Implementation of a Structured Guideline-Based Program for the Secondary Prevention of Ischemic Stroke in China

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Background and Purpose—High rates of ischemic stroke and poor adherence to secondary prevention measures are observed in the Chinese population.

Methods—We used a national, multicenter, cluster-randomized controlled trial in which 47 hospitals were randomized to either a structured care program group (n=23) or a usual care group (n=24). The structured care program consisted of a specialist-administered, guideline-recommended pharmaceutical treatment and a lifestyle modification algorithm associated with written and Internet-accessed educational material for patients for the secondary prevention of ischemic stroke. The primary efficacy outcome was the proportion of patients who adhered to the recommended measures at 12-month postdischarge. This trial is registered with ClinicalTrial.gov (NCT00664846).

Results—At 12 months, 1287 (72.1%) patients in the Standard Medical Management in Secondary Prevention of Ischemic Stroke in China (SMART) group and 1430 (72%) patients in the usual care group had completed the 12-month follow-up (P=0.342). Compared with the usual care group, those in the SMART group showed higher adherence to statins (56% versus 33%; P=0.006) but no difference in adherence to antiplatelet (81% versus 75%; P=0.088), antihypertensive (67% versus 69%; P=0.661), or diabetes mellitus drugs (73% versus 67%; P=0.297). No significant difference in the composite end point (new-onset ischemic stroke, hemorrhagic stroke, acute coronary syndrome, and all-cause death) was observed (3.56% versus 3.59%; P=0.921).

Conclusions—The implementation of a program to improve adherence to secondary ischemic stroke prevention efforts in China is feasible, but these programs had only a limited impact on adherence and no impact on 1-year outcomes. Further development of a structured program to reduce vascular events after stroke is needed.

Clinical Trial Registration—URL: http://www.clinicaltrials.gov. Unique identifier: NCT00664846. (Stroke. 2014;45:515-519.)

Key Words: guideline ■ patient compliance ■ secondary prevention ■ stroke

Stroke, a global health problem, is ranked third as a cause of disability-adjusted life-years (DALYs) according to the study of global burden of disease 2010 (GBD 2010). In developing countries, premature loss of life and stroke-related disability are a heavy burden with increasing economic and social costs. In China, the government has identified stroke as a high priority for both primary and secondary prevention and has supported the organization and publication of several national stroke guidelines to improve standards of care; however, these efforts have had an uncertain impact on patient outcomes.

Many studies have shown major evidence-practice gaps, including a decline in the adherence of patients to treatments after discharge from the hospital. A variety of structured programs, such as the Get With the Guidelines (GWTG) stroke program in the United States, have been shown to improve the quality of in-hospital stroke treatment. Long-term adherence to treatments is critical to ensure that secondary ischemic stroke prevention measures are maximally effective. A similar program must be implemented to improve the quality of secondary stroke prevention after hospital discharge. A cluster-randomized, guideline-based, structured care program, known as the Standard Medical Management in Secondary Prevention of Ischemic Stroke in China (SMART) study, was performed to assess the feasibility and effectiveness of...
structured care management and treatment to prevent recurrent ischemic stroke in China.

Methods and Patients

Patients

The details of the rationale and design of the SMART study have been published elsewhere. SMART was a national, multicenter, cluster-randomized controlled trial to assess the effectiveness of a guideline-based structured care program for secondary stroke prevention, as opposed to usual care, in China. For the trial, the following inclusion criteria were used: patients ≥18 years old; proven stroke because of cerebral infarction (according to standard clinical criteria with supporting brain imaging, either computer tomography or MRI), or transient ischemic attack; hospitalization within 30 days after the index event; clinical stability; and previous independence in their daily activities, as indicated by scores of 0 to 3 on the modified Rankin scale. The following exclusion criteria were used: radiological evidence of intracerebral hemorrhage; clear cause of stroke or transient ischemic attack unrelated to atherosclerosis (eg, cervical artery dissection or perivascular procedural stroke), although strokes resulting from cardioemboli were included; severe comorbid illness or unstable medical condition (eg, congestive cardiac failure, respiratory failure, renal failure, severe liver dysfunction, or malignancy with a likelihood of death within 2 years); significant memory or behavioral disorders requiring daily care; concurrent participation in another clinical trial; and pregnancy.

We obtained written informed consent from the participants or their legal surrogates. The study was approved by the central ethics committee at the principal study center at Peking Union Medical College Hospital and the ethics committees at the participating study sites.

We invited 48 hospitals (n=42 level-3 hospitals and n=6 level-2 hospitals) to participate in the study. The hospitals were stratified based on their size (level-2 hospitals had ≥100 inpatient beds providing acute medical care and preventative care services to populations of ≥100,000); level-3 hospitals were major tertiary referral centers in provincial capitals and major cities and location (by province). The hospitals were randomized to either the SMART program or the usual care group using a simple cluster method. However, 1 hospital (level 3) withdrew from the study before it began, leaving 23 hospitals (level-3 hospitals, n=20; level-2 hospitals, n=3) in the SMART group and 24 hospitals (level-3 hospitals, n=21; level-2 hospitals, n=3) in the usual treatment group.

Procedure

All patients were evaluated and followed up by neurologists. The SMART program comprised a combination of interventions, consistent with the current guidelines for the secondary prevention of ischemic stroke: pharmaceutical treatment targeted toward specific pathological subtypes, according to Trial ORG10172 in the Acute Stroke Treatment (TOAST) criteria (ie, large-artery atherosclerosis, small-vessel occlusion, cardioembolism, stroke of other determined pathogenesis, and stroke of undetermined pathogenesis); lifestyle modification; and patient education (Appendix I in the online-only Data Supplement). We discussed lifestyle modification with the patients, including smoking cessation, healthy diet, and regular exercise. Patient education included an interactive education session emphasizing the importance of adhering to the SMART program: that is, accessing a unique password-protected website that outlined aspects of the prevention of ischemic stroke and using materials discussing risk-factor control through medication and lifestyle changes. The usual care group received only those interventions chosen by their attending neurologist-clinician, without the use of the algorithm or interactive education and access to the educational website. After the initial central training in the study procedures, the key responsible clinician researchers at each participating hospital were required to register each eligible patient and record their essential demographic and clinical details on special study case record forms. We collected data at baseline and on follow-up dates. We performed site monitoring to assess the clinicians’ adherence to the SMART program and review the quality of the data by examining the source medical records.

Assessment of Outcomes

The primary efficacy outcome was the proportion of the patients who adhered to the secondary ischemic stroke prevention measures according to the recommendations of the SMART program. The secondary outcome was the composite of new-onset ischemic stroke, new-onset hemorrhagic stroke, acute coronary syndrome, and all-cause death. We recorded serious adverse events during follow-up, regardless of whether the local investigator considered the adverse effects related to the treatment (definite, uncertain, or no causality), and we reported all pertinent information to the data monitoring committee.

Statistical Analysis

The sample size estimation was 1771 patients per group, based on a 10% increase in the use of antiplatelet therapy in the SMART group versus a control usual care rate of 76%, assuming a 5% Type I error and a 2% allowance for variation using a 2-sided test. However, we estimated that a total of 4074 patients would be required for the study, assuming an overall dropout rate of 15% in each group.

We compared the baseline patient characteristics of the randomized groups using the t test or χ2 test, as appropriate. We calculated the adherence to each of the recommended measures for the hospital discharge and 12-month outcomes. To evaluate adherence, each measure for which a patient was eligible constituted an observation; the outcome was dichotomized as 1 (measure met) or 0 (measure not met) to indicate whether the recommended treatment was fulfilled. The percentage of adherence to each measure was defined as the total number of measures performed divided by the total number of eligible patients. To investigate the overall associations of the SMART group and the adherence to measures, a generalized estimating equations linear regression model was used to account for the interdependence of members from same center. Times to event outcomes were analyzed using Cox proportional hazards models, including the SMART program as a factor and with adjustments for covariates.

Table 1. Demographics and Baseline Characteristics

<table>
<thead>
<tr>
<th>Patient Characteristics</th>
<th>SMART Group (n=1795)</th>
<th>Usual Care Group (n=2026)</th>
<th>P Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Male sex, %</td>
<td>67</td>
<td>69</td>
<td>0.24</td>
</tr>
<tr>
<td>Age (mean, SD), y</td>
<td>61.48 (11.47)</td>
<td>60.36 (11.66)</td>
<td>0.004</td>
</tr>
<tr>
<td>NIHSS (mean, SD)</td>
<td>4.90 (4.45)</td>
<td>4.32 (4.26)</td>
<td>0.001</td>
</tr>
<tr>
<td>Past medical history, %</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ischemic stroke</td>
<td>24</td>
<td>23</td>
<td>0.20</td>
</tr>
<tr>
<td>Transient ischemic attack</td>
<td>7</td>
<td>7</td>
<td>0.77</td>
</tr>
<tr>
<td>Hypertension</td>
<td>64</td>
<td>63</td>
<td>0.08</td>
</tr>
<tr>
<td>Diabetes mellitus</td>
<td>24</td>
<td>21</td>
<td>0.16</td>
</tr>
<tr>
<td>Hypercholesterolemia</td>
<td>17</td>
<td>14</td>
<td>0.04</td>
</tr>
<tr>
<td>TOAST classification, %</td>
<td></td>
<td></td>
<td>0.03</td>
</tr>
<tr>
<td>Large-artery atherosclerosis</td>
<td>45</td>
<td>42</td>
<td></td>
</tr>
<tr>
<td>Small-vessel disease</td>
<td>47</td>
<td>52</td>
<td></td>
</tr>
<tr>
<td>Cardioembolism</td>
<td>3</td>
<td>2</td>
<td></td>
</tr>
<tr>
<td>Other determined pathogenesis</td>
<td>1</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>Undermined pathogenesis</td>
<td>5</td>
<td>4</td>
<td></td>
</tr>
<tr>
<td>Smoking, %</td>
<td></td>
<td></td>
<td>0.002</td>
</tr>
<tr>
<td>Lifelong nonsmoker</td>
<td>54</td>
<td>49</td>
<td></td>
</tr>
<tr>
<td>Ex-smoker</td>
<td>16</td>
<td>17</td>
<td></td>
</tr>
<tr>
<td>Current smoker</td>
<td>30</td>
<td>34</td>
<td></td>
</tr>
</tbody>
</table>

NIHSS indicates National Institutes of Health Stroke Scale score; SMART, Standard Medical Management in Secondary Prevention of Ischemic Stroke in China; and TOAST, Trial ORG10172 in the Acute Stroke Treatment.
A standard value of \( P < 0.05 \) was considered statistically significant. We performed all data analyses using SAS version 9.2 (SAS Institute Inc, Cary, NC).

## Results

Between April 1, 2008, and December 31, 2010, a total of 3821 patients were assigned to receive either care through the SMART program or usual care at 1 of the 47 participating hospitals. The baseline demographic and clinical characteristics demonstrated that the patients in the SMART group were slightly older (62±11 versus 60±12 years; \( P = 0.004 \)), had worse neurological impairments (ie, higher National Institutes of Health Stroke Scale [NIHSS] scores, 4.9±4.5 versus 4.3±4.3; \( P = 0.001 \)), were more likely to have a history of hypercholesterolemia (17% versus 14%; \( P = 0.04 \)), and were less likely to smoke (30% versus 34%; \( P = 0.002 \)) than the patients who received usual care (Table 1). After adjusting for age and NIHSS score, no significant difference in the proportion of medication use prescribed at discharge was observed between the 2 groups (Table 2).

### Adherence to Secondary Stroke Prevention Measures

The levels of adherence to measures (antiplatelet, antihypertensive, and antidiabetic medications, and statin and warfarin use) for the secondary prevention of ischemic stroke were calculated at 6 (Table 3) and 12 months (Table 4) after the index ischemic stroke event. A significant difference in adherence to statin use between the 2 groups was observed at 12 months (SMART group: 56% versus usual treatment group: 33%; \( P = 0.006 \)), although there were no significant differences in adherence to other measures between the 2 groups: antiplatelet drug use (SMART group: 81% versus usual treatment group: 75%; \( P = 0.088 \)), antihypertensive drug use (SMART group: 67% versus usual treatment group: 69%; \( P = 0.661 \)), and antidiabetic drug use (SMART group: 73% versus usual treatment group: 67%; \( P = 0.297 \)). Of 1791 patients, the educational website recorded 1624 entries from the SMART group during the study or 0.91 per patient per annum.

There was no significant decrease in the secondary end point (new-onset ischemic stroke, intracranial hemorrhage, acute coronary syndrome, and all-cause death) in the SMART group compared with the usual care group (3.50% versus 3.59%; \( P = 0.921 \); Table 5).

### Discussion

This pragmatic, nationwide, multicenter, cluster-randomized controlled trial presents updated information and recommends adherence to medical treatments for the prevention of secondary ischemic stroke using a program of guideline-based structured care and patient education in China. Compared with usual care, our specially designed SMART program increased patient adherence to the medical regimen of statins, although not to antiplatelet drugs, antihypertensive drugs, antidiabetic drugs, or warfarin for the treatment of cardioembolic stroke, during a 12-month follow-up period. There was no difference between the groups in the composite vascular end point of ischemic stroke, new-onset hemorrhagic stroke, acute coronary syndrome, and all-cause mortality.

Despite strong evidence supporting therapies and multiple guidelines for their use, high-risk patients often discontinue prescribed therapies after discharge from the hospital. The current status of secondary stroke prevention in China is not satisfactory. A recent study on the secondary prevention of ischemic stroke in urban China (ChinaQUEST) revealed that the use of antiplatelet drugs and lipid-lowering therapy substantially declined after hospital discharge.11 These findings indicate that physicians and patients should focus more attention on improving the quality of secondary stroke prevention after hospital discharge, which is crucial for prevention outcomes. Concerted efforts have been made to improve acute stroke management in various countries and districts. The GWTG-Stroke program has been associated with increased adherence to all 7 prespecified performance measures for

### Table 2. Proportions of Medications Prescribed at Discharge

<table>
<thead>
<tr>
<th>Medication</th>
<th>SMART Group (n=1795)</th>
<th>Usual Care Group (n=2026)</th>
<th>( P ) Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Antiplatelet</td>
<td>1245/1674 (85%)</td>
<td>1470/1795 (82%)</td>
<td>0.6963</td>
</tr>
<tr>
<td>Antihypertensive</td>
<td>757/1089 (70%)</td>
<td>790/1167 (68%)</td>
<td>0.4873</td>
</tr>
<tr>
<td>Antidiabetic</td>
<td>307/394 (78%)</td>
<td>264/379 (70%)</td>
<td>0.5532</td>
</tr>
<tr>
<td>Statin</td>
<td>991/1534 (65%)</td>
<td>802/1622 (47%)</td>
<td>0.1007</td>
</tr>
<tr>
<td>Anticoagulation</td>
<td>17/41 (42%)</td>
<td>13/42 (31%)</td>
<td>0.1652</td>
</tr>
</tbody>
</table>

Adjusted for age and National Institutes of Health Stroke Scale (NIHSS) score. SMART indicates Standard Medical Management in Secondary Prevention of Ischemic Stroke in China.

### Table 3. Adherence to Measures for Secondary Ischemic Stroke Prevention at 6-Months Poststroke

<table>
<thead>
<tr>
<th>Medication</th>
<th>SMART Group (n=1598)</th>
<th>Usual Care Group (n=1732)</th>
<th>Estimate</th>
<th>( P ) Value*</th>
<th>OR*</th>
<th>95% CI</th>
</tr>
</thead>
<tbody>
<tr>
<td>Antiplatelet</td>
<td>1301/1563 (83%)</td>
<td>1305/1702 (77%)</td>
<td>1.683</td>
<td>0.071</td>
<td>2.809</td>
<td>0.916 - 8.611</td>
</tr>
<tr>
<td>Antihypertensive</td>
<td>692/1011 (68%)</td>
<td>766/1100 (70%)</td>
<td>0.421</td>
<td>0.541</td>
<td>1.523</td>
<td>0.395 - 5.874</td>
</tr>
<tr>
<td>Antidiabetic</td>
<td>280/370 (76%)</td>
<td>246/350 (70%)</td>
<td>0.862</td>
<td>0.364</td>
<td>12.387</td>
<td>0.395 - 14.191</td>
</tr>
<tr>
<td>Statin</td>
<td>866/1466 (59%)</td>
<td>604/1622 (37.2%)</td>
<td>1.697</td>
<td>0.005</td>
<td>5.456</td>
<td>1.689 - 17.633</td>
</tr>
</tbody>
</table>

Adjusted for age, hypercholesterolemia, and National Institutes of Health Stroke Scale (NIHSS) score. Anticoagulation drugs were not included in this analysis model because of the small number of patients. CI indicates confidence intervals; OR, odds ratio; and SMART, Standard Medical Management in Secondary Prevention of Ischemic Stroke in China.

*Statistical significance \( P < 0.05 \).
in-hospital acute stroke care. A recent positive evaluation of the GWTG-Stroke program in Taiwan suggested that such initiatives are applicable outside the United States to improve the quality of stroke care. We suggest that similar programs for secondary stroke prevention be performed worldwide.

For patients with noncardioembolic ischemic stroke, antiplatelet agents are recommended to reduce the high risk of recurrent stroke and other cardiovascular events. Although these drugs are easy to use, inexpensive, and well tolerated, adherence to antiplatelet drugs is not optimal, as anticipated. The ChinaQUEST study demonstrated that antiplatelet use declined from 81% at the time of hospital discharge to 66% at 12 months poststroke. In contrast to antihypertensive therapy, in which blood pressure is monitored to achieve a treatment target, the effects of antiplatelet drugs are not visible, and patients might doubt the effectiveness of the treatment when recurrent ischemic events occur or worry about the risk of bleeding. Thus, patient education may be more critical than previously recognized to ensure good adherence to antiplatelet therapy.

In the present study, we demonstrated that patients with hypertension and those with diabetes mellitus exhibit consistent levels of adherence to antihypertensive and antidiabetic drugs. The randomized groups showed a minimal difference in use during 12 months, and this good adherence to antihypertensive drugs is consistent with the findings of a previous study. This adherence to medications might in part reflect the high level of awareness about the importance of hypertension as a major risk factor for stroke. In addition, the well-developed Chinese Hypertension Prevention and Treatment Guidelines and various medical and educational activities have contributed to increased public awareness of hypertension and diabetes mellitus.

In the present study, adherence to warfarin was only 28% in the SMART group and 29% in the usual care group 12 months poststroke. These figures are consistent with those obtained in a registry study in Taiwan, in which anticoagulant treatment (warfarin) was used by only 28% of patients with atrial fibrillation at the time of hospital discharge, and a recent German study, in which only 31% of patients with atrial fibrillation used anticoagulants. The main reason for the poor adherence to anticoagulant treatment is the inconvenience and complexities of regular monitoring. Strategies to improve adherence to anticoagulant treatment in China might include physician and patient education and easy access to facilities that provide international normalized ratio monitoring.

There is now strong evidence that the use of statins in the secondary prevention of ischemic stroke is beneficial. Although statin use was significantly higher in the SMART group than in the usual care group and statin use in the SMART group at 12 months after discharge was much higher than that observed in the ChinaQUEST study (56% versus 17%), the use of these drugs remains substantially lower than that in developed countries; statin use of 74% was observed in the Swedish Prescribed Drug Register at 12 months after stroke. This result indicated that patient education is effective in substantially increasing statin use in secondary ischemic stroke prevention; thus, these efforts should be strengthened in the future.

There were no significant differences in medication adherence (except statin use) and cardiovascular events compared with usual care. Several factors might account for the negative results. The primary reasons are likely the short follow-up time and small sample. Difference between SMART-based care and usual care might be more evident after long-term implementation in a larger population. In addition, the SMART

<table>
<thead>
<tr>
<th>Medication</th>
<th>SMART Group Adherence (n=1598)</th>
<th>Usual Care Group Adherence (n=1732)</th>
<th>Estimate</th>
<th>P Value*</th>
<th>OR*</th>
<th>95% CI Lower Limit</th>
<th>95% CI Upper Limit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Antibiotic</td>
<td>1020/1258 (81%)</td>
<td>1050/1402 (75%)</td>
<td>1.139</td>
<td>0.088</td>
<td>3.468</td>
<td>0.830</td>
<td>14.494</td>
</tr>
<tr>
<td>Antihypertensive</td>
<td>555/830 (67%)</td>
<td>621/906 (69%)</td>
<td>0.365</td>
<td>0.661</td>
<td>1.440</td>
<td>0.283</td>
<td>7.338</td>
</tr>
<tr>
<td>Antidiabetic</td>
<td>220/303 (73%)</td>
<td>190/284 (67%)</td>
<td>1.016</td>
<td>0.297</td>
<td>2.761</td>
<td>0.409</td>
<td>18.642</td>
</tr>
<tr>
<td>Statin</td>
<td>660/1183 (56%)</td>
<td>442/1342 (33%)</td>
<td>1.712</td>
<td>0.006</td>
<td>5.539</td>
<td>1.629</td>
<td>18.831</td>
</tr>
</tbody>
</table>

Adjusted for age, hypercholesterolemia, and National Institutes of Health Stroke Scale (NIHSS) score. Anticoagulation drugs were not included in this analysis model because of the small number of patients. CI indicates confidence intervals; OR, odds ratio; and SMART, Standard Medical Management in Secondary Prevention of Ischemic Stroke in China.

*Statistical significance P<0.05.

Table 5. End Points in the Randomized Groups at 12 Months Poststroke

<table>
<thead>
<tr>
<th>End-point Events</th>
<th>SMART Group (n=1795)</th>
<th>Usual Care Group (n=2026)</th>
<th>Hazard Ratio</th>
<th>95% CI for Hazard Ratio</th>
<th>P Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>All end-point events</td>
<td>63 (3.50%)</td>
<td>73 (3.59%)</td>
<td>0.982</td>
<td>0.694</td>
<td>1.391</td>
</tr>
<tr>
<td>Ischemic stroke (%)</td>
<td>33 (1.84%)</td>
<td>38 (1.87%)</td>
<td>1.054</td>
<td>0.648</td>
<td>1.715</td>
</tr>
<tr>
<td>Transient ischemic attack (%)</td>
<td>10 (0.56%)</td>
<td>10 (0.49%)</td>
<td>1.042</td>
<td>0.418</td>
<td>2.6</td>
</tr>
<tr>
<td>Nonfatal intracerebral hemorrhage</td>
<td>3 (0.17%)</td>
<td>4 (0.20%)</td>
<td>0.911</td>
<td>0.201</td>
<td>4.126</td>
</tr>
<tr>
<td>Nonfatal acute coronary syndrome</td>
<td>4 (0.22%)</td>
<td>6 (0.30%)</td>
<td>0.768</td>
<td>0.215</td>
<td>2.749</td>
</tr>
<tr>
<td>All-cause death (%)</td>
<td>13 (0.72%)</td>
<td>15 (0.74%)</td>
<td>0.941</td>
<td>0.445</td>
<td>1.99</td>
</tr>
</tbody>
</table>

The data are presented as n (%). Adjusted for age, sex, history of ischemic stroke, smoking, hypertension, hypercholesterolemia, and National Institutes of Health Stroke Scale (NIHSS) score. CI indicates confidence intervals; and SMART, Standard Medical Management in Secondary Prevention of Ischemic Stroke in China.
program improved adherence to only 1 of the 5 drugs assessed. Improving adherence to the intervention is the first step toward reducing the likelihood of a recurring stroke. Achieving the treatment target may be the next important step. Moreover, most of the participating hospitals were large and located in urban areas (eg, level-3 hospitals), where physicians have the resources to provide high levels of medical care, potentially increasing adherence to guidelines. Although the physicians at the usual care facilities were not familiar with the SMART program, they may improve their practice through continuous medical education gained via experience. The improvement of their practice in this manner would underestimate the power of the SMART program and potentially yield negative results for the comparison of the SMART program with usual care.

With increasing use of the Internet and social media, Internet-based education likely plays an increasingly important role in medical care. However, the percentage of individuals with Internet access is only 2% among people >60 years old (which comprises the majority of patients with stroke), according to a survey performed by the China Internet Network Information Center (CNNIC) in 2009. Other strategies include educating caregivers to provide support and using mobile phone text messaging to send information and reminders for scheduling appointments, adhering to a medical regimen, and monitoring patient health status. SMART is a nationwide, multicenter, cluster-randomized controlled trial that provides valuable information on the current status of secondary ischemic prevention. The results of the present study demonstrate that the SMART program is feasible and can improve adherence to statins. The results obtained from this study might provide valuable information for modifying strategies to further improve the quality of secondary stroke prevention.

The present study has several limitations. First, the drop-off rate was high, reflecting the current status of secondary stroke prevention. Patients and physicians typically pay more attention to in-hospital treatment during the acute phase of the illness than to long-term prevention after hospital discharge. Improvements to the SMART program may be necessary to reduce the observed drop-off rate, including methods for offsite follow-up such as regular telephone or text communication. Second, most stroke patients in China are treated in small, below-level-2 hospitals with limited high-quality medical resources; therefore, SMART should enroll more small hospitals to assess the effectiveness of the program. Third, there is an imbalance in the baseline characteristics, which likely reflects the cluster-randomized nature of the trial. A generalized estimating equations linear regression model was used to account for the interdependence of members from same center, and the analysis was adjusted for these imbalance characteristics. Finally, in addition to adherence to pharmacological interventions, adherence to various behavioral factors (eg, smoking cessation, healthy diet, and regular exercise) should be considered because these factors contribute to the prevention of cardiovascular events.

In conclusion, the implementation of a program to improve adherence to secondary ischemic stroke prevention efforts in China is feasible, but the current implementation had only a limited impact on adherence and no impact on 1-year outcomes. Further development of a structured program to reduce vascular events after stroke is needed.

Acknowledgments

We thank the Standard Medical Management in Secondary Prevention of Ischemic Stroke in China (SMART) investigators and centers (Appendix II in the online-only Data Supplement) for their participation in this trial. We thank all of the patients who participated in SMART study.

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Disclosures

None.

References

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### SUPPLEMENTAL MATERIAL

**Appendix I** Interventions applied to patients in SMART group according to the stroke subtype

<table>
<thead>
<tr>
<th>Stroke subtype</th>
<th>Recommended measures</th>
</tr>
</thead>
<tbody>
<tr>
<td>Large-artery atherosclerosis</td>
<td>Antiplatelet therapy if no contraindication: aspirin 75-150 mg/d or clopidigrel 75 mg/d</td>
</tr>
<tr>
<td>Small-vessels occlusion</td>
<td>Antihypertensive agents if eligible: diuretic agents or angiotensin-converting enzyme inhibitors (ACEIs)/angiotensin receptor blockers (ARBs) or long-acting calcium channel blockers (CCBs) as the first line choice</td>
</tr>
<tr>
<td>Stroke patient with undetermined etiology having one of the following criteria:</td>
<td>Statins</td>
</tr>
<tr>
<td>1) &gt;50% stenosis of extra-intracranial large artery</td>
<td>Antidiabetic agents if eligible: not specified</td>
</tr>
<tr>
<td>2) Carotid artery atherosclerosis plaque and &gt;55 years old</td>
<td>Smoke cessation</td>
</tr>
<tr>
<td>3) Age 30-55 years with more than two risk factors of hypertension, diabetic mellitus, smoking, hyperlipidemia, or hyperhomocystinemia</td>
<td>Healthy diet, exercise, booklet on stroke prevention</td>
</tr>
<tr>
<td>Cardioembolism</td>
<td>Anticoagulation if no contraindication: warfarin</td>
</tr>
<tr>
<td></td>
<td>Antihypertensive agents if eligible: diuretic agents or angiotensin-converting enzyme inhibitors (ACEIs)/angiotensin receptor blockers (ARBs) or long-acting calcium channel blockers (CCBs) as the first line choice</td>
</tr>
<tr>
<td></td>
<td>Antidiabetic agents if eligible: not specified</td>
</tr>
<tr>
<td></td>
<td>Smoke cessation</td>
</tr>
<tr>
<td>Stroke of other etiology</td>
<td>Healthy diet, exercise, booklet of stroke prevention education</td>
</tr>
<tr>
<td>--------------------------</td>
<td>---------------------------------------------------------------</td>
</tr>
<tr>
<td></td>
<td>Manage underlying disease</td>
</tr>
<tr>
<td></td>
<td>Aspirin 75-150 mg/d or warfarin if no contraindication</td>
</tr>
</tbody>
</table>
Appendix II:

Institutions participating SMART study (with numbers of patients enrolled and local lead investigators)

Beijing Daxing District Hospital (53, LZ Zhao);Beijing Ji Shui Tan Hospital, (100, YH Sun);Beijing Shi JiTan Hospital (129, ML He);China PLA General Hospital (50, CQ Pu);China Rehabilitation Research Center (27, T Zhang);Daping Hospital (60, HD Zhou);First Affiliated Hospital of Xinjiang Medical University (38, XN Zhang);General Hospital of the Navy (60, XK Qi);Guangzhou First Municipal People’s Hospital (105, MY Li);Henan Provincial People’s Hospital (78,JW Zhang);Huashan Hospital Fudan University (31,Q Dong);Inner Monoglia Batou City Central Hospital (115, JF Zhang);Luhe Hospital of Tongzhou District (49,HS Du);Jilin University (99, J Wu);Nanjing General Hospital of Nanjing Military Command,(54,XF Liu);No 263 Hospital of PLA (127, JL Zhang);No 309 Hospital of PLA, (50, YP Chen);Peking Union Medical College Hospital (133,LY Cui);Peking University Third Hospital (49, DS Fan);Pinggu County Hospital (60, GY Zhang); Qilu Hospital of Shandong University (60,CZ Yan);Qinghai Provincial People’s Hospital (66, SZ Wu);Shanghai Changzheng Hospital (79, XY Chen); Second Affiliated Hospital of Zhejiang University College of Medicine (74, MP Ding);Southwest Hospital (49, SG Shi);The Affiliated Drumtower Hospital of Nanjing University Medical School (72, Y Xu);The Appurtenant Hospital of Chifeng University (106, QF Cui);The First Affiliated Hospital of China Medical Sciences University (101, CD Zhang);The First Affiliated Hospital of College of Medicine (71, JW Wang);The First Affiliated Hospital Sun Yat-Sen University (49, QS Zeng);The First Hospital of Harbin Medical University (100, WZ Wang);The First Hospital of Hebei Medical University (46, MW Wang); The General Hospital Under Tianjin Medical Sciences University (105, Y Cheng);The Second Hospital of Harbin Medical University (115, LM Zhang);The Second Hospital of Hebei Medical University (97, ZZ Li);The Second Hospital of Shandong University (59, W Shang);The
Second Affiliated Hospital of Soochow University (51, YJ Cao); The Third Hospital of Hebei North University (85, SM Yue); The Third Hospital of Hebei Medical University (64, JY Liu); The Third People's Hospital of Dalian (197, JB Zhang); The Zhongnan Hospital of Wuhan University (56, JJ Zhang); Tiantan Hospital, Capital Medical University (175, YJ Wang); Tianjin Third Central Hospital, (82, ZZ Zhang); West China Center of Medical Sciences (98, D Zhou); Xiangya Hospital of Central South University (107, J Xia); Xuanwu Hospital, Capital Medical University (89, JP Jia); Yutian County Hospital (101, JC Wang)
Implementation of a Structured Guideline–Based Program for the Secondary Prevention of Ischemic Stroke in China


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卒中是全球性健康问题,2010年全球疾病负担研究(GBD2010)显示以疾病调整生命年(DALYs)评估,卒中居疾病负担第三位。在发展中国家,过早死亡与卒中相关疾病已导致日益增加的经济和社会负担。在中国,政府已认识到卒中一级二级预防的重要性,支持有关组织发布多项国家卒中指南以改善现状;但是指南对于患者结局的影响尚不清楚。

多项研究结果显示指南与临床实践中存在较大差距,尤其是患者出院后对预防措施的依从性明显下降。有研究显示规范的干预项目可改善住院期间卒中治疗的质量,如美国的跟着指南走-卒中项目(GWTG)。对干预措施的长期依从性对最大程度保障缺血性卒中二级预防有效性至关重要。应在患者出院后的二级预防中开展类似于住院期间的干预活动。我们开展实施一项全国多中心、区组随机对照、基于指南的规范干预项目-规范化药物治疗研究(SMART)来评估缺血性卒中二级预防规范治疗的可行性和有效性。

方法和患者

患者

SMART研究方案已在前期发表。SMART研究是一项全国多中心、区组随机、对照研究,旨在评估与常规治疗相比,基于指南的规范卒中二级预防项目的有效性。研究入组标准:年龄发病30天以内18岁以上患者,确诊的脑梗死(临床表现,CT或MRI影像学证据),或TIA患者;临床病情稳定,病前可独立生活,mRS 0-3分。排除标准:影像学证实脑出血患者,发病机制非动脉粥样硬化卒中(如颈动脉夹层或血管手术期出现的卒中)(心源性卒中除外),严重并存疾病,临床病情不稳(如充血性心力衰竭、呼吸衰竭、肾功衰竭、严重肝功不全或恶性肿瘤),预计生存时间小于两年;严重的记忆或行为障碍需他人护理;同时参加其他临床研究及妊娠。

所有参加者需签署知情同意书。本研究经中心伦理单位-北京协和医院伦理委员会批准并获各参加单位伦理委员会同意。共48家医院受邀参加研究(42家三级医院,6家二级医院)。根据医院的规模和地域分布采用区组随机法分组(二级医院指床位数超过100张,服务人群约10万;三级医院指地区或大城市的中心医院)。将医院分为规范化治疗组(SMART组)和常规治疗组。共48家医院参与研究,其中23家为规范化治疗组,24家为常规治疗组。规范治疗措施包括基于指南推荐的药物治疗方案和生活方式改进,采用书面材料和网络教育形式进行缺血性卒中二级预防健康宣教。项目组对各中心进行实地监测评估医师执行SMART项目的情况,检查核实医疗记录以评估实验数据的质量。

卒中是全球性健康问题,2010年全球疾病负担研究(GBD2010)显示以疾病调整生命年(DALYs)评估,卒中居疾病负担第三位。在发展中国家,过早死亡与卒中相关疾病已导致日益增加的经济和社会负担。在中国,政府已认识到卒中一级二级预防的重要性,支持有关组织发布多项国家卒中指南以改善现状;但是指南对于患者结局的影响尚不清楚。SMART组患者对他汀的依从性显著高于常规治疗组(56% vs 33%;P=0.006),但两组在抗血小板药物(81% vs 75%;P=0.088)、降压药物(67% vs 69%;P=0.661)和降糖药物(73% vs 67%;P=0.297)间没有显著差异。主要终点事件(新发缺血性卒中、出血性卒中、急性冠脉综合征和全因死亡)在两组间也没有显著差异(3.56% vs 3.59%;P=0.921)。SMART项目未改善卒中后1年的结局。应进一步完善项目以减少卒中后血管事件。
结局评估

研究主要有效性结局是患者对 SMART 项目中缺血性卒中二级预防措施的依从性。次要结局是包括新发缺血性卒中、脑出血、急性冠脉综合征和全因死亡的复合终点。不论各中心研究者认为是否与治疗有关（明确相关、不确定或无关），均记录随访中发生的严重不良事件，并上报数据监测委员会。

统计分析

基于前期研究，抗血小板药物使用率为 76%，预测实施 SMART 项目后，与常规治疗组相比，SMART 组可提高抗血小板药物使用率 10%。基于此，以 2% 作为允许差值，假设发生 1 类误差的概率为 5%，预测组样本数为 1771。采用双向 t 检验。但项目组预计失访率为 15%，最终估计需入组 4074 名患者。

我们使用 t 检验或卡方检验比较两组间的基线资料。计算患者出院后 12 个月的依从性。依从性的评估采用如下方法：评估患者根据指南需要采用的措施，对每一项措施，采用二分法统计数据，1 代表执行该措施 0 代表未执行该措施。对每一项措施的依从性定义为依从性率。我们采用广义估计方程（GEE）分析回归评估 SMART 组与依从性的关系，采用 Cox 比例风险模型分析事件时间结局。

P<0.05 代表统计学显著性差异。所有统计分析在 SAS 9.2 统计软件进行 (SAS Institute Inc, Cary, NC)。

结果

在 2008 年 4 月 1 日至 2010 年 12 月 31 间，47 家医院共入组 3821 名患者，患者基线资料显示与常规治疗组相比，SMART 组患者年龄略小 (62±11 vs 60±12; P=0.004)，神经功能更缺损略轻 (NIHSS 评分 4.9±4.5 vs 4.3±4.3; P=0.001)，高脂血症比例略高 (17% vs 14%; P=0.04)，吸烟患者略少 (30% vs 34%; P=0.002) (表 1)。调整年龄、NIHSS 评分后，出院时药物使用率在两组间无显著性差异 (表 2)。二级预防措施依从性

分别计算出院时、6 个月 (表 3) 及 12 月时 (表 4) 患者对干预措施的依从性 (抗血小板药物、降压药物、降糖药物、他汀和华法令)。尽管在 12 个月内抗血小板药物 (SMART 组 81% vs 常规治疗组 75%; P=0.008)、降压药物 (SMART 组 67% vs 常规治疗组 69%; P=0.661)、降糖药物 (SMART 组 73% vs 常规治疗组 67%; P=0.297) 的依从性在两组间无显著性差别，但他汀药物的使用率显著高于常规治疗组 (56% vs 33%; P=0.006)。在 SMART 组 3791 名患者中，记录 1624 次登陆网站记录 (0.91 次 / 人年)。次要终点 (新发缺血性卒中、脑出血、急性冠脉综合征及全因死亡) 在两组间无显著性差异 (3.50% vs 3.59%; P=0.921) (表 5)。

讨论

本研究是一项全国多中心、区组随机对照研究，提供了中国患者对规范缺血性卒中二级预防项目依从性的最新信息，与常规治疗组相比，尽管抗血小板药物、降压药物、降糖药物或华法令的使用率在两组间无显著性差别，但他汀药物的使用率显著高于常规治疗组 (56% vs 33%; P=0.006)。在 SMART 组 3791 名患者中，记录 1624 次登陆网站记录 (0.91 次 / 人年)。次要终点 (新发缺血性卒中、脑出血、急性冠脉综合征及全因死亡) 在两组间无显著性差异 (3.50% vs 3.59%; P=0.921) (表 5)。

我们使用 t 检验或卡方检验比较两组间的基线资料。计算患者出院后 12 个月的依从性。依从性的评估采用如下方法：评估患者根据指南需要采用的措施，对每一项措施，采用二分法统计数据，1 代表执行该措施 0 代表未执行该措施。对每一项措施的依从性定义为依从性率。我们采用广义估计方程（GEE）分析回归评估 SMART 组与依从性的关系，采用 Cox 比例风险模型分析事件时间结局。
血小板药物的有效性，有些患者还担心药物的出血性风险。因此，应更重视患者教育以提高抗血小板药物的依从性。

本研究结果显示患者对降压药物和降糖药物的依从性保持稳定。12 月的随访阶段差异不大，降压药物良好的依从性与其他研究类似。这在一定程度反映对高血压作为卒中主要危险因素的重视。此外，中国高血压防治指南及其他医学教育活动也提高了公众对高血压和糖尿病的认识。

在本研究中，12 个月时华法令的使用率在 SMART 组及常规治疗组仅为 28% 和 29%。这些数据与台湾登记研究的情况类似，出院时房颤患者华法令的使用率仅为 28%。抗凝药物使用率低的最主要原因是由于定期药物检测导致的使用不方便。在中国，提高抗凝药物使用率的策略包括对临床医师及患者的健康教育，以及为患者提供更方便的 INR 检测手段。

强有力的证据显示他汀在卒中二级预防中的有效性。尽管 12 个月时 SMART 组他汀使用率显著高于常规治疗组以及 ChinaQUEST。
研究终点数据（56% vs 17%），但与发达国家相比仍有不小差距。瑞典处方药物登记研究数据显示卒中后 12 个月时他汀药物使用率为 74%。本研究结果提示在缺乏性卒中二级预防中患者教育可显著提高他汀药物的使用率。因此，将来该项工作还应该得到加强。

与常规治疗组相比，SMART 组心血管事件结局并未减少。这可能与下列几项原因有关。最主要的可能是随访时间相对较短，样本量略少，在大样本长期随访中，SMART 项目可能显示出其有效性。其次，SMART 项目仅提高了 5 种药物中的一种药物的使用率。提高依从性是减少卒中复发风险的第一步，达到治疗目标可能是更重要的阶段。第三，本研究绝大多数医院是社区的（三级医院），临床医师的诊治水平较高，可能提高患者对指南的依从性。尽管常规治疗组的医师并不知道 SMART 项目方案，但他们可通过继续教育活动提高执业水平。常规治疗组医师水平的提高在一定程度上削弱了 SMART 项目的效果，可能导致阴性结果。

随着网络和社会媒体的广泛运用，基于网络的教育方式可能在医学教育中发挥重要的作用。但是，中国网络信息中心的研究显示 2009 年超过 60 岁的人群中上网的比例仅为 2%。应结合其他的策略来提高教育的有效性，如为患者提供健康教育、使用手机短信提醒定期随访信息、使用药物及监测患者健康状况。

SMART 研究是一项全国多中心、区组随机对照研究，为当前缺血性卒中二级预防提供了有价值的信息。研究结果显示 SMART 项目是可行的，可提高他汀药物的依从性。本研究结果对今后进一步改进卒中二级预防策略提供依据。

本研究有几项局限。第一，患者脱落率较高，这也反映目前卒中二级预防的现状。临床医师和患者更重视急性期住院期间的治疗，对出院后的长期预防重视不够。应改进 SMART 项目以减少患者脱落率，如定期电话随访或短信沟通等。第二，中国绝大部分卒中患者在小医院治疗，二级以下的医院高质量的医疗资源有限。因此，SMART 项目应纳入小医院。第三，在基线数据中存在不平衡，可能是由于区组随机所致。我们使用采用广义估计方程（GER）线性回归模型来分析同一中心个体间的相互关系，并在统计分析时对这些不均衡因素进行校正。第四，除评估药物依从性外，还应考虑不同行为因素（如戒烟、健康饮食及规律的锻炼）的影响，这些因素也有助于预防心血管事件。

综上所述，在中国开展旨在提高缺血性卒中二级预防依从性项目是可行的，不过现行的方案对依从性的影响尚有限，并未影响 1 年时的结局。应进一步改进项目以减少卒中后血管事件复发。

参考文献