Control of Hypertension 5 Years After Stroke in the North East Melbourne Stroke Incidence Study

Seana L. Paul, Amanda G. Thrift

Abstract—Control of blood pressure after stroke is important for reducing the risk of recurrent stroke. We examined the control of hypertension in a community-based population of 5-year stroke survivors. Cases of first-ever stroke from the North East Melbourne Stroke Incidence Study were interviewed at 5 years poststroke. Blood pressure, history of hypertension, and antihypertensive medications were recorded. Individuals were classified as normotensive (blood pressure <140/90 mm Hg, no history of hypertension, and no antihypertensive medications), controlled hypertensive (blood pressure <140/90 mm Hg, history of hypertension, and/or taking antihypertensive medications), uncontrolled hypertensive (blood pressure ≥140/90 mm Hg, history of hypertension, and/or taking antihypertensive medications), or uniformed hypertensive (blood pressure ≥140/90 mm Hg, no known history of hypertension, and no antihypertensive medications). At 5 years poststroke, 441 (45%) of 978 first-ever stroke cases were alive. Of these, 305 (69%) had complete data on blood pressure, antihypertensive medication use, and history of hypertension. No statistical differences existed between those with or without these data. Eighty-two percent were hypertensive; 63% had controlled hypertension, 30% had uncontrolled hypertension, and 7% were unaware that they were hypertensive. Overall, 67% of individuals classified as uncontrolled or uninformed hypertensive subjects were receiving treatment that was insufficient to achieve target blood pressure levels. Uncontrolled hypertensive subjects were more likely to recall receiving advice to manage their hypertension with medication (P<0.02) and diet (P<0.09). Although the majority of hypertensive individuals had controlled hypertension at 5 years poststroke, considerable improvement can be made in the control of hypertension after stroke. (Hypertension. 2006;48:1-6.)

Key Words: hypertension, detection and control ■ stroke ■ blood pressure ■ epidemiology ■ prospective studies

It is well established that secondary prevention of stroke with the use of antihypertensive medications, in both hypertensive and normotensive individuals, is effective in reducing the incidence of recurrent stroke and myocardial infarction.1-2 Indeed, the World Health Organization (WHO) and the International Society for Hypertension (ISH) guidelines recommend that individuals who are at high risk, such as an individual who has suffered a stroke, with a blood pressure ≥140/90 mm Hg (systolic blood pressure [SBP]/diastolic blood pressure [DBP]) should be immediately placed on antihypertensive medication.3 Despite the importance of controlling blood pressure among stroke patients, there is considerable evidence that survivors of stroke are treated inadequately. In the South London Stroke Register, ~30% of all those suitable for antihypertensive treatment were not treated at 3 months poststroke.4 Furthermore, even among those attending a stroke prevention clinic, 14% were found to have uncontrolled hypertension at 1 year poststroke.5 Little is known, however, about control of hypertension in the longer term after stroke. We, therefore, aimed to investigate the control of hypertension 5 years poststroke among a community-based population of stroke patients from the North East MELBOURNE Stroke Incidence Study (NEMESIS).

Methods

The study was completed as part of the 5-year follow-up of cases from NEMESIS. These methods have been described in detail previously.6 Briefly, NEMESIS is a community-based stroke incidence study that adheres to the criteria for an “ideal” incidence study.7,8 The study region was composed of a population of 306 631 in north eastern Melbourne. Multiple overlapping sources were used to ascertain all strokes among residents of this area occurring between May 1, 1997, and April 30, 1999. Both hospital (admission and discharge lists) and nonhospital (general practitioner and nursing home referrals) sources were used. Stroke was defined using the WHO clinical definition.9 All of the potential cases were assessed by a panel of stroke experts before inclusion in the study. Pathological stroke subtype (ischemic stroke, intracerebral hemorrhage, and subarachnoid hemorrhage) was established by neuroimaging or autopsy findings. Although cases of subarachnoid hemorrhage were included in incidence counts, they were not followed up. Stroke severity was measured using the National Institutes of Health Stroke Scale.10 Information was collected on age, gender, place of residence, and occupation, the latter of which was used as a marker for socioeconomic status and was dichotomized into manual and nonmanual occupations.11

Received March 13, 2006; first decision March 24, 2006; revision accepted April 27, 2006.

From the National Stroke Research Institute (S.L.P., A.G.T.) and Neurology Department (A.G.T.), Austin Health, Heidelberg Heights, Victoria, Australia; Department of Medicine (S.L.P., A.G.T.), University of Melbourne, Australia; and the Department of Epidemiology and Preventive Medicine (A.G.T.), Monash University, Melbourne, Australia.

Correspondence to Seana Paul, National Stroke Research Institute, Level 1, Neurosciences Building, Repatriation Hospital Heidelberg, Austin Health, 300 Waterdale Rd, Heidelberg Heights, Victoria, Australia, 3081. E-mail seana.paul@utas.edu.au

© 2006 American Heart Association, Inc.

Hypertension is available at http://www.hypertensionaha.org

DOI: 10.1161/01.HYP.0000230610.81947.0A
Follow-Up Assessment
At 5 years poststroke, all cases were contacted for an interview, preferably in their own home. When the case had severe cognitive impairment or dysphasia, the closest available informant was interviewed as a proxy respondent.

The individual’s residential status was recorded as either “institutionalized” (nursing home or hostel) or “not institutionalized” (living in own home or that of a relative). Smoking status at 5 years poststroke was classified as “ever” or “never” smoker. Alcohol consumption was classified into “nondrinker,” “moderate” (women, ≤2 standard drinks per day; men, ≤4 standard drinks per day), and “heavy” consumption (consuming above moderate levels). All of the individuals were asked if they limited their salt intake (yes/no). Exercise level was dichotomized into “at or above” or “below” recommended amount based on the Australian guidelines for vigorous physical activity of ≥3 times per week. If an individual stated that they had hypertension, their awareness of management strategies was established by asking whether they had ever been advised to use diet, exercise, or medication to manage their hypertension. Finally, we obtained information on their visits to general practitioners.

Three sources of information were used to classify hypertensive status: (1) measurement of blood pressure; (2) use of antihypertensive medications; and (3) known history of hypertension. First, blood pressure was measured with the case in a sitting position using a sphygmomanometer according to the British Hypertension Society Methodology. SBP was recorded at the appearance of Korotkoff sounds (phase I) and DBP at the disappearance of Korotkoff sounds (phase V). At least 3 measurements were taken; measurements continued until the last 2 measurements differed by ≤10 mm Hg for SBP and ≤6 mm Hg for DBP. All of the measurements were taken by trained research nurses. Hypertension was defined as a DBP ≥90 mm Hg and/or an SBP ≥140 mm Hg in accordance with the 1999 WHO-ISH guidelines for the management of hypertension. The names of all medications currently being taken were recorded at interview. In the majority of cases, the research nurse sighted the drugs or a prescription list. Antihypertensive medications were classified according to their mode of action: diuretics, β-blockers, calcium channel antagonists, angiotensin-converting enzyme (ACE) inhibitors, peripheral vasodilators, angiotensin receptor blockers, α-adrenergic receptor blockers, and methyldopa. Compliance with medication use was also noted. Finally, patients were asked whether they had ever been told by a doctor that they had high blood pressure.

Blood Pressure Control Groups
Five-year survivors were grouped according to the level of blood pressure control. Only those individuals with complete information on blood pressure, that is, clinical blood pressure measurement, medication use, and who had completed the questionnaire at 5 years poststroke, could be categorized into these groups: (1) normotensive group: no history of hypertension, were not taking any antihypertensive medication, and had a measured blood pressure level <140 mm Hg systolic and <90 mm Hg diastolic; (2) controlled hypertensive group: previous history of hypertension and/or were taking antihypertensive medication and had a measured blood pressure level ≤140 mm Hg systolic and <90 mm Hg diastolic; (3) uncontrolled hypertensive group: previous history of hypertension and/or were taking antihypertensive medications and had a measured blood pressure level ≥140 mm Hg systolic and/or ≥90 mm Hg diastolic; and (4) uninformative hypertensive group: no known history of hypertension, were not taking any antihypertensive medication, and had a measured blood pressure level ≥140 mm Hg systolic and/or ≥90 mm Hg diastolic.

Data Analysis
Differences between those with and without complete data were assessed using Student unpaired t test or Fisher’s exact test. The mean pressure of the last 2 readings for each of SBP and DBP (±SDs) were calculated for each individual. Based on the 1999 guidelines from the WHO-ISH collaboration, individuals were classified according to whether their measured blood pressure levels were within normal limits (no hypertension), were ≥90 mm Hg on diastole (diastolic hypertension), or were ≥140 mm Hg on systole (systolic hypertension). Having either diastolic or systolic hypertension was also classified as having “any” hypertension. The frequency of individuals in each blood pressure control group was calculated. The sociodemographic and clinical details between those with controlled and all uncontrolled (including uninformative hypertensives) hypertension were compared using Fisher’s exact test (categorical variables) or Student unpaired t test (continuous variables). The level of significance was set at a 2-sided P value ≤0.05. All of the analyses were undertaken using Stata 8.0.

Ethics
NEMESIS was approved by the ethics committee at each participating institution. Informed consent was obtained before any interview was conducted.

Results
At 5 years poststroke, 441 (45%) of the 978 first-ever stroke patients were alive. The mean age of survivors was 75±14 years, and 51% were men. Blood pressure was measured in 325 (74%) of those alive at 5 years. Those with blood pressure measurements were older than those without blood pressure measurements. There were no other statistical differences between those with and without blood pressure measurements. Medication data were complete in 358 (81%) survivors, and the questionnaire was completed by 351 (80%) survivors. Those with complete medication data or who completed the questionnaire were older and more often born in Australia than those without these data (P<0.05).

Overall, 305 (69%) individuals had complete data (blood pressure, medication, and questionnaire) and could, therefore, be classified into a blood pressure control group. There were no statistical differences in age, gender, socioeconomic status, baseline stroke severity, or stroke subtype between those with all 3 of the measurements and those who did not have all 3 of the measurements.

Level of Blood Pressure at 5 Years Poststroke
The mean SBP and DBP among 5-year survivors with blood pressure measurements (n=325) are shown in Table 1. Overall, 102 (31%) of the 325 individuals with blood pressure measurements had levels ≥140 mm Hg systolic or ≥90 mm Hg diastolic. Among these, 64 (63%) had isolated systolic hypertension and 13 (13%) had isolated diastolic hypertension, whereas 25 (25%) had both systolic and diastolic hypertension.

Blood Pressure Control Groups
Of those with complete data (n=305), 82% were hypertensive (Table 1), 63% of these having controlled hypertension and 37% having blood pressure levels that were in the hypertensive range (ie, SBP ≥140 mm Hg and/or DBP ≥90 mm Hg). In this latter group 30% had known hypertension, and 7% were unaware that their blood pressure levels were high.

Antihypertensive Medication Use at 5 Years Poststroke
Of those who had complete data on medication use (n=358), 233 (65%) individuals were taking antihypertensive medications at 5 years poststroke. For full information regarding medication usage, please see the online supplement available at http://hyper.ahajournals.org. Of these individuals, 152 (65%)
were taking a single antihypertensive, of which the most common were ACE inhibitors (28% of total taking medication) and diuretics (11%). Fifty seven (24%) were taking 2 antihypertensive medications, the most common combination being an ACE inhibitor with a diuretic (9%), followed by an ACE inhibitor with a β-blocker (4%) or an angiotensin receptor blocker with a calcium channel blocker (4%). The remaining 23 (10%) were taking a single antihypertensive, of which the most frequent was an ACE inhibitor with a β-blocker (3%). In total, there were 24 different combinations of antihypertensive medications being used by 233 individuals.

Within the blood pressure control groups (n = 305), similar proportions of individuals in the controlled (90%) and uncontrolled (82%) hypertensive groups were taking antihypertensive medications (P = 0.2). Overall, 46 (18%) of the 82% with hypertension were not receiving treatment. In an additional 25%, blood pressure was uncontrolled despite receiving treatment with antihypertensive medications.

Within the controlled group, 67% of those taking medication (n = 143) were taking a single antihypertensive agent. This was most commonly an ACE inhibitor (25% of total taking medication). In the uncontrolled group, 60% were taking a single medication. As in the controlled group, this was most commonly an ACE inhibitor (31%). Similar proportions were using 2 antihypertensive medications in the controlled and uncontrolled groups: 26% and 23%, respectively. In the controlled group, this combination was most frequently an ACE inhibitor with a diuretic (6%), whereas in the uncontrolled group, the most common combination was an ACE inhibitor with a β-blocker (10%).

Characteristics of Those With Controlled and Uncontrolled Hypertension

Patients with controlled and uncontrolled hypertension were similar in age, gender, disability, and risk factors (Table 2). Use of different types of antihypertensive agents was also similar apart from the use of an ACE inhibitor with a β-blocker being more commonly used in those whose hypertension was uncontrolled (P = 0.01) and marginally more individuals in the controlled group using the combination of an ACE inhibitor with a diuretic (P = 0.07). People with controlled hypertension were less often aware of diet and medication strategies to manage hypertension than those in the uncontrolled hypertensive group (Table 2).

Discussion

A large proportion of 5-year survivors of stroke in this community-based study were hypertensive (82%). These findings appear to be congruent with data from hospital-based samples of patients. The proportion with hypertension within these samples has been reported to be 60% at 3 months in a community stroke register,4 56% at 1 year after discharge from a stroke unit,15 74% in a 1-year follow-up of consecutive patients in a stroke prevention clinic,4 and 82% within a consecutive sample from a Veteran’s Affairs stroke clinic.16 The greater proportion of people with hypertension in the present study may be attributable to the age difference between the NEMESIS cohort and those in the above-mentioned studies. The mean age of NEMESIS survivors was between 3 and 11 years older than the mean age within the other studies. As the prevalence of hypertension increases with age, this may account for the greater prevalence of hypertension among NEMESIS survivors.17 Another possibility is that the definition of hypertension used within the current study may have led to an overestimate of the prevalence of hypertension. We classified people as hypertensive if their blood pressure measurement was high at a single meeting and when individuals were taking any medications that can be used to treat hypertension. Indeed, classification of an individual as hypertensive usually requires measurement of
blood pressure on >1 occasion, because blood pressure may be unusually high for other reasons. In addition, it is possible that patients taking medications used to treat hypertension may have been taking these medications for another reason. Finally, we may also have counted people as having hypertension when they have “white coat” hypertension, although the fact that blood pressure was measured in the patient’s own home may have minimized the effect of this.

Importantly, among those who were found to be hypertensive, 37% had measured blood pressure levels that were >140 mm Hg systolic or >90 mm Hg diastolic, these being above target levels. A similar prevalence of uncontrolled hypertension (42%) was found in a Veteran’s Affairs stroke clinic after 2 years of follow-up.16 Findings from investigations focused on elderly nonstroke populations also demonstrate that a large proportion of people have uncontrolled hypertension: 41% in a study of Italians18 and 30% among individuals in the Netherlands.19 Although the proportion with uncontrolled and uninformed hypertension (37%) within NEMESIS was comparable to these other studies, the finding is still disappointing and suggests that significant improvements in hypertension management after stroke can be made.

The high prevalence of uncontrolled hypertension may be attributable to noncompliance with treatment, as suggested by Joseph et al16 within their Veteran’s Affairs cohort. In the current study, however, the vast majority of individuals reported being compliant with medication use (data not shown). In addition, both the controlled and uncontrolled groups had similar proportions of individuals on single and combination therapy. Few patients had inappropriate therapy in either group, for example,

### Table 2. Comparison of Controlled and Uncontrolled Hypertensive Patients

<table>
<thead>
<tr>
<th>Variable</th>
<th>Controlled Hypertensive (n = 159)</th>
<th>All Uncontrolled Hypertensives (n = 92)*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age, mean years ± SD</td>
<td>159 77±11</td>
<td>74 76±11</td>
</tr>
<tr>
<td>Female gender</td>
<td>84 53</td>
<td>43 47</td>
</tr>
<tr>
<td>Manual occupation‡</td>
<td>61 46</td>
<td>36 42</td>
</tr>
<tr>
<td>Residing in institution</td>
<td>37 23</td>
<td>20 22</td>
</tr>
<tr>
<td>Disabled‡</td>
<td>77 48</td>
<td>42 91</td>
</tr>
<tr>
<td>Stroke subtype</td>
<td></td>
<td>0.3</td>
</tr>
<tr>
<td>Ischemic stroke</td>
<td>138 87</td>
<td>77 84</td>
</tr>
<tr>
<td>Intracerebral hemorrhage</td>
<td>19 12</td>
<td>11 12</td>
</tr>
<tr>
<td>Undetermined</td>
<td>2 1</td>
<td>4 4</td>
</tr>
<tr>
<td>Ever smoker</td>
<td>101 64</td>
<td>45 61</td>
</tr>
<tr>
<td>Alcohol consumption</td>
<td></td>
<td>0.6</td>
</tr>
<tr>
<td>None</td>
<td>88 56</td>
<td>46 50</td>
</tr>
<tr>
<td>Moderate</td>
<td>61 39</td>
<td>40 44</td>
</tr>
<tr>
<td>Heavy</td>
<td>8 5</td>
<td>6 7</td>
</tr>
<tr>
<td>Treatment‡</td>
<td>143 90</td>
<td>62 84</td>
</tr>
<tr>
<td>Single</td>
<td>96 67</td>
<td>38 60</td>
</tr>
<tr>
<td>Combination</td>
<td>37 26</td>
<td>14 23</td>
</tr>
<tr>
<td>Nonfatal recurrent stroke</td>
<td>18 11</td>
<td>17 19</td>
</tr>
<tr>
<td>Visits to GP per year (mean ± SD)‡</td>
<td>153 14±16</td>
<td>90 12±11</td>
</tr>
<tr>
<td>Lifestyle factors</td>
<td></td>
<td>0.4</td>
</tr>
<tr>
<td>Regular exercise</td>
<td>22 14</td>
<td>16 17</td>
</tr>
<tr>
<td>Salt restriction‡</td>
<td>103 66</td>
<td>55 60</td>
</tr>
<tr>
<td>Awareness of management strategies</td>
<td></td>
<td>0.4</td>
</tr>
<tr>
<td>Exercise</td>
<td>9 6</td>
<td>9† 12</td>
</tr>
<tr>
<td>Diet</td>
<td>7 4</td>
<td>8† 11</td>
</tr>
<tr>
<td>Medication</td>
<td>106 67</td>
<td>61† 80</td>
</tr>
<tr>
<td>GP indicates general practitioner.</td>
<td></td>
<td>0.09</td>
</tr>
</tbody>
</table>

*Includes uncontrolled (n = 74) and uninformed (n = 18) hypertensives. †% unless otherwise indicated. ‡Missing data: n = 33 for occupation data, n = 1 for disability, n = 2 for salt restriction data, and n = 9 for GP visits. §For full treatment information please see the online supplement available at http://hyper.ahajournals.org.

†Denominator uncontrolled group (n = 74) who responded to history of hypertension question.
a calcium channel blocker in combination with a diuretic. There were no statistical differences between the controlled and uncontrolled groups, although the combination of ACE inhibitor with diuretic reached borderline significance ($P=0.07$). Therefore, the uncontrolled blood pressure seen in the present study may be a result of other factors, such as treatment resistance, recent commencement of medications, or lack of physician follow-up. It is evident that most of these factors can be readily addressed.

An interesting finding was that 7% of 5-year survivors who were found to be hypertensive were unaware of their hypertensive status and were not taking any medications for hypertension. Although the level of awareness of hypertension has been reported in the nonstroke elderly literature, this has not been examined previously in a stroke population. Within NEMESIS, this finding could be attributed to several factors. First, the development of hypertension may have been recent and, therefore, not diagnosed by a doctor. Second, the diagnosis of hypertension was required to be recalled by the case, and it may be that the individuals could not recall being told by a doctor that they were hypertensive. Furthermore, they may not have considered that they were hypertensive, because they were not being treated for hypertension.

The overall proportion of hypertensive people not being treated for hypertension was low (18%). This is similar to that reported for other stroke and nonstroke elderly populations. In terms of stroke populations, the prevalence of nontreatment has been reported to be 9% in a 1 year follow-up of stroke unit patients, 14% within a Veteran’s Affairs stroke prevention clinic over a 2-year period, and 30% at 3 month poststroke in the South London Stroke Register. From elderly nonstroke populations, the proportion of nontreatment has been reported to be 18% in the Netherlands and 41% in men and 22% in women in Sweden. Within the blood pressure control groups in the present study, those with controlled blood pressure had a similar proportion of people not treated (10%) as the uncontrolled group (16%). It is important to note that nontreatment does not imply an absence of management of hypertension altogether. It may be that individuals not taking medications may be using other lifestyle strategies, such as dietary changes, weight loss, or exercise to manage their hypertension. However, given the high cardiovascular risk of these people and in light of the WHOISH guidelines, an aim should be to ensure that all stroke survivors with hypertension are treated with antihypertensive medication.

People with controlled and uncontrolled hypertension were similar in all characteristics apart from their awareness of management strategies for hypertension. Those with uncontrolled hypertension recalled this information more often than those in the controlled group. It may be that those in the uncontrolled group had hypertension that was more difficult to control or more severe than those in the controlled group. This may have made those in the uncontrolled group more aware of hypertension and its treatments. Because no other systematic differences between the groups were found, this provides evidence that all stroke patients may benefit from greater education about hypertension as a risk factor for stroke and cardiovascular disease, along with the treatments for hypertension.

There are some limitations to this study. First, blood pressure measurements were taken on a single day. This was overcome by taking measurements after the individual had been at rest for ≥10 minutes. Also, ≥3 measurements were taken, with a recovery period in between in each measurement. Second, the use of antihypertensive medication was assumed to mean a history of hypertension. It is acknowledged that a proportion of individuals would have been taking these medications for indications other than hypertension. This may have lead to an overestimation of individuals with controlled hypertension.

These data provide novel information regarding the level of hypertension control among stroke survivors in the long term after stroke. The proportion of 5-year survivors with hypertension was high (82%). Of these individuals, 37% had blood pressure that was above recommended levels. A large proportion of these individuals were not being treated with antihypertensive medications (33%). In the remaining 67%, blood pressure targets were not achieved despite treatment with medications.

**Perspectives**

This is the first exploration of long-term blood pressure management within a community-based stroke study. Indeed, in a community setting it is the only assessment of blood pressure management beyond 3 months poststroke. These data demonstrate that among a group of people who have suffered a stroke and are, therefore, at high risk of suffering a recurrent stroke, a substantial proportion are not receiving optimal management. Identification of those more likely to have poor management of hypertension after stroke may lead to improved treatment. Furthermore, increased education of those who suffer a stroke and their families about hypertension and the management of hypertension, both in terms of medication and lifestyle changes, has the potential to improve the control of hypertension among this high-risk population. Together, these strategies may help reduce the overall burden of this disease.

**Acknowledgments**

The contribution of the following research nurses is acknowledged: Steve Cross, Jean McLean, Sue Mosley, Mary Staios, and Cathy Taranto. Li Chun Quang provided assistance with data management.

**Sources of Funding**

This work was supported by grants from the National Health and Medical Research Council, the Victorian Health Promotion Foundation, the Foundation for High Blood Pressure Research, and the National Stroke Foundation. S.P. was supported by a VicHealth Public Health Post-Graduate Scholarship.

**Disclosures**

None.

**References**

1. PROGRESS collaborative group. Randomised trial of a perindopril-based blood-pressure-lowering regimen among 6105 individuals with previous stroke or transient ischaemic attack. Lancet. 2001;358:1033-1041.


Control of Hypertension 5 Years After Stroke in the North East Melbourne Stroke Incidence Study
Seana L. Paul and Amanda G. Thrift

Hypertension. published online June 19, 2006;
Hypertension is published by the American Heart Association, 7272 Greenville Avenue, Dallas, TX 75231
Copyright © 2006 American Heart Association, Inc. All rights reserved.
Print ISSN: 0194-911X. Online ISSN: 1524-4563

The online version of this article, along with updated information and services, is located on the World Wide Web at:
http://hyper.ahajournals.org/content/early/2006/06/19/01.HYP.0000230610.81947.04.citation

Data Supplement (unedited) at:
http://hyper.ahajournals.org/content/suppl/2006/07/25/01.HYP.0000230610.81947.04.DC1

Permissions: Requests for permissions to reproduce figures, tables, or portions of articles originally published in Hypertension can be obtained via RightsLink, a service of the Copyright Clearance Center, not the Editorial Office. Once the online version of the published article for which permission is being requested is located, click Request Permissions in the middle column of the Web page under Services. Further information about this process is available in the Permissions and Rights Question and Answer document.

Reprints: Information about reprints can be found online at:
http://www.lww.com/reprints

Subscriptions: Information about subscribing to Hypertension is online at:
http://hyper.ahajournals.org//subscriptions/