PAPERS AND ORIGINALS

Predicting the Outcome of Stroke: Acute Stage after Cerebral Infarction

J. M. OXBURY, R. C. D. GREENHALL, K. M. R. GRAINGER

British Medical Journal, 1975, 3, 125-127

Summary

On admission to hospital during the acute phase of a stroke presumed due to ischaemic infarction in one cerebral hemisphere 93 patients were examined to determine the factors associated with a poor prognosis for immediate survival. The patients particularly at risk were those who were overtly unconscious and those with any combination of impaired consciousness, dense hemiplegia, and failure of conjugate ocular gaze towards the side of the limb weakness. Necropsy evidence suggested that these signs usually indicate infarction of the whole of one middle cerebral artery territory which is often secondary to internal carotid artery occlusion and commonly produces fatal cerebral oedema.

Introduction

Rational assessment of any proposed treatment for acute stroke requires an understanding of its evolution so that the outcome in untreated patients can be predicted with reasonable accuracy. Physical signs elicited shortly after head injury are good indicators of prognosis.¹ Similarly, some studies^{2,3} suggest that certain features detected soon after the onset of a stroke are associated with a poor prognosis. Unfortunately most of these studies have been retrospective and did not differentiate between cerebral haemorrhage and ischaemic infarction.

During a recent investigation to determine whether dextran-40 can influence the outcome from ischaemic cerebral infarction⁴ it became clear that physical signs elicited on admission to hospital may be used to make a reasonably accurate prognosis.

Our report here is concerned only with the relation between such signs and death during the first three weeks in patients presumed to have cerebral hemisphere infarcts. Those with suspected cerebral haemorrhage or brain-stem infarction were excluded. The relation between the physical signs on admission and the long-term outcome in those who survived the first three weeks is considered elsewhere.⁵

Patients and Methods

The 93 patients studied were admitted under the care of one of the five general medical firms at the Radcliffe Infirmary or the neurology department at the Churchill Hospital. All were considered to have had a stroke due to ischaemic infarction which affected one cerebral hemisphere during the previous 48 hours, producing physical signs lasting at least 24 hours. In all cases the cerebrospinal fluid, obtained at lumbar puncture shortly after admission to hospital, contained fewer than 0.5×10^9 red cells/l. Forty of the patients were in the control group for a trial of treatment with dextran-40.⁴ The average age of all the patients was 63.9 years; 42 were under 65 (average age, 53.2) and 51 were over (average age, 72.7). Twenty-six of the older group and 30 of the younger were men, a male preponderance among patients under 65 which has been recorded.³

INITIAL EXAMINATION

All patients were examined by a member of the neurology department within a few hours of admission. The physical signs and history were recorded on a standard proforma so that the data could be transferred to punch cards for analysis. Particular attention was paid to the following points in the history: previous completed strokes; heart disease, particularly cardiac infarction or failure, arrhythmias, and rheumatic heart disease; recognized hypertension; and diabetes.

The neurological examination was directed towards determining the probable site and severity of the stroke. Each of the 52 items on the proforma concerned with the initial physical examination had to be completed. Those relevant to the present analysis are given below.

Conscious State.—The level of consciousness was graded on a six-point scale: 0=normal; 1=drowsy but rational; 2=confused but obeys commands; 3=no response to commands but adaptive responses to pain; 4=reflex responses only to pain; 5=no limb movements in response to pain. Patients graded 0-2 were regarded as "conscious" and those graded 3-5 as "unconscious." We had to exercise some discretion because, for example, severe dysphasia could result in a patient being classed as 3 (unconscious) even though he was alert.

Oxford University Department of Clinical Neurology, Churchill Hospital, Oxford OX3 7LJ

J. M. OXBURY, PH.D., M.R.C.P., First Assistant to the Professor of Clinical Neurology

R. C. D. GREENHALL, M.B., M.R.C.P., Research Registrar

K. M. R. GRAINGER, M.B., F.R.A.C.P., Research Registrar (Present address: Department of Neurology, Sir Charles Gairdner Hospital, Perth Medical Centre, Western Australia, 6008)

Visual Field Defects.—The presence of a homonymous visual field defect was recorded in conscious patients without any attempt to distinguish between inattention and true hemianopic blindness.

External Ocular Movements.—Any abnormality of eye movement or of the position of the eyes at rest was recorded.

Limb Movements.—The power of each individual limb was graded on a five-point scale for conscious patients: 0=normal; 1=minimal weakness; 2=moderate weakness; 3=slight movement only; 4=complete paralysis.

These physical signs were used to separate the patients with strokes presumed to be affecting the cerebral hemispheres from those with brain-stem strokes. Dysphasia and homonymous visual field defects were regarded as definite evidence of a hemisphere stroke, as were forced deviation of the eyes away from the side of the limb weakness or failure of conjugate gaze towards that side, or both. Only patients with definite evidence of brain-stem, medullary, or cerebellar dysfunction were classified as having brain-stem strokes; isolated dysarthria or nystagmus were not accepted as evidence. The 28 patients with hemiparesis only (with or without sensory diminution) were classified as having had a stroke involving the contralateral hemisphere though clearly there was some doubt in these cases.

Results

Fifty-three patients were diagnosed as having had left hemisphere infarcts and 40 right. Twenty-one had a history of a completed stroke, but such a history was not associated with a significantly increased acute-stage mortality. Twenty-four had signs or a previous history of heart disease and 21 others had hypertension which had required drug treatment. Thus, almost 50% had evidence of significant non-cerebral cardiovascular disease though these factors were not significantly associated with an increased risk of death.

Fifteen patients died in the acute stage, which was arbitrarily defined as the first three weeks after onset. Eight were diagnosed clinically as having left hemisphere strokes and seven right. The average age of those who died was 69.73 years compared with an average of 62.78 years for those who survived.

PHYSICAL SIGNS ON ADMISSION

Consciousness.—The state of consciousness is shown in table I. Both patients who made no response to commands but accurately localized pain (grade 3) had left hemisphere strokes, and severe dysphasia may have contributed to their failure to obey commands. A deteriorated level of consciousness was associated with a worse prognosis. No patient whose conscious state was normal on admission died during the first three weeks, whereas 15 of the other 41 did so ($\chi^2=20.06$; D.F.=1; $P<0.001$). Even those with only grade 1 drowsiness had a significantly higher mortality than those who were alert ($\chi^2=14.09$; D.F.=1; $P<0.001$).

TABLE I—Conscious Level on Admission and Death within Three Weeks

Grade:	0	1	2	3 and 4
No. of patients	52	19	16	6
Mean age (years)	62.25	63.47	68.93	66.17
No. dead within three weeks ..	0	6	6	3

Failure of Conjugate Ocular Gaze.—Seventeen patients had their eyes at rest deviated towards the side of the affected hemisphere (away from the hemiparesis) or were unable to voluntarily deviate them in the opposite direction, or both. Seven died, giving a mortality rate significantly higher than among patients without this sign ($\chi^2=7.51$; D.F.=1; $P<0.01$).

Visual Field Defect.—A hemianopic field defect was detected in 39 patients. In a further 10 cases the examiner was uncertain whether such a defect existed because either consciousness was impaired or there was severe dysphasia. Eight of the 39 patients with a field defect died compared with three of the 44 whose visual fields were considered to be full. The difference was not significant ($\chi^2=2.29$; D.F.=1).

Limb Weakness.—The distribution of limb weakness is shown in table II. Twenty-five patients had a dense hemiplegia as defined by a severe (grades 3 and 4) weakness of both the arm and the leg on the

affected side. Eight patients could not have their limb power accurately assessed, six of them because of impaired consciousness. Seven of the 25 with a dense hemiplegia died compared with only five of the other 60 whose limb power could be assessed—a statistically significant difference ($\chi^2=4.12$; D.F.=1; $0.02<P<0.05$) but only weakly so.

TABLE II—Distribution of Limb Weakness.* Number of Patients who Died are Given in Parentheses

Arm Grade	Leg Grade		
	0	1 and 2	3 and 4
0	7	1	1
1 and 2	7 (1)	25 (2)	2
3 and 4	3	14 (2)	25 (7)

*Eight patients could not be classified, and three of these died.

Combination of Signs.—Impaired consciousness, failure of conjugate ocular gaze, and dense hemiplegia were all associated with a significantly increased probability of death in the acute phase (table III). Thus, 41.2% of those with a gaze disturbance died, as did 36.6% of those with impaired consciousness and 28% of those with a dense hemiplegia. The increased probability of death, however, applied almost exclusively to those patients with a combination of these abnormalities. Nine of the 21 patients with more than one sign died in contrast to only three of the 26 with one sign alone. The difference was statistically significant ($\chi^2=4.46$; D.F.=1; $P<0.05$). Three of the six patients classed as unconscious (grades 3 and 4) in whom the state of ocular gaze and severity of hemiplegia were difficult to gauge also died. All seven patients with a dense hemiplegia but no disturbance of gaze or consciousness survived as did the two with the unusual presentation of a failure of conjugate gaze without dense hemiplegia or impaired consciousness. Three deaths occurred among patients who presented with a grade 1 or 2 impairment of consciousness but no dense hemiplegia or gaze disturbance (cases 1, 4, and 11; table IV). At necropsy two of these patients were found to have an undiagnosed haemorrhage rather than an infarction. Neither haemorrhage had ruptured into the subarachnoid space; one was into a cerebral hemisphere and was associated with acute myocardial infarction (case 1); the other was a cerebellar haemorrhage (case 4).

TABLE III—Death as Function of Combinations of Physical Signs

Combinations of Physical Signs			No. of Patients who Died	No. of Survivors
Grade of Consciousness	Gaze Palsy	Dense Hemiplegia		
3 and 4	±	±	3	3
1 and 2	+	+	4	3
0	+	+	0	3
1 and 2	—	+	3	5
1 and 2	+	—	2	1
0	—	+	0	7
0	+	—	0	2
1 and 2	—	—	3	14
0	—	—	0	40

FINDINGS AT NECROPSY

Necropsies were performed on 14 of the 15 patients who died (table IV). Four were found to have a previously unrecognized haemorrhage, three in a cerebral hemisphere and the other (case 4) in the cerebellum. In all cases the C.S.F., examined on admission, had been free of blood. None of the haemorrhages had ruptured into the subarachnoid space though blood had reached the ventricles in case 1.

Eight other patients had infarction of the whole middle cerebral artery territory or more, six with recent occlusion of the ipsilateral internal carotid artery and four with cerebral swelling sufficient to produce secondary mid-brain haemorrhages. Patients under 75 years usually had either a cerebral haemorrhage or the constellation of internal carotid artery occlusion, infarction of at least the whole middle cerebral artery territory, and severe cerebral swelling. The patients with this condition died within a week of the onset of their stroke. An early death in such patients was found to be usual in a larger series of cases.⁶ On admission they commonly had a dense hemiplegia combined with impaired consciousness or a failure of conjugate ocular gaze, or both.

TABLE IV—Clinical and Pathological Features of Patients who Died

Case No.	Age and Sex	Day of Death after Stroke	Signs on Admission				Cerebral Pathology			
			Consciousness Grade	Gaze Palsy	Visual Field Defect	Motor Grade		Infarct Territory*	Cerebral Swelling†	Internal Carotid Artery‡
						Arm	Leg			
1	46 M.	15	1	—	+	3	2		Haemorrhage	
2	55 M.	7	2	+	?	2	0		Haemorrhage	
3	60 M.	3	2	—	+	3	3	M.C.A.	++ +	Oc.
4	61 M.	19	1	—	—	2	1		Haemorrhage	
5	63 M.	2	1	+	+	4	4	M.C.A.	++ +	Oc.
6	67 M.	11	2	+	+	2	4	M.C.A. +		
7	72 F.	4	2	+	+	3	3	M.C.A. +	++ +	Oc.
8	74 M.	10	4	+	—			M.C.A.	++ +	Oc.
9	76 M.	3	1	—	+	4	4	M.C.A.	++ +	
10	77 F.	14	1	—	+	4	4		No Necropsy	
11	77 M.	15	1	—	—	2	2	M.C.A.	++ +	Oc.
12	77 F.	3	2	+	?	3	3		Haemorrhage	
13	79 M.	3	2	—	—			M.C.A. —		
14	80 F.	8	2	+	+	2	3	M.C.A. —		S.
15	82 M.	1	4	—	—			M.C.A. +	++	Oc.

*M.C.A. = Whole middle cerebral artery territory. M.C.A. + = More than whole middle cerebral artery territory. M.C.A. — = Less than whole middle cerebral artery territory.
†+ = Detectable hemisphere swelling. ++ = Hemisphere swelling and mid-brain distortion. +++ = Hemisphere swelling and mid-brain squeeze haemorrhages.
‡Oc. = Occlusion. S. = Stenosis.

Extracerebral disease was uncommon. One patient (case 1) had a recent myocardial infarct and another (case 8) an old one; two patients had pulmonary emboli (cases 2 and 6).

Discussion

The physical signs found on admission to hospital may be used to define a group of patients particularly at risk of dying in the acute stage of ischaemic stroke. These signs are mostly what might be expected from other retrospective studies of stroke patients which did not differentiate between cerebral haemorrhage and ischaemic infarction. Of the neurological signs which Rankin² found to be associated with a particularly high mortality only active conjugate deviation of the eyes occurred with any frequency in our series. Deep coma and pupillary abnormalities were unusual, presumably because we excluded patients with cerebral haemorrhage and brain-stem infarction. The finding of others that dense hemiplegia with fully preserved consciousness carries a good prognosis for survival was confirmed.^{2,3}

The patients particularly at risk were those who were overtly unconscious and those with any combination of impaired consciousness, dense hemiplegia, and failure of conjugate lateral gaze. Elsewhere such patients have been referred to as having "severe" strokes⁴ and probably correspond to Marquardsen's group³ of those with "initial signs of extensive lesion." Most have infarction of at least the whole territory supplied by one middle cerebral artery. Such patients are particularly apt to develop severe cerebral oedema—which may well extend the area of permanent brain damage even if it does not actually kill the patient. Thus, cerebral oedema is one of the major pathological processes requiring urgent treatment, and those particu-

larly at risk may be recognized very soon after their strokes. Consequently, the patients most in need of treatment could be selected if specialist acute stroke units with only limited facilities were established.

Acheson recognized that an appreciable number of patients with a contained intracerebral haemorrhage may be misdiagnosed as cases of ischaemic infarction.⁷ Their cerebrospinal fluid does not contain blood, and no clinical indicators of the underlying haemorrhage have been established. Rational treatments for cerebral haemorrhage and ischaemic infarction are likely to be different so that the two conditions must be distinguished accurately. The use of computerized axial tomography⁸ may enable the distinction to be made. The development of cerebral oedema and, one hopes, its treatment might be monitored in the same way.

We thank Drs. A. Davies-Jones, B. H. Eidelman, J. R. Ponsford, P. M. Rees, D. G. Small, C. W. M. Whitty, and A. C. Young who examined some of the patients on admission and kindly made the data available to us; Drs. J. T. Hughes and D. R. Oppenheimer who made necropsy data available; and Miss Sarah Collins and Mrs. Ruth Miller for considerable help in the analysis of the data. Financial support was given by the Medical Research Council under Grant No. 972/117C.

References

- Overgaard, J., *et al.*, *Lancet*, 1973, 2, 631.
- Rankin, J., *Scottish Medical Journal*, 1957, 2, 200.
- Marquardsen, J., *Acta Neurologica Scandinavica*, 1969, 45, Suppl. 38, p.192.
- Oxford Cooperative Study Group, in preparation.
- Oxbury, J. M., *et al.*, in preparation.
- Greenhall, R. C. D., *et al.*, in preparation.
- Acheson, J., *Quarterly Journal of Medicine*, 1971, 40, 25.
- Paxton, R., and Ambrose, J., *British Journal of Radiology*, 1974, 47, 530.