Background and Purpose—Total homocysteine (tHcy) levels are associated with secondary vascular events and mortality after stroke. The aim of this study was to investigate whether tHcy levels in the acute phase of a stroke contribute to the recurrence of cerebro-cardiovascular events and mortality.

Methods—A total of 3799 patients were recruited after hospital admission for acute ischemic stroke. Levels of tHcy were measured within 24 hours after primary admission. Patients were followed for a median of 48 months.

Results—During the follow-up period, 233 (6.1%) patients died. After adjustment for age, smoking status, diabetes mellitus, and other cardiovascular risk factors, patients in the highest tHcy quartile (>18.6 μmol/L) had a 1.61-fold increased risk of death (adjusted hazard ratio [HR], 1.61; 95% confidence interval [CI], 1.03–2.53) compared with patients in the lowest quartile (≤10 μmol/L). Further subgroup analysis showed that this correlation was only significant in the large-artery atherosclerosis stroke subtype (adjusted HR, 1.80; 95% CI, 1.05–3.07); this correlation was not significant in the small-vessel occlusion subtype (adjusted HR, 0.80; 95% CI, 0.30–2.12). The risk of stroke-related mortality was 2.27-fold higher for patients in the third tHcy quartile (adjusted HR, 2.27; 95% CI, 1.06–4.86) and 2.15-fold more likely for patients in the fourth quartile (adjusted HR, 2.15; 95% CI, 1.01–4.63) than for patients in the lowest tHcy quartile. The risk of cardiovascular-related mortality and the risk of recurrent ischemic stroke were not associated with tHcy levels.

Conclusions—Our findings suggest that elevated tHcy levels in the acute phase of an ischemic stroke can predict mortality, especially in stroke patients with the large-artery atherosclerosis subtype. (Stroke. 2015;46:2419-2425. DOI: 10.1161/STROKEAHA.115.009136.)

Key Words: acute ischemic stroke  atherosclerosis  homocysteine  long-term mortality  stroke
evidence that B vitamin therapy reduces the risk of stroke or other cardiovascular events, and these studies failed to account for the effects of renal function on response to vitamin therapy. It is now widely recognized that B vitamin therapy reduces tHcy levels, which leads to a reduced risk of stroke. Several studies and meta-analyses, including the HOPE-2 trial, the French SuFolOM3 trial, a subgroup analysis of the Vitamin Intervention for Stroke Prevention trial that excluded patients with renal failure, and a subgroup analysis of the VITATOPS trial that excluded patients on antiplatelet therapy, all showed a reduced risk of stroke. However, in patients with diabetic nephropathy or a glomerular filtration rate <50 mL/min/1.73 m², vitamin B12 supplementation results in cyanide production and is harmful to patients.12,13

The relationship between tHcy levels and vascular events and death after stroke remains inconclusive as a result of short follow-up periods14,15 and small sample sizes16,17 of many studies. Therefore, we conducted a prospective study of a large stroke population with a median follow-up period of 48 months to investigate whether elevated plasma tHcy levels in the acute phase of an ischemic stroke contribute to the risk of stroke recurrence and all-cause mortality.

Methods

Study Design

All patients admitted into the neurological department at Tianjin Huanhu Hospital in Tianjin, China, from September 2005 to March 2011 were assessed for eligibility for the study. Inclusion criteria included first ischemic stroke within 48 hours, which was confirmed by imaging studies of the head (magnetic resonance imaging or computed tomography). Exclusion criteria for this study were (1) age <18 or ≥80 years; (2) death during the hospital admission; (3) nonischemic stroke with a life expectancy <1 year; (4) renal failure; (5) B vitamin or statin therapy within 2 weeks of hospital admission; (6) residence outside the hospital’s catchment area; (7) unwillingness to participate; and (8) previous admission resulting in inclusion in the study.

A total of 3799 patients met the inclusion criteria and provided informed consent for participation. Patients were classified into stroke subtypes of large-artery atherosclerosis and small-vessel occlusion according to the Trial of Org 10172 in Acute Stroke Treatment criteria.19 The primary outcome measure was all-cause mortality and the median follow-up time was 48 months. Confirmation of survival and dates of death were obtained from the official population registry. Eleven patients, who emigrated from Tianjin, were lost to follow-up and considered alive at the day of emigration. The secondary outcome was incidence of recurrent ischemic stroke (ICD-9 codes 431, 432, 433, or 436 or ICD-10 codes I61, I62, I63, or I64). Patient comorbidities, such as hyperuricemia, coronary artery disease, obesity, and markers of inflammation, such as hsCRP. Statistical significance was defined as a P value <0.05.

Results

Baseline Characteristics

A total of 3799 patients (75.6% male; median age, 62 years; interquartile range, 54–71 years) were included in the study. The tHcy levels of all patients were obtained within 24 hours of admission for ischemic stroke. The mean±SD (range) tHcy level of all patients was 16.9±12.5 (2.13–162) μmol/L. Overall, 2732 (71.9%) patients had hypertension, 1150 (30.3%) had diabetes mellitus, 1157 (30.5%) had hyperlipidemia, 712 (18.7%) were alcohol drinkers, 1495 (39.4%) were smokers, 368 (9.7%) had hyperuricemia, 374 (9.8%) were obese, 903 (23.8%) had coronary artery disease, and 412 (10.8%) had low physical activity. The baseline characteristics of the patients, stratified according to tHcy quartiles, are presented in Table 1. Patients with elevated tHcy levels were more likely than patients with low tHcy levels to be older, male, smokers, and alcohol drinkers and have hyperuricemia, large-artery atherosclerosis stroke subtype, elevated LDL-C levels, and elevated ApoB/ApoAl ratios; patients with elevated tHcy levels were less likely to have type 2 diabetes mellitus and high fasting glucose levels.

Mortality and tHcy Levels

During a median follow-up period of 48 months, 233 (6.1%) patients died. The mortality rate was significantly higher in patients in the fourth (highest) tHcy quartile than in patients...
in the first (lowest) quartile (unadjusted HR, 1.95; 95% confidence interval [CI], 1.28–2.97; \( P = 0.002 \)). Similarly, the mortality rate was significantly higher in patients in the third quartile than in patients in the first quartile (unadjusted HR, 1.83; 95% CI, 1.18–2.82; \( P = 0.006 \)). This association remained significant for patients in the fourth quartile compared with patients in the first quartile after adjustment for age, smoking status, LDL-C level, hsCRP level, and ApoB/ApoAI ratio and the presence of hypertension, type 2 diabetes mellitus, hyperuricemia, coronary artery disease, and obesity (adjusted HR, 1.61; 95% CI, 1.03–2.53; \( P = 0.039 \); Table 2).

In the subgroup analysis, patients with the large-artery atherosclerosis stroke subtype in the highest tHcy quartile had a significantly higher risk of mortality than patients in the lowest quartile (unadjusted HR, 1.97; 95% CI, 1.20–3.22; \( P = 0.007 \)). This association was not significant for the small-vessel occlusion subgroup (unadjusted HR, 1.45; 95% CI, 0.61–3.44; \( P = 0.404 \)). Multivariate analysis did not affect this association (Table 2).

**Causes of Mortality**

During the follow-up period, 233 deaths occurred: 95 were caused by ischemic stroke, 39 were caused by cardiovascular disease, and 99 were caused by other causes. Among patients who died of stroke, the mortality rate was significantly higher in patients in the fourth quartile of tHcy levels than in patients in the first quartile (unadjusted HR, 2.41; 95% CI, 1.19–4.90; \( P = 0.015 \)). Similarly, the mortality rate was significantly higher in patients in the third quartile than in the first quartile (unadjusted HR, 2.45; 95% CI, 1.19–5.03; \( P = 0.015 \)). After adjustment for confounders, the association remained significant for patients in the third tHcy quartile and was borderline significant for patients in the fourth quartile compared with patients in the first quartile (adjusted HR, 2.27; 95% CI, 1.06–4.86; \( P = 0.029 \) and adjusted HR, 2.15; 95% CI, 1.01–4.63; \( P = 0.049 \), respectively; Table 3).

Among patients who died of cardiovascular disease, the mortality rate was significantly higher in patients in the fourth quartile of tHcy levels than in patients in the first quartile (unadjusted HR, 3.29; 95% CI, 1.11–9.74; \( P = 0.031 \)). This association was not significant after adjustment for confounding variables.

### Table 1. Baseline Characteristics of All Patients According to Quartiles of tHcy Levels

<table>
<thead>
<tr>
<th>Quartile of Plasma tHcy Levels, μmol/L</th>
<th>Q1 (≤10), n=973</th>
<th>Q2 (10–12.9), n=949</th>
<th>Q3 (12.9–18.6), n=932</th>
<th>Q4 (&gt;18.6), n=945</th>
<th>( P ) Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age, y, mean (SD)</td>
<td>61.0 (11.0)</td>
<td>62.8 (11.4)</td>
<td>64.3 (11.2)</td>
<td>62.3 (12.1)</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Male, n (%)</td>
<td>509 (52.3)</td>
<td>604 (63.6)</td>
<td>650 (69.7)</td>
<td>748 (79.2)</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>TOAST subtype:</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>0.19</td>
</tr>
<tr>
<td>Large-artery atherosclerosis, n (%)</td>
<td>662 (68.0)</td>
<td>664 (70.0)</td>
<td>683 (73.3)</td>
<td>695 (73.5)</td>
<td></td>
</tr>
<tr>
<td>Small-vessel occlusion, n (%)</td>
<td>311 (32.0)</td>
<td>285 (30.0)</td>
<td>249 (26.7)</td>
<td>250 (26.5)</td>
<td></td>
</tr>
<tr>
<td>Risk factors:</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hypertension, n (%)</td>
<td>715 (73.5)</td>
<td>664 (70.0)</td>
<td>675 (72.4)</td>
<td>678 (71.7)</td>
<td>0.377</td>
</tr>
<tr>
<td>Type 2 DM, n (%)</td>
<td>394 (40.5)</td>
<td>325 (34.2)</td>
<td>233 (25.0)</td>
<td>198 (21.0)</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Hyperlipidemia, n (%)</td>
<td>274 (28.2)</td>
<td>282 (29.7)</td>
<td>283 (30.4)</td>
<td>318 (33.7)</td>
<td>0.065</td>
</tr>
<tr>
<td>CAD</td>
<td>236 (24.3)</td>
<td>240 (25.3)</td>
<td>205 (22.0)</td>
<td>222 (23.5)</td>
<td>0.392</td>
</tr>
<tr>
<td>Alcohol drinker, n (%)</td>
<td>170 (17.5)</td>
<td>152 (16.0)</td>
<td>187 (20.1)</td>
<td>203 (21.5)</td>
<td>0.010</td>
</tr>
<tr>
<td>Smoking, n (%)</td>
<td>319 (32.8)</td>
<td>373 (39.3)</td>
<td>369 (39.6)</td>
<td>434 (45.9)</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Hyperuricemia n (%)</td>
<td>59 (6.1)</td>
<td>69 (7.3)</td>
<td>117 (12.5)</td>
<td>143 (15.1)</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Low physical activity, n (%)</td>
<td>105 (10.8)</td>
<td>95 (10.0)</td>
<td>122 (13.1)</td>
<td>90 (9.5)</td>
<td>0.064</td>
</tr>
<tr>
<td>Obesity</td>
<td>109 (11.2)</td>
<td>81 (8.5)</td>
<td>94 (10.1)</td>
<td>90 (9.5)</td>
<td>0.259</td>
</tr>
<tr>
<td>Laboratory findings*</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>TG, mmol/L</td>
<td>1.68</td>
<td>1.65</td>
<td>1.63</td>
<td>1.72</td>
<td>0.644</td>
</tr>
<tr>
<td>HDL-C, mmol/L</td>
<td>1.06</td>
<td>1.03</td>
<td>1.06</td>
<td>1.05</td>
<td>0.053</td>
</tr>
<tr>
<td>LDL-C, mmol/L</td>
<td>3.07</td>
<td>3.05</td>
<td>3.13</td>
<td>3.15</td>
<td>0.036</td>
</tr>
<tr>
<td>ApoAI, g/L</td>
<td>1.51</td>
<td>1.56</td>
<td>1.15</td>
<td>1.57</td>
<td>0.808</td>
</tr>
<tr>
<td>ApoB, g/L</td>
<td>1.12</td>
<td>1.02</td>
<td>1.04</td>
<td>1.02</td>
<td>0.513</td>
</tr>
<tr>
<td>ApoB/ApoAI ratio</td>
<td>0.89</td>
<td>0.93</td>
<td>0.94</td>
<td>0.94</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Fasting glucose, mmol/L</td>
<td>6.85</td>
<td>6.52</td>
<td>6.0</td>
<td>5.8</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>hsCRP, mg/L</td>
<td>2.00</td>
<td>1.88</td>
<td>2.11</td>
<td>2.50</td>
<td>0.264</td>
</tr>
<tr>
<td>Heart rate times/min*</td>
<td>72</td>
<td>70</td>
<td>72</td>
<td>72</td>
<td>0.102</td>
</tr>
</tbody>
</table>

Apo indicates apolipoprotein; CAD, coronary artery disease; DM, diabetes mellitus; HDL-C, high-density lipoprotein cholesterol; hsCRP, high-sensitivity C-reactive protein; LDL-C, low-density lipoprotein cholesterol; TG, triglycerides; and tHcy, total homocysteine.

*Median values.
Discussion

Our results demonstrate that elevated tHcy levels during the acute phase of an ischemic stroke significantly predict mortality in Chinese patients. Patients in the third and fourth quartiles of tHcy levels had a 1.83-fold or higher increased risk of death 48 months after stroke compared with patients in the first quartile. After multivariate analysis, this association in the highest (fourth) quartile remained statistically significant. Subgroup analysis showed that the association between tHcy levels and all-cause mortality was only significant in patients with the large-artery atherosclerosis stroke subtype; the association was not significant in the small-vessel stroke subtype.

Examination of the causes of mortality revealed that patients in the 2 highest quartiles of tHcy levels had a 2.15-fold or higher increased risk of mortality from ischemic stroke compared with patients in the lower quartiles. These findings suggest that quantifying tHcy levels in patients with acute, ischemic, large-vessel stroke may help to determine a patient’s prognosis and, thus, initiate methods to improve survival.

To the best of our knowledge, these are the first published results demonstrating that elevated tHcy levels during the first 24 hours after admission for an acute stroke significantly predict mortality within 48 months. Previous studies have only examined tHcy levels that were measured at least months before or after the first stroke. For the present study, we obtained plasma samples for tHcy measurements during the admission for acute stroke. In previous studies, blood levels of lipid were affected by furosemide therapy or dehydration. However, we obtained blood samples from all patients in the morning, after an overnight fast of 12 to 14 hours without fluid restriction. None of the patients were receiving furosemide therapy, and the patients who had dehydration before Table 3. Associations Between tHcy Levels and Causes of Mortality in 233 Patients Who Died During the Follow-up Period

<table>
<thead>
<tr>
<th>Cause of death</th>
<th>Quartile of Plasma tHcy Levels</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Q1</td>
</tr>
<tr>
<td>Initial ischemic stroke (n)</td>
<td>10</td>
</tr>
<tr>
<td>Crude HR (95% CI)</td>
<td>1.87 (0.87–4.020)</td>
</tr>
<tr>
<td>Adjusted HR (95% CI)*</td>
<td>1.69 (0.75–3.80)</td>
</tr>
<tr>
<td>CVD (n)</td>
<td>4</td>
</tr>
<tr>
<td>Crude HR (95% CI)</td>
<td>1.93 (0.58–6.427)</td>
</tr>
<tr>
<td>Adjusted HR (95% CI)</td>
<td>1.31 (0.37–4.69)</td>
</tr>
<tr>
<td>Other causes (n)</td>
<td>16</td>
</tr>
<tr>
<td>Crude HR (95% CI)</td>
<td>1.29 (0.67–2.47)</td>
</tr>
<tr>
<td>Adjusted HR (95% CI)</td>
<td>0.96 (0.48–1.94)</td>
</tr>
</tbody>
</table>

CI indicates confidence interval; HR, hazard ratio; and tHcy, total homocysteine.

*Adjusted for age, smoking status, low-density lipoprotein cholesterol level, high-sensitivity C-reactive protein level, Apolipoprotein B/Apoliprotein AI ratio, and the presence of hypertension, type 2 diabetes mellitus, hyperuricemia, coronary artery disease, and obesity.

†P<0.05 compared with Q1.
admission were given fluid and salt replacement. Therefore, dehydration may not have affected the results. Still, our results are almost identical to a previous study that reported that elevated tHcy levels 6 weeks after a stroke increased all-cause mortality by 1.75-fold when patients in the highest and lowest quartiles of tHcy levels were compared.22 Naess et al23 measured tHcy on an average of 6 years after primary stroke and found a smaller, though significant, HR for mortality of 1.02 (P=0.02). These findings indicate that tHcy levels are better predictors of mortality if measured before or within 6 weeks after the first stroke.

It is well established that tHcy increases the risk of developing large and small vessel strokes,8,26,27 but our study is the first to demonstrate that the association between tHcy levels and all-cause mortality is only significant in the large-vessel atherosclerosis stroke subtype and is not significant in the small-vessel occlusion subtype. These findings suggest that either (1) elevated tHcy levels in the acute phase of a stroke may be more detrimental in large-vessel strokes compared with small-vessel strokes or (2) tHcy levels increase in large-vessel strokes, but tHcy levels remain stable in serious and minor small-vessel strokes. Taken together, elevated tHcy may be a useful prognostic marker for large-artery atherosclerosis stroke subtypes.

In this study, we aimed to evaluate whether the relationship between tHcy levels and all-cause mortality is confounded by other risk factors. The univariate HR of mortality from ischemic stroke was significantly higher in patients in the third and fourth quartiles of tHcy levels than in patients in the first quartile. After adjustment for confounding factors including age, sex, smoking status, LDL-C level, and glucose level, the presence of diabetes mellitus, hypertension, hyperuricemia, coronary artery disease, and obesity and markers of inflammation, such as hsCRP, the association remained significant. This indicates that high tHcy levels are an independent risk factor for increased mortality from ischemic stroke. Cui et al10 also reported that patients in the highest tHcy quartile had a significantly increased risk of mortality from ischemic stroke (adjusted odds ratio, 4.35; 95% CI, 1.12–16.9) compared with patients in the lowest quartile.

However, a vital question still remains: do elevated plasma tHcy levels cause more serious strokes or do more serious strokes result in higher tHcy levels? Both scenarios are likely true. Studies have found that elevated tHcy levels induce oxidative injury to vascular endothelial cells and impair the production of nitric oxide, an effective vasodilator, from the endothelium.28,29 This results in higher arterial pressure, which reduces the production of nitric oxide, an effective vasodilator, from the endothelium.28,29 This results in higher arterial pressure, which increases the risk of stroke and can worsen a stroke that has already happened.30 Elevated tHcy also enhances platelet adhesion to endothelial cells,31 promotes the growth of vascular smooth muscle cells,32 and is associated with higher levels of prothrombotic factors, such as [beta]-thromboglobulin, tissue plasminogen activator, and factor VIIc.33 These mechanisms increase the risk of developing an ischemic stroke and are likely detrimental to the vulnerable penumbra. However, Perini et al14 observed no association between plasma tHcy and stroke severity, suggesting that elevated tHcy is not a cause of stroke and not associated with stroke severity. Future prospective studies examining the risk of stroke and the changes in tHcy levels before and after stroke are necessary to clarify these associations.

Concentrations of tHcy represent a modifiable risk factor for stroke, so an understanding of the prognostic impact of tHcy levels is clinically relevant. Therapy to lower tHcy levels with B vitamins has been found to reduce the risk of stroke, as well as the risk of myocardial infarction, in several recent trials and meta-analyses. The lack of efficacy of vitamin therapy reported in most large clinical trials is likely because of the failure to consider the metabolic deficiency of vitamin B12 and the influence of impaired renal function. Metabolic B12 deficiency is present in 30% of vascular patients over the age of 70 years, and higher doses of vitamin B12 are needed in elderly patients than in younger patients. However, high doses of cyanocobalamin increase cyanide levels in patients with renal failure. Therefore, B vitamin therapy is beneficial for patients with adequate renal function but detrimental for those with a glomerular filtration rate <50 mL/min/1.73 m².13,14

Dolichocarotids are geometric abnormalities of the internal carotid artery characterized by atypical elongation, angulations, and undulations. The clinical role of dolichocarotids is currently unclear, and studies have denied an association between these carotid abnormalities and cerebrovascular events. One study found kinking to be more frequently associated with cardiovascular death than tortuosity,35 and another study showed that dolichocarotids are associated with dilated cardiomyopathy.36 However, only a small proportion of patients (2% to 6%) have dolichocarotids and, in our study, we did not consider dolichocarotids as a confounding factor associated with cardiovascular-related mortality. Future studies are needed to assess the correlation between dolichocarotids and tHcy levels.

Our study has numerous strengths, including the large number of strokes confirmed by imaging studies and the analysis of serum tHcy within 24 hours of hospital admission. However, this study also has limitations that need to be considered when interpreting the results. First, the follow-up period was only 48 months. However, a previous prospective study with a follow-up period of 4.5 years reported nearly identical all-cause mortality rates when comparing patients in the highest and lowest quartiles of tHcy levels.22 Second, there was no control group in this study. An appropriate control group would include patients who had their first ischemic stroke 6 months previously and were matched for age, sex, and cardiovascular risk factors to the patients in this study. This would clarify if measuring tHcy within 24 hours of a stroke has more prognostic value for stroke recurrence and mortality than measuring tHcy 6 months after a stroke. Third, patients’ medications at the time of admission were not recorded in this study. Future studies should assess the associations between numerous medications, such as antihypertensives, aspirin, statins, and [beta]-blockers, and the risk of cerebrovascular events and mortality. However, compliance with these medications and medication dose and duration varies among patients, and this study measured the biological impact of such medications by measuring serum cholesterol and fasting glucose levels. Future studies should also measure variability in heart rate, which may have affected cardiovascular mortality.37,38

Fourth, the initial severity of stroke in the acute phase was
not measured. This would have been interesting to determine to observe whether elevated tHcy levels were associated with more serious strokes and, thus, a higher mortality rate or if tHcy was independent of the severity of the stroke. All patients who died from ischemic stroke in the first hospital admission were excluded from our study. Future prospective studies are needed to define the relationships between tHcy levels and stroke severity.

In conclusion, we observed that elevated plasma tHcy levels in the acute phase of an ischemic stroke are a strong predictor of mortality in patients with the large-artery atherosclerosis stroke subtype. There is a strong, independent association between elevated tHcy levels and the risk of mortality from ischemic stroke.

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Disclosures

None.

References


Elevated Total Homocysteine Levels in Acute Ischemic Stroke Are Associated With Long-Term Mortality
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The online version of this article, along with updated information and services, is located on the World Wide Web at:
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결과
WMP는 대조군보다 환자군에서 유의하게 높았다 (P<0.001). WMH 부담과 WMP 사이에는 상관관계가 없었다. 높은 투과도 영역은 첫 번째와 두 번째 촬영에서 약간 중첩되었다. WMP의 9%는 WMHs 내부였고, 49%는 정상으로 보이는 WM에, 52%는 WMH 주변부내에 있었다 (P<0.001; ANOVA).

결론
정상으로 보이는 WM와 WMH 경계 가까이에서 증가된 BBB 투과도는 BBB 파괴와 WMHs 발생 간의 관련성을 지지한다.

**Figure 1.** White matter permeability (WMP) from visit 1, visit 2, and controls. There are significant differences in WMP between controls versusBinswanger disease (BD) subjects' first and second visits (ANOVA, P<0.001), but no difference between patient visits. Box plots are shown with outliers as circles. WMP variances were higher in BD subjects than in controls (ANOVA, P=0.01).

**Figure 3.** Permeability maps in 4 representative control patients. The normal controls had some areas of white matter hyperintensities (WMHs) mainly in the periventricular regions (arrows). Green delineates the WMHs, the red areas of scattered increased permeability were lower than found in the Binswanger disease patients. None of the controls had regions of high permeability (yellow). The color code used showed increasing permeability from red to yellow.

**Abstract 10**

**한국어판**

급성혈혈뇌졸중에서 총 호모시스테인 수치의 상승은 장기간 사망과 연관된다

**Elevated Total Homocysteine Levels in Acute Ischemic Stroke Are Associated With Long-Term Mortality**

Zhihong Shi, MD, PhD; Yalin Guan, MD, MS; Ya Ruth Huo, BA, MD; Shuling Liu, RN, MS; Meilin Zhang, PhD; Hui Lu, MD, MS; Wei Yue, MD, MS; Jinhuan Wang, MD, PhD; Yong Ji, MD, PhD

*(Stroke. 2015;46:2419-2425.)*

**Key Words:** acute ischemic stroke ■ atherosclerosis ■ homocysteine ■ long-term mortality ■ stroke
방법
총 3799명의 환자들이 급성혈혈뇌졸증으로 병원입원 후 모집되었다. 총 호모시스테인 수치는 처음 입원 후 24시간 이내에 측정되었다. 중간값 48개월 동안 환자들을 추적관찰하였으나.

결과
추적관찰 기간 동안 233명(6.1%) 환자들이 사망하였다. 나이, 흡연, 당뇨병 및 다른 심혈관 위험인자들을 보정한 후에 가장 높은 호모시스테인 수치 사분위(>18.6 μmol/L)에 속해 있는 환자들은 가장 낮은 사분위(≤10 μmol/L)와 비교할 때 1.61배 높은 사망률을 보였다. 추가 하위그룹 분석에서 이러한 연관성은 단지 대혈관동맥경화증 아형에 한정되었으며, 소혈관폐색 아형의 뇌졸중에 있어서는 유의하지 않았다. 심혈관질환 연관 사망 위험도와 허혈뇌졸중의 재발 위험도는 호모시스테인 수치와 유의한 연관성을 보이지 않았다.

결론
본 연구에서는 허혈뇌졸중의 급성기, 특히 대혈관동맥경화증 아형의 뇌졸중에서 총 호모시스테인 수치의 상승이 사망을 예측할 수 있다는 것을 제시한다.