Cerebral function before and after extra-intracranial carotid bypass

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SUMMARY Thirty-eight patients had their cerebral function measured before and after extra-intracranial carotid bypass surgery using the Halstead-Reitan neuropsychology test battery. Two composite indices of cerebral function for each patient showed them to be impaired before operation. There was no improvement in the composite measures after operation to match that previously demonstrated after carotid endarterectomy. This may reflect the greater pre-operative cerebral impairment of the extra-intracranial group.

In 1975 Perry et al" reported improvement in cerebral function in 20 patients who had undergone carotid endarterectomy. The patients had demonstrable atheromatous plaque partially stenosing the origin of the internal carotid artery, causing reduction in cerebral blood flow. Operative procedures were considered when the patient presented with transient ischaemic attacks suggested by symptoms of ipsilateral visual disturbance (amaurosis fugax), contralateral hemiparesis and/or aphasia. Previous reports had shown that carotid reconstruction is effective in preventing recurrent transient ischaemic attacks and subsequent major strokes but Perry et al" suggested that carotid endarterectomy also protected cerebral function by reducing the release of micro-emboli into the cerebral circulation. Donaghy and Yasargil7 first reported that extra-intracranial bypass surgery could be used to restore cerebral blood flow in patients who have a surgically inaccessible occlusion of the internal carotid artery. Peerless et al6 reported improvement in the quality of life and reduction in the signs of dementia in 50% of institutionalised patients who received either unilateral or bilateral extra-intracranial arterial bypass surgery for cerebrovascular disease. However, no formal neuropsychological or mental state assessment was undertaken in their study.

The present study was designed to measure objectively neuropsychological functions before and after extra-intracranial bypass and to compare the results from this larger group with those obtained in the 1975 study.

Patients and methods

The 38 patients, six of whom were women, had a mean age of 54.9 years (SD = 11.4) and were admitted for investigation before extra-intracranial bypass. Extra-intracranial bypass was performed rather than endarterectomy because long standing occlusion or distal stenosis is not amenable to local carotid surgery. The duration of the symptoms from transient ischaemic attacks varied from 4 weeks to 5 years and 15 of the patients were known to have stroked, five in the right hemisphere and 10 in the left. Twenty had symptoms in limbs only, 10 had a combination of limb and visual symptoms, five had expressive speech and limb problems, two experienced only amaurosis fugax and one had speech difficulty only. None of the patients were considered to have multi-infarct dementia.

On angiography all patients had demonstrable atheroma occluding or distally stenosing at least one internal carotid artery. One patient had occlusions in both internal carotid arteries, 24 were occluded on one side and stenosed on the other. Five had occlusions and three distal stenoses in one internal carotid only and the remaining five had severe stenoses in both internal carotids.

All patients were assessed preoperatively and 6–9 months after extra-intracranial bypass, using a wide range of neuropsychological tests. These included the Wechsler Adult Intelligence Scale (WAIS), the Russell-Wechsler...
Memory Battery\(^6\) and the Halstead-Reitan Battery\(^6\). To achieve maximum clarity the results of the analysis on raw scores have been presented using the T score method, utilising norms provided by Heaton.\(^7\) Normality is represented at the level of 50 on the vertical axis (SD = 10), the average normal value taken from a normal population for each of the indices; the lower the T value, the more impaired the score.

The technique of extra-intracranial arterial bypass has been previously described.\(^4\) The superficial temporal artery was used for bypass in all patients, usually via its posterior branch. A single temporal burr hole was made to locate a cortical branch of the middle cerebral artery. Extension of the burr hole was sometimes required to find a suitable vessel for anastomosis. The superficial temporal branch was divided distally and Anastomosed end to side on the cortical vessel under an operating microscope, using 10/0 monofilament nylon interrupted sutures. Flow was confirmed with a Doppler probe and bone filings were placed loosely back into the bone defect. Temporalis muscle and skin were reapproximated and a light dressing applied.

Post-operative flow was followed by clinical and Doppler analysis and CBF measurement. Repeat cerebral angiography was not carried out routinely.

**Results**

The figure (a) shows both pre- and post-operative assessment, indicating that almost all the scores were impaired when compared to the normal population.

There was no improvement in the composite scores of all the other tests. Both Average Impairment Rating and Impairment Index did not change after operation. There was no improvement in any of the IQ or memory components, Trails A and B, TPT or Rhythm scores. There was a small positive change in TPT memory (p < 0.01) and Tapping Speed with non-dominant hand (p < 0.01) and improvements in Categories and dominant hand Tapping Speed (both p < 0.02) were also noted. The difference in Speech Perception and TPT Localisation scores before and after operation were significant only at the 5% level.

To enable a direct comparison to be made, T-scored results from the 1975 study, have been superimposed on the profile for the present study. (fig. b). On pre- and post-operative testing, extra-intracranial bypass patients obtain worst scores in Trails A and B and TPT time component and their composite scores (Average Impairment Rating and Impairment Index) are very poor compared with the normal population.

In the endarterectomy patient profile the variance between T score levels for the different tests is much less. Average T scores for the 1975 group are 42-2 (before operation) and 46-9 (after operation). For the extra-intracranial group the average T is much lower: 33-88 and 36-53 (respectively). The study also yielded data on the relationship between post-operative test performance and changes in regional
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cerebral blood flow which will be reported in a further paper.

Discussion

The figure (a) shows that the most outstanding features of patients undergoing extra-intracranial carotid bypass are the very poor Trails and Tactual Performance Test time scores, indicating that there is particular difficulty in completing tasks that involve novel problem solving within a time limit, with a motor component. It is of interest that although memory problems are prominent in the profile, the IQ scores are very close to those obtained from a normal population. Although there was improvement in four of the test items there was no significant change in the two composite scores (Average Impairment Rating and Impairment Index) most sensitive to overall adaptive abilities and higher level cognitive functions. As this group included 15 stroke patients, one would expect to see some improvement in motor skills merely as a function of the stroke recovery pattern and this may be what is reflected in the statistically significant difference between pre- and post-operative Tapping Test scores (Dominant and Non Dominant).

A comparison of the neuropsychological profiles for the 1975 and present studies (fig, b) suggests that improvement in cerebral function after extra-intracranial bypass is less than that reported for patients undergoing carotid endarterectomy. However, the patient populations were not at a comparable level of impairment initially, the extra-intracranial group being more severely impaired. It could be argued that this degree of impairment was a reflection of the inclusion of 15 patients with a history of stroke. However, as all strokes took place in middle cerebral artery territory one would expect the lowest scores in the parts of the profile reflecting motor skills (for example tapping) and this was not so.

Angiographic studies showed that 79% of the patients in this study have bilateral internal carotid disease compared with 65% in the previous study and in addition there was a higher incidence of occlusion of at least one carotid artery in the extra-intracranial group. The initial difference in impairment levels may thus represent a relation to the degree of cerebrovascular disease.

The present patients, like those of 1975, lack a non-operated control group. However, the methodology is the same in the two groups and allows direct comparisons of the results of neuropsychological examination. This comparison shows that in terms of improvement in cerebral function carotid endarterectomy is more successful than extra-intracranial carotid bypass surgery. The difference in degree of improvement may, however, be a consequence of the more impaired pre-operative status of the extra-intracranial group. It should also be noted that carotid endarterectomy serves not only to prevent reduction in blood flow across the carotid bifurcation but also to reduce the incidence of embolism due to platelet aggregation to the diseased intima. Following occlusions, there is still the possibility of embolism from the distal end of the carotid artery, at the level of the syphon. Prevention of micro-embolism in the cerebral circulation may, therefore, be the factor which, in addition to the increase in bloodflow produced by both operations, has led to a better level of cognitive functioning after endarterectomy.

References

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*J Neurol Neurosurg Psychiatry* 1984 47: 1041-1043
doi: 10.1136/jnnp.47.9.1041

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