Risk factors and outcomes associated with post-traumatic headache after mild traumatic brain injury

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ABSTRACT

Objectives To determine the prevalence and potential risk factors of acute and chronic post-traumatic headache (PTH) in patients with mild to moderate traumatic brain injury (TBI) in a prospective longitudinal observational multicentre study. Acute PTH (aPTH) is defined by new or worsening of pre-existing headache occurring within 7 days after trauma, whereas chronic PTH (cPTH) is defined as persisting aPTH >3 months after trauma. An additional goal was to study the impact of aPTH and cPTH in terms of return to work (RTW), anxiety and depression.

Methods This was a prospective observational study conducted between January 2013 and February 2014 in three trauma centres in the Netherlands. Patients aged 16 years and older with a GCS score of 9–15 on admission to the ED, with loss of consciousness and/or amnesia were prospectively enrolled. Follow-up questionnaires were completed at 2 weeks and 3 months after injury with the Head Injury Symptom Checklist, the Hospital Anxiety and Depression Scale and RTW scale.

Results In total, 628 patients were enrolled in the study, 469 completed the 2-week questionnaire (75%) at 2 weeks and 409 (65%) at 3 months. At 2 weeks, 238 (51%) had developed aPTH and at 3 months 95 (23%) had developed cPTH. Female gender, younger age, headache immediately at the ED and CT scan abnormalities increased the risk for aPTH. Risk factors for cPTH were female gender and headache at the ED. Patients with cPTH were less likely to have returned to work than those without cPTH (35% vs 14%, P=0.001). Patients with aPTH and cPTH more often report anxiety (20% and 28%, P=0.001) and depression (19% and 28%, P=0.001) after trauma in comparison with the group without PTH (10% anxiety and 8% depression).

Conclusions PTH is an important health problem with a significant impact on long-term outcome of TBI patients. Several risk factors were identified, which can aid in early identification of subjects at risk for PTH.

Key messages

What is already known on this subject?
Post-traumatic headache (PTH) is a common problem after mild to moderate traumatic brain injury (TBI). Little is known about prevalence and risk factors contributing to both acute and chronic PTH and their influence on outcome.

What might this study adds?
In this prospective observational study, acute post-traumatic headache occurred in 51% of patients, and 23% developed a chronic post-traumatic headache. Female gender, younger age, headache immediately at the ED and CT scan abnormalities increased the risk for acute PTH. Risk factors for chronic PTH were female gender and headache at the ED. A third of patients with chronic PTH did not return to work by 3 months, a significantly higher proportion than for those who did not develop chronic headache.

INTRODUCTION

Mild traumatic brain injury (mTBI) accounts for at least 75%–90% of all TBIs worldwide,[1–3] Most patients with mTBI recover within weeks to months without specific therapy. A subgroup of patients, however, continues to experience disabling symptoms (15%–20%) in physical, behavioural and cognitive domains, which may interfere with return to work (RTW) or resumption of social activities.[4 5] Headache is one of the most common reported complaints after TBI and may have profound impact on functional outcome.[6 7] In retrospective studies, the prevalence of post-traumatic headache (PTH) ranges between 30% and 90%.[7]

PTH is classified as a secondary headache syndrome in the International Classification of Headache Disorders. This classification is primarily based on time of onset after TBI and chronicity of headache.[8] Acute PTH (aPTH) is defined as newly developed headache or worsening of a pre-existing headache within 7 days after trauma, which is mostly self-limiting. If the headache persists for more than 3 months after injury, it is defined as chronic PTH (cPTH). Reported risk factors for both aPTH and cPTH are female gender, pre-existing migraine, history of psychiatric disorders, low socioeconomic status, low education level, medication overuse and short duration of post-traumatic amnesia (PTA).[3 9–12]

The aims of this study were to assess the prevalence and risk factors of aPTH and cPTH and their effect on outcome in patients with mild to moderate TBI. In addition, possible predictive factors for the transition from acute to cPTH were investigated.

Patients and methods

Study design

A prospective longitudinal observational multicentre study was conducted between January 2013

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Box 1 Marshall criteria

- No visible intracranial pathology seen on CT scan
- Cisterns are present with midline shift of 0-5 mm; high or mixed density lesion <25 cm^3
- Cisterns compressed/absent with midline shift of 0-5 mm; high or mixed density lesion <25 cm^3
- Midline shift >5 mm; high or mixed density lesion <25 cm^3
- High or mixed density lesion >25 cm^3; any lesion surgically evacuated
- High or mixed density lesion >25 cm^3; not surgically evacuated

and February 2014. Patients with mild to moderate TBI who were admitted to the ED of three trauma centres in the Netherlands were eligible for inclusion. Brain injury severity was determined with the GCS on admission. MTBI was defined by a GCS of 13–15 with any loss of consciousness (LOC) or PTA, moderate TBI was defined by a GCS of 9–12.[4]

Inclusion and exclusion criteria

Inclusion criteria comprised GCS score between 9 and 15 on arrival in the hospital with at least LOC and/or PTA, age ≥16 years. Exclusion criteria were: inability to follow-up (ie, severe psychiatric diseases, patients not living in the region or without a permanent home address), drug or alcohol addiction, dementia or previous TBI with hospital admission and language barriers or illiteracy, prohibiting understanding and completion of the questionnaires. For the current analysis, we only included patients who completed both the 2 weeks and 3 months questionnaires.

Study procedures

After admission to the ED and neurological examination, patients were asked to participate and written informed consent was obtained (only if the patient had a GCS of 15). If patients were under 18 years of age, their parents were asked to provide informed consent as well. Patients with a GCS <15 were admitted to hospital with consent obtained before discharge. At two-time intervals after injury (2 weeks and 3 months), patients received questionnaires. The study was approved by the Medical Ethical Committee of the University Medical Centre Groningen.

Data assessment

Baseline data included age, gender, medical history, education level, state of employment before injury, presence of LOC, PTA headache at the ED, trauma mechanism and duration of hospital admission. A non-contrast CT scan (Siemens Somatom 64) was performed when necessary as part of the clinical care and rated by an experienced radiologist. CT scan results were classified using the Marshall classification, comprising six categories (box 1).[13] For analysis, data was dichotomised into 'normal CT scan' (category I) and 'abnormal CT-scan' (categories II–VI).

Definition of acute or chronic post-traumatic headache

Headache was regarded as present when it was reported on the Head Injury Symptom Checklist (HISC). APTH was measured at 2 weeks and defined as new or worsening of pre-existing headache beginning within 7 days after trauma. CPTH was measured at 3 months and was defined as persisting aPTH 3 months after trauma; if patients had not reported aPTH but only reported headache at 3 months, this was not classified as cPTH. To compare patients who had developed PTH with those who had not, patients were separated into three groups. The aPTH group were those patients who had reported aPTH but not cPTH. The cPTH group were those who reported both aPTH and cPTH. These two groups were compared with the group of patients who did not report PTH.

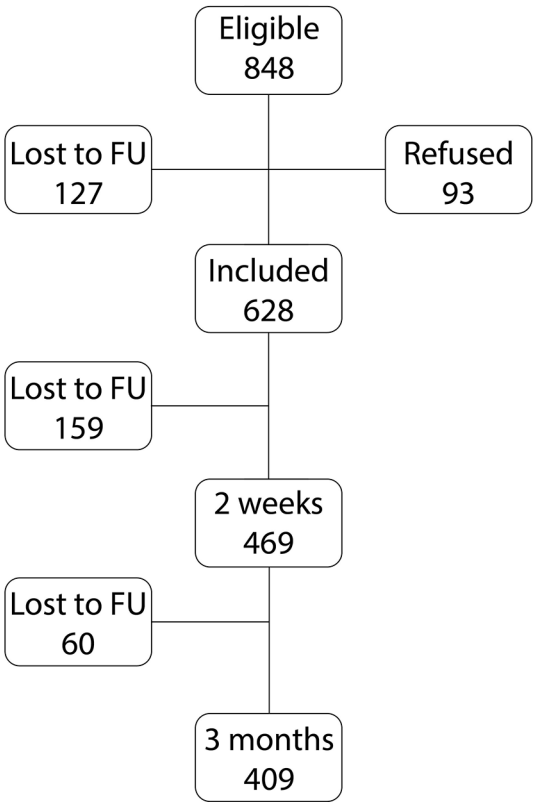

Figure 1 Flow diagram study population. FU, follow-up.

Questionnaires

The following questionnaires were applied at 2 weeks and 3 months, and not on their initial ED attendance.

The HISC[4 14]: The HISC contains the 21 most commonly described post-traumatic complaints, including headache. The questionnaire is described in detail elsewhere (see online supplementary file). It is derived from the Rivermead Post-concussion Symptoms Questionnaire,[15] which is the most common measure for post-traumatic complaints. For all 21 complaints, a preinjury and a current symptom level was indicated. Values range from 0 to 2 (0=never, 1=sometimes, 2=often). The total number of complaints (range 0–21) and the severity of complaints (range 0–42) can be determined. For analysis of PTH, scores for headache were dichotomised; no PTH (value=0) and in case of PTH (value=1 and 2).

Hospital Anxiety and Depression Scale (HADS)[16]: This is a 14-item questionnaire, comprising two subscales (depression and anxiety) of seven items each. Items are rated on a scale from 0 to 3. The presence of anxiety and/or depression was defined as a total score of 8 or more for either anxiety or depression-like symptoms. For analysis, scores were dichotomised with a cut-off value of 8.

RTW[14]: Resumption of preinjury vocational activities was measured with a RTW scale at 3 months. This five-point scale measures to which extent patients have resumed to their work: (1) previous work or study resumed; (2) previous work or study

Table 1 Demographics and characteristics in patients with acute and chronic PTH

	2 weeks 469 patients			3 months 409 patients		
	aPTH	Without aPTH	P value (95% CI**)	cPTH	Without cPTH	P value (95% CI**)
N (%)	238 (51)	231 (49)		95 (23)	314 (77)	
Male	135 (57)	157 (68)	0.01 (0.03 to 0.20)	45 (47)	209 (67)	0.001 (0.08 to 0.30)
Female	103 (43)	74 (32)	0.01 (0.02 to 0.20)	50 (53)	105 (33)	0.01 (0.08 to 0.30)
Age mean (years)	44	49	0.005 (1.52 to 8.58)	46	48	0.30 (-1.95 to 7.03)
Age >60 years	64 (27)	77 (33)		26 (27)	106 (33)	
Psychiatric history	17 (7)	24 (10)	0.20 (-0.02 to 0.09)	8 (8)	26 (8)	0.99 (-0.05 to 0.08)
Education			0.80 (-0.14 to 0.09)			0.50 (-0.23 to 0.05)
Basic	17 (7)	20 (9)	0.80 (0.11 to 0.05)	6 (6)	28 (9)	0.50 (0.13 to 0.03)
Middle	131 (57)	127 (56)	0.80 (0.63 to 0.50)	50 (53)	50 (56)	0.50 (0.63 to 0.43)
High	83 (36)	79 (35)	0.80 (0.42 to 0.30)	38 (40)	38 (35)	0.50 (0.50 to 0.31)
TLOC	187 (85)	181 (85)	0.90 (-0.07 to 0.08)	67 (77)	253 (88)	0.01 (0.01 to 0.21)
GCS at ED (median, (range))*	15 (13–15)	15 (10–15)	0.04 (0.01 to 0.38)	15 (12–15)	15 (13–15)	0.90 (-0.22 to 0.25)
Amnesia	186 (88)	192 (90)	0.60 (-0.02 to 0.12)	79 (90)	253 (89)	0.70 (-0.07 to 0.10)
Wounding skull/face	179 (77)	160 (70)	0.09 (-0.02 to 0.14)	72 (77)	225 (73)	0.40 (-0.06 to 0.13)
Headache at ED	127 (54)	84 (37)	<0.001 (0.08 to 0.26)	47 (50)	126 (41)	0.08 (-0.02 to 0.20)
CT scan abnormality	54 (23)	23 (10)	<0.001 (0.06 to 0.19)	22 (24)	49 (16)	0.09 (-0.01 to 0.18)
Injury mechanism	236	230	0.001 (-0.02 to 0.03)	93	313	0.06 (-0.01 to 0.07)
Collision	71 (30)	48 (21)	0.001 (0.36 to 0.25)	32 (34)	76 (24)	0.06 (0.44 to 0.26)
Fall	135 (57)	164 (71)	0.001 (0.63 to 0.51)	53 (57)	210 (67)	0.06 (0.67 to 0.47)
Violence	18 (8)	6 (3)	0.001 (0.12 to 0.05)	6 (7)	9 (3)	0.06 (0.13 to 0.03)
Sports	5 (2)	0	0.001 (0.05 to 0.01)	1 (1)	3 (1)	0.06 (0.06 to 0.002)
Other	7 (3)	12 (5)	0.001 (0.06 to 0.01)	1 (1)	15 (5)	0.06 (0.06 to 0.002)
Hospital stay	149 (63)	139 (61)	0.60 (-0.06 to 0.11)	55 (59)	204 (65)	0.20 (-0.04 to 0.18)

All values are reported as number (N) and percentages (%) if not indicated otherwise. Only 17 patients had moderate TBI. Education was categorised in basic, middle and high education group.

*Most of patients included had moderate TBI.

**95% CI for the difference between aPTH versus without aPTH and cPTH versus without cPTH.

aPTH, acute post-traumatic headache; cPTH, chronic PTH; mTBI, moderate traumatic brain injury; PTH, post-traumatic headache; TBI, traumatic brain injury; TLOC, transient loss of conscious.

resumed but with lower demands or part time; (3) previous work or study not resumed; (4) initially started working after injury but currently not working and (5) unemployed. For analysis, a dichotomy was applied: 'RTW' (categories 1–2) and 'no RTW' (categories 3–5).

Statistical analysis

Data were analysed with the statistical package for the social sciences (IBM SPSS V.22). Parametric (Student's t-test) or non-parametric (Mann-Whitney U test) tests were used for continuous variables; frequency analysis was performed using Pearson χ^2 tests. Univariate and multiple logistic regression analysis were used to assess the possible risk factors for aPTH and cPTH. For multiple regression analysis all variables with a P value <0.20 in the univariate analyses were included in the model. The model was subsequently simplified by excluding the least significant variable until only significant variables were present in the model.

RESULTS

After screening at the ED, 848 patients were eligible for inclusion. Of these patients, 93 (11%) declined participation and after discharge an additional 127 (15%) could not be traced, leaving 628 patients for analysis (figure 1). The response rate was 75% (n=469) at 2 weeks and 65% (n=409) at 3 months. The mean age of the total cohort was 45 years (SD ±20) with 37% women (mean age 47 years) and 63% men (mean age 44 years). The median GCS on admission was 15 (range 10–15), and 77% had transient LOC and PTA after trauma. Headache at the ED was reported by 45% of the total cohort. CT scan abnormalities were present in 15% of cases.

Acute and chronic PTH

At 2 weeks, aPTH was reported by 238 (51%) of patients, and at 3 months, 95 (23%) experienced cPTH. Of all patients with aPTH, 40% (n=95/238) had cPTH. Patient characteristics for aPTH and cPTH patients are presented in table 1.

Missing population

Table 2 shows comparison of responders (n=409) and non-responders (n=219) at 3 months. Non-responders were significantly younger, had fewer CT scan abnormalities, less amnesia and shorter duration of hospital admission. We also compared the initial loss to follow-up cohort (n=159) with the second loss to follow-up cohort (n=60). No significant differences were present regarding age, education, severity of injury, amnesia, duration of hospital stay and CT scan abnormalities.

Risk factors

Univariate analyses (table 3) identified potential risk factors for developing PTH (P≤0.05). For aPTH, these were female gender

Table 2 Demographics and characteristics in responders and non-responders at 3 months

N	Responders 409	Non-responders 219	P value (95% CI**)
Male	254 (62)	143 (65)	0.43 (-0.05 to 0.11)
Female	155 (38)	76 (35)	0.43 (-0.05 to 0.11)
Age mean (years)	48	40	<0.001 (-10.7 to –4.22)
Psychiatric history	34 (9)	10 (11)	0.52 (-0.01 to 0.07)
Education			0.25 (-0.17 to 0.10)
Basic	34 (9)	5 (6)	0.25 (0.12 to 0.06)
Middle	223 (56)	59 (65)	0.25 (0.60 to 0.51)
High	144 (36)	27 (30)	0.25 (0.41 to 0.31)
TLOC	320 (85)	163 (85)	0.89 (-0.03 to 0.11)
GCS at ED (median, (range))*	15 (3–15)	15 (7–15)	0.68 (-0.14 to 0.20)
Amnesia	329 (89)	156 (83)	0.05 (0.02 to 0.16)
Wounding skull/face	297 (74)	143 (68)	0.09 (-0.002 to 0.15)
Headache at ED	173 (48)	110 (58)	0.03 (-0.002 to 0.16)
CT scan abnormality	71 (18)	24 (12)	0.05 (0.01 to 0.12)
Injury mechanism			<0.001 (0.11 to 0.40)
Collision	108 (27)	44 (21)	<0.001 (0.31 to 0.22)
Fall	263 (65)	115 (54)	<0.001 (0.69 to 0.60)
Violence	15 (4)	41 (19)	<0.001 (0.06 to 0.02)
Sports	4 (1)	4 (2)	<0.001 (0.03 to 0.004)
Other	16 (4)	10 (5)	<0.001 (0.063 to 0.02)
Hospital stay	259 (64)	111 (51)	0.003 (0.05 to 0.21)

All values are reported as number (N) and percentages (%) if not indicated otherwise. Education was categorised in basic, middle and high education group.
*Most of patients included had mild TBI, only 17 patients had moderate TBI.
** 95 for the difference between the responders and non-responders.
aPTH, acute post-traumatic headache; cPTH, chronic PTH; PTH, post-traumatic headache; TBI, traumatic brain injury; TLOC,transient loss of conscious.

(OR 1.6), headache at the ED (OR 2.4) and CT scan abnormalities (OR 2.7). Factors that decreased the risk for aPTH were low GCS (OR 0.8). Potential risk factors for developing cPTH after 3 months that can be determined at the ED were female gender (OR 2.2 for female) and headache at ED (OR 1.7). Protective factors for cPTH were LOC (OR 0.5).

With multiple regression analyses, risk factors were identified that were independently associated with PTH (table 4). For aPTH, female gender (OR 1.7), headache at ED (OR 2.1) and CT scan abnormalities (OR 3.1) were associated with a higher risk. For cPTH, female gender (OR 2.1) and headache at ED (OR 1.6) were associated with a higher risk, while LOC (OR 0.4) was associated with a lower risk of cPTH.

Association of PTH with outcome

Table 5 reports RTW levels, anxiety and depression for both aPTH and cPTH patients. Both groups had significantly higher scores for anxiety and depression when compared with patients without PTH. Regarding RTW, the cPTH group showed a significant lower level of work resumption compared with patients without cPTH (35% vs 14%, respectively, P=0.001).

DISCUSSION

In this prospective study from three trauma centres, over half of minor TBI patients developed aPTH and nearly a quarter cPTH. Our study showed that patients with PTH, both acute and chronic, more often report anxiety and depression. Patients with cPTH were also significantly less likely to RTW at 3 months.

The reported prevalence in literature for aPTH and cPTH ranges 31%–96% versus 8%–58%, respectively.[9] An important explanation for this large variation is the variety of applied definitions for aPTH and cPTH. In the current study for example, the prevalence for cPTH based on the total patient group was 23% compared with 40% (95/238) when the calculation was based on patients that transitioned from aPTH to cPTH.

Although headache is one of the most common reported post-traumatic complaints, its association with psychological and functional outcome is not clear. Persistent complaints after trauma contribute significantly to loss of productivity and health care-related costs although this is largely associated with severe TBI. Most patients with mild TBI resume work within 1 to 3 months after injury, with approximately 60%–70% regaining their full-time job within 6 months.[3 4 17] However, even those who resumed their work reported complaints like headache, irritability, forgetfulness and poor concentration.[4] In these studies, the percentage of patients with incomplete RTW seems to increase with injury severity and number of complaints. Post-traumatic complaints like fatigue, headache and poor memory have been found to be among the most frequent reported complaints even years after injury and associated with limitations in daily functioning and lower levels of life satisfaction.[3]

In our study, 35% of patients with cPTH did not RTW 3 months after injury, which is comparable to other studies.[3 4 17] Patients with headache were less likely to have returned to work when compared with patients without headache. Although we did not

Table 3 Risk factors for acute and chronic PTH in univariate analysis

	aPTH			cPTH			
Variables	OR	95% CI for OR	P value	OR	95% CI for OR	P value	
Female	1.6	1.1 to 2.4	0.01	2.2	1.4 to 3.5	0.001	
Age (years)	0.99	0.97 to 0.99	0.01	0.99	0.98 to 1.0	0.30	
Psychiatric history		0.7	0.3, 1.3	0.20	1.0	0.4, 2.3	0.99
Education	1.1	0.8 to 1.5	0.60	1.3	0.9 to 1.9	0.20	
TLOC	0.9	0.6 to 1.7	0.90	0.5	0.3 to 0.9	0.01	
GCS at ED	0.8	0.6 to 1.0	0.04	1.0	0.8 to 1.2	0.90	
PTA	0.9	0.5 to 1.6	0.60	1.2	0.5 to 2.7	0.70	
Wounding skull/face	1.4	0.9 to 2.2	0.09	1.3	0.7 to 2.2	0.40	
Headache at ED	2.4	1.6 to 3.5	<0.001	1.7	1.0 to 2.8	0.04	
CT scan abnormalities	2.7	1.6 to 4.6	<0.001	1.6	0.9 to 2.9	0.09	
Hospital admission	1.1	0.8 to 1.6	0.60	0.7	0.5 to 1.2	0.20	

aPTH, acute post-traumatic headache; cPTH, chronic PTH; PTA, post-traumatic amnesia; PTH, post-traumatic headache; TLOC, transient loss of consciousness.

Table 4 Risk factors for acute and chronic PTH in multiple regression analysis

	aPTH			cPTH		
Variables	**OR**	**95% CI for OR**	**P value**	**OR**	**95% CI for OR**	**P value**
Female	1.7	1.1 to 2.6	0.01	2.1	1.2 to 3.5	0.01
Age (years)	0.98	0.97 to 1.0	0.003	0.99	0.98 to 1.0	0.29
TLOC	1.0	0.6 to 1.9	0.01	0.4	0.2 to 0.8	0.01
GCS at ED	0.8	0.6 to 0.9	0.06	0.9	0.8 to 1.3	0.90
Headache at ED	2.1	1.4 to 3.2	<0.001	1.6	1.0 to 2.8	0.07
CT scan abnormality	3.1	1.7 to 5.8	<0.001	1.7	0.8 to 3.3	0.14

aPTH, acute post-traumatic headache; cPTH, chronic post-traumatic headache; PTH, post-traumatic headache; TLOC, transient loss of conscious.

Table 5 Working state in patients with acute and chronic PTH at 3 months

Variables	**aPTH n=94**	**Without aPTH n=85**	**P value (95% CI**)**	**cPTH n=48**	**Without cPTH n=126**	**P value (95% CI**)**
Not returned to work*, N (%)	21 (22)	14 (17)	0.32 (–0.06 to 0.17)	17 (35)	17 (13)	0.001 (0.09 to 0.35)

P value was calculated by using the Mann-Whitney U test and Pearson χ^2 test.
*Included only those patients that were employed preinjury.
**95% CI for the difference between aPTH versus without aPTH and cPTH versus without cPTH.
aPTH, acute post-traumatic headache; cPTH, chronic post-traumatic headache; PTH, post-traumatic headache.

Table 6 Anxiety and depression in patients with acute and chronic PTH at 3 months

Variables	**aPTH**	**Without aPTH**	**p Value (95% CI†)**	**cPTH**	**Without cPTH**	**p Value (95% CI†)**
Anxiety median score (range)	4 (0–21)	3 (0–15)	<0.001 (–2.26 to –0.59)	6 (0–21)	2 (0–18)	<0.001 (–4.0 to –2.21)
N with score≥8 at HADS (%)	36 (20)	19 (11)	0.02 (0.02 to 0.17)	26 (28)	26 (10)	<0.001 (0.08 to 0.28)
Depression median score (range)	4 (0–21)	2 (0–16)	<0.001 (–1.9 to –0.40)	4 (0–18)	1 (0–14)	<0.001 (–3.89 to –2.23)
N with score ≥8 at HADS (%)	35 (19)	13 (8)	<0.001 (0.05 to 0.19)	26 (28)	19 (8)	<0.001 (0.11 to 0.30)

p Value was calculated by using the Mann-Whitney U test and Pearson χ^2 test.
†95% for the difference between aPTH versus without aPTH and cPTH versus without cPTH.
aPTH,acute post-traumatic headache; cPTH, chronic post-traumatic headache; HADS, Hospital Anxiety and Depression Scale; PTH, post-traumatic headache.

assess the direct influence of headache on work resumption, this finding might provide an argument for improved clinical monitoring immediately after discharge from the ED. With an early treatment of headache and concurrent reduction of all post-traumatic complaints, earlier resumption of work and other previous activities may be facilitated.

We found a similar prevalence of depression and anxiety in our study compared with prior literature. Prevalence of depression after TBI ranges 29%–33% and for anxiety 14%–26%.[4 12 18] There is an ongoing debate on the causality between these mood disorders and post-traumatic complaints. In previous studies, the presence of anxiety and depression was found to be related to vocational outcome; patients who become unemployed after TBI showed more symptoms of anxiety and depression than those who resumed their activities after mTBI.[14] It is unclear however whether PTH is a cause or symptom of anxiety and depression and whether RTW itself is a cause or an effect.

In the current study, the main risk factors for aPTH comprised female gender, younger age, presence of headache at the ED and CT scan abnormalities. Risk factors for developing cPTH were only female gender and presence of the headache in the ED. Female gender and CT scan abnormalities have also been identified as risk factors for PTH in previous studies.[9 10 19 20] Lower educational level or psychiatric problems were not associated with a higher risk for aPTH or cPTH in contrast to other studies.[5 21]

Limitations

This study had several limitations. Follow-up was incomplete: The response rate was 75% at 2 weeks and 65% at 3 months. Because non-responders were younger with significant fewer CT scan abnormalities, less PTA and shorter duration of hospital admission suggesting less severe injury, which might have led to overestimation of the occurrence of PTH. However, since neither age nor CT findings were associated with cPTH, we believe this estimate to be realistic. We included only those patients with TBI who were seen at the ED. It has been estimated that around a quarter of patients with TBI visit the ED after sustaining an injury, others visit only a general practitioner or no physician at all.[1] This is a recognised problem in TBI research and unfortunately not much is known about the patients who are not admitted to the ED.[22] We did not examine some risk factors that have been included in prior studies, for example, history of migraine, medication overuse and socioeconomic status, thereby limiting the comparison of our population with that of existing literature. Additionally, we did not ask for the exact reason for not resuming work. This may be related to depression and

anxiety but also because of headache or other post-traumatic complaints. Feelings of anxiety and depression were not assessed at the ED. Therefore, we are not able to answer the question whether depressed/anxious patients report more headaches or that headache (if present) causes more depression and anxiety. Finally, in this study the relation of headache with other cognitive complaints was not determined. In an earlier study, headache at the ED was related to complaints of mental fatigue at 6 months.[17] As headache is often reported to increase with cognitive tasks, it would be interesting to determine a possible relation between headache and cognitive complaints in a future study.

CONCLUSION

PTH is a highly prevalent complaint after mild to moderate TBI, and risk factors for its development can be determined during the ED visit. A considerable proportion of patients develop aPTH and/or cPTH and this is associated with anxiety, depression and failure to RTW. It is important that increased awareness enables the identification of symptoms and risk factors for PTH to treat patients more effectively.

Correction notice This article has been corrected since it was published Online First. The name of the first author has been corrected.

Competing interests None declared.

Patient consent Detail has been removed from this case description/these case descriptions to ensure anonymity. The editors and reviewers have seen the detailed information available and are satisfied that the information backs up the case the authors are making.

Ethics approval Medical Ethical Committee of the UMCG.

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Data sharing statement We used all the data we have for this study.

REFERENCES

1 Scholten AC, Haagsma JA, Panneman MJ, *et al*. Traumatic brain injury in the Netherlands: incidence, costs and disability-adjusted life years. *PLoS One* 2014;9:e110905.
2 Silverberg ND, Gardner AJ, Brubacher JR, *et al*. Systematic review of multivariable prognostic models for mild traumatic brain injury. *J Neurotrauma* 2015;32:517–26.
3 Ahman S, Saveman BI, Styrke J, *et al*. Long-term follow-up of patients with mild traumatic brain injury: a mixed-method study. *J Rehabil Med* 2013;45:758–64.
4 van der Naalt J, van Zomeren AH, Sluiter WJ, *et al*. One year outcome in mild to moderate head injury: the predictive value of acute injury characteristics related to complaints and return to work. *J Neurol Neurosurg Psychiatry* 1999;66:207–13.
5 Lingsma HF, Yue JK, Maas AI, *et al*. Outcome prediction after mild and complicated mild traumatic brain injury: external validation of existing models and identification of new predictors using the TRACK-TBI pilot study. *J Neurotrauma* 2015;32:83–94.
6 Lundin A, de Boussard C, Edman G, *et al*. Symptoms and disability until 3 months after mild TBI. *Brain Inj* 2006;20:799–806.
7 Hoffman JM, Lucas S, Dikmen S, *et al*. Natural history of headache after traumatic brain injury. *J Neurotrauma* 2011;28:1719–25.
8 Headache Classification Committee of the International Headache Society (IHS). The International Classification of Headache Disorders, 3rd edition (beta version). *Cephalalgia* 2013;33:629–808.
9 Erickson JC, Neely ET, Theeler BJ. Posttraumatic headache. *Continuum* 2010;16:55–78.
10 Hou R, Moss-Morris R, Peveler R, *et al*. When a minor head injury results in enduring symptoms: a prospective investigation of risk factors for postconcussional syndrome after mild traumatic brain injury. *J Neurol Neurosurg Psychiatry* 2012;83:217–23.
11 D'Onofrio F, Russo A, Conte F, *et al*. Post-traumatic headaches: an epidemiological overview. *Neurol Sci* 2014;35 Suppl 1:203–6.
12 Formisano R, Bivona U, Catani S, *et al*. Post-traumatic headache: facts and doubts. *J Headache Pain* 2009;10:145–52.
13 Marshall LF, Marshall SB, Klauber MR, *et al*. The diagnosis of head injury requires a classification based on computed axial tomography. *J Neurotrauma* 1992;9(Suppl 1):S287–92.
14 van der Horn HJ, Spikman JM, Jacobs B, *et al*. Postconcussive complaints, anxiety, and depression related to vocational outcome in minor to severe traumatic brain injury. *Arch Phys Med Rehabil* 2013;94:867–74.
15 King NS, Crawford S, Wenden FJ, *et al*. Early prediction of persisting post-concussion symptoms following mild and moderate head injuries. *Br J Clin Psychol* 1999;38(Pt 1):15–25.
16 Zigmond AS, Snaith RP. The hospital anxiety and depression scale. *Acta Psychiatr Scand* 1983;67:361–70.
17 Stulemeijer M, van der Werf S, Bleijenberg G, *et al*. Recovery from mild traumatic brain injury: a focus on fatigue. *J Neurol* 2006;253:1041–7.
18 McMurtray AM, Saito EK, Diaz N, *et al*. Greater frequency of depression associated with chronic primary headaches than chronic post-traumatic headaches. *Int J Psychiatry Med* 2013;45:227–36.
19 Ganti L, Khalid H, Patel PS, *et al*. Who gets post-concussion syndrome? an emergency department-based prospective analysis. *Int J Emerg Med* 2014;7:31.
20 Lucas S, Hoffman JM, Bell KR, *et al*. A prospective study of prevalence and characterization of headache following mild traumatic brain injury. *Cephalalgia* 2014;34:93–102.
21 Wäljas M, Iverson GL, Lange RT, *et al*. A prospective biopsychosocial study of the persistent post-concussion symptoms following mild traumatic brain injury. *J Neurotrauma* 2015;32:534–47.
22 Vikane E, Hellstrøm T, Røe C, *et al*. Missing a follow-up after mild traumatic brain injury--does it matter? *Brain Inj* 2014;28:1374–80.

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Notes