Urinary kallidinogenase for the treatment of cerebral arterial stenosis

Liandong Zhao1,2
Ying Zhao2
Qi Wan1
Haijun Zhang3

1Department of Neurology, The First Affiliated Hospital of Nanjing Medical University, Nanjing, 2Department of Neurology, The Second People’s Hospital of Huaian and The Affiliated Huaian Hospital of Xuzhou Medical College, Huaian, Jiangsu, 3Department of Oncology, Zhongda Hospital, Medical School, Southeast University, Nanjing, People’s Republic of China

Aim: Urinary kallidinogenase (UK) has shown promise in improving cerebral perfusion. This study aimed to examine how UK affects cognitive status and serum levels of amyloid betas (Aβ) 1-40 and 1-42 in patients with cerebral arterial stenosis.

Methods: Ninety patients with cerebral arterial stenosis were enrolled, of whom 45 patients received UK + conventional treatment (UK group), and 45 patients received conventional treatment alone as control group. Cognitive status and Aβ1-40 and Aβ1-42 serum levels were determined before treatment and at 4 weeks and 8 weeks after treatment.

Results: At 4 weeks after treatment, cognitive status in patients treated with UK clearly improved accompanied by Aβ1-40 serum levels decreasing while there was no change of Aβ1-42. Cognitive status in patients receiving UK continued to improve, Aβ1-40 serum levels declined further as well as Aβ1-42 serum levels began to decrease dramatically at 8 weeks after treatment.

Conclusion: UK could improve cognitive status and decrease both Aβ1-40 and Aβ1-42 serum levels to prevent ischemic cerebral injury, which represents a good option for patients with cerebral arterial stenosis.

Keywords: urinary kallidinogenase, arterial stenosis, Alzheimer’s disease, Aβ1-40, Aβ1-42

Introduction

Urinary kallikrein, a glycoprotein extracted from urine, can activate kallikrein–kinin system (KKS) and thus transfer kininogen hydrolysis into kallidin and kinin.1 Kinin in turn could activate B1 and B2 receptors induced by ischemic brain tissue and trigger a series of biological effects, releasing nitric oxide and relaxing vascular smooth muscle.1 Thus, it can expand blood vessels in the ischemic area, improve cerebral blood supply of penumbra, and restore the neurological deficit.1 Urinary kallidinogenase (UK) for injection (Kailikang®, Techpool Bio-Pharma Co, Ltd, Guangdong, People’s Republic of China) has been approved by Chinese State Food and Drug Administration and used clinically in People’s Republic of China to treat patients with stroke2 (molecular formula and structure are shown in Figure 1). In addition, studies on hind limb ischemia, cardiac infarction, and renal ischemia confirmed that kallikrein attempts to maintain an adequate tissue perfusion.3 However, whether the commercially available KKS-regulating medicine, UK for injection (Kailikang®), is capable to improve the outcome of the cerebral arterial stenosis has not been reported yet.

Cerebral arterial stenosis, including intracranial and/or extracranial artery stenosis, is characterized by narrowed arteries that supply blood to the brain, resulting in cerebral hypoperfusion.4 Patients with severe cerebral artery stenosis run a higher risk of distal embolization, hemodynamic changes, and sudden vascular occlusion.5–7 Alzheimer’s disease (AD) is associated with decreased cerebral blood flow. It was found that AD cases displayed a degree of cerebral artery occlusion and that there was a positive

Reference

1. Bouchard A, et al. Kinin in turn could activate B1 and B2 receptors induced by ischemic brain tissue and trigger a series of biological effects, releasing nitric oxide and relaxing vascular smooth muscle.1 Thus, it can expand blood vessels in the ischemic area, improve cerebral blood supply of penumbra, and restore the neurological deficit.1 Urinary kallidinogenase (UK) for injection (Kailikang®, Techpool Bio-Pharma Co, Ltd, Guangdong, People’s Republic of China) has been approved by Chinese State Food and Drug Administration and used clinically in People’s Republic of China to treat patients with stroke2 (molecular formula and structure are shown in Figure 1). In addition, studies on hind limb ischemia, cardiac infarction, and renal ischemia confirmed that kallikrein attempts to maintain an adequate tissue perfusion.3 However, whether the commercially available KKS-regulating medicine, UK for injection (Kailikang®), is capable to improve the outcome of the cerebral arterial stenosis has not been reported yet.

Cerebral arterial stenosis, including intracranial and/or extracranial artery stenosis, is characterized by narrowed arteries that supply blood to the brain, resulting in cerebral hypoperfusion.4 Patients with severe cerebral artery stenosis run a higher risk of distal embolization, hemodynamic changes, and sudden vascular occlusion.5–7 Alzheimer’s disease (AD) is associated with decreased cerebral blood flow. It was found that AD cases displayed a degree of cerebral artery occlusion and that there was a positive
Zhao et al

Figure 1 Molecular formula (A) and structure (B) of urinary kallidinogenase.

correlation between the degree of arterial stenosis and neurofibrillary tangle (NFT) score. Chronic brain hypoperfusion leading to cerebral hypoxia represents an important aspect of neurodegenerative processes in AD. The current hypothesis of the pathogenesis of familial AD results mainly from aberrant cleavage of amyloid beta (Aβ) precursor protein, which produces cytotoxic Aβ fragments, causes progressive degeneration and dysfunction of neurons, and ultimately leads to the development of AD. The contribution of Aβ deposition in the pathogenesis of AD has been well established, and Aβ appears to have a role in ischemic cerebral damage.

For patients with cerebral arterial stenosis, improving the cerebrovascular perfusion remains a good option to rescue injured tissue and alleviate neurological deficits. In this study, we evaluated the cognitive status and the serum levels of Aβ1-40 and Aβ1-42 in patients with cerebral arterial stenosis treated with or without UK before treatment and at 4 weeks and 8 weeks after treatment. Our intention was to provide additional evidence on the efficacy of UK in the application of patients with cerebral arterial stenosis.

Materials and methods

Patients

Ninety patients were recruited from the Second People’s Hospital of Huai’an from June 1, 2013, to May 31, 2015. The study was approved by the Ethics Committee of the Second People’s Hospital of Huai’an, and informed consents were obtained from all the participants. Patients with...
dizziness, transient ischemic attack, and 70% or more internal carotid artery stenosis on one or both sides as determined by neuroimaging examination such as digital subtraction angiography and magnetic resonance imaging were included in the study. Patients were excluded if they had a history of major medical illness, such as heart failure, pulmonary insufficiency, renal insufficiency, hepatic dysfunction, or blood diseases unfit for antiplatelet therapy. Participants were randomly assigned (1:1) to receive either a UK treatment (UK group) or a conventional treatment (control group) using a computer-generated random sequence. The UK group consisted of 45 patients (24 men and 21 women) aged from 42 years to 84 years, including 21 cases of unilateral internal carotid artery stenosis, twelve cases of bilateral internal carotid artery stenosis, eight cases of unilateral internal carotid artery stenosis associated with vertebral artery stenosis, and four cases of unilateral internal carotid artery stenosis associated with middle cerebral artery stenosis. The control group also consisted of 45 patients (26 men and 19 women) aged from 40 years to 79 years, including 19 cases of unilateral internal carotid artery stenosis, eleven cases of bilateral internal carotid artery stenosis, ten cases of unilateral internal carotid artery stenosis associated with vertebral artery stenosis, and five cases of unilateral internal carotid artery stenosis associated with middle cerebral artery stenosis. All patients had experienced at least 1 month of nervous-system dysfunctions. No severe cerebrovascular problems such as stroke occurred during the study period. Clinical symptoms of cerebral ischemia, such as paralysis of limbs and/or disturbance of consciousness, were observed in most of the cases.

**Procedures**

The study procedure is shown in Figure 2. During the study period, all patients were given 75 mg of clopidogrel and 100 mg of enteric-coated aspirin orally once a day in addition to the use of salvia, puerarin (Conba Pharmaceuticals, Zhejiang, People’s Republic of China), and an anti-free-radical agent, edaravone (Lijun Pharmaceuticals, Xian, People’s Republic of China), as conventional treatment in the control group. In addition, UK was injected into patients in the UK group at a dose of 0.15 paranitroanilinum (PNA)/d every day for 21 days. There was no daily and total effect of a daily injection of UK on blood pressure (BP), pulse rate, and heart rate. Mini-mental state examination (MMSE) scale was performed to evaluate the efficacy of UK on the cognitive status before treatment and at 4 weeks and 8 weeks after treatment in all patients. MMSE scale was scored by experienced

![Figure 2](https://www.dovepress.com)  
**Figure 2** The schedule of the study.  
**Abbreviations:** MMSE, mini-mental state examination; UK, urinary kallidinogenase.
neurologists, who had over 10 years of experience in professional neuropsychological scale assessment and were blinded to the clinical findings. Moreover, 5 mL blood samples were collected via cubital vein from patients before treatment and at 4 weeks and 8 weeks after treatment. The blood samples were centrifuged at 1,000 rpm for 10 minutes, and sera were immediately collected and stored at −70°C. Then, serum concentrations of Aβ were determined using solid-phase sandwich enzyme-linked immunosorbent assay kit as per the manufacturer’s instructions (Adlitteram Diagnostic Laboratories, San Diego, CA, USA). Furthermore, the evaluator of Aβ was blind to the results of grouping.

Statistical analysis
Statistical analyses were performed using SPSS software (Version 10.0; IBM Corporation, Armonk, NY, USA). Continuous variables were expressed as mean ± standard deviation, whereas categorical variables were expressed as percentage. The F-test was used for significance testing of continuous variables, and the χ² statistic was used for testing of categorical variables. P<0.05 was considered to be statistically significant.

Results
Characteristics of enrolled patients
As shown in Table 1, 90 patients were enrolled, of whom 45 patients received conventional treatment + UK (UK group) and another 45 patients only received conventional treatment (control group), and the two groups were similar in basic characteristics for analysis.

Comparison of MMSE before and after treatment
To investigate the effect of UK on the cognitive status in patients with cerebral arterial stenosis, we first evaluated the cognitive status with MMSE scale before any treatment. As shown in Figure 3, there was no obvious difference of the score of MMSE between the UK group and the control group before any treatment. The score of MMSE obviously improved at 4 weeks and 8 weeks after patients treated with UK. However, during the study, the MMSE score of patients with conventional treatment still remained similar to that of patients before treatment.

Effect of UK on serum levels of Aβ
As shown in Table 2, no significant difference was found in the serum levels of Aβ1-40 and Aβ1-42 between the UK group and the control group before treatment. There were no significant changes of both Aβ1-40 and Aβ1-42 in the control group throughout the study. However, the serum levels of Aβ1-40 in the UK group decreased significantly at 4 weeks after treatment and further 8 weeks after treatment. The serum levels of Aβ1-42 in the UK group display different manners than that of Aβ1-40 that began to decrease significantly at 8 weeks after treatment.

Discussion
Perfusion and hypoxia due to cerebral arterial stenosis may promote β-site cleavage of Aβ precursor protein and cleavage activity of γ-secretase, resulting in increased levels of various Aβ fragments such as Aβ1-40 and Aβ1-42 in the brain.4 An imbalance between production and clearance of Aβ fragments may cause abnormal accumulation of these peptides inside the brain and the subsequent development of AD.11-13 Various mechanisms are involved in the detrimental effects of Aβ. For example, Aβ could activate astrocytes and microglia and cause inflammatory reactions via stimulating expression and release of tumor necrosis factor-alpha, interleukin-1, interleukin-6, and NO.14,15 Aβ might also induce nerve-cell apoptosis and disrupt the

Table 1 Characteristics of enrolled patients

<table>
<thead>
<tr>
<th>Characteristics</th>
<th>UK group</th>
<th>Control group</th>
<th>P-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age (years), (mean ± SD)</td>
<td>57.26±9.35</td>
<td>56.81±9.27</td>
<td>0.82</td>
</tr>
<tr>
<td>Sex</td>
<td></td>
<td></td>
<td>0.67</td>
</tr>
<tr>
<td>Male</td>
<td>24</td>
<td>26</td>
<td></td>
</tr>
<tr>
<td>Female</td>
<td>21</td>
<td>19</td>
<td></td>
</tr>
<tr>
<td>Distribution of arterial stenosis</td>
<td></td>
<td></td>
<td>0.92</td>
</tr>
<tr>
<td>Unilateral ICA</td>
<td>21</td>
<td>19</td>
<td></td>
</tr>
<tr>
<td>Bilateral ICA</td>
<td>12</td>
<td>11</td>
<td></td>
</tr>
<tr>
<td>Unilateral ICA + VA</td>
<td>8</td>
<td>10</td>
<td></td>
</tr>
<tr>
<td>Unilateral ICA + MCA</td>
<td>4</td>
<td>5</td>
<td></td>
</tr>
</tbody>
</table>

Abbreviations: UK, urinary kallidinogenase; ICA, internal carotid artery; VA, vertebral artery; MCA, middle cerebral artery.

Figure 3 MMSE scores before and after treatment.
Note: *P<0.05.
Abbreviations: MMSE, mini-mental state examination; UK, urinary kallidinogenase.
Table 2 Effect of UK on serum levels of amyloid beta

<table>
<thead>
<tr>
<th>Aβ</th>
<th>Group</th>
<th>Before treatment (ng/L)</th>
<th>4 weeks after treatment (ng/L)</th>
<th>8 weeks after treatment (ng/L)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Aβ1-40</td>
<td>UK</td>
<td>1.25±0.29</td>
<td>1.01±0.22**</td>
<td>0.87±0.18**</td>
</tr>
<tr>
<td></td>
<td>Control</td>
<td>1.24±0.33</td>
<td>1.14±0.27</td>
<td>1.16±0.24</td>
</tr>
<tr>
<td>Aβ1-42</td>
<td>UK</td>
<td>0.95±0.21</td>
<td>0.94±0.23</td>
<td>0.75±0.18***</td>
</tr>
<tr>
<td></td>
<td>Control</td>
<td>0.93±0.33</td>
<td>0.94±0.28</td>
<td>0.93±0.32</td>
</tr>
</tbody>
</table>

**Notes:** Data are presented as mean ± SD. Compared with control group, *P<0.05;***P<0.001; compared with before treatment, **P<0.01;***P<0.001.

**Abbreviation:** UK, urinary kallidinogenase.
Zhao et al

Drugs Design, Development and Therapy

Publish your work in this journal

Drug Design, Development and Therapy is an international, peer-reviewed open-access journal that spans the spectrum of drug design and development through to clinical applications. Clinical outcomes, patient safety, and programs for the development and effective, safe, and sustained use of medicines are a feature of the journal, which has also been accepted for indexing on PubMed Central. The manuscript management system is completely online and includes a very quick and fair peer-review system, which is all easy to use. Visit http://www.dovepress.com/testimonials.php to read real quotes from published authors.

Submit your manuscript here: http://www.dovepress.com/drug-design-development-and-therapy-journal


