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Journal of Theoretical & Experimental Pharmacology

ISSN (electronic): 1916-6958

2010; Volume 1; Number 1 (January-April): 21-26

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Journal of Theoretical & Experimental Pharmacology

ISSN 1916-6958
2010; Volume 1 (Number 1): Pages 21-26

ORIGINAL RESEARCH

Perinatal outcomes to uterine stimulation with breast massage alone or in combination with oxytocin in dystocic sows

Miguel GONZÁLEZ-LOZANO[a], Daniel MOTA-ROJAS[b,*], Alejandro A. NAVA-OCAMPO[c,d], María ALONSO-SPILSBURY[b], E. Yadira VELÁZQUEZ-ARMENTA[d], Rafael HERNÁNDEZ-GONZÁLEZ[e], Ramiro RAMÍREZ-NECOECHEA[b], María E. TRUJILLO-ORTEGA[f]

[a]Postgraduate Div. of Animal Science and Health, School of Veterinary and Animal Production, UNAM, México DF, México, [b]Dept. of Animal Production & Agriculture, Research Area: Ecodesarrollo de la Producción Animal, UAM-Xochimilco, México DF, México, [c]Department of Pharmacology & Toxicology, Faculty of Medicine, University of Toronto, Toronto, Canada, [d]PharmaReasons, Toronto, Canada, [e] Department of Experimental Research & Animal Resources, Instituto Nacional de Ciencias Médicas y Nutrición 'Salvador Zubirán', and [f]Department of Animal Medicine and Production: Swine, School of Veterinary and Animal Production, UNAM, México DF, México.

*Corresponding author: dmota100@yahoo.com.mx

ABSTRACT

Objective: Our goal was to evaluate the obstetric and fetal outcomes in dystocic sows receiving udder massage stimulation alone or in combination with oxytocin. **Methods:** 120 sows with maternal or fetal dystocia were randomly allocated to receive either intravulvar (I-Vu) saline (control group), udder massage followed by I-Vu saline, or udder massage followed by I-Vu oxytocin 10 IU (groups 1, 2 and 3, respectively). Udder massage consisted in the application of natural oil while rubbing the udder in a cephalic-to-caudal direction. Obstetric and fetal outcomes were obtained and compared among the three groups. The statistically significant limit was fixed to a two-tailed $P < 0.05$ in every test. **Results:** Intensity of uterine contractions decreased from 18.1 ± 3.6 mmHg in the control group to 14.1 ± 3.8 mmHg ($P < 0.001$) in group 2. Compared to the control group, there was an approximately 3.3-fold reduction in the number of moderate-to-severe meconium stained live-born piglets and 50% reduction of intrapartum deaths in group 2. In group 3, the reduction in these two outcomes was less evident but remained statistically significant. **Conclusions:** Dystocic sows that received udder massage had better obstetric and fetal outcomes than control sows. However, co-administration of oxytocin might reverse the advantages of udder massage.

Key words

Dystocia; Experimental animal models; Neuroendocrine system; Uterine stimulants

RÉSUMÉ

Objectif: Les effets obstétricaux et fœtaux de la stimulation mammaire seule ou associée à l'ocytocine ont été évalués chez des truies avec mise-bas dystocique. **Méthodes:** 120 truies avec dystocie maternelle ou fœtale ont été randomisées à un des trois groupes suivants: administration de sérum physiologique intravulvaire (I-Vu) (groupe témoin), stimulation mammaire suivie d'une administration de sérum physiologique I-Vu, ou stimulation mammaire suivie d'une administration de 10 UI d'ocytocine I-Vu (groupes 1, 2 et 3). La stimulation mammaire a consisté en l'application d'huile naturelle avec massage des mamelles en direction céphalocaudale. Les effets obstétricaux et fœtaux ont été enregistrés et comparés entre les trois groupes. Une valeur de $P < 0,05$ en bidirectionnel a été considérée comme statistiquement significative. **Résultats:**

Une diminution de l'intensité des contractions utérines de 18,1 ± 3,6 mmHg dans le groupe témoin à 14,1 ± 3,8 mmHg est observée dans le groupe 2 (P < 0,001). De même, le nombre de porcelets nés vivants avec liquide amniotique modérément à sévèrement méconial est réduit de 3,3 fois et la mortalité périnatale est réduite de 50 % dans le groupe 2. Dans le groupe 3, la réduction de ces paramètres est moins marquée, la différence vis-à-vis du groupe témoin restant cependant statistiquement significative. **Conclusions**: La stimulation mammaire procure des avantages obstétricaux et fœtaux chez les truies dystociques. L'administration concomitante d'ocytocine pourrait en diminuer les avantages.

Mots clés

Dystocie; Modèles expérimentaux animaux; Système neuroendocrinien; Stimulants utérins

RESUMEN

Objetivo: Evaluar los efectos obstétricos y fetales en cerdas distócicas que recibieron estimulación con masaje mamario solo o en combinación con oxitocina. **Métodos:** 120 cerdas con distocia materna y fetal fueron asignadas en forma aleatoria a cualquiera de los siguientes tres grupos: solución salina intravulvar (I-Vu) (grupo control); masaje mamario y solución salina I-Vu; o masaje mamario y oxitocina 10 UI (grupos 1, 2 y 3, respectivamente). El masaje mamario consistió en la aplicación de aceite natural mientras se masajeaba a la ubre en dirección cefálico-caudal. Los resultados obstétricos y fetales observados se compararon entre los tres grupos. El límite de significancia estadística fue de P < 0.05 de dos colas en todos los análisis realizados. **Resultados:** La intensidad de las contracciones uterinas disminuyó de 18.1 ± 3.6 mmHg en el grupo control a 14.1 ± 3.8 mmHg (P < 0.001) en el grupo 2. En comparación con el grupo control, en el grupo 2, el número de lechones nacidos vivos y con tinción de meconio de moderada a severa se redujo 3.3 veces mientras que el número de lechones muertos intraparto se redujo un 50%. La reducción de estos dos parámetros fue menos evidente en el grupo 3, aunque la diferencia resultó estadísticamente significativa. **Conclusiones:** Las cerdas distócicas sometidas a masaje mamario tuvieron mejores resultados obstétricos y fetales que las cerdas controles. Sin embargo, la coadministración de oxitocina revertió parcialmente las ventajas del masaje mamario.

Palabras clave

Distocia; Modelos animales experimentales; Sistema neuroendócrino; Estimulantes uterinos

INTRODUCTION

Dystocia is a common obstetric and public health problem because of the increased risk of intrauterine asphyxia, operative delivery, and maternal morbidity [1]. In pregnant women, breast stimulation may result in labor induction and reduction of rates of postpartum hemorrhage [2] [3]. However, breast stimulation may fail to enhance uterine response in 50% of parturient women [4], requiring the subsequent administration of oxytocin. Despite its technical simplicity, a number of problems have been recognized for developing appropriate trials to evaluate labor augmentation by breast stimulation in parturient women [5] [6]. This is probably the reason why insufficient information is available in the literature on this topic [3].

Pregnant sows appear to be a relevant animal model for studying uterine stimulation. In sows, low plasma levels of oxytocin are associated with prolonged parturition [7]. Conversely, udder stimulation has been associated with increased plasma levels of oxytocin in ewes [8]. However, few studies have focused on the uterotonic activity of teat massage during parturition, as breast massage had shown very strong effects, similar to the use of oxytocin.

The objective of the present study was to evaluate the obstetric and fetal outcomes in dystocic sows receiving udder massage stimulation alone or in combination with oxytocin.

METHODS

Animals

Previous approval by the Institutional Review Board of the Universidad Autónoma Metropolitana-Xochimilco, México DF, Mexico, and in accordance with the guidelines of the ethical use of animals in applied ethologic studies [9], the study was performed at a commercial farm of Yorkshire-Landrace sows located in the State of Hidalgo, Mexico. Approximately 120 sows deliver per month at this farm, and 2% to 4% have dystocia. The animals were artificially inseminated and received prenatal care throughout pregnancy including a diagnostic ultrasound (Renco Pregnant-Alert, Minneapolis MN, USA) at 5 weeks of pregnancy. Parturition was induced with an intramuscular prostaglandin injection (dinoprost tromethamine 10 mg; Lutalyse, Pharmacia & Upjohn, Mexico DF, Mexico) 24 hours prior to the expected delivery date, at 114 days of gestation, according to the farm's breeding-farrowing records. Animals were housed in individual crates of 1.76 m × 1.0 m for 5 days prior to the expected delivery date and for 21 days after delivery until complete weaning occurred in all the litters. The sows were in their first to fifth pregnancy.

Treatments

By means of a predesigned table of random numbers, at the time of delivery, 120 sows with maternal or fetal dystocia were allocated to one of the following

3 groups. In group 1 (controls), saline was injected by intravulvar route. In group 2, animals received an udder massage for 5 min starting after maternal or fetal dystocia was identified, followed by an intravulvar injection of saline. In group 3, sows received udder massage for 5 min starting after maternal or fetal dystocia was identified, followed by intravulvar administration of 10 IU of oxytocin. Udder massage involved the application of natural oil while rubbing the udder in a cephalic-to-caudal direction; this procedure was performed by the same investigator in all occasions.

For purpose of the study, fetal dystocia was considered as present when a sow delivered one or two consecutive intrapartum stillbirths prior to the inclusion of the animal into the study. Maternal dystocia was defined as a 40-min period of uterine quiescence that occurred in the parturient sow after the delivery of any of the piglets. Parturition was manually assisted by two of the investigators when the interval of time between piglets was longer than 1 hour.

Study outcomes

As obstetric outcomes, the number, intensity (mmHg) and duration (seconds) of uterine contractions were monitored by means of an electronic digital cardiotocograph (Fetal Monitor Coriometric, Medical Systems Inc. Co., Connecticut, CN, USA). Duration of parturition (min) was registered starting from the first tocographic evidence of consistent uterine activity until the delivery of the placenta. The time to deliver each piglet (time interval between piglets; min) was measured and averaged for each sow. The number of manual obstetric interventions per sow, performed by one of the investigators, was also registered.

As fetal outcomes, the number of live-born and stillborn piglets was registered. Stillbirths were classified into type I or type II, according to the classification criteria previously described in detail elsewhere [10] [11]. Type I or ante-partum stillbirths had a characteristic edematous and hemorrhagic appearance, a grayish-brown discoloration because of beginning mummification; if the process was advanced then the fetuses were dehydrated and started to lose hair. Type II or intra-partum stillbirths had the exact appearance of their normal littermates with the exception that they did not breathe. Finally, based on the degree of meconium staining at birth, life-born piglets were classified as unstained-to-mildly and moderate-to-severely stained [11].

Statistical analysis

The number of piglets born per sow was compared among groups by means of the Kruskal-Wallis test followed by the Mann-Whitney test in order to distinguish the differences between group 1 (controls) and either group 2 (udder massage) or 3 (udder massage and oxytocin). The other continuous variables were compared among groups by an Analysis of Variance (ANOVA) followed by a Dunnett test to distinguish the differences between group 1 and either group 2 or 3. Categorical variables were compared among the three groups by a '2 by k' X^2 test followed by a comparison between group 1 and either group 2 or 3 by a '2 by 2' X^2 test. The statistically significant limit was fixed to a two-tailed $P < 0.05$ in every test.

RESULTS

Udder massage alone or in combination with oxytocin did not increase the number of uterine contractions in comparison to the control group (Table 1). However, the duration of uterine contractions and the overall duration of parturition were decreased by approximately 9 s and 20 min by udder massage, respectively; as expected, the reduction was more evident in group 3 (approximately 12 s and 50 min, respectively). Paradoxically, the intensity of uterine contractions decreased from 18.1 ± 3.6 mmHg in group 1 to 14.1 ± 3.8 mmHg in group 2 ($P < 0.001$) (Table 1).

In group 3, however, the intensity of uterine contractions increased approximately 3 mmHg above that observed in the control group ($P \leq 0.0025$). Piglets were delivered at intervals of approximately 16 min in the control group and 15 min in the group treated with udder massage; time interval between piglets was reduced by 3 min ($P < 0.001$) in group 3 compared to the control. The number of manual obstetric interventions significantly decreased in sows in group 2 compared to the control group; this reduction was more evident in group 3.

Table 1 Obstetric outcomes of dystocic sows treated with udder massage alone or in combination with oxytocin

	Group 1 (controls) n = 40	Group 2 (udder massage) n = 40	Group 3 (udder massage + oxytocin) n = 40	P value
Uterine contractions per piglet (n)	3.8 ± 1.2	3.7 ± 0.7	4.3 ± 1.8	0.08
Intensity of uterine contraction (mmHg)	18.1 ± 3.6	14.1 ± 3.8*	21.1 ± 4.1*	< 0.01
Duration of uterine contraction (s)	25.6 ± 5.7	16.7 ± 4.5*	13.1 ± 2.8*	< 0.001
Duration of parturition (min)	205.2 ± 33.1	185.2 ± 36.6*	156.3 ± 37.3*	< 0.001
Time interval between piglets (min)	16.9 ± 3.3	15.4 ± 3.3	13.1 ± 3.6*	< 0.001
Manual obstetrics interventions [n (% of piglets)]	76 (14.9)	49 (10.1)*	30 (6.2)*	< 0.001

*P < 0.05, control group versus either udder massage or udder massage followed by oxytocin administration.
Data are mean ± SD or where specified n (%).

Table 2 Fetal outcomes of dystocic sows treated with udder massage alone or in combination with oxytocin

	Group 1 (controls) n = 40	Group 2 (udder massage) n = 40	Group 3 (udder massage + oxytocin) n = 40	P value
Piglets per sow [median (range)]	13 (11 – 15)	12 (10 -16)*	12 (8 -15)	0.048
Live born piglets [n (%)]	407 (79.6)	433 (89.1)*	398 (82.2)	< 0.001
Antepartum deaths [n (%)]	6 (1.2)	4 (0.8)	10 (2.0)	0.2
Intrapartum deaths [n (%)]	98 (19.2)	49 (10.1)*	76 (15.7)	< 0.001
Moderate-to-severe meconium stained piglets [n (% of live-born piglets)]	117 (28.7)	36 (8.8)*	58 (17.2)*	< 0.001

*P < 0.05, control group versus either udder massage or udder massage followed by oxytocin administration

The number of piglets born per sow was similar between groups 1 and 3; it was slightly, but significantly, lower in group 2 (Table 2). The number of live born piglets was significantly higher in group 2 than in the control group, whereas no differences were observed between groups 1 and 3. There was an approximately 3.3-fold reduction in the number of moderate-to-severe meconium stained piglets born to dystocic sows treated with udder massage (P < 0.001). In group 3, there was a 1.7-fold reduction (P < 0.001). Although the number of antepartum-death piglets was similar among the three groups, there was a reduction of approximately 50% in the number of intrapartum deaths in group 2 whereas the difference was not significant between groups 1 and 3 (Table 2).

DISCUSSION

The current study showed that udder massage applied to dystocic sows resulted in better obstetric and fetal outcomes than sows without any intervention. The demonstration that breast stimulation can successfully be used for ripening the cervix and labor induction was described as early as in the 18th and 19th centuries [5]. However, few advances to study the uterotonic effects, produced in response to breast stimulation, have been performed.

The uterotonic effect of udder massage in parturient sows can be enhanced by the subsequent administration of oxytocin. However, the rate of adverse obstetric and fetal outcomes also increased with the co-administration of oxytocin. Gestation-related changes in uterine activity include alterations in hormonal, metabolic, and neural inputs to the uterus, changes in the responsiveness of the myometrium to bioactive substances through alterations in receptors, and coupled signal transduction mechanisms resulting in myometrial layer-dependent differences in

responsiveness to bioactive substances less marked than that observed in non-pregnant sows [12].

Uterine response to breast stimulation has not shown any correlation with oxytocin levels [13], and the effects observed in the present study further support that breast stimulation may act through a different mechanism to oxytocin. For example, udder massage in dystocic sows significantly decreased uterine activity whereas oxytocin administration evidently enhanced it. In contrast, either udder massage alone or followed by oxytocin administration resulted in shorter duration of uterine contractions and parturition. In pregnant mammals, including humans, an abrupt increase in oxytocin binding sites in the uterus may occur at approximately 24 h before the onset of labor, reaching the greatest levels during labor and sharply decreasing after parturition to reach baseline levels 2-5 days postpartum [14] [15] [16]. These physiological changes explain the participation of endogenous oxytocin during parturition as well as the efficacy of this hormone when exogenously administered. Breast stimulation may facilitate the oxytocin-induced uterine stimulation by other pathways involved in the parturition process.

In our study, a 50% reduction in the rates of meconium-stained live-born piglets was observed in the group of dystocic sows that received udder massage in comparison to the control group. Similar significant, though less evident, results were previously reported in studies performed in parturient women [3]. In this study, however, the positive effect of udder massage was partially reversed by the administration of oxytocin. The adverse fetal and obstetric outcomes to oxytocin could be related to uterine hyperstimulation [17]. However, dystocia may not only result from uterine hyperstimulation but also from the lack of uterine response to oxytocin administration [18]. In a study on breast stimulation in parturient women, this maneuver failed to produce adequate uterine stimulation in 50% of cases, but there was no case of uterine hyperstimulation in those patients who subsequently received oxytocin [4]. The dose and the rate at which oxytocin is administered might define whether it may or may not produce uterine hyperstimulation. However, the current evidence points to a mechanism of action different to that produced by breast stimulation in mammals.

In conclusion, udder massage applied to dystocic sows resulted in better obstetric and fetal outcome than sows without any intervention. The mechanism of action of udder massage appears to be different to oxytocin. However, the subsequent administration of oxytocin partially reversed the benefits of udder massage.

AUTHORS' PARTICIPATION

D MR, M AS, R RN, M GL, and ME TO conceived the idea, drafted the protocol and proposed the study design. D MR, MGL, and M Z were responsible for the experimental part of the study. AA NO, and EY VA performed the data analysis. D MR, M AS, R RN, and ME TO drafted the manuscript. All participated in the discussion of the results and contributed to the final version of the manuscript.

ACKNOWLEDGEMENTS

The study was supported by a grant from the Programa de Mejoramiento del Profesorado (PROMEP) No. UAM-PTC-028 to the Academic Staff of Etología, Producción Porcina y Fauna Silvestre. D Mota-Rojas, M Alonso-Spilsbury, R Ramírez-Necoechea and ME Trujillo-Ortega, were supported, as members, by the Sistema Nacional de Investigadores. The authors are grateful to Pedro Sánchez Aparicio, Gloria González Hernández and Adriana Olmos, for the animal husbandry and technical assistance throughout the study.

CONFLICT OF INTERESTS/DISCLAIMERS

M GL, D MR, AA NO, M AS, EY VA, and R RN are members of the Editorial Board of the journal.

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