

ORIGINAL ARTICLE

The significance of post-traumatic amnesia as a risk factor in the development of olfactory dysfunction following head injury

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Objective: To test the following hypothesis in the assessment of head injury patients: only patients with 5 min or more of post-traumatic amnesia (PTA) are at risk of acute olfactory dysfunction (OD).

Methods: This was a retrospective comparative study of olfactory status in head injury patients seen at a head injury clinic at Glasgow Royal Infirmary from 1985 to 2003. Of 828 clinic attenders, 101 had acute OD. These subjects were compared with a randomly selected control group of 102 patients with head injury but normal olfactory function. The main outcome measure was a significant likelihood of patients with PTA lasting for 5 or more minutes having acute OD compared with those with PTA of less than 5 min.

Results: The likelihood of patients with a PTA of 5 min or more having acute OD compared to those with PTA of less than 5 min is clinically significant with an odds ratio of 9.6 ($p < 0.01$).

Conclusion: Examination of patients with 5 min or more of PTA should include a simple test of sense of smell. Patients with impaired smell sensation should be aware of their condition prior to discharge from hospital. In addition, the need for a CT brain scan and appropriate follow up should be considered.

Olfactory dysfunction (OD), including complete and partial loss of sense of smell, is a complication of head injury which was first described in the medical literature by Hughlings Jackson in 1864.¹ It occurs most frequently after severe brain injury but also presents in patients with apparently mild injury.^{2–4} The estimated prevalence of OD in the general population is about 1–2%. The reported incidence of OD following head injury varies from 5% to 65% depending on the type and severity of brain injury.^{4–5} In a study of 271 patients with head injuries who attended a follow-up clinic at Glasgow Royal Infirmary (GRI) from 1985 to 1991, acute OD was identified in 19 patients (7%).⁶

Normal smell capacity has important implications for social and working life. For example, cooks, firemen, car mechanics, and industrial workers rely on their sense of smell for their livelihood and safety. Loss or distortion of the sense of smell can spoil the ability to enjoy pleasant odours and impairs the appreciation of food.^{3–5,7,8}

The mechanism of head injury which is most often associated with anosmia is an occipital impact leading to shearing of the olfactory nerves at the cribriform plate. Bruising of the antero-medial aspect of the frontal lobes where the centre for smell sensation locates has also been implicated.⁹

Our personal observation of current clinical practice suggests that patients in accident and emergency (A&E) departments and even patients admitted for observation following head injury often fail to receive a full assessment of their cranial nerve function including sense of smell. This is understandable due to the busy nature of the clinician's job and the feeling that precious clinical time should not be spent on such examination if the yield is negligible or the result irrelevant to the subsequent care of the patient. Therefore, it would be useful to be able to identify those patients who are at significant risk of OD and rule out those where testing sense of smell would be unnecessary.

A relationship between OD and the severity of head injury as measured by post-traumatic amnesia (PTA) has previously

been recognised, but these studies have not specifically addressed issues of clinical assessment by busy A&E clinicians.^{4–10,11} In a previous study of 784 adults presenting with head injury to A&E, 82% had less than 5 min PTA. As the vast majority of these patients with little or no PTA had minor injuries, it is not surprising that most of these patients were considered safe to discharge from A&E.¹² Since this study in 1981, we have used >5 min PTA as a guide for admission and this accords with current national guidelines in Scotland.¹³ Also, because this information on PTA duration was routinely recorded in our clinical notes, it seemed appropriate to use a 5 min PTA threshold in our hypothesis.

This study aims to determine the value of testing smell function in certain head injured patients. Specifically, the aim is to test the hypothesis that only patients with 5 min or more of PTA are at risk of acute OD.

METHODOLOGY

Patients were selected from those who attended the head injury follow-up clinic at GRI from 1985 to 2003 and included patients from the study published in 1993.⁶ Most patients were referred to the clinic after observation on an A&E ward if they had one or more of the following four referral criteria: PTA >1 h, evidence of intracranial injury on CT scan, skull fracture, or psycho-social issues resulting from head injury. Some were referred from general practitioners because of continuing symptoms after discharge from hospital and a few were seen for medico-legal reports.

The default rate for attendance at the clinic was about 25%. A few patients were excluded from the study group if the clinic was too busy to allow proformas to be completed and occasionally a patient was too severely disabled or disturbed to allow a comprehensive neurological assessment to be recorded.

At the first clinic attendance, prospectively collected clinical and demographic data were recorded on proformas.

Abbreviations: GRI, Glasgow Royal Infirmary; OD, olfactory dysfunction; PTA, post-traumatic amnesia

Table 1 Age effect

Age (years)	Normosmic control group, n = 102	Acute OD, n = 97	Chronic OD, n = 32	Total, n = 231	χ^2 test for trend
<15	4	1	0	5	p<0.01
15<25	33	5	1	39	
25<35	23	14	1	38	
35<45	12	23	7	42	
45<55	16	22	7	45	
55<65	8	15	6	29	
65+	6	17	10	33	

Information was collected from 828 patients who attended the clinic from 1985 to 2003. Data included mode of referral, age, gender, mechanism of injury, site of impact, type and severity of injury, imaging results, neurological findings, and previous medical history. To facilitate analysis these data were transferred from the clinic proformas to a computer database using Microsoft Access 2000.

PTA was defined as the time elapsed from injury to the return of continuous memory. Assessment of PTA requires careful attention to the patient's story and was helped by the availability of A&E records and ward notes which had specific questions on duration of PTA. Olfactory function was tested by the ability of patients to accurately smell peppermint liquid and oil of cloves.

The outcome measures were:

- Anosmia (complete loss of smell) – unable to smell both odours and unable to distinguish between the two test odours
- Normosmia (intact smell) – able to accurately identify or appropriately describe both test odours
- Hyposmia (partial loss of smell) – unable to identify or describe both odours appropriately but able to distinguish between the two odours

Patients who were aware of a pre-existing abnormal sense of smell (partial or complete), which was not altered by their head injury, were categorised as having chronic OD.

A group of patients with acute OD was compared to a randomly selected control group of head injured patients with normosmia. The characteristics of the two groups were compared using χ^2 tests for association and trend.

The hypothesis was tested using the odds ratio to establish the likelihood of acute OD after head injury in those with a

Table 2 Past medical history

Type of PMH	Normosmic, n = 102 (%)	Acute OD, n = 101 (%)	Chronic OD, n = 33 (%)	All, n = 236 (%)
Alcohol abuse	23 (23)	29 (29)	17 (51)	69 (29)
Head injury [severe]	25 (25) [5 (5)]	21 (21) [12 (12)]	19 (58) [12 (36)]	65 (28) [29 (12)]
Psychiatric/ nerves	14 (14)	22 (22)	5 (15)	41 (17)
Allergy	17 (17)	16 (16)	5 (15)	38 (16)
Accident or assault	18 (18)	7 (7)	5 (15)	30 (13)
Headache	16 (16)	6 (6)	3 (9)	25 (11)
Hypertension	8 (8)	8 (8)	5 (15)	21 (9)
Seizure	1 (1)	7 (7)	4 (12)	12 (5)
Other	23 (23)	28 (28)	17 (52)	68 (29)
No PMH	25 (25)	21 (21)	1 (3)	47 (20)

PMH, past medical history.

Table 3 Mechanism of head injury in 236 patients

Mechanism	Norm-osmic, n = 102 (%)	Acute OD, n = 101 (%)	Chronic OD, n = 33 (%)	All, n = 236 (%)	χ^2 test for association
Fall	42 (41)	62 (61)	23 (70)	128 (54)	p=0.0001
Assault	38 (37)	13 (13)	2 (6)	53 (22)	
RTA	16 (16)	20 (20)	5 (15)	41 (17)	
Other	6 (6)	6 (6)	3 (9)	14 (6)	

RTA, road traffic accident.

PTA of at least 5 min compared to those with PTA of less than 5 min. The sensitivity and specificity of the length of PTA is discussed.

RESULTS

Of the 828 head injured patients followed up in the clinic, 134 (16%) had OD. Thirty three of these (4%) had chronic OD and 101 (12%) had acute OD. The group of 101 patients with acute OD comprised 79 with anosmia (9.5%) and 22 (2.7%) with hyposmia. A control group of 102 patients was randomly selected from the remaining 694 normosmic patients.

Most patients (75%) were referred to the head injury clinic from a hospital ward. There was even representation between the study and control groups as regards the modes of referral to the clinic except that only two patients with acute OD were referred directly from the A&E department compared to 13 from the control group.

Male sex predominated in both the study group (81%) and the control group (87%). There were only five children under 15 years of age as children were usually followed up elsewhere. When the age effect is presented in decades (table 1), there is a significant trend for increase in age from the normosmic through the acute OD to the chronic OD group.

Nineteen of the 33 patients with chronic OD (58%) had previously sustained a head injury and in 12 the injury was severe enough to warrant admission (table 2).

The chronic OD group also had a high incidence of previous alcohol abuse (51%). If we compare the chronic OD and normosmic groups for previous alcohol abuse, a 95% confidence interval (0.096 to 0.418) calculated on the difference of proportions in each group indicates that those with previous alcohol abuse are more likely than those without to have chronic OD.

Seventeen patients with chronic OD had other previous conditions which included arthritis, back pain, asthma, meningitis, blackout, cerebrovascular accident, extracranial fractures, bronchitis, and a lazy eye.

There is good evidence of a relationship between the mechanism of head injury and the outcome of acute OD. Overall, the commonest mechanism was a fall (54%) and this was most striking in patients who had acute OD (61%) (table 3). In this acute OD study group, 43% of patients had fallen after consuming alcohol compared to 24% of the normosmic control group.

A significantly greater proportion (p<0.05) of patients with acute OD had skull fractures in comparison with the normosmic group. Occipital fractures were identified in 46% of the acute OD group compared to 24% of the normosmic group where the most common fracture site was temporal (33%) (table 4).

In addition to the fracture site, the main scalp injury site was also recorded. In 58 patients with acute OD, the predominant scalp wound was occipital (38%) followed by frontal (12%). When the impact site (either fracture or scalp

Table 4 Main skull fracture site in 68 patients with acute OD compared to 42 controls where a fracture was noted

Main fracture site	Normal smell, n=42 (%)	Acute OD, n=68 (%)	χ^2 test for association
Occipital	10 (24)	31 (46)	p=0.002
Multiple	0 (0)	9 (13)	
Temporal	14 (33)	11 (16)	
Parietal	9 (21)	12 (18)	
Frontal	9 (21)	5 (7)	

wound site) is considered, 25 patients with acute OD had sustained occipital impact secondary to a fall under the influence of alcohol compared to only four of the normosmic group.

In table 5 are shown the proportions of those who were normosmic compared to those with acute OD with respect to the number with an abnormal CT (34.6%) or a normal CT/did not require CT (67.7%). The 95% confidence interval on the difference of proportions clearly shows that those with intracranial injury are more likely to have acute OD than those with a normal CT scan or those who do not require one.

The frontal lobe or multiple areas of the brain were injured in 69% of the study group compared to 40% of the normosmic patients, but data on the site of intracranial injury and acute OD were insufficient for statistical tests to be carried out.

The length of PTA was noted in 97 of the 101 patients with acute OD and in all 102 with normosmia (table 6). Of the 159 patients with PTA >5 min, 30 (19%) had PTA of between 5 and 60 min and 12 of these had acute OD.

Only five patients with PTA <5 min had acute OD. The likelihood of patients with PTA \geq 5 min having acute OD compared to those with PTA of less than 5 min is very significant with an odds ratio of 9.6 (p<0.01). The 99% confidence interval is 2.61 to 35.16.

The sensitivity of the PTA 5 min test is 94%, that is, 94% of those with anosmia had a PTA >5 min. However, the specificity of the test is only 34%, that is, 66% of patients who are normosmic had a PTA greater than 5 min and will be identified as being at possible risk of having impaired OD. They require a smell test to confirm this or not.

DISCUSSION

In this study of 828 patients followed up in a head injury clinic over an 18 year period, 101 patients (12%) had acute OD. For the hospital in the study (GRI), this represents only about 0.6% of head injury admissions but may be an underestimate of the size of the problem as some patients who were transferred to the regional neurosurgery unit and others who refused admission were not included. About one quarter of those offered clinic appointments failed to attend. Many with injuries deemed too trivial for them to be admitted were not followed up and some patients with

Table 5 Intracranial injury and acute olfactory dysfunction

	Abnormal CT*	Normal CT/ not required
Normosmic	37	65
Acute OD	70	31
Total	107	96
95% CI of difference of proportions	0.331 \pm 1.96*0.0662 = 0.201 to 0.461	

*Intracranial haematoma, blood or air, but excluding fracture alone.

Table 6 Post-traumatic amnesia (PTA) and acute olfactory dysfunction

	PTA of at least 5 min	PTA of less than 5 min	Total	Odds ratio
Acute OD	92	5	97	9.6
Normal smell	67	35	102	
All patients	159	40	199	

multiple injuries who were treated on orthopaedic or surgical wards may have had a head injury which was not considered a priority for follow up or was unrecognised.¹⁴

Only two patients with acute OD were referred to the clinic directly from the A&E department compared to 13 from the control group. This is probably because the patients with acute OD had more severe brain injury as evidenced by intracranial injury on CT scan, skull fracture, or length of PTA, and were admitted and then referred from a ward (tables 4 and 5).

The study group differs from the control group in that the acute OD patients are older. There is also a difference in the number with previous severe head injury (12 v 5 patients). Even if these patients are excluded, the analysis of age by χ^2 test for trend still shows a significant difference in age, so perhaps the older brain is more vulnerable to shearing of the olfactory nerves or contusion of the frontal lobes.

The length of PTA which is linked to risk of OD is a key consideration for this study. The assessment of PTA requires careful attention to the patient's story and is helped by the availability of accurate ambulance and A&E records and reliable information from witnesses or relatives. The accuracy of evaluating amnesia depends on the expertise of and the time spent by the clinician. In this study the evaluation was almost entirely by one experienced A&E consultant.

In most patients with mild or moderate head injury (PTA of at least 5 min but less than 24 h), the PTA can be most reliably evaluated a few days or weeks after the event. If a patient is assessed too soon after injury when they are in continuing amnesia and not laying down permanent memories, the PTA may be underestimated. If patients are assessed many months after the head injury, it may also be difficult to accurately assess the PTA because it can be obscured by subsequent events and competing information. In this study, most patients were assessed about 6–8 weeks after injury.

A trade off between sensitivity and specificity is always required, but in this case where the sensitivity is very good (94% of those with acute OD had PTA >5 min) and the cost, time, and discomfort to the patient and doctor of the smell test is relatively small, a low specificity (34%) does not carry a large penalty and the PTA 5 min test is therefore deemed effective.

Five patients with acute OD seem to disprove the hypothesis because they had a PTA of less than 5 min, but four of these had a skull fracture. The other patient had retrograde amnesia, and was assessed almost 4 years after the injury for a medico-legal report which makes the assessment of PTA less reliable. Thus in the context of the management of recently head injured patients, only those with a head injury severe enough to cause concussion with a PTA of at least 5 min or those with a skull fracture are at risk of acute OD.

Because of the social and psychological consequences of OD, it is very important that patients are aware of their condition prior to discharge from hospital. Not all patients will recognise their problem immediately and some initially think they have lost their sense of taste because their

appreciation of food is impaired by anosmia. One patient kept burning toast and had to be prompted to get smoke alarms (this was during a fire service strike!). Rarely was anosmia regarded as beneficial except by one mother when she was changing nappies.

In our study, the typical patient with a high likelihood of acute OD is the intoxicated man who falls hitting the back of his head but remembers nothing about the subsequent events for a period of at least 5 min.

The results imply that any patient with PTA lasting longer than 5 min and any with a skull fracture are at risk of acute OD. Most of these patients are admitted for neurological observation on a non-neurosurgical ward and some will have had a CT brain scan before admission.¹⁵ Once acute intracranial haemorrhage has been excluded or treated, nursing and medical staff have the opportunity to identify neurological symptoms and signs which are relevant to recovery including simple testing of the sense of smell.

Because of the known link between acute OD and intracranial injury, all patients with acute OD should be considered for urgent CT brain scanning. Where there is doubt about the need for CT imaging, the finding of OD can be a deciding factor. The discovery of even a small frontal contusion that does not require surgery will help to focus attention on the need for such patients to undergo careful observation and receive rehabilitative support and appropriate follow up.

CONCLUSIONS

Examination of head injured patients with PTA lasting 5 min or more should include a simple test of sense of smell. This will be necessary for most admitted patients. Patients with impaired smell sensation should be made aware of their condition prior to discharge from hospital. In addition, the need for an urgent CT brain scan and appropriate follow up should be considered.

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CONTRIBUTORS

IJS had the idea for the study and its design. He provided the clinical data and put most of these data onto an electronic database. He is the main contributor to planning and reporting of the work described in the article and is the paper guarantor.

BB and VS conducted the literature review and both contributed to draft versions and final paper presentation.

RC developed the computerised database, advised on its use, and helped with analysis of results.

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