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Neuraxial blocks and spinal haematoma: Review of 166 cases published 1994 – 2015. Part 2: diagnosis, treatment, and outcome

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HIGHLIGHTS

- 166 case reports of spinal haematoma (SH) after neuraxial block (CNB) are analysed.
- Most often, the signs of a SH started within 72 h, though in some cases after weeks.
- Surgical evacuation of the SH is best option in most cases with neurological deficits.
- A conservative approach can be employed in cases with mild or receding symptoms.
- Best results are seen in patients surgically evacuated within 12 hours
- Complete recoveries occurred in many cases operated after more than 24 hours.
- The prognosis after surgical evacuation of subdural SH was worse than after epidural SH.

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ABSTRACT

Background: Bleeding into the vertebral canal causing a spinal haematoma (SH) is a rare but serious complication to central neuraxial blocks (CNB). Of all serious complications to CNBs, neurological injury associated with SH has the worst prognosis. Around the turn of the millennium, the first guidelines aiming to reduce the risk of this complication were published. These guidelines are based on known risk factors for SH, rather than evidence from randomized, controlled trials (RCTs). RCTs, and hence meta-analysis of RCTs, are not appropriate for identifying rare events. Analysing data from a significant number of published case reports of rare complications may reveal risk factors and patterns undetectable in reports on occasional cases, and can thereby help to improve management of CNBs. The aims of the present review were to analyse case reports of SH after CNBs published between 1994 and 2015 with regard to diagnosis, treatment, and outcome of SH after CNB.
Methods: MEDLINE and EMBASE were utilized to find case reports published in English, German, or Scandinavian languages between 1994 and end of 2015, using appropriate search terms. Reference lists were also scrutinized for case reports. We documented initial and worst symptoms and signs of SH, diagnostic methods, treatment, and outcome of the SH. We calculated occurrences in per cent using the number of informative reports as denominator.
Results: One hundred and sixty-six case reports on spinal hematomas after CNB published during the years between 1994 and 2015 were identified. Eighty per cent of the patients had severe neurological symptoms (paresis or paralysis). When compared over time, outcomes have improved significantly. Among patients subjected to surgical evacuation of the hematoma, outcomes were best if surgery was performed within 12 hours from the first sign of motor dysfunction. However, even patients operated after more than 24 hours had relatively favourable outcomes. Whereas the outcomes after surgical evacuation of the epidural haematomas were quite satisfactory, only one of the operations for subdural haematoma (SSDH) resulted in a favourable outcome.

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Conclusions and implications: Suspicion of a spinal hematoma calls for the consultation of an orthopaedic or neurological surgeon without delay. MRI is the recommended diagnostic tool. Surgical evacuation within 12 h from the first sign of motor dysfunction seems to lead to the best outcome, although many patients operated as late as after more than 24 hours did regain full motor function. Despite the poor prognosis after surgical evacuation of SSDH, the outcomes after post-CNB spinal haematoma in general have improved significantly over time.

Contents

1. Introduction

Spinal haematoma (SH) is a rare but serious complication to central neuraxial block (CNB). Of all serious complications to epidural (EDA), spinal (SPA), or combined spinal/epidural (CSE) anaesthesia, neurological injury associated with SH has the highest risk of permanent disability. Around the turn of the millennium, the first guidelines aiming to reduce the risk of this complication were published [1,2]. These guidelines are based on known risk factors for SH, antihaemostatic drugs in particular, rather than evidence from randomized, controlled trials (RCTs) since these, and hence meta-analysis of RCTs, are not appropriate for identifying rare events [3]. Analysing data from a significant number of published case reports of rare complications may reveal risk factors and patterns not detectable in occasional reports [3], and can thereby help to improve management of CNBs. Current guidelines are often based on case report reviews published over 20 years ago [4–6]. The aim of the present review was to collect data from case reports on SH after CNBs published between 1994 and 2015 with respect to diagnosis, treatment, and outcome of patients suffering an SH after CNB for analysis and comparison with data from previous reviews [4–6]. Comparisons were also made between the first half (1994-2004) and the second half of the study period.

2. Methods

For collection of data etc. see Part 1 [7].

2.1. Severity of spinal haematoma

The severity of the initial and most serious symptoms and signs from the spinal haematoma was indicated by a four-graded scale according to Domenicucci et al [8]:

grade I: symptoms and signs were only somato-sensory (back pain, localized or radiating, paraesthesia, decreased sensibility) and/or sphincter deficits,

grade II: paresis,

grade III: paralysis (complete motor deficits).

Grade 0 indicates that none of the above symptoms or signs was present.

2.2. Grading of outcome of patients with SH after CNB

The outcome in patients with motor deficits was graded in four classes:

- *complete recovery* indicates that the motor function returned to the same level as before the CNB,
- *good recovery* indicates the motor function did not quite return to the pre-CNB level, but the patient was only marginally disabled and could resume normal, daily activities,
- *partial recovery* indicates that the patient was moderately disabled (e.g. could walk with crutches or walker),

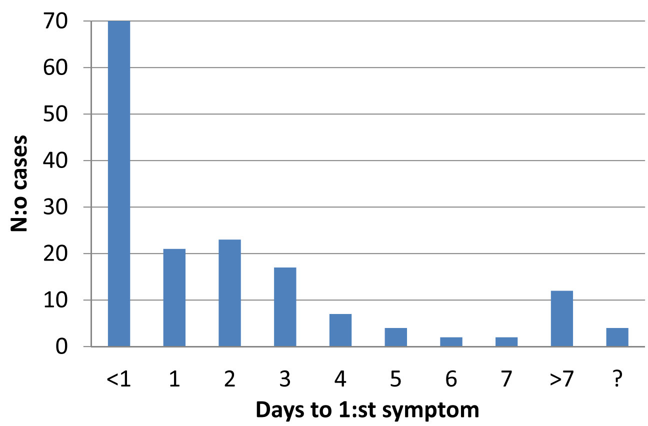

Fig. 1. Interval between CNB procedure or catheter removal and first sign of spinal haematoma (Grade 0 excluded). See Section 3.1 for further explanation. The question mark indicates inconclusive cases.

- *poor recovery* indicates that there was no significant return of motor function (patient bed ridden or wheel chair dependent).
- patients who died within 30 days of the procedure were referred to as *dead*.

In patients with grade I, recovery was classified as complete, partial, or poor (= pain was not improved or even worsened, or incontinence persisted).

Favourable outcomes were complete or good recoveries; otherwise outcomes were referred to as *unfavourable*.

2.3. Statistics

Differences between study groups (first half *vs.* second half of the years between 1994 and 2015, outcomes in various groups) were analysed with the Chi square test, or Fischer's exact test. A $P < 0.05$ indicated statistical significance.

3. Results

For demographic data, see part 1 [7].

3.1. Timing

Times from the procedure or, when appropriate, catheter removal or manipulation to the first symptom or sign of a SH are shown in Fig. 1 (4 cases with Grade 0 excluded). In 70 cases (44%), symptoms/signs started in less than 24 hours and in another 44 cases (28%) within 24-72 h. In 12 cases (7.6%) the delay was over 1 week, in 1 case as much as 3 months. In 65 cases, symptoms started after removal of the catheter. Based on the length of catheterization time, together with the proximity between removal and presenting signs, it is reasonable to assume that in 25 of these (38%) the haematoma was caused by the removal. Also, manipulations (withdrawal 1-2 cm) of catheters *in situ* caused 2 haematomas.

3.2. Symptoms and signs of the spinal haematoma (Table 1)

Initial and most severe symptoms are listed in Table 1. Pain/incontinence was the presenting sign in 81 patients, a majority of whom had back pain. In 50 of them (62%), symptoms progressed into grade II (24 cases) or grade III (26 cases) (Table 1). Motor deficits were seen in 81 cases, 60 grade II and 21 grade III. Of those initially in grade II, symptoms progressed to grade III in 19 cases (32%). In 4 cases, initial symptoms were uncharacteristic. One of these eventually developed into paralysis (grade III), a 73 y old woman with initial signs of meningeal irritation, which 12 days later evolved into paraplegia. A subdural haematoma was surgically evacuated, but the patient remained paraplegic [9].

Pain (grade I) as the final symptom was more common in patients with a subarachnoid haematoma (57%) than in patients with subdural or epidural haematomas (17%) ($P < 0.001$).

Table 1
Symptoms and signs of the spinal haematoma. See Section 3.2 for further explanation.

Initial		**Most severe**			
Grade	N:o	Grade 0	Grade I	Grade II	Grade III
0	4	3[1]	0	0	1
I	81		31[2]	24	26
II	60			41	19
III	21				21[3]
Total n:o of cases		**3**	**31**	**65**	**67**

[1] All 3 cases with grade 0 [10–12] were excluded from outcome analysis. The signs were:
1 signs of meningitis [10]
1 appearance of blood in an intrathecal catheter [11]
1 appearance of blood in an EDA needle at reoperation (fem. bypass) [12]
[2] One patient with a subdural and subarachnoid SH had a simultaneous intracranial subarachnoid and intraventricular haemorrhage [13], and was excluded from outcome analysis.
[3] One patient with a preoperative multiple sclerosis with paraparesis [14], suffering from a subdural haematoma, was excluded from outcome analysis

3.3. Diagnosis of spinal haematoma

The diagnosis was confirmed with magnetic resonance imaging (MRI) in 144 cases, computer tomography (CT) scan in 18 cases (of which 3 with a CT-myelography) and with plain myelography in 3 cases. In 3 cases, 2 because of metallic implants and 1 because of overweight, MRI was impossible. In one case [11] no radiologic examination was made.

3.4. Location of the haematoma (Table 2)

The haematoma was located epidurally in 121 patients, of whom 100 (83%) had motor deficits, subdurally in 31 (26 or 84%, with motor deficits), and subarachnoidally in 14 cases (5, or 38% with motor deficits). Six of the subdural haematomas also had some blood subarachniodally. Eight of the subdural, and 2 of the subarachnoid haematomas occurred after epidural blocks. In only one of these 10 cases were any signs of an accidental dural puncture in connection with the procedure reported. Among the spinal blocks, 10 haematomas were subarachnoid, 20 subdural (one with a simultaneous intracranial subarachnoid haematoma [13]), and 15 epidural. In the CSE group, there were 1 subarachnoid, 3 subdural, and 11 epidural haematomas (Table 2).

Table 2
CNB technique vs. haematoma location. Figures within brackets denote percentage.

Type of block	Location of the spinal haematoma			N:o of cases
	Epidural	Subdural	Subarachnoid	
Epidural	96[1]	8	2	**106**
Spinal	14[1]	20[2]	11[3]	**45**
Combined	11	3	1	**15**
N:o of cases	**121 (73)**	**31 (19)**	**14 (8.7)**	**166**

[1] Two patients with epidural haematoma, 1 after EDA [12], and 1 after SPA [10], both with Grade 0, were excluded from outcome analysis.
[2] One patient with a simultaneous intracranial haemorrhage [13], was excluded from outcome analysis.
[3] One patient with Grade 0 [11], and 1 patient with preoperative paraparesis (MS) (Grade III) [14] were excluded from outcome analysis.

Table 3
Outcome of all patients with grade I (n = 30). Figures within brackets denote percentage. One patient excluded [13], see section 3.5 and Table 1.

Time to decompressive laminectomy (h)	Complete recovery	Partial recovery	Poor recovery	Dead	Total
<12	3 (100)	0	0	0	3
12-24	0	0	1 (100)	0	1
>24	4 (67)	2 (29)	1 (14)	0	7
Inconclusive[1]	0	0	0	0	0
All operated	**7 (64)**	**2 (18)**	**2 (18)**	**0**	**11**
Not operated	**18 (95)**	**1 (5.3)**	**0**	**0**	**19**
Total	**25 (83)**	**4 (13)**	**1 (3.3)**	**0**	**30**

[1] Patients who were laminectomized, but timing of surgery could not be determined

3.5. Treatment and outcome

Laminectomy and evacuation of the haematoma was carried out in 119 patients, while 47 were treated conservatively. Surgical treatment was carried out in 37% of grade I patients, and in 83 and 82% respectively in patients with grade II and III.

The reasons to refrain from surgical evacuation varied: most important was the severity of symptoms. None of the patients with grade 0 [10–12] underwent surgical evacuation of the haematoma. In 3 cases, the reason was too longstanding symptoms (surgical evacuation was considered to be of questionable benefits).

Five patients were excluded from outcome analysis: 3 patients with grade 0 [10–12], 1 patient with a simultaneous intracranial haemorrhage [13], and 1 patient with longstanding paraparesis because of a multiple sclerosis, who became paralytic [14]. Thus, outcomes were analysed in 161 cases: 30 with grade I, 65 with grade II, and 66 with grade III.

A favourable outcome (complete or good recovery) was seen in 83% of the patients with grade I, in 49% of those with grade II, and in 42% with grade III ($P < 0.001$ between grade I and grades II–III, $P = 0.43$ between grade II and grade III).

3.5.1. Outcomes in patients with grade I manifestations of SH (Table 3)

In patients with grade I, the absence of serious neurological deficits also weakened the indication for surgical evacuation. Still, 12 of these 30 patients were operated with evacuation of the haematoma. Of these, 8 had a complete recovery (i.e. freedom from pain and/or return of full sphincter function), two had slight residual pain (VAS < 3), one had residual back pain, and one patient "developed backache and suffered from emotional distress" following surgical evacuation [15]. Nineteen patients were treated conservatively; of these 18 had complete recovery, including the 2 with decreased tonus of the anal sphincter. One had slight residual pain (VAS 3/10) at the end of the observation period (2 months).

3.5.2. Outcomes in patients with grade II-III (Tables 4a–4c)

Table 4a shows the outcome of 131 patients with motor dysfunction (grade II-III) operated on within various time intervals, or treated conservatively (1 patient excluded). Surgical evacuation was carried out in 108 cases (82%). The time from appearance of motor symptoms to surgical evacuation varied from less than 8 hours to 4 days. More patients had a favourable outcome if operation was performed within 12 h from first sign (50%), compared with after 12 h (26%). Also, patients operated after more than 24 h had better outcomes than those operated between 12 and 24 h (44 *vs.* 5% favourable outcomes). There were no differences in outcome between those operated within 12 h and those operated after > 24 h ($P = 0.6$). There were no differences between grade II and grade III patients, neither with regard to treatment (surgical vs. conservative), nor with regard to outcomes (see Section 3.5).

3.5.2.1. Outcomes of grade II-III patients with epidural haematoma (SEDH) (Table 4b). Surgical evacuation was carried out in 80 (80%), with 49% favourable outcomes. There were 63% favourable outcomes in the group evacuated within 12 h, *vs.* 31% in those operated after more than 12 h from the development of neurological symptoms. Also, those operated after more than 24 h (50% favourable outcomes) had better outcomes than those operated between 12 and 24 h (one patient, 7.1%). Again, there was no difference between those operated within 12 h and those operated after > 24 h. Twenty patients were treated conservatively. Fifteen of these, or 75%, recovered completely, 3 had poor recovery, and 2 died.

3.5.2.2. Outcomes of grade II-III patients with subdural haematoma (SSDH) (Table 4c). Surgical evacuation was carried out in 24 (92%), 11 within 12 h and 9 after 12 h (4 unreported timing). Only one patient, operated after > 24 h, experienced a favourable outcome [16]. Five (two operated within 12 h, two after 12 h, and 1 with unreported timing) had a partial recovery. Two patients were treated conservatively, both with complete recoveries.

3.5.2.3. Outcomes of patients with subarachnoid haematoma (SSAH). There were only 12 cases with symptomatic SSAH (2 excluded), of which 5 with grades II-III. Four underwent surgical evacuation, 2 with favourable and 2 with unfavourable outcomes, one was treated conservatively (complete recovery). Seven were grade I, 6 of these were treated conservatively, all with complete recoveries. One laminectomized patient remained in slight residual pain.

3.5.3. Outcomes during 1994-2004 vs. 2005-2015

The prevalence of favourable outcomes was 41% during the first half of the study period, *vs.* 64% during the second half ($P < 0.001$). Among cases with motor deficits (grade II-III), the prevalence of favourable outcomes was 36% and 57%, for the two periods respectively ($P < 0.05$). Similar differences were seen whether patients were surgically evacuated (30% *vs.* 49%) or conservatively treated (62% *vs.* 100%).

4. Discussion

4.1. Diagnosis

Eighty-one cases reported from 2005 to 2015 (96%) were diagnosed with MRI, 2 cases with CT-scan, 1 of these because of contraindication to MRI (pacemaker) [17], and 1 case with myelography, the case occurred in 1977 [18]. Only 77% were examined with MRI during the first 11 years (1994-2004). Today, MRI is undoubtedly the investigation of choice for verifying and localising a post-CNB spinal haematoma.

4.2. Outcomes

The outcomes were divided into several subgroups: with regard to gravest symptom or sign of the haematoma, with regard to location of the haematoma in relation to the meninges, and with regard to the treatment of the haematoma. Surgically treated patients were compared with regard to the time lapse from the presenting neurological symptom to laminectomy: less than 12 h, 12-24 h, and more than 24 h. The 12 h interval was chosen for several reasons. Firstly, in many clinical settings (e.g. small rural hospitals far from nearest neurosurgical clinic) a shorter interval does not seem realistic to achieve in all cases [19] secondly, this choice is supported by several neurosurgical studies [8,20–22]. Thirdly, we compared

Table 4a
Outcomes of all patients with motor deficits (grades II-III, n = 131). Figures within brackets denote percentage. One patient [14] excluded, see section 3.5.

Time to decompressive laminectomy (h)	Favourable outcomes		Unfavourable outcomes			Total
	Complete recovery	Good recovery	Partial recovery	Poor recovery	Dead[1]	**Total**
< 12	20 (37)	7 (13)	7 (13)	17 (31)	3 (5.6)	**54**
12-24	1 (5.3)	0	6 (32)	11 (58)	1 (5.3)	**19**
> 24	5 (22)	5 (22)	5 (22)	8 (34)	0	**23**
Inconclusive[2]	4 (33)	0	3 (25)	5 (42)	0	**12**
All operated	**30 (28)**	**12 (11)**	**21 (19)**	**41 (38)**	**4 (3.7)**	**108**
Not operated[3]	**18 (78)**[3a]	**0**	**0**	**3 (13)**[3b]	**2 (8.7)**[3c]	**23**
Total	**48 (37)**	**12 (9.2)**	**21 (16)**	**44 (34)**	**6 (4.6)**	**131**

[1]Patients who died within 30 days from the procedure (without recovering)
[2]Patients who were laminectomized, but timing could not be determined
[3]Reason to refrain from laminectomy:
[a] Mild, stable or disappearing symptoms (n = 12), too long time elapsed from 1st sign (2), poor medical condition (2), alternative treatment (hyperbaric oxygen) (1), reason not reported (1)
[b] Patient refusal (2), "no therapeutic measures were deemed possible" (1)
[c] Poor medical condition (1), too long time elapsed from 1st sign (1)

patients operated within 8 h with those operated 8-12 h after first sign of motor dysfunction, and found no difference in outcome.

4.2.1. Patients without motor deficits (grade I, Table 3)

In patients with grade I symptoms (mostly back pain), surgical evacuation did not seem to improve outcomes. In the non-operated group 95% were completely recovered, vs. 64% after surgical decompression. A wait-and-see approach, with meticulous follow up, seems to be the best option in patients without motor deficits.

4.2.2. Patients with motor deficits (grade II-III, paresis or paraplegia, Table 4a)

In patients with grade II-III (motor deficits), decompressing laminectomy within 12 hours resulted in the best surgical outcome in the present as well as in several other studies [e.g. 8, 20–22] (Table 4a). There were 50% favourable outcomes in this group, compared with 26% in those operated after more than 12 h.

Of special interest however, are the good results in the group with late laminectomy (>24 h), with 44% favourable outcomes, which compared well with the group < 12 h (50%), and superior to the group 12-24 h (5.3%, Table 4a). In 5 of the 6 cases with complete neurological recovery among those operated after 12 h [16,23–26], laminectomies were performed 24-96 h after the first sign. These results indicate that *it is not justified to refrain from decompressive laminectomy because of longstanding symptoms alone.* Therefore the view that there is a certain time limit from development of neurologic symptoms until surgical intervention (sometimes given as 8 h) after which complete neurological recovery is unlikely [e.g. 27–29] does not seem accurate. Such time limits are too pessimistic. Three patients in this review were denied surgical evacuation of their haematoma because of such a defeatist strategy. Two of them recovered completely (see below), while one died.

Several authors claim that surgery is the only effective treatment of patients suffering from a spinal haematoma with motor deficits [e.g. 4–6,20,30,31]. However, the present review clearly shows that this may not always be true, since outcomes of patients among those who were treated conservatively compared excellent with those operated within 12 h; favourable outcomes occurred in 18 of 23 (78%) in the non-surgical group vs. 27/54 (50%) among those laminectomized within 12 h (Table 4a). Indeed, this is not surprising, since the reason to refrain from surgical evacuation was often that neurological symptoms had stabilized (2 cases) or were resolving (10 cases), of which all made complete recoveries. Eight patients were denied surgery since an operation would be of questionable benefits, either because of long standing symptoms or poor medical condition, still 5 of them recovered completely. One of these was a 90-year old woman with gastric cancer, who developed an epidural haematoma after having a thoracic epidural catheter inserted for gastrectomy [28]. More than 12 h had elapsed from start of symptoms (paraparesis) until diagnosis, and the patient was treated conservatively since operation was considered having questionable benefits because of this delay, and also because of her age and malignancy. Her recovery was still poor after 15 days, was partial after 30 days, but was complete after 56 days.

If surgical evacuation is not indicated, the patient must be monitored carefully for any sign of progressing symptoms, and offered alternative treatment, e.g. physiotherapy. One interesting option is hyperbaric oxygen (HBO) therapy. One patient with grade II (weakness of the legs) was treated with HBO while waiting for surgical evacuation of a lumbar SEDH [32]. During this first HBO session prompt relief of the symptoms occurred, why operation was cancelled. Instead, the patient received four additional HBO sessions the following days, leading to a complete recovery. One month later, a follow up MRI demonstrated complete absorption of the haematoma.

4.2.3. Spinal subdural haematomas (Table 4c)

Of special interest are also the many unfavourable outcomes, reported in patients who underwent surgical evacuation of their spinal *subdural* haematomas (SSDH) (96%). Only one patient (4.2%) had a favourable outcome (Table 4c, Fig. 2). In comparison, 49% in the SEDH group had favourable outcomes ($P < 0.001$) (Table 4b, Fig. 2).

In 18 patients with SSDH (75%), of whom 2 died, surgical evacuation resulted in no significant improvement at all, while 5 patients

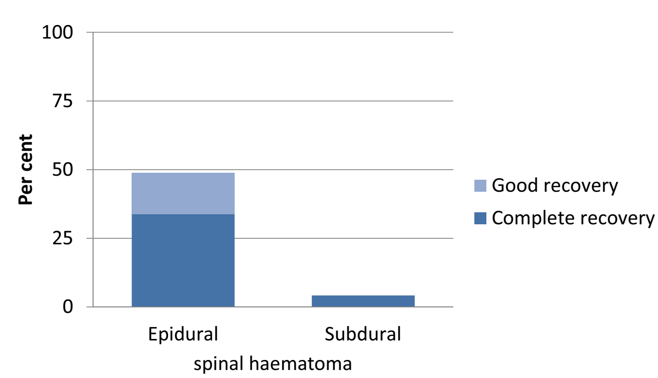

Fig. 2. Favourable outcomes *after surgical evacuation of the haematoma* in per cent of patients undergoing decompressive laminectomy for spinal epidural (left bar; N = 80) or subdural (right bar; N = 24) haematoma. Only 1 patient among those with a spinal subdural haematoma had a favourable outcome (complete recovery). See Section 4.2.3 for further explanation.

Table 4b
Outcomes of patients with motor deficits from an epidural haematoma (grades II-III, n = 100). Figures within brackets denote percentage.

	Favourable outcomes		Unfavourable outcomes			
Time to decompressive laminectomy (h)	Complete recovery	Good recovery	Partial recovery	Poor recovery	Dead[1]	**Total**
< 12	19 (46)	7 (17)	5 (12)	9 (22)	1 (2.4)	**41**
12-24	1 (7.1)	0	5 (36)	7 (50)	1 (7.1)	**14**
> 24	4 (22)	5 (28)	4 (22)	5 (28)	0	**18**
Inconclusive[2]	3 (43)	0	2 (29)	2 (29)	0	**7**
All operated	**27 (34)**	**12 (15)**	**16 (20)**	**23 (29)**	**2 (2.5)**	**80**
Not operated[3]	**15 (75)[3a]**	**0**	**0**	**3 (15)[3b]**	**2 (10)[3c]**	**20**
Total	**42 (42)**	**12 (12)**	**16 (16)**	**26 (26)**	**4 (4)**	**100**

[1]Patients who died within 30 days from the procedure (without recovering)
[2]Patients who were laminectomized, but timing could not be determined
[3]Reason to refrain from laminectomy:
[a] Mild, stable or disappearing symptoms (n = 10), too long time elapsed from 1st sign (2), alternative treatment (hyperbaric oxygen) (1), poor medical condition (1), reason not reported (1)
[b] Patient refusal (2), "no therapeutic measures were deemed possible" (1)
[c] Poor medical condition (1), too long time elapsed from 1st sign (1)

Table 4c
Outcomes of patients with motor deficits from a subdural haematoma. (grades II-III, n = 26) Figures within brackets denote percentage. One patient [14] excluded, see section 3.5.

	Favourable outcomes		Unfavourable outcomes			
Time to decompressive laminectomy (h)	Complete recovery	Good recovery	Partial recovery	Poor recovery	Dead[1]	**Total**
< 12	0	0	2 (18)	7 (64)	2 (18)	**11**
12-24	0	0	1 (25)	3 (75)	0	**4**
> 24	1 (20)	0	1 (20)	3 (60)	0	**5**
Inconclusive[2]	0	0	1 (25)	3 (75)	0	**4**
All operated	**1 (4.2)**	**0**	**5 (21)**	**16 (67)**	**2 (8.3)**	**24**
Not operated[3]	**2 (100)[3]**	**0**	**0**	**0**	**0**	**2**
Total	**3 (12)**	**0**	**5 (19)**	**16 (62)**	**2 (7.7)**	**26**

[1]Patients who died within 30 days from the procedure (without recovering)
[2]Patients who were laminectomized, but where timing could not be determined
[3]Reason to refrain from laminectomy: Mild, stable or disappearing symptoms (n = 2)

had partial recoveries. The timing of surgery was unimportant. Eleven patients had surgery within 12 h, 7 of those had poor outcomes, 2 died, and 2 did recover partially. Three additional patients made partial recoveries, 1 of them was laminectomized after more than 30 h. The only patient in whom surgery resulted in a favourable outcome (complete recovery) complained of back pain immediately postoperatively, was discharged but returned to the hospital 2 weeks later with persistent pain, and also incontinence and leg weakness since 24 h [16]. Thus, operation took place > 24 h after first neurologic symptom. Two patients were treated conservatively, 1 grade II [33] and 1 grade III [34]; both made complete recoveries. These figures may cast a shadow of doubt as to the beneficial effects of surgical evacuation in patients suffering from a spinal subdural haematoma, even if symptoms and signs have developed into severe neurologic deficits. It must be emphasized however, that this notion is only valid for CNB cases. Yang et al [35] analysed 106 cases of non-traumatic SSDH. Of the 59 cases that were treated surgically, 42% had favourable outcomes, compared with 43% in the non-surgical group (47 cases) [35]. The reason for the poor surgical prognosis in patients with a post-CNB subdural haematoma is unclear. The motor deficits were not worse compared with those with a spinal epidural haematoma, 42% complete deficits in both groups. Regardless of location, whenever a spinal haematoma is suspected, an urgent neurosurgical consultation is mandatory.

4.3. Better outcome of post CNB spinal haematoma after 1994 (Table 5)

Overall, the outcomes after post-CNB SH among the present case reports differ from previous reviews [4–6] (Table 5). In particular, the mortality rate is much lower (3.7 *vs.* 26-28%), and the prevalence of complete recoveries is higher (45 *vs.* 20-22%). Possible explanations are improvements in diagnostic and therapeutic tools. E.g. among the present cases, MRI was used in 89%, while the corresponding figure reported by Vandermeulen et al [5] was 10%.

Outcomes were also improving during the study period. In the first half (1994-2004), 36% of the patients recovered completely,

Table 5
Outcomes in patients with symptomatic spinal haematoma after a CNB (grades I-III). NR = not reported. All figures denote per cent of reported cases.

Authors, year, and reference number	Cases from years	Neurologic recovery				
		Complete	Good	Partial	Poor	Dead
Schmidt and Nolte 1992 [4] (n = 29)	1974 - 1991	20.7		24.1	13.8	27.6
Vandermeulen et al., 1994 [5] (n = 61)	1906 - 1993	19.7		18	47.5	26.2
Wulf, 1996 [6] (epidurals only) (n = 51)[1]	1952 - 1996	22	11	23	44	NR
Present review, 2017 (n = 161)[2]	*1994 - 2015*	*45*	*7.5*	*15*	*29*	*3.7*

[1]Numbers estimated from a graph over patients after surgical evacuation of their haematoma.
[2]Two patients excluded, see Section 3.5 (Three patients had grade 0).

and 41% hade favourable outcomes. During the second half (2005-2015) the corresponding figures were 54% and 64% respectively ($P = 0.004$). Even here, improved diagnostic tools may explain the better outcomes. In the first period, MRI was used in 77% of the cases, during the second period it was used in 96%.

5. Conclusions and implications

We have analysed 166 cases of spinal haematoma after central neuraxial blocks published between 1994 and 2015. This review clearly shows that the clinical pattern of this complication has changed significantly during the last two decades.

- Magnetic resonance imaging has been increasingly used to verify diagnosis, and is now mandatory, except when contraindicated.
- The outcome of patients has been improved, whether these are treated surgically or conservatively. The prevalence of patients with complete recovery was doubled compared with reports from the 1990's.
- Although surgical evacuation of the haematoma is strongly indicated in most patients, it may not be the best option in those without motor deficits, or when these are stable or receding.
- Only one of the patients with motor dysfunction from a spinal *subdural* haematoma did recover significant motor function after surgical evacuation.
- In patients with motor deficits from an *epidural* haematoma, the best surgical results were achieved after surgical evacuation within 12 h after the appearance of neurologic symptoms.
- Importantly, a delay of more than 24 h should not in itself deter from decompressive laminectomy if this is indicated. Several patients with severe deficits regained full neurological function even after delayed surgical evacuation.

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References[1]

[1] Tryba M. European practice guidelines: thromboembolism prophylaxis and regional anaesthesia. Reg Anesth Pain Med 1998;23:178–82.
[2] Horlocker TT, Wedel DJ, Benzon HT, Brown DL, Enneking FK, Heit JA, Mulroy MF, Rosenquist RW, Rowlingson J, Tryba M, Yuan C-S. Regional anesthesia in the anticoagulated patient (the second ASRA consensus conference on neuraxial anesthesia and anticoagulation). Reg Anesth Pain Med 2003;28:172–97.
[3] Butterworth JF. Case Reports: unstylish but still useful sources of clinical information (editorial). Reg Anesth Pain Med 2009;34:187–8.
[4] Schmidt A, Nolte H. Subdural and epidural hematomas following epidural anesthesia. A literature review. Anaesthesist 1992;41:276–84.
[5] Vandermeulen E, Aken H van, Vermylen J. Anticoagulants and spinal-epidural anesthesia. Anesth Analg 1994;79:1165–77.
[6] Wulf H. Epidural anaesthesia and spinal haematoma. Can J Anaesth 1996;43:1260–71.
[7] Lagerkranser M. Neuraxial blocks and spinal haematoma: Review of 166 cases published 1994-2015. Part 1: demographics and risk factors. Scand J Pain 2017;00, 00-00.
[8] Domenicucci M, Ramieri A, Ciapetta P, Delfini R. Nontraumatic acute spinal subdural hematoma. Report of five cases and review of the literature. J Neurosurg (Spine 1) 1999;91:65–73.
[9] Cabitza P, Parrini M. Slow-onset subdural hematoma, evolving into paraplegia, after attempted spinal anesthesia – a case report. Acta Orthop Scand 1998;69:650–2.
[10] Dahlgren N, Törnebrandt K. Neurological complications after anaesthesia. A follow-up of 18 000 spinal and epidural anaesthetics performed over three years. Acta Anaesthesiol Scand 1995;39:872–80.
[11] Rabito SF, Ahmed S, Feinstein L, Winnie AP. Intrathecal bleeding after the intraoperative use of heparin and urokinase during continuous spinal anesthesia. Anesth Analg 1996;82:409–11.
[12] Harvey SC, Roland PJ, Curé JK, Cuddy BC, O'Neil MG. Spinal epidural hematoma detected by lumbar epidural puncture. Anesth Analg 1997;84:1136–9.
[13] Rocchi R, Lombardi C, Marradi I, Di Paolo M, Cerase A. Intracranial and intraspinal hemorrhage following spinal anesthesia. Neurol Sci 2009;30:393–6.
[14] Christensen PH, Johnstad B. Alvorlig neurologisk sekvele i tilslutning til spinal- og epiduralbedövelse. Tidsskr Nor Laegeforen 1998;118:244–6.
[15] Pánek V. Epidural haematoma and timing of heparin prophylaxis. Anaesthesia 2001;56:811–2.
[16] Seouw K, Drummond KJ. Subdural spinal haematoma after spinal anaesthesia in a patient taking aspirin. J Clin Neurosci 2011;18:1713–5.
[17] Madhisetti KR, Mathew M, Pillai SS. Spinal epidural haematoma following rivaroxaban administration after total knee replacement. Indian J Anaesth 2015;59:519–21.
[18] Li S-L, Wang D-X, Ma D. Epidural hematoma efter neuraxial blockade: a retrospective report from China. Anesth Analg 2010;111:1322–4.
[19] Bedforth NM, Aitkenhead AR, Hardman JG. Haematoma and abscess after epidural analgesia. Editorial. Brit J Anaesth 2008;101:291–3.
[20] Kreppel D, Antoniadis G, Seeling W. Spinal hematoma: a literature survey with meta-analysis of 613 patients. Neurosurg Rev 2003;26:1–49.
[21] Liao C-C, Lee S-T, Hsu W-C, Chen L-R, Lui T-N, Lee S-C. Experience in the surgical management of spontaneous spinal epidural hematoma. J Neurosurg (Spine1) 2004;100:38–45.
[22] Lawton MT, Porter RW, Heiserman JE, Jacobowitz R, Sonntag VKH, Dickman CA. Surgical management of spinal epidural hematoma: relationship between surgical timing and neurological outcome. J Neurosurg 1995;83:1–7.
[23] Persson J, Flisberg P, Lundberg J. Thoracic epidural anaesthesia and epidural haematoma. Acta Anaesthesiol Scand 2002;46:1171–4.
[24] Varitimidis SE, Paterakis K, Dailiana ZH, Hanres M, Georgopoulou S. Epidural hematoma secondary to removal of an epidural catheter after a total knee replacement. A case report. J Bone Joint Surg Am 2007;89:2048–50.
[25] Kasodekar SV, Goldszmidt E, Davies SR. Atypical presentation of an epidural hematoma in a patient receiving aspirin and low molecular weight heparin. Was epidural analgesia the right choice? J Clin Anesth 2009;21:595–8.
[26] Ulivieri s, Olivieri G. Spinal epidural hematoma following epidural anesthesia. Case report. G Chir 2009;30:51–2.
[27] Chan L, Bailin MT. Spinal epidural hematoma following central neuraxial blockade and subcutaneous enoxaparin: a case report. J Clin Anesth 2004;16:382–5.
[28] Schwarz SKW, Wong CL, McDonald WN. Spontaneous recovery from a spinal epidural hematoma with atypical presentation in a nonagenarian. Can J Anesth 2004;51:557–61.
[29] Goswami D, Das J, Deuri A, Deka AK. Epidural haematoma: rare complication after spinal while intending epidural anaesthesia with long-term follow-up after conservative treatment. Indian J Anaesth 2011;55:71–3.
[30] Horlocker TT. Regional anaesthesia in the patient receiving antithrombotic and antiplatelet therapy. Brit J Anaesth 2011;107:i96–106.
[31] Meikle J, Bird S, Nightinggale JJ, White N. Detection and management of epidural haematomas related to anaesthesia in the UK: a national survey of current practice. Br J Anaesth 2008;101:400–4.
[32] Wajima Z, Aida S. Does hyperbaric oxygen have positive effect on neurological recovery in spinal-epidural haematoma? A case report. Brit J Anaesth 2011;106:785–91.
[33] Pedraza Gutiérrez S, Coll Masfarré S, Castaño Duque CH, Suescún M, Rovira Cañellas A. Hyperacute spinal subdural haematoma as a complication of lumbar spinal anaesthesia: MRI. Neuroradiology 1999;41:910–4.
[34] Bougher RJ, Ramage D. Spinal subdural haematoma following combined spinal-epidural anaesthesia. Anaesth Intens Care 1995;23:111–3.
[35] Yang NR, Kim SJ, Cho YJ, Cho do S. Spontaneous resolution of nontraumatic acute spinal subdural hematoma. J Korean Neurosurg Soc 2011;50:268–70.

[1] For a complete list of case reports: see Part 1 [7].