Brief communication

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The effect of antiseptic compounds on umbilical cord healing in piglets in a commercial facility

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Summary

Four hundred and seventy piglets were assigned to four treatment groups: iodine, trisodium citrate, a dry dip created using nisin with talc, and no treatment. No treatment differences were noted on change in diameter or incidence of infection of the umbilical cord during the first 48 hours ($P > .05$).

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Resumen - El efecto de los compuestos antisépticos en la recuperación del cordón umbilical en lechones de un establecimiento comercial

Se asignaron cuatrocientos setente lechones a cuatro grupos de tratamiento: yodo, citrato de trisodio, un desinfectante seco a base de nisina con talco, y sin tratamiento. No hubo diferencia entre los tratamientos al evaluar el cambio en diámetro o incidencia de la infección del cordón umbilical durante las primeras 48 horas ($P > .05$).

Résumé - Effet de produits antiseptiques sur la guérison du cordon ombilical de porcelets provenant d'une entreprise commerciale

Quatre cent soixante porcelets furent assignés à quatre groupes de traitement: iode, citrate trisodique, un bain sec créé en utilisant de la nisine avec du talc, et aucun traitement. Aucune différence entre les traitements ne fut notée relativement au diamètre ou à l'incidence d'infection du cordon ombilical durant les premières 48 heures ($P > .05$).

The umbilical cord serves as a channel for the blood supply between the fetus and the placenta throughout pregnancy. During the birthing process, the umbilical cord ruptures, leaving it open-ended. This umbilical cord may become a potential route for pathogen entry into the newborn, increasing the risk of septicemia. Nielsen et al[1] reported that 2.1% of live-born piglets died from septicemia, which may result from umbilical infections, although there are several other common causes of this condition in piglets. Subclinical umbilical infections may prevent the abdominal wall musculature from healing completely, increasing the risk for umbilical hernias during the growing phase.[2] The prevalence rate of umbilical hernias in the swine industry is approximately 1%.[3] Preventing infections of the umbilical stump at birth through the use of antiseptic compounds is the most common approach for producers to attempt to decrease the prevalence of umbilical hernias,[1] and tincture of iodine is the most commonly used antiseptic for this purpose.[4] In 2007, the Drug Enforcement Administration listed iodine under the Controlled Substances Act. This regulation has made it difficult to obtain anything greater than 2% tincture of iodine.[5] Trisodium citrate is a component of a recently developed, commercially available umbilical dip (NavelShield Navel Dip; Zurex Pharmagra LLC, Middleton, Wisconsin). It is a non-iodine formulation that provides a wide spectrum of germicidal activity.[6] The nisin dry dip was developed in efforts to increase drying and healing time of umbilicus tissue. In pigs, nisin has effective antimicrobial activity against *Streptococcus suis*, a major worldwide swine pathogen associated with meningitis, arthritis, pneumonia, and septicaemia.[7] The nisin compound was mixed in a talc base because talc is relatively biologically inert and absorbs moisture without caking.[8]

The objective of this project was to compare three antiseptics (2% iodine, 10% trisodium citrate, and a nisin-based product) to no antiseptic treatment and determine their impact on umbilical healing and 24- and 48-hour infection rates in piglets in a field trial.

Materials and methods

This study was approved by the Iowa State University IACUC committee.

A total of 470 mixed-sex commercial piglets (PIC 1050 sow × Danbred 600 sire; average birth weight, 1.15 kg; standard error, 0.33 kg) from a breed-to-wean sow farm were enrolled in this study. Piglets received small ear tags that identified treatment groups. Sows were housed in farrowing stalls (2.1 m × 0.91 m). The piglet area was 0.6 m × 1.8 m on each side of the farrowing stall, with a heat lamp 0.7 m above the floor surface and one rubber mat on the floor underneath the lamp.

Piglets were randomly assigned by alternating the four treatments across birth order within a litter: 2% iodine (n = 116); 10% trisodium citrate (n = 119); a novel dry dip created using an antibacterial peptide (nisin) mixed with talc (formulation concentration = 3.105 g nisin per 100 g talc on a weight per weight basis (n = 117); and no treatment (n = 118). Piglet umbilical cords were dipped within 1 hour of birth using a small disposable cup filled with the antiseptic. Treatments were applied to the umbilical cord tissue and the

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umbilical stump for 5 seconds to ensure consistency of application between treatments and to ensure that the vulnerable opening of the cord was thoroughly disinfected.

At the end of the farrowing period, stall conditions of the farrowing area behind the sow and next to the sow on the rubber mat in each individual stall were evaluated on a wet-dry 3-point scale (1 = < 10% wet, 2 = 10% to 70% wet, and 3 = > 70% wet) and a clean-dirty 3-point scale (1 = < 10% dirty, 2 = 10% to 70% dirty, and 3 = > 70% dirty). Prior to initial dipping, diameter of each umbilical cord just distal to the abdomen, at the widest width of the cord, was determined using digital calipers (Mitutoyo 500-197-30 Absolute Digital Caliper, Aurora, Illinois) at birth and 24 ± 1 hours of age as an indicator of cord drying and healing. As a potential indicator of early umbilical infection, surface temperature of the umbilical stump (along with a reference point at the midpoint of the sternum) was measured using a dual laser infrared thermometer (Model 42570; Extech Instruments, Nashua, New Hampshire). The infrared temperature measurements were obtained at birth, at 24 ± 1 hours of age, and at 48 hours of age. In addition, redness and swelling of the umbilical stump were evaluated visually at both 24 and 48 hours. Redness was recorded as either being present or not present, while swelling was evaluated as either not present, minimal, or clinically significant. Piglets were available for this trial for only the first 48 hours of life.

All data were analyzed using the PROC UNIVARIATE procedure of SAS to determine normality of distribution. All data were further analyzed using mixed linear regression (PROC MIXED; SAS Version 9.3, SAS Institute Inc, Cary, North Carolina). All models included the fixed effects of umbilical diameter at birth, sex (female or male piglets), stall conditions, and treatment. Orthogonal contrasts were used to determine differences in the rate of healing and incidence of infection between piglets with untreated umbilical cords and those that were treated with antiseptics, as well as differences among the antiseptic treatments. All values reported are least squares means. Significance was declared at $P < .05$.

Results

Variations in stall conditions at birth in this study had no effect on healing of the umbilical stump or umbilical infection in the piglets ($P > .05$). Mean stall cleanliness score at farrowing was 2.1 ± 0.7, while mean stall dryness score at farrowing was 1.6 ± 0.6. Mean diameter of umbilical cords for all piglets was 6.60 mm at birth and decreased to a mean of 3.25 mm at 24 hours of age. Additionally, 32.6% of piglets had an umbilical cord that had healed to the point of separation from the body at 48 hours of age. There were no observed treatment differences ($P > .05$) for umbilical cord drying and healing (Table 1). There were no observed umbilical infections (as indicated by elevated umbilical stump surface temperatures) in piglets within the first 48 hours. In addition, no umbilical infections were observed (as indicated by redness and swelling measurements at 24 hours and 48 hours) in any of the piglets within the first 48 hours of life.

Discussion

Despite the perceived importance of umbilical cord care after birth for potentially reducing the incidence of umbilical infections and possible subsequent umbilical hernias, very few randomized trials have evaluated umbilical cord care and antiseptic use in production-animal settings. In one epidemiological study using dairy calves,[9] risk of calf mortality was significantly lower following use of chlorhexidine than after use of iodine or no cord care, while iodine tended to increase mortality risk. In a more recent study, Robinson et al[10] reported no differences between umbilical antiseptic treatments (7% iodine, 10% trisodium citrate, 4% chlorhexidine, and 1000 mmol per L chlorine) for enhancing healing or reducing the incidence of infection in Jersey calves in a clean, dry environment. However, an important consideration when comparing across species is that calves have a much larger umbilical cord than do piglets, which may affect both healing time and risk of infection.

However, the findings of this study with piglets indicated that appropriate antimicrobial solutions applied to the umbilical cord within 1 hour of birth did not affect umbilical infection rate in the first 48 hours of life. There were no observed differences between any of the treatments tested for decreasing the incidence of omphalitis in newborn piglets. In fact, there were no clinical umbilical infections observed in any piglets in this trial, whether they were treated with antiseptic or remained untreated. Umbilical infections often occur after 2 days of age; however, we were able to observe piglets only during the first 48 hours. These data suggest that dipping the piglet umbilical cord with an antiseptic within an hour of birth does not affect the incidence of umbilical infection or healing within the first 48 hours of life if piglets are kept in a clean, dry environment. Because no infections were observed during this time period, we were unable to validate the usefulness of surface temperature for detecting umbilical infections in newborn piglets. Validation of the infrared surface temperature thermometer for detecting infections has yielded mixed results in previous studies.[11,12]

Each antiseptic used in this trial has a different mode of action. Iodine rapidly penetrates into microorganisms and attacks key groups of proteins, nucleotides, and fatty acids, which culminates in cell death.[13] Trisodium citrate affects Mg^{2+} binding and removal of Ca^{2+} from the surrounding milieu of microorganisms that confers antimicrobial properties, as Ca^{2+} may regulate several genes responsible for growth and survival of microbes.[14] Nisin is generally more active on gram-positive than on gram-negative bacteria, and its bactericidal effect is exerted at the cytoplasmic membrane.[15] Nisin kills susceptible bacteria through a multi-step process that destabilizes the phospholipid bilayer of the cell and creates transient pores. Nisin is a small amphiphilic peptide that is cationic at neutral pH. It has been shown to adsorb to surfaces, maintain activity, and kill cells that have adhered in vitro.[16] Nisin is a safe chemical to use for food-animal treatment according to the FDA Code of Federal Regulation listing nisin as a Generally Recognized As Safe (GRAS) substance.[17] In addition, for the purposes of this trial, nisin was mixed with talc to absorb water and help increase the drying and necrosis time of the umbilicus tissue, thus decreasing the availability of a potential route for pathogen entry.

The current study also evaluated a potentially novel technique for assessing early signs of infection using the surface temperature of the umbilicus area compared to the sternal temperature (as determined using infrared technology). An increase in umbilical stump temperature when compared to the sternal temperature, combined with a tender umbilical stump, may indicate the presence of an infection. Similar approaches using infrared technology have been used to diagnose infection in human medical applications.[18] The application of this technology has the potential to be used in detecting subclinical umbilical infections, but could not be vali-

Table 1: Treatment effects on umbilical parameters in piglets during the first 48 hours*

	Treatment				Treatment effect†
Measure	2% iodine	10% trisodium citrate	Nisin dry dip	No treatment	*P*
Umbilical diameter at birth (mm)	6.4 ± 1.3	6.8 ± 1.3	6.7 ± 1.2	6.6 ± 1.1	> .05
Umbilical diameter at 24 hours (mm)	3.2 ± 1.2	3.4 ± 1.2	3.1 ± 1.2	3.3 ± 1.1	> .05
Stump temperature at birth (°C)	28.9 ± 3.1	29.1 ± 3.0	29.0 ± 3.0	29.1 ± 3.0	> .05
Sternal temperature at birth (°C)	30.1 ± 3.3	30.4 ± 3.1	30.1 ± 3.0	30.3 ± 3.3	> .05
Stump temperature at 24 hours (°C)	32.2 ± 2.8	32.5 ± 2.5	32.4 ± 2.6	32.4 ± 2.0	> .05
Sternal temperature at 24 hours (°C)	33.2 ± 2.0	33.4 ± 2.0	33.2 ± 2.0	33.2 ± 1.8	> .05
Stump temperature at 48 hours (°C)	35.0 ± 2.2	35.1 ± 1.9	34.6 ± 2.6	35.1 ± 2.3	> .05
Sternal temperature at 48 hours (°C)	35.4 ± 2.3	35.7 ± 1.8	35.3 ± 2.4	35.7 ± 2.4	> .05

* 470 piglets were assigned to four antiseptic treatment groups: iodine, trisodium citrate, a dry dip created using an antibacterial peptide (nisin) with talc, and no treatment. Piglet umbilical cords were dipped within 1 hour of birth, with treatments applied to the umbilical cord tissue and stump for 5 seconds. Diameter of the widest part of the umbilical cord, just distal to the abdomen, was determined using digital calipers at birth and 24 ± 1 hours of age. Surface temperature of the umbilical stump was measured at birth, at 24 ± 1 hours of age, and at approximately 48 hours of age of age using a dual laser infrared thermometer. Redness and swelling of the umbilical stump were evaluated visually at 24 and 48 hours.

† All data were analyzed using mixed linear regression and orthogonal contrasts. Significance was declared for values of $P < .05$.

dated in this study. Sternal temperature was used as a reference point for normal body temperature. Umbilical stump temperatures were lower than sternal temperatures at birth in all piglets (n = 470) due to decreased blood flow to that area associated with healing. This may have been because of low ambient temperature in the pen areas where the piglets were born, diverting blood flow away from non-essential areas and reducing umbilical stump temperature.

In addition, the use of digital calipers to measure the diameter of the umbilical cord may be useful to assess healing rate of the cord. A decrease in the diameter of the cord indicates that the umbilical cord is desiccating and the stump is healing.

In conclusion, there was no benefit to using an antiseptic treatment on piglet umbilical cords for improving healing or reducing the incidence of infections during the first 48 hours of life under the clean, dry stall conditions that were present in this study. Several management and environmental factors specific to this study may have affected the association between disinfectants, infection rate, and cord healing. Piglets in this study originated from a single farm, were born during the same season, and were housed in temperature-controlled facilities. In addition, piglets were removed from the study at 48 hours of age, and there may have been differences in infection rate after that time point.

Implication

Under the conditions of this study, none of the three dips tested differ from no treatment in preventing umbilical infections and permitting healing of the umbilical cord when used within 1 hour of birth.

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References

1. Nielsen NC, Riising HJ, Larsen, JL, Bille N, Svendsen J. Preweaning mortality in pigs. 5. Acute septicaemia. *Nord Vet Med.* 1975;27:129–139.

*2. Blackwell T, Hayes R, Charbonneau G. Umbilical hernias: problems for pigs, producers, and packers. *Pig Chat News Letter*. 2007;10:4. Available at http://devsouthwestvets.diligens.com/Portals/15/2007/PIGCHAT%200407.pdf. Accessed 30 March 2016.

3. Spicer EM. Preweaning mortality. In: Straw BE, Zimmerman JJ, D'Allaire S, Taylor DJ, eds. *Diseases of Swine.* 9th ed. Ames, Iowa: John Wiley and Sons; 2006:993–1009.

*4. Miller RF, Ingram R. Care and management. In: Farley JL, van Riet WJ, eds. *Swine Care Practices.* California Pork Industry Group and University of California Cooperative Extension. Available at http://www.vetmed.ucdavis.edu/vetext/local-assets/pdfs/pdfs_animal_welfare/swineCarePrax.pdf. Accessed 7 April 2016.

5. Drug Enforcement Administration (DEA). Changes in the Regulation of Iodine Crystals and Chemical Mixtures Containing Over 2.2 Percent Iodine. 2007. Available at http://www.deadiversion.usdoj.gov/fed_regs/rules/2007/fr0702.htm. Accessed 7 April 2016.

*6. Zurex Pharmagra Brochure. 2012. Available at http://zurexpharmagra.com/products/ZuraLac/. Accessed 7 April 2016.

7. LeBela G, Pichéa F, Frenettea M, Gottschalk M, Grenier D. Antimicrobial activity of nisin against the swine pathogen *Streptococcus suis* and its synergistic interaction with antibiotics. *Peptides.* 2013;50:19–23.

8. FDA. Food and Drug Administration. Talc. 2014. Available at http://www.fda.gov/Cosmetics/ProductsIngredients/Ingredients/ucm293184.htm. Accessed 26 April 2016.

9. Waltner-Toews D, Martin SW, Meek AH. Dairy calf management, morbidity and mortality in Ontario Holstein herds. IV. Association of management with mortality. *Prev Vet Med.* 1986;4:159–171.

10. Robinson AL, Timms LL, Stalder KJ, Tyler HD. Short communication: The effect of 4 antiseptic compounds on umbilical cord healing and infection rates in the first 24 hours in dairy calves from a commercial herd. *J Dairy Sci.* 2015;98:595–601.

11. Mufti A, Coutts P, Sibbald GR. Validation of commercially available infrared thermometers for measuring skin surface temperature associated with deep and surrounding wound infection. *Adv Skin Wound Care.* 2015;28:11–16.

12. David R, Kristin B, Martin LL. A comparative study of non-contact infrared and digital rectal thermometer measurements of body temperature in the horse. *J Equine Vet Sci.* 2011;31:191–193.

13. McDonnell G, Russell AD. Antiseptics and disinfectants: Activity, action, and resistance. *Clin Microbiol Rev.*1999;12:147–179

14. Weijmer MC, Debets-Ossenkopp YJ, van de Vondervoort FJ, ter Wee PM. Superior antimicrobial activity of trisodium citrate over heparin for catheter locking. *Nephrol Dial Transplant*. 2002;17:2189–2195.

15. Lubelski J, Rink R, Khusainov R, Moll GN, Kuipers OP. Biosynthesis, immunity, regulation, mode of action and engineering of the model antibiotic nisin. *Cell Mol Life Sci.* 2008;65:455–476.

16. Bower, CK, McGuire J, Daeschel MA. Suppression of *Listeria monocytogenes* colonization following adsorption of nisin onto silica surfaces. *Appl Enviro Microbiol* 1995;61:992–997.

17. FDA. Food and Drug Administration. Nisin GRAS Notice Information. 2000. Available at **http://www.fda.gov/ucm/groups/fdagov-public/@fdagov-foods-gen/documents/document/ucm266587.pdf**. Accessed 26 April 2016.

18. Fierheller M, Sibbald RG. A clinical investigation into the relationship between periwound skin temperature and local wound infection in patients with chronic leg ulcers. *Adv Skin Wound Care.* 2010;23:369–379.

* Non-refereed references.