ANALYSIS OF THE RELIABILITY OF CLINICAL EXAMINATION IN PREDICTING TRAUMATIC CEREBRAL LESIONS AND SKULL FRACTURES IN PATIENTS WITH MILD AND MODERATE HEAD TRAUMA

ANDRZEJ ŻYLUK¹, AGNIESZKA MAZUR¹, BERNARD PIOTUCH¹, KRZYSZTOF SAFRANOW²

Department of General and Hand Surgery, Pomeranian Medical University in Szczecin¹
Kierownik: prof. dr hab. A. Żyluk
Department of Biochemistry and Chemistry, Pomeranian Medical University in Szczecin²
Kierownik: prof. dr hab. med. D. Chłubek

The aim of the study was to assess the reliability of neurological examination and other factors in predicting traumatic cerebral lesions and skull fractures in patients with mild and moderate head trauma (GCS 10-15).

Material and methods. Over a one-year period, 227 patients: 145 male and 82 female, aged a mean of 51 years who sustained mild or moderate head trauma (GSC 10-15) were examined neurologically and had performed head CT scans. The neurological examination as a whole and each finding of the neurological examination were tested as predictors of the presence of traumatic abnormalities in the head CT scan.

Results. Post-traumatic lesions in head CT scan were found in 109 patients (48%): skull fractures in 66 of these and brain injuries in 94; fifty-eight patients had skull fracture combined with brain injury. Seventeen patients required neurosurgical intervention (hematoma evacuation). Abnormal neurological examination showed the highest reliability in identifying patients with brain injuries in CT (sensitivity 87%, specificity 79%). Of single findings, gait abnormalities and consciousness disturbances, present in sober patients, were the strongest predictors of cerebral lesions. Likewise, abnormal neurological examination was the best indicator of skull fractures (sensitivity 77%, specificity 63%). Gait abnormalities and “racoon eyes” present in alcohol intoxicated patients were the strongest individual predictors of skull fractures.

Conclusion. Results of our study show neurological abnormalities as the most reliable (although not 100% accurate) in identifying patients who are likely to have brain injuries and/or skull fracture following head trauma. Use of clinical decision rules may reduce the number of head CT scans performed “just in a case”.

Key words: head injury, head computer tomography, clinical decision rules

Head injuries, both isolated and accompanying multitrauma are very common and every day hundreds such patients are diagnosed in Emergency Departments. It is without doubt that unconscious patients (at presentation) following head trauma require computed tomography (CT) imaging. This is, however, not so obvious in minor head injuries (transient loss of consciousness and normal neurological status). Most trauma centres obtain head CT scans on all patients even those without loss of consciousness. It is motivated by doctors' self-assurance and fear of the legal and ethical consequences of missing a traumatic intracranial lesion which does not manifest clinically. This policy results in hundreds CT scans ordered “just in case”, and showing no pathology (1, 2, 3). This approach is also costly, because CT scanning is still relatively expensive and the clinical management of these patients is rarely changed by the result of the CT.
Being involved every day in diagnosing head injuries, we attempted to assess the reliability of neurological examination and other factors (such as gender and alcohol use) in predicting traumatic cerebral lesions and skull fractures in patients with mild and moderate head trauma (GCS 10-15).

MATERIAL AND METHODS

Patients

During 2011, 269 patients with isolated head injuries were referred or delivered by ambulance to the Emergency Department of the University Hospital nr 1 in Szczecin. Of this number, 227 (84%) were admitted to the hospital and 42 were sent home after diagnostics or declined hospitalization.

Clinical notes of all patients admitted to the hospital in 2011 with diagnosis of head injury were retrospectively reviewed. Inclusion criteria were as follows:

a) age >18 years
b) isolated head trauma sustained within 24 hours before presenting to the hospital,
c) possible oral contact at presentation (full or limited consciousness, GCS score 10-15),
d) neurological examination performed at presentation,
e) head CT scanning performed at presentation.

Two hundred and twenty-seven patients, 145 male (64%) and 82 female (36%), aged a mean of 51 years (range 18-83) met the inclusion criteria and composed the study group. Patients were admitted to general surgical (n=129) or neurosurgical (n=98) departments, depending on severity and type of head injury.

Methods

All clinical data that were recorded and compared with results of head CT are summarized in tab. 1.

Neurological examination was performed by the specialist (neurologist or neurosurgeon) and recorded in patient’s notes. Presence of any abnormal finding from the list (tab. 1) was considered an abnormal result of neurological examination. For statistical calculation purposes, abnormal findings in neurological examinations were recorded in categorical manner: present or absent. Gait abnormality was recorded when the patient could not maintain vertical (upright) position, or walk normally due to inadequate strength, loss of balance, reeling or ataxia. Consciousness disturbances referred to disorientation to person, place or time, incomplete cooperation, lack of logical response, abnormal alertness and somnolence. The remaining components of the neurological examination do not need additional explanation.

All the components of the neurological examination and other variables, such as gender and alcohol use, were tested as predictors for the presence of post-traumatic abnormalities in the head CT scans. Calculations were performed separately for cerebral injuries and skull fractures. An analysis of the predictive value was performed for individual (single) components and for linked (paired) variables.

Statistical analysis

The sensitivity and specificity of the prediction of post-traumatic cerebral lesions and skull fractures in CT was calculated for each individual clinical parameter. The predictive power was expressed by Fi coefficient with values ranging from 0 (complete lack of association with CT result) to 1 (complete concordance). The statistical significance of associations was analysed using a two-sided Fisher’s exact test.

A multivariate logistic regression model was used to select a set of independent predictors of post-traumatic lesions. For each independent variable odds ratio (OR), 95% confidence interval (95%CI) and statistical significance (p) are presented. The statistical analysis was performed using STATISTICA 10 program.

RESULTS

The most frequent causes of the head injuries were: traffic accident – 73 patients (32%), assault with fist, feet or blunt object – 45 (20%), simple fall onto head – 38 (17%) and fall from height onto head – 23 patients.
Predicting cerebral lesions and skull fractures in patients with mild/moderate head trauma

Table 1. Clinical parameters which recorded and compared with result of CT scans in 227 patients with head traumas

<table>
<thead>
<tr>
<th>Parameters analyzed</th>
<th>no</th>
<th>Parameters status</th>
</tr>
</thead>
<tbody>
<tr>
<td>Trauma-related loss of consciousness</td>
<td>19 (8%)</td>
<td>yes 208 (92%)</td>
</tr>
<tr>
<td>Neurologic status</td>
<td>normal 117 (51%)</td>
<td>abnormal 110 (49%)</td>
</tr>
<tr>
<td>Gait abnormalities</td>
<td>absent 134 (59%)</td>
<td>present 93 (41%)</td>
</tr>
<tr>
<td>Consciousness status</td>
<td>normal 171 (75%)</td>
<td>disturbed 56 (25%)</td>
</tr>
<tr>
<td>„Raccoon eyes”</td>
<td>absent 187 (82%)</td>
<td>present 40 (18%)</td>
</tr>
<tr>
<td>Strength</td>
<td>symmetrical 196 (86%)</td>
<td>unilateral weakness 31 (14%)</td>
</tr>
<tr>
<td>Reflexes</td>
<td>symmetrical 199 (88%)</td>
<td>asymmetrical 28 (12%)</td>
</tr>
<tr>
<td>Babinski sign</td>
<td>negative 208 (92%)</td>
<td>positive 19 (8%)</td>
</tr>
<tr>
<td>Anizocoria</td>
<td>absent 214 (94%)</td>
<td>present 13 (6%)</td>
</tr>
<tr>
<td>Meningeal signs (+)</td>
<td>absent 216 (95%)</td>
<td>present 11 (5%)</td>
</tr>
<tr>
<td>Sensory disturbances</td>
<td>absent 224 (98%)</td>
<td>present 3 (2%)</td>
</tr>
<tr>
<td>Age</td>
<td>≤ 50 years 110 (48%)</td>
<td>&gt;50 years 117 (52%)</td>
</tr>
<tr>
<td>Alcohol intoxication</td>
<td>absent 160 (70%)</td>
<td>present 67 (30%)</td>
</tr>
</tbody>
</table>

(10%). The remaining 48 persons (21%) sustained head trauma under other various circumstances. In 67 patients (30%) alcohol intoxication was confirmed by blood test (range 0.04-0.23%).

Trauma-related loss of consciousness reported 208 patients (92%). Neurological abnormalities are summarized in tab. 1. Almost half of the patients displayed at least one abnormal finding in neurological examination, the most common being gait abnormalities in 93 (41%) and consciousness disturbances in 57 (25%) patients. Gait abnormalities concerned inability in maintaining a vertical (upright) position in 61 patients and loss of balance or reeling in 32.

Traumatic lesions in head CT imaging were present in a total of 109 patients (48%). Skull fractures were found in 66 (61% of the 109), of this number 33 had cranial, 14 facial and 19 cranial and facial fractures. In 94 patients (86% of the 109) brain injuries were found: intracranial hematoma in 72 (76%) (subdural in 67 and epidural in five), brain contusion in 42 (45%) and subarachnoidal haemorrhage in 20 (21%). Of these, 33 patients had hematoma combined with brain contusion and nine had subarachnoidal haemorrhage combined with brain contusion. Fifty-eight patients had skull fracture combined with brain injury.

Of the 72 patients with intracranial hematomas, 17 (24%) were operated on and 55 (76%) were treated conservatively. Neurosurgical interventions included 11 unilateral craniotomies with evacuation of hematomas, one bilateral craniotomy, four craniotomies combined with trepan-puncture and one cranioplasty. All operated patients survived.

In 63 patients CT scans revealed pathological findings unrelated to the trauma: most frequently cortical-subcortical atrophy in 23, followed by old post-stroke foci in 17.

Of the 110 patients with no abnormalities in neurological examination, in twelve (11%) the CT scan revealed traumatic cerebral lesions: brain contusion in nine patients and minor subdural hematoma in five (two had both pathologies). None of these patients required surgery. In another 34 patients (31% of the 110) with normal neurological status, CT
revealed skull fractures and in 30 (27%) old, non-traumatic pathologies.

Correlation analysis

Table 2 illustrates the correlation between clinical findings and cerebral lesions in CT scans. All abnormalities in the neurological examination, excepting anisocoria, disturbed sensation and “racoon eyes” were statistically significantly more frequently present in the group with positive CT (presence of traumatic lesions). Loss of consciousness occurred significantly less frequently in this group, comparing to the group with negative CT and alcohol use was the same frequent.

Gait abnormalities (as a single ingredient) were the strongest (highest Fi coefficient) predictor of brain injuries in CT, with 84% sensitivity and 89% specificity. The sensitivity might be slightly improved (up to 85%) without loss of specificity by combining gait abnormality with meningeal signs, (taking as a predictor occurrence of gait abnormality or meningeal signs). Maximal sensitivity (90%) but with loss of specificity (75%) might be reached considering gait abnormality or “racoon eyes” or consciousness disturbances or meningeal signs. Multivariate logistic regression analysis revealed statistically significant correlation between cerebral traumatic lesions in CT and:

a) gait abnormality (OR=37.2, 95%CI=14.9 – 93.2, p<0.00001),

b) consciousness disturbances (OR=3.6, 95%CI=1.3 – 10.3, p=0.016) and
c) absence of alcohol (OR=0.29, 95%CI=0.1 – 0.8, p=0.016).

Table 3 illustrates the correlation between clinical findings and skull fractures in CT scans. “Racoon eyes”, consciousness disturbances, meningeal signs and gait abnormalities occurred statistically significantly more frequently in the group with skull fractures in CT. Male gender and alcohol intoxication
correlated also statistically significantly with skull fractures. Gait abnormalities appeared again the strongest predictor of skull fracture in CT (the highest Fi coefficient), with 74% sensitivity and 73% specificity. The sensitivity might be improved (up to 86%) by combining gait abnormality with “racoon eyes” (taking as a predictor the occurrence of gait abnormality or “racoon eyes”), but was associated with loss of specificity to 66%. Using a multivariate logistic regression model analysis, the statistically significant independent factors associated with the presence skull fractures were:

- a) gait abnormality (OR=7.7, 95% CI=3.8 – 15.6, p<0.00001),
- b) “racoon eyes” (OR=4.7, 95% CI=2.1 – 10.8, p=0.00021) and
- c) alcohol intoxication (OR=2.5, 95% CI=1.2 – 4.9, p=0.015).

We analysed whether alcohol intoxication might influence the occurrence of gait abnormalities. Of 67 patients that were intoxicated at presentation, 33 (49%) showed gait abnormalities and 34 (51%) did not. Of 160 patients that were sober at presentation, 60 (37%) had gait abnormalities and 100 (63%) did not. Statistical analysis showed no significant correlation between alcohol intoxication and occurrence of gait abnormalities (Fisher exact test, p=0.11).

### DISCUSSION

Head CT scan is the diagnostic standard for identifying intracranial injuries: cerebral lesions or skull fractures with almost 100% accuracy. However, if performed routinely, regardless of the severity of the trauma and clinical symptoms and signs, it generates substantial costs and exposure of patients to radiation. Results of studies of one million emergency department visits for minor head injuries found that although CT scans show traumatic abnormalities in 6-12% of patients,
they include mostly skull or facial fractures. Cerebral lesions requiring neurosurgical intervention occur in only 0.13-0.3% of these patients, thus, at very most in 3 per 1000 (3, 4, 5). Therefore, it seems important to determine which clinical (neurological) findings are reliable predictors of traumatic cerebral lesions and skull fractures.

Our study analysed patients with head injuries of varying severity (GCS scores 10-15); however, all patients were conscious at presentation in the Emergency Department. Abnormalities in neurological examination (treated as a whole) showed the strongest predictive value for traumatic cerebral lesions, with 87% sensitivity and 79% specificity. Of single findings, gait abnormalities and consciousness disturbances present in sober patients were the strongest predictors of cerebral lesions. By contrast, such obvious pathological signs as anizocoria, meningeal signs, reflex and strength asymmetry showed high sensitivity (>90%), but poor specificity (10-28%). Thus, if these signs are present, cerebral lesion is very likely, but their absence shows poor clinical importance.

Likewise, abnormal neurological examination was the best indicator for skull fractures, however with somewhat less sensitivity – 77% and specificity – 63%, compared to cerebral lesions. Gait abnormalities and “racoon eyes” present in intoxicated persons were single findings showing the highest predictive value for skull fractures.

All 17 patients requiring neurosurgical intervention for intracranial hematoma had abnormalities in neurological examination, including gait and consciousness disturbances. Thus, these signs appeared to be strong predictors of the necessity for operative treatment in head injuries, too.

In 12 patients (11%) with a normal neurological examination, the CT scans revealed traumatic brain injuries, none requiring surgery. This finding suggests that although normal neurological status does not imply lack of intracranial traumatic lesions, nevertheless they are mild and development of complications is very unlikely. Data from the literature show that brain injuries diagnosed by CT in patients following mild head traumas, with no neurologically abnormal findings do not require specific treatment and rarely cause further complications (1, 2, 4).

We found two papers in the literature analysing the predictive value of neurological changes and other factors in predicting traumatic brain injuries. Mower et al. analysed the results of CT scans performed on more than 13 thousand patients with mild and moderate brain trauma (GCS 12-15). Intracranial injuries were found in 917 patients (6.7%), including hematomas, brain contusions, subarachnoideal haemorrhage and other. The best predictors of cerebral lesions were: neurological deficit at examination (sensitivity 64%); consciousness disturbances – abnormal alertness and somnolence (64%); abnormal behaviour – aggression, incompliance (43%); and presence of skull fracture (21%). Injuries were also rare among patients under age 65 who had no evidence of skull fracture, scalp hematoma, coagulopathy and persistent vomiting. These characteristics would have identified 900 brain injury cases (sensitivity 98%), while classifying 1700 patients (13%) as “low risk”.

The authors conclude that clinical characteristics can reliably identify patients who are unlikely to have brain injuries following head trauma and who do not require CT imaging (6). These results are partially consistent with those obtained in our study; however, these authors did not analyse the individual components of a neurological examination instead treating it “as a whole”.

Falmirski et al. assessed the predictive value of the following symptoms and signs: headache, somnolence, abnormal behaviour (changed alertness, confusion, preservation, and aggression), nausea and vomiting, seizure post trauma, neurological deficit (strength, sensation, reflexes) and vision abnormalities as predictors of cerebral lesions in patients with mild head trauma. A total of 331 patients were included, of which 146 (41%) had at least one of above-mentioned symptoms/signs, whereas 195 (59%) had none. CT scans showed intracranial injuries in 29 patients (21%) from the former and in 11 (6%) from the latter group. The best predictors for cerebral lesions were: somnolence (observed in 25 patients of whom 10 – 40% had brain lesion in CT), followed by abnormal behaviour (39/13 – 33%) and seizure post trauma (3/1 – 33%). The remaining features considered displayed minor predictive value (<10%). Surprisingly, head-
ache was more frequently observed in patients without intracranial pathology (1).

Likewise in both quoted papers, the results of our study show neurological abnormalities (the most reliable in identifying patients who are likely to have brain injuries and/or skull fractures following head trauma. The importance of gait abnormalities (as a single ingredient) in prediction of cerebral lesions and skull fractures seems to be a valuable finding of this study, not mentioned previously. Combination with other variables: consciousness disturbances, “raccoon eyes” and alcohol intoxication improved the accuracy of prediction of traumatic brain pathologies and, thus, the selection of patients who require CT imaging or not. Although 14% of patients with normal neurological examination had traumatic brain injuries revealed by the CT, none of them required surgery, which suggests that at a normal neurological examination they are minor and not dangerous.

**REFERENCES**
