

Passive Transfer of Naturally Acquired Specific Immunity against West Nile Virus to Foals in a Semi-Feral Pony Herd

Pamela A. Wilkins, Amy L. Glaser, and Sue M. McDonnell

Horses naturally exposed to West Nile Virus (WNV) or vaccinated against WNV develop humoral immunity thought to be protective against development of clinical disease in exposed or infected animals. No reports evaluate the efficacy of passive transfer of naturally acquired specific WNV humoral immunity from dam to foal. The purpose of this study was to investigate passive transfer of naturally acquired immunity to WNV to foals born in a herd of semi-feral ponies, not vaccinated against WNV, in an endemic area, with many dams having seroconverted because of natural exposure. Microwell serum neutralization titers against WNV were determined in all mares and foals. Serum IgG concentration was determined in foals by serial radial immunodiffusion. Differences in IgG concentration between seropositive and seronegative foals were examined by means of the Mann-Whitney *U*-test. Linear regression was used to evaluate the association between mare and foal titers. Seventeen mare-foal pairs were studied; 1 foal had inadequate IgG concentration. IgG concentration was not different between seronegative and seropositive foals ($P = .24$). Mare and foal titers were significantly correlated in foals with adequate passive transfer of immunity (Spearman's $\rho = .84$; $P < .001$); >90% of the foal's titer was explained by the mare's titer ($R^2 = 0.91$; $P < .001$). Passive transfer of specific immunity to WNV is present in pony foals with adequate passive transfer of immunity born to seroconverted mares.

Key words: Endemic; Equine; Immunoglobulin; Titer.

West Nile Virus (WNV) was introduced to the United States in 1999 and has now been recognized in horses throughout the continental United States.¹ The horse population has been particularly affected by this virus, with thousands of horses ill or dying because of severe neurologic injury occurring in a percentage of infected horses. Horses that produce antibody in response to vaccination appear to be protected, and one treatment for clinically affected horses has been administration of hyperimmune plasma^a or serum^b products.¹ There is 1 report of demonstrated passive transfer of specific WNV immunity in a single foal from a seropositive mare, but no larger studies of passive transfer of naturally acquired immunity are available.² The purpose of this study was to investigate passive transfer of naturally acquired specific immunity to WNV to foals born in an endemic area. Foals studied were born in a herd of semi-feral ponies not vaccinated against WNV, but with many dams seroconverted because of natural exposure. We hypothesized that adequate passive transfer of immunity from dam to foal would result in transfer of specific immunity to WNV in foals approximating that observed in their dams.

From the University of Pennsylvania School of Veterinary Medicine, Department of Clinical Studies-New Bolton Center, Kennett Square, PA (Wilkins, McDonnell); and the Cornell University College of Veterinary Medicine Diagnostic Laboratory, Ithaca, NY (Glaser).

Reprint requests: Pamela A. Wilkins, DVM, PhD, DACVIM, DACVECC, University of Pennsylvania School of Veterinary Medicine, New Bolton Center, 382 West Street Road, Kennett Square, PA 19348; e-mail: pwilkins@vet.upenn.edu.

Submitted November 8, 2005; Revised January 24, 2006; Accepted February 13, 2006.

Copyright © 2006 by the American College of Veterinary Internal Medicine

0891-6640/06/2004-0040/\$3.00/0

Materials and Methods

Animals

The animals used were pony mares and their foals that were resident members of a semi-feral pony herd (N = 50–65 animals) that since 1994 had been maintained at pasture in southern Chester County, Pennsylvania, an area known to be endemic for WNV infections in horses. Members of this herd were not vaccinated against WNV and all foals resulted from pregnancies after natural cover of the mares by a stallion member of the herd. There was no history of disease because of WNV within this herd, but approximately 63% of the herd was seroconverted against WNV in 2004.^c

Sample Collection

Whole blood was collected into evacuated glass tubes without anticoagulant from foals between 2 and 6 hours after parturition and initial colostrum ingestion by direct jugular venipuncture.^d The entire herd was sampled on April 11, 2005, and values from this occasion were used as the maternal antibody titers for mares foaling between April 11 and May 19. Mares foaling before April 11 or after May 19 also were sampled on the day of parturition, and maternal titers were determined from those samples. Blood was allowed to clot and serum was harvested, separated into multiple 2-ml aliquots, and immediately frozen at -20°C . Serum was sent frozen by overnight carrier to both testing laboratories, and all samples were assayed at the same time.

Testing

Microwell serum neutralization titers against WNV (MSNT) were determined at the New York State Diagnostic Laboratory at Cornell University College of Veterinary Medicine. Titers $\geq 1:16$ were considered positive. Serum IgG concentrations were determined from blood drawn from the foals, simultaneously with samples obtained for MSNT, for determination of adequacy of passive transfer by serial radial immunodiffusion assay at Iowa State University. Passive transfer of immunity was considered adequate at IgG concentrations >800 mg/dL. IgG concentrations were not measured beyond 3,200 mg/dL.

Statistical analysis

Data were analyzed with Minitab 12.^d Descriptive data are presented as (median; 25th–75th percentile range). Differences in IgG concentrations between seropositive and seronegative foals were examined with the Mann-Whitney *U*-test. The relationship between mare and foal titers was investigated with log-transformed data and application of Spearman's rho test and linear regression. Significance was set at $P \leq .05$.

Results

Seventeen mare-foal pairs were tested. Sixteen of 17 foals had adequate passive transfer of immunity, whereas 1 foal had no measurable IgG and was determined to have complete failure of passive transfer (FPT). This foal had been discovered separated from its dam, and had not been observed nursing. The foal never thrived and ultimately was euthanized. Excluding the foal with FPT, median serum IgG concentration in foals was 3,200 (2,425–3,200) mg/dL. IgG concentration was not different between seronegative (3,200; 1,550–3,200 mg/dL) and seropositive (3,200; 2,850–3,200 mg/dL) foals ($P = .24$, adjusted for ties).

Ten mares had positive MSNT at the time of parturition (1:2,048; 1:28–1:4,096), with 5 foals being MSNT-positive and 5 foals being MSNT-negative. All dams positive at $\leq 1:64$ ($n = 4$) had foals that were MSNT-negative. One foal born to a mare with a MSNT titer of 1:2,048 was MSNT-negative. This animal was the foal with FPT. The remaining mares with positive foals had titers of $\geq 1:2,048$. In 2 cases, MSNT titers were higher in the foal than in the dam, 2 mare-foal pairs had identical MSNT titers, and 1 foal had a MSNT titer lower than its dam. All 7 mares seronegative at the time of foaling had foals with adequate passive transfer of immunity and negative MSNT titers. Again excluding the mare-foal pair that contained the foal with FPT, mare and foal titers were significantly correlated in foals with adequate passive transfer of immunity (Spearman's rho = .84; $P < .001$) with $>90\%$ of the foal's titer explained by the mare's titer ($R^2 = 0.91$; $P < .001$; log foal titer = $-0.268 + 1.05$ log mare titer).

Discussion

The data demonstrate passive transfer of specific immunity against WNV from dam to foal associated with adequate passive transfer of humoral immunity in the immediate postnatal period. This particular herd demonstrated an increase in MSNT seropositivity in the year before the study, with 63% of the herd having seroconverted by the end of the mosquito season compared to 40% before the onset of mosquito season, including 13 of the 17 mares in this study.^c In foals with adequate passive transfer of immunity, MSNT titers should approximate those of the dam if the dam's titer is obtained within 30 days before parturition. Questions not answered by these data include whether a passively acquired MSNT-positive titer is associated with protection from WNV infection, as appears to be the case with equine arteritis virus, or whether maternally derived antibody potentially could interfere with de-

velopment of protection after vaccination against WNV, as described for influenza and tetanus toxoid.^{3–5} Despite ongoing seroconversion within this herd of ponies and its location in southern Chester County, PA (where the largest number of equine cases in the United States occurred in 2003), there have been no documented cases of clinical disease because of WNV in the herd. In an endemic region, approximately 20% of infected people will develop West Nile Fever and 1 in 150 infected will develop more severe clinical signs, including neurologic manifestations.⁶ If the same ratios are true in equids, some mild cases of fever may have gone unrecognized in this herd because these ponies are minimally handled, although closely observed twice daily.

Foals in this study were sampled at an earlier time period than traditionally suggested in order to evaluate passive transfer of immunity.⁷ Prior work in this herd, in which foals ($n = 16$) were sampled before nursing and at 0.5, 1, 2, 4, 6, 12, and 24 hours after first nursing, demonstrated that IgG concentration in all cases where foals nursed were considered adequate (ie, >800 mg/dL) by 0.5 to 1 hour after first nursing, with peak values achieved by 6 hours (McDonnell, unpublished data). Except for 1 foal that eventually required euthanasia, all foals in the current study had adequate IgG concentrations, confirming that adequate colostrum ingestion and IgG absorption occurred before sampling.

This study can provide no information regarding the duration of maternally derived antibody, because foals and mares remained at pasture 24 hours per day 7 days per week exposed to endemic WNV. Passively acquired antibody to other equine diseases has been described as persisting in foals from 76 to 230 days for equine arteritis virus, with a suggested half-life of 27 to 39 days for most.^{4,7–10} Those data, as well as data investigating the possible interference of maternal antibody with vaccination against WNV, need to be investigated in other models. However, our data demonstrate that maternally derived antibody against WNV arising from natural exposure will be acquired by the foal following ingestion of colostrum and absorption of antibody, and the foal will develop an MSNT serum titer approximating that of the dam.

Adequate passive transfer of specific immunity to WNV occurs in pony foals born to seroconverted mares. The potential role of this passively acquired immunity remains unexamined, as does its duration.

Footnotes

^a West Nile Virus Antibody, Equine Origin, Lake Immunogenics, Inc, Ontario, NY

^b West Nile Virus Antibody, Equine Origin, Novartis Animal Health US, Inc, East Hanover, NJ

^c McDonnell SM, Grogan EH, Glaser AL, Wilkins PA. West Nile Virus titers in a herd of semi-feral ponies in Pennsylvania. *J Vet Intern Med* 2005;19:482 (abstract)

^d Vacutainer, Becton Dickinson and Company, Franklin Lakes, NJ

^e Minitab 12, Minitab Inc., State College, PA

Acknowledgments

This is a Dorothy Russell Havemeyer Foundation project. Elkanah Grogan assisted with herd care and sample collection and processing.

References

1. Wilkins PA, Del Piero F. West Nile Virus: Lessons from the 21st century. *J Vet Emerg Crit Care* 2004;14:2–14.
2. Ostlund EN, Crom RL, Pedersen DD, et al. Equine West Nile encephalitis, United States. *Emerg Infect Dis* 2001;7:665–669.
3. Del Piero F, Wilkins PA, Lopez J, et al. Equine arteritis virus in newborn foals: Clinical, pathological, serological, microbiological, and immunoperoxidase histochemical findings. *Eq Vet J* 1997;29:178–185.
4. Wilson WD, Mihalyi JE, Hussey S, Lunn DP. Passive transfer of maternal immunoglobulin isotype antibodies against tetanus and influenza and their effect on the response of foals to vaccination. *Eq Vet J* 2001;33:644–650.
5. Van Oirschot JT, Bruin G, de Boer-Luytze E, Smolders G. Maternal antibodies against equine influenza virus in foals and their interference with vaccination. *Zentralbl Veterinarmed B* 1991;38:391–396.
6. Dean JL, Palermo BJ. West Nile Virus encephalitis. *Curr Infect Dis Rep* 2005;7:292–296.
7. Giguere S, Polkes AC. Immunologic disorders in neonatal foals. *Vet Clin N Am Eq Pract* 2005;21:241–272.
8. Breathnach CC, Allen GP, Holland RE, et al. Problems associated with vaccination of foals against Equine herpesvirus4 and the role of anti-EHV-4 maternal antibodies. In: Wernery U, Wade JF, Mumford JA, Kaaden O, eds. *Proc 8th Int Conf. Newmarket, England: R&W Publications; 1999:426–427.*
9. Gibbs EP, Wilson JH, All BP. Studies on passive immunity and the vaccination of foals against eastern equine encephalitis in Florida. In: Powell DG, ed. *Equine Infectious Diseases V: Proc 5th Int Conf. Lexington, KY: The University Press of Kentucky; 1988:201–205.*
10. Hullinger PJ, Wilson WD, Rossitto PV, et al. Passive transfer, rate of decay, and protein specificity of antibodies against equine arteritis virus in horses from a Standardbred herd with high seroprevalence. *J Am Vet Med Assoc* 1998;213:839–842.
11. van Maanen C, Flore PH, Minke J, et al. Immune response of foals after vaccination against EHV-1/EHV-4 and persistence of maternal antibodies. In: Nakajima H, Plowright W, eds. *Equine Infectious Diseases VII: Proc 7th Int Conf. Newmarket, England: R&W Publications; 1994:351–352.*