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Influence of Ginseng Saponins on the Isolated Aortic Contractile Response of the Spontaneously Hypertensive Rat

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Abstract : The present study was attempted to investigate the effects of total ginseng saponin (GTS), panaxadiol-type (PDS) and panaxatriol-type saponin (PTS) on contractile responses of vasoconstrictors in aortic smooth muscle stripes of normotensive (NR) and spontaneous hypertensive rats (SHR). Phenylephrine (an adrenergic α_1-receptor agonist) and high potassium (a membrane depolarizing agent) caused greatly contractile responses in both NR and AHR aorta, respectively. Phenylephrine- and high potassium-induced contractile responses were greater in NA than those in SHR aortic smooth muscle stripes. In NR, the contractile responses of high potassium (5.6×10^{-2} M) were not affected in the presence of GTS (300 μg/m*l*), PDS (300 μg/m*l*), and PTS (300 μg/m*l*), respectively whereas phenylephrine (10^{-6} M)-induced contractile responses were markedly inhibited. In SHR, the contractile responses of high potassium (5.6×10^{-2} M) were not affected in the presence of GTS (300 μg/m*l*), PDS (300 μg/m*l*), and moderate doses of PTS (150-300 μg/m*l*), respectively but greatly blocked by high concentration of PTS (600 μg/m*l*). Phenylephrine (10^{-6} M)-induced contractile responses were inhibited in a dose dependent fashion (150-600 μg/m*l*) by the pretreatment with PTS while not altered in the presence of GTS (300 μg/m*l*) and PDS (300 μg/m*l*), respectively. Taken together, these experimental results suggest that ginseng saponins cause vascular relaxation through blockade of adrenergic α_1-receptors and some unknown mechanisms, and that there is some difference in sensitivity of vascular smooth muscle between NR and SHR in responses to ginseng saponins. It seems that panaxatriol type of some ginseng saponins has the greatest potency in vascular relaxation.

Key words : Contractile response, aortic smooth muscle, spontaneous hypertensive rat, phenylephrine, vascular relaxation

INTRODUCTION

Ginsenosides are found to induce endothelin-dependent relaxation and to increase tissue content of cGMP in isolated rat thoracic aorta, possibly due to the release of EDRF.[1] Protopanaxatriol group and its purified ginsenoside Rg_1 (Rg_1) and Re caused endothelium-dependent relaxation, which is associated with the formation of cGMP.[2] It has been also reported that ginsenosides may induce vasorelaxation via activation of Ca^{2+}-dependent K^+-channels resulting in hyperpolarization of the vascular smooth muscle with subsequent inhibition of the opening of voltage-dependent Ca^{2+}-channels.[3] In experimental and clinical study of Korean Red Ginseng (KGR) treatment on hypertension, KRG is shown to have a certain effect in preventing retinopathy of hypertensive arteriosclerosis, and also well tolerated and effective on lowering blood pressure during treatment with hypertension.[4]

Hong and his coworkers (1999)[5] has reported that total ginseng saponin can inhibit the releasing effect of catecholamines evoked by nicotinic receptor stimulation from the isolated perfused rat adrenal medulla, which seems to be associated to the direct inhibition of calcium influx into the rat adrenomedullary chromaffin cells. However, in the isolated perfused rabbit adrenal glands, total ginseng saponin increases a calcium-dependent secretion of catecholamines via direct action on chromaffin cells with partly mediation of muscarinic action.[6] Moreover, Lim and his coworkers (1988; 1989)[7,8] have also found that both of panaxadiol and panaxatriol type saponins cause the increased secretion of catecholamines (CA) in a Ca^{2+}-dependent fashion from the isolated perfused rabbit adrenal glands through the activation of cholinergic (both nicotinic and muscarinic) receptors and partly the direct action on the rat adrenomedullary chromaffin cells.

It has been shown that total ginseng saponin produces the pressor and depressor actions in the anesthetized normotensive rats.[9] It has suggested that this depressor

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response is mediated in part through the blockade of adrenergic α-receptors as well as the stimulation of cholinergic muscarinic receptors, and that its pressor response is caused by stimulation so nicotinic cholinergic receptors at the sympathetic ganglia. In previous studies, it has been known that ginseng extract cause the hypotensive action[10-14] while it rather produces the hypertensive action.[15-16] Some studies have suggested that Ginseng extract causes a biphasic response on blood pressure, namely, transient fall followed by prolonged elevation.[17-19]

Furthermore, Ginseng, when given at small dose in spontaneously hypertensive rat (SHR), cause pressor response, but at relatively large dose rather produces dose-dependent hypotensive response with decreased plasma renin activity.[20-22] Sokabe and his coworkers (1984)[23] have shown that administration of KRG powder for 11 weeks has no effect on blood pressure in normotensive Donryu (DON) rats, SHR and renal hypertensive rats, whereas it elevates slightly blood pressure in deoxycorticosterone salt hypertensive rats. As mentioned so far, there are many controversial reports on vascular effects of ginseng. Therefore, the present study was attempted to investigate the effects of total Ginseng saponin, panaxadiol-type and panaxatriol-type saponins on contractile responses evoked by stimulation of adrenergic α_1-receptors and membrane depolarization in the isolated aorta of normotensive (NR) and spontaneously hypertensive rats (SHR) as well as their underlying mechanisms.

MATERIALS AND METHODS

1. Experimental procedure

Normotensive male Sprague-Dawley rats (NR) and spontaneously hypertensive rats (SHR), weighing 150 to 350 grams, were used in the present experiment. The animals were housed individually in separate cages, and food (Cheil Animal Chow) and tap water were allowed ad libitum for at least a week to adapt to experimental circumstances. On the day of experiment, a rat was anesthetized with thiopental sodium (40 mg/kg) intraperitoneally, and tied in supine position on fixing panel. The thorax was opened by a mid-line incision, and the heart and surrounding area were exposed by placing three hook retractor. The heart and portion of the lung were not removed, but pushed over to the right side and covered by saline-soaked gauge pads in order to obtain enough working space for isolating aortic vessel.

The aorta was isolated from the proximal part to the vicinity of liver and immediately immersed in cold Krebs solution. The blood within the aorta was rapidly removed. The aorta was cut into the ring of 4-5 mm length.

2. Recording of mechanical activity

As shown in Fig. 1, the ring segment of aorta isolated from NR and SHR was mounted in a muscle bath by sliding the ring over two parallel stainless-steel hooks (0.15 mm in diameter). The lower hook was fixed on bottom of the bath and the upper was connected to isomeric transducer (Grass FT. 03). The signal from the transducer was displayed on a polygraph (Grass Instruments Model 79). The volume of bath was 25 m*l* and the bath solution was saturated with 95% O_2 and 5% CO_2 at 37°C.

The composition (mM) of Krebs was: NaCl, 118.4; KCl, 4.7; $CaCl_2$, 2.5; $MgCl_2$, 1.18; $NaHCO_3$, 25; KH_2PO_4, 1.2; glucose, 11.7. The final pH of the solution was maintained at 7.4-7.5. During equilibration period of 2 hours at 2 g, the final resting tension was adjusted to 0.5 g. After the equilibration period, the ring was challenged two times with 56 mM KCl, and if it responded with contraction, the proper experiment was started. Vasoconstrictors were

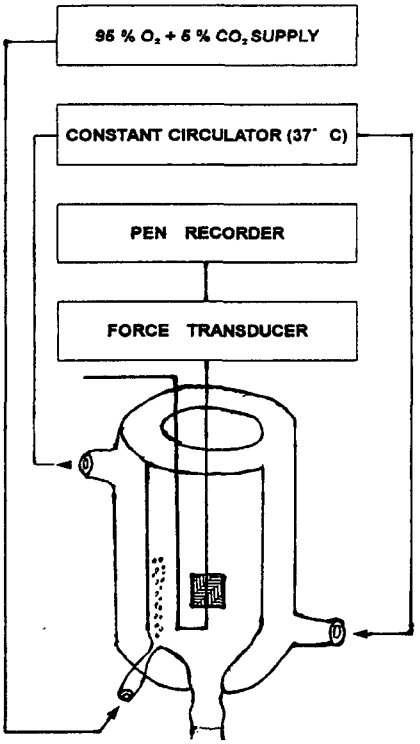

Fig. 1. A schematic representation of the isometric contraction recording system with a vertical chamber. The chamber (15 m*l*) was maintained at 37°C with temperature-regulated circulator and aerated with 95% O_2 and 5% CO_2.

administered into the bath in order to obtain dose-response curves. In the subsequent experiments, under the presence of total ginseng saponin some vasoconstrictors were administered. The data were expressed as the active tension in gram.

3. Statistical analysis

All data are presented as means with their standard errors, and the significance of differences were analyzed by Student's paired t-test using the computer program of statistics system as previously described.[24]

4. Drugs and their sources

The following drugs were used: phenylephrine hydrochloride and potassium chloride (Sigma Chemical Co., U.S.A.). Total Ginseng saponin, panaxadiol-type and panaxatriol-type saponins were gifted from late Professor Young-Ho Kim (Sejong University, Seoul, Korea). Drugs were dissolved in distilled water (stock) and added to the normal Krebs solution as required. Concentrations of all drugs used are expressed in terms of molar base.

RESULTS

1. The effects of total ginseng saponin on contractile responses induced by phenylephrine and high K^+ in the rat aortic strips isolated from NR and SHR

The resting (basal) tension from the isolated rat aortic strips reaches a steady state after the perfusion with oxygenated Krebs-bicarbonate solution for 90 min before the experimental protocol is initiated. The resting tension was adjusted to 0.5 g. The effect of total Ginseng saponin on phenylephrine- as well as potassium chloride-mediated contractile responses in the rat aorta was examined. In the present study, total Ginseng saponin itself did not produce any effect on the resting tension in both aortas isolated from NR and SHR (data not shown). However, it was found that there is difference in the contractile responses induced by phenylephrine and high potassium between NR and SHR as shown in Fig. 2.

When 10^{-6} M of phenylephrine was administered into the aortic bath, the active tension was 2.6± 0.2 g in NR and 0.8± 0.3 g in SHR from the resting tension level, respectively. However, under the pre-loading with total Ginseng saponin at a concentration of 300 μg/ml, phenylephrine-induced tensions were amounted to 1.4± 0.2 g ($P< 0.01$, n=10) in NR and 1.0± 0.2 g (ns, n=5) in SHR, respectively. They were 54% and 125% of the control contractile responses (100%), respectively (Fig. 3 and 4).

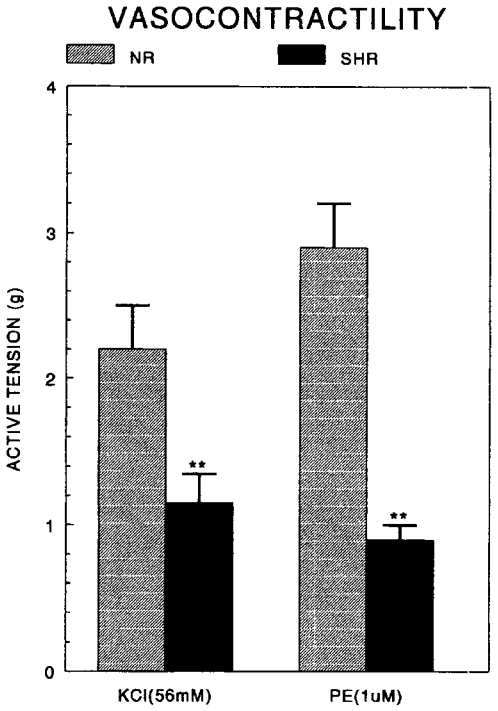

Fig. 2. Comparison of contractile responses induced by high KCl and phenylephrine (PE) in the isolated aortic strips of normotensive and spontaneous hypertensive rats. The contractile responses were induced by adding 56 mM KCl and 1 mM PE into the bath, respectively after adaptation with normal Krebs solution for two hours prior to initiation of the experimental protocol. "NR" and "SHR" denote normotensive rats and spontaneously hypertensive rats, respectively. Vertical bars represent mean± S.E. Ordinate: the active tension (gram). Abscissa: concentrations of KCl and PE. Statistical difference was obtained by comparing the NR with the SHR group from 6 experiments. PE: phenylephrine. **P< 0.01.

High K exerts two distinct effects on cells: (1) depolarization of cell membrane, and (2) depolarization- induced influx of calcium via voltage-dependent calcium channels.[25] When added through the bath, high potassium at the concentration of 56 mM, which is membrane-depolarizing agent, caused an increase in aortic contraction. As shown in Fig. 3, high potassium-induced contractile responses before pre-loading with total ginseng saponin were 2.2±0.2 g in NR and 0.6±0.1 g in SHR, respectively, while, after pretreatment with total ginseng saponin at a concentration of 300 μg/ml, they were not altered to 0.6±0.05 g (ns, n=5) and 1.8±0.1 g (ns, n=12), which were nearly close to 100% and 82% of the corresponding control, respectively. These results are in agreement with that by the previous study.[3]

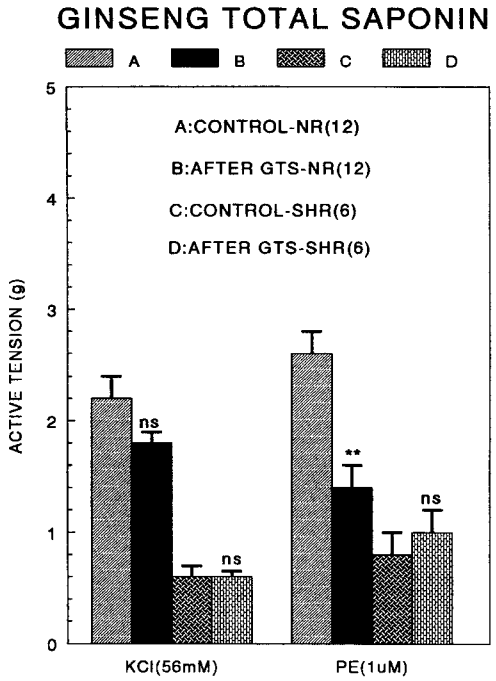

Fig. 3. Influence of total Ginseng saponin (GTS) on high KCl- and phenylephrine (PE)-induced contractile responses in the isolated aortic strips of normotensive rats (NR) and spontaneously hypertensive rats (SHR). The contractile responses were induced by adding 56 mM KCl and 1 μM PE, respectively after adaptation with normal Krebs solution for two hours prior to initiation of the experimental protocol. "A" and "C" denote active tension of the control induced evoked by KCl or PE in NR and SHR, respectively before adding GTS. "B" and "D" denote active tension of the control induced evoked by KCl or PE in NR and SHR, respectively after adding GTS (300 μg/m*l*). Number in the parenthesis indicates number of rat aorta. Statistical difference was obtained by comparing the control with the GTS-pretreated group in NR and SHR, respectively. Other legends are same as in Fig. 2. **P<0.01. ns: Statistically insignificant.

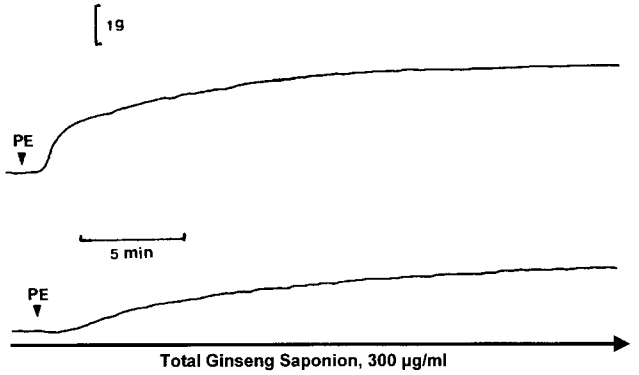

Fig. 4. The typical tracing showing the effect of total Ginseng saponin on phenylephrine (PE)-induced contractile responses in aortic strips of the normotensive rat. Upper: PE-induced contractile response. Lower: PE-induced contractile response in the presence of total ginseng saponin (300 μg/m*l*). At arrow mark, the indicated dose (1 μM) of PE was added into the bath. The chart speed was 5 mm/min.

2. The effects of panaxadiol-type saponin on contractile responses induced by phenylephrine and high K^+ in the rat aortic strips isolated from NR and SHR

Ginsenosides are a mixture of saponin from *Panax ginseng*, the major form of glycosides belong either to the protopanaxadiol group or the protopanaxatriol group. Therefore, it was likely interesting to compare the effects of ginseng saponins on the contractile responses induced by high potassium and phenylephrine.

In the presence of panaxadiol-type saponin (300 μg/m*l*), the aortic contractile response of the NR evoked by phenylephrine (10^{-6} M) was 2.0± 0.3 g (P< 0.01, 74% of the control)) from the resting tension level from 8 experiments in comparison with its corresponding control response of 2.7± 0.2 g, while the aortic contractile response of the SHR evoked by phenylephrine was 0.7± 0.1 g (ns, 88% of the control)) from 14 rat aortae in comparison with its corresponding control response of 0.8± 0.1 g as depicted in Fig. 5 and 6.

High potassium-induced contractile responses before treatment with panaxadiol-type saponin were 2.2± 0.5 g in NR and 1.7± 0.3 g in SHR, while after pretreatment with panaxadiol-type saponin at a concentration of 300 μg/m*l* they were 2.1± 0.3 g (ns, n=8) and 1.8± 0.4 g (ns, n=7), respectively, which were nearly close to 96% and 106% of the corresponding (Fig. 5).

3. The effects of panaxatriol-type saponin on contractile responses induced by phenylephrine and high K^+ in the rat aortic strips isolated from NR and SHR

High potassium (56 mM)-induced aortic contractile response of the NR before pre-loading with panaxatriol-type saponin were 2.3± 0.2 g while after pretreatment with panaxatriol-type saponin at a concentration of 300 μg/m*l*, it was 2.5± 0.3 g (ns, n=8), which was 109 % of the corresponding control (Fig. 7). However, in aortic strips of the SHR, the contractile responses of high potassium (56 mM) in the presence of panaxatriol-type saponin at concentrations of 150, 300 and 600 μg/m*l* were 1.0± 0.05 g (ns, n=6), 1.1± 0.2 g (ns, n=6) and 0.4± 0.1 g (P< 0.01, n=6) as compared their corresponding control responses of 1.0± 0.1 g, 1.2± 0.4 g and 1.4± 0.2 g,

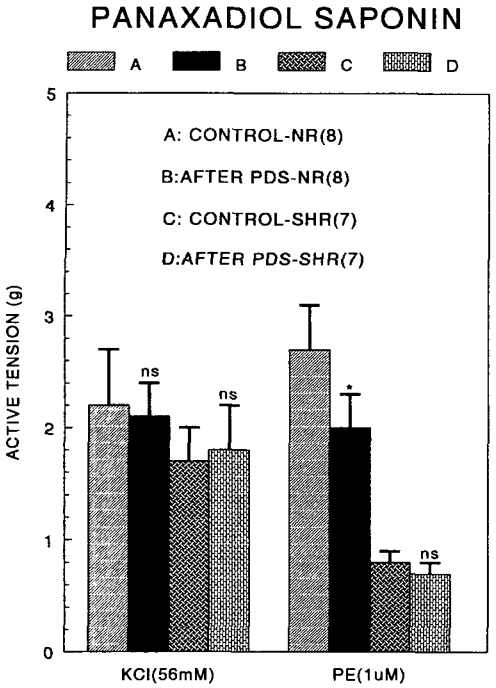

Fig. 5. Influence of panaxadiol-type saponin (PDS) on high KCl- and phenylephrine (PE)-induced contractile responses in the isolated aortic strips of normotensive rats (NR) and spontaneously hypertensive rats (SHR). The contractile responses were induced by adding 56mM KCl and 1 μM PE, respectively after adaptation with normal Krebs solution for two hours prior to initiation of the experimental protocol. "A" and "C"denote active tension of the control induced evoked by KCl or PE in NR and SHR, respectively before adding PDS. "B" and "D" denote active tension of the control induced evoked by KCl or PE in NR and SHR, respectively after adding PDS (300 μg/m*l*). Other legends are the same as in Fig. 2 and 4. The statistical difference was obtained by comparing the control with the PDS-pretreated group in NR and SHR, respectively. *P<0.05. ns: Statistically insignificant.

respectively (Fig. 7 and 8).

The active tension of phenylephrine (10^{-6} M) given into the aortic bath before the treatment with panaxatriol-type saponin was 3.5± 0.3 g in NR from the resting tension level. However, under the pre-loading with panaxatriol-type saponin at a concentration of 300 μg/m*l*, phenylephrine-induced tension was greatly inhibited to 2.4± 0.3 g (P< 0.01, n=8), which was 69% of the control contractile response (Fig. 9 and 11). However, in aortic strips of the SHR, the contractile responses of phenylephrine (10^{-6} M) in the presence of panaxatriol-type saponin at concentrations of 150, 300 and 600 μg/m*l* were a dose-dependently

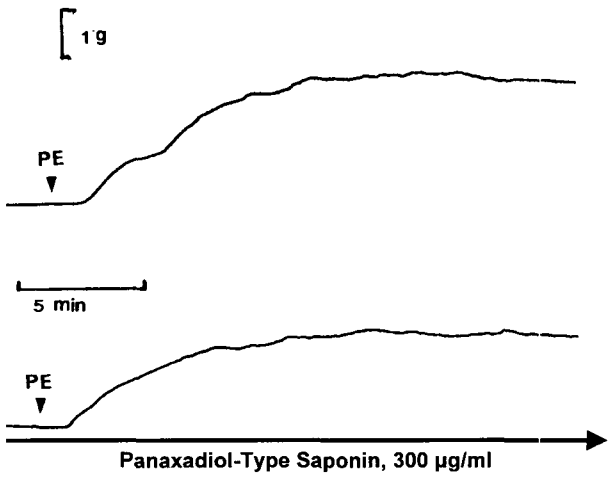

Fig. 6. The typical tracing showing the effect of panaxadiol-type saponin on phenylephrine (PE)-induced contractile response in aortic strips of the normotensive rat. Upper: PE-induced contractile response. Lower: PE-induced contractile response in the presence of PDS (300 μg/m*l*). At dots, the indicated does (1 μM) of PE was added into the bath. The chart speed was 5 mm/min.

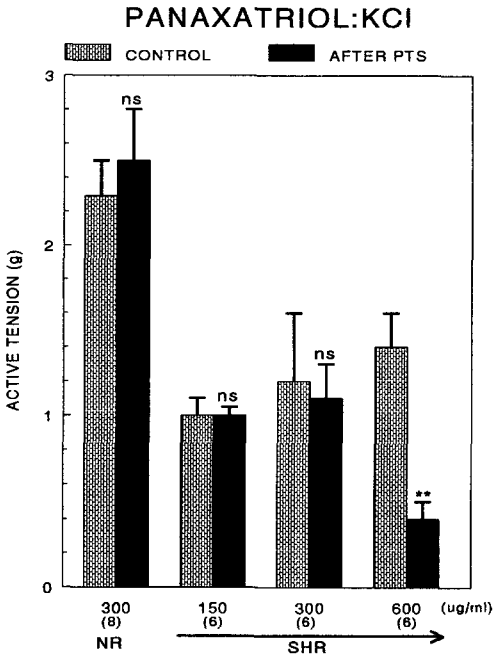

Fig. 7. Influence of panaxatriol-type saponin (PTS) on high potassium-induced contractile responses in the isolated aortic strips of normotensive rats (NR) and spontaneously hypertensive rats (SHR). High potassium (56 mM) was added into the bath before (CONTROL) and after pretreatment with PTS (150, 300 and 600 μg/m*l*, respectively) in SHR and NR (300 μg/m*l*). Other legends are the same as in Fig. 2 and 4. **P<0.01. ns: Statistically insignificant.

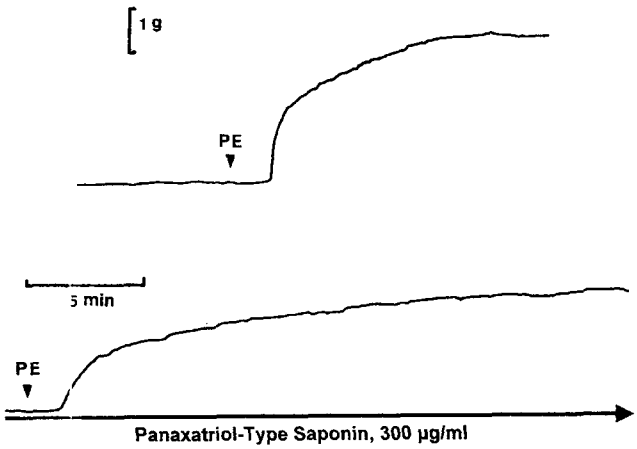

Fig. 8. The typical tracing showing the effect of panaxatriol-type saponin on high potassium-induced contractile response in aortic strips of the spontaneously hypertensive rat. Upper: high KCl (56 mM)-induced contractile response. Lower: KCl-induced contractile response in the presence of PTS (600 μg/m*l*). At dots, the indicated dose of KCl (56 mM) was added into the bath. The chart speed was 5 mm/min.

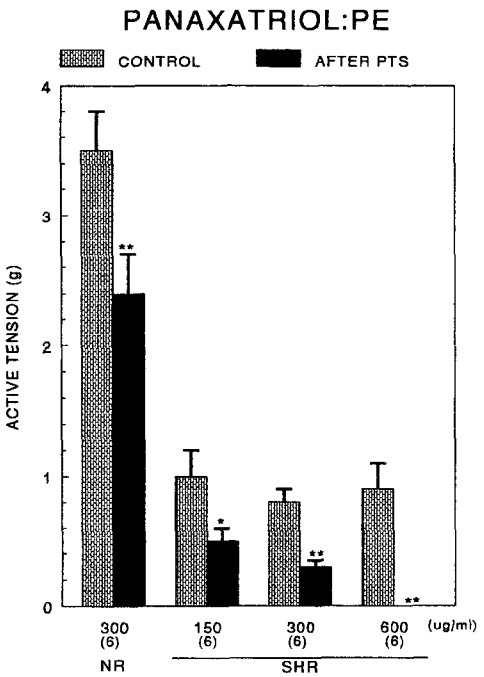

Fig. 9. Influence of panaxatriol-type saponin (PTS) on high potassium-induced contractile responses in the isolated aortic strips of normotensive rats (NR) and spontaneously hypertensive rats (SHR). High potassium (56 mM) was added into the bath before (CONTROL) and after pretreatment with PTS (150, 300 and 600 μg/m*l*, respectively) in SHR and NR (300 μg/m*l*). Other legends are the same as in Fig. 2 and 4. **P<0.01. ns: Statistically insignificant

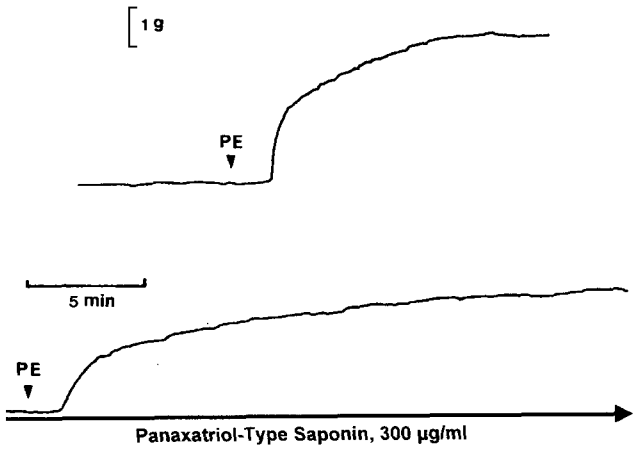

Fig. 10. The typical tracing showing the effect of panaxatriol-type saponin on phenylephrine (PE)-induced contractile response in aortic strips of the normotensive rat. Upper: PE-induced contractile response. Lower: PE- induced contractile response in the presence of PTS (300 μg/m*l*). At dots, the indicated dose (1 μM) of PE was added into the bath. The chart speed was 5 mm/min.

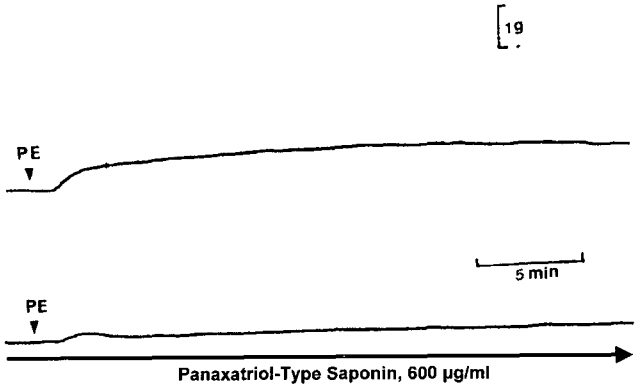

Fig. 11. The typical tracing showing the effect of panaxatriol-type saponin on phenylephrine (PE)-induced contractile response in aortic strips of the spontaneously hypertensive rat. Upper: PE (1 μM)-induced contractile response. Lower: PE-induced contractile response in the presence of PTS (600 μg/m*l*). At dots, the indicated dose of PE (1 μM) was added into the bath. The chart speed was 5 mm/min.

inhibited to 0.5± 0.1 g (P< 0.05, n=6), 0.3± 0.05 g (P< 0.01, n=6) and 0± 0 g (P< 0.01, n=6) as compared their corresponding control responses of 10± 0.2 g, 8 ± 0.1 g and 9± 0.2 g, respectively (Fig. 9 and 11).

DISCUSSION

The present experimental results suggest that ginseng

saponins cause vascular relaxation through blockade of adrenergic α_1-receptors and some unknown mechanisms, and that there is some difference in sensitivity of vascular smooth muscle between NR and SHR in responses to ginseng saponins. It seems that panaxatriol type of some ginseng saponins has the greatest potency in vascular relaxation.

In support of this idea, among drugs which interfere with peripheral sympathetic function, adrenergic α-receptor blocking agents alone cause reversal of the epinephrine pressor response.[26] When epinephrine is administered to untreated animals, its α-agonist properties predominate, resulting in a rise in mean arterial pressure. However, in the presence of adrenergic α-receptor blockade, the peripheral β_2-agonist properties of epinephrine predominate and a fall in arterial pressure or reversal of the pressor response is observed. In contrast, the pressor responses to norepinephrine are impaired by adrenergic α-receptor blockade, but are not reversed[27] as this agent processes little β_2-agonist activity.[28] In terms of the fact that phenylephrine-evoked contractile response is greatly depressed by ginseng saponins, it is thought that gisenseng saponins have vascular dilatatory activity through the adrenergic α-receptor blockade. Furthermore, It has been shown that total ginseng saponin produces the pressor and depressor actions in the anesthetized normotensive rats.[9] It has suggested that this depressor response is mediated in part through the blockade of adrenergic α-receptors as well as the stimulation of cholinergic muscarinic receptors, and that its pressor response is caused by stimulation of nicotinic cholinergic receptors at the sympathetic ganglia.

Generally, it well known that potassium chloride (KCl) opens voltage-dependent calcium channels by depolarizing the cell membrane of vascular smooth muscle, resulting in increased influx of extracellualr Ca^{2+} (Bolton, 1979; Schwartz & Taira, 1983; Dube *et al.*, 1985; 1988)[29-32]. Kim and his colleagues (1989)[33] have shown that the contractile responses of vascular smooth muscle induced by $CaCl_2$ and KCl may result most likely from increased influx of extracellular Ca^{2+} through the voltage-dependent calcium channels. In terms of these results, the present findings that PTS of some ginseng saponins inhibited the contraction of rat aortic smooth muscle evoked by phenylephrine (α_1-adrenergic receptor agonist) and KCl (membrane depolarizer) suggest strongly that PTS can facilitate the opening of potassium channels. Moreover, Kim and his colleagues (1998)[3] have shown that ginsenosides cause a concentration-dependent relaxation of rat aortic rings without endothelium constricted with 25 mM KCl but affected only minimally those constricted with 60 mM KCl. They have also suggested that ginsenosides may induce vascular dilatation via activation of Ca^{2+}-dependent K^+ channels resulting in hyperpolarization of the vascular smooth muscle with subsequent inhibition of the opening of voltage-dependent Ca channels.[3]

In previous studies, three cellular mechanisms have been proposed to explain relaxant response of vascular smooth muscle: (i) blockade of extracellular Ca^{2+} entry into cells,[34-35] (ii) increase in binding or sequestration of intracellular Ca^{2+},[36-37] and (iii) inhibiting the release of intracellular stored Ca^{2+}.[37-39] In contrast, the contractions of vascular smooth muscles induced by neurohumoral agents have been composed of two components: Phasic contraction induced by the Ca^{2+} released from inside the cell and tonic tension related to the Ca^{2+} influx,[33,40] both leading to increased intracellular calcium.

In the light of these findings, it could not be ruled out that ginseng saponins can dilate the contractile responses of vascular smooth muscle evoked by phenylephrin and/or KCl through the blockade of extracellular Ca^{2+} entry into the muscle cells. Thus, these effects of ginseng saponins seem to contribute at least partly to the facts that ginseng extract causes the hypotensive action,[10-14] but not to the facts that it rather produces the hypertensive action.[15-16] Some studies have suggested that ginseng extract causes a biphasic response on blood pressure, namely, transient fall followed by prolonged elevation.[17-19]

In the present study, GTS, PDS and PTS inhibited markedly the contractile response induced by phenylephrine in NR, but not that by high potassium. In SHR, PTS only inhibited a concentration-dependently phenylephrine-induced contractile response, and high concentration of PTS (600 μg/ml) also depressed high potassium-induced contraction. It has been shown that PTS of some ginseng saponin components produces the greatest potency in relaxation of aortic smooth muscle contraction.

Taken together, these experimental results suggest that ginseng saponins cause vascular relaxation through blockade of adrenergic α_1-receptors and some unknown mechanisms, and that there is some difference in sensitivity of vascular smooth muscle between NR and SHR in responses to ginseng saponins. It seems that panaxatriol type of some ginseng saponins has the greatest potency in vascular relaxation.

요 약

본 연구에서는 인삼사포닌 성분 즉, 총인삼사포닌(GTS), panaxadiol-type saponin(PDS) 및 panaxatriol-type saponin(PTS)이 정상 혈압

쥐(NR) 및 자연발증 고혈압쥐(SHR)의 대동맥편에서 혈관수축약물의 수축반응에 대한 영향을 관찰하고자 시도하였으며, 얻어진 연구결과는 다음과 같다. Phenylephrine(아드레날린성 α_1-수용체 효능약)과 고농도 칼륨(막탈분극약)은 NR 및 SHR의 대동맥편에서 각각 현저한 혈관수축반응을 나타내었다. 이들의 수축반응은 SHR보다 NR에서 현저하게 나타났다. NR에서 고농도 칼륨(5.6×10^{-2} M)에 의한 혈관수축반응은 GTS(300 μg/m*l*), PDS(300 μg/m*l*) 및 PTS(300 μg/m*l*)의 존재 하에서 각각 별다른 영향을 받지 않았다. 반면에, phenylephrine(10^{-6} M)에 의한 혈관수축반응은 현저하게 억제되었다. SHR에서 고농도 칼륨(5.6×10^{-2} M)에 의한 혈관수축반응은 GTS(300 μg/m*l*), PDS(300 μg/m*l*) 및 PTS(300 μg/m*l*)의 존재하에서 각각 별다른 영향을 받지 않았으나 고농도의 PTS(600 μg/m*l*)의 전처치에 의해서 유의하게 억제되었다. Phenylephrine(10^{-6} M)에 의한 혈관수축반응은 PTS의 전처치에 의해서 용량 의존적(150-600 μg/m*l*)으로 유의하게 억제되었으나 GTS (300 μg/m*l*)나 PDS(300 μg/m*l*)의 존재 하에서는 별다른 영향을 받지 않았다. 이상과 같은 실험 결과를 종합하여 보면, 인삼사포닌 성분은 흰쥐 적출 대동맥편에서 아드레날린성 α_1-아드레날린 수용체 차단작용과 일부 미지의 기전에 의해서 혈관이완작용을 일으키며, 이러한 인삼사포닌 성분에 대한 반응에서 NR과 SHR간에 혈관 평활근의 감수성의 차이가 있는 것으로 생각된다. 또한 인삼사포닌 성분 중 PTS가 혈관이완작용에 대한 효력이 가장 큰 것으로 사료된다.

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