Onderstepoort J. vet. Res., 54, 493–495 (1987)

THE BLOCK METHOD OF VACCINATION AGAINST HEARTWATER

J. L. DU PLESSIS and LETITIA MALAN, Veterinary Research Institute, Onderstepoort 0110

ABSTRACT

DU PLESSIS, J. L. & MALAN, LETITIA, 1987. The block method of vaccination against heartwater. *Onderstepoort Journal of Veterinary Research*, 54, 493–495 (1987)

A critical evaluation is made of reports in the literature on the block method of vaccination and the relevant factors that play a role in the immunization against heartwater are also discussed. The most important of these is the fact that in heartwater immunogenicity parallels pathogenicity. It is shown that the more severe the reaction of the host to the immunizing infection, the stronger its immunity to subsequent challenge. The importance of this principle in the block method is emphasized.

Other factors that play a role are the average incubation periods recorded in the different domestic ruminants after experimental infection and differences in age and breed susceptibility. The survival rate of experimentally infected Bonsmara cattle and Merino sheep that were treated on different days of the febrile reaction also serve as a guideline to determine the day after infection on which block treatment can be applied. The danger of a fatal recrudescent infection if block treatment is given too early, necessitating additional treatment and close observation, is indicated.

In conclusion, recommendations on the day of block treatment are made for each domestic ruminant species. It is emphasized that the other methods of immunization of large groups of animals, such as treatment only after the commencement of the febrile reaction determined by the daily recording of early morning temperatures, or the prolonged prophylactic chemotherapy of susceptible stock exposed to heavy tick challenge, are preferable to the block method. The block method does, however, find application in certain instances where these procedures are impractical or inappropriate.

INTRODUCTION

The present heartwater (HW) vaccine is virulent and vaccinated animals must be kept under close observation and the course of the infection controlled with treatment to prevent the loss of highly susceptible animals.

The prevention of fatal reactions by the so-called block method of vaccination, i.e. the indiscriminate treatment irrespective of whether the animal develops a febrile reaction to the vaccine or not, is widely practised (Fick & Schuss, 1952; Uilenberg, 1971; Poole, 1962 a & b).

Although this method is seldom advocated, and certainly not recommended in the case of valuable, highly susceptible animals (Uilenberg, 1983), it is still used when large numbers of commercial stock are introduced in HW endemic regions and where daily temperature monitoring is impractical or not feasible.

Before the factors that play a role in HW immunization are considered, an evaluation of the literature dealing with this method is appropriate.

REVIEW OF THE LITERATURE

The attempts at vaccination recorded in the literature where block treatment was given irrespective of whether the febrile reaction had commenced or not, are summarized in Table 1. A number of instances where treatment was administered on days 1–3 of the febrile reaction are included to compare the results.

It can be seen that only a small number of cattle blocked 13–15 days after inoculation (Fick & Schuss, 1952) had to be retreated, except in one case (Uilenberg, 1971) where a large number required additional treatment, possibly because of too low a dosage of tetracycline. In small stock, however, the shorter the interval between the day of inoculation and the day of block treatment, the larger the numbers of animals that required more than one treatment (Poole, 1962a, b). Once again the low antibiotic dosage levels must be pointed out.

On the other hand, not one out of 33 sheep or 39 Angora-cross goats blocked on the 12th or 13th day post-infection (Poole, 1962a, b) or 14 Dorper lambs blocked on day 11 (Du Plessis, unpublished observation, 1985), had to be retreated. The highly susceptible Angora goat appears to be extremely vulnerable. Thus only 4 out of 22 goats treated at a high dosage level on the 2nd or 3rd day of the febrile reaction survived, whereas only one out of 24 animals treated on the first day of the febrile reaction died (Du Plessis, Jansen & Prozesky, 1983).

A critical evaluation of the level of immunity attained after block treatment immunizations recorded in the literature is impossible because the immunized animals were either not challenged artificially, or the number of animals that succumbed to subsequent natural tick challenge was seldom recorded. The 34 out of 152 goats that died from natural HW after they had been blocked on days 5 and 6 post-infection (Poole, 1962b), suggests that early blocking is seldom followed by good immunity. The fact that not one out of 14 lambs blocked on day 11 was lost from the natural disease does not necessarily suggest that the method of immunization was satisfactory, because the small number that were serologically positive 6–18 months later indicates that the tick challenge was low (J. L. du Plessis, unpublished observation, 1985). The finding that 4 out of 22 Angora goats treated on days 2 or 3 of the febrile reaction survived and were subsequently immune, whereas only 15 out of 23 goats that survived after having been treated on the first day of the febrile reaction were immune (Du Plessis *et al.*, 1983) underlines the necessity of obtaining proof of the subsequent immunity of animals to assess the value of any immunization procedure.

Relationship between immunogenicity and pathogenicity

The immunity elicited by an inoculum infected with the HW agent seems to depend on the severity of the reaction that it causes. Observations made on sheep (Table 2) and mice (Table 3) suggest that this characteristic of HW is of cardinal importance in immunization against the disease. In the case of the block method it would imply that if treatment is given too early in the incubation period or even too early in the febrile reaction, the development of the disease process is interrupted too early for an adequate immune response to be elicited.

Ten out of 28 sheep inoculated with blood collected from susceptible one-month-old calves and year-old immune oxen infected with Ball 3 sheep's blood 12 and 15 days earlier, failed to show a febrile reaction (Table 2). When they were challenged with the homologous strain, all 10 developed severe reactions. Furthermore, only one out of 10 sheep that had developed a mild reaction to the *Cowdria ruminantium* infective bovine blood showed a mild reaction when they were challenged, whereas all the others developed severe or fatal reactions. On the other hand only one out of 8 sheep that had reacted

Received 1 April 1987—Editor

TABLE 1 Vaccination against heartwater by infection and treatment

No. of animals	Day post-infection blocked	Day febrile reaction treated	Drug mg/kg	No. retreated	No. that died	Subsequent immunity	Reference
374 adult cattle	13 & 15		Uleron & sulphadimidine	UN[1]	19	NC[2]	Fick & Schuss 1952
123 adult cattle		1	OTC; ?	0	5	NC	Sutton, 1960
25 adult cattle		1, 2 or 3	OTC; 5[3]	21	1	NC	Uilenberg, 1971
12 adult cattle	14		OTC; 5	9	0	NC	Uilenberg, 1971
2 743 cattle		1	OTC; 10	UN	24	NC	Van der Merwe, 1979
33 Merino sheep	10 & 12		CTC; 2[4]	0	0	NC	Poole, 1962a
33 Merino sheep	10		CTC; 2,5	18	0	NC	Poole, 1962a
135 lambs	8		CTC; 2–3	81	1	NC	Poole, 1962a
14 Dorper lambs	11		OTC; 10	0	0	[5]	Du Plessis, Unpublished
80 Angora × goats	5		CTC; 2–4	19	4		Poole, 1962b
72 Angora × goats	6		CTC; 2–4	8	2	[6]	Poole, 1962b
39 Angora × goats	11 & 13		CTC; 2	0	0	NC	Poole, 1962b
22 Angora goats		2 or 3	OTC; 20–40	12	18	4	Du Plessis *et al.*, 1983
24 Angora goats		1	OTC; 20–40	5	1	15	Du Plessis *et al.*, 1983

1 UN = An unspecified small number were retreated
2 NC = Not subsequently challenged
3 OTC; 5 = Oxytetracycline at 5 mg/kg
4 CTC = Chlortetracycline
5 4 out of 14 serologically positive 6–18 months after vaccination
6 34 goats subsequently succumbed to natural heartwater

TABLE 2 Relationship between pathogenicity and immunogenicity in sheep as reflected by the severity of their reactions at infection and challenge

No. of sheep	Reaction at infection	Reaction to challenge			
		No febrile reaction	Mild	Severe	Fatal
10	No febrile reaction	0	0	10	0
10	Mild	0	1	5	4
8	Severe	7	1	0	0

severely to the initial infection developed a mild reaction when challenged, whereas the other 7 proved to be solidly immune. The more severe the reaction at infection or immunization, therefore, the stronger the subsequent immunity seems to be.

Numerous experiments with the Kümm strain of *C. ruminantium* in which mice were used to determine the infectivity of tissues or tick homogenates (Du Plessis, 1982) confirm the observation that immunogenicity parallels pathogenicity. It can, for example, be seen from Table 3 that only 4 of the 63 mice that survived after having been inoculated with a homogenate of infected mouse liver and spleen, irradiated at the rate of 9 krad/h for varying periods of time, were resistant when they were challenged a month later. It can also be seen that the mice that were immune invariably belonged to the groups that had been inoculated with the lower dilutions in a series in which some members of the group had died. This shows that the immune mice had been infected with a sublethal dose that nevertheless rendered them immune, whereas those inoculated with the higher dilutions did not become infected with a sufficient number of organisms and were therefore fully susceptible when challenged.

Determination of the optimal time for block treatment

It can be seen from Table 4 that the febrile reaction of 12 % of 92 Friesian and Bonsmara cattle infected with the Ball 3 strain commenced before the 13th day after infection. The reaction of the majority started either the 13th or the 14th day and that of 40 % only after the 14th day.

It is evident from Table 5 that only 3 out of 11 Bonsmara cattle infected with the Ball 3 strain, and treated as late as the 5th day of the febrile reaction, died, whereas all 7 treated on days 3 and 4 survived. Likewise only one out of 7 Merino sheep treated on day 6 died, whereas all 7 treated on days 3–5 survived. Furthermore, not all cattle that develop severe febrile reactions die if they are not treated. Thus only 4 12–18-month-old animals out of 28 untreated Bonsmara cattle that had developed severe reactions to the Ball 3 strain, eventually died (Table 6). Depending on the breed and age of cattle that are immunized, it is evident that animals are often treated unnecessarily or too early during the febrile reaction. These observations must be taken into account when establishing guidelines on the day of block treatment.

RECOMMENDATIONS

If it is accepted that the greatest immunity is obtained when block treatment is given at the latest possible time, and when it is considered that certain animals still survive if they are treated late during the febrile reaction or even if they are not treated at all, guidelines can be laid down for the day after immunization on which block treatment can be given with reasonable safety (Table 7).

TABLE 3 Infectivity to mice of Kümm strain infected mouse liver and spleen homogenate exposed to radiation at the rate of 9 krad/h

Radiation time in min	Mortality score of mice homogenate dilutions			No. of mice that survived infection	No. of mice that survived challenge	Reciprocal of infectivity titre
	10^{-1}	10^{-2}	10^{-3}			
5	5	4/1*	1/0	5	1	2,5
30	5	3/1	0/0	7	1	2,2
60	5	2/0	0/0	8	0	1,8
90	3/1	1/0	0/0	11	1	1,3
120	2/0	0/0	0/0	13	0	0,8
180	0/0	0/0	0/0	15	0	0
Non-radiated control homogenate	5	4/1	2/0	4	1	2,7

* 4/1 = 4 mice died and the one that survived was immune to challenge

TABLE 4 Incubation period of 92 experimentally infected Friesian and Bonsmara Cattle 2–24 months old

	Day of commencement of febrile reaction								
	11	12	13	14	15	16	17	18	>18
No. of animals	4	7	26	18	11	14	4	3	5
%	4	8	28	20	12	15	4	3	6
	12		48				40		

TABLE 5 Outcome of 18 experimentally infected Bonsmara Cattle and 14 Merino sheep treated on different days of febrile reaction

No. of animals	Day of febrile reaction treated			
	3	4	5	6
18 cattle	1/0	6/0	8/3*	—
14 sheep	1/0	2/0	4/0	6/1

* 8/3 = 8 out of 11 animals treated on day 5 of the febrile reaction survived and 3 died

TABLE 6 Outcome of 24 experimentally infected Bonsmara cattle that showed a good reaction but were not treated

	Age in months					Outcome	
	3	6	12	18	24	Died	Survived
No. of animals	2	7	12	5	2	3 1	2 7 9 4 2
Total			28			4	24

TABLE 7 Day after immunization on which block treatment is recommended*

Ruminant species	Breed	Day after immunization
Cattle	Exogenous breeds	14
	Indigenous breeds	16
Sheep	Merino	11
	Dorper	11
Goats	Angora	11
	Boerbok	12

*These guidelines should not be applied rigorously but with circumspection. Highly susceptible individual animals may have to be treated sooner than indicated and it must be emphasized that this method of immunization should be avoided in the case of valuable animals.

The immunization method of treating animals only after the commencement of the febrile reaction is detected by the daily recording of early morning temperatures is, however, still preferred to the block method. The latter is not without risks and the immunity is often inferior. Valuable animals should therefore always be treated only after the commencement of the febrile reaction to ensure a better immunity. If the stock owner is willing to incur the higher expenses involved and provided that the cattle are exposed to heavy tick challenge during the process of immunization, the prolonged prophylactic chemotherapy method of Purnell (1984) in all probability also gives a better immunity and is less risky.

A modification of the block method deserves consideration. The temperatures of a representative proportion (about 10 %) of the group to be immunized are recorded daily and depending on the age and breed involved, the whole group is treated 1–4 days after the first distinct rise in temperature of one or more of the monitored animals. It does not involve much more labour and compensates for the fact that the infectivity of different batches of vaccine is not always the same and may result in variations in incubation periods, a fact not taken into consideration when block treatment is given on a fixed day.

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