Research in Progress

The Stroke Prevention Patient Outcomes Research Team

Goals and Methods

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**Background and Purpose:** The aim of the present study, based at Duke University and involving 14 other institutions, is to identify the most appropriate and cost-effective clinical strategies for prevention of ischemic (thrombotic or embolic) stroke in high-risk individuals and to design and test an intervention to disseminate this information to providers and the public.

**Methods:** The study uses (1) secondary data from literature review, Medicare claims, and population-based data from three epidemiological studies and (2) primary data generated in national physician and patient surveys and in demonstration trials. Phases I through III involve data collection and analysis using a decision/cost-effectiveness model and consensus development methods. Phase IV includes intervention in physicians' practice patterns. Data is collected by literature survey and abstraction, review of medical records, claims analysis, and patient and physician surveys.

**Conclusions:** A structured decision model and a well-defined clinical focus provide a successful organization for a PORT on stroke prevention *(Stroke, 1993;24:2135-2142.)*

**KEY WORDS** • cerebrovascular disorders • decision modeling • stroke prevention

The Stroke Prevention Patient Outcomes Research Team (PORT) is one of 15 PORT projects funded by the Agency for Health Care Policy and Research (AHCPR) under the Medical Treatment Effectiveness Program. PORT projects are large-scale, multiyear, multidisciplinary studies that focus on variations in clinical practice and outcomes for a particular disease or condition. Each PORT project is designed to identify and analyze the outcomes and costs of alternative practice patterns for a specific condition, determine the best strategy for treatment or clinical management, and develop and test methods for reducing inappropriate variations in practice. PORTs include four components: literature review and synthesis, analysis of variations in practice and patient outcomes, dissemination of findings, and evaluation of the effects of dissemination of findings.1,2 The purpose of this paper is to discuss the goals and methods of the recently funded Stroke PORT.

Stroke is the third leading cause of death in the United States and the leading cause of disability among adults. Every year about 500 000 Americans suffer a stroke, with immense human cost and with financial costs estimated at $25 billion.3 Due to this enormous burden, identification of patients at risk for stroke and prevention of stroke in individuals with elevated risk levels is a high clinical and health policy priority.

Individuals at increased risk for ischemic stroke can be identified by a variety of clinical and behavioral factors. Several general risk factors contribute to the development and progression of atherosclerosis, and these may incite an acute stroke in a susceptible individual. These factors include hypertension,4 cigarette smoking,5-8 hypercholesterolemia,9,10 diabetes mellitus,11,12 and alcohol consumption.13-17 Risk factors more directly associated with ischemic stroke include the presence of cerebrovascular disease and conditions that promote formation of cardiac emboli (such as atrial fibrillation, prosthetic valve, and cardiomyopathy). Patients with asymptomatic carotid bruit (often associated with carotid stenosis) have a stroke risk up to four times that of the general population.18-22 Patients with carotid stenosis, documented by noninvasive or invasive testing, have a stroke risk up to 10 times greater.23-25 Patients who have had a transient ischemic attack (TIA) or previous stroke have a five times greater risk for stroke.26 Furthermore, the presence of multiple risk factors dramatically increases the probability of stroke.

Management of patients at increased risk for ischemic stroke includes diagnostic evaluation as well as specific therapeutic maneuvers. Diagnostic tests, such as
The stroke PORT, funded by the AHCPR and based at Duke University, will evaluate clinical strategies for preventing ischemic (thrombotic or embolic) strokes in people who are at high risk for having such events. Specific groups targeted in this effort include patients who have had either minor strokes or TIsAs as well as individuals who have never had strokes or TIsAs but who do have medically defined markers of cerebrovascular disease (such as carotid bruit and known carotid artery lesion) or conditions associated with embolism (such as atrial fibrillation, presence of a prosthetic heart valve, or cardiomyopathy). Based on the results of these efforts, the PORT team will develop recommendations for preventive strategies, disseminate this information, and evaluate the impact of dissemination on physician attitudes and practices. They will use a comprehensive decision model of stroke development and outcome to coordinate these tasks. Hemorrhagic stroke will be considered in the model as a possible complication of treatment, but the model will not address strategies for prevention of hemorrhagic strokes per se.

**Objectives**

The overall goal of this PORT is to improve health outcomes for persons at risk for stroke by identifying the most appropriate and cost-effective clinical strategies for stroke prevention for high-risk individuals and by designing and testing an intervention to disseminate this information to providers and the public. The specific goals are as follows:

1. to critically review and assess available evidence regarding the benefits and risks of strategies for stroke prevention for high-risk persons;
2. to identify practice variations in the diagnosis, treatment, and management of cerebrovascular disease intended to prevent stroke;
3. to explain observed variations in relation to scientific uncertainties, patient characteristics and preferences, physician knowledge and attitudes, practice characteristics, and available resources;
4. to develop clinical recommendations regarding the prevention of stroke in high-risk populations;
5. to disseminate project findings and recommendations to practitioners and the public;
6. to evaluate the effectiveness of the dissemination in terms of measurable changes in physician attitudes and practice patterns.

**Project Phases**

The Stroke PORT involves the integration of four phases, each representing different research paradigms (Figure). In phase I the PORT team will perform a formal literature review. In phase II existing clinical and administrative data as well as newly collected data will be analyzed. In phase III the results of phases I and II will be used to identify variations in the use of stroke prevention strategies for those at high risk; to explain these variations; and to provide information on patient outcomes, resource use, and scientific uncertainties related to these strategies. In conjunction with an advisory panel consisting of experts in clinical evaluation, methodology, and policy analysis, the PORT team will use formal consensus development methods, decision analysis, and cost-effectiveness analysis to integrate this information and develop recommendations. In phase IV the team will design and carry out a dissemination plan for these recommendations and evaluate
the impact of such recommendations on physician knowledge, attitudes, and practices.

Scope of the PORT

Patient Groups

Four major, stroke-related health conditions, corresponding to four major patient groups, are of interest to the PORT. These conditions, termed “fundamental states,” are as follows: (1) having no overt symptoms but at increased risk for cerebrovascular disease (asymptomatic); (2) having had at least one recent TIA; (3) having had at least one stroke with a minor residual deficit (minor stroke); and (4) having had at least one stroke with a major residual deficit (major stroke). “Asymptomatic” refers only to the absence of symptoms of cerebrovascular disease. Recognizing that symptom status is only one of a variety of patient characteristics involved in making stroke prevention decisions, we also characterize patients by a more complete taxonomy termed “expanded states.” In the asymptomatic group, patients will be characterized by the presence of carotid bruit, carotid stenosis, cardioembolic risk factors, potentially modifiable risk factors (specifically, smoking and hypertension), as well as other variables (age, gender, and race). Symptomatic patients will be characterized by the recency of their symptoms (1 month or less, or greater than 1 month), etiology and vascular distributions of symptoms, modifiable risk factors, as well as age, gender, and race.

Management Strategies

The primary management strategies considered by the PORT are diagnostic testing and therapeutic interventions. The diagnostic tests of interest are invasive and noninvasive evaluation of the carotid and cerebral circulation (including conventional angiography, various forms of ultrasonography and Doppler scanning, and magnetic resonance angiography), examinations of brain structures (including computed tomography and magnetic resonance imaging), and tests used to characterize embolic risk (including electrocardiography and transthoracic and transesophageal echocardiography). Therapeutic interventions include no action, risk-factor reduction, platelet inhibition, anticoagulation, and carotid endarterectomy.

Outcomes

The primary outcome variables to be considered by the PORT are complication rates, costs, transition probabilities, patient preferences (utilities), and utilization of services. Complication rates are associated with diagnostic and treatment interventions and include both mortality and morbidity. Costs primarily consist of direct medical costs, but indirect costs associated with disability will also be estimated. Transition probabilities describe the probability of changing, over time, from one stroke-related health state to another (for example, the probability of a patient with a TIA having a subsequent major stroke in the following month). Utilities are quantitative representations of patient preferences for health states and interventions. Utilities will be obtained using the time trade-off method (for example, patients will be asked about their willingness to hypothetically trade more years of life in their current state for fewer years of life in perfect health). Utilization will be quantified as number of outpatient visits, length of hospitalization, and use of skilled nursing facilities.

Organizing Structures

Three main organizing structures will be used by this PORT: (1) a taxonomy of patients at elevated stroke risk, (2) a basic model of the natural history of stroke development and outcome and the impact of stroke prevention interventions, and (3) a common data format for all data sources.

To standardize patient-based subgroups, we started with the fundamental patient states classified by cerebrovascular symptom status (asymptomatic but at elevated risk, TIA, minor stroke, and major stroke). These were further subdivided into mutually exclusive and exhaustive subgroups (“expanded states”), based on additional factors (eg, symptomatic patients may be classified by the recency and vascular distribution of symptoms, presence of modifiable risk factors, age, gender, and race). These expanded states represent a compromise between substantive detail and analytical tractability and describe clinically important factors likely to be accurately recorded on all data sources.

The basic stroke model represents stroke risk as having no more than two phases: an early phase (1 month since the defining event) and a late phase. Similarly, the impact of stroke prevention strategies, both in reducing stroke risk and inducing complications, is represented as having both early and late phases. This basic model permits comparison of various data sources and simplifies the formulation of the decision-cost-effectiveness model.

Two types of data tables will provide an organizing structure for PORT data. The Evidence Tables will summarize evidence regarding the natural history of disease and the impact of various stroke prevention interventions. One data table will be developed for each outcome. Recommendations for stroke prevention practices will be derived from these tables through the efforts of an expert panel supplemented by the use of a decision cost-effectiveness model. The Variations Table will summarize information regarding the degree of variation in physician attitudes and practices related to various stroke prevention interventions. Optimal stroke prevention practices, as indicated by the Evidence Tables, will be compared with the variations in clinical practice summarized in the Variations Table. Areas of discordance will provide the focus for the dissemination effort.

Data Sources

Data sources to be used in the PORT are summarized in Table 1.

Literature Review

The overall goal of the literature review is to evaluate current information about management strategies for prevention of strokes in high-risk individuals. The five major topic areas to be covered in the literature review include natural history, medical management, surgical management, risk-factor reduction, natural history, and diagnostic testing. For each area, the risks, efficacy, effectiveness, and complications of diagnostic testing and interventions will be considered. In addition, the
Table 1. Data Sources to Be Used in the Stroke PORT

<table>
<thead>
<tr>
<th>Phase</th>
<th>Title</th>
<th>Primary Outcomes</th>
</tr>
</thead>
<tbody>
<tr>
<td>I</td>
<td>Literature Review</td>
<td>Transition probabilities, complication rates, utilities</td>
</tr>
<tr>
<td>II</td>
<td>Medicare Claims</td>
<td>Utilization, costs</td>
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<td></td>
<td>National Physician Survey</td>
<td>Self-reported physician attitudes and utilization</td>
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<td>National Patient Surveys</td>
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<td>Academic Medical Center Consortium</td>
<td>Utilities, functional status</td>
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<td>Cardiovascular Health Study</td>
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<tr>
<td></td>
<td>United HealthCare Corporation</td>
<td>Utilities, functional status</td>
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<tr>
<td></td>
<td>Outcome Studies</td>
<td>Transition probabilities, complication rates, costs</td>
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<td>Rochester/Olmsted County</td>
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<td>II and III</td>
<td>Framingham Study</td>
<td>Transition probabilities, complication rates</td>
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<tr>
<td>III and IV</td>
<td>Intervention</td>
<td>Self-reported physician attitudes and practices</td>
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PORT indicates prevention patient outcomes research team.

literature review will serve to identify gaps in current knowledge.

The literature review process is designed to capture and abstract data in a manner that facilitates the use of the data in the Evidence Tables and, if appropriate, for meta-analysis. The primary source of articles will be a MEDLINE-based search of stroke-related studies published in English after 1976. The MEDLINE search will be supplemented by a review of bibliographies from selected articles and textbooks (including important articles published before 1976) and a computer search of a local stroke reference system.

At the first screening stage, trained nurse-reviewers will read the title, abstract retrieved articles, and accept or reject an article based on designated criteria. If approved by at least one reviewer, the article is passed to a working group defined by one of the major topic areas. In the working groups, physician specialists and methodologists will read and review the entire article, make the final inclusion decision, and characterize the research design and results. Articles are read in a hierarchical fashion according to the research design (beginning with randomized controlled trials). Results from the selected studies will be summarized using meta-analyses (when appropriate). These, in turn, will be included in the Evidence Tables.

Medicare Claims

Medicare claims files will be used to (1) develop a national profile of patients hospitalized with acute stroke conditions, including medical care costs and utilization; (2) develop a similar national profile of patients hospitalized for carotid endarterectomy; and (3) perform small-area analyses of variations in the use of noninvasive cerebrovascular tests, cerebral angiography, and carotid endarterectomy, controlling for differences in stroke admission rates. For this project, analyses will be limited to individuals at least 65 years of age. ICD-9 diagnostic codes 430 to 438 will be selected for analysis. Data from the Medicare claims files will be used for the Variations Tables and possibly for the Evidence Tables (if they prove useful for cost analyses).

National profiles of patients admitted with acute stroke and/or carotid endarterectomy will be developed by sampling Medicare hospital claims records for 1991. Prior hospital admissions (1987 through 1990) for the sample will be merged in order to differentiate incident events from recurrent events, and claims from 1992 through 1993 will also be merged to follow longitudinal outcomes. Costs will be contrasted with two comparison groups: Medicare enrollees hospitalized during 1991 and all Medicare enrollees (ie, whether hospitalized or not) during 1991. Costs considered will include those incurred for care at acute care hospitals, rehabilitation facilities, skilled nursing facilities, home health agencies, and hospital outpatient services, as well as charges for physician services, physical/occupational therapy, and durable medical equipment. Small-area analyses will be performed by stratifying metropolitan statistical areas (MSAs) into high-, medium-, and low-stroke incidence areas; by sampling MSAs within these strata; and by describing the pattern of the three stroke prevention interventions within and across strata.

Additional Data to Address Cost

Direct medical costs will be obtained from two additional sources: United HealthCare Corporation (UHC) and the Academic Medical Centers Consortium (AMCC). UHC will provide all health care claims for individuals under 65 years of age who are served by five geographically dispersed independent practice health plans affiliated with UHC and who have been identified during the period 1989 through 1992 as either asymptomatic at increased stroke risk or symptomatic. Inpatient and outpatient claims will be examined, including physician and pharmacy charges and, for some enrollees, skilled nursing home and other long-term services. AMCC will provide complete inpatient claims on all persons, both over and under 65 years of age, admitted to one of five tertiary medical centers with a stroke-related diagnosis in 1992.

Rochester, Minn, Cohorts

Rochester/Olmsted County, Minnesota, provides a unique context for population-based epidemiological
research because the population is relatively stable and isolated from other urban centers, medical care is concentrated among a small number of providers, and area providers routinely contribute demographic and clinical information to an ongoing computerized database. This project links population-based medical records and is supplemented by additional abstraction of medical records (when necessary) to describe the natural history of stroke. For example, calculating transition probabilities describing the rate of major stroke among patients with prior TIAs in a population-based context mitigates the usual sources of selection bias.

Other Data Sources

Although Rochester, Minn, will be the primary source of population-based data, its computerized data bases do not contain sufficient information to classify asymptomatic patients into those at increased risk for cerebrovascular disease and those not at increased risk. Accordingly, other sources of population-based data, including the Cardiovascular Health Study (CHS) and the Framingham Study, will supplement the Rochester data.

The CHS is a 6-year, observational, population-based study of the onset, progression, and course of heart disease and stroke in individuals 65 years of age and older.33 A random sample of approximately 5000 men and women have been selected from four communities. The participants undergo extensive clinical assessment at baseline and 3 years after entry. In addition, the presence of a carotid bruit and carotid stenosis is assessed by noninvasive testing. Participants are contacted at 6-month intervals to identify incident and recurrent cardiovascular and stroke events, document hospitalizations and use of medical therapies, and identify changes in selected risk factor levels.

The Framingham Study, a cohort study of a general population sample in Framingham, Mass, has collected data with 30 years of follow-up.34 Framingham investigators have identified incident stroke events and have used these data to develop a stroke risk profile for subjects aged 55 to 84 years.35

National Patient Survey

The goal of the national patient survey is to elicit patient preference (utility), functional status, and quality-of-life information directly from patients. Data will be collected by computer-assisted telephone interviews. Each participant will be asked about utilities for health states using the time-trade-off method.36 Stratification will be according to recruitment site and stroke-related health state (ie, asymptomatic, TIA, and minor stroke only). Patients with major stroke will not be included because we anticipate that participating in a telephone interview would be too burdensome. Because sampling frames are not available to produce nationally representative population-based groups, the sampling is designed to access patients from a variety of health-care delivery sites: the CHS (Forsyth County, North Carolina); five IPA-model health maintenance organization sites of UHC (a nationwide managed-care organization); and five academic medical centers that are members of the AMCC. All subjects in the UHC sample and half of those in the AMCC sample will be under 65 years of age. Subjects recruited from the CHS will be 65 years of age or older. Eligible subjects for the surveys will be identified by sampling at each site from ICD-9 CM diagnostic codes that capture cerebrovascular disease and identify patients with cardioembolic risk factors and major cardiovascular disease.

In-person interviews will be performed for the subsample of patients in the CHS site. For this sample, patients will also be asked about complications and utilities for specific interventions (for example, carotid endarterectomy and use of warfarin). Patient utilities will be entered into the Evidence Tables and Decision Model. Self-reported patient data regarding outcomes, quality of life, and functional status will also be analyzed.

Development of Recommendations

The planned approach takes advantage of the two major methods for developing recommendations: decision modeling and expert “consensus” panels.

Decision/Cost-effectiveness Modeling

The decision/cost-effectiveness model provides estimates of the impact of various stroke-prevention strat-
egies. The form of the model is a simulation model based on a previously developed Markov model. Based on the estimated transition probabilities (the probabilities of moving from one stroke-related state to another), the model projects the natural history of a hypothetical cohort with a given risk profile. The transition probabilities can be modified, reflecting the impact of a specific stroke-prevention strategy in reducing stroke or inducing treatment complications.

The model permits a summary of the impact of various stroke prevention strategies. For example, outputs that can be provided by the model for any intervention applied to any patient group include quality-adjusted life expectancy, cumulative cost, and marginal cost-effectiveness. To calculate quality-adjusted life expectancy and cumulative cost with a simulation model, one must associate an incremental utility and an incremental cost with each stroke-related health state. The incremental utility is the length of time of the model “clock” cycle (here, 1 day) multiplied by a quality-adjustment factor reflecting the patient’s disability level in his or her current state. Incremental costs are those associated with the disability as well as the direct and indirect costs of any medical interventions utilized during the month.

In addition to providing estimates of the relative effectiveness and cost-effectiveness of alternative stroke-prevention strategies, the decision model provides an organizational framework for the Stroke PORT. It serves as a conceptual model of stroke development and prevention so that data from a variety of sources can be interpreted in a straightforward fashion. Moreover, we use the model to focus on collecting those data most likely to improve our ability to make judgments about stroke-prevention interventions and to reduce distractions emanating from secondary questions.

**Expert Panels**

The recommendations for stroke prevention strategies will be formed primarily by (1) the Evidence and Variation Tables developed in phases I and III, (2) inferences based on decision and cost-effectiveness analyses, and (3) the judgments of appropriateness and necessity given by a formal expert consensus panel. A panel of experts involved in the care and study of patients at risk for cerebrovascular disease will be assembled to participate in a formal consensus conference. The panel will be provided with the results of our findings from various data sources: literature review, meta-analysis, Medicare claims analysis, primary and secondary data sources, and the decision model. Using the “modified Delphi” approach, the expert panel will rate the appropriateness of each stroke-prevention strategy. The recommendations from the different methods will be compared. The scientific advisory panel will resolve any areas of discordance and make the final recommendations.

**Dissemination**

In phase IV PORT will undertake an intervention-demonstration trial. This trial is designed to ascertain whether the clinical practice recommendations for preventing strokes in high-risk persons (including the evaluation of symptoms and subsequent clinical manage-
Despite the various challenges inherent in a PORT, the advantages of the process far outweigh the potential disadvantages. PORTs build upon the strengths of a wide variety of data sources, methodological approaches, and disciplines, all coordinated by a consistent clinical focus. Our research team looks forward to this opportunity to contribute to the technology of PORTs and ultimately to the health of patients at risk for stroke.

Appendix

Full PORT Participant List
David Matchar, MD, Principal Investigator; Gordon DeFries, PhD, Co-Principal Investigator; Jack P. Whisnant, MD, Co-Principal Investigator; and Pamela W. Duncan, PhD, Project Director.

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Collaborating Centers
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