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# A study of prognostic predictors of supratentorial haematomas

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**Abstract** The prognosis of supratentorial haematomas is based on clinical signs and radiological features. The role of evoked potentials has not been evaluated systematically. In a prospective study of supratentorial haemorrhage a number of clinical (17), radiological (3) and evoked potential (2) parameters were evaluated employing univariate logistic regression analysis in 69 patients and multivariate logistic regression stepdown analysis in 51 patients. The outcome was graded on the basis of the Barthel index (BI) score at 3 months as good (BI ≥ 12) or poor (death or BI < 12) recovery. Employing univariate analysis the significant prognostic variables were Glasgow Coma Scale, Canadian Neurological Scale, tendon reflex, associated medical complications, urinary incontinence, ventricular extension of the haematoma and motor evoked potentials. Using multivariate logistic regression analysis the best set of parameters in relation to outcome inlcuded Glasgow Coma Scale ($P < 0.05$), Canadian Neurological Scale ($P < 0.05$), tendon reflex ($P < 0.1$), ventricular extent ($P < 0.01$) and motor evoked potentials ($P < 0.05$). From this study it is concluded that, in addition to clinical and radiological parameters, motor evoked potentials also have an important role in predicting outcome.

**Key words** Haemorrhage · Supratentorial haematoma · Prognostic predictors · Evoked potentials

## Introduction

The predictors of the outcome of intracerebral haemorrhage (ICH) have been reported on the basis of a number of clinical and radiological features, such as: level of consciousness, blood pressure, pupillary change, gaze paralysis, degree of weakness, size of haematoma, intraventricular blood and midline shift [6, 12]. There have been, however, few studies on somatosensory evoked potential (SEP) and motor evoked potential (MEP) changes in stroke, and none has systematically evaluated the role of evoked potentials in predicting the outcome [21, 24]. Recent studies on ischaemic strokes and pure motor hemiplegia due to putaminal haemorrhage have reported the role of a recordable MEP in predicting good outcome [10, 18], but such information is lacking regarding ICH. A number of prognostic variables may jointly affect the outcome. Multivariate analysis has been employed to study the simulatenous effect of different variables influencing the recovery from ICH [22, 25]. In the first study of its kind, we report our results concerning the role of clinical, radiological and evoked potential paramters in predicting functional recovery from supratentorial haematoma employing multivariate logistic regression analysis.

## Subjects and methods

During the period 1991–1993 we examined 105 consecutive patients with spontaneous ICH, 79 of whom were followed up for at least 3 months. Sixty-nine of these patients had supratentorial and 10 infratentorial haemorrhage. The clinical, radiological and elec-

trophysiological variables of the patients with supratentorial haemorrhage have been analysed in this study. The patients with aneurysm, arteriovenous malformation, tumour bleed and anticoagulant bleeds were excluded. All the patients were admitted under the authors' care and were personally examined (U. K. M. and J. K.) after a mean duration of 6.5 (range 1–20) days and followed at 1– and 3–month intervals. The diagnosis of haematoma was confirmed by CT in all patients. The haematomas were classified on the basis of their maximum diameter as small (< 2 cm), medium (2–4 cm) and large (> 4 cm) [1]. The midline shift, if exceeding 5 mm, and ventricular extension of the haematoma were also recorded. The haematomas were classified according to their location as lobar, thalamic and putaminal. MEPs were recorded by stimulating the motor cortex and the spinous process of the seventh cervical vertebra employing a Digitimer D180 electrical stimulator and recording from the abductor digiti minimi in a belly tendon montage. Inexcitability of central motor pathways was regarded as abnormal [19]. Median SEPs were recorded by stimulating the median nerve at the wrist by a 0.1 ms square wave pulse at 3 Hz to elicit a painless twitch of the thumb. The recording electrodes were placed over the contralateral parietal cortex (CPC) and Erb's point with a midfrontal reference. A bandpass of 3 Hz–3 kHz, a sweep time of 100 ms, and a gain of 2 μV/ division were used to twice average 512 responses. Cortical potentials (N20, P25, N30, P45) were recorded. The absence of N20 or subsequent potentials was regarded as abnormal [16]. SEP and MEP studies could be performed in 51 patients only. In 18 patients electrophysiological investigations could not be performed because of unwillingness of the patients to undergo the study (3), young age (1) and serious clinical conditions (14). The last-mentioned however, were not an absolute contraindication for MEP studies.

**Table 1** Variables related to recovery from supratentorial intracerebral haemorrhage (ICH)

| |
|---|
| Demographic |
| Age |
| Sex |
| Clinical |
| Previous stroke |
| Alcohol |
| Pulse pressure |
| Headache |
| Vomiting |
| Glasgow Coma Scale (GCS) |
| Canadian Neurological Sclae |
| Activities of daily life |
| Power (MRC) |
| Tone |
| Reflex |
| Medical complications |
| Renal impairment |
| Pupils |
| Incontinence |
| Radiological |
| Size |
| Ventricular extension |
| Midline sift |
| Electrophysiological |
| Motor evoked potentials |
| Sensory evoked potentials |

Outcome was graded as good or poor recovery on the basis of Barthel index (BI) score at 3 months. A score of 12 or more was defined as good and below 12 as poor recovery [13]. Deaths were included in the poor recovery group for the purposes of statistical analysis.

The risk factors listed in Table 1 were analyzed initially by univariate logistic regression analysis (69 patients), which was followed by multivariate conditional logistic regression analysis (51 patients) to model the relation between the risk factors and recovery [17]. The dichotomous dependent variable, recovery ($Y$) was assigned a value of 1 when the outcome was good (3-months BI ≥ 12) and a value of 0 when the outcome was poor (death or 3-month BI 0–11). If $X_1$, $X_2$, $X_3 ... X_p$ were the characteristics related to the outcome, then the logistic regression model specified that the conditional probability of recovery was as follows

$$P(Y = 1/X_1, X_2, X_3 ... X_p) = 1/1 + \exp[-(A + P\sum_{j=1} B_j X_j)] \quad (1)$$

The multivariate logistic risk function could be formulated as Eq. 1, where $B_j$ is the logistic coefficient and A is the constant. The parameters of the model were obtained by the maximum likelihood method [2]. Initially all the variables were analysed, but later the best model was obtained using stepwise logistic regression analysis. To study any selection bias, the clinical characteristics of the patients who were excluded from the multivariate analysis ($n$ = 18) were compared with the group included in multivariate logistic regression analysis ($n$ = 51). Student's $t$-test was employed for continuous variables [age, Glasgow Coma Scale (GCS ), Canadian Neurological Scale] and test of difference between proportions for categorical variables (sex, size of haematoma and medical complications).

## Results

Our results are based on 69 patients with supratentorial ICH who were followed up for a period of 3 months. The mean age of these patients was 51 years (range 4–83); there were 47 males. A history of headache was reported by 50% and of vomiting also by 50% of patients. Thirteen patients were deeply comatose, 19 had a moderate and 37 had a mild degree of impairment of consciousness. The overall severity of stroke was assessed by the Canadian Neurological Scale at the time of admission and revealed that the stroke was severe in 39, moderate in 21 and mild in 9 patients. The mean Canadian Neurological Scale score at the time of admission was 3.8 (range 1.5–11.5). The hemiplegia was severe (MRC grade 0–1) in 53 and partial (grade III–IV) in 11 patients. The muscle tone on the hemiplegic side was reduced in 26 patients and increased in 26 patients. Hypotonia was associated with diminished tendon jerks in 15. On admission pupillary asymmetry was present in 22 and urinary incontinence in 41 patients. The haematomas were putaminal in 38, thalamic in 17 and lobar in 14 patients; 25 of them communicated with the ventricular system. Midline shift was present in 35 patients. The haematomas were small in 10, of medium size in 46 and large in 13 patients. MEP and SEP studies were carried out in 51 patients but potentials were unrecordable in 29 patients each. Thirty-two patients had a good recovery, 20 a poor one and 17 died. The medical complications in

**Table 2** The significant prognostic variables in relation to the outcome of supratentorial ICH

| Variable | Level | Number of patients | Number with poor recovery | *Z* score |
|---|---|---|---|---|
| GCS | | | | |
| < 6 | 1 | 13 | 9 | 2.08* |
| 6–12 | 2 | 19 | 12 | |
| > 12 | 3 | 37 | 16 | |
| Canadian Neurological Scale | | | | |
| < 3.5 | 1 | 39 | 28 | 3.63** |
| 3.5–7 | 2 | 21 | 9 | |
| > 7 | 3 | 9 | 0 | |
| Reflex | | | | |
| Hypo | 1 | 15 | 12 | 3.05** |
| Hyper | 2 | 38 | 21 | |
| Normal | 3 | 16 | 4 | |
| Medical complications | | | | |
| Present | 1 | 34 | 25 | 3.17** |
| Absent | 2 | 35 | 12 | |
| Incontinence | | | | |
| Present | 1 | 41 | 29 | 3.32** |
| Absent | 2 | 28 | 8 | |
| Ventricular extension | | | | |
| Present | 1 | 25 | 18 | 2.26* |
| Absent | 2 | 44 | 19 | |
| MEPs | | | | |
| Unrecordable | 1 | 29 | 20 | 2.79* |
| Recordable | 2 | 22 | 5 | |

* $P < 0.05$, ** $P < 0.01$

**Table 3** Logistic regression model showing most significant parameters for recovery from supratentorial ICH [likelihood ratio statistics (5 *df*) 35.31]

| Variable | Regression coefficient | SE | Odds Ratio | 95 % confidence interval | | |
|---|---|---|---|---|---|---|
| | | | | Upper | Lower | *P* |
| Glasgow Coma Scale score | –2.07 | 1.04 | 0.13 | 0.97 | 0.02 | < 0.05 |
| Canadian Neurological Scale score | 1.01 | 0.44 | 2.75 | 6.54 | 1.16 | < 0.05 |
| Reflex | 1.36 | 0.87 | 3.91 | 21.65 | 0.70 | < 0.10 |
| Ventricular extension | 3.30 | 1.22 | 27.09 | 295.13 | 2.49 | < 0.01 |
| MEPs | 2.47 | 1.05 | 11.85 | 93.15 | 1.51 | < 0.05 |
| Constant | –9.31 | | | | | |

the later patients included pulmonary complications ($n = 3$) septicaemia ($n = 4$) and myocardial infarction ($n = 2$).

The important variables derived by univariate logistic regression analysis for predicting outcome of ICH included: Canadian Neurological Scale score, tendon reflex on the hemiplegic side, medical complications, incontinence ($P < 0.01$), GCS, ventricular extension and MEPs ($P < 0.05$). The proportion of patients with a poor outcome with each of these variables is shown in Table 2. A multivariate stepdown variable selection procedure was used to derive the best set of parameters for predicting the outcome. These variables included GCS, Canadian Neurological Scale score, tendon reflex, ventricular extension of haematoma and MEP. Some factors like medical complications and urinary incontinence were significant in the initial analysis but did not figure in the final multivariate analysis. The best model for predicting recovery from supratentorial ICH at 3 months is shown in Table 3. The age, GCS and Canadian Neurological Scale score (mean, SD) of the patients excluded from multivariate analysis ($n = 18$) was 50.7, SD 20.7 years, 9.6, SD 5.0 and 3.9, SD 2.9 and that of the patients included in the multivariate analysis ($n = 51$) was 50.9, SD 12.7 years, 11.6, SD 3.9 and 3.8, SD 2.7 respectively. In the former group there

were 4 females; 4 patients had large and 9 had medium-size haematomas. In the latter group there were 18 females; 9 patients had large and 37 medium-size haematomas. These differences were not statistically significant.

## Discussion

The mortality in cases of ICH has been reported to range between 14% and 58% [5, 22, 23, 27]. Surviving patients may have varying degrees of disability. Most studies have evaluated the prognostic factors in reference to mortality [22, 25]. Little attention has been paid to the factors influencing the overall functional outcome. Most studies have evaluated the clinical and radiological paramaters for assessing the prognosis of ICH patients and have generally relied upon univariate analysis. The prognostic factors have inlcuded age, GCS score, systolic blood pressure, pulse pressure, gaze palsies, severity of weakness, presence of brain stem and cerbellar deficit, interval stroke course, size of haemorrhage, location of haemorrhage, bilateral plantar extensor and chronicity of hypertension [7, 14, 15, 25–27]. A number of these variables may be simultaneously influencing the outcome; therefore, a multiple regression analysis has been performed to study the combined effect. A model, comprising GCS, Canadian Neurological Scale, tendon reflex on the hemiplegic side, ventricular extension and MEP, was found to be suitable for predicting the 3-months outcome in our study.

The canadian Neurological Scale assesses the severtiy of stroke. It evaluates the level of consciousness, orientation, speech and weakness. It is easy to administer, has high inter-rater reliability [4] and can be used even in comatose or uncooperative patients. The previous studies have reported a good correlation between the score and 6-month outcome in stroke patients [3]. The level of consciousness was assessed by GCS, which has been most consistently associated with the outcome of stroke [5, 11, 23] and figured in our study as well. On initial examination hyporeflexia may signify a state of neuronal shock and suggests severe damage and the possibility of a poor outcome. Intraventricular communication of haematoma was found to be a significant prognostic factor in our study as well as in a number of other studies [5, 14, 23, 27]. Intraventricular communication in lobar and putaminal haemorrhage may be related to size, i.e. only the large haematoma would communicate into the ventricle. On the other hand, a relatively small thalamic haemorrhage, if medially located, may have ventricular extension. This may explain the discrepancy between the size and ventricular communication in our study. As with our findings, the size of the haematoma was not found to be a significant prognostic variable in another study [5], although most studies have emphazised the importance of size in predicting the outcome of ICH [9, 14, 26]. The location of the haematoma may also be an important prognostic variable, as illustrated by a medium-size occipital haematoma with a good outcome (patients 43, 44, 48), whereas a small medial putaminal haematoma in a critical location may be associated with profound clinical abnormalities and a poor outcome (patient 15). The importance of the location of the haematoma has also been highlighted in another study [22].

In our study, MEP was a significant parameter predicting the outcome. We have included the inexcitability of the motor pathway as the criterion of abnormality. Latency of MEPs can be influenced by the level of preactivation, which is not possible in a comatose or paralysed patient; therefore, the prolongation of central motor conduction time has not been used as the criterion for defining the abnormality in our study. The importance of the primary motor area or its connections in recovery from hemiplegia has been emphasized [8]. By MEP study, we can objectively assess the integrity of the motor pathways. Recently the importance of recordable MEPs (delayed or normal) in predicting recovery from ischaemic stroke has been reported [10]. Our studies on ischaemic stroke and putaminal haemorrhage leading to pure motor hemiplegia have also revealed similar results [18, 20]. In a comatose patient assessment of motor functions is not very reliable. An MEP study in such a situation may offer the advantages of objectivity and simplicity.

The medical complications and urinary incontinence, although initially significant, did not achieve statistical significance in the multivariate analysis. This does not undermine the importance of these variables; however, these do not provide additional information in the presence of the variables included in the final model.

Our results are based on consecutive patients with supratentorial haemorrhage. Eighteen patients could not be included in the multivariate logistic regression analysis owing the lack of evoked potential studies. These patients, however, were not significantly different in important demographic (age, sex), clinical (GCS, Canadian Neurological Scale) and radiological (haematoma size) variables compared with the group of patients on whom our model is based. This excludes any selection bias in our study. Our results, therefore, are applicable to the group of supratentorial haematomas as a whole. There have been only a few studies employing the multivariate analysis for the prognistication of ICH. In a retrospective study of 112 patients with supratentorial ICH, GCS, haematoma size and ventricular extension were found to predict the outcome at the end of 2 weeks [22]. In another study comprising 94 patients, the factors predicting 30-day survival included ventricular extension and GCS [25]. The results of these studies differ from ours because of the end-point, which was 3-months outcome rather than mortality at the end of 15 or 30 days [22, 25]. We have evaluated not only the role of clinical and CT changes but also the evoked potential parameters. Our study highlights the important role of MEPs in addition to clinical and radiological features in predicting the outcome.

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