Efficacy of acycloguanosine against herpetic ulcers in rabbit cornea

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SUMMARY The effect of a new antitherpetic compound of very low toxicity called acycloguanosine (Wellcome 248U) on herpetic ulcers in rabbit cornea was studied by the Corneal Epithelial Lesion Therapeutic Assay (CELTA). The therapeutic effect of 3% acycloguanosine ointment on dendritic ulcers was equal to that of 0.5% 5-ido-2'-deoxyuridine (IDU) ointment. No toxic symptoms could be detected by slit-lamp on 4 days' treatment with this concentration of acycloguanosine. Because of its selective action on virus only, its extremely low toxicity in animals, and its availability for systemic administration, acycloguanosine seems to be an ideal antiviral compound for use in the treatment not only of herpetic keratitis but also of other herpetic diseases in man.

Herpes simplex virus (HSV) is one of the main infectious causes of eye disease in industrialised countries. IDU, first shown to be effective by Kaufman et al. (1962), has been the main drug used in the treatment of herpetic keratitis. However, cases that fail to respond to IDU or that develop allergic or toxic signs have been reported (Pavan-Langston and Dohlman, 1972; McGill et al., 1974; Hyndiuk et al., 1975), and so other antivirals are required. Adenine arabinoside (ara-A) and trifluorothymidine (F3T) appeared to be suitable alternatives several years ago and they have in fact proved effective against ulcerative herpetic keratitis (Pavan-Langston and Dohlman, 1972; Wellings et al., 1972).

However, ara-A is scarcely soluble in water and has little effect on deep herpetic keratitis by topical application, while F3T, though more soluble and effective than ara-A or IDU, is rather unstable and very expensive. Furthermore these 3 compounds all affect the replication of normal cells, causing some degree of toxicity. Thus more suitable antivirals are required for the treatment of HSV infections.

A possible candidate for this purpose is a guanine derivative called acycloguanosine (Wellcome 248U) (Fig. 1). This drug has marked antiviral activity on HSV and extremely low toxicity, so that it may be administered systemically (Schaeffer et al., 1978; Kaufman, 1978). In this study the efficacy of acycloguanosine against HSV was verified and the therapeutic effect of the drug against ulcerative herpetic keratitis in rabbit cornea was compared with that of IDU by the Corneal Epithelial Lesion Therapeutic Assay (CELTA), a method which gives an indication of the action of antiviral drugs in large-scale clinical trials (Shiota, 1979).

Methods and materials

Pigmented rabbits weighing between 2.0 and 3.0 kg were used. For inoculation of virus a modification of the multiple microtrephination method of Jones and Al-Hussaini (1963) was used. Rabbits were anesthetised with intravenous pentobarbital sodium (30 mg/kg) and given a retrobulbar injection of...
0.5 ml of 1% procaine. One eye was closed with Cellophane tape while the other was propossed and inoculated with HSV. For inoculation a suspension of the RE strain of HSV (type 1) with a titre of 2.27 × 10^6 plaque-forming units/ml was drawn into a fine glass capillary tube of 1.0 mm internal diameter, and the upper end of the capillary was plugged with Plasticine.

**CELTA METHOD**
Trephinations through the corneal epithelium with the capillary tube were made at 25 sites in the cornea (Fig. 2a) as for the corneal epithelial lesion reduction assay (Falcon and Jones, 1977). After inoculation the eye was left open for 30 seconds and then the lids were closed with Cellophane tape. The same procedure was repeated on the other eye. In one group of 4 rabbits the right eyes were treated with 3% acycloguanosine ointment and the left eyes with 0.5% IDU ointment, or vice versa. In another group 4 eyes received no treatment as controls. The treatment was started 48 hours after inoculation and continued every 2 hours during the daytime 5 times a day for 4 days. The eyes were examined 48 hours after inoculation and then every 24 hours with a photo-slit lamp after applying 1% Bengal rose, which stains plaques of HSV-replicating cells in the corneal epithelium (Jones and Patterson, 1967). Each inoculation site was scored 0 to 4 according to the extent of the circumference infected, and 1 or 2 was added if half or the whole of the cornea in the circle was ulcerated. Thus each site gave a score of between 0 and 6 as illustrated in Fig. 2b. The total daily score for each eye was calculated and expressed as a percentage of the score (percentage score) immediately before treatment. The therapeutic efficacies of acycloguanosine and IDU against ulcerative herpetic keratitis were compared by calculating their average per centage scores.

**Results**
At 48 hours after HSV inoculation large dendritic ulcers extending along almost the whole circumference infected at each site were seen in all eyes as shown in Fig. 3a, and the mean total score per eye was 95.6. In control eyes these ulcers developed steadily, forming wide geographic ulcers with prominent corneal oedema and severe ciliary injection by 6 days after inoculation, as shown in Fig. 3b. In contrast, in eyes treated with 3% acycloguanosine ointment the large dendritic ulcers gradually became smaller. After treatment with acycloguanosine for 3 days these lesions became punctate, and after treatment for 4 days they became minute and some sites did not show any lesions at all (Fig. 3c). Infected eyes were thus nearly or completely cured by 4 days’ treatment with acycloguanosine. Treatment with 0.5% IDU ointment caused the same clinical improvement as treatment with acycloguanosine. A representative eye after 4 days’ treatment with IDU is shown in Fig. 3d.

These results are summarised in Table 1 and Fig. 4. The antiviral efficacy of 3% acycloguanosine ointment on ulcerative herpetic keratitis appeared to be

**Table 1 Percentage scores of severity of herpetic ulcers in rabbit cornea**

<table>
<thead>
<tr>
<th>Days of treatment</th>
<th>3% 248U (n=4)</th>
<th>0.5% IDU (n=4)</th>
<th>Control (n=4)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>100</td>
<td>100</td>
<td>100</td>
</tr>
<tr>
<td>1</td>
<td>82 ± 17</td>
<td>83.4 ± 12.7</td>
<td>105.5 ± 11.4</td>
</tr>
<tr>
<td>2</td>
<td>40.7 ± 7.0</td>
<td>45.5 ± 8.4</td>
<td>83.4 ± 21.9</td>
</tr>
<tr>
<td>3</td>
<td>26.7 ± 5.7</td>
<td>25.5 ± 2.3</td>
<td>89.3 ± 27.3</td>
</tr>
<tr>
<td>4</td>
<td>20.3 ± 8.7</td>
<td>20.3 ± 5.8</td>
<td>122.2 ± 20.9</td>
</tr>
</tbody>
</table>

Treatment was started 48 hours after HSV inoculation.
Efficacy of acycloguanosine against herpetic ulcers in rabbit cornea

Fig. 3 Responses of herpetic ulcers in rabbit cornea to acycloguanosine and IDU. (a) Eye before treatment, 48 hours after inoculation. (b) Control eye 6 days after inoculation. (c) Eye treated with 3% acycloguanosine (248U) ointment for 4 days. (d) Eye treated with 0.5% IDU ointment for 4 days.

Equal to that of 0.5% IDU ointment. No signs of toxicity were detectable by slit lamp during treatment with either drug.

Discussion

We have shown that acycloguanosine was highly effective for treating herpetic ulcers and that the effect of 3% acycloguanosine was similar to that of 0.5% IDU. These findings are in good accord with those of Kaufman (1978). However, Pavan-Langston et al. (1978) reported from similar experiments on rabbits that the therapeutic efficacy of 3% acycloguanosine was significantly better than that of 0.5% IDU and 3% ara-A. Kaufman also reported that acycloguanosine was effective against herpetic iritis when given systemically or subconjunctivally (1978). Moreover, Schaeffer et al. (1978) found that acycloguanosine was effective against herpetic keratitis in rabbits by topical application, against herpetic encephalitis in mice per os, and against cutaneous herpetic infections in guinea-pigs.

Particular attention should be paid to the mode of the selective action of this compound. Acyclo-
guanosine is phosphorylated by a virus-specified thymidine kinase and converted to acycloguanosine triphosphate, which inhibits viral DNA polymerase (Elion et al., 1977). Since acycloguanosine is not appreciably phosphorylated by cellular kinase, it does not affect host cells and thus has extremely low toxicity. In addition Schaeffer et al. (1978) found that it is not metabolised when given systemically.

From the facts that acycloguanosine has marked antiviral activity but extremely low toxicity, and that it can be administered systemically and is not metabolised on systemic administration, this drug should be ideal for treatment not only of herpetic keratitis but also of other herpetic infections in man.

We are indebted to Wellcome Research Laboratories, Kent, UK, and Professor Barrie R. Jones, University of London, for provision of 3% 248U ointment; Mr M. Okamoto for provision of the RE strain of HSV; Dr M. Imai, Dr T. Ogawa, and Mrs Y. Endo for technical assistance.

This study was supported in part by a research grant from the Japanese Ministry of Education, Science, and Culture.

References


