

THE MATERNAL TRANSMISSION OF VACCINIAL IMMUNITY IN SWINE

By JOHN B. NELSON, PH.D.

(From the Department of Animal and Plant Pathology of The Rockefeller Institute for Medical Research, Princeton, N. J.)

PLATE 43

(Received for publication, June 30, 1932)

The route by which antibodies are transmitted from an immune female animal to her young has been determined for most of the domesticated and laboratory animals. There are comparatively few observations, however, on the maternal transmission of protective substances, aside from the antitoxins. In the case of antibodies the path of conveyance is either a direct one by way of the placenta or an indirect one by way of the mother's colostrum or milk. As pointed out by Kuttner and Ratner (1) the direct passage of antibodies is influenced by the histologic structure of the placenta. Whether or not the same relations are applicable to the transmission of protective substances can be decided only by actual test. In the cow, with a transitional type of placenta, it was shown by Smith and Little (2), in their work on calf scours, that protective substances were conveyed by the colostrum. It was already known that antibodies were transferred from cow to calf by the indirect route. The present work with swine was undertaken to determine the route of transmission in an animal with a different placental structure, specifically a true adeciduous placenta.

Considerable attention has been paid to the transmission of protection in swine by reason of its bearing on vaccination procedures in hog cholera. It was recognized from field experience and demonstrated in controlled experiments by McArthur (3) and by Pickens, Welsh, and Poelma (4) that the young of sows immune to hog cholera were temporarily resistant. This resistance was generally attributed to a transfer through the colostrum or milk but the possibility of placental transmission was not definitely excluded. The route of antibody transmission was worked out by Connaway (5) who in a study of swine abortion found that the colostrum was the chief vehicle of conveyance.

TenBroeck and Ring (6) had recently shown that it was possible to take newborn pigs from their dams, before suckling, and raise them on a mixture of commercial cow's milk powder and normal swine serum. The controls essential for ruling out a placental transmission, which were lacking in the earlier work on hog cholera, could be supplied by this procedure.

Vaccinia virus was selected as the immunizing agent for the demonstration of maternal transmission. Swine were found to be naturally susceptible to vaccinia, responding to the presence of virus in the skin with the usual vesicular reaction. The first manifestation, after vaccination, was a slight elevation of the skin with a little congestion, appearing generally on the 2nd day. Definite papules, discrete or confluent, developed on the 3rd or 4th day. These increased in size and usually became vesicular a day later. At this time the lesion appeared as a white-tipped nodule measuring up to 10 mm. at the surface and generally surrounded by a red zone of congestion. In some cases the vesicles persisted for an additional day, rarely longer, but usually scab formation was visible on the 6th or 7th day. The swelling rapidly subsided, the congestion faded, and after a variable period the scabs fell off. The reaction period, it may be noted, is considerably shorter than in man and there is no permanent scar formation.

Methods

Young sows in their first or second pregnancy were vaccinated with vaccinia virus immediately before or shortly after breeding.¹ The vaccine was introduced into the superficial layers of the skin over the inner surface of the flank, an area which is relatively hairless, clean, and protected. With adult animals the skin was washed with alcohol and dried with ether. This procedure was generally omitted in the vaccination of young animals with no unfavorable results. Two parallel scratches, approximately 2 inches long and 1/2 inch apart were made in the skin with a pointed hypodermic needle. Three drops of vaccine fluid were placed along each line with a capillary pipette and rubbed into the abraded area.

The gestation period in swine, approximately 115 days, allows ample time for the development of a solid immunity. The vaccinated sows were kept in confinement towards the close of the estimated gestation period and closely watched. At parturition, their young were taken before they had suckled and divided into two groups. One group was subsequently returned to the sow and allowed to nurse. The pigs of the other group were fed by hand a mixture of dried cow's

¹ The vaccine employed in this work was obtained from the Laboratories of the New York City Department of Health through the courtesy of Dr. W. H. Park.

milk and normal swine serum. On the 7th day, in most instances, the young pigs were vaccinated and kept under observation for 10 days or more.

The experimental findings with the young of three vaccinated sows are presented in detail in the following case reports and summarized in Table I. The cutaneous reaction in suckling and hand-fed pigs, following vaccination, is shown in Figs. 1 and 2.

TABLE I

The Reaction to Vaccinia Virus in the Suckling and Hand-Fed Young of Immune Sows

Sow No.	Date of vaccination	First litter		Second litter		Third litter			
		Date of birth	No. of suckling pigs vaccinated and result	No. of hand-fed pigs vaccinated and result	Date of birth	No. of suckling pigs vaccinated and result	Date of birth	No. of suckling pigs vaccinated and result	No. of hand-fed pigs vaccinated and result
	1930	1931			1931		1932		
1	Dec. 18	Apr. 6	3 —*	4 +	Oct. 1	3 —	Mar. 20	3 —	
2	Nov. 6	May 1	3 —	1 +	Oct. 18	4 —	Apr. 14	3 —	3 +
	1931				1932				
3	July 7	Oct. 29	1 — 1 ±	2 +	Mar. 25	3 —			

* — = no reaction; ± = papular reaction; + = vesicular reaction.

Case Reports of the Suckling and Hand-Fed Pigs from Vaccinated Sows

Sow 1 was born Mar. 28, 1930; bred for the first time Dec. 16; and vaccinated Dec. 18 with a typical vesicular reaction. A litter of seven pigs was born Apr. 6, 1931. Three young were placed with the dam and allowed to suckle. Four were fed by hand. The pigs of both groups were vaccinated Apr. 13. The three suckling pigs failed to react during a period of 14 days. The four hand-fed pigs showed vesicle formation on the 4th day. One pig died at this time. The three remaining pigs showed beginning scab formation on the 8th day. A suckling pig, of approximately the same age, from a non-immune sow was vaccinated at the same time and reacted typically. Scab formation began on the 6th day.

Sow 2 was born Apr. 8, 1930; vaccinated Nov. 6; and bred Feb. 10, 1931, for the first time. A litter of nine pigs was born May 1. Three young were placed with their dam to nurse and six were fed by hand. All of the young were vaccinated May 5. The three suckling pigs showed no reaction through a period of 2 weeks.

Five of the hand-fed pigs died during the first 48 hours after vaccination. The remaining hand-fed pig showed vesicle formation on the 6th day and scabbing on the 9th. A suckling control pig farrowed by a non-immune sow was likewise vaccinated and reacted with the formation of vesicles which began to scab on the 7th day.

Sow 3 was born Mar. 28, 1930, a litter mate of No. 1; vaccinated July 7, 1931, with a typical reaction; and bred for the second time July 10. Four pigs were born Oct. 29. Two of them nursed their mother and two were fed by hand. They were vaccinated Nov. 5. One suckling pig showed no reaction during a 10 day interval. The other developed several papules on the 3rd day after vaccination. These began to scab on the 5th day without vesicle formation. The two hand-fed pigs reacted with typical vesicles which appeared on the 4th day and began to scab on the 7th.

The three immune sows were rebred and the young of their second pregnancies, after vaccination, were tested for protection to vaccinia virus. The new-born pigs which numbered six, eight, and four, respectively, were all placed with their dams and allowed to nurse. On the 7th day after birth, three young from the first sow, four from the second, and three from the third were vaccinated and kept under observation for 10 days. In no case was any local reaction visible during this time. Two control pigs, the suckling young of non-immune sows, reacted with the formation of typical vesicles.

The first two sows were rebred for the third time. They farrowed during the early spring of 1932, approximately 15 months after they were vaccinated. Sow 1 had a litter of six pigs, all of which were allowed to suckle. Three of the nursing young were vaccinated without "take" on the 7th day. Eleven pigs were farrowed by Sow 2. Three of this litter were allowed to suckle and eight were fed by hand. Five of the latter group died before the 7th day of life. The other three were vaccinated at that time and showed typical vesicular reactions.

DISCUSSION

The combined vaccinated young of successive litters farrowed by the three immune sows numbered 34, of which 24 were suckled pigs and 10 were fed by hand. Twenty-three of the first group showed no reaction to vaccinia virus introduced into the skin. They were completely protected against the concentration of virus used for vaccination. The acquired resistance, as will be shown at a later time, was of relatively short duration. One suckling pig displayed an incomplete reaction, which progressed only to the formation of papules, indicative of a partial protection. The hand-fed pigs all responded to the presence of virus with the formation of typical vesicles. The only observed difference in the reactions of hand-fed pigs and the suckling young of non-

immune dams was the somewhat delayed appearance of scabs in the case of the former. One pig in the group of suckling young whose dams were unprotected was farrowed by Sow 3 prior to vaccination. The susceptibility of this pig to vaccinia contrasted sharply with the resistance of the suckling young from the same sow following vaccination.

In spite of a considerable loss of protective substance at each parturition, two of the vaccinated sows continued to transmit protection to the suckling young of three consecutive pregnancies. The suckled pigs of the two litters showed no significant difference in the degree of resistance acquired by the ingestion of their dams' colostrum. The time interval between the vaccination of the sow and the test vaccination of the third pregnancy young was approximately 15 months. The sow, meanwhile, had received no additional virus from an outside source.

These observations indicate that protection against vaccinia in swine, initiated by the cutaneous introduction of virus, may be transmitted from sow to young. They show, moreover, that the porcine placenta is impermeable to any appreciable amount of protective substance and that the function of immunity transfer is taken over by the colostrum. These conclusions coincide with those pertaining to the maternal transmission of antibodies in swine and suggest that similar controlling factors are involved.

SUMMARY

The introduction of vaccinia virus into the skin of swine calls forth a typical vesicular reaction which may be followed by a solid immunity. This acquired state of resistance was utilized in determining the route of immunity transmission from sow to young. The suckling young of immune sows, vaccinated on the 7th day or earlier, showed no reaction to the virus. Their hand-fed litter mates, however, were susceptible and reacted with the formation of vesicles. These observations indicate that the porcine placenta is largely impermeable to protective substances and establish the fact that colostrum functions as the vehicle for their transmission as it does for antibodies.

The writer is indebted to Mr. E. R. Ring for his meticulous supervision of the feeding and handling of the young pigs.

REFERENCES

1. Kuttner, A., and Ratner, B., *Am. J. Dis. Child.*, 1923, **25**, 413.
2. Smith, T., and Little, R. B., *J. Exp. Med.*, 1922, **36**, 181.
3. McArthur, C. L., *J. Infect. Dis.*, 1919, **24**, 44.
4. Pickens, E. M., Welsh, M. F., and Poelma, L. J., *J. Am. Vet. Med. Assn.*, 1920-21, **58**, 403.
5. Connaway, J. W., *J. Am. Vet. Med. Assn.*, 1921-22, **60**, 448.
6. TenBroeck, C., and Ring, E. R., unpublished work.

EXPLANATION OF PLATE 43

The skin reactions, on the 4th day after vaccination, in young pigs from the third litter of Sow 2.

FIG. 1. Suckling young with only the scab covering the original scratches visible.

FIG. 2. Hand-fed young with discrete and confluent vesicles visible along both scratches.



(Nelson: Transmission of immunity in swine)