HANDBOOK OF CLINICAL NEUROLOGY

VOLUME 23

INJURIES OF THE BRAIN AND SKULL
PART I

INJURIES OF THE BRAIN AND SKULL

PART I

Edited by

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in collaboration with

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（内部交流）

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Foreword to volumes 23 and 24

Head injuries have existed as long as mankind. Originally, they were exclusively the result of hunting accidents, falls, and, most commonly of all, hand-to-hand combat. (It is sad to have to recall that mankind has not progressed significantly beyond this aetiology.) Then, warriors took to wearing protective head outfits and even today, in this nuclear age, the helmet is still the symbol of the military profession. The first known records of man's surgical practice deal with the treatment of wounds of the scalp, skull, and brain. Trephining of the skull is one of the oldest major surgical procedures.

However, during the centuries little progress in management was made and Guthrie's remarks (1847) that 'injuries of the head affecting the brain are difficult of distinction, treacherous in their course and, for the most part, fatal in their result' remained applicable to severe head injury until very recently. Management of penetrating injuries underwent significant improvements in the latter part of World War II amongst the U.S., and particularly British, armed forces, due to the admission of victims in special head injury centres (for example, Oxford), where well-documented case histories were collected and studied. This lesson was not taken to heart insofar as civilian head injuries were, and are, concerned, most of which are still scattered in general surgical and neurological wards in regional hospitals. Truly such cases are the poor cousins. Even today they attract the attention of astonishingly few clinicians and scientists, whose international contact all too often is taken up with fruitless semantic discussions about terminology.

As a result of the growth in motor traffic in the last decade, there has been an enormous increase in the number of serious civilian head injuries, with the resultant large number of severely disabled survivors, and head injuries are now the most important cause of death in the first half of life in the developed countries of the Western world. This fact has given a new impetus to research, particularly into the phenomena occurring after the accident, such as changes of microcirculation-pattern, impaired autoregulation, and development of brain oedema. The nature of the persistent disability, the influence of rehabilitation on the rate and the degree of recovery, and the possibility to estimate the degree of attainable improvement in the early stages of recovery are amongst the large gaps in our current knowledge which still have to be filled.

Head injuries constitute a major health problem and do not attract the (limited) attention of neurologists only, but also that of bioengineers, and specialists in traffic medicine and public health. This has placed the Editors in a difficult position. They aim at complete coverage of the subject, but only from the clinical-neurological point of view. Accordingly, some borderline areas (e.g. prevention, social, and financial aspects) have been deliberately excluded. Some topics, splendidly dealt with in previous volumes, have been included again for the sake of completeness, although they have sometimes been written by other authorities. In the chapters on the post-traumatic syndromes, there has been a greater overlap than usual and differences of opinion were unavoidable, due to the strong convictions held by authors from various countries. The Editors were unable to arrange for the timely receipt of an acceptable chapter on birth injuries. Transplantation of kidneys would be impossible without the co-operation of the clinical neurologist. Consequently, chapters on brain death and its medico-legal aspects have also been included. During the preparation of his manuscript, Professor Verjaal of Leiden suddenly died. The Editors are indebted to Dr. van 't Hooft for having seen this chapter through to completion.

P. J. V.
G. W. B.
R. B.

Acknowledgement

Several illustrations and diagrams in this volume have been obtained from other publications. Some of the original figures have been slightly modified. In all cases reference is made to the original publications in the figure caption. The full sources can be found in the reference lists at the end of each chapter. The permission for the reproduction of this material is gratefully acknowledged.

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Contents

CHAPTER 1

Classification of head injuries

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Attempts at classifying head injuries have evolved from such clinical descriptions as those of Hippocrates to the classical distinction of commotio from contusio and compressio as elaborated by Boirel, Petit and Dupuytren in the XVIIth, XVIIIth and XIXth centuries. Contemporary authors have attempted to establish anatomo-pathological correlations (Ritter and Strebel 1928), patho-physiological mechanisms (Tönnis and Loew 1953) or predominantly clinical syndromes (Trotter 1925; Russell 1932; Cairns 1942; Guttmann 1943; Symonds and Russell 1943). Neurosurgical and Intensive Care Unit approaches in all countries have been based on the evaluation of early danger signals.

Recent neuropsychological approaches (Teuber 1966, 1969; Hecaen 1972; Luria 1973) have permitted a better understanding of the underlying disturbances of brain function and added detailed information to the classical neurological evaluation.

Longitudinal psycho-social studies have shown up the inconsistencies between the early clinical picture, later psychological developments (Ota 1969; Kay et al. 1971) and socio-economic outcome (Muller 1969, 1970b; Cook 1972). This is sometimes explainable by simulation and malingering (Miller 1965; Miller and Cartlidge 1972), or by psycho-social factors, and disturbances of the special senses (Kay et al. 1971), but may also be due to genuine organic evolutional syndromes with adjustment problems (Walker 1972).

Modern approaches to classification tend to be descriptive, prospective and, by using computer facilities, aim at collecting all accessible information in order to establish interdisciplinary and longitudinal correlations (Ommaya and Sadowski 1966; Goutelle and Mouret 1970; Teasdale and Jennett 1974).

HISTORICAL DATA

Beginnings

'Apart from the examination you shall have done yourself, whatever aspect the bone may present, you shall enquire about the circumstances of the injury (these give you indications as to the degree of gravity), and if the injured person was confused, if darkness gathered around him, if he became giddy, if he fell down.'

Hippocrates (Translation of 1955)

This admirable description written in the 4th century B.C. pin-points some of the problems which have troubled the evaluation of head injuries for more than 2,000 years: the independence of brain lesions from skull injury, the variability of disturbances of consciousness and the difference between subjective amnesia and

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objective coma. In the first century A. D., Celsus, in 'De Arte Medica' (Keiser 1968) noted that there could be a cerebral hemorrhage without skull injury. Rhazes (850–923), a native of Basra on the Persian Gulf (Singer 1944), established the difference between a concussive state and injuries without obvious brain pathology. He recognized that the concussive state could occur without skull damage (Keiser 1968).

Definitions

Although all schools used the basic division in commotio, contusio and compressio, these concepts evolved differently in the various languages.

The French school has stuck to the original definition that commotio is to be regarded as a direct paralysis of nervous function which is completely reversible and thus leaves no anatomical traces.

The German school undertook a painstaking research of the anatomopathological and physiopathological substratum of a large clinical picture described as 'Gehirnerschütterung' (commotio) and found itself in a maze of contradictions which brought the basic definitions of contusio and commotio into doubt.

The Anglosaxon school, beginning from the same large clinical basis as the German authors, progressively limited itself to an empirical description of 'concussion' based exclusively on post-traumatic amnesia and permitting a differential diagnosis from other clinical pictures.

Recent experimental work done mostly in the United States, suggests that head injuries are not an 'all or nothing' phenomenon, but that allowances should be made for a progressive graduation of clinical, as well as pathophysiological and anatomopathological findings.

In order to appreciate international differences and the resulting difficulties in classification which exist, the present author has, somewhat arbitrarily, studied the evolution of these basic ideas (as expressed in the traditional textbooks of the various lands before the advent of recent clinical observations and experimental work).

French school. In the XIIIth century, Lanfranco of Milano taught in Paris that the brain was shaken by concussion (Keiser 1968).

In the XVIth century Ambroise Paré (1517–1590) viewed commotio as a disorder of brain movement. He was already fully aware that the visible fractures, hemorrhages and brain swelling occurring after head injuries could be considered as epiphenomena to the basic functional paralysis of cerebral concussion (Ommaya et al. 1964). Boirel (1674) and J. L. Petit (1674–1750) started to distinguish commotio from contusio and compressio, a classification still much used today although it has been seriously challenged (Tönnis and Loew 1953).

'In 1705 Alexis Littre (1658–1725) performed the post mortem examination on a patient who dashed his head into a wall, fell down unconscious and died a few minutes later. There was no damage to the brain visible to the naked eye' (Ommaya et al. 1964). Thus it was considered for a long time that there was no anatomical basis for concussion, and the problem of light, severe and fatal concussion was first encountered, the latter however, could hardly be considered as reversible.

Petit had already used the expression contusio for lesions of the skull, and the notion of contusio cerebri was introduced by Dupuytren (1777–1839) (Tönnis and Loew 1953).

'Contre-coup' contusion seems to have been a common concept in France already in the XVIIIth century according to Saucerotte, quoted by Cohadon et al. (cited by Lazorthes 1973).

Dupuytren (1839) provided an extensive clinical description of commotion, compression and contusion, relating the contre-coup contusion to the 'fractures par contre-coup', but added – somewhat wistfully – that 'it would be easy to distinguish commotion from compression and contusion, and vice versa, if these different states existed separately'.

Anglosaxon school. John Hunter (1728–1793) had emphasized the basic importance of concussion 'when there is depression of bone or extravasation, the symptoms of concussion are lost, although it may be at the bottom of all' (Ommaya 1966).

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Hughlings Jackson (1835–1911) studied the disturbance of consciousness which could range 'from the slightest confusion of thought to the deepest coma' (Ommaya 1966). Basing their work on his findings, English authors started to give particular attention to disturbances of consciousness, and finally took subjective amnesia to be an adequate measure of the gravity of head injury with prognostic value. This was done and elaborated by Trotter (1925), Russell (1932), Cairns (1942), Guttmann (1943) and Symonds and Russell (1943). Cairns (1942) proposed relating the length of posttraumatic amnesia (PTA) to the shortest time in which the ability to carry out full-time work might be expected to return (Fig. 1). These attempts at correlation may be numerically fascinating but, as pointed out by Symonds (1960), the length of PTA, although of undoubted value as a measure of prognosis, may be fallacious and should be used with caution.

PTA	Months after which full work may be resumed
5 minutes–1 hour	1–1½
1–24 hours	1½–2
1–7 days	2–4
over 7 days	4–8

Fig. 1. Relation of the length of posttraumatic amnesia (PTA) to return to full-time work. (Cairns 1942.)

Following the ideas of Trotter (1925, 1930, 1932), Symonds developed the notion of 'minor cerebral contusion' to explain posttraumatic headaches, giddiness, insomnia, loss of power of concentration, even without initial loss of consciousness, on an organic basis.

Mapother (1937) suggested that the only practicable criterion of 'recovery of consciousness' is awareness of external environment as well as accessibility, and thus rejects the notion of subjective amnesia for the benefit of objective evaluation of disturbance of consciousness.

Taylor and Bell (1966), Taylor (1969) and Taylor et al. (1971) have invoked slowing of cerebral circulation and vestibular disturbances to explain the subjective posttraumatic syndrome even after minor concussion. On the other hand, Miller (1961, 1965) and Miller and Cartlidge (1972), analysed those aspects of the posttraumatic syndrome explainable by simulation and malingering.

German school. Victor von Bruns (1811–1883) and von Bergmann (1836–1907) defined commotio as an immediate and diffuse disturbance of brain function without anatomical findings, which improves progressively and disappears without sequelae, unless followed by sudden death. It should be distinguished from contusio as a localized and uneven damage to brain substance which can occur immediately or later (Tönnis and Loew 1953).

In 1926, Ritter, and in 1928, Ritter and Strebel, in line with the then prevailing preoccupation of correlating clinical observations with anatomopathological facts, established the following classification:

– Commotio medullae oblongatae: This syndrome is characterized by immediate loss of consciousness ranging from some minutes to, but not extending beyond, 5 hours, as well as by an association of symptoms referable to the brain stem, like respiratory and circulatory disturbances, vomiting and changes in blood pressure. In most cases retrograde amnesia was observed, to the point that the diagnosis was questioned when retrograde amnesia was missing. The onset of symptomatology was sudden, the improvement progressive.

– Commotio cerebri s.s.: Loss of consciousness only occurs in 80% of the cases but is deeper and in 60% lasts longer than 5 hours. Symptomatology is more varied. Recovery takes longer and organic sequelae are more frequent as well as more severe. Temperature tends to be slightly increased.

– Contusio cerebri diffusa: ('allgemeine Hirnquetschung') shows many focal symptoms which suggest diffuse localisation and tends to evolve in a capricious manner. More complex cases were explained on the basis of combined lesions. By introducing notions like localized concussion and diffuse contusion Ritter and Strebel tended

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to invalidate previous fundamental definitions. Gamper et al. (cited by Tönnis and Loew 1953) considered concussion as a symptom due to local damage to the mesodiencephalic region. Tönnis and Loew (1953) invoking pathophysiological events, claimed that the observation of neurological and vegetative facts permit a reliable prognosis as to the outcome. They spoke of a first degree closed head injury when the deficiencies (motor and sensory disturbances, aphasia, pupillary changes, circulatory changes) vanish before the fourth day; of a second degree closed head injury when the disturbances disappear only within three weeks; and of a third degree closed head injury when they last longer than three weeks. In fact they introduced the notions of duration and of rate of improvement of clinical signs (Rückbildungsdauer). The first degree of closed head injury could still be considered as 'commotio cerebri', the second degree as lighter 'contusio cerebri', the third degree as severe 'contusio cerebri'. These categories have prognostic value.

Bues (1961, 1965) took up the classification of Tönnis and Loew and added a fourth category of 'extreme gravity' (Fig. 2). Using this classification he then established significant correlations with the outcome in terms of subjective complaints, headaches, objective psychic changes as well as neurological findings.

Tönnis and Loew (1953) had recognized the initial utility of the distinction between 'commotio' and 'contusio', but then proceeded to show up its inconsistencies. Clinical descriptions of 'contusio' and 'commotio' do not provide any information on the reversibility or irreversibility of lesions and thus are of no prognostic value. They quoted Bay (1939a, b, c, 1941, 1947, 1948, 1949, 1951) who separated the clinical definitions of 'contusio' and 'commotio' from the pathophysiological observations. The difficulties of anatomo-clinical correlations are shown up by extreme cases, e.g. when 'commotio' is defined as a localized contusion of the brain stem, or when a reversible localizing sign without any anatomo-pathological alterations is described

		I Light	II Medium	III Severe	IV Extreme
Psychic disturbances	Severe (Unconscious)	Minutes (1–60)	Hours (1–24)	Days (1–7)	Weeks
	Light (Dazed, confused)	1 day →	to →	more than →	—
			4. day →		
Neurologic disturbances	Severe (Pyramid, tract disorder, paresis)	—	→ to	→ more than	Extremely severe status (Brain stem)
	Light (Reflex difference, eye disturbance)	to 4. day →	more than →	—	—
Other disturbances	(Vomiting, EEG)	→	—	—	—

Fig. 2. (Bues 1965.)

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as 'contusio'. This inconsistency was felt by many authors and they tried to distinguish concussion from contusion by the duration of loss of consciousness, the limit varying from 1–2 minutes (Merritt 1959) to 12 hours (Tönnis and Loew 1953).

Zülch (1969) considered a pressure wave involving the brain stem as essential for concussion, but rejected the theory of a primary disturbance at the level of the synapses and considered a molecular process at the level of the mesencephalic reticular substance and the oral part of the medulla oblongata as more likely. He pointed out the differences between the German 'Gehirnerschütterung' and the Anglosaxon concept of 'concussion'.

The differentiation between 'contusio' and 'commotio' has also been questioned in recent experimental work (Sato et al. 1971).

Contemporary approaches

Experimental work. From the early works of Polis (1894) and Witkowski (1877) to the publication of Ommaya et al. (1964) and the later extensive anatomo-pathological descriptions of Oppenheimer (1968) and Strich (1969), it has been suggested that degeneration of nerve fibers in the cerebral hemisphere and brain stem frequently occurs in cases of mild, as well as severe, head injury, and that the concept of concussion as a reversible clinical syndrome without any permanent anatomo-pathological changes is therefore incorrect.

Metabolic and circulatory disturbances. Very extensive studies of the brain metabolism after head injury have been done by several authors, e.g. Frowein and Karimi-Nejad (1968), Karimi-Nejad and Frowein (1969, 1970), Vapalahti (1970) and Laine (1973) and have considerably improved diagnosis and adequate treatment of severely impaired patients.

The work of Langfitt and Kassell (1966) has clarified the relationship between circulatory disturbances and cerebral oedema. Studies correlating cerebral blood flow, metabolism, clinical findings and EEG by Ingvar and Brun (1972) and Ingvar (1973) have permitted a better understanding and differential diagnosis of akinetic mutism, posttraumatic stupor, apallic syndromes and coma due to reticular disturbances.

Neurosurgical approaches. Munro in 1938, following the teaching of John Hunter, describes the different situations according to their clinical gravity. 'Thus brief loss of consciousness without other signs after head injury is called concussion; a similar condition but with bloody spinal fluid is called cerebral contusion or laceration – but this term is also used to describe the patient with neurological deficits and prolonged unconsciousness; if the CSF pressure is raised the diagnosis of cerebral oedema is advanced. If a depressed fracture or intracranial haematoma is found, this diagnosis dominates the clinical picture.'

Mainly clinical and practical classifications have been proposed by neurosurgeons, e.g. Rowbotham (1949), Tönnis and Loew (1953), Gros et al. (1960), Jouvet (1961), Houdart (1964), Columella et al. (1970) and Vigouroux et al. (1972). These classifications are all based on the state on admission after severe head injury and tend to provide guidelines for the neurosurgeon as to what measures should be taken.

Ommaya (1966) has called attention to the fact that gravity of a head injury can have several interpretations: 'Thus there are the prognostic danger signals of immediate surgical importance, such as pyrexia, compound skull fracture, respiratory abnormality, neurological deficits, convulsions, worsening of the level of consciousness after initial improvement, rising blood pressure with falling pulse rate and bloody CSF. But these surgical signposts may have no relationship to the ultimate severity of disability produced by the head injury. Thus the clinical diagnoses in common usage are at best unreliable approximations to a small part of the overall picture.'

Jennett (1972), working from a neurosurgical perspective, has attempted to correlate initial case selection, outcome categories and prognostic criteria by statistical methods and computer technics.

Intensive care approaches. Vapalahti and Troupp (1971) in Finland have established prognostic

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