Stroke Rehabilitation Outcome: Impact of Coronary Artery Disease

Elliot J. Roth, MD, Karen Mueller, MS, PT, and David Green, MD, PhD

The frequency of clinically significant coronary artery disease (CAD) among stroke patients and the impact of CAD on stroke rehabilitation were studied in 132 patients with first thrombotic or embolic stroke who participated in comprehensive rehabilitation. Sixty-one patients (46%) had a history of CAD, and 16 of the 61 also had congestive heart failure (CAD-CHF). Patients with CAD, and especially those with CAD-CHF, had significantly longer intervals from stroke onset to rehabilitation admission ($p<0.001$), and once in rehabilitation they experienced three times as many cardiac complications ($p<0.001$). While all patient groups improved function during rehabilitation, those with CAD and CAD-CHF improved significantly less than did those without CAD ($p<0.01$). Patients with CAD did least well with rolling, moving in bed, transferring from a wheelchair to bed, and walking. CHF not only adversely influenced overall function and mobility task performance but also affected the potential for achieving functional gains. These data suggest that specific measures of function and rehabilitation are affected by CAD and that the levels of achievement for patients with CAD-CHF are limited. (Stroke 1988;19:42-47)

Although the strength of the relation between coronary artery disease (CAD) and cerebrovascular disease is clear, the impact of ischemic heart disease on the ability to function after stroke has not been fully elucidated. Because atherosclerosis is a systemic disease, it is not surprising that concomitant carotid and coronary arterial occlusive disease has been found in many clinical, angiographic, epidemiologic, and pathologic studies. Many authors have reported that myocardial infarction (MI) is the leading cause of late mortality among patients with completed stroke, transient ischemic attacks, or carotid bruises, and among those who undergo carotid endarterectomy. Predisposing factors for ischemic heart disease and atherothrombotic brain infarction are similar, and the presence of CAD itself has an adverse effect on occurrence of and survival following stroke.

Many investigators have studied the influence of a number of clinical variables on the prognosis for function after stroke rehabilitation. Those studies have yielded conflicting results concerning a relation between heart disease and stroke rehabilitation outcome. In one report, Gresham and associates used data derived from the Framingham cohort to show that cardiac comorbidity adversely influenced the degree but not the pattern of disability among patients with stroke. In another investigation, Anderson et al used stepwise multiple regression analysis of 652 rehabilitation admission variables and found that cardiac disease did not predict functional improvement during rehabilitation. Similarly, Feigenson and associates found that atherosclerotic heart disease was unrelated to functional outcome, length of rehabilitation stay, or discharge disposition after stroke. Sheikh et al., however, found that ischemic heart disease, arrhythmias, and congestive heart failure (CHF) each were associated with increased likelihood of stroke mortality or disability. Performance of functional activities by hemiplegic patients has been found to require more energy than does performance of similar activities by normal subjects. The effects of increased energy demands on the heart, superimposed on a background of compromised coronary circulation and reduced cardiac reserves, may limit participation in exercise therapy programs, may inhibit functional skill performance, or may result in clinical manifestations of CAD during stroke rehabilitation. The present investigation was undertaken to determine the frequency of CAD among patients who participated in a comprehensive inpatient stroke rehabilitation program, to investigate the functional significance of coronary heart disease in terms of its effect on the course of stroke rehabilitation, and to evaluate the impact of specific ischemic heart disease manifestations on various measures of stroke outcome.

Subjects and Methods

Patients

A retrospective analysis was performed of all patients aged 40 years or older who completed initial rehabilitation after a first thrombotic or embolic stroke at the Rehabilitation Institute of Chicago between May 1, 1983, and December 31, 1984. All patients underwent similar comprehensive inpatient rehabilitation programs. Patients who had had prior strokes or who...
had any of the following diagnoses in addition to stroke were excluded to avoid possible confounding effects of other disabilities on outcome: subarachnoid or intracerebral hemorrhage (3 patients), traumatic brain injury (1), amputation (4), dementia impairing ability to follow commands (6), chronic lung disease requiring continuous oxygen supplementation (4), polyarthritis (3), parkinsonism (2), or disabling arthritis (1). Only patients who were assessed to have been in New York Heart Association Classification Functional Classes I, II, or III were included.

Procedure

Patient characteristics, including age and sex, and stroke characteristics, including side (right or left hemisphere), site (superficial or deep), and type (thrombotic or embolic), were recorded. The side, site, and type of stroke were determined, as much as possible, by assessment of the clinical presentation, medical history, computed tomography findings, and other laboratory results. Other data, including days between stroke onset and rehabilitation admission, length of rehabilitation stay, and disposition at discharge (home or not home) were documented. Spontaneous natural improvement of hemiparetic lower extremity motor function was evaluated by comparing admission and discharge levels of voluntary lower extremity muscle activity using the assessment technique of Brunnstrom.33

A history of clinically significant CAD was determined for each patient based on the presence of at least one of the following diagnoses: MI by history or electrocardiogram, angina pectoris, or coronary artery bypass graft (CABG) surgery. Among patients with CAD, a history of CHF was sought as an indicator of the severity of heart disease. Patients were then divided into groups based on the presence and severity of ischemic heart disease. Group 0 patients had no CAD; Group 1 patients had a clinical history of CAD but no CHF; Group 2 patients had a history of both CAD and CHF.

Acute cardiac complications requiring medical management during the rehabilitation hospitalization were also documented. These included MI, angina, CHF, major ventricular or atrial arrhythmia, and death.

Overall and individual functional abilities were assessed for each patient at admission and discharge using a portion of the Rehabilitation Institute of Chicago Activities of Daily Living (RIC-ADL) scale,34 which rates each patient's ability to perform six mobility tasks: rolling to the hemiparetic side, moving in bed, propelling a wheelchair forward, transferring from a wheelchair to bed, walking 50 feet indoors, and climbing stairs. Each activity was rated on an 8-point scale, objective criteria for which have been clearly defined. Complete independence scored 7 or 8 points, complete dependence scored 1 or 2 points, and increasing degrees of independence scored from 3 to 6 points. The RIC-ADL scale was found to be a valid and reliable measure of functional abilities for patients with neurologic causes of disability.34

Table 1. Patient Characteristics

<table>
<thead>
<tr>
<th></th>
<th>Group 0</th>
<th>Group 1</th>
<th>Group 2</th>
<th>Significance</th>
</tr>
</thead>
<tbody>
<tr>
<td>No. Patients</td>
<td>71</td>
<td>45</td>
<td>16</td>
<td></td>
</tr>
<tr>
<td>Age (yr, mean±SD)</td>
<td>64.2±10.3</td>
<td>67.9±10.3</td>
<td>67.0±11.4</td>
<td>NS</td>
</tr>
<tr>
<td>Sex</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Male</td>
<td>55%</td>
<td>58%</td>
<td>44%</td>
<td>NS</td>
</tr>
<tr>
<td>Female</td>
<td>45%</td>
<td>42%</td>
<td>56%</td>
<td></td>
</tr>
<tr>
<td>Side</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Right</td>
<td>46%</td>
<td>62%</td>
<td>56%</td>
<td>NS</td>
</tr>
<tr>
<td>Left</td>
<td>54%</td>
<td>38%</td>
<td>44%</td>
<td></td>
</tr>
<tr>
<td>Site</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Superficial</td>
<td>72%</td>
<td>82%</td>
<td>81%</td>
<td>NS</td>
</tr>
<tr>
<td>Deep</td>
<td>28%</td>
<td>18%</td>
<td>19%</td>
<td></td>
</tr>
<tr>
<td>Type</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Thrombotic</td>
<td>75%</td>
<td>64%</td>
<td>56%</td>
<td>NS</td>
</tr>
<tr>
<td>Embolic</td>
<td>25%</td>
<td>36%</td>
<td>44%</td>
<td></td>
</tr>
</tbody>
</table>

Group 0, without coronary artery disease; Group 1, with coronary artery disease; Group 2, with coronary artery disease and congestive heart failure.

Statistical Analysis

Patient characteristics and rehabilitation parameters of the groups were compared using one-way analysis of variance, which also was used to compare RIC-ADL scale scores of individual and overall functional task performance. The independent effects of component CAD diagnoses on outcome parameters were evaluated using analysis of variance. Multiple regression analysis was used to determine the strongest predictors of individual functional ratings.

Results

Patient Characteristics

The mean age of the entire sample of 132 stroke patients was 65.8 years. Seventy-two patients (55%) were men; 70 patients (53%) had right hemisphere involvement and 62 had left hemisphere infarctions. Probable etiologies of the strokes were thromboembolic in 94 (71%) and emboli in the remainder. Superficial brain lesions were present in 101 patients (77%) and deep lesions in 31. Of the 61 patients (46%) with a history of CAD, 49 had MI by history or electrocardiogram, 29 had angina, and 13 had CABG. Sixteen of the 61 patients had CHF in addition to CAD. As noted in Table 1, there were no significant differences in demographic or stroke characteristics between groups.

Rehabilitation Characteristics

The overall mean duration between stroke onset and rehabilitation admission was 33.1 days, and the overall mean length of rehabilitation stay was 56.0 days. Overall, 59 patients (45%) demonstrated some neurologic recovery of motor function in the hemiparetic lower extremity during rehabilitation. Thirty-six patients (27%) experienced one or more acute cardiac
complications requiring acute medical management during rehabilitation hospitalization, as enumerated in Table 2. Overall, 78% of the patients were discharged home after rehabilitation. Features of the poststroke courses for the three groups are listed in Table 3, which shows significant differences between groups only for onset–admission interval and frequency of cardiac complications during rehabilitation.

Functional Ratings

All groups made significant functional improvements measured by RIC-ADL scores during rehabilitation (Group 0: 30.4 to 36.0, p<0.0001; Group 1: 27.3 to 34.8, p<0.0001; Group 2: 24.3 to 29.8, p<0.005) as shown in Figure 1. However, the groups started at and improved by varying amounts to different levels of discharge function such that overall scores were stratified at both admission and discharge according to presence and severity of CAD. Differences between the groups at admission were significant (p<0.01), as were differences between the groups at discharge.

Table 4 shows significant differences (p<0.05) between the groups in mean functional ratings for four of the six mobility tasks at admission and at discharge. Only moving in bed at admission, transferring from a wheelchair to bed at discharge, and climbing stairs at both admission and discharge were not significantly different between groups.

Table 5 illustrates the influence of CAD, each component diagnosis, CHF, and the occurrence of cardiac complications during rehabilitation on functional ratings. On admission, overall function and individual abilities were related to the presence of MI and CHF and to a lesser extent to angina and CABG. Discharge function was most closely associated with CHF and cardiac complications during rehabilitation. Multiple regression analysis was used to determine the best cardiac predictors of admission and discharge function. The results of this analysis demonstrated that linear equations that included only MI (for 4 equations), angina (for 1 equation), and CHF (for 2 equations) best predicted admission functional rating, and that linear equations that included only CHF (for 5 equations), cardiac complications during rehabilitation (for 6 equations), and MI (for 1 equation) best predicted discharge functional rating.

Discussion

This study documented the magnitude and nature of the influence of CAD on a number of stroke rehabilitation course and outcome measures. The precise relation between heart disease and stroke outcome was mixed; onset–admission intervals, cardiac complication frequencies, overall functional ratings, and some individual task performances were highly associated with the presence, type, and severity of CAD, but other aspects of stroke rehabilitation outcome were unrelated to CAD.

Patients with ischemic heart disease were admitted to rehabilitation an average of 8 days later than were those without ischemic heart disease. This prolonged interval between stroke onset and rehabilitation admission for patients with CAD probably was related to the longer times required by these patients for medical stabilization before transfer to rehabilitation. Although the significance of long onset–admission intervals is controversial,35 there is considerable evidence that delayed initiation of rehabilitation is associated with unfavorable outcomes23•24•37 and that longer times to rehabilitation especially impair mobility skill performance.37 Delayed institution of therapeutic exercise regimens may result in contractures, cardiopulmonary de-

Table 3. Rehabilitation Characteristics

<table>
<thead>
<tr>
<th></th>
<th>Group 0 (n = 71)</th>
<th>Group 1 (n = 45)</th>
<th>Group 2 (n = 16)</th>
<th>Significance</th>
</tr>
</thead>
<tbody>
<tr>
<td>Days from stroke to rehab admission (mean ± SD)</td>
<td>28.3 ± 22.2</td>
<td>32.1 ± 23.0</td>
<td>56.8 ± 48.4</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Days of rehabilitation stay (mean ± SD)</td>
<td>53.4 ± 24.6</td>
<td>59.8 ± 23.2</td>
<td>57.0 ± 19.1</td>
<td>NS</td>
</tr>
<tr>
<td>Improvement in lower extremity motor function</td>
<td>38%</td>
<td>53%</td>
<td>50%</td>
<td>NS</td>
</tr>
<tr>
<td>Cardiac complications during rehabilitation</td>
<td>14%</td>
<td>40%</td>
<td>50%</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Discharge disposition</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Home</td>
<td>76%</td>
<td>82%</td>
<td>75%</td>
<td>NS</td>
</tr>
<tr>
<td>Not home</td>
<td>24%</td>
<td>18%</td>
<td>25%</td>
<td></td>
</tr>
</tbody>
</table>

Group 0, without coronary artery disease; Group 1, with coronary artery disease; Group 2, with coronary artery disease and congestive heart failure.
conditioning, and complications of prolonged bed rest, which may further decrease functional performance.

During rehabilitation hospitalization, stroke patients with CAD were approximately three times as likely to experience cardiac complications than were those without CAD. Moreover, patients who had complicated rehabilitation courses tended to have lower functional ratings at discharge. Although these findings are not surprising, they represent more detailed and precise documentation of the occurrence, type, and impact of medical morbidity during participation in stroke rehabilitation than has previously been published. Recognition that stroke patients with CAD may be at risk for such complications as major arrhythmia, CHF, or angina during rehabilitation hospitalization is the first step toward possible prevention and remediation of manifestations of cardiac disease. Timely institution of protocols for assessing patients before therapy and for monitoring patients during activity could provide opportunities for the application of appropriate therapeutic modifications to medical and exercise regimens. These changes might enhance the likelihood of achieving favorable outcomes by minimizing medical complications and by reducing the degree to which complications impede active rehabilitation.

Length of rehabilitation stay and discharge disposition were not significantly related to the presence or severity of CAD in this study. This is not surprising since these factors frequently are influenced by specific psychologic, cognitive, social, and economic variables that were not examined in this investigation.

Objective evidence of the degree of cardiac impairment is difficult to obtain in patients with stroke. The New York Heart Association Functional Classification relies on subjective clinical exercise tolerance, which often correlates poorly with measured exercise capacity. Formal objective exercise testing requires the physical ability to walk on a treadmill or ride a bicycle. Because CHF is a major prognostic indicator for patients with CAD, CHF may be the best measure of heart disease severity.

In this study, the severity of heart disease had an important influence on functional gains. Patients with CAD but without CHF did better than any other group. Similar observations were reported by Lehman et al, who noted that CHF on rehabilitation admission predicted poor functional outcomes but that a history of MI and electrocardiographic changes did not. In the present investigation, CHF appeared to limit achievement of functional independence, but even the CHF group made significant gains during rehabilitation. The reduced ability of CHF patients to improve function probably was due to a number of problems including cardiovascular deconditioning as a result of delayed initiation of therapy, limited endurance for sustained activity, and altered hemodynamic response to exercise.

Because rehabilitation involves a variety of exercise types, intensities, and formats, documentation of the specific effects of coronary disease on the ability to perform individual mobility tasks is important. In this study, improvements in all six tasks were noted, but performance of each skill was affected differently by CAD and CHF. When performed by hemiplegic patients, such skills as rolling in bed, transferring from a

Table 4. Mean RIC-ADL Scores for Six Skills

<table>
<thead>
<tr>
<th>Skill</th>
<th>Admission (n = 71)</th>
<th>Discharge (n = 67)</th>
<th>Significance</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rolling</td>
<td>6.2</td>
<td>6.5</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Moving</td>
<td>5.6</td>
<td>5.3</td>
<td>NS</td>
</tr>
<tr>
<td>Propelling</td>
<td>5.8</td>
<td>5.1</td>
<td>&lt;0.05</td>
</tr>
<tr>
<td>Transferring</td>
<td>5.4</td>
<td>4.6</td>
<td>&lt;0.01</td>
</tr>
<tr>
<td>Walking</td>
<td>4.4</td>
<td>3.8</td>
<td>&lt;0.01</td>
</tr>
<tr>
<td>Climbing</td>
<td>3.0</td>
<td>2.6</td>
<td>NS</td>
</tr>
</tbody>
</table>

RIC-ADL, Rehabilitation Institute of Chicago Activities of Daily Living. Group 0, without coronary artery disease; Group 1, with coronary artery disease; Group 2, with coronary artery disease and congestive heart failure.
wheelchair to bed, and walking often require isometric muscle contractions, abnormal upper extremity activity, Valsalva maneuvers, and inefficient use of muscles in movement patterns to which the patients are unaccustomed. These activities demand increased energy and place undue cardiac stresses on patients with heart disease, but propelling a wheelchair, a relatively nonstressful activity, was not. Indeed, Hildebrandt and associates found that the energy expended with wheelchair use was less than that associated with normal walking at corresponding speeds. The relation between CAD and stroke rehabilitation outcome is not a simple one; only certain manifestations of CAD influence stroke rehabilitation, and only certain measures of outcome are affected. As noted by other observers, it is important to study many aspects of rehabilitation and several measures of function to avoid overlooking the multiplicity of factors that define outcome.

Acknowledgment
The authors gratefully acknowledge the assistance of Ms. Patricia Wagner in manuscript preparation.

References

**KEY WORDS** • coronary disease • rehabilitation
Stroke rehabilitation outcome: impact of coronary artery disease.
E J Roth, K Mueller and D Green

Stroke. 1988;19:42-47
doi: 10.1161/01.STR.19.1.42
Stroke is published by the American Heart Association, 7272 Greenville Avenue, Dallas, TX 75231
Copyright © 1988 American Heart Association, Inc. All rights reserved.
Print ISSN: 0039-2499. Online ISSN: 1524-4628

The online version of this article, along with updated information and services, is located on the World Wide Web at:
http://stroke.ahajournals.org/content/19/1/42

Permissions: Requests for permissions to reproduce figures, tables, or portions of articles originally published in Stroke 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 Stroke is online at:
http://stroke.ahajournals.org/subscriptions/