Thermography of Tuberculin Reactions in Cattle

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The allergic reactions of dermal induration and hyperthermia were compared in tuberculin-hypersensitive calves. Tuberculins prepared from Mycobacterium avium, M. bovis, and M. paratuberculosis were administered intradermally and the responses were compared. The inductions from immediate and delayed hypersensitivity reactions were readily distinguishable, but the hyperthermic responses appeared to contain elements of both immediate and delayed hypersensitivity.

Tuberculin hypersensitivity usually is measured as induration or erythema after intradermal injection of tuberculin; also, after systemic tuberculin administration, the elevation of the body temperature or leukocytic responses may be measured. Cutaneous thermography offers an additional method for assessing allergic reactions to diagnostic antigens. Commercially available equipment for remote sensing and recording of surface emission of infrared radiation now makes it possible to map the temperature gradients of skin areas. The purpose of this work was to compare the dermal temperature responses with the induration after intradermal injection of tuberculins in hypersensitive cattle.

MATERIALS AND METHODS

The animals used in this work were subjects of another experiment. They were purchased as day-old calves; five were vaccinated subcutaneously with living Johne’s disease vaccine when 1 week old. At 6 weeks of age, the five vaccinated calves plus six nonvaccinated calves each were fed 187 mg (dry weight) of virulent Mycobacterium paratuberculosis suspended in cream (14% butterfat). Two nonvaccinated calves that had no history of mycobacterial infection were used as controls. The living Johne’s disease vaccine used contained attenuated M. paratuberculosis in oil and was obtained from the Ministry of Agriculture, Weybridge, England. The virulent M. paratuberculosis was isolated from a cow with Johne’s disease and had been grown on mycobactin-egg yolk medium (1).

The test products, injected intradermally, consisted of 0.1 ml of each of the following: (i) an M. paratuberculosis tuberculin purified protein derivative (PPD) (johnin), (ii) an M. avium tuberculin PPD (avian tuberculin), and (iii) an M. bovis tuberculin PPD (bovine tuberculin), all suspended in saline containing 0.5% phenol, and (iv) saline containing 0.5% phenol. The johnin had been balanced in cattle with Johne’s disease against a standard johnin for potency, whereas the avian and bovine tuberculins were balanced against one another in guinea pigs hypersensitized with the respective organisms.

The skin tests were conducted when the calves were 8 months old. Four days before the tests were to be conducted, an area approximately 30 by 30 cm was clipped on the side of the neck of each calf. Before injection, and at intervals of 2, 6, 24, 48, and 72 h after injection, thermographs (AGA Thermovision, AGA Corp., Secaucus, N.J.) of the clipped areas were recorded photographically; then, the skin thickness at each injection site was measured with a dermal thickness gauge.

The thermographs were recorded with a 10 C total temperature span, with each degree represented by a different color indicated at the bottom of the thermograph. In addition, isotherms connecting all points of identical temperature could be recorded. The size of each area of hyperthermia was graded from the photographs on a 0 to 4 basis and multiplied by the maximum temperature difference between the surrounding skin and the hottest part of the reaction area for each product. The resulting numerical data were averaged for each group at each observation period and plotted. The inductions recorded as increased skin thickness (resulting from each product in the calves fed M. paratuberculosis and in those vaccinated and then fed the organisms) were averaged for each observation period and plotted.

RESULTS

The averaged inductions resulting from each sensitin in the two main groups of calves are presented graphically (Fig. 1). The immediate response to all tuberculins was maximal at 2 h and had subsided materially at 6 h. The inductions from the delayed hypersensitivity responses from johnin and avian tuberculins were maximum at 24 h in the calves fed the
organisms but not vaccinated; however, indurations from these sensitins continued to enlarge and were maximal at 72 h in the vaccinated calves. Bovine tuberculin induced substantial immediate responses in both groups of calves, but indurations had nearly disappeared at later periods. No significant indurations resulted from injection of phenolized saline in any of the calves, and none of the sensitins caused indurations in the control calves.

Phenolized saline did not cause hyperthermia, and none of the sensitins caused hyperthermia in the control calves. The averaged numerical data abstracted from the thermographs of the two main groups of calves are presented graphically (Fig. 2). In contrast to the indurations, dermal hyperthermia was minimal during the immediate hypersensitivity response (2-h reaction) and had waned considerably at the 72-h period in both groups. Maximum hyperthermia was at 24 h in some calves in each group and at 48 h in the others. Maximum temperature elevations in the injection sites ranged from 0.3 to 1.5 C. A ther-
graph showing the total temperature differentials on a vaccinated calf 6 h after sensitin injection is shown in Fig. 3A. Isotherms adjusted to the hottest part of the weakest reaction on the same calf, but without total temperature differentials, are shown in Fig. 3B. Figure 3C to F illustrate the reactions in one calf 6 h postinjection with the isotherms being increased by 0.2 C increments.

Areas of hyperthermia frequently were two to five times larger than the areas of the visible indurations; however, in the 2-h reaction sites, hyperthermia sometimes was not measurable even in large indurations.

DISCUSSION

These data illustrate that dermal hyperthermia accompanies the development of hypersensitivity responses to tuberculin in cattle and that the temperature increases can be mapped with remote sensing of infrared emission from the injection sites. On an absolute time scale, the dermal temperature increases appeared to be related to the development of the delayed responses rather than to immediate responses. However, the significant temperature increases in sites injected with tuberculin from M. bovis, in which the induration responses were almost totally of the immediate type, indicate that immediate type tuberculin hypersensitivity also is an important source of dermal hyperthermia in tuberculin reactions of cattle.

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LITERATURE CITED