

Prescription of antihypertensive medication at discharge influences survival following stroke

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Abstract

Objective

To investigate the risk of death from cardiovascular disease between patients who were and were not prescribed antihypertensive medication following stroke or TIA.

Methods

This was a large cohort study using routinely collected prospective data from the Australian Stroke Clinical Registry. Patients registered between 2009 and 2013 who were discharged to the community or rehabilitation were included. Cases were linked to the National Death Index to determine the date and cause of death. Propensity score matching with stratification was utilized to compare between similar subgroups of patients. Multivariable competing risks regression, with noncardiovascular death as a competing risk, was conducted to investigate the association between the prescription of antihypertensive medications and cardiovascular death at 180 days after admission.

Results

Among 12,198 patients from 40 hospitals, 70% were prescribed antihypertensive medications. Patients who were older, were treated in a stroke unit, and had better socioeconomic position were more often discharged from hospital with an antihypertensive medication. Including only patients within propensity score quintiles with acceptable levels of balance in covariates between groups ($n = 8,786$), prescription of antihypertensive medications was associated with a 23% greater reduction in the subhazard of cardiovascular death compared to those who were not prescribed these agents (subhazard ratio 0.77; 95% confidence interval 0.61 to 0.97).

Conclusions

People who are prescribed antihypertensive medications at discharge from hospital after a stroke or TIA demonstrate better cardiovascular and all-cause survival outcomes than those not prescribed these agents.

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Glossary

AHA = American Heart Association; AuSCR = Australian Stroke Clinical Registry; CI = confidence interval; CVD = cardiovascular disease; ICD-10 = *International Classification of Diseases–10*; ICH = intracerebral hemorrhage; IRSAD = Index of Relative Advantage and Disadvantage; NDI = National Death Index; SHR = subhazard ratio.

The risk of cardiovascular disease (CVD) can be reduced by up to 31% and all-cause mortality by 13% with the use of antihypertensive medications.^{1,2} The recommendation by the American Heart Association (AHA) in 2011 that antihypertensive medications should be provided to all patients “beyond the first 24 hours” of stroke or TIA unless contraindicated³ was based on the results of the Perindopril Protection Against Recurrent Stroke Study (PROGRESS) clinical trial.⁴ In this trial, antihypertensive medications were beneficial for those with high and normal blood pressure.⁴

More recent evidence^{5–7} has raised doubt on the benefit of blood pressure lowering too early following ischemic stroke, but not for other stroke types.^{8–10} Consequently, the 2014 AHA guidelines were more conservative, with recommendations that antihypertensive therapy should be initiated or resumed after “the first several days” of the stroke.¹¹ Although most patients are discharged from acute care several days after stroke onset, there is now uncertainty among clinicians as to whether or not patients should be prescribed these medications prior to discharge from acute hospital care,^{12,13} as evidenced by recent declines in patients with all stroke types being prescribed these agents at discharge.¹⁴ The use of data from clinical registries can provide important population-based perspectives on how antihypertensive therapies are incorporated into routine clinical discharge practices.

We aimed to examine differences in the risk of death due to CVD among patients with stroke or TIA discharged to the community or rehabilitation between those who were and were not prescribed antihypertensive medication.

Methods

Data sources

This was a large retrospective cohort study using routinely collected prospective data from the Australian Stroke Clinical Registry (AuSCR). The AuSCR is a national database designed to monitor the quality of acute care provided to patients who are hospitalized with stroke or TIA, excluding subarachnoid hemorrhage. Eligible cases were identified using a clinical diagnosis of stroke or TIA, i.e., determined by a clinician, based on diagnostic assessments rather than relying on ICD-10 primary discharge diagnosis codes, which are determined by administrative coders. This method is consistent with other national registries.^{16,17} See table e-1 (links.lww.com/WNL/A192) for the specific definitions used. In situations where the clinical diagnosis was missing or undetermined, the ICD-10 codes were used to differentiate among infarct, intracerebral

hemorrhage (ICH), or TIA (103 cases, 0.8%). Patient data were entered into the registry prospectively by clinicians, from participating hospitals, who were provided with a data dictionary and standardized training. In-built logic checks, data quality checks by registry staff, and medical record audits undertaken by external auditors were used to ensure data quality. Data on date and underlying cause of death were provided for all AuSCR registrants through annual linkages with the National Death Index (NDI), a national registry of deaths held by the Australian Institute of Health and Welfare (specificity and sensitivity >98% between AuSCR and death registry data for in-hospital deaths; unpublished AuSCR data).

A nationally endorsed clinical minimum dataset, collected for each episode of care, included clinical and demographic data as well as information on clinical care performance measures. The AuSCR is one of the few national stroke registries that monitors the prescription of antihypertensive medications at discharge.¹⁷ All registrants who are alive at discharge are considered eligible to receive antihypertensive medications because only a small proportion of patients (2%–3%) have contraindications to receiving these medications (unpublished data from the Stroke Foundation¹⁴).

In the AuSCR data dictionary, antihypertensive medication is defined as

Antihypertensive agents commonly include angiotensin converting enzyme inhibitors (e.g., Perindopril, Ramipril) with or without diuretic and angiotensin II receptor antagonists (e.g., Telmisartan, Losartin) with or without diuretic. Other agents include alpha blockers (e.g., Prazosin), beta blockers (e.g., Atenolol, Metoprolol), calcium channel blockers (e.g., Amlodipine, Diltiazem hydrochloride) and thiazide diuretics (refer to Monthly Index of Medical Specialties for full list).

Patients who are continuing with previously prescribed antihypertensive medications or who have been prescribed these medications for the first time during their admission are recorded as having been discharged on these medications.

Data coding and analysis

In this study we included adults (aged ≥18 years) with a first episode of stroke or TIA, registered in the AuSCR database between 2009 and 2013, who were discharged home, to residential care, or to inpatient rehabilitation. This time delay provided an allowance of up to 2 years for receiving information on the underlying cause of death for any potential deaths within 180 days of admission. We excluded those who experienced an in-hospital stroke (4% excluded). These restrictions ensured that patients who may have been

transferred to end-of-life care were not included in the analyses. Patients were considered not to have been prescribed an antihypertensive medication if this indicator was coded as “no,” “unknown,” or where a response was missing in the database (2% of data were missing). Following these adjustments, missing data were present in 4 of the covariates used (<1% for age, sex, and stroke type and 9% for ability to walk on admission) and were excluded from the denominators. Socioeconomic position of registrants was derived using the Index of Relative Advantage and Disadvantage (IRSAD) provided by the Australian Bureau of Statistics.¹⁸ Greater IRSAD scores indicate lesser relative disadvantage.

As our primary outcome was death due to CVD, we excluded registrants who were known to have died within 180 days of their stroke admission (i.e., had a recorded date of death) but had a missing cause of death (n = 94, 11% of deaths). This was because it was not possible to categorize them as having died of CVD for the competing risk analysis (figure 1). Sensitivity analyses were performed to examine the effect of this exclusion on our results. In the first sensitivity analysis, the deaths with an unknown cause were classified as being due to CVD, and in the second, the deaths with an unknown cause were classified as being due to a non-CVD cause.

Statistics

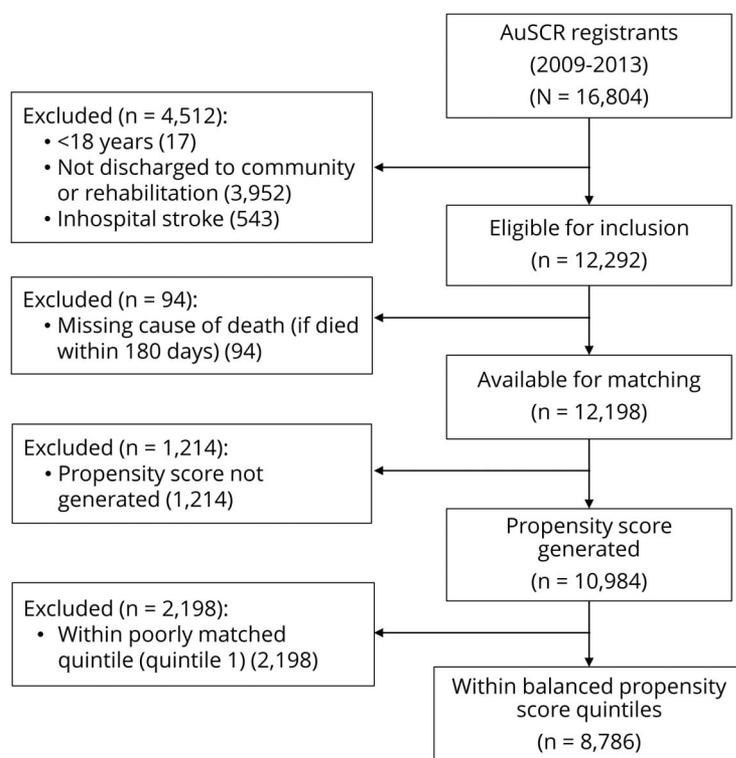
Mann-Whitney *U* tests and χ^2 tests were used to assess differences between those who were and were not prescribed

antihypertensive medications at discharge. As there may be reasons, valid or otherwise, as to why some patients are not prescribed antihypertensive medication, we used propensity score matching to minimize confounding by indication. Matching on propensity scores is commonly used in non-randomized studies to account for differences between individuals who do and do not receive a treatment based on the probability that they will receive the treatment.^{19–21}

A propensity score was generated for each registrant, using multivariable logistic regression, based on the probability of being prescribed antihypertensive medication at discharge (dependent variable). Eleven independent clinical and demographic variables (table 1), shown to be associated with prescription of antihypertensive medication or death at 180 days on univariable analysis, were included in the model. Ability to walk on admission was used as a measure of stroke severity and has been shown to be a reliable predictor of death in large population samples.^{22,23} Discharge destination (categorized as home, inpatient rehabilitation, or residential care) was also included because this is decided prior to prescription of medications at discharge, is often related to severity of disability, and may therefore influence clinical decision-making.

After fitting the model, registrants were ranked according to their propensity score and categorized into quintiles; 5 strata are recommended to remove approximately 90% of bias

Figure 1 Flow diagram of patient exclusions



AuSCR = Australian Stroke Clinical Registry.

Table 1 Baseline characteristics by prescription of antihypertensive medications at discharge prior to stratification by propensity score

	Prescribed antihypertensive medication at discharge, n (%)		p Value
	No, n = 3,616	Yes, n = 8,582	
Received care in a stroke unit	2,728 (75)	7,168 (84)	<0.001
Age, y^a			
<65	1,351 (38)	1,944 (23)	
65–74	760 (21)	2,161 (25)	<0.001
75–84	867 (24)	2,790 (33)	
85+	608 (17)	1,626 (19)	
Female^a	1,623 (45)	3,819 (45)	0.7
Able to walk on admission (stroke severity measure)^b	1,688 (54)	3,803 (48)	<0.001
Stroke type^a			
Intracerebral hemorrhage	391 (11)	782 (9)	
Ischemic	2,156 (60)	5,725 (67)	<0.001
TIA	886 (25)	1,852 (22)	
Unknown cause	169 (5)	221 (3)	
Index of relative socioeconomic advantage and disadvantage^c			
Quintile 1	674 (19)	1,459 (17)	
Quintile 2	530 (15)	1,490 (17)	
Quintile 3	550 (15)	1,419 (17)	<0.001
Quintile 4	651 (18)	1,705 (20)	
Quintile 5	1,211 (33)	2,509 (29)	
Transfer	435 (12)	821 (10)	<0.001
Discharge destination			
Home	2,448 (68)	4,927 (57)	
Rehabilitation	858 (24)	3,122 (36)	<0.001
Residential care	310 (9)	533 (6)	
Year of admission			
2009	129 (4)	432 (5)	
2010	325 (9)	1,087 (13)	
2011	510 (14)	1,413 (16)	<0.001
2012	1,234 (34)	1,987 (23)	
2013	1,418 (39)	3,663 (43)	

Table 1 Baseline characteristics by prescription of antihypertensive medications at discharge prior to stratification by propensity score (continued)

	Prescribed antihypertensive medication at discharge, n (%)		p Value
	No, n = 3,616	Yes, n = 8,582	
Previous stroke	644 (18)	1,714 (20)	0.006
Interpreter required	144 (4)	405 (5)	0.07

^a Missing data (<1%).

^b Missing data (9%).

^c Lower quintiles indicate a greater level of social disadvantage.

resulting from certain types of patients being preferentially allocated to certain treatments.^{21,24} Data were then analyzed within strata rather than matching on the propensity score. This method was chosen as it enabled us to retain almost all of our sample, thereby maximizing the external validity of our results, an important feature of clinical registries.²⁴ Each stratum was assessed for balance in baseline characteristics between treated and untreated groups based on standardized differences in the mean or prevalence.^{25,26} An SD of <0.1 indicated a negligible difference between those who were and were not prescribed antihypertensive medication at discharge, i.e., optimal matching for that covariate.¹⁹

Multivariable competing-risk regression, in which deaths due to non-CVD causes were the competing risk, was used to assess the association between prescription of antihypertensive medications at discharge and deaths due to CVD. Competing-risks regression enabled us to account for potential bias due to death from non-CVD causes. The statistical analysis was undertaken with STATA IC version 12. The assumptions for this model are as per Fine and Gray,¹⁵ a semiparametric, subdistribution model. Postestimation tests to confirm assumptions of proportionality were undertaken. Graphically, the Schoenfeld residuals appeared to be relatively constant over time (figure e-1, links.lww.com/WNL/A191), with a significance of $p = 0.0204$, which was considered acceptable given our large sample size. For comparison, a Cox proportional hazard regression was also conducted for death from any cause. Models were run separately for each propensity score quintile. An overall model, using bootstrap standard errors to account for the variability in estimation,²⁶ was also run in which the propensity score from each individual quintile was included as a covariate in the model. The overall regression analyses were repeated excluding strata with poor balance on baseline differences based on SDs. All models were adjusted for patient clustering by hospital.

Standard protocol approvals, registrations, and patient consents

Hospitals participating in the registry are required to obtain ethics approval before commencing data collection. To minimize selection bias, an opt-out method of consent is used.

The annual opt-out rate for acute demographic and clinical data for the study period was <3% each year.²⁷ Additional ethics approval was also obtained from the Australian Institute of Health and Welfare to allow linkage with the NDI.

Results

A total of 12,198 patients from 40 hospitals were included. The proportion prescribed antihypertensive medication at discharge was 70%, with large variations between hospitals (range 44%–89%; see figure e-2, links.lww.com/WNL/A191). Among this cohort, 45% were female, 65% had experienced an ischemic stroke, and the median age was 74 years. Most (60%) were discharged directly to home, 33% to rehabilitation, and 7% to residential care. The median length of stay was 7 days for those with an ICH, 6 days for those with ischemic stroke, and 2 days for those with TIA.

All the variables included in the calculation of our propensity score were associated either with prescription of antihypertensive medications at discharge or with death due to CVD at 180 days after their admission or both (table 1). Older patients (aged >65 years), those treated in a stroke unit, and those with greater socioeconomic advantage were more likely to be prescribed antihypertensive medications at discharge. At 180 days following their acute hospital admission, 785 patients who survived their hospitalization had died (7%) and 521 (66%) of these deaths were due to CVD. Other common causes of death were neoplasms (15%), endocrine and metabolic disorders (6%), and respiratory disorders (4%).

Propensity scores, based on the odds of being discharged on antihypertensive medication, were able to be generated for 10,984 (90%) eligible registrants. The fit of the model used to derive the propensity score had acceptable discrimination (area under the receiver operating curve of 0.7) and calibration (Hosmer-Lemeshow test $\chi = 4,713$, $p = 0.13$). The mean variance inflation factor was acceptable at 1.12 (range 1.02, 1.28). The distribution of the propensity scores for the full sample and the sample excluding quintile 1 is displayed in figure e-3 (links.lww.com/WNL/A191). Following stratification by propensity scores, those who were and were not prescribed antihypertensive medication at discharge were well-matched within quintiles 2 and 3 (i.e., negligible difference, SD < 0.1) for all covariates used to estimate the propensity score. There were small differences in the SD for some covariates (SD 0.1–0.16) for the other strata, with the greatest heterogeneity being observed in quintile 1 (imbalance in 4 of the 11 variables included in the propensity score development) (table e-2, links.lww.com/WNL/A192).

For the strata in which all covariates were balanced, there was a 36%–37% reduction in the subhazard of death due to CVD at 180 days following stroke admission (quintile 2 subhazard ratio [SHR] 0.64, 95% confidence interval [CI] 0.43–0.97 and quintile 3 SHR 0.63, 95% CI 0.46–0.86) (table 2, figure 2). In

the overall model, excluding quintile 1, there was a 23% reduction in the subhazard of death due to CVD associated with the prescription of antihypertensive medication (SHR 0.77, 95% CI 0.61–0.97). Similar results were found for the outcome of all-cause death, where covariates were balanced between groups (table 2; figures 2 and 3). In a sensitivity analysis, analogous results were found when we ran our analyses including patients with a documented date but missing cause of death ($n = 94$, 11%) re-classified as having (1) a CVD or (2) a non-CVD cause of death (table e-3, links.lww.com/WNL/A192).

Discussion

The major finding from this large observational study is that prescription of antihypertensive medications at discharge from acute care following stroke or TIA was associated with improved survival at 180 days after admission. This finding was robust and clinically relevant irrespective of the outcome assessed (death due to CVD or all-cause deaths). The difference in outcomes between those prescribed and not prescribed antihypertensive medications was greatest for propensity score quintiles in which there was balance between the groups in covariates used to develop the score (i.e., the strata with the least chance that the effect of prescription of antihypertensive medication would be confounded).

The context of our findings is different from those from clinical trials in this area. We specifically investigated whether patients were prescribed a blood pressure–lowering medication at discharge. Patients in our observational study did not necessarily commence or restart blood pressure–lowering therapy in the first few days following stroke. In clinical trials, such as the Scandinavian Candesartan Acute Stroke Trial,⁵ where outcomes were poorer in people on blood pressure–lowering therapy than those who were not, all patients commenced therapy during hospitalization and sometimes on the same day as the stroke.

Findings from our study are critical to understanding the benefits of clinician prescription of antihypertensive medications as part of discharge planning in acute stroke care. Prescribing these medications in the acute hospital setting has been shown to be associated with long-term adherence to medications,²⁸ improved long-term control of blood pressure,²⁹ and continued prescription.³⁰ It may be that medications prescribed within this setting are perceived as being more important by the patient, leading to better adherence. Furthermore, once the patient is in the community, patients may not be prescribed antihypertensive medications due to lapses in continuity of care. Up to a quarter of patients do not have an appointment with a doctor within 3 months of their stroke.^{31,32}

We did not achieve balance in clinical and demographic characteristics within all propensity score quintiles. These

Table 2 Effect of prescription of antihypertensive medication at discharge on death due to cardiovascular disease (CVD) at 180 days after hospital admission by quintiles based on propensity scores and overall

	Propensity score		Alive 180 days, n (%)	Died (CVD), n (%)	Died (non-CVD), n (%)	CVD death within 180 days, subhazard ratio (95% CI)	Death within 180 days, hazard ratio (95% CI)
	Median (range)	n					
Full sample unadjusted							
Antihypertensives	NA	8,582	517 (6)	351 (4)	166 (2)	0.86 (0.67, 1.11)	0.80 (0.69, 0.94)
No antihypertensives	NA	3,616	268 (7)	170 (5)	97 (3)		
Quintile 1							
Antihypertensives	0.56 (0.30, 0.62)	1,177	1,115 (95)	39 (3)	23 (2)	1.3 (0.6, 2.8)	0.92 (0.62, 1.35)
No antihypertensives	0.54 (0.26, 0.62)	1,021	963 (94)	26 (3)	32 (3)		
Quintile 2							
Antihypertensives	0.67 (0.62, 0.70)	1,442	1,356 (94)	64 (4)	22 (2)	0.64 (0.43, 0.97)	0.69 (0.46, 1.02)
No antihypertensives	0.66 (0.62, 0.70)	755	691 (92)	51 (7)	13 (2)		
Quintile 3							
Antihypertensives	0.74 (0.70, 0.77)	1,644	1,541 (94)	75 (5)	28 (2)	0.63 (0.46, 0.86)	0.61 (0.44, 0.85)
No antihypertensives	0.74 (0.70, 0.77)	552	497 (90)	39 (7)	16 (3)		
Quintile 4							
Antihypertensives	0.80 (0.77, 0.82)	1,745	1,649 (95)	61 (4)	35 (2)	0.99 (0.58, 1.67)	1.08 (0.75, 1.57)
No antihypertensives	0.79 (0.77, 0.82)	453	430 (95)	16 (4)	7 (2)		
Quintile 5							
Antihypertensives	0.85 (0.82, 0.91)	1,862	1,727 (93)	92 (5)	43 (3)	1.3 (0.72, 2.24)	0.80 (0.55, 1.15)
No antihypertensives	0.85 (0.82, 0.91)	333	303 (91)	13 (4)	17 (5)		
Overall excluding quintile 1							
Antihypertensives	0.78 (0.62, 0.91)	6,693	6,950 (94)	312 (4)	143 (2)	0.77 (0.61, 0.97)	0.74 (0.64, 0.87)
No antihypertensives	0.74 (0.62, 0.91)	2,093	2,385 (92)	144 (6)	65 (3)		
Overall							
Antihypertensives	0.75 (0.67, 0.82)	7,870	7,388 (94)	331 (4)	151 (2)	0.84 (0.64, 1.11)	0.78 (0.65, 0.92)
No antihypertensives	0.67 (0.58, 0.77)	3,114	2,884 (93)	145 (5)	85 (3)		

Abbreviation: CI = confidence interval.

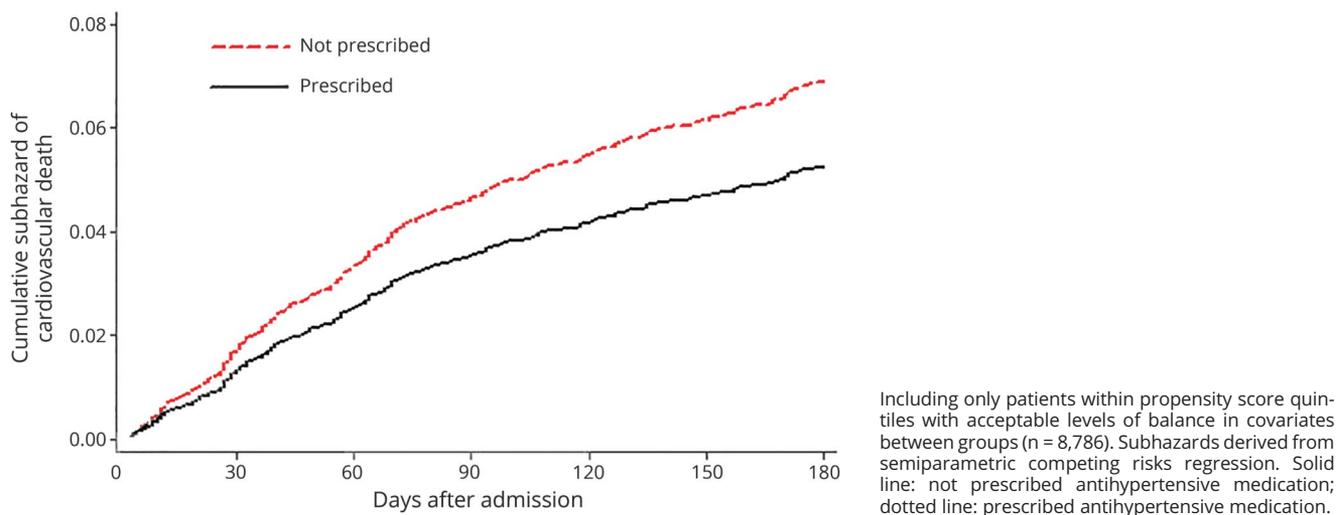
differences are caused by patients in the dataset with outlying characteristics. Patients in the propensity score strata with the greatest imbalance of covariates (quintile 1) had the greatest proportion of patients aged <65 years. This group is likely to have better survival outcomes compared to their older counterparts, regardless of their management. This may have influenced the outcomes observed in quintile 1 (table e-2, links.lww.com/WNL/A192).

Not having a measure of blood pressure in the dataset is a limitation and means that patients who were not provided antihypertensive therapy due to contraindications such as low blood pressure were included in these analyses. Another

common reason for not prescribing antihypertensive medication is the associated greater risk of falls in the elderly.^{33,34} There is also recent evidence from community-based studies or post hoc analyses of clinical trial data that low blood pressure is associated with poor outcomes in survivors of stroke.^{35–37} The inability to account for these contraindications would underestimate the risk differences between patients prescribed and not prescribed antihypertensive medications. However, only about 3% of patients with stroke have a contraindication to antihypertensive therapy.

We additionally adjusted for potential sources of unmeasured confounding through stratification by propensity score and

Figure 2 Cumulative subhazard of death due to cardiovascular disease

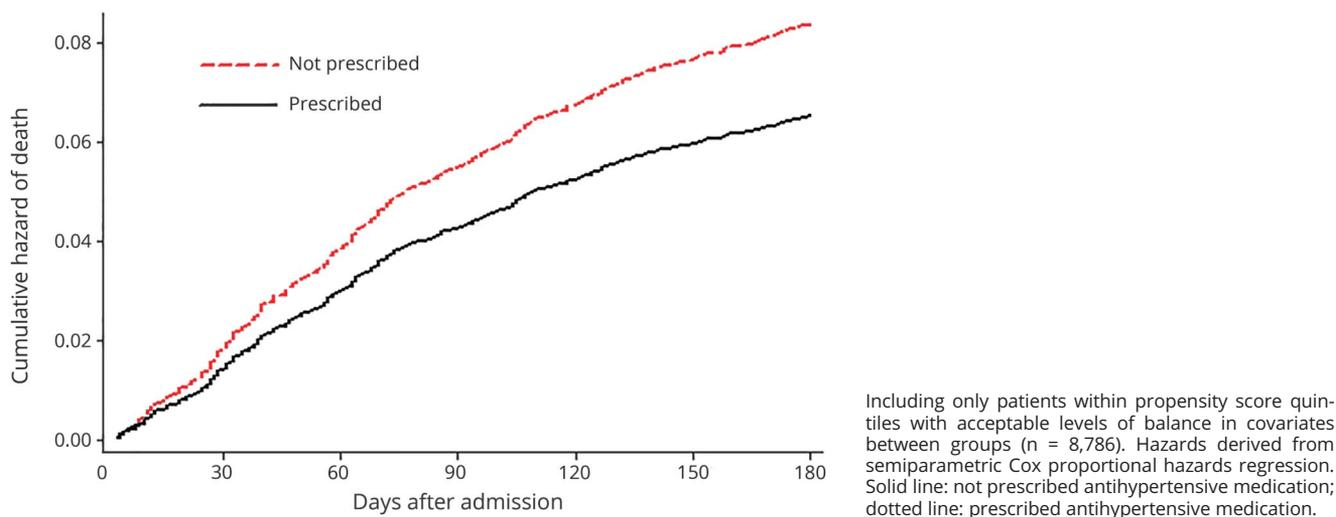


exclusion of those in the poorly matched stratum. Exclusion of the poorly matched stratum increased the internal validity of our findings at the expense of external validity (generalizability). As is common with registry datasets, our analyses were limited to variables routinely collected in the registry. This limited the scope of our analyses and our ability to account for all possible confounding factors, such as comorbidities, in our analyses. It is unlikely that this would greatly affect our findings. In yet to be published work by the authors, the addition of a comorbidity index derived from patient-level administrative data and merged with the AuSCR data increased the predictive ability of the registry only model for survival by <1%.

Another limitation was missing cause of death for a small number of patients. However, including these missing data in

sensitivity analyses resulted in no change in the primary interpretation of our results. We also do not know whether patients utilized the medications they were prescribed at discharge from hospital or whether some patients were prescribed medications after discharge. However, these scenarios would have biased our results towards the null and led to a possible underestimation of our effect sizes. In future work, the AuSCR data will be linked to the Australian Pharmaceutical Benefits Schedule database to provide more robust data with regards to adherence and persistence with these medications. Patients with mild stroke or TIA who were not admitted to hospital and managed entirely in ambulatory services would not have been captured in our study. Thus, our results pertain to patients admitted to hospital. Finally, the number of outcomes in the cohort was not large enough to

Figure 3 Cumulative hazard of death



permit subgroup analyses such as stratification by age groups or type of stroke.

There remains uncertainty regarding the optimal timing to prescribe antihypertensive medications after a stroke. Due to the indisputable benefit of lowering blood pressure, ethical approval to conduct clinical trials to unequivocally answer this question is challenging. Using appropriate statistical techniques and a real-world sample of patients with stroke and TIA, we provide evidence that can be used to support the provision of antihypertensive medications at discharge from hospital after stroke, as is common practice in Australia and other countries.

Author contributions

N.E.A.: drafting of the manuscript, literature review, analysis of data, interpretation of the data. J.K.: drafting of the manuscript, literature review, analysis of data, interpretation of the data. A.G.T.: drafting of the manuscript, conceptualization and design of the study, revisions and interpretation of the data. M.F.K.: drafting of the manuscript, contribution to data analysis methods, revisions and interpretation of the data. N.A.L.: conceptualization and design of the study, revisions and interpretation of the data. C.S.A.: conceptualization and design of the study, revisions and interpretation of the data. G.A.D.: conceptualization and design of the study, revisions and interpretation of the data. K.H.: conceptualization and design of the study, revisions and interpretation of the data. S.M.: conceptualization and design of the study, revisions and interpretation of the data. C.L.: conceptualization and design of the study, revisions and interpretation of the data. S.F.: conceptualization and design of the study, revisions and interpretation of the data. R.G.: conceptualization and design of the study, revisions and interpretation of the data. N.G.: acquisition of data, revisions and interpretation of the data. R.G.: acquisition of data, revisions and interpretation of the data. S.E.: acquisition of data, revisions and interpretation of the data. D.A.C.: conceptualization and design of the study, supervision of analyses, interpretation of the data.

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Prescription of antihypertensive medication at discharge influences survival following stroke

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Study question

How do antihypertensive medication prescriptions influence the risk of cardiovascular death in patients who have survived strokes or TIAs?

Summary answer

Cardiovascular and all-cause mortality rates are lower for patients who are prescribed antihypertensive drugs at discharge than for those who are not.

What is known and what this paper adds

The American Heart Association recommends that patients who survive a stroke be prescribed antihypertensive drugs, but some studies have questioned the benefits in patients with ischemic stroke. This study, conducted in Australia, provides evidence for the utility of antihypertensive drugs for patients who survive strokes or TIAs.

Participants and setting

The authors examined 12,198 patients who were enrolled in the Australian Stroke Clinical Registry (AuSCR) between 2009 and 2013 and discharged to the community or rehabilitation.

Design, size, and duration

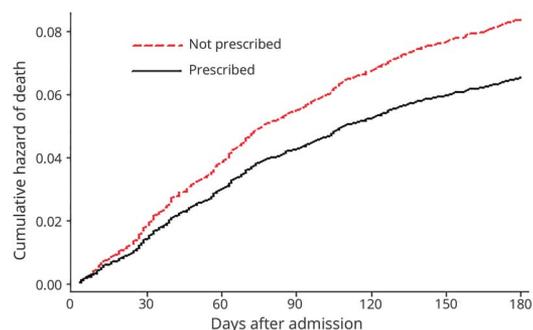
The authors retrospectively accessed the AuSCR for clinical and outcome data including antihypertensive prescriptions at discharge from acute care hospitals. Propensity scores were calculated based on various factors associated with antihypertensive prescriptions, and on death at 180 days. These scores were used to stratify patients into propensity score quintiles for multivariable competing-risks regression with cardiovascular death as a competing risk.

Primary outcomes

The primary outcome was cardiovascular death within 180 days of hospital admission.

Main results and the role of chance

Of the patients, 70% were prescribed antihypertensive drugs at discharge from 40 hospitals, and 785 (7%) died within 180 days of admission. Of those deaths, 521 (66%) were from cardiovascular events. The authors successfully calculated



propensity scores for 10,984 (90%) patients. A multivariable regression model excluding the lowest propensity score quintile (due to its high heterogeneity) showed that antihypertensive drug prescriptions were associated with a 26% reduction in the risk of all-cause death (hazard ratio, 0.74; 95% CI, 0.64–0.87) and a 23% reduction in the risk of cardiovascular death (sub-hazard ratio, 0.77; 95% CI, 0.61–0.97).

Bias, confounding, and other reasons for caution

Contraindications against antihypertensive drug prescription could not be taken into account, and the cause of death was unknown for some patients.

Generalizability to other populations

A subgroup that had poor matching of characteristics (i.e., those in the lowest propensity quintile) between treated and untreated patients were excluded. This subgroup had the greatest proportion of patients aged less than 65 years. This may limit generalizability to relatively young patients.

Study funding/potential competing interests

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A draft of the short-form article was written by M. Dalefield, a writer with Editage, a division of Cactus Communications. The authors of the full-length article and the journal editors edited and approved the final version.