4-44 R972 R743.31



in rat brain following middle cerebral artery occlusion. Stroke 1990; 21: 1727－33.

5 Sakatani K, Iizuka H, Young W. Somatosensory evoked potentials in rat cerebral cortex before and after middle cerebral artery occlusion. Stroke 1990; 21: 124－32.

6 Helps SC, Meyer-Witting M, Reilly PL, Gorman DF. Increasing doses of intracarotid air and cerebral blood flow in rabbits. Stroke 1990; 21: 1340－5.

7 Wang YL, He RR. Protective effect of dipfluzine on experimental brain edema in rats. Acta Pharmacol Sin 1994; 15: 201－5.

8 Shimada N, Graf R, Rosner G, Heiss W-D. Differences in ischemia-induced accumulation of amino acids in the cat cortex. Stroke 1990; 21: 1445－51.

9 Wang YL, Li YS, Fu SX, Jin S. Acute toxicity of dipfluzine and its effects on isolated vascular smooth muscle. Acta Pharmacol Sin 1990; 11: 39－42.

## 双苯氟嗪对大鼠缺血脑皮层诱发电位和氨基酸含量的影响

王永利，何瑞荣[1] （河北医学院药理教研室，[1]生理教研室，石家庄050017，中国）

**关键词** 双苯氟嗪；微透析；氨基酸；脑缺血；体感诱发电位；钙通道阻滞剂

目的：测定双苯氟嗪(Dip)对大鼠缺血脑细胞内外氨基酸含量及皮层体感诱发电位(SEP)的影响。方法：在结扎双侧颈总动脉雌性 Wistar 大鼠，用 HPLC 法测定脑透析液和脑组织中的氨基酸含量，用电生理技术测定 SEP。结果：Dip ip 50 mg·kg$^{-1}$可防止缺血所致 SEP 潜伏期的延长及其幅度的过分增大，降低脑透析液中的谷氨酸、天冬氨酸和甘氨酸浓度以及减轻脑组织中谷氨酸、天冬氨酸、甘氨酸、牛磺酸和 γ-氨基丁酸的消耗。结论：Dip 能够改善脑缺血所致的皮层功能紊乱和脑内兴奋性与抑制性氨基酸释放失调，为其抗缺血性脑损伤作用提供了进一步的实验证据。

BIBLID: ISSN 0253-9756 Acta Pharmacologica Sinica 中国药理学报 1996 Jan; 17 (1): 44－48

# Influences of ginsenosides $Rb_1$ and $Rg_1$ on reversible focal brain ischemia in rats[1]

ZHANG Ying-Ge[2], LIU Tian-Pei
*(Department of Pharmacology, Nanjing Medical University, Nanjing 210029, China)*

**KEY WORDS** ginseng; saponins; cerebral ischemia; cerebral infarction; calcium; potassium

**AIM**: To study the influences of ginsenosides $Rb_1$ and $Rg_1$ (active components of the total saponins of *Panax ginseng*) on the brains against ischemia-reperfusion injury. **METHODS**: Rat focal cerebral ischemia was induced by reversible middle cerebral artery occlusion (MCAO) without craniectomy. The influences of ginsenoside $Rb_1$ and $Rg_1$ on infarct size (IS), neurologic deficit (ND) and the contents of calcium and potassium in the infarct were observed. **RESULTS**: In a 2-h ischemia, $Rb_1$ 10－40 mg·kg$^{-1}$ iv 30 min before MCAO decreased IS by 20 %－49 % and ND score from 5.1 to 4.1－2.3, and inhibited Ca accumulation and K loss by 22 %－50 % and 18－37 %, respectively; $Rb_1$ 10－40 mg·kg$^{-1}$ iv immediately after MCA was recanalized decreased IS by 12 %－35 % and ND score from 5.2 to 4.3－3.3, and inhibited Ca accumulation and K loss by 10 %－40 % and 17 %－30 %, respectively. In permanent ischemia, $Rb_1$ 40 mg·kg$^{-1}$ iv reduced IS, ND, Ca accumulation and K loss. However, $Rg_1$ 40 mg·kg$^{-1}$ iv did not show effect on both permanent and 2-h MCAO. **CONCLUSIONS**: $Rb_1$ protected brain from ischemic and reperfusion injuries.

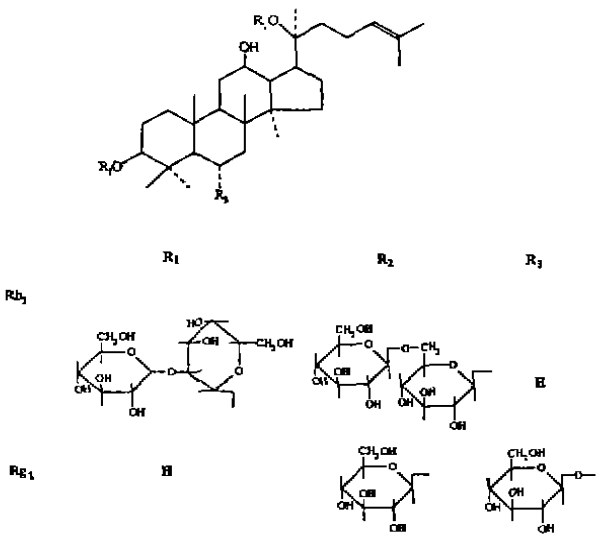
Ginsenosides could protect the brains against ischemia and decrease the infarct size (IS) produced by middle cerebral artery occlusion (MCAO)[1-2]. Ginsenosides are composed of many different monoginsenosidic saponins. That

[1] Project supported by the National Natural Science Fundation of China, № 39170857.

[2] Now in *Institute of Pharmacology and Toxicology, Academy of Military Medical Science, Beijing 100850, China.*

Received 1992-10-09 Accepted 1995-04-25

which saponin is active remains to be elucidated. $Rb_1$, one of the panaxadiols, may be beneficial to the ischemic brain in 2 aspects: $Rb_1$ could reduce intracellular calcium[3,4] while the calcium entry into cells is the final commom pathway leading to cell death[6]; $Rb_1$ inhibited the $Na^+$-$K^+$-exchanging ATPase in normal brain[5], which may be capable of reducing the calcium sequestered in the microsomes. In this study we intended to find out if $Rb_1$ and $Rg_1$, were effective in protecting ischemic brain.




## MATERIALS AND METHODS

**Drugs and chemicals** $Rb_1$ and $Rg_1$ were extracted and purified by Kunming Institute of Botany, Chinese Academy of Science, purity >98 %. 0.05 % Nimodipine (Nim) injection (batch № 910429) was made by the Fourth Hospital of Wu-han. Glass fiber was Astron 3# fishing line made in Japan, which could be obtained from the market.

**Rat model** Sprague-Dawley rats, $n=150$, weighing $400 \pm s$ 46 g of either sex were used. For permanent MCAO, 48 rats were equally divided into 6 groups: Nim 20 $\mu g \cdot kg^{-1}$, $Rb_1$ 10, 20, 40 $mg \cdot kg^{-1}$, $Rg_1$ 40 $mg \cdot kg^{-1}$, and the control groups. For transient MCAO, 96 rats were divided into 6 groups as those in permanent MCAO, but each group was further divided into 2 subgroups: the drugs were injected iv before or after MCAO. The rats were anesthetized by sodium pentobarbital 60 $mg \cdot kg^{-1}$ ip. Blood pressure was monitored through cannulation of right femoral artery. Rectal temperature was kept at 38 C by an infrared lamp. MCAO was performed according to the method of Longa *et al*[1], save that the nylon suture was replaced by a piece of glass fiber which was pretreated with nitric acid 10 $mol \cdot L^{-1}$ for 3 s to obtain satisfactory flexibility and rigidity for advancement in the arterial lumen while not perforating the wall. For reperfusion, the fiber was pulled out after 2-h MCAO and the external carotid artery stump was ligated with 0# silk suture. Drugs were injected through right femoral vein. One group (6 rats) were subjected to sham operation: the fiber was in the internal carotid artery without MCAO. In permanent MCAO, drugs were given before operation; In 2-h MCAO, drugs were given before ischemia or immediately after the MCA was recanalized. The control was given equal volume of saline.

**EEG** EEG was recorded percutaneously through 2 silver pin electrodes by an LMS-2B polygraph. Recording electrode was percutaneously placed on the surface of parietal scalp 3 mm lateral to the sagittal line and the reference one was placed to the nasion. Band pass filter, 100 Hz; time constant, 0.2 s; sensitivity, 2 $mV \cdot m^{-1}$; standard voltage, 50 $\mu V$. The amplitude[8] before MCAO was taken as 100 %. The period of EEG falling to lowest value was measured from MCAO to the beginning of the constant lowest value.

**Neurologic deficits (ND)** At 24 h after the onset of MCAO, the severity of ND was scaled in 8 levels[2]: 0 — no recognizable impairment in activity; 1 — upon hunging upside down, the left forepaw could not fully extend; 2 — the left forelimb could not straightly downwards accompanied by the adduction of the left shoulder; 3 — the left forelimb stuck to the thoracic wall upon hunging upside down; 4 — circling to the left without obvious pulling back of the left forepaw; 5 — circling to the left accompanied by the pulling back of the forepaw; 6 — rotating to the left and could not go ahead effectively; 7 — the left limbs were completely paralysed and could only lie on the left. ND scores were evaluated by a paramedical attendant who did not know the treatment drugs. A close correlation was found between ND scores and IS ($r=0.906$, $P<0.01$).

**IS and water content** At 24 h after the onset of MCAO, rats were decapitated. The brains were stained and the necrotic tissues were pooled out[2]. The necrotic tissues and the non-necrotic tissues were dried at 110 C. The relative IS was expressed in a dry weight % of the necrotic tissue to the entire hemisphere. The water content = [wet weight − dry weight]/[wet weight] × 100 %.

**Calcium accumulation and potassium loss** The dried tissues were digested in 1 mL nitric acid ($10 mol \cdot L^{-1}$) and 0.1 mL perchloric acid at 90 C for 2-h. Ca and K contents were determined by an AA-1475 atomic absorption spectrometer (Varian, USA). Ca accumulation and K loss were the differences between the contents in the necrotic tissue and that in contralateral hemisphere.

## RESULTS

**ND** All the rats with MCAO showed ND while the control rats suffered more 24 h after

MCAO. Recirculation for 22 h did not significantly affect the ND despite of a trend of alleviation. Nim 20 $\mu g \cdot kg^{-1}$ iv improved the movement function of the rats with permanent or 2-h MCAO. In 2-h MCAO, $Rb_1$ 10—40 $mg \cdot kg^{-1}$ iv before ischemia and immediately after ischemia showed decreases of ND scores of 1—2.8 and 0.9—1.9, respectively. In permanent MCAO, $Rb_1$ 40 $mg \cdot kg^{-1}$ reduced ND but 10—20 $mg \cdot kg^{-1}$ had no significant effects on ND. $Rg_1$ 40 $mg \cdot kg^{-1}$ iv had no significant effect on ND in permanent or 2-h MCAO (Tab 1).

**IS** At 24 h after the onset of MCAO, all the rats developed obvious infarction in the hemisphere. Recirculation tended to reduce IS but there was no statistically significant difference *vs* the control ($P > 0.05$). In permanant MCAO, $Rb_1$ 40 $mg \cdot kg^{-1}$ reduced IS by 14 % ($P < 0.05$). In 2-h MCAO, $Rb_1$ 10—40 $mg \cdot kg^{-1}$ iv before and after ischemia reduced the IS by 20 %—49 % and 12—35 % respectively. $Rb_1$ 20—40 $mg \cdot kg^{-1}$ iv before ischemia was more effective than after ischemia. $Rg_1$ was ineffective on IS. Nim 20 $\mu g \cdot kg^{-1}$ reduced the IS in both permanent and 2-h MCAO (Tab 1).

**Ca accumulation, K loss, and water content** At 24 h after the onset of MCAO, there was a large Ca accumulation and K loss in the infarcted *site* which swelled greatly. In permanent MCAO, $Rb_1$ 40 $mg \cdot kg^{-1}$ decreased the Ca accumulation by 14 %, the K loss by 23 %, and the water content by 3.1 %, $Rb_1$ 10—20 $mg \cdot kg^{-1}$ exhibited a mild tendency of reduction. In 2—h MCAO, $Rb_1$ 10—40 $mg \cdot kg^{-1}$ before ischemia reduced the Ca accumulation, K loss and water content by 22 %—50 %, 18 %—37 %, and 1.8 %—4.2 %, respectively $Rb_1$ 10—40 $mg \cdot kg^{-1}$ iv after ischemia reduced the Ca accumulation, K loss and water content by 10 %—40 %, 17 %—30 %, and 2.5 %—5.8 %, respectively. $Rg_1$ 40 $mg \cdot kg^{-1}$ iv decreased only the water content, while Nim 20 $\mu g \cdot kg^{-1}$ reduced only the Ca accumulation and K loss (Tab 2).

**EEG** Within $10 \pm s$ 2 min after MCAO, EEG amplitude fell to a lowest level, 33 % ± 4 % of that before MCAO. $Rb_1$ 10—40 $mg \cdot kg^{-1}$ improved the EEG amplitude and prolonged the period of EEG falling from normal to the lowest level. Nim 20 $\mu g \cdot kg^{-1}$ iv had the same effect as that of $Rb_1$. $Rg_1$ 40 $mg \cdot kg^{-1}$ did not influence the EEG amplitude significantly (Tab 3). The EEG of the rats with sham operation showed no changes before and after operation.

## DISCUSSION

$Rb_1$ effectively reduced the IS and ND, and improved the EEG amplitude, which implied that $Rb_1$ was one of the active components of the total saponins of *Panax ginseng* in protecting the

**Tab 1. Effects of $Rb_1$, $Rg_1$, nimodipine (Nim), and normal saline on neurologic deficits and infarct size produced by permanent and 2-h middle cerebral artery occlusion (MCAO) in rats. $n = 8$ (NS $n = 10$), $\bar{x} \pm s$. ivB: iv before MCAO; ivA: iv immediately after the MCA was recanalized.**
**$^aP > 0.05$, $^bP < 0.05$, $^cP < 0.01$ *vs* Saline. $^dP > 0.05$, $^eP < 0.05$, $^fP < 0.01$ *vs* ivB.**

| Drugs | | Infarct size/% | | Neurologic deficit scores | |
|---|---|---|---|---|---|
| | | ivB | ivA | ivB | ivA |
| Permanent MCAO | | | | | |
| Saline | 1 $mL \cdot kg^{-1}$ | 36±3 | — | 5.4±0.9 | — |
| Nim | 20 $\mu g \cdot kg^{-1}$ | 30±3$^c$ | — | 4.4±0.5$^b$ | — |
| $Rb_1$ | 10 $mg \cdot kg^{-1}$ | 34±2$^a$ | — | 5.3±0.9$^a$ | — |
| | 20 $mg \cdot kg^{-1}$ | 33±3$^a$ | — | 4.8±0.8$^a$ | — |
| | 40 $mg \cdot kg^{-1}$ | 31±3$^b$ | — | 4.4±0.7$^b$ | — |
| $Rg_1$ | 40 $mg \cdot kg^{-1}$ | 34±2$^a$ | — | 4.9±0.7$^a$ | — |
| 2-h MCAO | | | | | |
| Saline | 1 $mL \cdot kg^{-1}$ | 32±2 | 33±4 | 5.1±0.8 | 5.2±0.8 |
| Nim | 20 $\mu g \cdot kg^{-1}$ | 20±1$^c$ | 24±3$^c$ | 4.3±0.7$^b$ | 3.8±0.8$^e$ |
| $Rb_1$ | 10 $mg \cdot kg^{-1}$ | 25±2$^c$ | 28±2$^{cd}$ | 4.1±0.7$^b$ | 4.3±0.6$^{bd}$ |
| | 20 $mg \cdot kg^{-1}$ | 20±1$^c$ | 24±2$^{cd}$ | 3.0±0.8$^c$ | 4.0±0.9$^{be}$ |
| | 40 $mg \cdot kg^{-1}$ | 16±1$^c$ | 21±2$^{cf}$ | 2.3±0.7$^c$ | 3.3±0.9$^{cd}$ |
| $Rg_1$ | 40 $mg \cdot kg^{-1}$ | 28±2$^a$ | 27±3$^{ad}$ | 4.9±0.6$^a$ | 4.5±0.8$^{ad}$ |

**Tab 2. Influence of ginsenosides $Rb_1$, $Rg_1$, nimodipine (Nim) and normal saline on the calcium accumulation, potassium loss and the water contents in the infarcted area determined at 24 h after the onset of the middle cerebral artery occlusion (MCAO) in rats. $n=8$ (control $n=10$), $\bar{x}\pm s$. ivB: iv before MCAO; ivA: iv immediately after the MCA was recanalized. Dw: dry weight. $^aP>0.05$, $^bP<0.05$, $^cP<0.01$ vs Saline. $^dP>0.05$, $^eP<0.01$ vs ivB.**

| Drugs | | CA/mmol·kg$^{-1}$ Dw | | PL/mmol·kg$^{-1}$ Dw | | $H_2O$/% | |
|---|---|---|---|---|---|---|---|
| | | ivB | ivA | ivB | ivA | ivB | ivA |
| Permanent MCAO | | | | | | | |
| Saline | 1 mL·kg$^{-1}$ | 25.2±2.3 | — | 124±21 | — | 84.2±0.9 | — |
| Nim | 20 μg·kg$^{-1}$ | 21.8±2.1$^c$ | — | 75±15$^c$ | — | 83.1±1.0 | — |
| $Rb_1$ | 10 mg·kg$^{-1}$ | 23.9±1.9$^a$ | — | 112±23$^a$ | — | 83.2±1.0$^a$ | — |
| | 20 mg·kg$^{-1}$ | 22.9±2.1$^a$ | — | 104±19$^a$ | — | 82.9±1.3$^b$ | — |
| | 40 mg·kg$^{-1}$ | 21.7±1.8$^c$ | — | 95±15$^c$ | — | 81.1±1.3$^c$ | — |
| $Rg_1$ | 40 mg·kg$^{-1}$ | 24.8±2.2$^a$ | — | 108±14$^a$ | — | 81.8±1.2$^c$ | — |
| 2-h MCAO | | | | | | | |
| Saline | 1 mL·kg$^{-1}$ | 22.2±2.2 | 21.9±2.3 | 104±20 | 106±18 | 83.2±0.8 | 84.9±1.0 |
| Nim | 20 μg·kg$^{-1}$ | 13.9±1.1$^c$ | 18.3±1.4$^c$ | 47±10$^c$ | 70±11$^c$ | 82.0±0.8 | 82.3±0.8 |
| $Rb_1$ | 10 mg·kg$^{-1}$ | 17.4±1.3$^c$ | 20.0±1.8$^{bd}$ | 86±13$^c$ | 87±11$^b$ | 81.4±0.9$^c$ | 82.4±0.8$^b$ |
| | 20 mg·kg$^{-1}$ | 13.6±1.1$^c$ | 17.2±1.0$^{ce}$ | 76±11$^c$ | 83±14$^c$ | 80.1±1.1$^c$ | 81.3±1.3$^c$ |
| | 40 mg·kg$^{-1}$ | 11.3±1.0$^c$ | 13.5±1.1$^{ce}$ | 66±7$^c$ | 73±10$^c$ | 79.0±1.1$^c$ | 79.1±1.1$^c$ |
| $Rg_1$ | 40 mg·kg$^{-1}$ | 20.9±2.1 | 19.9±2.0 | 92±15 | 98±13 | 80.2±1.2$^c$ | 79.9±1.4$^c$ |

**Tab 3. Effects of $Rb_1$, $Rg_1$, nimodipine (Nim) and normal saline on EEG after MCAO in rats. $n=8$, $\bar{x}\pm s$. The EEG value before MCAO (pre-MCAO) was taken as 100 %. post-MCAO: the EEG value after MCAO. Pn-1: the period of EEG falling from pre-MCAO valne to the lowest post-MCAO value. $^aP>0.05$, $^bP<0.05$, $^cP<0.01$ vs Saline.**

| Drugs | | Amplitude/μV pre-MCAO | Amplitude/μV post-MCAO | % of pre-MCAO | Pn-1/min |
|---|---|---|---|---|---|
| Saline | 1 mL·kg$^{-1}$ | 36±4 | 12±2 | 33±4 | 10±2 |
| Nim | 20 μg·kg$^{-1}$ | 34±5 | 15±3 | 45±5$^c$ | 13±1$^c$ |
| $Rb_1$ | 10 mg·kg$^{-1}$ | 38±3 | 15±4 | 37±3$^c$ | 12±2$^c$ |
| | 20 mg·kg$^{-1}$ | 37±4 | 16±2 | 44±4$^c$ | 14±2$^c$ |
| | 40 mg·kg$^{-1}$ | 37±5 | 21±3 | 56±6$^c$ | 14±3$^c$ |
| $Rg_1$ | 40 mg·kg$^{-1}$ | 38±4 | 13±3 | 35±5$^a$ | 11±3$^a$ |

ischemic brain. In 2-h MCAO, $Rb_1$ administered even after ischemia exhibited significant effects, which indicated that $Rb_1$ might protect the brain against reperfusion injury or/and the delayed ischemic neuronal damage. $Rb_1$ decreased the Ca accumulation in the infarcted area as well as the IS, and the reduction rate of Ca accumulation was fairly close to that of IS. This suggested that the inhibition of Ca accumulation was a possible mechanism of $Rb_1$ in protecting ischemic and reperfused brain. Because Ca accumulation in the tissues is attributed to the calcium sequestered in the ischemic cells[9], we assumed that the reduction of Ca accumulation might be the result of $Rb_1$ blocking of the calcium entry into the cells, which suggested that $Rb_1$ might possess some calcium antagonist action.

We once expected that $Rg_1$ might have some effect on cerebral ischemia though it was weak, but it was found that 10—20 mg·kg$^{-1}$ had no effect in the pre-experiment. Therefore, we selected 40 mg·kg$^{-1}$, equivalent to the largest dose of $Rb_1$, as the dose in formal experiment but even at this dosage $Rg_1$ still showed no effect on IS, ND, CA and K loss though it ameliorated brain edema. This suggests that $Rg_1$ be less beneficial than $Rb_1$ to the ischemic brain.

Reversible MCAO without craniectomy[7] is a newly developed focal ischemia model, which was modified in our experiment. A piece of nylon suture was used to the occlusion of MCA[7] but we found it was too soft to introduce to the origin of MCA. Therefore, a piece of acid-treated glass fiber was used to the occlusion of MCA in our experiment, which provided a higher success rate than the nylon suture because of its satisfactory

rigidity and flexibility allowing smooth advancement in the artery lumen while not perforating the artery wall. We once used the nylon suture, only 5 out of 10 rats were successful. When we used acid-treated glass fiber, a 95 % success rate was obtained. It was considered that in the operation of this model, a kind of ideal material was the key to success.

## REFERENCES

1 Zhang YG, Liu TP. Protective effects of total saponins of *Panax ginseng* on ischemia-reperfusion injury in rat brains. Chin J Pharmacol Toxicol 1994; **8**: 7-12.

2 Zhang YG, Liu TP. Influence of total saponins of *Panax ginseng* on infarct size and polyamine contents in rat brains after middle cerebral artery occlusion. Chin J Pharmacol Toxicol 1994; **8**: 250-5.

3 Xiong ZG, Sun JJ. Effects of *Panax notoginseng* saponin $Rb_1$ and $Rg_1$ on myocardial action potential and slow inward current. Acta Pharmacol Sin 1989; **10**: 520-2.

4 Jiang Y, Zhong GG, Chen L, Ma XY. Influence of ginsenosides $Rb_1$, $Rb_2$, and $Rb_3$ on electric and contractile activities of normal and damaged cultured myocardiocytes. Acta Pharmacol Sin 1992; **13**: 403-6.

5 Cao J, Zheng YQ, Liu TP, Feng LZ. Inhibitory effects of ginsenoside $Rg_1$ and $Rb_1$ on rat brain microsomal $Na^+$, $K^+$-ATPase activity. Acta Pharmacol Sin 1990; **11**: 10-4.

6 Schanne FAX, Kane AB, Young EE, Farber JL. Calcium dependence of toxic cell death: a final common pathway. *Science* 1979; **206**: 700-2.

7 Longa EZ, Weinstein PR, Carlson S, Commins R. Reversible middle cerebral artery occlusion without craniectomy in rats. Stroke 1989; **20**: 84-91.

8 Huang YG. The basic components of EEG. In: Huang YG, Wu SL, editors. Clinical electroencephalogram. Xi'an Shan Xi Science & Technology Publ. 1st ed. 1984: 88-97.

9 Rappaport ZH, Young W, Flamm ES. Regional brain calcium changes in the rat middle cerebral artery occlusion model of ischemia. Stroke 1987; **18**: 760-4.

## 人参皂苷 $Rb_1$ 和 $Rg_1$ 对大鼠可逆性局灶性脑缺血的影响

R286.2 R743.31

张英鸽，刘天培

(南京医科大学药理教研室，南京210029，中国)

**关键词** 人参；皂苷类；脑缺血；脑梗死；钙；钾

**目的**：研究人参皂苷 $Rb_1$ 和 $Rg_1$ 对脑缺血和再灌损伤的影响. **方法**：用可逆性不开颅大鼠大脑中动脉梗塞(MCAO)模型观察人参皂苷 $Rb_1$ 和 $Rg_1$ 对梗塞范围(IS)、运动障碍(ND)及钙，钾含量的影响. **结果**：在2-h 缺血、$Rb_1$ 10-40 mg·kg$^{-1}$ iv 于 MCAO 前给药减小 IS 20 %-49 %，使 ND 由5.1减至4.1-2.3，抑制钙积累22 %-50 %，减少钾丢失18 %-37 %. MCA 再通后给药减小 IS 12 %-35 %，使 ND 由5.2减至4.3-3.3，抑制钙积累10-40，减少钾丢失17 %-30 %. 在永久缺血，$Rb_1$ 40 mg·kg$^{-1}$ iv 可减少 IS、ND，钙积累和钾丢失. $Rg_1$ 对永久和2-h 缺血均无效. **结论**：$Rb_1$ 是保护缺血脑的活性成份，对缺血和再灌损伤均有效.

**中国药理学报基金会热忱感谢**
**以下单位和个人给予的大力支持！**

| | |
|---|---|
| 香港百草堂有限公司 | 周文轩 董事长 郭次仪 总经理 |
| 上海大众医药科技服务公司 | 苏定冯 总经理 |
| 成都地奥制药公司 | 李伯刚 总经理 |
| 广州奇星药业有限公司 | |
| 中国台湾中国医药学院 | 林昭庚 教授 |
| 重庆第三军医大学 | 胡友梅 教授 |