

Short report

# Arterial spasm and recovery from subarachnoid haemorrhage<sup>1</sup>

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**SYNOPSIS** In a series of 120 cases of subarachnoid haemorrhage due to ruptured intracranial aneurysm the occurrence of preoperative arterial spasm was found to have no effect upon the clinical outcome. After surgery, generalised arterial spasm was found to lead to an increased probability of fatality, and to an increased probability of psychological impairment among the survivors. The occurrence of spasm only in the vessels immediately adjacent to the haemorrhage did not constitute a risk to survival. However, the presence of generalised or localised spasm led to an increased risk of neurological impairment. It is suggested that the mechanisms by which postoperative arterial spasm is responsible for fatalities and for neurological impairment are distinct.

It has been assumed for some time that arterial spasm after subarachnoid haemorrhage may be an important prognostic factor. However, recent research by Millikan (1975) and by Loach and De Azevedo (1976) has shown that the occurrence of spasm between the haemorrhage and surgical treatment has little predictive value, though the latter study did demonstrate a strong correlation between postoperative spasm and a poor prognosis. This report provides further evidence concerning the importance of postoperative spasm obtained from the patients investigated by Loach and De Azevedo. It investigates whether spasm is responsible not only for fatality after subarachnoid haemorrhage, but also for neurological impairment among the survivors (Logue, 1956), and it considers whether the clinical outcome depends upon spasm being generalised throughout the intracerebral arterial system.

## METHODS

Records were reviewed of 120 cases in whom the diagnosis of subarachnoid haemorrhage was established, and who were referred to this department, being all of the patients referred between January 1972 and December 1974, on whom satisfactory clinical informa-

tion was available. Angiographic examination on admission was routine, and all of the patients underwent surgery for ruptured intracranial aneurysm using microneurosurgical techniques. Postoperative angiography was performed in 88 patients to evaluate the performance of the vascular clip or to assess a deteriorating neurological state. The survivors attended a follow-up examination six weeks after discharge.

## RESULTS

Each angiogram was classified from the radiologist's report as to the extent of arterial spasm: no spasm (NS); localised spasm (LS)—that is, spasm only in those arteries at whose junction the haemorrhage occurred; and generalised spasm (GS)—that is, spasm generalised throughout the intracerebral arterial system. Each surviving patient was classified from the follow-up report regarding neurological impairment and psychological state. There was no significant difference among the three preoperative angiographic categories in terms of the likelihood of fatality, of neurological or of psychological impairment among the survivors ( $P > 0.5$  in each case). There was no concordance between the classification of the preoperative and the postoperative angiograms ( $P > 0.3$ ).

The Table relates the clinical outcome to the postoperative angiograms. The patients who had no postoperative angiograph (NA) are also shown. The probability of fatality in each of the three angio-

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TABLE

120 CASES CLASSIFIED\* ACCORDING TO EXTENT OF POSTOPERATIVE ARTERIAL SPASM AND NEUROLOGICAL AND PSYCHOLOGICAL OUTCOME

Outcome	GS	LS	NS	NA	Total
Normal	4	12	22	23	61
Neurologically impaired	2	16	4	3	25
Psychologically obtunded	0	0	3	0	3
Neurologically and psychologically impaired	6	2	2	4	14
Died	9	4	2	2	17
Total	21	34	33	32	120

\*See text.

graphic categories was: GS, 43%; LS, 12%; and NS, 6%.<sup>3</sup> The concordance between the extent of spasm and fatality was highly significant ( $P < 0.005$ ). One-tailed pair-wise tests among the three categories of patient showed that the GS group contained more fatalities than either the LS group ( $P < 0.02$ ) or the NS group ( $P < 0.005$ ), but that the two latter groups did not differ from each other ( $P > 0.3$ ).

The numbers of survivors with postoperative angiography were analysed by a partition of chi-square (Winer, 1962). This employed the factors of neurological outcome, psychological outcome, and postoperative spasm, and each of the first-order interactions among these factors was significant ( $P < 0.005$  in each case). The probability of neurological impairment in each of the three groups of patients was: GS, 67%; LS, 60%; and NS, 19%. One-tailed pair-wise tests among the three groups showed that the NS group was less likely to show neurological impairment than the GS group ( $P < 0.005$ ) or the LS group ( $P < 0.005$ ), but that the two latter groups did not differ from each other ( $P > 0.4$ ). The probability of psychological impairment in each of the three groups of patients was: GS, 50%; LS, 7%; and NS, 16%. One-tailed pair-wise tests among the three groups showed that the GS group was more likely to show psychological impairment than the LS group ( $P < 0.005$ ) or the NS group ( $P < 0.05$ ), but that the two latter groups did not differ from each other ( $P > 0.5$ ). The concordance between neurological outcome and psychological outcome is a corollary of these results.

<sup>3</sup> The overall proportion of fatalities in the series described here (14%) was much smaller than that found in unselected groups of patients with subarachnoid haemorrhage. This reflects the extent to which the patients had been selected for referral to the neurosurgical unit by the general hospitals in the region served by the unit. For example, patients were rejected on the basis of a poor clinical state (Loach and De Azevedo, 1976).

If neurological impairment follows either generalised or localised spasm, while psychological impairment follows only generalised spasm, it follows that psychological impairment usually occurs with neurological impairment. Indeed, neurological impairment occurred in 82% of those patients who were psychologically blunted, whereas it occurred in only 29% of those who were psychologically normal.

## DISCUSSION

This study has shown that preoperative arterial spasm has no effect on the clinical outcome after subarachnoid haemorrhage; that the presence of preoperative spasm is not related to the development of postoperative spasm; but that postoperative spasm is a reliable predictor of the clinical outcome. However, it would also appear that the extent of postoperative spasm does not bear a simple monotonic relationship to the probability of survival or to the quality of survival, and that it has different effects upon mortality and morbidity.

The relationship between postoperative spasm and mortality was restricted to generalised spasm: spasm localised in the vessels immediately adjacent to the haemorrhage did not increase the fatality rate. There was a similar effect of postoperative spasm upon the psychological state on follow-up examination. Thus the risk to survival and the psychological state of the survivors depend upon the nature of arterial spasm in an all-or-none fashion: the risk increases at the point where spasm is no longer localised in the vessels immediately adjacent to the haemorrhage, which is also the point where the haemorrhage produces general cerebral anoxia and affects the vessels supplying the brain stem (Stornelli and French, 1964).

On the other hand, the risk of neurological impair-

ment increased after either generalised or localised spasm, and there was no additional increase if the spasm was generalised throughout the intracerebral arterial system. This suggests that neurological deficits are the result of pathological changes which accompany vasospasm within the neighbourhood of the haemorrhage. While it is true that arterial spasm may be responsible both for fatalities and for neurological impairment in the survivors (Logue, 1956), the mechanisms by which spasm has these two sorts of effect must be quite distinct.

Nevertheless, the findings described here enable one to specify more clearly the prognostic importance of vasospasm of the intracerebral vessels after subarachnoid haemorrhage due to ruptured intracranial aneurysm. First, arterial spasm identified before surgical intervention does not appear to be a reliable indicator of the subsequent clinical outcome. Second, postoperative arterial spasm does not produce an increased risk to survival if it is localised only in the vessels immediately adjacent to the haemorrhage, but there is an increased probability of neurological impairment on recovery. Third, if postoperative arterial spasm is generalised throughout the intracranial arterial system, the frequently reported ominous prognostic significance of vasospasm applies: in this case, there is an increased risk to survival, and an in-

creased probability that the patient will be psychologically blunted should he survive.

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