Quality Measures in Stroke

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Abstract

Stroke is a major public health burden, and accounts for many hospitalizations each year. Due to gaps in practice and recommended guidelines, there has been a recent push toward implementing quality measures to be used for improving patient care, comparing institutions, as well as for rewarding or penalizing physicians through pay-for-performance. This article reviews the major organizations involved in implementing quality metrics for stroke, and the 10 major metrics currently being tracked. We also discuss possible future metrics and the implications of public reporting and using metrics for pay-for-performance.

Keywords

stroke, cerebrovascular disorders, quality < techniques

More than 795 000 strokes occur in the United States annually, and stroke accounts for 889 000 hospitalizations per year.¹ Despite published evidence-based guidelines for stroke care, there remain inconsistencies in how these are applied, leading to a recent push toward measuring and improving the quality of care provided to these patients. Several organizations have created guidelines involving measures of quality, including the Joint Commission (Primary Stroke Center Certification), the American Stroke Association (Get With the Guidelines), the Centers for Disease Control (Paul Coverdell Registry), the National Quality Forum (NQF), and most recently the Centers for Medicare and Medicaid Services (CMS).² These organizations have both independently and collaboratively established quality metrics associated with health care delivery in the inpatient care of patients with stroke, some of which have been distinguished as “performance measures” or metrics that are suitable for public reporting and may be used for comparing institutions and rewarding those who meet specific thresholds (“pay for performance”).³ Quality metrics and performance measures typically focus on processes of care based on specific recommendations in clinical guidelines, and ideally are based on sufficient evidence that failure to provide the recommended care is likely to result in suboptimal clinical outcomes.³ Most stroke registries and quality measurement programs are currently based on voluntary participation, which is in line with the Physician Quality Reporting Initiative, an incentive-based quality reporting system established as part of the 2006 Tax Relief and Health Care Act. In a major shift of perspective from incentive- to disincentive-based systems, however, CMS has recently announced their intention to likely include the NQF-endorsed stroke measures as part of the Reporting Hospital

Quality Data for Annual Payment Update (RHQDAPU) initiative.⁴ Beginning with inpatient discharges in Fiscal Year 2011, most hospitals will be required to report these measures in order to receive full Medicare payments.

Since many registries and organizations have published guidelines for stroke quality measures, they differ somewhat from one another. Beginning in January 2008, a set of 10 performance measures for inpatient acute stroke care was agreed upon by 3 major stakeholders: the Joint Commission, the American Stroke Association, and the Centers for Disease Control, as part of the Stroke Performance Measure Consensus Group. All 10 measures apply to the care of acute ischemic strokes, and 5 of them also apply to hemorrhagic stroke subtypes. Eight of these measures were endorsed by the NQF, and more recently, CMS has announced that these 8 measures will be included in the RHQDAPU initiative.² The 10 harmonized performance measures (Table 1) will be discussed below, along with evidence supporting them.

Acute Treatment

Intravenous Thrombolysis (Ischemic Stroke Only)

Intravenous administration of recombinant tissue plasminogen activator (rtPA) was approved by the FDA for treatment of

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Table 1. Harmonized Performance Measures of the Major QI Organizations

Performance Measure	Stroke Subtypes	Endorsing QI Organizations
Acute treatment		
Thrombolytic therapy: administered within 180 minutes in patients arriving within 2 hours of symptom onset	Ischemic	CDC, AHA, TJC, NQF, CMS
Early treatment with antithrombotics: initiated by the end of hospital day 2.	Ischemic	CDC, AHA, TJC, NQF, CMS
In-hospital management		
Dysphagia screening: bedside swallow evaluation prior to anything by mouth	Ischemic, hemorrhagic	CDC, AHA
Venous thromboembolism prophylaxis: initiated by the end of hospital day 2	Ischemic, hemorrhagic	CDC, AHA, TJC, NQF, CMS
Rehabilitation assessment	Ischemic, hemorrhagic	CDC, AHA, TJC, NQF, CMS
Secondary stroke prophylaxis		
Antithrombotic therapy: prescribed at discharge	Ischemic	CDC, AHA, TJC, NQF, CMS
Anticoagulation: prescribed at discharge for patients with atrial fibrillation	Ischemic	CDC, AHA, TJC, NQF, CMS
Cholesterol-reducing medication: prescribed at discharge for patients with LDL > 100, LDL not measured, or on a cholesterol-reducing medication prior to admission	Ischemic	CDC, AHA, TJC, NQF, CMS
Stroke education: for patients or caregiver prior to discharge, addressing personal risk factors, warning signs, emergency medical services activation, need for follow-up and medications	Ischemic, hemorrhagic	CDC, AHA, TJC, NQF, CMS
Smoking cessation counseling: for patients or caregivers prior to discharge in patients who have smoked cigarettes in the year prior to hospitalization	Ischemic, hemorrhagic	CDC, AHA

Abbreviations: CDC, Center for Disease Control; CMS, Centers for Medicare and Medicaid Services; NQF, National Quality Forum; TJC, The Joint Commission.

acute stroke in 1996 based on the NINDS rtPA Stroke Study.⁵ In this study, 624 patients with ischemic stroke were treated with placebo or rtPA within 3 hours of symptom onset, with about a 12% absolute improvement in favorable outcome in those treated with rtPA at 3 months. The patients treated with intravenous (IV) rtPA within 90 minutes derived more benefit than those treated between 90 and 180 minutes (OR 2.11 vs. 1.69). More recent evidence suggests that treatment within the 3- to 4.5-hour window portends some benefit in 90-day outcome, though it is, again, decremental as compared with earlier time points (OR 1.31).⁶ Because of this data, one performance measure tracked by the major stroke quality improvement (QI) organizations is the number of patients arriving within 2 hours of the onset of their stroke symptoms who are treated with IV rtPA within the 3-hour time window. Many registries collect data on the “door-to-needle” time in acute stroke, indicating the time it takes for IV rtPA to be administered after a patient with stroke arrives in the emergency department. The Joint Commission has specified a target door-to-needle time of less than 60 minutes for primary stroke centers. This metric has not yet been specified as a performance measure but has been a significant focus of many QI organizations. It is clear that the time of rtPA administration is associated with likelihood of good outcome, but time-based metrics are difficult to enforce, as they may encourage the inappropriate use of treatments. In addition,

there is an increasing push toward the use of more sophisticated imaging procedures in the acute evaluation of stroke, such as magnetic resonance imaging (MRI),⁷ which makes adhering to this time window more difficult. The data for the 4.5-hour time window for IV rtPA administration is not as globally accepted as that for the 3-hour window and therefore has not been incorporated into guidelines or performance measures as of yet.

Early Treatment With Antithrombotics (Ischemic Stroke Only)

Aspirin is the only antiplatelet medication which has been studied in the acute stroke setting. Two studies, the International Stroke Trial (IST) and the Chinese Acute Stroke Trial (CAST) studied aspirin at different doses given within 48 hours of symptom onset. The IST found fewer recurrent ischemic strokes within 14 days of symptoms in the group treated with aspirin, without a significant increase in hemorrhagic strokes.⁸ CAST similarly found a decrease in the early recurrence of strokes, with a slight increase in hemorrhagic strokes. Based on these trials, guidelines recommend that aspirin be given within 24 to 48 hours of symptom onset in most patients with stroke.⁹ One of the major quality measures adopted by the major QI organizations is the administration of antithrombotic therapy by the end of hospital day 2, though this does not specify type of antithrombotic therapy.

In-hospital treatment

Dysphagia Screening

(Ischemic and Hemorrhagic Stroke)

Dysphagia occurs frequently after stroke. A substantial portion of patients with stroke (37%-78% depending on the method of screening) have clinical signs of swallowing dysfunction shortly after stroke. The relationship between dysphagia and the development of pneumonia is clear with a significant increase in incidence if clear aspiration is observed on screening (RR 11.56).^{10,11} The type of screening, which is the most sensitive and specific, as well as the cost effectiveness and utility of screening in preventing pneumonia remains somewhat controversial. The major QI organizations did adopt dysphagia screening as one of the 10 stroke performance measures, requiring a simple bedside testing protocol before being given any food, fluids, or medication by mouth. Of note, the Joint Commission has dropped this from their core measures as of January 2010, but it remains part of other stroke quality programs. This measure is also not endorsed by the NQF and will not be included in the CMS initiative.

Venous thromboembolism Prophylaxis

(Ischemic and Hemorrhagic Stroke)

Thirty-four percent of patients with stroke have deep venous thrombosis (DVT; either symptomatic or asymptomatic) when screened with venography, and 1% of all patients with stroke have pulmonary embolism, accounting for 10% of deaths after stroke.^{12,13} Risk factors making the development of venous thromboembolism more likely in patients with stroke include advanced age, immobility, paralysis of the lower extremity, severe paralysis, and atrial fibrillation.^{14,15} Results of studies evaluating the use of mechanical devices have been mixed. There are some studies supporting the use of graduated compression stockings,¹⁶ and others suggesting no benefit with possible increased adverse events.¹⁷ Evidence better supports the use of pharmacological treatment. The Prevention of Venous Thromboembolism After Acute Ischemic Stroke (PREVAIL) study found that low-dose low-molecular-weight heparin (LMWH) reduced the incidence of venous thromboembolism (VTE) significantly compared to unfractionated heparin (RR 0.57, 95% CI 0.44-0.76) when given within 48 hours after stroke, with no difference in intracranial bleeding risk, but extracranial bleeding risk was higher in those on LMWH.¹⁸ Current ASA/AHA guidelines suggest "subcutaneous administration of anticoagulants or the use of intermittent external compression stockings or aspirin for patients who cannot receive anticoagulants among immobilized patients."¹⁹ Stroke performance measures require the institution of VTE prophylaxis by the end of hospital day 2. Both mechanical and pharmacological treatments are considered acceptable, though graduated compression stockings alone are not adequate in the Joint Commission performance measures. Of note, the National Quality Forum has endorsed performance

measures for all hospitalized patients, which has, since 2007, included VTE prophylaxis within 24 hours of hospital admission or surgery, or documentation of why no VTE prophylaxis was given.²⁰ This measure, if relevant to other hospitalized populations, is crucial in patients admitted to the hospital with stroke, as patients with stroke are at a particularly high risk of VTE given their frequent immobilization.

Rehabilitation Assessment

(Ischemic and Hemorrhagic Stroke)

Most medical interventions for stroke are aimed at preventing further stroke, and those interventions aimed at minimizing the impact of stroke can only be applied very early in the stroke course. Recovery from stroke is mainly dependent on physical, occupational and speech therapy, and organized rehabilitation programs. It should be noted that the evidence supporting rehabilitation in stroke is difficult to interpret. Many studies have been done comparing specific therapy interventions, but more general evidence is less clear. There is evidence that specialized stroke units lead to improved outcomes among patients with stroke,²¹ and specialized rehabilitation services are perceived as one of the key factors in this association, but clear evidence is lacking.²² Early mobilization after stroke, implemented by rehabilitation services, has been found in 1 study to be one of the most important factors in the ability of patients with stroke to be discharged to home.²³ For this reason, inpatient assessment for rehabilitation is included in the harmonized stroke performance measures.

Secondary Stroke Prophylaxis

Antithrombotics on Discharge (Ischemic Stroke Only)

Four antiplatelet agents have been shown to reduce the risk of ischemic stroke after stroke or transient ischemic attack (TIA) and are currently approved by the FDA for this indication (aspirin, clopidogrel, aspirin/dipyridamole, ticlopidine). A meta-analysis of results of 21 randomized trials comparing antiplatelet therapy with placebo in 18 270 patients with prior stroke or TIA found that antiplatelet therapy was associated with a 28% relative odds reduction in nonfatal strokes and a 16% reduction in fatal strokes.²⁴ Several large trials have shown antiplatelet agents to be at least as effective as anticoagulation in noncardioembolic ischemic strokes.^{25,26} QI programs track the number of patients with stroke discharged from the hospital on antithrombotic treatment, without specification of which antithrombotic therapies are used.

Anticoagulation on Discharge for Patients

With Atrial Fibrillation (Ischemic Strokes Only)

Several clinical trials have demonstrated the therapeutic benefit of warfarin compared with placebo in the prevention of thromboembolic events among patients with nonvalvular

atrial fibrillation. Pooled data from 5 primary prevention trials of warfarin versus control show an overall relative risk reduction of 68% with warfarin (95% CI, 50 to 79%). In 2 major secondary prevention trials, warfarin was found to significantly reduce the risk of all vascular events and recurrent strokes when compared with antiplatelet therapy.²⁷ The European Atrial Fibrillation Trial (EAFT) found a reduction in the absolute risk of recurrent stroke from 10% per year in patients on aspirin to 4% per year in patients on warfarin.²⁸ Warfarin use has been shown to be relatively safe, with an annual rate of major bleeding of 1.3% for patients on warfarin compared with 1% for patients on placebo or aspirin. Due to this strong evidence, QI organizations track the number of patients with AF discharged on anticoagulation therapy.

Cholesterol-Reducing Treatment at Discharge (Ischemic Stroke Only)

The Stroke Prevention by Aggressive Reduction in Cholesterol Levels (SPARCL) trial, a large (n > 4000) randomized double-blind study, compared high-dose atorvastatin (80 mg daily) to placebo in patients with no known coronary disease who had experienced an ischemic stroke or TIA within the previous 6 months and had an low-density lipoprotein (LDL) > 100. In the 5-year follow-up, the absolute risk reduction of fatal or nonfatal stroke was 2.2%, and the absolute risk reduction for major cardiovascular events was 3.5%. Based on this trial, the AHA/ASA Secondary Stroke Prevention Guidelines were updated, suggesting "... statin therapy with intensive lipid-lowering effects in patients with atherosclerotic ischemic stroke or TIA and without known CHD..." in addition to the previous recommendation to manage patients with elevated cholesterol, comorbid coronary artery disease, or evidence of an atherosclerotic origin according to NCEP III guidelines. The major stroke QI organizations endorse "Discharge on cholesterol-reducing medication in patients with ischemic stroke with LDL > 100, or LDL not measured, or on a cholesterol-reducer before admission" as a performance measure.

Stroke Education (Ischemic and Hemorrhagic Stroke)

Per the major QI organizations, patients or their caregivers should be given educational materials during the hospital stay, addressing personal risk factors for stroke, stroke warning signs, activation of emergency medical services, the need for follow-up after discharge, and medications prescribed. The role of education in stroke outcome is not clear. There is clear documentation that many patients are dissatisfied with the amount of information that they are given after stroke, and that educational interventions improve their satisfaction.²⁹⁻³¹ There is also evidence that some educational interventions improve patient mood after stroke, with improved scores on anxiety and depression scales.^{30,31} The impact of education on functional outcome, medication compliance, and recurrent

stroke is less clear. The most effective type of educational intervention is also not clear.³¹

Smoking Cessation (Ischemic and Hemorrhagic Stroke)

One of the 10 major performance measures for stroke previously included smoking cessation advice or counseling during the hospital stay for patients with a history of smoking cigarettes within the last year or with caregivers who smoke cigarettes. This was not included in the NQF stroke measure set because it is already included in global measures applied to all hospital patients. In addition, this performance measure has been dropped from the Joint Commission requirements for primary stroke center certification as of January 2010.

Are Stroke Performance Measures Effective?

The motivation behind developing stroke quality measures is to standardize stroke care among hospitals, and ideally to improve outcomes after stroke. Some of the QI programs have now been tracking enrolled patients for several years and have now published some of these results. Get with the Guidelines, a voluntary registry initiated by the American Stroke Association in 2003, has now published results from the first one-million stroke hospitalizations registered. They found significant improvements in each of the 7 performance measures tracked.²⁹ In addition, the odds of a patient receiving all of the performance measures they were eligible for was 9.4-fold higher at the end of the study period as compared with the beginning, independent of patient and hospital characteristics. There were improvements in length of stay and in-hospital mortality over the study period, though it is not clear whether these trends were related to improved stroke care related to the GWTG program or to national trends or other factors.³² There is other evidence that backs up the association of shorter length of stay with participation in a quality improvement program.³³ These studies do not follow patients long term to evaluate recurrent stroke risk, long-term disability, and other important clinical outcomes.

Are There Drawbacks to Performance Measures?

There is certainly some evidence that implementing stroke performance measures may be helpful in improving stroke care, and they are generally based on evidence-based guidelines set by experts in the stroke field. So why not require reporting of quality measures widely, and use them for pay-for-performance?

Public reporting of quality measures is intended to improve public access to information for patients to make informed decisions and to reward institutions who are providing quality care. A study in 2008, however, found that stroke quality data being reported on the internet at that time were confusing, not always clearly indicating what was truly being measured by certain outcomes, and unreliable, with disparities in ratings

of the same hospitals by different sites.³⁴ Inconsistent or inaccurate public reporting of quality data can have unintended consequences, including a reluctance by some hospitals to care for high-risk patients, rewarding or punishing institutions inappropriately, and misinforming consumers. In addition, there are previous examples of performance measure implementation causing paradoxically lower quality clinical care.³⁵ The time to antibiotic administration in pneumonia, for example, is a current metric in use which has encouraged the quick and frequent use of antibiotics in patients who have minimal signs of pneumonia and has contributed to antibiotic resistance rates.³⁶⁻³⁸

Possible Future Metrics

Many facets of stroke care which are not currently included in the major performance measures may contribute to better stroke outcomes and could be considered performance measures in the future. While some of the QI organizations apply the existing metrics to TIA, such as AHA and The Joint Commission several do not. In recent years, the high risk of stroke after TIA or minor stroke has been more clearly defined, and perhaps these conditions deserve metrics of their own, emphasizing their urgent diagnostic workup and treatment. Significant evidence now exists for the efficacy of timely carotid endarterectomy (and now some evidence for carotid stenting) in patients with symptomatic severe carotid stenosis.³⁹⁻⁴¹ Urgent carotid artery evaluation after stroke or TIA suggestive of large vessel etiology, consideration of carotid revascularization in those with symptomatic severe carotid stenosis, and time to carotid revascularization could all be considered as possible future quality metrics. Hypertension is a significant modifiable primary risk factor for stroke, and there is some evidence that antihypertensive treatment also reduces secondary stroke risk.⁴² As inpatient initiation of secondary stroke prevention measures has been associated with high compliance rates 90 days after discharge,⁴³ initiation of antihypertensive treatment after the acute stroke period but prior to discharge could be considered a quality metric. Both fever and hypoxia are frequent complications during hospitalization for stroke and have been found to predict clinical worsening during hospitalization.⁴⁴ Whether treating these complications during hospitalization will improve stroke outcomes remains to be seen, but further research is needed to clarify appropriate measures and to help define what should be tracked for performance.

Conclusions

Implementation of quality metrics in stroke is inevitable, and CMS will require reporting beginning in 2011. It is important for stroke specialists to be intimately involved in defining what measures are used to evaluate quality care, as these will affect the care our patients receive as well as

the compensation given to physicians and institutions. Many metrics applied to other hospitalized patients, such as those tracking hospital-acquired infections (such as ventilator-associated pneumonia and catheter-associated urinary tract infections) have been applied to stroke and other neurology patients by default, when it may be that they are not appropriate in these populations. Moreover, metrics initiated by nonneurologists or nonphysicians could have dangerous consequences for our patients and for neurologists. It is important that we, as neurologists, perform high-quality research to better define what measures are reasonable to track publicly in our patient population, and how the implementation of these metrics affects patient outcomes, and to be strong advocates in setting policies regarding these metrics.

References

1. Lloyd-Jones D, Adams R, Carnethon M, et al. Heart disease and stroke statistics—2009 update: a report from the American heart association statistics committee and stroke statistics subcommittee. *Circulation*. 2009;119(3):e21–181.
2. Reeves MJ, Parker C, Fonarow GC, Smith EE, Schwamm LH. Development of stroke performance measures: definitions, methods, and current measures. *Stroke*. 2010;41(7):1573–1578.
3. Bonow RO, Masoudi FA, Rumsfeld JS, et al. ACC/AHA classification of care metrics: performance measures and quality metrics: a report of the american college of cardiology/american heart association task force on performance measures. *J Am Coll Cardiol*. 2008;52(24):2113–2117.
4. Centers_for_Medicare_and_Medicaid_Services. Quality measures for the FY 2011 payment determination and subsequent years. *Federal Register*. 2009;74:43866.
5. Tissue plasminogen activator for acute ischemic stroke. The national institute of neurological disorders and stroke rt-pa stroke study group. *N Engl J Med*. 1995;333(24):1581–1587.
6. Lansberg MG, Bluhmki E, Thijs VN. Efficacy and safety of tissue plasminogen activator 3 to 4.5 hours after acute ischemic stroke: a metaanalysis. *Stroke*. 2009;40(7):2438–2441.
7. Schellinger PD, Bryan RN, Caplan LR, et al. Evidence-based guideline: the role of diffusion and perfusion MRI for the diagnosis of acute ischemic stroke. *Neurology*. 2010;75(2):177–185.
8. The international stroke trial (IST): A randomised trial of aspirin, subcutaneous heparin, both, or neither among 19435 patients with acute ischaemic stroke. International stroke trial collaborative group. *Lancet*. 1997;349(9065):1569–1581.
9. CAST: Randomised placebo-controlled trial of early aspirin use in 20 000 patients with acute ischaemic stroke. Cast (Chinese acute stroke trial) collaborative group. *Lancet*. 1997;349(9066):1641–1649.
10. Hinchey JA, Shephard T, Furie K, Smith D, Wang D, Tonn S. Formal dysphagia screening protocols prevent pneumonia. *Stroke*. 2005;36(9):1972–1976.

11. Perry L, Love CP. Screening for dysphagia and aspiration in acute stroke: a systematic review. *Dysphagia*. 2001;16(1):7–18.
12. Vergouwen MD, Roos YB, Kamphuisen PW. Venous thromboembolism prophylaxis and treatment in patients with acute stroke and traumatic brain injury. *Curr Opin Crit Care*. 2008;14(2):149–155.
13. Wijdicks EF, Scott JP. Pulmonary embolism associated with acute stroke. *Mayo Clin Proc*. 1997;72(4):297–300.
14. Kelly J, Rudd A, Lewis RR, Coshall C, Moody A, Hunt BJ. Venous thromboembolism after acute ischemic stroke: a prospective study using magnetic resonance direct thrombus imaging. *Stroke*. 2004;35(10):2320–2325.
15. Warlow C, Ogston D, Douglas AS. Deep venous thrombosis of the legs after strokes: Part 2-natural history. *Br Med J*. 1976;1(6019):1181–1183.
16. Kamran SI, Downey D, Ruff RL. Pneumatic sequential compression reduces the risk of deep vein thrombosis in stroke patients. *Neurology*. 1998;50(6):1683–1688.
17. Dennis M, Sandercock PA, Reid J, et al. Effectiveness of thigh-length graduated compression stockings to reduce the risk of deep vein thrombosis after stroke (clots trial 1): a multicentre, randomised controlled trial. *Lancet*. 2009;373(9679):1958–1965.
18. Sherman DG, Albers GW, Bladin C, et al. The efficacy and safety of enoxaparin versus unfractionated heparin for the prevention of venous thromboembolism after acute ischaemic stroke (prevail study): an open-label randomised comparison. *Lancet*. 2007;369(9570):1347–1355.
19. Adams HP Jr, del Zoppo G, Alberts MJ, et al. Guidelines for the early management of adults with ischemic stroke: A guideline from the american heart association/american stroke association stroke council, clinical cardiology council, cardiovascular radiology and intervention council, and the atherosclerotic peripheral vascular disease and quality of care outcomes in research interdisciplinary working groups: The american academy of neurology affirms the value of this guideline as an educational tool for neurologists. *Stroke*. 2007;38:1655–1711.
20. Nqf #0371 venous thromboembolism (VTE) prophylaxis. www.Qualityforum.Org/measures_list.2010. Accessed 6/30/2010
21. Organised inpatient (stroke unit) care for stroke. Stroke unit trialists' collaboration. *Cochrane Database Syst Rev*. 2000: CD000197.
22. Langhorne P, Legg L, Pollock A, Sellars C. Evidence-based stroke rehabilitation. *Age Ageing*. 2002;31(suppl 3):17–20.
23. Indredavik B, Bakke F, Slordahl SA, Rokseth R, Haheim LL. Treatment in a combined acute and rehabilitation stroke unit: which aspects are most important? *Stroke*. 1999;30(5): 917–923.
24. Collaborative meta-analysis of randomised trials of antiplatelet therapy for prevention of death, myocardial infarction, and stroke in high risk patients. *BMJ*. 2002;324(7329):71–86.
25. Mohr JP, Thompson JL, Lazar RM, et al. A comparison of warfarin and aspirin for the prevention of recurrent ischemic stroke. *N Engl J Med*. 2001;345(20):1444–1451.
26. Halkes PH, van Gijn J, Kappelle LJ, Koudstaal PJ, Algra A. Medium intensity oral anticoagulants versus aspirin after cerebral ischaemia of arterial origin (esprit): a randomised controlled trial. *Lancet Neurol*. 2007;6(2):115–124.
27. Saxena R, Koudstaal P. Anticoagulants versus antiplatelet therapy for preventing stroke in patients with nonrheumatic atrial fibrillation and a history of stroke or transient ischemic attack. *Cochrane Database Syst Rev*. 2004: CD000187.
28. Secondary prevention in non-rheumatic atrial fibrillation after transient ischaemic attack or minor stroke. Eaft (European atrial fibrillation trial) study group. *Lancet*. 1993;342(8882): 1255–1262.
29. Rodgers H, Atkinson C, Bond S, Suddes M, Dobson R, Curless R. Randomized controlled trial of a comprehensive stroke education program for patients and caregivers. *Stroke*. 1999;30(12): 2585–2591.
30. Smith J, Forster A, Young J. A randomized trial to evaluate an education programme for patients and carers after stroke. *Clin Rehabil*. 2004;18(7):726–736.
31. Smith J, Forster A, Young J. Cochrane review: Information provision for stroke patients and their caregivers. *Clin Rehabil*. 2009;23(3):195–206.
32. Fonarow GC, Reeves MJ, Smith EE, et al. Characteristics, performance measures, and in-hospital outcomes of the first one million stroke and transient ischemic attack admissions in get with the guidelines-stroke. *Circ Cardiovasc Qual Outcomes*. 2010;3(3):291–302.
33. Schouten LM, Hulscher ME, Akkermans R, van Everdingen JJ, Grol RP, Huijsman R. Factors that influence the stroke care team's effectiveness in reducing the length of hospital stay. *Stroke*. 2008;39(9):2515–2521.
34. Kelly A, Thompson JP, Tuttle D, Benesch C, Holloway RG. Public reporting of quality data for stroke: is it measuring quality? *Stroke*. 2008;39(12):3367–3371.
35. Werner RM, Asch DA. The unintended consequences of publicly reporting quality information. *JAMA*. 2005;293(10): 1239–1244.
36. Kanwar M, Brar N, Khatib R, Fakihi MG. Misdiagnosis of community-acquired pneumonia and inappropriate utilization of antibiotics: side effects of the 4-h antibiotic administration rule. *Chest*. 2007;131(6):1865–1869.
37. Price CI, Curless RH, Rodgers H. Can stroke patients use visual analogue scales? *Stroke*. 1999;30(7):1357–1361.
38. Welker JA, Huston M, McCue JD. Antibiotic timing and errors in diagnosing pneumonia. *Arch Intern Med*. 2008;168(4): 351–356.
39. Brott TG, Hobson RW 2nd, Howard G, et al. Stenting versus endarterectomy for treatment of carotid-artery stenosis. *N Engl J Med*. 363(1):11–23.
40. Beneficial effect of carotid endarterectomy in symptomatic patients with high-grade carotid stenosis. North american symptomatic carotid endarterectomy trial collaborators. *N Engl J Med*. 1991;325(7):445–453.

41. Randomised trial of endarterectomy for recently symptomatic carotid stenosis: final results of the mrc European carotid surgery trial (ecst). *Lancet*. 1998;351(9113):1379–1387.
42. Rashid P, Leonardi-Bee J, Bath P. Blood pressure reduction and secondary prevention of stroke and other vascular events: a systematic review. *Stroke*. 2003;34(11):2741–2748.
43. Ovbiagele B, Saver JL, Fredieu A, et al. In-hospital initiation of secondary stroke prevention therapies yields high rates of adherence at follow-up. *Stroke*. 2004;35(12):2879–2883.
44. Rocco A, Pasquini M, Cecconi E, et al. Monitoring after the acute stage of stroke: a prospective study. *Stroke*. 2007;38(4):1225–1228.