
HANDBOOK OF CLINICAL NEUROLOGY

Edited by

P.J. VINKEN and G.W. BRUYN

VOLUME 26

INJURIES OF THE SPINE AND SPINAL CORD
PART II



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Edited by

P.J. VINKEN and G.W. BRUYN

in collaboration with

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(内部交流)

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临床神经学手册 第26卷 《脊椎和脊髓损伤》 第2部分

本卷介绍了脊髓硬膜下血肿、脓肿、脊髓休克、四肢瘫痪及截瘫的处理和预后；也介绍了脊椎损伤对心血管、呼吸系、泌尿系、皮肤和体温调节的影响。书中包含有作者的临床经验，内容比较丰富。可供神经内科、神经外科、骨科医师及医学院校教师参阅。

目次：①脊髓硬膜外血肿，②脊髓硬膜下血肿，③脊髓硬膜外脓肿，④顿挫性损伤引起的颈动脉外伤性闭塞，⑤分娩时椎动脉的损伤，⑥脊椎损伤时椎动脉血栓形成，⑦动脉损伤对脊髓的影响，⑧放射性脊髓病变，⑨颈椎增生性神经根病变和脊髓病变，⑩外伤性脊髓空洞症，⑪脊髓损伤后的脊椎畸形，⑫强直性脊椎炎时四肢瘫痪，⑬脊髓损伤早期临床鉴定，⑭脊髓休克，⑮脊髓损伤患者的放射诊断，⑯引起脊髓和脊神经根损伤的脊柱闭合性损伤的保守疗法，⑰脊髓损伤的预后，⑱四肢瘫痪和截瘫患者的心血管系统，⑲呼吸系统，⑳脊髓损伤时的压迫性溃疡，㉑脊髓损伤的体温调节，㉒脊髓损伤病人血液和生化方面所见，㉓泌尿道，㉔截瘫和四肢瘫痪时的性功能，㉕褥疮，㉖脊髓损伤时痉挛状态，㉗脊髓性截瘫时的疼痛和幻觉，㉘旁骨关节病，㉙脊髓性截瘫和四肢瘫痪机能恢复时的运动。

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INJURIES OF THE SPINE AND SPINAL CORD

PART II

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CLINICAL NEUROLOGY

P. J. VINKEN and G. W. BRUYN

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VOLUME 36



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INTEGRITY OF THE SPINE AND SPINAL CORD
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VOLUME 26



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Foreword to volumes 25 and 26

'Basically, management in neurology consists of prudently doing nothing'. This was the opinion of the neurology professor of one of the editors.

Many neurologists practising today would probably disagree with this statement. They would not be able to deny, however, that it has been pre-eminently applicable to the management of traumatic paraplegia for many thousands of years. The writer of the Edwin Smith papyrus considered tetraplegia as 'an ailment not to be treated'. Treatment of traumatic para- and tetraplegia was not even improved by the sadly all too rich experience of World War I. Although the literature of this period, particularly the British literature, contained many excellent papers on spinal cord injuries, they dealt with neurophysiology and pathology, but were not at all concerned with therapy. In World War I, 90% of patients suffering from this type of injury died within one year, and probably only 1% survived for more than 20 years. The literature appearing between the two World Wars was scant and no real advance was made in the late care of spinal cord injuries. In 1924, the Medical Research Council summarised the situation at that time as: 'The paraplegic patient may live for a few years in a state of more or less ill-health'. Gowland's paper to the Harveian Society (1934) illustrates how these poor victims lived their short incarcerated lives in institutions. In 1937, Courville stated: 'It is a matter of preserving life by constant and meticulous care when life is of little value to the patient and costly to his relatives'.

After World War II, the influence of a few pioneers (in Europe, Guttman; in the U.S.A., Munro and Bors) caused a drastic reduction in mortality; hence the current survival rate is high. Guttman with his straightforward thinking and dynamism realised his concept of a paraplegic as a disabled but healthy person independent of mind and body and often with an independent future. In this new era, the spinal man (or woman) can usually be re-educated to perform a useful job and to take a useful place within the community.

The experience derived from observations on longer living paraplegics have initiated and stimulated clinical research, especially in Europe, thus shedding new light on spinal cord physiology. This gratifying development has given an enormous impetus to experimental research over the last ten years, particularly in the U.S.A.

Thirty years ago, a handbook editor would have found it difficult to think of more than a few chapters on injuries of the spine and cord. Today, even two volumes are insufficient to cover the field.

Volume 25 contains basic experimental, biomechanical, pathological and epidemio-

logical aspects, as well as the various causes and types of acute injury to the different parts of the spine and cord.

In Volume 26, the non-acute aetiology of spine and cord lesions is covered, together with extramedullary haematomata, abscesses and some vascular lesions not dealt with in previous volumes. Clinical appraisal, management and prognosis of para- and tetraplegia with their influences on the cardiovascular, respiratory, gastrointestinal and urinary systems, are included. The effects of spinal injury on skin temperature regulation and sexual behaviour are also covered.

Physicians actively engaged in spinal units (paraplegists) who may feel that certain topics, such as psychological effects, vocational training, etc., have not been included, are kindly requested to bear in mind that this is a Handbook of Clinical Neurology and not of rehabilitation. The Editors had intended to include a chapter devoted to rehabilitation, but unfortunately the authors invited to undertake this assignment were unable to give to its completion that degree of priority which they and we would have wished. Faced with the problem of whether to extend the manuscript deadline or go ahead with publication, the latter course was adopted.

The Editors are grateful for the continuing enthusiasm of the editorial staff, Mrs. M. Posthuma-Bosma and Mrs. B. Vollers-King, which has greatly contributed to the publication of these volumes within four years of their commencement.

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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Spinal extradural haematoma

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Spinal extradural haematoma stands out amongst the multitude of spinal space-occupying lesions by virtue of a few very distinctive features; it is a rare condition with only about 180 cases having been reported since the mid-nineteenth century. Most neurologists will probably never encounter a case during their active professional life. Its cause is unknown; in the majority of instances of the so-called 'spontaneous' type it is a neurological and neurosurgical urgency. If recognised at an early stage, however, and surgically treated, it is an eminently curable disease.

Although the authors of this chapter have observed a case of this disorder in a 68-year-old man (who developed the haematoma between C6 and Th2 during his sleep, was operated upon within 16 hours, but remained paraplegic and survived for two years), and know of eight other cases (three observed by Dr. Weersma, one by Dr. W. V. M. Perquin at the Ursula Clinic, Wassenaar, in 1972 and four by Dr. R. Braakman in the University of Rotterdam Neurosurgical Clinic), no other cases have, to their knowledge, been noted in the Netherlands since the beginning of this century. Inasmuch as these nine cases were diagnosed by four different specialists in a period of \pm five years, it is a safe assumption that many more such cases are diagnosed and treated routinely in the various Dutch centers every year.

The present chapter will be devoted to a review

of the world literature. Information on historical data will be provided, together with a short survey of the anatomy of the epidural space and its constituent structures, and the physiology of its blood flow and pressure. The clinical features and variants of this disorder, a critical evaluation of its causes, the diagnosis and differential diagnosis, and surgical treatment will also be discussed.

HISTORY

As any study of source material teaches – though there are a few fortunate exceptions – the further one goes back in history, the hazier become the descriptions of case histories. The search for an 'observatio princeps' may seem futile, but it does nevertheless provide the patient researcher with both a notion of medical awareness through the ages and a proper perspective which is a sound prophylactic against an overestimation of contemporaneous knowledge.

Du Verney (1688) may have been the first to signal the occurrence of intraspinal haemorrhage by his narrative before the Parisian Royal Academy of Sciences of the observation of 'un magistrat illustre, mort presque subitement d'une espèce particulière d'apoplexie qui ne lui avait pas ôté la connaissance'. The autopsy did not reveal anything extraordinary in the brain, but, on

turning the cadaver 'il sortit une grande quantité de sang du côté de la moelle épinière', probably originating from that portion of the vertebral canal 'd'où sortent une grande quantité de nerfs qui fournissent des rameaux au nerf intercostal'. The observation by Du Hamel, quoted by Abercrombie (1828) and by Plagne (1962) is most intriguing. Mr. P. P. Wade, Librarian for the Royal Society of Medicine was so kind as to trace this reference more exactly. We would like to quote from his astute observations:

'Even some French authors (e.g. Hayem 1872) appear to rely on the detail given in some edition, or translation, of John Abercrombie's 'Pathological and Practical Researches on Diseases of the Brain and Spinal Cord'. One has only to compare the passage as it appears on page 364 of the first 1828 edition of Abercrombie and the parallel passage on page 23 of Hayem's 'Des hémorrhagies intrarachidiennes'.

In Abercrombie it is apparent that Abercrombie is quoting from the Latin 'Regiae Scientiarum Academiae Historia' which was prepared by Du Hamel (though Hayem conceals that fact by translating the title back into French); the details given in Abercrombie seem to tally remarkably closely with those given in the report in the French Hist. Acad. Roy. Sci. 2 (1733) page 47, covering the period 1686–1689.

It also seems very odd that Hayem should be able to quote the Du Verney report direct from the French Hist. Acad. Roy. Sci. (even if he does give the reference as 'Memoire' instead of 'Histoire'), but should have to rely on Abercrombie for details of Du Hamel. Moreover, Hayem, by rendering the title in French, conceals the fact that Abercrombie was quoting from the Latin version prepared by Du Hamel; and also conveys the impression that Du Hamel was personally responsible for observing the case.

I..... suggest that there are not two distinct cases, but only one, that in which the post mortem examination was carried out by Du Verney and reported before the Royal Academy of Science in 1688; and that Abercrombie's report is simply a condensed English version (which does not make it clear that Du Verney carried out the post mortem examination) of the Latin text prepared by Du Hamel.

If one takes Abercrombie's reference 'An. 1683 sec. 5 cap. 2' as correct, one cannot find anything remotely related to the case quoted by Abercrombie in either the Paris edition (1698) of *Regiae Scientiarum Acad. Hist.* or in the Dutch edition of 1700. I would also, however, accuse Abercrombie of bad handwriting, or bad proof-reading, or both, which has resulted in the printing of 1683 for 1688. If one takes the 1683 as a misprint for 1688, then 'sectio quinta caput 11' (page 253 of the 1698 Paris edition, or page

269 of the 1700 Dutch edition) leads directly to Du Hamel's Latin version of the case examined, post mortem by Du Verney.

I therefore think it very likely that in quoting and re-quoting yet another 'bibliographical ghost' – a personal report by Du Hamel in 1683 – has been created.

These early observations bring out in remarkable clarity some outstanding features of the condition sub judice, viz. the apoplectiform onset implicating a vascular disease, and the intact consciousness.

Gautier de Claubry (1808) reported a rather complicated case: a man aged 61 years, travelling by calèche from Champagne to Paris, suddenly developed atrocious pain radiating from the cervical to the sacral region, followed, after one hour, by urinary incontinence and paraplegia. He died within a day and, at autopsy, a combined extradural, subdural and intramedullary haemorrhage was found extending from C7 downwards.

Chevalier (1812) reported three cases: one of a L1–L5 haematoma in a girl, aged 14 years, one a less well-defined case in a child, aged one year, and a third in an adult male who developed acute paraplegia while lifting a heavy sack of flour. This last case died from a lumbar haematoma within two weeks.

The cases reported by Ollivier d'Angers (1827) are dubious. However, he provided a virtually complete survey of the literature (including Abercrombie's case from Ireland), distinguished subdural and extradural haemorrhage and understood the clinical differences.

The 42-years old male patient reported by Costello (1834) developed a lumbar haematoma while jumping a few steps from a staircase. This was followed after a few hours by loss of sensation, paraplegia and urinary retention. On autopsy, in the lumbar canal, 'clots of crassamentum adhered to the bones, whilst the serous portion of the blood floated'.

The case reported by Chalvet (1859) was purely traumatic: a man aged 44 years fell from a staircase, developed multiple fractures (but not of the skull or vertebrae) and died within a few hours during a status epilepticus. The cranial contents were normal, as were the spinal cord and spinal subarachnoid space. The spinal canal, however,

was filled entirely with an extradural haemorrhage.

Jackson's (1869) much-cited case was one of a 14-years old girl, who developed weakness in the fingers while dressing, which progressed to paresis of the arm muscles and respiratory paralysis, ending fatally within four days. The diagnosis and prognosis ('a speedy and fatal result') was posed by Sir William Jenner whose opinion had been requested by Jackson. The epidural haemorrhage extended over the entire cervical cord, particularly anteriorly – which is exceptional – and to the left side.

Hayem (1872) collected a dozen or so cases from the literature which, for the most part, were either incomplete, dubious or misdiagnosed, but there are three instances of epidural haemorrhages, and he distinguished clearly between epidural and subarachnoid haemorrhages.

The last reports in the 19th century come from Bain (1897) and from Hopkins (1899). A housemaid, aged 18 years, after straining at stool, developed pain in the neck, difficulty in breathing, numbness in all limbs and paralysis of the left arm and right leg. Finally, tetraplegia developed together with difficulties in swallowing, and she died within two hours. Post mortem examination revealed a clot between the dura mater and spinal canal at the level of C2–C3 (Bain 1897). Hopkins (1899) reported the case of a 40-years old man who suddenly developed thoracolumbar pain, paraplegia and urinary incontinence while shovelling coal. After a transient improvement lasting two days, he died on the fourth day. Autopsy revealed epidural clots in the lumbar area and epidural haemorrhage at higher levels, up to the cervical region.

The first case to be operated upon was the patient treated by Jonas (1911): a traumatic case of epidural haematoma in a man aged 35 years, which developed one hour after a fall from a hayloft. The course was progressive with sensory loss, paraplegia and urinary retention. The Th3 vertebra was fractured. Thoracic laminectomy performed 24 hours after the accident revealed a haematoma at Th5–Th7. The patient initially recovered, but ultimately died. Jonas also reported a second case of traumatic epidural haematoma at Th7–Th8, which occurred in a 40-years old man.

According to Bulloch and Fildes (1911) two cases of paraplegia, possibly resulting from epidural haematoma, have been reported as occurring in haemophilia, i.e. in an 1850 report by Van der Scheer, and in an 1876 communication by Ledoux. Although the present authors have not taken the trouble to trace these sources, the information presented puts the theories on the aetiology of this disorder in perspective: the case of Ledoux was a haemophilic boy, six years of age, who suddenly developed severe girdle pains and paralysis of the trunk and legs, while Van der Scheer's case was a man aged 30 years who, upon first coitus, developed back pain, paraplegia, coma and then died.

Either interest in this condition, or diagnostic awareness of its possibility, appears to have waned for quite a time. Apparently this interest was hard to revive because up to the time of the Second World War only a handful of reports could be found in the literature. Reid and Kennedy (1925) communicated the case of a girl, aged 20 years, who was knocked from her bicycle in a road accident and showed what may be termed a subacute traumatic type of this disorder. She developed leg pain within 24 hours, progressing to paraparesis over a period of three days. Autopsy disclosed an epidural haemorrhage extending from C3 to S2.

In retrospect, it is astonishing to read the opinion of Farquhar, Buzzard and Symonds (1928) that '... the amount of blood poured into the extradural space is rarely sufficient to produce symptoms ...'. These distinguished authors list as causes of the disorder: trauma, violent muscular contractions such as occur in tetany, eclampsia and epilepsy (there is not a single case in the literature to justify this statement), venous congestion resulting from cardiac or pulmonary disease (the same lack of documentation), or the bursting of an aortic aneurysm. The latter may have been the cause in Gautier de Claubry's (1808) case, while Hayem listed a dubious second instance of this which had been reported by Laennec (Hayem, page 33). If this reflected the generally accepted opinion of the medical world (stated in a contribution for Osler's *Modern Medicine* by two leading neurologists), then one can understand the paucity of reports.

It was not until 1935 that two communications appeared on the subject, neither exempt from critique as to the correctness of the diagnosis. In 1935, Priest reported the case of a man aged 27 years, suffering from haemophilia, who had acute neck pain and showed hyperreflexia; the CSF was yellow and contained 1200 mg/100 ml protein. Slow improvement continued over a period of two months. Neither the history nor the findings or course, however, justify the diagnosis.

Hassin and Stone (1935) reported the case of a 32-years old woman who developed progressive gait disturbances after the delivery of a child. She fell frequently, and a diagnosis of subacute combined degeneration of the cord was postulated. After a minor fall she developed urinary retention for 12 days, paraplegia and disturbances of sensation; the CSF was yellow and showed a block on the Stookey-Queckenstedt manoeuvre. On surgery, an epidural clot measuring 2 cm × 2 cm × 1.4 cm was found attached to the Th8 root. Notwithstanding improvement, however, she died on the 12th postoperative day.

Johnston's (1938) case was the last pre-World War II report and the second to receive surgical treatment. This case was most instructive: a boy, aged five years, showing a Cobb-Cushing syndrome (i.e. segmental, hemimeric spinal cutaneous haemangioma), suddenly developed abdominal pains whilst playing. The pains progressed to opisthotonos, flaccid paraplegia and the CSF (no block!) contained 80 lymphocytes/cu mm. The diagnosis of poliomyelitis was posed, but subsequently changed to one of transverse myelitis. The boy died one year later. Autopsy revealed an atrophic spinal cord and a haemangioma at Th9-Th11, with fresh epidural clots at Th8-Th12.

This historical survey illustrates that, although approximately ten cases were reported in the 19th century and five in the first half of the 20th (of which two were treated surgically), the clinical picture was not well-established in spite of sufficient data. A survey of the literature also shows that both the introduction of neuroroentgenographic techniques and the gradual advances in neurosurgery made a definitive recognition of the disorder possible. Since 1945 an explosion has occurred in the appearance of reports on spinal extradural haematoma if compared to the relative

silence of the 150 years prior to 1945: 7 reports appeared between 1945 and 1950, 12 between 1950 and 1955, 17 between 1955 and 1960, 27 between 1960 and 1965, and 25 from 1965 to 1970. Since 1970, 36 cases have already been reported, making a total of 120 reports in just over 25 years (Fig. 1).

The historical survey also illustrates that the clinical picture, even with its few variants, is rather uniform with two stages of progression: namely one of apoplectiform onset of back pain radiating to the limbs, subsequently followed by paraesthesiae and later by the signs and symptoms of the second stage (compression of spinal nerve roots or of the spinal cord, depending on the site of the haemorrhage) viz. sensory loss, paralysis and urinary incontinence. The course is almost invariably progressive, may range from a few hours to a few weeks with the patient remaining fully conscious, and nearly always ends fatally unless neurosurgical treatment is instituted. Even when reading with a critical mind, the cause or causes of this disorder remain rather vague: it may come on spontaneously, or during or just after physical exertion as well as during trivial activities; it may also occur in association with a systemic disorder or be of traumatic origin.

The objections to be raised against any of these lesions listed as causative are incompatible with the peace of mind of those whose 'Kausalbedürfnis' exceeds their capacity for critical thought. How many thousands of spinal injuries and vertebral fractures are sustained annually without the development of an epidural haematoma? How many haemophiliacs are living, or have first coitus, without this condition occurring? How many

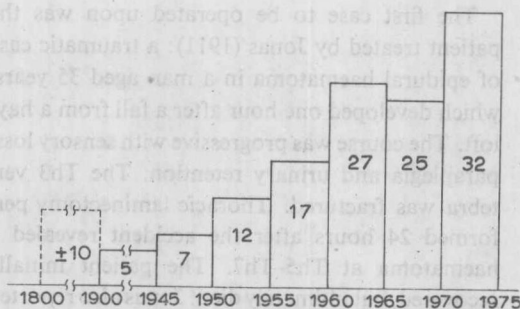


Fig. 1. The number of case reports of spinal epidural haematoma presented between 1800 and 1973.

millions of people execute such trivial actions as shovelling coal, lifting heavy objects, or fall, strain at stool, cough or take part in sporting activities without causing their epidural vasculature to begin bleeding? How many spinal haemangiomas have been reported in order to make clear that epidural haemorrhage or haematoma is definitely not one of its presenting, or usual, symptoms?

The virtue of going back to original sources lies in its revelation of the true proportions of our present level of knowledge. Even at the time of writing we still do not know the exact cause of this dramatic and curable disorder.

ANATOMY

The epidural space (cavum epidurale, cavum peridurale or cavum extradurale) denotes the virtual loge limited by the walls of the spinal and sacral canal on the one side, and by the dural sac containing the spinal cord, spinal nerve roots, arachnoid and the CSF, on the other. Essentially, the epi- or extradural space is not extradural at all, but intradural as the following discussion will make clear.

The vertebral canal (canalis vertebralis) constituted by vertebral foramina is bounded ventrally by the dorsal facies of the vertebral bodies (corpora vertebrorum) and of the intervertebral discs, laterally by the pedicles of the arcus vertebrae, the superior and inferior articular vertebral processes and the intervertebral foramina, and dorsally by the arcus vertebrae with the ligamenta flava joining these arcus. The shape of this vertebral canal varies from triangular in the cervical and lumbar regions, to circular in the thoracic.

The ventral wall of the vertebral canal is lined in its medial part by the posterior longitudinal ligament, which begins as a rather narrow layer in the sacral canal, broadens at each intervertebral disc with which it is securely joined, and then narrows again at the level of each vertebral body until it thins out and broadens once more cranially from the third cervical vertebra. From C3 it is covered by the tectorial membrane (attached to the foramen magnum and clivus blumenbachii) and is closely joined to the dura mater. The dorsal wall of the spinal canal is largely formed by the

ligamenta flava, which are extremely strong in the lumbar region and whose fibres are longitudinally orientated; the fibres show a dehiscence in the median plane, leaving a narrow slit.

The spinal dura mater consists of two leaves known as the internal and external laminae. Tradition has it that the encephalic dura mater splits up into these two laminae at the level of the foramen magnum, but it is not exceptional to find that both dural laminae start their individual existence as high as the tentorium cerebelli (Luyendijk 1962). The internal lamina of the spinal dura mater contains – as it constitutes the spacious dural sac – the spinal cord, spinal nerve roots and arachnoid, while the extradural lamina of the spinal dura mater lines the walls of the vertebral canal, and is closely attached to the posterior longitudinal ligament, the vertebral periosteum and the ligamenta flava. In adult man, this external dural lamina is not distinguishable as a separate layer; only in infants below the age of two years is this lamina identifiable as a fibrous membrane of approximately 1 mm thickness.

The internal lamina, constituting the dural sac, assumes a sheathlike form to accompany the spinal nerve roots into the intervertebral foramina, later merging into the foraminal periosteum (cervically, the ventral and dorsal spinal nerve roots each have a separate dural sheath merging into one at the site where both roots join, whereas at lower levels there is only one dural sheath); the dural sac usually ends at the level of the first or second sacral vertebra in the filum duralae matris terminalis.

Strictly speaking, the epidural or extradural space, which is the space between the external and internal laminae of the spinal dura mater, clearly is an intradural space. Inasmuch as tradition prevails upon accuracy (Farquhar Buzzard and Symonds correctly denoting haematorrhachis as intradural haemorrhage), the present authors will continue to use the terms 'epidural' and 'extradural' in distinction to 'subdural'.

Since the caudal limitation of the dural sac may vary from the fifth lumbar to the fourth sacral vertebra, and its cranial boundary may range from the foramen magnum (in the great majority of instances) to the tentorium cerebelli, the size of the epidural space can vary greatly. Moreover,