Legal Medicine 11 (2009) 278–284

Contents lists available at ScienceDirect

Legal Medicine

journal homepage: www.elsevier.com/locate/legalmed

Frequency, types and causes of intraventricular haemorrhage in lethal blunt head injuries

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ARTICLE INFO

Article history:
Received 5 June 2009
Received in revised form 31 July 2009
Accepted 26 August 2009
Available online 13 October 2009

Keywords:
Head injury
Traumatic intraventricular haemorrhage
Neurotraumatology
Forensic pathology

ABSTRACT

Autopsy findings and neuropathological examination of formalin-fixed brains in 676 deaths due to blunt head injury, here with special attention to injuries of the inner (periventricular) cerebral structures and haemorrhages into the ventricles.

Intraventricular haemorrhage of any degree was present in 17.6%, considering only distinct and massive haemorrhage in 10% of all cases. Considering the types of trauma, the frequency was lowest in ground level falls and highest in traffic accidents (pedestrians with head contact to the car) – indicating a relation between the severity of impacts and the likelihood of ventricular haemorrhage. They predominantly resulted from periventricular injuries (27%) or retrograde expansions of infratentorial lesion with subarachnoid bleeding (19%), from massive contrecoup lesions (14%) or deep intracerebral ruptures (13%). In cases with predominant lesions of the cerebral surface the rate was lower than in those with more diffuse or internal damages.

Injuries of the internal cerebral regions (away from cortex and subcortical white matter) were classified into those directly affecting the periventricular structures (9.1–13.5%; half of them affecting corpus callosum and/or fornix) and lesions of deep white matter or basal ganglia not adjoining the ventricular walls (4.0–5.9%). Intraventricular haemorrhage as well as injuries of the inner cerebral structures mostly are one element of a complex and severe blunt head injury. Solitary lesions – without other intracranial findings clearly indicating a trauma and therefore cases producing difficulties in forensic classification (spontaneous? traumatic?) – are rarities according to literature as well as our experiences.

1. Introduction

Intraventricular haemorrhage (i.h.) is a well-known feature of – predominantly severe – head injuries. In most instances, i.h. is only one aspect in a complex of several significant intracranial injuries and only seldom the single or at least most serious one. The rate of cases of isolated i.h. – especially such causing relevant problems in forensic interpretation – is very low [1–11]; Table 1 presents some of these reports. The combination between i.h. and damages of the inner cerebral (periventricular, centroaxial) structures is evident, and in post-mortem studies as well as standard textbooks, i.h. and internal injuries ("inner cerebral trauma") are generally mentioned and sometimes described in detail [12,13].

However, systematic studies are infrequent and the most comprehensive presentations date back some time (several publications by Grcevic, for example: [14–16]).

Over a long period in our department, lethal intracranial injuries due to blunt forces have been a topic of special interest [17–20] and the experiences of examinations of a large collection of formalin-fixed brains exist. The present report highlights the frequency, causes and additional intracranial injuries of intraventricular haemorrhages.

2. Methods

In forensic autopsies – in our institution – after sawing the skull, the brain is cut in this plane so that the calvarium, still including the upper half of the brain, is cut (so-called Flechsig's cut). This method generally allows an immediate diagnosis of gross intracerebral lesions as well as extracerebral haematomas, and a special care for the parasagittal veins in cases of subdural haematoma, by radiological examination and careful preparation [17,20]. Unfortunately, cutting the brain at this level crosses the delicate periventricular structures and may impair clear recognition of their lesions. After complete removal of the upper and lower half of the brain the specimen was fixed by formalin for 2–3 weeks and reinvestigated by renewed inspection of the entire surface, removal of the upper dura mater and cut into thin slices in the coronal plane. Complete autopsy was performed in the majority of cases and all re-examinations of the brains after fixation by H.M.

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doi:10.1016/j.legalmed.2009.08.005

Table 1
Publications presenting the rate or single reports of "isolated" intraventricular haemorrhages (i.h.) in blunt head injuries, generally based upon diagnosis by CT. No inf. = no information; fr. = frontal; lat. = lateral; occ. = occipital impact; n.m. = non-midline.

Reference/year of publication	Number of isolated i.h. (all cases with i.h.)	Type of trauma	Direction of injury	Outcome
[1]/1978	6 (17)	No detailed info	Inf. in only 1 case: lat.–occ.	1 death
[2]/1978	3 (6)	Traffic accidents	No inf.	2 deaths, 1 veget. state
[3]/1981	2	1 t.a., 1 sport accident	Lat	Recovery
[4]/1981	2 (10)	1 tr. acc, 1 "acc"	No inf.	1 death, 1 good recovery
[5]/1983	2 (30)	"Mostly tr. acc."	No inf.	1 death, 1 good recovery
[6]/1985	2 (4; children)	Fall from height	2 fr., 1 lat., 1 occ.	1 recovery, 1 veget. state
[7]/1991	6 (24)	Traffic accidents, 1 fall	No inf.	5 recovery, 1 veget. state
[8]/1994	1	Beating	Lat. + fr., n.m.	Death
[9]/1994	1	Fall (from horse)	No inf.	Recovery
[10]/2001	1	Fall	Occ.	Moderate disability
[11]/2006	12 (118)	(Traffic accidents, falls)	No inf.	9 good, 3 poor outcome

3. Material

Six hundred and seventy-six lethal blunt head injuries of adults ($n = 656$) and a small portion of youth ($n = 20$; age limit 14 years). Massive injuries with head destructions (fall from height, collision with a train, rolled over by a vehicle) have not been included. Four hundred and fifty-eight victims were male (mean age: 51 years; older than 70 years: 15%), 218 were female (mean age 60 years; older than 70 years: 39%).

Causes of injury, as far as known, were predominantly falls (ground level, except traffic accidents: 196, downstairs: 61; some height: 47), traffic accidents (pedestrian falls due to a collision with a car: 86; head impacts by the vehicle: 85; passengers: 59), falling objects (28) and fights (37). 155 victims were found dead; 114 survived the injury up to 0.5 day and 53 0.51–1 days, 62 persons 1–2 days, 111 2 days until 1 week and 151 longer. In 29 cases, possible survival time remained indeterminate.

Simple classification of the gross types of cranial injury, depending on the most significant lesion(s); all cases as well as patients treated by trepanation ():

Type A: contrecoup lesions without significant subdural bleeding: 157 (31).
Type B: contrecoup lesions, additionally significant subdural bleeding: 122 (68).
Type C: pure subdural haematoma 91 (32).
Type D: brain swelling without intracranial mass and with (macroscopically) only slight cerebral lesions (predominantly diffuse axonal injury) 66 (11).
Type E: focal infratentorial lesion (cerebellum, brain stem) 28 (6).

The remaining cases concerned pure epidural haematomas (15), complex or unique cases not easily to be integrated into types A–E: 137 (operated: 15), and massive trauma with complex skull fractures: 42.

4. Results

4.1. Ventricular bleeding

Cerebrospinal fluid (CSF) was inconspicuous in 493 cases. Intraventricular haemorrhage (i.h.) was present in a small (51) or distinct (55) amount or completely filling the ventricles (ventricular tamponade): 13 – all degrees in 17.6% of all cases; considering only distinct and massive i.h.: 10%.

CSF was haemolytic – not unambiguously interpretable as vital haemorrhage – additionally in 26 cases of non-operated and in 36 patients with neurosurgical intervention.

Depending on (short) survival time, the portions of no/small/distinct/massive haemorrhage were: survival up to 12 h (105 cases): 74%, 9.5%, 8.5%, 1% – 0.5 to 1 day ($n = 62$): 65%, 13%, 10%, 2% – 1 to 2 days ($n = 62$): 61%, 6%, 11%, 5%.

A clear relation between survival time and the extent of i.h. could not be observed; ventricular tamponades in five cases quickly developed (retrograde from a severe brainstem lesion, in a patient treated with anticoagulants, resulting from a large haematoma of basal ganglia rupturing into a ventricle, originating from torn basal arteries).

i.h. of all degrees was present in nearly 20% of all trauma causes – except with pedestrians who sustained direct impacts of their heads with the vehicle – situations with twice the frequency (Fig. 1). The lowest rate was in the injury type which generally causes most lethal head injuries investigated in forensic departments: ground level falls.

Ventricular tamponades were found in approx. 5% of downstairs falls and pedestrians who fell in traffic accidents, and in approx. 10% of victims injured by fights and pedestrians with head impact with a car and subsequent serious fall on their head.

Fig. 2 presents the frequency of (90) i.h. in the different types of cerebral injury – including only 430 patients without neurosurgical intervention (such a procedure may result in bloody cerebrospinal fluid [5]). In cases with predominant lesions of the cerebral surface, the rate was lower than in more diffuse or internal injuries. The

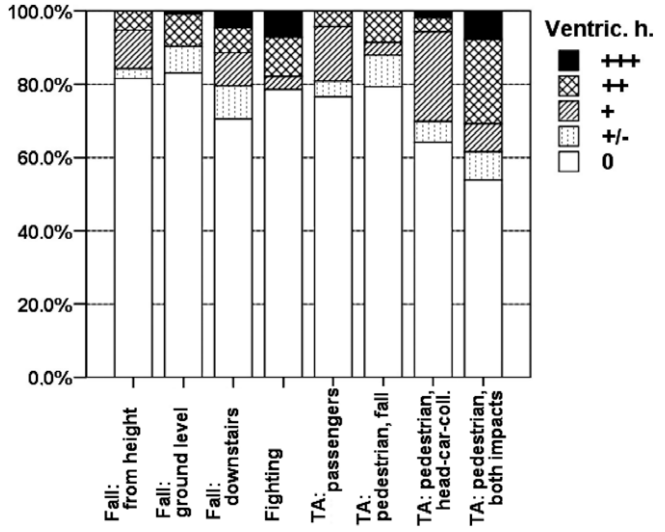

Fig. 1. Intraventricular haemorrhage (i.h.) in 676 lethal head injuries. Diagram presents the types of injury, where known, and the belonging rates of haemorrhages, simply classified in three degrees. +/−: haemolytic liquor, not definitively assessed as intravital haemorrhage. Numbers of cases: falls from height: 47; ground level falls: 197; downstairs falls: 61; fighting: 37; traffic accident-passengers: 59, pedestrians injured by fall: 86; by car impact against head: 65; by both mechanisms: 20.