Measurement of post-traumatic amnesia: how reliable is it?

N S King, S Crawford, F J Wenden, N E G Moss, D T Wade, F E Caldwell

Abstract

***Objective*—To develop and test a clinical protocol for determining post-traumatic amnesia by retrospective questioning. To establish its limits and factors which influence reliability.**

***Design*—Two independent assessments using the Rivermead post-traumatic amnesia protocol were undertaken by separate observers on various groups of patients at various time intervals. Analysis investigated the correlations between assessments, the percentage difference between assessments, the number of patients changing category, and the differences between these analyses in the different patient subgroups. Assessments were undertaken both in hospital and in the patients' homes. Four different patient groups were studied. These were group A: 12 inpatients with very severe head injury late after injury; Group B: 40 patients interviewed at home six months after injury; group C: 22 patients interviewed within a few weeks of injury at home; group D: 116 patients interviewed initially within a few weeks and then at six months, on both occasions at home. The Rivermead post-traumatic amnesia protocol involved clinical questioning of the patient to establish how long after injury (in hours/days/weeks) the patient regained continuous day to day memory. All periods of coma were included. Severity was categorised with standard criteria.**

***Results*—Overall correlation was good (Spearman's r 0·79), but the correlation was lower for patients with post-traumatic amnesia < 24 hours and when there was a long delay between assessments. In all groups 19%–25% of patients changed categories between assessments, but only 2% changed by two categories.**

***Conclusions*—The assessment of post-traumatic amnesia with the Rivermead post-traumatic amnesia protocol is reasonably reliable. The misclassification rate however, is significant enough that some caution should be taken in individual cases. Other evidence does show post-traumatic amnesia to be valid, and it probably remains the best simple prognostic item available. In clinical practice one should avoid placing too much weight on post-traumatic amnesia alone.**

Oxford Head Injury Service, Rivermead Rehabilitation Centre, Abingdon Road, Oxford OX1 4XD, UK
N S King
S Crawford
F J Wenden
N E G Moss
D T Wade
F E Caldwell

Correspondence to:
Dr N S King.

Received 19 February 1996
and in revised form
3 June 1996
Accepted 27 August 1996

(*J Neurol Neurosurg Psychiatry* 1997;62:38–42)

Keywords: post-traumatic amnesia; measurement reliability

The period of post-traumatic amnesia is usually defined as the time between receiving a head injury and the resumption of normal continuous memory.[1–3] It includes any periods of unconsciousness, confusion, and disorientation.

As single measures, post-traumatic amnesia and the Glasgow coma scale (GCS)[4] are widely considered the two best single predictors of outcome after head injury. The GCS is most useful if given when a patient is first admitted to hospital[5] and cannot be used as a retrospective measure of severity of head injury. The facts that post-traumatic amnesia can be assessed relatively quickly and after the recovery of the patient are therefore major clinical advantages.[6] In addition, some patients have significant post-traumatic amnesia with short or negligible coma. In these circumstances the amnesia correlates better than GCS with radiological measures of severity of head injury.[7]

Russell and Smith[1] put forward a taxonomy of severity of head injury based on post-traumatic amnesia as follows—mild head injury: post-traumatic amnesia less than one hour; moderate head injury: post-traumatic amnesia between one and 24 hours; severe head injury: post-traumatic amnesia between one and seven days; and very severe head injury: post-traumatic amnesia more than seven days. Used as a broad measure of severity of head injury, post-traumatic amnesia has consistently shown an ability to predict important outcomes. Day to day living abilities (as measured by instruments such as the Glasgow outcome scale[8]), for example, have shown good correlation with duration of post-traumatic amnesia.[9] Similarly, a range of neuropsychological performance variables have shown a strong relation with duration of amnesia.[10–12] A recent study has suggested that the conventional classifications of severity of head injury based on post-traumatic amnesia may not be those which most accurately predict outcome.[12] However, it did confirm the efficacy of post-traumatic amnesia in predicting functional outcome. Thus the reliability of the measurement of post-traumatic amnesia may be a very important issue.

Difficulties in measuring post-traumatic amnesia have been well documented. It can be underestimated due to "islands of memory".[2] These are recollections of isolated events,

which on closer examination do not occur within a continuous memory for events and are reported by about one third of patients with mild and moderate head injury.[13] It can also be underestimated if the patients are deemed to be out of post-traumatic amnesia once they are oriented in time and place. Gronwall and Wrightson have shown that there is often little relation between responding correctly to orientation questions and subsequently remembering that such questions had been asked.[13] It is suggested that post-traumatic amnesia can be overestimated by including periods of natural sleep or impaired consciousness due to medication, alcohol, or drugs.[2] It seems, for some, to end sharply and to coincide with a memorable event such as being in an ambulance, leaving hospital, or going home. For others, recovery seems to be a slow and protracted process. This variability can further complicate its measurement.

In response to these types of difficulties, specific methodologies have been proposed to measure post-traumatic amnesia, one of which is the Galveston orientation and amnesia test (GOAT).[14] It has major limitations, however; patients can attain normal scores even when unable to answer questions relating to amnesia; it seems to measure post-traumatic disorientation rather than amnesia[15]; it is dependent on the assessor knowing a great deal about the patient; and it is only appropriate for long periods of post-traumatic amnesia (more than three days). Artiola *et al*[16] and Shores *et al*[17] have also published measures and these involve both orientation questions and simple learning tasks. Such measures mean that post-traumatic amnesia becomes "a measurable clinical entity on which independent observers can agree".[16] These measures are limited, however, because they require repeated administration over at least three consecutive days and therefore require intensive resources and are only appropriate for amnesia longer than three days. They have obvious research utility but are severely limited as clinical tools.

Clinically, post-traumatic amnesia is invariably measured by asking the patient to recall in chronological order, the events they can remember after their injury.[13] This method, although widely used, presents difficulties. Firstly, much of the published literature does not describe the procedure or protocol used.[17 18] Secondly, when used in mild head injury, test-retest reliability can be poor.[13] Although this is an important finding, its clinical relevance is probably limited, because few clinicians use post-traumatic amnesia as a fine grained measure of severity of head injury. The use of post-traumatic amnesia as a broad measure of severity is, however, widespread and it is an integral part of most neurological and neuropsychological assessments.

The reliability of measuring post-traumatic amnesia by retrospective questions across the full range of severity of head injury thus has great clinical importance. A recent study has shown good reliability between prospective and retrospective measures in a population with severe head injury three and a half to six years after the injury.[19] As yet, however, no data have been reported on the interrater reliability of retrospective measurements in a more representative sample of patients with head injury. This study aims (1) to describe explicitly a method for measuring post-traumatic amnesia by retrospective questioning—the Rivermead post-traumatic amnesia protocol; (2) to assess the interrater reliability of this method across a wide range of severity of head injury and clinically relevant situations.

Methods

To obtain data from various clinical situations, patients were recruited from four different sources. These were chosen to be representative of variables including severity of head injury, time between assessments, and time at which post-traumatic amnesia was first assessed. There was no overlap of patients between these sources. In all cases the Rivermead post-traumatic amnesia protocol was used to measure post-traumatic amnesia. This protocol was derived from descriptions of measurement of post-traumatic amnesia in the literature and from clinical experience.

MEASUREMENT OF POST-TRAUMATIC AMNESIA: THE RIVERMEAD POST-TRAUMATIC AMNESIA PROTOCOL

Post-traumatic amnesia is taken as the time between receiving a head injury and the resumption of normal continuous memory, including all periods of unconsciousness, confusion, and disorientation for whatever reason.

Patients are asked to recall their memories after the injury in chronological order. It is emphasised that they should relate what they can actually recall rather than what they have been told. After each event, the patient is asked "what is the next thing you remember?" and thus it is clarified whether each memory is an isolated one or part of a longer memory sequence. This process is continued until the assessor is satisfied that normal continuous memory is being described. The patient is then asked if this is the point at which he or she thinks that normal continuous memory for events returned. The patient might need to compare memory for that point with memory for a time a few days or weeks before the injury (when it was normal). If the assessor and patient disagree after discussion, the assessor's measure is used.

The Rivermead post-traumatic amnesia protocol is designed to be used by clinicians with experience in head injury assessment and all the clinicians in this study fulfilled this criterion.

SOURCES OF PATIENTS

Group A Rivermead Rehabilitation Centre (RRC) (n = 12)

Patients who had sustained a very severe head injury sufficient to warrant inpatient or outpatient treatment at the Rivermead Rehabilitation Centre were included if they had received their injury within two years of the study and consented to take part in it. An

Table 1 Group characteristics for each source of patients

	Rivermead rehabilitation centre n = 12 (A)	*Six month follow up only n = 40 (B)*	*OXHIS early follow up n = 22 (C)*	*OXHIS early follow up and six month n = 116 (D)*
Age:				
Mean (SD) (y)	39 (12·3)	34 (13·1)	36 (14·5)	34 (13·6)
Range	17–61	17–60	17–63	16–65
Sex:				
Male	8 (66·7%)	25 (62·5%)	17 (77·3%)	68 (58·6%)
Female	4 (33·3%)	15 (37·5%)	5 (22·7%)	48 (41·4%)
PTA:				
Mean (SD)	11 (7·7) weeks	65 (192·6) hours	76 (154·4) hours	19 (78·6) hours
Range	1–7 months	1 minute–6 weeks	20 minutes–4 weeks	1 minute–4 weeks
Time from head injury to first assessment:				
Mean (SD)	38 (25·8) weeks	27 (1·4) weeks	4 (5·4) weeks	11 (9·2) days
Range	11–84 weeks	25–30 weeks	0·5–26 weeks	4 days–12 weeks
Time delay between assessments:				
Mean (SD)	17 (2·6) days	9 (4·0) days	14 (9·9) days	26 (2) weeks
Range	13–21 days	3–20 days	3–46 days	21–34 weeks*

*One missing as date of head injury unclear. PTA = post-traumatic amnesia.

investigator interviewed the patient for between 10 and 30 minutes and used the Rivermead post-traumatic amnesia protocol to assess length of post-traumatic amnesia. The patient was then told that a second investigator would discuss their head injury with them again in between one and three weeks. A second investigator then repeated the procedure one to three weeks later. Factual information such as date of head injury, age, etc, were taken from medical records. Patients were approached consecutively over a four month period of admissions to Rivermead and the sample included those who were already inpatients at the time of the study.

Group B: Oxford Head Injury Service (OXHIS) six month follow up team (n = 40)

The service aims to register all patients between 16 and 65 years who sustain any type of head injury requiring hospital treatment in Oxfordshire. During a routine follow up as part of a pilot study of outcomes at six months after injury, those patients who consented were interviewed at home by one of the follow up team (SC, FJW). The investigator assessed the patient's post-traumatic amnesia using the Rivermead post-traumatic amnesia protocol and administered other follow up questionnaires. A brief structured interview was used to establish basic epidemiological information. About 10 days later, the other member of the follow up team visited the patient and repeated the procedure. The two investigators alternated between interviewing patients on the first or second visit. Patients were approached consecutively over a six month period of notifications to the register.

Group C: OXHIS early intervention team (n = 22)

A member of OXHIS (NSK, FEC, NEGM) routinely assessed a random half of all registered patients 7–10 days after injury. Patients were interviewed in their homes and counselling and ongoing treatment were provided as required. During the first interview, post-traumatic amnesia was established using the Rivermead post-traumatic amnesia protocol and consent was requested for another member of the team to revisit in the near future. Consenting patients were then interviewed in their homes 7–14 days later and the amnesia was reassessed. The investigators alternated between seeing patients on the first or second visit. Patients were approached consecutively over a 10 month period of notifications to the register which included several months when the register was not fully operational. Patients measured as having no post-traumatic amnesia at first assessment were excluded.

Group D: OXHIS early Intervention and six month follow up teams combined (n = 116)

Many patients received visits from both the OXHIS intervention team at 7–10 days after injury and the follow up team at six months after injury. On both occasions post-traumatic amnesia was established using the Rivermead post-traumatic amnesia protocol. Patients were approached consecutively over a 13 month period of notifications to the register and were excluded if amnesia was zero on both assessments.

Table 1 summarises the characteristics of each of these groups for age, sex, duration of post-traumatic amnesia, time from head injury to first assessment, and time delays between assessments.

A Spearman's rank correlation coefficient (r) was generated for post-traumatic amnesia assessments from first and second interviews for all patients. Coefficients were also generated for subgroups of the sample according to (*a*) duration of post-traumatic amnesia, (*b*) time at which post-traumatic amnesia was first assessed, and (*c*) time between the two assessments. The data were also analysed to determine the difference between the two assessments, the results being expressed as a percentage of the longer post-traumatic amnesia estimate.

Results

Table 2 shows Spearman's r for measures of post-traumatic amnesia at the first and second assessments. It displays coefficients for the sample as a whole and for subsamples selected according to severity of head injury, time of first assessment, and time between assessments. It also shows the percentage of patients

Table 2 Reliability of PTA assessment

Sample	*No of patients*	*Spearman's r*	*Significant difference between correlations*	*Percentage of sample who changed category n (%)*
Whole sample	190	0·79	—	39 (21)
PTA:				
< 24 hours	139	0·59	*	27 (19)
⩾ 24 hours	51	0·82		12 (24)
Time between assessments:				
⩽ 6 weeks	74	0·90	**	14 (19)
⩾ 6 months	116	0·64		25 (22)
Time until first assessment:				
⩽ 3 months	142	0·76	NS	27 (19)
⩾ 6 months	48	0·87		12 (25)

*P < 0·05; **P < 0·01. PTA = post-traumatic amnesia.

Table 3 Number of patients who changed head injury severity categories between assessments for the whole sample

PTA classification at 1st assessment	*PTA Classification at 2nd assessment*				
	Mild	*Moderate*	*Severe*	*Very severe*	*Totals*
Mild	75	12	[2]	0	89
Moderate	12	37	6	[1]	56
Severe	[1]	2	21	1	25
Very severe	0	0	2	18	20
Totals	88	51	31	20	190

Patients in boxes changed by more than one category.

who changed categories of severity of head injury between assessments using the criteria of Russell and Smith.[1] It indicates that post-traumatic amnesia was less reliably assessed in patients in whom post-traumatic amnesia was brief and in patients with a long time delay between assessments.

Table 3 shows the number of patients who changed categories of severity of head injury between assessments using the criteria of Russell and Smith. The numbers in boxes indicate the four patients who changed by more than one category. Three of these patients were from group D and one was from group B.

Table 4 shows the data described as the percentage difference between first and second assessments of post-traumatic amnesia. This was calculated using the formula (a-b)/a where a is the higher and b is the lower of the two measures, which minimises the sensitivity of the data to the severity of head injury. The table displays the percentage of change for the whole sample and for the subsamples selected according to severity of head injury, time of first assessment, and time between assessments. When one of the assessments of post-traumatic amnesia was zero this artificially caused the percentage change to be 100% (n = 50) and this is highlighted in the table. The other assessors' measurement of post-traumatic amnesia for these 50 patients ranged from one minute to 48 hours; mean 2·3 hours, median 5 (SD 9·5) minutes. Forty three were assessed as mild, five as moderate, two as severe, and none as very severe.

Discussion

Table 2 shows that, using a defined clinical protocol, the retrospective assessment of post-traumatic amnesia has reasonable reliability with a correlation coefficient of 0·79 and with 79% of patients being allocated to the same grade of severity by both assessors. This applied to all levels of severity and at various time points after injury. Table 3 however, indicates that a significant minority of patients can be misclassified, with 2% being allocated to widely differing categories of severity by two different assessors.

As would be expected, table 2 indicates that measurement was more reliable for longer durations of post-traumatic amnesia and when time intervals between assessments were shorter. The second finding accords with many reliability studies which show decreasing reliability as time intervals between testing increases. The finding that post-traumatic amnesia is measured more reliably for more severe head injuries has not been previously reported, but is consistent with the findings of Gronwall and Wrightson.[13] They found that assessing post-traumatic amnesia by retrospective questioning was often unreliable in patients with mild head injury. It is also consistent with the finding of McMillan *et al* that good reliability exists in severe head injuries between prospective and retrospective assessments.[19] Their Spearman's *r* of 0·87 is remarkably similar to a coefficient of 0·82 for the patients with more severe head injury in the present study (see table 2).

The Rivermead post-traumatic amnesia protocol was developed to reflect normal clinical practice and to be usable by clinicians on a day to day basis without difficulty. It is probably a method similar to that used by most clinicians who regularly assess patients with head injury and the definition of post-traumatic amnesia underlying the Rivermead post-traumatic amnesia protocol is generally accepted.[1-3] The study shows that using the Rivermead protocol is reasonably reliable, but there is scope for variability in measurement.

Table 4 Percentage change in post-traumatic amnesia (PTA) between first and second assessment

	Range of percentage change in PTA						
	0	*1–24%*	*25–49%*	*50–74%*	*75–99%*	*100%**	*Totals*
Whole sample (n (%))	34 (18)	16 (8)	34 (18)	19 (10)	37 (20)	50 (26)	190
PTA < 24 hours (n (%))	23 (17)	10 (7)	16 (11)	12 (9)	29 (21)	49 (35)	139
PTA ⩾ 24 hours	11 (22)	6 (12)	18 (35)	7 (14)	8 (16)	1 (2)	51
Time between assessments ⩽ 6 weeks (n (%))	19 (26)	9 (12)	18 (24)	6 (8)	12 (16)	10 (14)	74
Time between assessments ⩾ 6 months (n (%))	15 (13)	7 (6)	16 (14)	13 (11)	25 (22)	40 (34)	116
Time until first assessment ⩽ 3 months (n (%))	22 (16)	12 (8)	24 (7)	16 (11)	27 (19)	41 (29)	142
Time until first assessment ⩾ 6 months	12 (25)	4 (8)	10 (21)	3 (6)	10 (21)	9 (19)	48

Numbers in parentheses indicate percentage of total number for each range of change.
*50 patients were assessed as having no PTA on one of the assessments, giving a percentage change of 100%.

The clinician has to interpret information obtained from the patient and the information itself may potentially be inconsistent. This study shows the extent of that variability. It is not known to what extent the underlying phenomenon of post-traumatic amnesia itself varies, but clinical experience certainly suggests that some patients can seem to be out of post-traumatic amnesia when seen on a ward (are oriented and can recall events from 24–48 hours before) yet have no recall of seeing the assessor when reviewed four weeks later. Unfortunately there is no gold standard with which measurements of post-traumatic amnesia can be compared. Prospective measures have been developed,[14–16] but they cannot be used routinely and they are not applicable in mild head injuries. Indeed, the validity of post-traumatic amnesia as a measure of severity was largely established using clinical procedures which were not detailed.[1]

The findings of this study, which indicate the variability in assessments of post-traumatic amnesia, should be interpreted cautiously. The duration of post-traumatic amnesia is often used in group studies to characterise the sample and to measure severity (prognosis). The fact that studies have repeatedly demonstrated that duration of post-traumatic amnesia correlates with outcome,[9] radiological findings,[7] and neuropsychological abnormalities[10–12] demonstrates the validity of post-traumatic amnesia as a measure. It also suggests that reliability must have been at least reasonable otherwise no association would have been found. The study starts to quantify the uncertainty associated with a clinical assessment of post-traumatic amnesia. It should inform group studies, but does not limit the usefulness of post-traumatic amnesia.

The findings highlight some of the risks associated with relying solely on post-traumatic amnesia as a measure of severity in individual patients and in using it to define rigid taxonomies of severity. Certainly post-traumatic amnesia should be used as a major factor when considering the severity of a patient's head injury, but it should not necessarily be the sole determining factor. Indeed, many years after the event residual problems (if any) need to be born in mind when determining current severity even if these do not necessarily reflect the severity of the original brain damage.

The study does have some potential limitations and weaknesses. The sample was collected opportunistically and is not entirely complete epidemiologically. Epidemiological studies suggest that at least 75% of all head injuries are mild[20] and as few as 8% may be severe.[16] The sample in this study comprised 73% mild and moderate head injuries and 27% severe or very severe injuries. Patients with major head injury are therefore probably overrepresented. This, however, was a deliberate choice. The numbers would be too small to allow subgroup analysis if a "pure" epidemiological sample were relied on, when the results appertaining to minor head injuries would dominate any analysis. In addition the methodology allowed sampling across a wide range of clinically relevant situations which, otherwise, might have been impossible. Thus we believe that the sample is adequately representative of general clinical practice.

In conclusion, measuring post-traumatic amnesia by retrospective questioning had good reliability when the explicit method described in this study was used. The Rivermead post-traumatic amnesia protocol may therefore be a useful way of measuring the duration of post-traumatic amnesia in clinical practice. The protocol standardises the procedure of assessment, but is associated with a 21% misclassification rate. In only 2% of cases however, is this category change of unequivocal clinical significance (a change of over more than one category). This is probably as good as can be achieved in routine clinical practice. Future research should concentrate on improving the clinical assessment of post-traumatic amnesia, developing other better measures of severity of head injury and prognosis, and investigating more definitive measures of post-traumatic amnesia for use as a gold standard.

We thank Mrs Ann White for typing this manuscript, the Department of Health for funding the Oxford Head Injury Service as part of the their traumatic brain injury initiative, and the patients for all their cooperation.

1 Russell WR, Smith A. Post traumatic amnesia after closed head injury. *Arch Neurol* 1961;**5**:16–29.
2 Whitty CWM, Zangwill OL. Traumatic Amnesia. In: Whitty CWM, Zangwill OL, eds. *Amnesia*. London: Butterworths Press, 1977:118–35.
3 Lezak MD. *Neuropsychological assessment*. New York: Oxford University Press, 1983;165–75.
4 Teasdale G, Jennett B. Assessment of coma and impaired consciousness. *Lancet* 1974;**ii**:81–4.
5 Teasdale G, Jennett B. Assessment and prognosis of coma after head injury. *Acta Neurochir (Wien)* 1976;**34**:45–55.
6 Williams JM, Gomes F, Drudge O, Kessler M. Predicting outcome from closed head injury by early assessment of trauma severity. *J Neurosurg* 1984;**61**:581–5.
7 Wilson JTL, Teasdale GM, Hadley DM, Wiedman KD, Lang D. Post-traumatic amnesia: still a valuable yardstick. *J Neurol Neurosurg Psychiatry* 1993;**56**:198–201.
8 Jennett B, Bond M. Assessment of outcome after severe brain damage. *Lancet* 1975;**i**:480–4.
9 Brooks DN. Wechsler memory scale performance and its relation to brain damage after severe closed head injury. *J Neurol Neurosurg Psychiatry* 1976;**39**:593–601.
10 Brooks DN, Aughton ME, Bond MR, Jones P, Rizui S. Cognitive sequelae in relationship to early indices of severity of brain damage after severe blunt head injury. *J Neurol Neurosurg Psychiatry* 1980;**43**:529–34.
11 Karzmark P. Prediction of long-term cognitive outcome of brain injury with neuropsychological, severity of injury and demographic data. *Brain Inj* 1992;**6**:213–17.
12 Bishara SN, Partridge FM, Godfrey MPD, Knight RG. Post-traumatic amnesia and Glasgow coma scale related to outcome in survivors in a consecutive series of patients with severe closed head injury. *Brain Inj* 1992;**6**:373–80.
13 Gronwall D, Wrightson P. Duration of post traumatic amnesia after mild head injury. *Journal of Clinical Neuropsychology* 1980;**2**:51–60.
14 Levin HS, O'Donnell VM, Grossman RG. The Galveston orientation and amnesia test: a practical scale to assess cognition after head injury. *J Nerv Ment Dis* 1979;**167**: 675–83.
15 Shores EA, Morosszeky JE, Sandanam J, Batchelor J. Preliminary validation of a clinical scale for measuring the duration of post-traumatic amnesia. *Med J Aust* 1986;**155**:569–72.
16 Artiola I, Fortuny L, Briggs M, Newcombe F, Ratcliffe G, Thomas C. Measuring the duration of post-traumatic amnesia. *J Neurol Neurosurg Psychiatry* 1980;**43**:377–9.
17 Schacter DL, Crovity HF. Memory function after closed head injury: a review of the quantitative research. *Cortex* 1977;**13**:150–76.
18 Forrester G, Encel J, Geffen G. Measuring post-traumatic amnesia (PTA): an historical review. *Brain Inj* 1994;**8**: 175–84.
19 McMillan TM, Jongen ELMM, Greenwood RJ. Assessment of post traumatic amnesia after severe closed head injury: retrospective or prospective? *J Neurol Neurosurg Psychiatry* 1996;**60**;422–7.
20 Kraus JF, Nourjah P. The epidemiology of mild uncomplicated brain injury. *Trauma* 1988;**28**:1637–43.