Sow and litter performance following farrowing induction with prostaglandin: Effect of adjunct treatments with dexamethasone or oxytocin

Glen Cassar, DVM, PhD; Roy N. Kirkwood, DVM, PhD, Diplomate ECAR; Robert Friendship, DVM, MSc, Diplomate ABVP; Zvonimir Poljak, DVM, MSc

Summary

Objective: To evaluate effects of dexamethasone (DEX) and oxytocin in prostaglandin $F_{2\alpha}$ (PGF) farrowing-induction protocols.

Materials and methods: In Experiment One, 144 sows were induced with two injections of PGF 6 hours apart (split dose) with or without injection of 20 mg DEX with the second PGF. Interval from initial PGF to farrowing, duration of farrowing, litter size born alive, number of stillbirths, and piglet weight gain to 10 days of age were recorded. In Experiment Two, 106 sows were induced with single or split-dose injections of PGF with or without injection of 20 IU oxytocin 24 hours after initial PGF. Time to onset and duration of farrowing were recorded, as were requirement for manual intervention, total litter size born, and incidence of stillbirths.

Results: For sows farrowing 24 to 32 hours after initial PGF injection in Experiment One, there was no effect of DEX treatment on the PGF-to-farrowing interval, duration of farrowing, or piglet growth and survival to 10 days of age. In Experiment Two, more sows farrowed by 32 hours after the split dose of PGF than after a single dose ($P < .05$). The PGF injection protocol did not influence the farrowing response to oxytocin. Oxytocin injection was associated with higher stillbirth rates when cervical dilation was incomplete.

Implications: These data do not support a role for corticosteroid in farrowing induction protocols. Oxytocin administered 24 hours after PGF (single or split dose) was associated with farrowing problems, suggesting that routine use of oxytocin in periparturient sows is contraindicated.

Key words: swine, farrowing, prostaglandin $F_{2\alpha}$, dexamethasone, oxytocin

Received: March 4, 2004
Accepted: September 14, 2004

Resumen – Efectos del tipo de aparato y su cubierta en la recuperación de virus y microorganismos del polvo en los aparatos de ultrasonido utilizados en granjas de cerdos de Alemania

Objetivos: Investigar si el polvo del interior de los aparatos de ultrasonido, utilizados para exámenes ginecológicos en las granjas de cerdos de Alemania, contenían virus y microorganismos, y si el tipo de aparato y su cubierta afectaban la contaminación interna viral y microbiana.

Métodos: Con hisopos e recolectaron muestras de 18 aparatos de ultrasonido de tres tipos comunes. Cinco estaban completamente cubiertos (con bolsas de plástico cerradas o plástico adhesivo de de uso casero), cuatro estaban cubiertos de forma incompleta (con bolsas de plástico abiertas o perforadas), y nueve estaban descubiertos. Los hisopos fueron examinadas en busca del circovirus porcino tipo 2; (PCV-2 por sus siglas en inglés), mediante la reacción en cadena de la polimerasa (PCR por sus siglas en inglés), del virus del síndrome reproductivo y respiratorio porcino (PRRSV por sus siglas en inglés) a través del PCR de trascripción reversa anidado y de bacterias, hongos y levaduras a través de cultivo. Ocho aparatos nuevos y sin usar (dos o tres de cada tipo) sirvieron como controles negativos.

Resultados: Ni el DNA del PCV-2 ni de las bacterias se recuperaron de ninguna máquina. Nueve aparatos fueron positivos al RNA del PRRSV, sin embargo, ningún aparato nuevo fue positivo. Todos los aparatos usados y dos de los aparatos nuevos tenían bacterias y hongos. Dentro de la categoría de aparatos usados, el tipo de aparato no afectó la contaminación. El cubrir a los aparatos completamente fue el tratamiento más efectivo para reducir la contaminación interna con bacterias y hongos.

Implicaciones: Las máquinas de ultrasonido de diferentes tipos pueden contaminarse internamente con el PRRSV y con numerosos microorganismos durante su uso en las granjas de cerdos. Una cubierta que elimine completamente el contacto con el aire podría ser efectiva para prevenir la contaminación con PRRSV de estos aparatos. Se deben establecer procedimientos de bioseguridad para el uso de aparatos de ultrasonido en granjas de cerdos, incluyendo su cubierta total con bolsas de plástico intactas.

GC, RF, ZP: Department of Population Medicine, University of Guelph, Guelph, Ontario, Canada.

RNK: Department of Large Animal Clinical Sciences, Michigan State University, East Lansing, Michigan.

Corresponding author: Dr Roy Kirkwood, Department of Large Animal Clinical Sciences, Michigan State University, East Lansing, MI 48824-1314; Tel: 517-432-5198; E-mail: kirkwood@cvm.msu.edu.

This article is available online at http://www.aasv.org/shap.html.

Cassar G, Kirkwood RN, Friendship R, et al. Sow and litter performance following farrowing induction with prostaglandin: Effect of adjunct treatments with dexamethasone or oxytocin. *J Swine Health Prod.* 2005;13(2):81–85.

Resumé – Effets du type de machine et sa couverture sur la récupération des virus et micro-organismes dans machines ultrasoniques utilisées dans les fermes porcines allemandes

Objectifs: Enquêter si la poussière a l'interior de machines ultrasoniques utilisées pour les examens gynécologiques dans les fermes porcines allemandes héberge des virus et des micro-organismes, et si le type de machine et sa couverture affectent la contamination interne virale et microbienne.

Méthodes: Écouvillons avec la poussière ont été rassemblées de 18 machines ultrasoniques de trois types communs. Cinq ont été utilisés complètement couvert (sacs plastiques fermés ou film plastique), quatre couvert incomplètement (avec sacs plastiques ouverts ou perforés), et neuf à découvert. Les écouvillons ont été testés pour circovirus porcin type 2 (PCV-2 par ses initiales en anglais) par amplification en chaîne par polymérase (PCR par ses initiales en anglais), pour le virus du syndrome reproducteur et respiratoire porcin (PRRSV par ses initiales en anglais) par n-PCR par transcriptase inverse, et pour bactéries, fungique, et levures par une culture. Huit machines nouvelles inutilisées (deux ou trois de chaque type) ont servi comme contrôles négatives.

Résultats: Ni l'ADN du PCV-2 ni levures n'ont été récupérés de aucune machine. Neuf machines usagées, mais aucune machine nouvelle, ont testé positif pour l'ARN de PRRSV. Toutes les machines usagées et deux machines nouvelles ont hébergé des bactéries et des fungiques. Dans les machines usagées, le type de machine n'a pas affecté la contamination. Le revêtement complet était très efficace pour réduire la contamination interne avec bactéries et fungiques.

Implications: Les machines ultrasoniques de types différents peuvent être contaminées intérieurement avec le PRRSV et nombreux micro-organismes pendant leur usage sur les fermes porcines. Une couverture qui éliminerait complètement le contact avec l'air peut être efficace pour prévenir la contamination de PRRSV de ces machines. Des procédures de biosécurité devraient être établies pour l'usage de machines ultrasoniques sur fermes porcines, en comprenant leur revêtement complet avec les sacs du plastique intacts.

In addition to initiating piglet delivery, peripartum endocrine changes may also affect early postnatal piglet survival. High levels of maternal corticosteroids are involved in advancing fetal visceral (ie, lung and intestinal) maturation, which may impact postnatal survival.[1,2] Further, the prepartum injection of 100 mg of prednisolone has been associated with a reduced duration of farrowing and increased piglet survival to 3 days of age.[3] The effect on piglet survival must be interpreted with caution, since any direct effect of corticosteroid is confounded with effects on duration of farrowing, although enhanced piglet neonatal growth has been observed following a prepartum injection of 20 mg dexamethasone.[4]

The objective of induced farrowing is to allow increased supervision of piglet delivery to improve neonatal survival.[5] To induce parturition, manufacturers recommend that a single intramuscular injection of prostaglandin $F_{2\alpha}$ (PGF) or PGF analogue be administered up to 2 days before due date. This protocol usually results in approximately 50% to 60% of sows farrowing the next working day.[6] However, the farrowing response was markedly improved when two injections of PGF were administered 6 hours apart (split-dose protocol).[7] Although the predictability of the day of farrowing was improved by the split-dose induction protocol, the time during the day at which the sow farrowed remained variable.

To improve the synchronization of farrowing, some producers inject oxytocin 20 to 24 hours after a single PGF injection, which usually results in a more rapid delivery of the first pig. However, this use of oxytocin also often increases the need for manual intervention, because it is associated with a higher incidence of interrupted farrowings.[8,9] An interrupted farrowing is characterized by a prolonged interval between delivery of the first pig and the subsequent piglets. Why some sows experience an interrupted farrowing is not known. However, it may be that the injection of oxytocin occurs before complete cervical dilation and so results in a painful delivery of the first piglet. In turn, pain may induce release of epinephrine and result in a transient tocolysis. When oxytocin was administered after delivery of the first piglet and so, presumably, after complete cervical dilation, a shorter duration of farrowing resulted, with no evidence of interrupted farrowings.[10] From the above, we reasoned that the improved farrowing response to a split dose of PGF suggests that more sows will have complete cervical dilation at 24 hours after PGF injection and so may be less likely to experience farrowing problems associated with oxytocin treatment.

The objectives of the present experiments were to further examine the effect of dexamethasone on the farrowing response of the sow and growth of the litter, as well as to determine the incidence of oxytocin-associated farrowing problems after induction with a single or split dose of PGF.

Materials and methods

Animals and facilities

These studies were approved by the animal care committees of the University of Guelph and Michigan State University and were conducted in accordance with their guidelines for the care and use of experimental animals. Experiment One was conducted on each of two facilities, one a commercial 700-sow farrow-to-feeder facility in Guelph, Ontario, Canada, and the other a 220-sow farrow-to-finish facility at Michigan State University. Experiment Two was conducted at the Guelph facility.

Experimental design

For Experiment One, 144 mixed-parity sows were induced to farrow 2 days before their due date (day 113 of gestation) with two vulvar injections of 2.5 mg or 5.0 mg prostaglandin $F_{2\alpha}$ (PGF; Lutalyse, Pharmacia, Orangeville, Ontario) administered 6 hours apart by 12-mm, 20-gauge needle. The different dosages reflect different management protocols for each farm but, on the basis of previous data,[6] no dose-dependant difference in farrowing response was anticipated. The initial injection was administered between 7:00 AM and 8:00 AM. At the time of the second injection, sows were assigned to receive an injection of 20 mg dexamethasone (DEX; Dexadreson, Intervet Canada, Whitby, Ontario; n = 73) or to serve as controls (n = 71). This dose of dexamethasone is at the high end of the therapeutic range and was administered intramuscularly (IM) in the neck.

The following working day (24 to 32 hours after initial PGF injection), sows were monitored continuously for piglet delivery until farrowing was complete. If an interval between piglet deliveries exceeded 45 minutes, manual intervention was employed. Sows farrowing < 24 hours after initial PGF injection were not observed, and their data were not included in the analysis. Similarly, sows farrowing > 32 hours after initial PGF injection were deemed to be nonresponsive to the induction protocol and excluded from data analysis. Piglets of sows farrowing 24 to 32 hours after PGF injection were individually identified by ear notching at birth, and incidences of piglet mortality were recorded. For sows farrowing 24 to 32 hours after initial PGF injection, records were maintained for the interval from initial PGF injection to onset of farrowing, duration of farrowing, litter size born (alive and stillborn), and piglet weights and survival at birth and at 3 and 10 days of age.

For Experiment Two, 106 mixed-parity sows were assigned, 2 days before their due-to-farrow date, to injection of 5 mg PGF (PG1; n = 29); injection of 5 mg PGF followed 24 hours later by 20 IU oxytocin (Bimeda-MTC Pharmaceuticals, Cambridge, Ontario) (PG1-OT; n = 28); injection of 2.5 mg PGF followed in 6 hours by a second injection of 2.5 mg PGF (PG2; n = 24); or injection of 2.5 mg PGF followed in 6 hours by a second injection of 2.5 mg PGF and then 20 IU oxytocin 24 hours after the initial PGF injection (PG2-OT; n = 25).

The dose of oxytocin was based on literature evidence indicating effective doses of between 10 and 30 IU[8,9,11] and anecdotal evidence of 20 IU being a commonly used dose in commercial practice. The PGF was administered into the vulva and the oxytocin was administered IM in the neck. Initial PGF injections were administered between 7:00 AM and 8:00 AM on day 113 of gestation. During the following working day, sows were monitored continuously for piglet delivery until farrowing was complete. If an interval between piglet deliveries exceeded 45 minutes, manual intervention was employed. As in Experiment One, sows farrowing < 24 hours or > 32 hours after initial PGF injection were excluded from data analysis. Where oxytocin injection was indicated, an assessment of cervical dilation was performed prior to injection. A gloved hand was inserted into the vagina and cervical dilation confirmed if at least two fingers could be inserted comfortably into the cervical canal. Records were maintained for interval from initial PGF injection to onset of farrowing, duration of farrowing, requirement for manual intervention, and litter size born (alive and stillborn).

Statistical analysis

All analyses were performed by ANOVA using SAS (SAS Institute Inc, Cary, North Carolina). The treatment means for intervals from initial PGF injection to delivery of the first pig, duration of piglet delivery, and total born litter size were compared using the MIXED procedure. The proportion of sows farrowing 24 to 32 hours after initial PGF injection and proportion of stillbirths were analysed using logistic regression in GENMOD procedure and tested by the Wald chi-square test. Differences in the variances around the means were tested by F-ratio test and analyses were adjusted for parity. Data from Experiment Two were analyzed as a 2 × 2 factorial.

For Experiment One, treatment effects on piglet birth weights and average daily gain to 10 days of age were compared for all piglets using the MIXED procedure with litter as a random effect and piglet birth weight as covariate in the model for average daily gain. Treatment effects on mortality of piglets until 10 days of age were tested using logistic regression in GENMOD procedure with birth weight as covariate and accounting for the within-litter correlation using compound symmetry correlation structure. Separate analyses for average daily gain and mortality were performed for all piglets with birth weight < 1.1 kg.

Results

In Experiment One, 24 sows from each treatment farrowed < 24 hours after initial PGF injection and were not included in data analysis. Of the remaining sows, 41 DEX sows and 43 control sows commenced farrowing 24 to 32 hours after the initial PGF injection, and the response was not affected by DEX treatment. Eight DEX and four control sows farrowed > 32 hours after initial PGF injection and were not included in the data analysis. Manual intervention was performed in eight sows per treatment. For sows farrowing 24 to 32 hours after initial PGF injection, there was no effect of DEX on the PGF-to-farrowing interval, the duration of the farrowing process, total born litter size, stillbirth rate, or piglet growth or mortality to 10 days of age (Table 1). Similarly, there were no effects of DEX when analyses were restricted to piglets with birth weights < 1.1 kg.

In Experiment Two, more sows receiving two PGF injections farrowed 24 to 32 hours after initial PGF injection than did those receiving a single PGF injection ($P < .05$; Table 2). There was no effect of oxytocin treatment on numbers of sows farrowing 24 to 32 hours after PGF injection. However, for sows farrowing 24 to 32 hours after the first PGF injection, the variance in the interval to farrowing was less ($P < .05$) for oxytocin-treated sows (Table 2). In sows that responded to induction, there was no overall treatment effect on the PGF-to-farrowing interval, farrowing duration, percent live births, or the need for manual interventions (Table 2). For the eight oxytocin-treated sows that farrowed > 32 hours after initial PGF injection, the stillbirth rate was 50%, while the stillbirth rate was 14% for the nine sows farrowing > 32 hours after initial PGF injection that did not receive oxytocin.

Discussion

The data presented for Experiment One indicate no effect of dexamethasone on the timing or duration of farrowing. An earlier report had shown that prepartum injection of prednisolone resulted in a shorter period of piglet delivery.[3] An explanation for the shorter delivery time was not provided, but it is reasonable to infer the involvement of an analgesic effect of the corticosteroid allowing for a more comfortable delivery. However, the sows used in the present study were relatively mature and so less likely to suffer a painful delivery. If true, an effect of dexamethasone on the piglet delivery process may become apparent only in young sows.

Other authors have demonstrated that dexamethasone treatment of the periparturient sow resulted in enhanced neonatal piglet growth, especially of the low-birth-weight pigs.[4] Also, injection of dexamethasone into newborn piglets may improve growth, although the effect has proven inconsistent with either a general or a sex-linked growth response, or no growth response being observed.[12–14] In the present study, no effect of dexamethasone was observed on litter

Table 1: Adjusted mean effects[1] on the timing of farrowing and litter growth and survival (means ± SE) in sows treated prepartum with prostaglandin (PGF) alone (Control) or with prostaglandin and dexamethasone (DEX)[2]

Variable	Control	DEX
Number of sows	43	41
PGF-to-farrow interval (hours)	26.6 ± 0.3	27.0 ± 0.4
Duration of farrowing (hours)	2.7 ± 0.3	3.0 ± 0.3
Total born litter size	10.8 ± 0.4	11.5 ± 0.4
Birth weight (kg)	1.49 ± 0.06	1.52 ± 0.06
Average daily gain to 10 days (g)	215.4 ± 9.4	216.4 ± 9.3
Probability (%) of stillbirths[3]	5.3 (3.6 - 7.9)	4.3 (2.8 - 6.6)
Probability (%) of piglet mortality to 10 days[3]	6.8 (3.5 - 12.8)	8.2 (5.2 - 12.9)

1 Maximum likelihood estimates. Means for PGF-to-farrowing interval, duration of farrowing, and total born litter size compared using an ANOVA and the MIXED procedure of SAS (SAS Institute Inc, Cary, North Carolina). Means for birth weight and ADG to 10 days of age compared using the MIXED procedure with litter as a random effect in the model for birth weight. There were no significant differences for any effects at $P < .05$.

2 All 144 sows induced by two injections of prostaglandin $F_{2\alpha}$ (PGF) administered 6 hours apart, with DEX administered to 73 sows at the time of the second PGF injection. Data included only for sows farrowing 24 to 32 hours after initial PGF injection.

3 Estimated (with a 95% confidence interval) using logistic regression in GENMOD procedure, with within-litter correlation for piglet mortality. There were no significant differences for stillbirths or piglet mortality ($P > .05$).

growth and survival regardless of birth weight. Therefore, given the unpredictable response to corticosteroid treatment, the use of dexamethasone in the farrowing induction protocol does not appear to be warranted.

In Experiment Two, the farrowing response to induction supports previous reports that the vulval route for PGF injection produces acceptable results at lower than label dosages.[6,15] Further, in terms of the numbers of sows farrowing 24 to 32 hours after initial PGF injection, the split-dose PGF protocol produced a superior response compared to the single dose, also supporting earlier observations.[7] In the present study, oxytocin did not result in a general increase of stillbirths in sows with a dilated cervix, but may have been a factor in the farrowing complications and the high number of stillbirths in sows with a closed cervix at the time of oxytocin treatment. An increased stillbirth rate associated with the use of oxytocin has been observed previously.[16] Since evaluation of cervical dilation is not routinely performed prior to oxytocin injection, the prepartum use of oxytocin cannot be recommended.

Recent research has suggested that even after delivery of the first piglet, the use of oxytocin might produce undesirable results.[10] The latter authors described larger numbers of stillbirths per litter, with the highest incidence being among the first four pigs rather than towards the end of farrowing. This pattern of stillbirth deliveries was associated with an increased incidence of umbilical cord abnormalities, suggesting that inappropriately powerful uterine contractions may be detrimental to piglet survival even when the cervix is fully patent. In the present study, oxytocin-treated sows had numerically more farrowing problems requiring manual intervention (30 compared to 20 not requiring intervention), but there were too few sows to detect a significant difference. This research would suggest that there is little to be gained by routine use of oxytocin as part of an induction program. Indeed, the potential for oxytocin to cause problems if dilation of the cervix has not

Table 2: Descriptive statistics of farrowing response in sows receiving prostaglandin (PGF) as a single injection (PG1) at day 113 of gestation or two injections (PG2) 6 hours apart on day 113 of gestation, with or without oxytocin (OT) 24 hours after initial PGF injection

Variable	PG1	PG1-OT	PG2	PG2-OT
Number of sows treated[1]	29	28	24	25
Parity[1]	6.4 ± 3.0	8.1 ± 3.2	8.4 ± 2.6	8.4 ± 2.9
Parity >7 sows[1] (%)	41	67	67	70
Sows farrowing in 24-32 hours[2] (%)	17 (58.6)[a]	21 (75.0)	21 (87.5)[b]	20 (80.0)
Sows not responding (%)	8 (27.6)	5 (17.9)	1 (4.2)	3 (12.0)
Interval to farrowing[1,3] (hours)	25.8 ± 2.3	24.8 ± 0.4	26.3 ± 3.1	24.8 ± 0.6
Farrowing duration[1] (hours)	3.1 ± 1.0	2.7 ± 1.6	2.8 ± 1.2	2.6 ± 1.1
Litters with intervention[1]	8	17	12	13
Litter size (total born)[1]	11.7 ± 2.6	10.5 ± 2.9	12.0 ± 2.5	10.6 ± 2.8
Mean stillbirths[1] (%)	8.1	7.8	8.5	7.6
Median stillbirths[1] (%) (5th - 95th percentile)	0 (0 – 43)	0 (0 – 25)	7.1 (0 – 31)	0 (0 – 47)

1 Data included only for sows farrowing 24 to 32 hours after initial PGF injection. All analyses, including proportion of sows farrowing in 24 to 32 hours, performed by ANOVA in SAS (SAS Institute Inc, Cary, North Carolina) with statistical significance set at $P < .05$.

2 More sows receiving two PGF injections farrowed 24 to 32 hours after initial PGF injection (chi-square test, $P < .05$).

3 Variance around the means smaller for OT sows (F-ratio testing, $P < .05$).

ab Means in the same row with different superscripts are different ($P < .05$).

advanced sufficiently to allow easy passage of the piglets, and its potential to cause interrupted farrowings, suggest that the routine use of oxytocin in periparturient sows is contraindicated.

Implications

- Administration of dexamethasone to periparturient sows does not impact neonatal piglet growth or survival.
- The use of a split-dose PGF induction protocol decreases the likelihood of sows not farrowing in response to PGF.
- As some sows may have a nondilated cervix 24 hours after initial PGF injection, even with split-dose PGF induction, the use of oxytocin in periparturient sows is contraindicated.

Acknowledgment

This work was generously supported by Ontario Pork.

References

1. Olson EB Jr. Role of glucocorticoids in lung maturation. *J Anim Sci*. 1979;49:225–238.

2. Moog F. Endocrine influences on the functional differentiation of the small intestine. *J Anim Sci*. 1979;49:239–249.

*3. Bilkei G. The effect of prednisolon on perinatal mortality of piglets. *Proc 12th Congress IPVS,* The Hague, The Netherlands. 1992;2:465.

4. De Rensis F, Sottocorona M, Kirkwood RN. Effect of prostaglandin and dexamethasone injection on farrowing and piglet neonatal growth. *Vet Rec*. 2002;151:330–331.

5. Holyoake PK, Dial GD, Trigg T, King VL. Reducing pig mortality through supervision during the perinatal period. *J Anim Sci*. 1995;73:3543–3551.

6. Kirkwood RN, Thacker PA, Aherne FX, Goonewardene LA. The effect of dose and route of administration of prostaglandin F_{2a} on the parturient response of sows. *Swine Health Prod*. 1996;4:123–126.

7. Kirkwood RN, Aherne FX. Increasing predictability of cloprostenol-induced farrowing in sows. *Swine Health Prod*. 1998;6:57–59.

8. Welp C, Jochle W, Holtz W. Induction of parturition in swine with a prostaglandin analog and oxytocin: A trial involving dose of oxytocin and parity. *Theriogenology.* 1984;22:509–520.

9. Kirkwood RN, Thacker PA. Effect of propranolol on the onset and duration of parturition in sows. *Can Vet J*. 1995;36:238–239.

10. Mota-Rojas D, Martinez-Burnes J, Trujillo-Ortega ME, Alonso-Spilsbury ML, Ramirez-Necoechea R, Lopez A. Effect of oxytocin treatment in sows on umbilical cord morphology, meconium staining, and neonatal mortality of piglets. *Am J Vet Res*. 2002;63:1571–1574.

11. Dial GD, Almond GW, Hilley HD, Repasky RR, Hagen JC. Oxytocin precipitation of prostaglandin-induced farrowing in swine: determination of the optimal dose of oxytocin and optimal interval between prostaglandin F2 alpha and oxytocin. *Am J Vet Res*. 1987;48:966–970.

12. Carroll JA. Dexamethasone treatment at birth enhances neonatal growth in swine. *Dom Anim Endocrinol*. 2001;21:97–109.

13. Gaines AM, Carroll JA, Allee GL, Yi GF. Pre- and postweaning performance of pigs injected with dexamethasone at birth. *J Anim Sci*. 2002;80:2255–2262.

*14. Young MG, Tokach MD, Dritz SS, Goodband RD, Nelssen JL. Effect of dexamethasone injection at birth on growth performance of pigs from birth to weaning. Kansas State University Swine Day. 2002;20–22. Available at **http://www.oznet.ksu.edu/library/lvstk2/samplers/srp897.asp**. Accessed January 7, 2005.

15. Friendship RM, Templeton CL, Deckert AE. An evaluation of vulvomucosal injections of prostaglandins for induction of parturition in swine. *Can Vet J*. 1990;31:433–436.

16. Yang P-C, Fang W-D, Huang S-Y, Chung W-B, Hsu WH. Farrowing induction with a combination of prostaglandin $F_{2\alpha}$ and a peripherally acting α_2-adrenergic agonist AGN 190851 and a combination of prostaglandin $F_{2\alpha}$ and oxytocin. *Theriogenology.* 1996;46:1289–1293.

* Non-refereed references.