Effect of ATP-Dependent K\(^+\) Channel Openers and Blockers on Serum Concentration of Aldosterone in Rats

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ABSTRACT

There are many reports for involvement of ATP-sensitive potassium channels in pancreatic, cardiac and vascular smooth muscle cells. This study examined the effect of single doses of K\(^+\) channel openers; diazoxide, minoxidil and K\(^+\) channel blockers; chlorpropamide, glibenclamide on serum concentration of aldosterone in male rats. Blood samples were obtained 60 minutes after drug treatment and serum aldosterone level was determined by RIA. The basal serum aldosterone was 659.32 ± 71.48 pg/ml and after diazoxide or minoxidil administration increased to 1188.53 ± 99.45 pg/ml and 1392.69 ± 177.83 pg/ml, respectively. Chlorpropamide or glibenclamide treatment did not produce any change in basal serum aldosterone concentration, but in early streptozotocin-induced diabetic rats decreased serum aldosterone level significantly (P<0.001). Pretreatment with glibenclamide blocked aldosterone response to diazoxide but did not affect aldosterone response to exogenous ACTH to the same extent. Effect of diazoxide in insulin-treated rats was approximately similar to that of normal rats. Comparison of blood glucose concentration determined in normal, insulin treated and diabetic rats after different drug administration showed that there is no correlation between blood glucose level and the responses observed in serum hormone concentration. The results indicate that regulatory processes involved in the secretion of aldosterone are responsive to drugs affecting glibenclamide-sensitive K\(^+\) channels.


Keywords: ATP-dependent K\(^+\) channel, Aldosterone, Blood glucose, ACTH

INTRODUCTION

The control of the synthesis and release of aldosterone is complex. Angiotensin II (AII) and potassium are the primary regulators of aldosterone secretion by adrenal zona glomerulosa cells [1]. ACTH produces a moderate stimulation of aldosterone release. Low plasma sodium or high plasma potassium concentration directly affects the zona glomerulosa cells of the adrenal, stimulating aldosterone release [2].

In addition to its independent regulatory role, K\(^+\) synergies with other adrenal secretagogues notably angiotensin II, [3]. Angiotensin II itself affect glomerulosa cell permeability to K\(^+\), causing a transient increase followed by a sustained decreases [4]. Aldosterone also involved in the regulatory process of potassium homeostasis [5]. Effects of extracellular K\(^+\) on aldosteronogenesis and effects of AN II on K\(^+\) fluxes must be exerted through K\(^+\) channels in the cell membrane [6]. Previous studies have shown that ionophores for monovalent cations are potent inhibitors of aldosteronogenesis and A II [7]. On the other hand, there are many reports for involvement of ATP-sensitive potassium channels in pancreatic, cardiac, and vascular smooth muscle cells [8]. Cromakalim, a K\(^+\) channel activator, was also found to produce rennin secretion in healthy volunteers and to promote rennin secretion when applied directly to primary cultures of rat juxtaglomerular cells [9]. ATP-sensitive potassium channels also may involve in a rapid secretary mechanism of renal kallikrein by high potassium [10].

This observation provides a basis to study the effect of some ATP-dependent K\(^+\) channel affecting drugs on serum concentration of aldosterone. Since K\(^+\) channel affecting drugs used in our studies are known to change blood glucose level. Therefore, the effect of potassium channel openers was also determined in the presence of exogenous insulin and the effect of K\(^+\) channel blockers in streptozotocin-induced diabetic rats.
MATERIALS AND METHODS

Male Wistar rats (150-200 g) (n = 108) were obtained from animal house of Pharmacology Department of Isfahan University of Medical Sciences. They had 12:12 h dark/light cycle. Glibenclamide, 20 mg/kg (Chimidaru, Iran) and chlorpropamide 100 mg/kg (Razak, Iran) were dissolved in one ml of 0.05 M NaOH. Minoxidil, 10 mg/kg (Upjohn, USA) was dissolved in 0.1% of acetic acid and diluted with 0.9% NaCl and then administered intraperitoneally (i.p.). Stereptotocin, 75 mg/kg (Novo, Denmark), insulin, 0.5 I.U/kg (Novo, Denmark) and ACTH, 0.25 mg/kg (Organon, Holland) were diluted with saline and injected intraperitoneally.

RESULTS

Effect of potassium channel openers and blockers on serum aldosterone level in normal rats. Changes in mean serum aldosterone concentration after the administration of K+ channel openers and blockers are shown in Figure 1. The basal level of serum aldosterone was 659.32 ± 71.48 pg/ml. Diazoxide or minoxidil administration increased serum aldosterone concentration to 1188.53 ± 99.45 pg/ml and 1392.69 ± 177.83 pg/ml, respectively. After the injection of glibenclamide in diazoxide treated animals, serum aldosterone level was decreased from 1188.53 ± 99.45 pg/ml to 850.0±75.08 pg/ml. Chlorpropamide or glibenclamide did not changed serum concentration of aldosterone in normal rats.

Effect of potassium channel openers and blockers on serum aldosterone level in the presence of exogenous ACTH. The effects of K+ channel affecting drugs on serum aldosterone level were studied in the presence of exogenous ACTH, which is a moderate stimulant of aldosterone releases. The aldosterone responses to ACTH and the effect of glibenclamide and diazoxide in the presence of exogenous ACTH are shown in Figure 2. Serum aldosterone concentration increased significantly (p<0.01) one hour after ACTH administration (0.25 mg/kg). Pretreatment of rats with diazoxide produced about 15% increase in response to ACTH, but this change was not

Blood samples were obtained 60 minutes after the last injection. Rats receiving glibenclamide plus diazoxide, glibenclamide was administered 30 minutes before diazoxide. Sampling was performed by decapitation or by orbital sinus puncture from the eye. To avoid any diurnal changes in the biochemical parameters, sampling and experiments were performed at 8-9 a.m. each day. Samples were left to clot at room temperature for 15 minutes and then centrifuged at 628 x g for 10 min. Serum layers were then frozen until used. Commercial Radioimmunoassay kits (Sorin, Italy) was used for determination of aldosterone [11]. In this method, 200 µl of standard, control or serum samples were added to separate radiolabeled test tubes. After vortex-mixing tubes were incubated for 18-22 h at room temperature and after careful aspiration of incubation mixture, the radioactivity of tubes was measured by Gamma counter (Kontron, USA). Blood glucose concentration was measured by the method of Dubowski [12]. Briefly, 0.1 ml of fresh blood was added to 1.9 ml of 5% trichloroacetic acid (Merck, Germany), mixed and then centrifuged. O-toluidine reagent (2.5 ml) was added to 0.5 ml of the supernatant and left in a boiling water bath for 10 minutes. Tubes were removed and after cooling, the absorbance was measured by spectrophotometer (Perkin-Elmer, Germany) at 630 nm. Results are expressed as the mean ± SEM. One way analysis of variance (ANOVA) and student’s t-test was used for comparison of the means [13].
Effect of diazoxide or glibenclamide on serum aldosterone response to exogenous ACTH. Each bar indicates mean ± S.E.M of six rats per group *P<0.01 V.S control rats; **P<0.05 V.S ACTH + diazoxide treated rats.

Effect of potassium channel blockers on serum aldosterone level in diabetic rats. To investigate the possible involvement of hypoglycemic effect of glibenclamide and chlorpropamide in hormonal responses of rats, we studied the effect of these drugs in streptozotocin-induced diabetic rats.

Four days after streptozotocin administration, the serum aldosterone level was increased 3 folds (Table 1). However, serum aldosterone concentration decreased significantly by chlorpropamide and glibenclamide K⁺ channel blockers (P<0.01 and P<0.05, respectively). Pretreatment with diazoxide partially but not completely blocked the aldosterone response associated with glibenclamide administration in diabetic rats. Blood glucose concentrations due to the administration of some potassium channel affecting drugs in different conditions of our study were shown in Table 2.

Table 1. Serum aldosterone response to K⁺ channel openers in insulin treated and to K⁺ channel blockers in diabetic rats.

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Insulin Treated</th>
<th>Diabetics</th>
</tr>
</thead>
<tbody>
<tr>
<td>Control</td>
<td>534.27 ± 30.57</td>
<td>1561.23 ± 125.07</td>
</tr>
<tr>
<td>Diazoxide (DZ)</td>
<td>1148.20 ± 43.09***</td>
<td>775.59 ± 198.68*</td>
</tr>
<tr>
<td>Minoxidil</td>
<td>1235.60 ± 96.18***</td>
<td>503.99 ± 62.69**</td>
</tr>
<tr>
<td>Glibenclamide (GL)</td>
<td>576.48 ± 146.70*</td>
<td>944.27 ± 169.50</td>
</tr>
<tr>
<td>Chlorpropamide</td>
<td></td>
<td></td>
</tr>
<tr>
<td>GL+DZ</td>
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</tbody>
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Diabetic rats received streptozotocin (75 mg/kg, I.P.) four days before experiments. Insulin treated rats received regular insulin (0.5 I.U/kg) one hour before drug treatment. Each value represents Mean ± SEM of serum Aldosterone (pg/ml) levels of six rats. *P<0.05 V.S related control; **P<0.01 V.S related control; ***P<0.001 V.S related control
This sluggish aldosterone and, sensitive the ACTH induced aldosterone, decreased basal plasma renin 85.02 ± 10.87. Eventually [quinine and lidocaine] decreased potassium 91.52 ± 8.45. 

Similar, [18 ± 6.98] diastolic blood pressure, 51.47 ± 8.45, indicating glibenclamide. Results obtained for aldosterone after diazoxide administration in insulin treated rats seemed similar.
to those of normal rats. This indicates ACTH or aldosterone response to diazoxide was not secondary to changes, which was observed in serum insulin level.

Based on the above observations, we suggest that aldosterone response to potassium channel affecting drugs not secondary to the change in serum glucose level. Also, ATP-sensitive potassium channels are involved in the regulatory process of aldosterone secretion.

REFERENCES