute fetal suffering in uterus and that survived this process (showed acidosis ($pH < 7.2$) and umbilical cord rupture). Glucose value was taken 1 min after birth (mean \pm standard error). ^{a,b}Significant differences ($p < 0.01$) among lines, ANOVA test

groups 1, 2, 3 and 4, respectively. The number of neonates with AFS in this category was significantly more ($p < 0.01$) in high and medium oxytocin dosage groups, compared to the low dosage group and the control. There was no significant difference between the low dosage oxytocin group and the control.

There was a significant increase ($p < 0.05$) in the number of neonates with AFS that breathed 1 min after expulsion (qualification = 0), in the groups with high and medium dosages of oxytocin, compared to the control. The number of neonates with AFS per group were 2, 16, 26 and 8, respectively for groups 1 to 4. Again, there was no significant difference between the low dosage oxytocin group and the control group.

Regarding snout color of the neonates with AFS, frequent paleness and cyanosis number of observations were significantly greater ($p < 0.05$) in the groups treated with a high and medium dosage of oxytocin, in comparison to the control group and the group that received low dosages of oxytocin (Table 4).

Figure 4 shows that there were no significant differences in the glucose plasma concentration between stained and un-stained neonates in various levels of meconium staining. There was a numerous increase in the glucose concentration for the high and medium oxytocin dosage groups compared to the mild and moderate level stained neonates. There was a decrease in the low and medium oxytocin dosage groups with serious staining; however, neither one of them were significant ($p > 0.05$). Nevertheless these same figures have significant differences regarding the level of meconium stains of the skin, that is the neonates with low and moderate level staining on the skin exhibited AFS and showed drastic elevation in glucose plasma levels independent of treatment. Whereas the neonates that exhibited AFS with severe skin staining showed low levels of glucose plasma, independent of treatment. The correlation between AFS neonates and bradycardia was highly positive ($r = 0.74$, $p < 0.05$) in the high and medium dosage groups.

When comparing the plasmatic concentrations of glucose in neonates with AFS according to the level of meconium staining we found that the groups with mild and moderate staining experienced significant increments ($p < 0.01$) comparing the non-stained and severely stained. On the other hand we found that the plasmatic glucose decreased significantly ($p < 0.01$) regarding the seriously stained in comparison to the mildly and moderately stained neonates (Fig. 4).

The level of correlation between mildly stained AFS neonates and the possibility of the presence of hyperglycemia was high, $r = 0.52$ ($p < 0.05$), even though the correlation between severely stained AFS neonates and the hypoglycemic variable ($r = 0.61$, $p < 0.05$).

In 100% of the neonates born with meconium stains of the skin, only 9% were not afflicted with acidosis, hypothermia and ruptured umbilical cord, for which the neonates in these cases were not considered AFS.

In Fig. 5, a significant decrease ($p < 0.01$) in body temperature of the neonates with AFS in the high and medium oxytocin dosage groups is depicted. It was also noted that there were no significant differences ($p < 0.05$) between the control group and the low oxytocin dosage group regarding the body temperature trait.

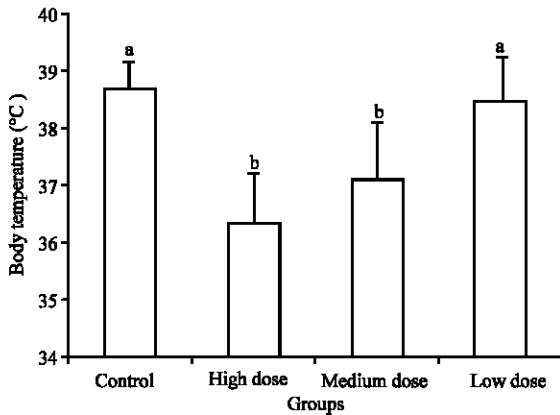


Fig. 5: Body temperature of neonates with acute fetal suffering. Temperature was monitored 1 min after birth. ^{a,b}Significant differences ($p < 0.01$) among groups, ANOVA test

DISCUSSION

Using high dosage oxytocin had a notable effect on the dynamics of the uterus by increasing the number and intensity of contractions. This dosage also increased the number of fetus that experienced deceleration in cardiac frequencies (dips II), an indication of acute fetal suffering.

The average dips II in the group that received a low dosage maintained half that of the group treated with the high dosage, since the intensity of the contraction even though different compared to the control group, simulated a normal pattern. Also in the former group the number of ruptured umbilical cords in deaths by asphyxia were reduced. This explains that asphyxia during birth could be caused by rupture of the umbilical cord, that provokes acute asphyxia and sudden death of the fetus, or the temporary obstruction of the umbilical cord during contraction of the uterus, that leads to a reduction in the plasmatic oxygen in the blood supply and an increase in the carbon dioxide in the same, causing respiratory arrest and finally asphyxia (Curtis, 1974; Svendsen *et al.*, 1986). It is important to point out that when the oxytocin dosage was decreased, the number of stillbirths with adhered umbilical cord increased.

The relation that exists between damage to the umbilical cord and fetal hypoxia has been demonstrated in studies carried out in experimentation on the obstruction of the umbilical artery in lambs. This study showed that when obstructing the blood flow for one min, with a frequency of 2.5 min provoked fetal acidosis and hypotension, while decreasing the frequency to half

the time provoked hypotension without acidosis (Westage *et al.*, 2001). This makes it clear that during birth (Lucia *et al.*, 2002) the intensity and frequency of the contractions are risk factors for the survival of the piglets.

The use of exogenous oxytocin to induce or accelerate birth is commonly used by obstetricians (Willcourt *et al.*, 1994); however, the use of liberal pharmacological dosages of oxytocin has created concern for both the mother and fetus mortality rate (Cummiskey *et al.*, 1989; Satin *et al.*, 1994). On the other hand, stillborns continue to be a problem on intensive production farms even with the use of pharmacological products used to induce birth (Straw *et al.*, 2002). Approximately 6% of piglets are stillborn or with reduced vitality signs at birth (Mota *et al.*, 2004).

In the present study neither the size of the litter or the number of liveborn piglets were affected by the various dosages applied. However, the duration of expulsion was significantly less in the groups treated with a high and medium dosage (G_2 and G_3 , respectively).

Regarding the neonatal with signs of AFS, it is worth mentioning that independent of the group each piglet belonged to, the fact that they had metabolic acidosis, ruptured umbilical cord and some level of meconium staining had an effect on their postnatal development, since they had bradycardia, occurrences of latency over 1 min in the first attempt to breath, latency over 5 min in attempt to stand and a cyanotic or pale colored snout. However, it is important to reiterate that the number of neonates with acute fetal suffering was significantly high ($p < 0.05$) in groups treated with high ($n = 43$) and medium ($n = 43$), dosages as compared to the control ($n = 19$) and low dosage group ($n = 20$).

This study reveals a high incidence of serious bradycardia in neonates with AFS in the groups treated with high and medium oxytocin dosages, since the fetus responds to asphyxia with an ample spectrum of hormonal, cellular and physiological reactions. A study by Da Silva *et al.* (2000) indicated that the most important physiological reaction is bradycardia in infants, this produced by compression of the umbilical cord, inducing an increase in the arterial pressure of the fetus, that in turn stimulate the aortic baroreceptors and carotids causing an integrated reaction in the brain stem, therefore causing an abrupt fall in the FCF. The correlation between bradycardia and AFS in neonates was highly positive in high and medium dosage groups and coincides with the finding of Satin *et al.* (1992a, b) who found that high dosages of oxytocin caused deceleration in fetal cardiac frequency that serves as a diagnosis of fetal suffering

before birth, in addition, Guy (2000) found that excessive dosages of oxytocin are recognized as a fetal retention risk.

Another interesting aspect to point out are the significantly different plasmatic glucose concentrations of the neonates with AFS according to the level of meconium staining of the skin. We found that the group with mild and moderate staining experienced exaggerated increase in glucose in plasma compared to the piglets without staining and piglets with severe meconium staining. On the other hand, we found that plasmatic glucose levels decreased significantly compared to AFS neonates without staining and neonates with mild and moderate staining. The level of correlation between mildly stained AFS neonates and the possibility of hyperglycemia was high, as well as the level of correlation between severely stained AFS neonates and the hyperglycemia variable. These results explain why the body temperature of the asphyxiated neonatal decreased and was affected by hypothermia.

Herpin *et al.* (1998) mentions that fetal asphyxia makes it hard for the newborn to produce heat. Herpin *et al.* (1996) indicates an increase in plasma catecholamines and at the same time an increase in liver glycogen.

Another positive note worth mentioning, is the reduction in ruptured umbilical cords, the intensity of contractions were reduced in the low dosage group. In human medicine, Shyken and Petrie (1995) indicate that low dosages help avoid over stimulation of the uterus and fetal suffering (Cummiskey *et al.*, 1989), although it requires more study, since the way oxytocin works in women (Blanks and Thornton, 2003) and diverse animal species (Schellenberg, 2002; Mota *et al.*, 2005b) is not well established yet.

The results of the study show that oxytocin should not be used routinely, since it does not reduce the number of stillborn piglets compared to the control group. Future studies should monitor the uterus dynamics and neonatal suffering through a blood-gas analysis of the umbilical cords of newborn piglet born to sows with dystocia and treated with oxytocin.

ACKNOWLEDGMENTS

Daniel Mota Rojas acknowledges the Doctorate grant number 176363, given by the "Consejo Nacional de Ciencia y Tecnología (CONACYT, Mexico) and the Cuerpo Académico de Etología, Producción Porcina y Fauna Silvestre" for the study financing.

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