Evaluation of the buccal component of systemic absorption with inhaled fluticasone propionate

Owen J Dempsey, Wendy J R Coutie, Andrew M Wilson, Peter Williams, Brian J Lipworth

Abstract
Background—Inhaled corticosteroids have dose related systemic effects determined by oral (swallowed or oropharyngeal absorption) and lung bioavailability. A study was undertaken to evaluate the significance of oropharyngeal absorption for fluticasone propionate.

Methods—Sixteen healthy volunteers of mean age 29.3 years were studied using an open randomised, placebo controlled, four way crossover design. Treatments were: (a) fluticasone metered dose inhaler (pMDI) 250 µg, 8 puffs; (b) fluticasone pMDI 250 µg, 8 puffs + mouth rinsing/gargling (water); (c) fluticasone pMDI 250 µg, 8 puffs + mouth rinsing/gargling (charcoal); and (d) placebo pMDI, 8 puffs + mouth rinsing/gargling (water). Overnight (ONUC) and early morning (EMUC) urinary cortisol/creatinine ratios and 8 am serum cortisol (SC) levels were measured.

Results—Significant (p<0.05) suppression of ONUC, EMUC, and SC occurred with each active treatment compared with placebo. The mean values (95% CI for difference from placebo) were: (a) ONUC (nmol/mmol): fluticasone (2.8, 95% CI 3.6 to 7.9), fluticasone + water (3.1, 95% CI 3.3 to 7.7), fluticasone + charcoal (2.3, 95% CI 4.1 to 8.5); placebo (8.6); (b) EMUC (nmol/mmol): fluticasone (5.6, 95% CI 8.4 to 24.5), fluticasone + water (7.6, 95% CI 6.6 to 22.4); fluticasone + charcoal (5.6, 95% CI 8.7 to 24.5); placebo (22.1). There were no significant differences between active treatments. The numbers of subjects with an overnight urinary cortisol of <20 nmol/10 hours were 0 (placebo), 11 (fluticasone), 12 (fluticasone + water), and 13 (fluticasone + charcoal).

Conclusions—Oropharyngeal absorption of fluticasone does not significantly contribute to its overall systemic bioactivity as assessed by sensitive measures of adrenal suppression. In view of almost complete hepatic first pass inactivation with fluticasone, there is no rationale to employ mouth rinsing to reduce its systemic effects although it may be of value for reducing oral candidiasis.

Keywords: adrenal suppression; inhaled corticosteroids; asthma; fluticasone propionate

Methods

Subjects
Sixteen healthy non-smoking volunteers (eight men) were recruited into the study. Their mean (SE) age was 29.3 (2.3) years. The subjects were all non-smokers with no history of respiratory or other disease. In addition, all had normal physical examination, spirometric indices, urinalysis and routine haematology/biochemical blood tests. Pregnant women and those on the oral contraceptive pill were excluded. Approval for the study was obtained from the Tayside medical ethics committee and all patients gave written informed consent.

Study Design
This was an open label single centre, placebo controlled, randomised study with a four way crossover design. Subjects attended an initial screening during which they were instructed in...
Table 1 Mean values with 95% confidence intervals for each treatment compared with placebo

<table>
<thead>
<tr>
<th></th>
<th>Placebo</th>
<th>Fluticasone</th>
<th>Fluticasone + water</th>
<th>Fluticasone + charcoal</th>
</tr>
</thead>
<tbody>
<tr>
<td>8.00 am serum cortisol (nmol/l)</td>
<td>425.3</td>
<td>202.0 (130.7 to 316.0)</td>
<td>241.5 (91.2 to 276.5)</td>
<td>186.0 (146.7 to 332.0)</td>
</tr>
<tr>
<td>Overnight urinary cortisol/creatinine (nmol/mmol)</td>
<td>8.6</td>
<td>2.8 (3.6 to 7.9)</td>
<td>3.1 (3.3 to 7.2)</td>
<td>2.3 (4.1 to 8.5)</td>
</tr>
<tr>
<td>Early morning urinary cortisol/creatinine (nmol/mmol)</td>
<td>22.1</td>
<td>5.6 (8.4 to 24.5)</td>
<td>7.6 (6.6 to 22.4)</td>
<td>5.6 (8.7 to 24.5)</td>
</tr>
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Results
Significant (p<0.05) suppression of overnight and early morning urinary cortisol/creatinine ratio and serum cortisol levels occurred with each treatment containing fluticasone propionate compared with placebo (table 1, fig 1).

DATA ANALYSIS
The study was powered at 80% with a sample size of 16 in order to detect a 20% difference in overnight urinary cortisol excretion. All data were analysed with a Statgraphics software package (STSC Software Group, Rockville, Maryland, USA). All data were normally distributed and analysed parametrically. Comparisons were made by a multifactorial analysis of variance (MANOVA) using subject, treatment, and period as factors. This was followed by Bonferroni multiple range testing set at 95% confidence interval in order to obviate multiple pairwise comparisons. Hence, all comparisons are reported as being significant (p<0.05, two tailed) or not. 95% confidence intervals for differences between treatments were calculated.

Figure 1 Mean overnight and early morning urine cortisol/creatinine ratios, and early morning serum cortisol levels for each treatment. Error bars represent 95% confidence intervals from pooled SE values. All three active treatments were significantly (p<0.05) different from placebo for all three end points. P = placebo, F = fluticasone propionate, W = water mouth rinse + gargle, C = charcoal mouth rinse + gargle.
No significant differences were observed in the mean degree of adrenal suppression between fluticasone propionate alone or in combination with vigorous mouth washing with either water or activated charcoal. Individual data for uncorrected urinary free cortisol levels are shown in Fig 2 to illustrate dispersion and outliers. No subjects in the placebo group had urinary cortisol excretion suppressed to below 20 nmol/10 hours compared with 11 subjects given fluticasone only, 12 subjects given fluticasone + water, and 13 subjects given fluticasone + charcoal mouth wash.

**Discussion**

Our study is the first to assess the contribution of oropharyngeal absorption of inhaled fluticasone propionate towards adrenal suppression, a surrogate marker of overall systemic bioavailability. It is now clear using charcoal block that absorption of fluticasone across the oropharyngeal mucosa does not contribute significantly to the overall systemic bioactivity profile. Furthermore, gargling with water, in conjunction with use of fluticasone via a pressurised metered dose inhaler does not lead to reduced systemic bioactivity.

Fluticasone propionate is a suitable corticosteroid for assessing the buccal absorption moiety for several reasons. Firstly, because of 99% first pass metabolism in the liver, even if our patients had inadvertently swallowed any corticosteroid this would be unlikely to reach the systemic circulation and be implicated in subsequent adrenal suppression. Any adrenal suppression seen can therefore be assumed to be secondary to absorption of fluticasone directly from the lung, assuming the effectiveness of activated charcoal in attenuating buccal absorption. Secondly, fluticasone propionate has a high degree of lipophilicity relative to other inhaled corticosteroids, thus ensuring good mucosal absorption. Thirdly, we have previously found a marked degree of detectable systemic bioactivity via a pMDI, as assessed by sensitive markers of adrenal suppression, with similar doses of fluticasone propionate.

Measuring adrenal suppression is a recognised way of assessing systemic bioactivity of an inhaled corticosteroid. An overnight or first waking collection of urinary free cortisol is simple for the patient to collect and is as sensitive as a 24 hour collection, particularly when corrected for creatinine excretion. Using activated charcoal as a mouth wash effectively removes possible oropharyngeal absorption from the oral bioavailability equation and allows assessment of the relative gut and lung components of systemic bioavailability. No differences were observed in the degree of adrenal suppression associated with the use of rigorous mouth washing (water or charcoal) between each inhalation of fluticasone. Our results suggest that direct buccal absorption of fluticasone propionate is not an important component of systemic bioactivity, which is more likely to be due to absorption across the lung vascular bed of the inhaled fraction. Intuitively, this is perhaps not surprising, given the relatively small absorptive surface area of the buccal mucosa compared with the lung and the short mucosal exposure time before swallowing occurs.

Mouth washing with water is unlikely therefore to reduce the systemic bioactivity of fluticasone propionate. This may not apply to other corticosteroids such as beclomethasone dipropionate or budesonide due to their lower first pass hepatic inactivation, estimated to be 90% and 70%, respectively. Studies examining the effect of mouth rinsing on systemic bioactivity of these corticosteroids have produced conflicting results. In one study mouth rinsing was associated with a 15% difference in serum cortisol suppression with 1.6 mg budesonide daily via a Turb hologer whilst another study suggested mouth rinsing had no impact on 24 hour urinary free cortisol in patients taking 1.6 mg budesonide daily via Turb hologer for two weeks. Following a single 2 mg dose of beclomethasone by Diskhaler, mouth rinsing without swallowing also did not appear to influence adrenal suppression (as 8.00 am serum cortisol), perhaps reflecting the use of only 20 ml of water after the last inhalation. Despite this, the same authors noted in another study that swallowing 50 g of activated charcoal after a single dose of 2 mg beclomethasone by Diskhaler reduced 8.00 am serum cortisol suppression by 48%. This result is in keeping with the known low degree of hepatic first pass metabolism of beclomethasone. Nevertheless, whatever the inhaled corticosteroid, mouth washing with water after use may be of value to obviate local complications such as buccal candidiasis, particularly when using higher doses.

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