Short communication

The effect of stress on the response of chickens to coccidiosis vaccination

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Abstract

Six-week-old Leghorn chickens, which had been adapted to both their environment and cage mates, were orally inoculated with 400 *Eimeria tenella* oocysts as a means of low-dose vaccination. At 2, 3, 4, 5 or 6 days after vaccine administration, the birds were subject to 24 h of social stress through a prescribed method of random redistribution. Two weeks after vaccine administration, the birds were challenged by oral inoculation with 8000 oocysts. Caecal lesion scores were determined 6 days after challenge. Vaccinated chickens were more resistant to lesion formation than unvaccinated controls, and protection, as determined by lower lesion scores, was significantly enhanced when stress in the form of social disruption was applied on the fourth day following vaccine administration. © 1997 Elsevier Science B.V.

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1. Introduction

Changes in social structure or environment, adverse conditions, noxious stimuli, and any other real or perceived threat to homeostasis may be considered stressors. The effects of such stressors on an individual as manifested in the primary, catecholamine mediated, 'flight or fight response' are of immediate benefit to survival. The secondary corticosteroid mediated effects which have short-term benefit may, however, be detrimental to immune function and health if the perceived stress is long-term. In the case of birds, it has been determined that susceptibility to viral and mycoplasmal infections increases as the intensity and duration of stress increases (Gross and Colmano, 1969).

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This has resulted in a common misconception that all stress is bad. In fact, it is not. A certain amount of stress appears to be necessary for optimal performance (Gross and Siegel, 1981) and can be beneficial with regard to defense against other types of disease challenge. For example, it has been demonstrated that resistance to the development of clinical disease subsequent to infection with Escherichia coli (Gross and Colmano, 1969), coccidia (Gross, 1976), and northern fowl mites (Hall et al., 1979) is greater when birds are subjected to high levels of stress. The question therefore arises; can stress be used as a means of beneficially modifying the immune response to certain disease agents?

The purpose of this study was to determine whether vaccine efficacy, e.g., protection afforded by low-dose oral inoculation with live Eimeria tenella, could be enhanced by the strategic application of a stressful stimulus.

2. Materials and methods

2.1. Animals

Chickens were from a line of Leghorns selected for a low antibody response to sheep erythrocytes (Gross et al., 1980). The low antibody line was chosen because of the decreased responsiveness of their humoral immune system and their demonstrated susceptibility to coccidiosis (Gross, 1984).

2.2. Inocula

A suspension of E. tenella oocysts was obtained from Dr. A. Martin of the Protozoal Diseases Laboratory, USDA Agricultural Research Service, Beltsville, MD. The vaccine dose, suspended in saline, was 400 oocysts administered 14 days before challenge. The challenge dose was 8000 oocysts.

2.3. Application of stress

At 4 weeks-of-age, chickens were moved into seven Horsfall-Bauer isolation units. Experimental groups were composed of three males and three females. In order to reduce social stress prior to experimentation, all of the birds assigned to a particular isolation unit were obtained from the same brooder. After a 2-week adaptation period, one group was designated as ‘unvaccinated, unstressed’ controls and the birds in the remaining six groups were orally inoculated using the vaccine dose described previously. Of the six inoculated groups, one served as ‘vaccinated, unstressed’ controls and the birds in the remainder were subjected to short term social stress through a prescribed method of random redistribution (Gross, 1985). In summary, two days after administration of the vaccine, each of the birds in the group so designated was moved to a separate isolation unit of unfamiliar birds of the same sex, e.g., each of the three males was moved to another unit of five unfamiliar males; each of the three females, to a unit of five unfamiliar females. After 24 h of contact, they were returned to their original isolation unit. This procedure was then repeated for the birds designated to receive stress on the third, fourth, fifth, and sixth day after vaccine administration. ‘Unvaccinated, stressed’ controls were not included in the study because the effects of short term stress are
Table 1
The effect of vaccination and stress on post-challenge lesion score

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Day of stress application</th>
<th>Lesion score post-challenge</th>
</tr>
</thead>
<tbody>
<tr>
<td>Not vaccinated</td>
<td>*</td>
<td>4.8 ± 0.6d</td>
</tr>
<tr>
<td>Vaccinated</td>
<td>*</td>
<td>3.0 ± 1.5c</td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>2.0 ± 0.6b</td>
</tr>
<tr>
<td></td>
<td>3</td>
<td>1.5 ± 0.6ab</td>
</tr>
<tr>
<td></td>
<td>4</td>
<td>1.0 ± 0.0a</td>
</tr>
<tr>
<td></td>
<td>5</td>
<td>1.5 ± 0.5ab</td>
</tr>
<tr>
<td></td>
<td>6</td>
<td>2.7 ± 1.1c</td>
</tr>
</tbody>
</table>

* Not stressed.
(a-d) Means followed by different letters are significantly different (P < 0.05).

known from previous work (Gross, 1984) to subside within 72 h of application. Thus, the response of ‘unvaccinated, stressed’ controls to challenge 14 days after vaccine administration would have been similar to that of the ‘unvaccinated, unstressed’ controls which were incorporated into the study.

2.4. Lesion scoring

Chickens were euthanized by cervical dislocation and caeca examined for lesions 6 days post-challenge (2 weeks and 6 days after vaccine administration). Caecal lesions were scored by a single observer according to the following scheme: 0 = no detectable lesions; 1 = slight thickening of the caecal wall particularly at the caudal end; 2 = moderate thickening of the caecal wall; 3 = severe thickening of the caecal wall; 4 = severe thickening of the caecal wall with some hemorrhage into the lumen; and 5 = severe thickening of the caecal wall and severe hemorrhage into the lumen.

2.5. Statistical analysis

Data were examined by one-way analysis of variance. The significance of observed differences between means was determined by the Duncan multiple range test.

3. Results

There were significant differences noted between experimental groups at p < 0.0001 (f value = 15.2 with 6 and 35 degrees of freedom). ‘Vaccinated, unstressed’ birds were more resistant to lesion formation post-challenge than ‘unvaccinated, unstressed’ controls. Twenty-four hours of social stress resulted in a significant increase in resistance to lesion formation when applied 2, 3, 4, or 5 days after administration of the vaccine. Application of stress on the fourth day following vaccine administration was associated with the greatest degree of protection (Table 1).

4. Discussion

In chickens, a classic glucocorticoid mediated stress response, e.g., peripheral leukopenia and an increased heterophil/lymphocyte ratio, usually occurs within 24 h of
the initiation of short-term stressful stimuli (Gross and Siegel, 1983) and subsides within 72 h (Gross, 1984). This is known to occur following the disruption of social structure (Gross and Siegel, 1973). Therefore, the effects of social stress applied on the fourth day post-vaccination were likely manifested on the fifth day. This would have coincided with the release of second stage merozoites which, by virtue of their numbers, would have constituted the greatest immunoreactive biomass associated with vaccination (McDougald and Reid, 1991). Following this type of primary exposure, innate, cell-mediated immunity involving such components as natural-killer cells and macrophages, is responsible for initial parasite elimination and subsequent antigen presentation (Leathem and Burns, 1967; Lillehoj, 1989; Lillehoj et al., 1989). Thus, enhancement of such activity via glucocorticoid stimulation seems a likely explanation for the improvement in host response to vaccination as demonstrated by resistance to lesion formation post-challenge.

Given these observations, it is likely that the effectiveness of vaccination for coccidiosis can be improved if immunocompetent birds are subject to some form of short duration stress 4 days after vaccine administration. This may be of particular benefit in the case of pullet replacements or other birds in which vaccination might be performed at 10–14 days-of-age or older.

References


