

## PAPERS AND SHORT REPORTS

**Neurological complications of coronary artery bypass graft surgery: six month follow-up study**

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**Abstract**

As part of a major prospective study of the neurological complications of coronary artery bypass graft surgery patients were reviewed over six months to determine the clinical course and functional impact of early postoperative complications. One hundred and ninety one out of 312 (61%) patients had developed early postoperative disorders.<sup>1</sup> At six months 165 of the 191 patients with early neurological complications were reviewed. Of the 165, 85 still had detectable neurological signs, but these were often minor and of little functional importance. Only 10 patients had neurological disability at six months, and this was major in only four patients, all of whom had suffered major perioperative stroke. No patient with non-disabling neurological complications in hospital became functionally impaired on returning home.

Neurological disorders are not a major cause of failure to return to work by six months after coronary artery bypass surgery. Of 139 patients who were of working age and had not returned to work by six months, only four were prevented by neurological injury related to surgery. The long term prognosis

for early neurological disorders after coronary artery bypass surgery is usually favourable, except in those patients who have sustained major perioperative stroke.

**Introduction**

Increased attention has recently been paid to neurological complications as a principal cause of morbidity after coronary artery bypass graft surgery.<sup>1,4</sup> In a recent study from Newcastle upon Tyne 191 out of 312 patients (61%) developed early postoperative neurological abnormalities.<sup>1</sup> Of the 191 patients with neurological complications during the early postoperative period in hospital, four (2%) were severely incapacitated; 48 (25%) were mildly disabled; and 138 (72%) had no important disability.

Two important questions arise from these early findings. Firstly, do those patients with neurological complications but without significant disability while in hospital develop difficulties after returning to the more demanding activities of normal life? Secondly, to what extent does early postoperative neurological disability disappear, and what is the frequency and severity of long term neurological morbidity after coronary artery bypass surgery? There is little information on the clinical course of neurological complications after heart surgery in general and coronary artery bypass surgery in particular. Previous studies that have mentioned long term outcome have usually recorded only the overall incidence without details of severity and functional disability.

Selection criteria for coronary artery bypass surgery have become less restrictive as the safety of surgical and extracorporeal perfusion techniques has increased. Nowadays surgical treatment is usually offered to patients with milder and less life threatening coronary disease. In view of this and the documented high incidence of early neurological complications of coronary artery bypass surgery, it is important that a clear and detailed picture of long term outcome should be available.

The aims of this follow up study were, firstly, to document accurately over six months the clinical course of early postoperative neurological complications of coronary artery bypass surgery; secondly, to evaluate the functional impact of neurological dis-

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orders, particularly with respect to whether the patients returned to work; and thirdly, to record any new neurological events developing after discharge from hospital.

### Patients and methods

The study cohort comprised 312 patients (276 men and 36 women) who underwent elective coronary artery bypass surgery during the 12 months from September 1983 to August 1984 at the regional cardiothoracic centre in Newcastle upon Tyne. Detailed preoperative and early postoperative neurological assessments were recorded for all patients.<sup>1</sup> In all, 308 patients were discharged from hospital, four having died soon after operation.

To determine the degree of recovery from early postoperative disorders and long term neurological outcome, we reviewed the patients at one month and six months after discharge from hospital. On each occasion they were closely questioned about neurological symptoms, and particular attention was paid to functional capacity and whether they were working. The development of any clinically important, new neurological events or signs was recorded. A detailed neurological examination was performed on each occasion. At six months a neuropsychological examination was repeated, the results of which will be reported separately. All assessments were made by one investigator (PJS).

### Results

One month after surgery 248 (81%) of the 308 patients were reviewed. Of these, 155 had developed early postoperative neurological disorders, and 114 (74%) remained neurologically abnormal at one month. By six months four more patients had died (two died suddenly and were presumed to have had cardiac deaths, one died after a myocardial infarction, and one died after reoperation for a coronary arteriovenous fistula). Of the 304 patients of the original cohort who remained alive, 260 (86%) attended for reassessment at six months. Information was obtained from the general practitioners of those patients who were unable to attend for review.

Of the 260 patients seen at six months, 165 (62%) had developed early postoperative neurological complications. Just over half these patients (85/165, 52%) still had clinically detectable neurological abnormalities at six months, but 80 (48%) had returned to normal. Early postoperative neurological disorders were subdivided into seven categories.<sup>1</sup> Table I summarises the outcome at six months for each of these groups.

TABLE I—Early postoperative complications after coronary artery bypass graft operation and patient outcome at six months

Early postoperative, neurological complication	No of patients	No of patients seen at six months	Outcome at six months	
			Recovery (%)	Persistent deficit (%)
Vegetative state	1	—		Patient died
Depression of conscious level	10	8	9 (90)	1 patient died
Definite stroke	15	12	5 (42)	7 (58)
Possible minor stroke	9	8	7 (88)	1 (13)
Retinal emboli	8	6	5 (83)	1 (17)
Retinal infarcts	54	52	49 (94)	3 (6)
Reduced visual acuity	14	14	13 (93)	1 (7)
Visual field defect	8	7	3 (43)	4 (57)
Palmontal reflexes	107	93	33 (36)	60 (64)
Pout reflex	36	32	14 (44)	18 (56)
Grasp reflex	1	1	1 (100)	—
Psychosis	4	1	4 (100)	—
Brachial plexopathy	21	19	13 (68)	6 (32)
Other peripheral neuropathy	17	15	9 (60)	6 (40)

TABLE II—Employment of patients after coronary artery bypass graft surgery

No employed		No unemployed	
Working full time	84	Unable to find a job	16
Working part time	8	Redundancy	10
Housewife	17	Too early after operation	10
		Above retirement age	12
		Early retirement preoperatively	44
		Loss of confidence or tiredness	8
		Previous work too demanding	18
		Cardiac symptoms	16
		Neurological symptoms	4
		Other medical problems	13

### EARLY POSTOPERATIVE DISORDERS

*Vegetative state*—The one patient who suffered extensive cerebral hypoxic damage resulting in the vegetative state died on the 16th day after operation.

*Depression of conscious level*—This was not a long term problem in our study. Apart from the patient mentioned above who died, the remaining patients in this group achieved a normal level of consciousness by the 12th day after operation.

*Stroke*—Of the 15 patients who developed early postoperative stroke, 12 were reviewed at six months. Seven of the 12 still had a detectable neurological deficit, which in five cases resulted in persistent significant functional disability. The remaining five patients had made a good recovery. Of the three patients who could not be seen at six months, one had died, one still had a minor motor deficit (reported by the general practitioner), and one was of uncertain neurological state. Nine patients had developed signs suggesting minor focal damage to the central nervous system in the early postoperative period. Only one patient had a persistent sign at six months: this consisted of hyperreflexia of the left arm and was of no functional importance to the patient.

*Ophthalmological abnormalities*—Six of the eight patients who had developed intraoperative retinal emboli were reviewed at six months. The emboli had disappeared in all but one patient, who had no visual symptoms related to its presence. Fifty-four patients had developed retinal cotton spots and 52 were re-examined. At one month 29 of them had patches of retinal scarring with a gliotic appearance at the site of previous retinal infarction. By six months only three patients still had detectable retinal scars; in the remaining patients the fundal appearance had returned to normal. None of the 52 patients had significant residual visual symptoms at six months. Isolated reduction in visual acuity was observed in the early postoperative period in 14 patients, and all but one had recovered by six months. This patient with persistent bilateral impairment of visual acuity was thought to have sustained bilateral hypoxic or ischaemic occipital lobe injury during surgery, particularly as he had other evidence of posterior cerebral hemisphere damage. Eight patients had developed visual field defects and seven were reviewed at six months. Of these, three had fully recovered, one had shown some improvement, and three remained unchanged.

*Primitive reflexes*—Palmontal reflexes developed in the early postoperative period in 107 patients. Of these, 93 patients were reviewed at six months, and the palmontal reflexes persisted in 60 patients. Pout reflex was still detectable at six months in 18 out of 32 patients. One patient had developed bilateral grasp reflexes in the early postoperative period, but this sign was no longer seen at six months.

*Psychosis*—Four patients developed a florid paranoid hallucinatory state early after surgery. In two patients the psychosis recovered within 48-72 hours. The other two patients regained a normal mental state within a few days of returning home.

*Peripheral neurological lesions*—Brachial plexopathy affecting the C8 and T1 roots was observed after surgery in 21 patients. Significant recovery was not seen in most patients in the first month, yet by six months 13 of the 19 patients seen had returned to normal. Of the remaining six patients, four had residual motor weakness, three with associated sensory signs. Two patients had a persistent Horner's syndrome. Only two of these six patients considered the residual deficit to be disabling. Other peripheral nerve injuries were present in 17 patients after surgery. Nine of the 15 patients reviewed had fully recovered by six months; two had evidence of a mild ulnar neuropathy; three had persistent numbness in the distribution of the lateral femoral cutaneous nerve; and one had had evidence of continuing dysfunction of the common peroneal nerve. One of the patients with ulnar neuropathy thought he was mildly disabled at six months, but the other five were not significantly incapacitated.

### FUNCTIONAL DISABILITY AT SIX MONTHS

Forty eight patients were considered to have mild functional disability resulting from neurological complications in the early postoperative period. Of these, only six patients continued to have some difficulty in managing their normal daily activities at six months. Two patients had residual deficit from stroke, one had persistent visual symptoms, and three had residual problems from peripheral neurological damage. Four patients were considered to have severe neurological disability in the early postoperative period, resulting in each case from major stroke. Unfortunately, all four of these patients remained severely incapacitated at six months. One patient remained cortically blind with a dense left hemiparesis and cognitive dysfunction; one patient continued to have a dense left hemianopia and a non-dominant parietal syndrome. He also showed profound personality change and intellectual impairment and by three months after surgery had developed seizures. The third patient had persistent hemianopia, a non-dominant parietal syndrome, and evidence of more diffuse cerebral dysfunction.

tion. The fourth patient had a persistent left hemianopia and severe paresis of the left arm, but no major cognitive impairment.

Interestingly, in each of these patients with major stroke resulting in severe persistent neurological disability the brunt of the cerebral damage was borne by the right hemisphere. The reason for this is uncertain, but the right carotid artery, being the first major branch of the ascending aorta, may possibly be more liable to embolisation. None of the patients with non-disabling neurological signs in hospital became functionally impaired on returning home.

#### NEUROLOGICAL ABNORMALITIES DEVELOPING AFTER DISCHARGE

Eight patients developed new neurological problems during outpatient follow up. Three developed a retinal cholesterol embolus, which was symptomatic in only one case. One patient, who had suffered a perioperative right temporoparietal haemorrhagic stroke, developed epilepsy three months after surgery. Three patients had transient cerebral ischaemic episodes, and one sustained a right carotid territory stroke during the six months after surgery. Only in the case of the patient who developed epilepsy could the development of these late disorders be attributed to surgery.

#### STATE OF EMPLOYMENT

Table II summarises the state of employment of the 260 patients seen six months after operation. A total of 109 patients (42%) were employed full time or part time or were housewives able to undertake their normal domestic work. Also 26 (10%) felt capable of working but could not find a job or had been made redundant by their former employers; 10 patients (4%) intended to return to work but considered that six months after surgery was too soon to do so. All 10 considered that they would be able to resume work within a further three to six months. Twelve patients (5%) were not working because they were above retirement age. Forty four patients (17%) were unemployed as a result of a decision taken before the operation to retire early. The mean age of these patients was 57 years (range 33-64, SD 7.0); half of them were above 60 and three quarters above 55. The mean length of retirement before operation was 4 years (range one month to 18 years, SD 4.0 years). Of these patients, 68% had taken early retirement because of disabling cardiac symptoms, 7% for other medical reasons, 20% because they were made redundant near retiring age, and 5% because they considered that they were financially as well off without working. All of these patients preferred to remain in retirement after operation or considered that prospects for obtaining a job were hopeless.

Twenty six patients (10%) had decided not to return to work because of loss of confidence, malaise, or because they considered their previous work to be too physically demanding or mentally stressful. Thirty three patients (13%) had not returned to work because of medical problems; 16 still had disabling cardiac symptoms; and 13 had other illnesses such as peripheral vascular disease, stroke, malignancy, or pulmonary embolus. Neurological disability was responsible for failure to return to work in only four patients. Three of the four had suffered a major stroke and one still had disabling weakness of his dominant hand owing to damage to the brachial plexus.

#### Discussion

Information on long term neurological morbidity after heart surgery is scarce. Those authors who have mentioned late neurological outcome have often recorded only the overall incidence without detailing the nature and severity of the disorders and the resultant functional disability. The first indication that long term neurological dysfunction may result from cardiac surgery arises from two reports of patients undergoing closed heart operations in the 1950s. Priest *et al* referred to central nervous system complications lasting as long as six months,<sup>5</sup> and Zaks commented on the development of "organic changes" after surgery that persisted after three years.<sup>6</sup> In 1974 Aberg reported a 14.5% incidence of cerebral complications six months after heart surgery.<sup>7</sup> Javid *et al* found that 53% of patients developed neurological abnormalities after heart surgery<sup>8</sup>; 12% had persistent neurological deficit at the time of discharge from hospital, but only one patient remained abnormal after two years.

In a retrospective study Coffey *et al* found a 3.8% incidence of complications of the central nervous system after coronary artery bypass surgery<sup>9</sup>; 29% of the patients died soon after operation, but those who survived made a full functional recovery. In the study from the Cleveland Clinic and prolonged encephalopathy

were the major defects of the central nervous system found after coronary artery bypass surgery.<sup>4</sup> Stroke resulted in severe persistent disability in 2% of patients, but patients with encephalopathy usually recovered before discharge from hospital. Peripheral neurological disorders resolved in most cases within six to eight weeks.<sup>10</sup> In 1985 Sotaniemi found a 9% prevalence of permanent neurological abnormalities after heart valve surgery.<sup>11</sup>

Our follow up study has provided useful information on the clinical course and functional importance of neurological complications after coronary artery bypass surgery. We have shown that clinically detectable abnormalities commonly persist (52%), but that these are often minor and of little functional importance. Only 10 of the 260 patients reviewed had functionally important neurological dysfunction, and this was severe in only four cases.

The long term neuropsychological morbidity in this group of patients is another potentially important factor influencing outcome, and data on this aspect are currently in preparation for publication. Previous studies on employment after coronary artery bypass surgery have neglected to consider neurological morbidity as a possible factor influencing whether patients return to work. Age, degree of education, the type of work performed, the length of inactivity before surgery, and the recurrence of angina have been regarded as the major determinants of whether work can be resumed after the operation.<sup>12,13</sup> Our study has shown that neurological disorders are not a major cause of failure to return to work after coronary artery bypass surgery. Of 139 patients of working age who had not returned to work six months after surgery, only four were prevented by neurological injury related to surgery.

The long term prognosis for early neurological disorders after coronary artery bypass surgery is therefore favourable in most cases. In good centres the risk of neurological death or severe, persistent, neurological disability is less than 2% after elective surgery. The main cause of severe, long term neurological disability is major stroke. Our study shows that these patients can be identified soon after operation. The fact that many early neurological complications are recoverable should not detract from a search for solutions to such problems. Major stroke is the principal neurological problem that may nullify the clinical benefits of cardiac surgical repair, and our efforts should particularly be directed towards preventing this complication.

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