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Clinical versus Autopsy Diagnosis of Cranio-cerebral Injury*

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Summary. The accuracy of the clinical diagnoses of the victims who died at the Department of Neurosurgery, Helsinki University Central Hospital in 1975 and 1976 of a lethal injury to the head was investigated. Standard clinical and X-ray means were used without computed tomography whose value as an additional tool will be reported later. Most of the patients were traffic accident victims of which 71% died within 24 h after trauma. The rate of the correct diagnoses of fractures was 87% in the vault, 76% at the base of the skull, and 67% in the facial bones. Of all intracranial lesions, 75% were correctly and 9% partially diagnosed. The discrepancy would have been more marked if such entities as cerebral contusion and laceration and hemorrhage had been presented separately. This study indicates that many head injuries remained undiagnosed by standard clinical means. The value of X-ray examination also appeared small in the postmortem diagnostics of skull fractures and intracranial lesions.

Key words: Head injuries – Brain injuries – X-ray diagnostics

Zusammenfassung. Die Richtigkeit klinischer Diagnosen bei Patienten wurde untersucht, die in der Neurochirurgischen Abteilung des Zentralkrankenhauses der Universität Helsinki von 1975–76 an einer tödlichen Kopfverletzung verstorben waren. Regelrechte klinische und Röntgenuntersuchungen wurden angewandt, nicht jedoch die Computertomographie, über deren Bedeutung als ein zusätzliches Diagnosemittel später berichtet werden soll. Die meisten Patienten waren Opfer eines Verkehrsunfalles, 71% starben innerhalb von 24 h nach dem Unfall. Der Prozentsatz für richtige Diagnosen von Frakturen betrug 87% für Verletzungen der Schädeldecke, 76% für Schädelbasisbrüche und 67% für Frakturen des Gesichtsschädels. Von allen intrakranialen Verletzungen wurden 75% richtig, 9% teilweise richtig diagnostiziert. Die Diskrepanzen würden noch deutlicher werden,

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wenn cerebrale Kontusionen, Verletzungen und Blutungen separat aufgeschlüsselt würden. Die Studie zeigt, daß viele Kopfverletzungen durch übliche klinische Untersuchungen nicht diagnostiziert werden. Auch scheint der Wert einer Röntgenuntersuchung gering bei Post-mortem-Diagnosen von Schädelfrakturen und intrakranialen Läsionen.

Schlüsselwörter: Schädelverletzungen - Hirnverletzungen - Röntgendiagnostik

Little attention has been paid to the validity of the clinical diagnoses of fatally injured patients [1] despite that there are numerous well-documented clinical studies [7–13]. In a previous study [6] we analyzed a series of patients who died of a severe injury to the trunk. We compared the clinical vs. autopsy findings and found out that some lethal injuries, e.g., rupture of aorta, were relatively often missed clinically. In this study, we have made a similar comparative study on head injuries which is a basic analysis from the time before the computed tomography was employed. A similar prospective study on the value of computed tomography as an additional diagnostic tool is in progress.

Material and Methods

This report concerns all patients who died within 7 days of injury at the Dept. of Neurosurgery, Helsinki University Central Hospital, in 1975 and 1976 with a primary cranio-cerebral lesion as the underlying cause of death. The material comprised 132 cases of which 95 (72%) were males and 37 (28%) females. The age distribution is presented in Table 1. In each case a complete medicolegal autopsy was made at the Dept. of Forensic Medicine, University of Helsinki. In 76 cases (58%) the external cause of death was a traffic accident, in 34 (26%) accidental falling or jumping from a high place, and in 12 cases (9%) a suicide by means of a gunshot wound in the head. Ten patients (7%) died of some other cranio-cerebral injury as the accidental cause of death (Table 2). The survival time of the patients is presented in Table 2.

All patients were investigated with ordinary physical and neurologic examinations, standard X-ray examinations, and laboratory tests. In addition, 80 carotid angiographies were made on 55 patients. In 1975–1976 there was no computed tomography in use. The clinical diagnoses were derived from the hospital records and, in addition, all radiographs were re-examined by one of the authors (EML).

The injuries to the head were divided into the following categories; fractures of the vault (75 patients) and the base of the skull (100 patients), fractures of the facial bones (15 single fractures in 12 patients) and intracranial injuries (236 single injuries in 132 patients) [16].

Results

Fractures

The fractures of the vault of the skull were divided into closed solitary and multiple fractures, and open fractures, the last referring to an open wound or a foreign body in connection with the fracture (Table 3). In 65 (87%) cases the

Table 1. Sex and age of victims with cranio-cerebral injury

Age in years	Males (*n*)	Females (*n*)	Total	
			(*n*)	(%)
Below 15	7	4	11	8.3
15–24	28	3	31	23.6
25–34	15	6	21	15.9
35–44	8	3	11	8.3
45–54	12	6	18	13.6
55–64	13	6	19	14.4
Over 64	12	9	21	15.9
Total (*n*)	95	37	132	
(%)	72.0	28.0		100.0

Table 2. External circumstances causing death vs. survival time

External circumstances	Death within			Total	
	0–6 h (*n*)	6–24 h (*n*)	1–7 d (*n*)	(*n*)	(%)
Traffic accident	31	25	20	76	57.6
Falling or jumping from high place	9	10	15	34	25.8
Suicide by firearms	8	4	–	12	9.0
Injury by other means	3	4	3	10	7.6
Total (*n*)	51	43	38	132	
(%)	38.6	32.6	28.8		100.0

fracture of the vault of the skull was correctly diagnosed. The correct diagnoses consisted of 35 solitary, 22 multiple, and eight open fractures. Ten fractures (13%) remained undiagnosed, nine being solitary and one open. In five cases the fracture was apparently missed because of suboptimal radiographs because the head was moving during examination or the radiograph was taken only in an anteroposterior projection. In three patients who died within 1 h no radiographs were taken. Three solitary fractures of the vault of the skull, also seen in the re-examination of the pictures, were not mentioned in the autopsy reports.

Fractures of the base of the skull were similarly subdivided into three types as above (Table 3). Fifty-one (51%) of these fractures were solitary, 41 (41%) multiple, and eight (8%) open. The material presented in Table 3 consists mainly of the same patients because in 68 patients a combination of the fractures of the vault and the base of the skull was seen. On the other hand, in ten cases only fracture of the vault and in 32 cases that of the base was seen.

Table 3. Diagnostic accuracy of fractures of the base and vault of the skull

Diagnostic accuracy	Type of fracture			Total	
	Solitary (*n*)	Multiple (*n*)	Open (*n*)	(*n*)	(%)
Vault of skull					
Correct-positive	35	22	8	65	86.7
False-negative	9	–	1	10	13.3
Total (*n*)	44	22	9	75	
(%)	58.7	29.3	12.0		100.0
Base of skull					
Correct-positive	36	34	6	76	76.0
False-negative	15	7	2	24	24.0
Total (*n*)	51	41	8	100	
(%)	51.0	41.0	8.0		100.0

Table 4. Diagnostic accuracy of fractures facial bones

Diagnostic accuracy	Fracture			Total	
	Nasal bone (*n*)	Maxillary bone (*n*)	Mandible (*n*)	(*n*)	(%)
Correct-positive	1	5	4	10	66.6
False-positive	1	-	-	1	6.7
False-negative	1	1	2	4	26.7
Total (*n*)	3	6	6	15	
(%)	20.0	40.0	40.0		100.0

In 76 cases (76%) fracture of the skull base was diagnosed clinically, but in the remaining 24 cases (24%) it was either missed or misdiagnosed. In four of these cases only radiographs of poor quality were available, and in three cases the patient died within 1 h, and no radiographs were taken. In fifteen cases (15%) the continuation of the fracture line from the vault into the base of the skull was not diagnosed by the clinicians. In five of these patients a gunshot wound to the head was the primary lesion.

As a summary, 34 fractures of the vault or the base of the skull were either missed or incorrectly diagnosed by clinical means in 28 patients.

More than half (67%) of the fractures of the facial bones were correctly diagnosed (Table 4). One fracture of the nasal bone was not found at autopsy and was apparently erroneously diagnosed in the hospital. Four fractures (27%) were

Table 5. Diagnostic accuracy of intracranial injuries

Diagnostic accuracy	Type of injury or injury pattern			Total	
	Extradural hemorrhage	Subdural and/or subarachnoid hemorrhage	Cerebral contusion and/or hematoma	(*n*)	(%)
	(*n*)	(*n*)	(*n*)		
Correct-positive	9	41	128	178	75.4
Partially correct-positive	20	–	–	20	8.5
False-negative	4	33	1	38	16.1
Total (*n*)	33	74	129	236	
(%)	14.0	31.3	54.7		100.0

missed, namely one fracture of the nasal bone, one of the maxillary bone, and two of the mandible. Radiographs of poor quality were the apparent reason for the false-negative result. Two fractures of the articular process of the mandible were not recorded in the autopsy reports, although they were readily diagnosed by clinical methods.

Correct clinical diagnostics of fractures of the skull base were also dependent on the survival time of the patients. The respective rates of the correct diagnoses were 74%, 82%, and 86% in the patients who lived for 0–6 h, 6–24 h, and 1–7 days after admission. This trend was not found in the diagnostics of fractures of the vault of the skull or facial bones.

Intracranial Injuries

The total number of single intracranial lesions was 236 in 132 patients 178 (75%) of which were correctly diagnosed. The accuracy of the diagnostics of the intracranial injuries is summarized in Table 5.

The number of the partially diagnosed lesions was 20 comprising 9% of all intracranial lesions. In fifteen of these cases intracerebral circulation examined by angiography had almost stopped, leaving no chance of detecting the specific location of the extradural, subdural or subarachnoid hemorrhage. Furthermore, in five cases the subdural hemorrhage was diagnosed by means of angiography but the concomitant extradural hemorrhage remained undiagnosed.

Thirty-eight lesions (16% of all) were not found clinically. These false negative diagnoses comprised four extradural hemorrhages, 33 subdural and/or subarachnoid hemorrhages and one cerebral contusion. In most of these cases (28 patients) there was either no time to perform an angiographic examination or it was withheld because of the hopeless clinical or poor physical condition of the patient, advanced age, etc. In some cases the diagnostics and treatment of other injuries were given priority. In ten cases extracerebral hemorrhage was clinically

missed in spite of angiography. In six of them the thickness of the hemorrhage was 5–10 mm as observed at the medicolegal autopsy. In two cases the result of the angiographic examination was of poor quality. In two patients it was not possible to detect a hemorrhage outside the cerebellum by carotid angiography.

In three autopsy reports there was no mention of an extracerebral hematoma clearly visible in the angiography. No craniotomy was carried out in these cases.

Carotid angiography, which in several cases was bilateral, was performed on 55 patients. In many patients the angiography was repeated so that there was a total of 80 examinations. Intracranial circulation was slowed in 48 examinations (60%) and completely stopped in five cases (6%). Spasticity of the main arteries was recorded in 26 and that of the peripheral arteries in 11 angiographies.

Forty-four traumatic subarachnoid hemorrhages were noted, either alone or in combination with subdural hemorrhage at autopsy. Such a specific diagnosis was impossible to establish with the clinical facilities available and the corresponding clinical entity was subdural hematoma (Table 5). Most of the small subarachnoid hemorrhages were not of any major clinical importance. In forensic practice the morphological entities of cerebral contusion (bruise), cerebral laceration, and intracerebral hemorrhage are indisputable. In this report, however, no distinction was made between them because of the nonexistent clinical facilities for the diagnostics of these lesions. The rate of the extracerebral hemorrhages diagnosed correctly improved from 14% to 45% and 85% 0–6 h, 6–24 h, and 1–7 days after admission, respectively.

Discussion

The purpose of this report was to study the accuracy of the diagnostics of acute cranio-cerebral trauma by comparing the clinical diagnoses with the medicolegal autopsy findings. The material consisted of all lethal injury patients admitted to the Dept. of Neurosurgery at the Helsinki University Central Hospital during 2 years, with a head trauma as the underlying cause of death. The corresponding results on the lethal trauma of the trunk and extremities for the same period have previously been reported [6]. This study comprises several patients with head trauma who also had injuries of the trunk and/or the extremities. However, in all cases the head injury was the primary lethal lesion on which the main attention of the clinicians was focussed. Patients who survived for more than 7 days after injury were excluded. In these cases the prospects for making the correct diagnosis by clinical means are good, and therefore, they were not of interest to us [8]. The cases declared dead at the scene of the accident or on the arrival at the hospital were also excluded.

The external cause of injury in our material was mostly a traffic accident or falling or jumping from a high place, whereas suicides by shooting, and other diverse causes comprised the rest of the material. About 39% of the patients died within 6 h of arrival. Sevitt [10] reported that more than half (54%) of the patients with a lethal injury died within 4 h. However, 4% of these cases were dead at the site of the accident, and therefore the results are not completely comparable. In our material 71% of the patients died within 24 h after trauma. Rokkanen and

Slätis [8] reported that the corresponding rate was 55% in the present clinic in 1964 and 1965. Perhaps the modern emergency care has prolonged the survival time of the severely injuried patients in comparison to that of 10 years ago. There were 132 cases with acute lethal head injuries in this material but only 31 cases with acute lethal injuries of the trunk or extremities in our clinic in 1975 and 1976. This indicates that cranio-cerebral lesions represent the vast majority of all lethal injuries as discussed also by several previous authors [1, 3, 4, 8, 10].

Fractures of the vault and the base of the skull are clinically important even when a solitary fracture in itself is not the lethal lesion. However, the fractures correlate roughly with the intensity of the violence and contribute to the initiation of search for other severe intracranial lesions and complications [4].

Therefore, the diagnostics of skull fractures are important. The present results, however, showed that a considerable number of the fractures of the skull base and facial bones remained undiagnosed. Similar results have been reported earlier, and Webber et al. [15] stated that even relatively large depressed fractures in both parietal and occipital regions of the skull were in some instances considered to be radiographically uninterpretable.

Gammelgaard et al. [4] demonstrated 25 years ago that the clinical lethal head trauma diagnoses of 115 road traffic accident victims issued by the clinicians on the death certificate deviated by 14% from the autopsy diagnoses. The overall percentage of all incorrect diagnoses in this study (Tables 3–5) was 18%. These results are not directly comparable because our analysis has also taken into account all minor non-lethal lesions, whereas Gammelgaard et al. [4] considered only the main or lethal lesions.

A strong similarity was observed in our study between the clinical and autopsy diagnoses of cerebral contusion, cerebral laceration and hemorrhage. This is explained by the preselection of the material admitted to our emergency unit and because of the great experience in diagnosing these kinds of lesions. On the other hand, the discrepancy would have been more marked if these lesions had been tabulated separately (see Results). When a computed tomography is applied in our clinic it is anticipated that the clinical differentiation between these three entities will improve [2, 14, 17].

Of all extracerebral hemorrhages 16% were missed and 9% were only partially diagnosed. "When cerebral circulation is very slow or has stopped naturally, angiographic diagnosis is not its best" (Heiskanen [5]). This was also the most prominent disadvantage in our material. Several recent studies indicate that the computed tomography technique will also improve the diagnostics and differentiation between extradural, subdural, and even subarachnoid traumatic hemorrhages, the last having been thus far impossible to detect by cerebral angiography [2, 14, 17].

Patients with a head injury easily aspirate gastric content or blood, especially when they are unconsicious. Gammelgaard et al. [4] stated that 33% of the patients with a cranial lesion suffered from obstructed air passage. In our material the total cases with blood or gastric content in the air passages was 23 (17%). In half of these cases the amount was significant according to the autopsy report.

This study indicates, furthermore, that addition of a postmortem X-ray examination is apparently of little value when skull fractures or intracranial

injuries are concerned, with the exception of cases when a missile or other foreign body or its fragments must be sought. Another application would be the detection of fractures of the facial bones to avoid cosmetic damage caused by the postmortem dissection of the face.

Skull fractures and various types of intracranial soft tissue lesions are well diagnosed at autopsy provided that it is duly performed. However, in a few cases of the present material some single lesions were not mentioned in the autopsy report which had been verified by clinical means and seen in radiographs.

References

1. Alker GJ, Oh YS, Leslie EV, et al. (1975) Postmortem radiology of head and neck injuries in fatal traffic accidents. Radiology 114 : 611–617
2. Dublin AB, French BN, Rennick JM (1977) Computed tomography in head trauma. Radiology 122 : 365–369
3. Eckert WG, Kemmerer WT, Chetta NJ (1959) The traumatic pathology of traffic accidents. The review of 302 autopsies. J Forensic Sci 4 : 309–329
4. Gammelgaard PA, Gormsen H, Halkier E, et al. (1956) Traffic deaths in Denmark during 1955. Acta Med Leg Soc (Liège) 9 : 47–64
5. Heiskanen O (1963) Cerebral circulatory arrest caused by acute increase of intracranial pressure. A clinical and roentgenological study of 25 cases (Thesis). Acta Neurol Scand [Suppl 7] 40 : 41–50
6. Laasonen E, Penttilä A, Sumuvuori H (1980) Acute lethal trauma of the trunk. J Trauma 20 : 657–662
7. McLaughlin HL (1959) Preliminary management of traffic casualties. Am J Surg 98 : 539–543
8. Rokkanen P, Slätis P (1967) Causes of death after severe trauma. An analysis of 298 consecutive medico-legal autopsies in an accident hospital. Ann Chir Gynecol Fenn 56 : 313–318
9. Ruffel-Smith HP (1972) Time to die from injuries received in road traffic accidents. Injury 2 : 99–102
10. Sevitt S (1973) Fatal road accidents in Birmingham (1973). Times to death and their causes. Injury 4 : 281–293
11. Sköld G, Voigt GE (1977) Spinal injuries in belt-wearing car occupants killed by head-on collisions. Injury 9 : 151–161
12. Slätis P (1962) Injuries in fatal traffic accidents. An analysis of 349 medicolegal autopsies. Acta Chir Scand [Suppl] 297 : 31–38
13. Slätis P (1967) Injury patterns in road traffic accidents. An analysis of 529 cases recorded in Finland during three months in 1962. Health Serv Res Natl Board Health Finland 3 : 1–39
14. Tsai FY, Teal JS, Itabashi HH, Huprich JE, Hieshima GB, Segall HD (1980) Computed tomography of posterior fossa trauma. J Comput Assist Tomogr 4 : 291–305
15. Webber RL, Folio J (1976) Radiographic detectability of occipital and temporal-parietal fractures induced in cadaver heads. J Trauma 16 : 115–124
16. WHO (1969) International classification of diseases, 1965. Revised vols 1–2
17. Zimmerman R, Bilaniuk L, Gennarelli T, Bruce D, Dolinskas C, Uzzell B (1978) Cranial computed tomography in diagnosis and management of acute head trauma. Am J Roentgenol 131 : 27–34

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