Cognitive Changes Post Carotid Endarterectomy

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Carotid endarterectomy, since its introduction by Eascott, Pickering, and Robb (1954) has become an acceptable and widely used surgical procedure in the treatment of extracranial occlusive disease for the prevention of stroke (Thompson, 1976). Strokes remain the third leading cause of death in the United States, with an incidence of approximately 160 new strokes per 100,000 population per year (1977). The Framingham study (Gersham et al., 1975) discovered that out of 119 stroke victims, 16% became institutionalized and 71% had decreased vocational function when evaluated at a mean of 7 years post stroke. In a separate study of 737 stroke survivors who were followed for at least 5 years, the incidence of death was three times greater than the incidence found in an age-matched comparable control population without antecedent stroke. Most impressive was the fact that overall, 53% died as a result of recurrent stroke (Robinson et al., 1959). This poor survival and functional result has lead to an aggressive program within the surgical community to diagnose, evaluate, and operatively correct potential stroke precipitating lesions. This aggressive approach has been bolstered by a greater understanding in etiology, nature, history, and treatment of potential stroke-producing carotid lesions. Only within the last two and one half decades has it become widely accepted that, for the majority of patients, etiology of stroke is extracranial rather than intracranial. The establishment of a nation-wide study of extracranial occlusive disease in 1961 found that 75% of the patients evaluated for mild symptoms of cerebral ischemia had correctable lesions isolated to a small area at the bifurcation of the common carotid artery (Fields et al., 1968). Subsequently, the same study showed the feasability and safety of surgically correcting the lesions within the mid neck.

THE ENDARTERECTOMY PROCEDURE

In Figure 1 the anatomy of the mid neck region is shown. Four main blood vessels course to the region known as the Circle of Willis which is responsible for cerebral circulation. The common carotid artery leaves the heart area and courses to the mid neck region where it bifurcates into the internal and external carotid branches. Lesions that appear in the carotid artery may be discovered through noninvasive testing. Often the referral for those noninvasive tests rests on the occurrence of a transient ischemic attack, or TIA. The TIA is considered a focal neurologic deficit that is within the hemispheric distribution and resolves spontaneously within 24 hours. The occurrence of stroke has been shown to be forewarned in up to 30% of patients who have reported symptoms of a TIA (Millikan, 1980). The lesions which may cause TIAs tend to be of two types. One is the result of stenotic disease, which is a buildup of plaque resulting in the narrowing of the artery, closing off the blood flow through that artery. The other type of lesion is termed "ulceration," which is the formation of areas of

roughened plaque on one side of the artery. Projectiles could break off from these areas and precipitate a stroke.

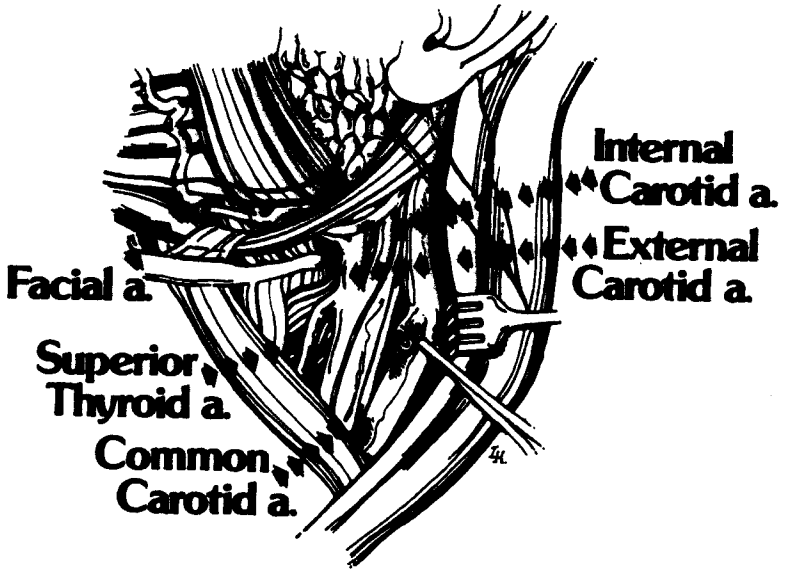

Figure 1. Anatomy of the mid neck region.

In determining the presence of a lesion, four basic noninvasive measures are used, the first being oculoplethysmography (OPG) which measures the amplitude of pulse arrival to both eyes and to one ear. A delay in the arrival time at either of the eyes can be interpreted as indicating the presence of a lesion in the carotid artery. Another diagnostic tool occasionally used is the ultrasonic arteriograph. The transducer on this instrument is sensitive to the sound waves emitted by the blood flow to the artery and transmits an indication of vessel occlusion. The third noninvasive device utilized is the carotid phonoangeograph which amplifies sounds or bruits. Bruits are indicative of stenotic or narrowed areas in the carotid artery and are detected as blood travels through these areas. Transducers placed at these areas of the neck give indication of blood flow above, below, and at the level of bifurcation. The fourth diagnostic tool is x-ray (angiogram) which further identifies lesions as well as giving evidence regarding the feasibility of surgical correction. Following this evaluation, endarterectomy may be recommended. If so, the lesion will be scraped off, leaving a smooth surface of the artery wall.

In the endarterectomy procedure, the surgical area is first exposed in the midneck region and an incision is made into the carotid artery. Before the external and common carotid arteries have been clamped off, a pressure reading will be taken from the internal carotid artery to determine the necessity of a bypass shunt. After this has been noted and a shunt implanted (if necessary), the common and external arteries are clamped. Next the plaque is removed from the artery (Figure 2). Following plaque removal, the shunt is removed and the artery sewn closed.

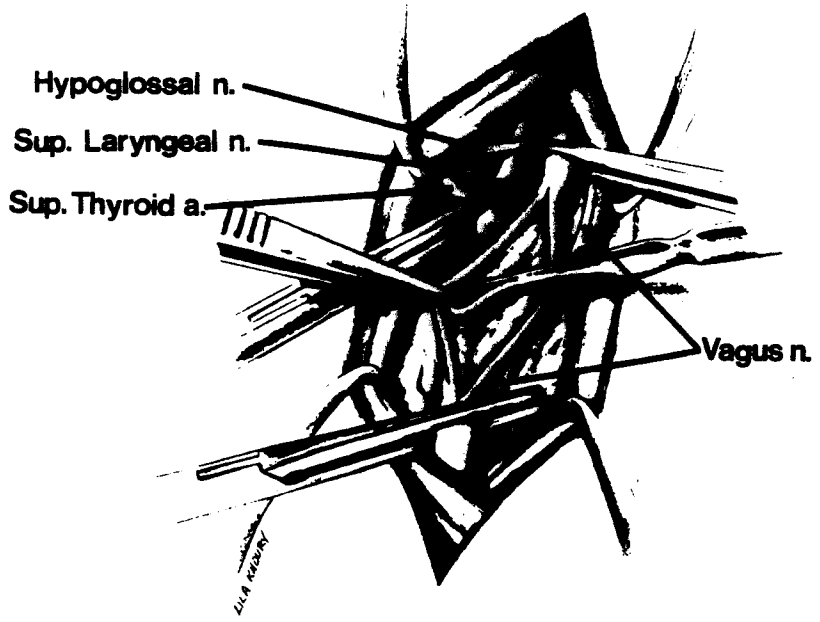

Figure 2. Endarterectomy surgical procedure.

THE NEED FOR THE STUDY

Many investigators have hypothesized that the diminished blood flow to the Circle of Willis through the carotid artery may have an effect on the patient's cognition. Therefore, a number of studies have been undertaken to evaluate potential cognitive improvement following endarterectomy. In general, the research has been somewhat controversial. A number of researchers have concluded that cognitive ability does improve (Kelly et al., 1980; Haynes et al., 1976; Perry et al., 1974; Jacques et al., 1978; Owens et al., 1980), while a number of investigators tend to feel that cognitive ability is not affected (Matarazzo et al., 1979; Goldstein et al., 1970; Drake et al., 1968; Williams and McGee, 1964). Still other researchers supported the notion that cognitive abilities were maintained rather than decreased (Horne and Royle, 1974). Researchers who felt that cognitive ability was not improved felt that the blood is recirculated through the vertebral arteries and that by the time it reaches the Circle of Willis, blood flow through the brain is not different whether or not there is a stenosis of the carotid arteries. In other words, collateral circulation has occurred. Because these questions have plagued the literature, a long term investigation of potential cognitive change post-carotid-endarterectomy was undertaken. This paper will provide preliminary findings.

SUBJECTS

Subjects in this study were 20 males and 16 females ranging in age from 37 to 86 years. They were divided into two groups based on the results of

preoperative noninvasive testing. One group consisted of patients presenting with stenotic lesions and the other group consisted of patients presenting with ulcerated lesions. All patients who had suffered completed strokes were excluded from the study.

PROCEDURE

Each subject was administered a series of cognitive tests which included the Wechsler Adult Intelligence Scale (WAIS) and the Wechsler Memory Scale (WMS). All patients were seen preoperatively after admission to the hospital and postoperatively at the time of their first outpatient followup visit. These followup visits were scheduled from two to six weeks after release from the hospital. The total testing period lasted 90 minutes to two hours. Both the WAIS and the WMS were administered according to standard instructions. A different form of the WMS was used for the pre- and posttest administrations. In addition to these quantitative data, a questionnaire evaluating functional abilities was designed to survey the patient's subjective opinion of his/her cognitive improvement, as well as eliciting a family member's opinion of the patient's improvement. These questionnaires were mailed to the patient's home and inquired about various memory, language, or problem solving abilities which could potentially have improved.

RESULTS

The WAIS contains three overall scores: the full scale score, the performance overall score, and the verbal overall score. The Wilcoxson signed rank non parametric procedure was utilized to evaluate the statistical significance of differences between pre- and post-scores. The difference in overall scores, the difference in performance scores, and the difference in verbal scores were significant ($p < .01$). For six of the subtests the median change in scaled scores was "one." These subtests included information, arithmetic, digit symbol, picture completion, block design, and object assembly. The median change scores for all remaining subtests was zero. Results of the Wilcoxson signed rank procedure for change in the overall memory quotient from the WMS indicated a significant improvement ($p < .01$). When looking at specific subtest scores on this test, a significant difference in performance was found for the memory passage, for the visual reproduction test, and for the digit span subtest ($p < .01$). The median change on the memory quotient (full scale score) was 10 points. Further evaluation of changes on the memory scale was undertaken to analyze differences between patients presenting with stenotic or the ulcerated lesions. The Wilcoxson rank sum test was used to analyze the potential difference between the scores from these two groups of patients. Results of this test indicated patients with ulcerated plaques exhibited significantly more change than patients with stenotic plaques ($p < .05$).

The results of administration of the questionnaire to patients and their families indicated that for the most part, both the patients and family members felt that the patient's cognitive abilities did not change after surgery. The patients replied to 75% of the questionnaire items that no change had occurred. Fourteen percent of patient responses indicated that they felt they had become worse following surgery, while 11% of their responses indicated impressions of cognitive improvement. Sixty-eight percent of family members felt that their aphasic relative had remained the

same, 10% felt he or she had become worse and 23% felt that he or she had become better. Three of the four items which were most frequently scored as "improved following surgery" related to memory ability. The questions included 1) the ability to remember recipes, 2) ability to remember stories, errands, or directions, 3) the ability to initiate talking or relating a story, and 4) the ability to follow tasks, sporting events, or stories related by others.

DISCUSSION

Our results indicate that patients did not achieve great enough changes on the WAIS to be notable. The amount of change we observed could easily be accounted for by practice effects. These results are similar to those found by other researchers. For example, Matarazzo et al. (1979), found that when tested pre- and postoperatively, 17 endarterectomy patients did not change in WAIS performance by an amount larger than could be explained by practice effects. (The practice effect has been determined by test-retest administration to control subjects.) Further support for this finding can be obtained by examining the results of our questionnaire. Patients and their families usually responded that they felt that the patient's cognitive abilities had remained the same. Thus we were not able to provide support for the hypothesis that cognition improves post endarterectomy, from changes in WAIS scores or from the majority of responses to the questionnaire. On the other hand patients did change significantly on the WMS. The amount of change from pre- and posttest scores is too large to be accounted for by practice effects. Further, two different test forms are available for this scale which reduces the chance of practice effect interference. As noted previously, questionnaire results indicated that the items most frequently scored as improved had to do with memory. Approximately a third of the questionnaire memory items were scored as improved. Thus the results of this pilot study indicate that if there is cognitive change post endarterectomy, one may not be able to measure it by a test such as the WAIS. Evaluation of specific memory abilities in more detail, as well as further evaluation of type of presenting lesion may help us further to understand the possibility of patients' behavior change following endarterectomy.

REFERENCES

Asken, M. and Hobson, W. Intellectual change and carotid endarterectomy, subjective speculation or objective reality: A review. Journal of Surgical Research, 23, 367-375, 1977.

Drake, W. et al. The quality and duration of survival in bilateral carotid occlusive disease: A preliminary survey of the effects of thromboendarterectomy. In J. Toole, R. Sieckert and J. Whisnant, (Eds.), Cerebral Vascular Disease. New York: Grune and Stratton, 1968.

Eastcott, H.H.G., Pickering, G.W., Rob, C.G. Reconstruction of internal carotid artery in a patient with intermittent attacks of hemiplegia. Lancet, 2, 994, 1954.

Fields, W.S. et al. Joint study of extracranial arterial occlusion as a course of stroke. Journal of the American Medical Association, 203, 955-960, 1968.

Fields, W.S. et al. Joint study of extracranial arterial occlusion - V. Progress report of prognosis following surgery or non-surgical treatment

for transient cerebral ischemic attacks and cervical carotid artery lesions. Journal of the American Medical Association, 211, 1993-2003, 1970.
Gersham, G.E. et al. Residual disability in survivors of stroke-The Framingham study. New England Journal of Medicine, 293, 954-956, 1975.
Goldstein, S., Kleinknecht, R., Gallo, A. Neuropsychological changes associated with carotid endarterectomy. Cortex, 6, 308-322, 1970.
Haynes, D. et al. Improvement of cognitive and personality changes after carotid endarterectomy. Surgical Forum, 26, 288, 1975.
Horne, D. and Royle, J. Cognitive changes after carotid endarterectomy. Medical Journal of Australia, 1, 316-317, 1974.
Jacques, S. et al. Improved cognition after external carotid endarterectomy. Surgical Neurology, 10, 223-225, 1978.
Kelly, M. et al. Carotid artery disease, carotid endarterectomy, and behavior. Archives of Neurology, 37, 743-748, 1980.
Millikan, C.H. Transient cerebral ischemia: definition and natural history. Progress in Cardiovascular Diseases, 22, 5, 303-308, 1980.
Motarazzo, R. et al. IQ and neuropsychological changes following carotid endarterectomy. Journal Clinical Neuropsychology, 1, 97-116, 1979.
Owens, M. et al. The effect of small infarcts and carotid endarterectomy on postoperative psychological test performance. Journal of Surgical Research, 28, 209-216, 1980.
Perry, P. et al. Neuropsychological tests and carotid artery disease. British Medical Journal, 4, 215-216, 1975.
Robinson, R.W. et al. Life-table analysis of survival after cerebral thrombosis - ten year experience. Journal of American Medical Association, 169, 1149-1152, 1959.
Thompson, J.E., M.D. Surgical progress - carotid endarterectomy. Annals of Surgery, 184, 1-14, 1976.
Williams, M. and McGee, T. Psychological study of carotid artery occlusion and endarterectomy. Archives of Neurology, 10, 293-297, 1964.