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Severe Neurological Complications after Central Neuraxial Blockades in Sweden 1990–1999

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Background: **Central neuraxial blockades find widespread applications. Severe complications are believed to be extremely rare, but the incidence is probably underestimated.**

Methods: **A retrospective study of severe neurologic complications after central neuraxial blockades in Sweden 1990–1999 was performed. Information was obtained from a postal survey and administrative files in the health care system. During the study period approximately 1,260,000 spinal blockades and 450,000 epidural blockades were administered, including 200,000 epidural blockades for pain relief in labor.**

Results: **The 127 complications found included spinal hematoma (33), cauda equina syndrome (32), meningitis (29), epidural abscess (13), and miscellaneous (20). Permanent neurologic damage was observed in 85 patients. Incidence of complications after spinal blockade was within 1:20–30,000 in all patient groups. Incidence after obstetric epidural blockade was 1:25,000; in the remaining patients it was 1:3600 ($P < 0.0001$). Spinal hematoma after obstetric epidural blockade carried the incidence 1:200,000, significantly lower than the incidence 1:3,600 females subject to knee arthroplasty ($P < 0.0001$).**

Conclusions: **More complications than expected were found, probably as a result of the comprehensive study design. Half of the complications were retrieved exclusively from administrative files. Complications occur significantly more often after epidural blockade than after spinal blockade, and the complications are different. Obstetric patients carry significantly lower incidence of complications. Osteoporosis is proposed as a previously neglected risk factor. Close surveillance after central neuraxial blockade is mandatory for safe practice.**

CENTRAL neuraxial blockades (CNB) find widespread application in anesthesia as well as in postoperative and labor analgesia. Recent studies also suggest a reduction in postoperative mortality when CNB are used in major surgery.[1] The use of CNB will probably increase in the future, as serious complications have been reported to be extremely rare.[2] Studies are scarce, and their results difficult to compare.[3–8] Many complications are known through case reports, and these rare events might not be evenly distributed within the patient population. Because the enormous number of patients needed to perform prospective studies exceeds feasibility, it is important that retrospective studies try to minimize the inherent weakness of such study designs. Underreporting is common in retrospective studies, causing underestimation of risk. In recent years, interest has focused on spinal hematoma after administration of low molecular weight heparin (LMWH).[9–12] To investigate the incidence of serious neurologic complications after CNB in Sweden from 1990 to 1999, all available sources of information were searched. The aim was also to identify subgroups of patients with higher or lower prevalence of risk factors.

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Materials and Methods

First and Second Survey

A first postal survey was sent to head of department in all 85 departments of anesthesia in Sweden. The receivers were asked to report the occurrence of specified complications after CNB from 1990–1999. The complications specified were epidural abscess, meningitis, spinal hematoma, and cauda equina syndrome. Other serious complications could be reported, but patient identity or details regarding the incidents were not warranted.

The respondents were also required to state the number of spinal blockades (SB) and epidural blockades (EB) performed in the department during 1998.

One letter and at least two telephone calls of reminder were directed to late responders. Answers were obtained from 72 of the inquiry receivers (85%), and in 42 of these departments 117 complications were reported to have occurred. The survey was carried out in the fall of 1999, and the results were presented at a national symposium dedicated to the topic of complications after CNB.

A second survey was launched with approval of the ethical committees at the universities in Linkoping, Lund and the Karolinska Institute in Stockholm (Sweden). The scope of this second survey was to link each complication previously reported to identified patients. The 42 departments reporting complications in the first survey were thus again contacted as were the 13 nonresponding departments from the first survey. One letter and at least two telephone calls of reminder were directed to late responders.

Table 1. Cases and Sources of Information

Type of Complications	Number of Cases First Survey	Number of Cases in Present Study: Second Survey	Administrative Files	Total Number of Complications
Spinal hematoma	32	25	8	33
Cauda equina syndrome	22	5	27	32
Purulent meningitis	28	18	11	29
Epidural abscess	25	7	6	13
Miscellaneous	10	9	11	20
Total	117	64	63	127

In the first survey, 42 departments reported 117 cases. After request for patient identification, the number of reporting departments was reduced to 27, and only 64 cases could be reclaimed. The final 127 complications had occurred in 55 departments, leaving without complications 30 departments located in one county hospital, two university hospitals and 27 small local hospitals, with few anesthetics performed. The 20 miscellaneous complications retrieved in the second survey include nine cases of traumatic cord lesions, five cases of intracranial subdural hematoma and four cases of paraparesis. Two cases followed accidental dural puncture, resulting in permanent abducens paresis in one patient and in Horner's syndrome with facial pain in another patient.

The clinicians were asked to specify symptoms, management, and outcome for each complication and, if possible, details concerning difficulties encountered when performing the CNB. Information regarding spinal diseases or deformities, vascular disease, diabetes, immunosuppression, coagulopathy, or any other pathologic condition of clinical importance was required, as well as indication for surgery, thromboprophylaxis, and medication interfering with coagulation.

In Sweden, each of the 8.8 million citizens is provided with a personal identification number. Every complication was related to an individual person identified through this identification number, thus excluding the possibility of any complication being counted more than once (table 1).

Administrative Files

Parallel to the mailed enquiry, administrative files in the health care system were searched. According to the law of "Lex Maria," medical institutions are obliged to inform the National Board of Health and Welfare (Stockholm, Sweden) regarding actions that have seriously injured any patient. The Medical Responsibility Board (Stockholm, Sweden) specifically evaluates claims of medical malpractice. The Patient Insurance Claims (Stockholm, Sweden) compensates mishaps on a no-fault basis. Patients who sustain significant injuries resulting from side effects of drugs can be compensated by the Swedish Pharmaceutical Insurance (Uppsala, Sweden). All cases reported to these boards are subject to peer review. Six cases were known to the authors through personal communications. These cases are included among the cases referred to as retrieved through the administrative files.

Definitions

Intravertebral hematomas can be located in the epidural or the subdural space. In this article, all intravertebral hematomas are referred to as "spinal hematoma."

The cauda equina syndrome can occur as a result of neuronal local anesthetic toxicity or compression, as when the syndrome occurs after spinal hematoma, abscess, or spinal stenosis.[13] In the current study, causal diagnosis has been used as often as possible. Therefore, this paper includes in the cauda equina group of complications exclusively cases believed to have been caused by the local anesthetic, either by toxicity or through presumed compression by local anesthetic volume-effect. No cases of spinal hematoma or epidural abscess are included in the cauda equina syndrome group.

Iatrogenic meningitis can be aseptic, as when meningitis is caused by disinfectants, or purulent, as when caused by bacteria. "Meningitis" in this article refers exclusively to purulent meningitis.

Risk Factors

The first Swedish guidelines regarding CNB, thromboprophylaxis, and coagulation disorders were accepted in 2001 by the Association of Swedish Anesthesiologists. In the current article, risk factors for spinal hematoma correspond to those indicated by these guidelines. Suggested risk factors were concentrations of thrombocyte count less than 150,000/mm^3 and international normalized ratio levels above 1.4. Thromboprophylaxis with LMWH was defined as dalteparin 2,500–5,000 IE daily or enoxaparin 40 mg daily. LMWH exceeding these doses were considered risk factors when given within 24 h, as was heparin, usually in doses of at least 5,000 IE, administered during vascular surgery. Thromboprophylaxis with LMWH administered within 10 h before administration of CNB or catheter removal was also considered a risk factor, as was CNB or catheter removal within 2 h before treatment. Other suggested risk factors were diseases that may be associated with coagulation disorders, such as renal or liver failure, or the obstetric syndrome of hemolysis, elevated liver enzymes, and low platelets. Further, the presence of ankylosing spondylitis, evident spinal deformity, or increased trauma when performing CNB were considered risk factors. In this study, difficulties recorded when performing CNB include repeated attempts, bloody taps, accidental dura perforation, and paresthesia or pain on injection.

Denominators

The 72 respondents in the first survey stated that during 1998 a total of 83,000 SB and 38,800 EB had been performed. The high response rate justified the assumption that the numbers obtained were representative for all departments, and 1998 was considered a yearly mean for the decade. According to the Swedish Medical Birth Registry (Stockholm, Sweden) 23,200 EB for labor pain were performed during 1998.

The numbers corresponding to all 85 departments during the decade were initially calculated as 975,000 SB and 225,000 EB, excluding obstetric use. The numbers obtained were truncated to the closest thousand.

To increase the accuracy of this estimate, AstraZeneca AB (Sodertalje, Sweden) was contacted. The company is by far the dominant merchant of local anesthetics in Sweden; practically all local anesthetics for spinal anesthesia are sold by this company. In the decade under investigation, they sold 1,264,000 ampoules of local anesthetics for spinal use. We therefore adjusted the number of SB to 1,260,000. The number of EB was adjusted to 250,000. This assumption was justified by the higher prevalence of local hospitals among the nonresponders in the first survey, and the answers indicating that smaller departments performed SB substantially more often than EB.

Combined spinal epidural blockade (CSE) was not quantified. When calculating incidence of complications, CSE is treated as EB unless otherwise stated. No distinction of EB with or without catheter could be made based on our information. According to a survey performed in 1993, SB was preferred for shorter surgical procedures whereas EB and CSE were chosen when severe postoperative pain could be anticipated.[14] Continuous epidural analgesia was already well established for postoperative pain management in Sweden in 1993. Most EB can therefore be considered as performed with indwelling catheter.

The total number of EB could not be cross-validated, as no administrative file records the total number of CNB performed. Registers of procedures frequently involving CNB were therefore consulted.

During the period under investigation the Swedish Medical Birth Registry (Stockholm, Sweden) recorded 5,000 EB and 50,000 SB for cesarean section and 200,000 EB for labor pain. According to the National Knee Replacement Register (Department of Orthopaedic Surgery, University Hospital, Lund, Sweden) knee arthroplasty was performed in 36,000 females and 18,000 males. Hip arthroplasty was performed in 95,000 females and 46,000 males according to the Swedish National Total Hip Arthroplasty Register (Department of Orthopaedic Surgery, Sahlgrenska University Hospital, Gothenburg, Sweden). The Standardized Audit of Hip Fractures in Europe (Department of Orthopaedic Surgery, University Hospital, Lund, Sweden) recorded surgical correction of hip fracture in 130,000 females and 45,000 males in Sweden.

The use of CNB in orthopaedic patients was documented in a national survey performed in 1993, indicating that CNB was used in the majority of lower limb orthopaedic surgery.[14] Spinal blockade was considered the standard procedure in surgical correction of hip fracture, as SB was adopted in 86% of all procedures. In the current study, calculations of incidence in these patient subgroups were based on this information.

Patients (males and females) not included in any of these registers are referred to as "general population."

Statistics

Confidence limits were calculated using exact values from the binomial distribution. Differences between groups of patients were compared using chi-square test for contingency tables with Yates correction. A P value of <0. 05 was considered statistically significant.

Results

A total of 127 identified patients were found to have suffered complications after CNB during the decade under investigation. The departments identified 64 patients, of which 17 also were found in the administrative files. An additional 63 cases were found exclusively in the administrative files (table 1). All cases retrieved from the administrative files had been examined by experts and judged to have been caused by CNB.

Of all 127 complications 73 (58%) had occurred during the last 5 yr of the decade, and 40 (62%) of the 64 cases identified by the departments had occurred during the same period.

Most complications were seen in orthopaedic surgery, whereas few complications were observed in the large obstetric population (table 2). Despite the larger number of SB performed, more complications were seen after EB (table 3). Permanent neurologic damage was observed in 85 patients (table 4).

Of the 42 departments reporting 117 complications in the first survey, 32 departments answered in the second survey (76%). Of these, 27 departments could identify 64 of the previously reported cases; the loss of 23 cases was explained by inadequate filing routines. In the administrative files, an additional 24 patients were found. Thus, 88 complications were found in 30 of these 32 answering departments.

No answers were obtained from the remaining 10 departments that had reported 30 cases in the first survey. According to the administrative files, 16 complications had occurred in eight of these 10 departments.

Thus, a total of 104 complications were found in 38 of the 42 departments reporting complications in the first survey.

Table 2. Types of Complications According to Indication for Central Neuraxial Blockade

	Spinal Hematoma	Cauda Equina Syndrome	Purulent Meningitis	Epidural Abscess	Miscellaneous	Total
Orthopaedic surgery	13 (1/12)	21 (12/9)	9 (3/6)	1 (0/1)	3 (2/1)	47 (18/29)
Obstetrics	2 (0/2)			1 (0/1)	7 (0/7)	10 (0/10)
Gynaecology	1 (0/1)		1 (0/1)	1 (0/1)		3 (0/3)
General surgery	8 (3/5)	6 (2/4)	8 (7/1)	8 (4/4)	6 (2/4)	36 (18/18)
Vascular surgery	8 (4/4)	1 (0/1)		1 (1/0)	2 (2/0)	12 (7/5)
Urology		3 (3/0)	7 (6/1)		2 (2/0)	12 (11/1)
Thoracic surgery	1 (1/0)					1 (1/0)
Pain clinic			3 (1/2)	1 (0/1)		4 (1/3)
Other		1 (1/0)	1 (0/1)			2 (1/1)
Total	33 (9/24)	32 (18/14)	29 (17/12)	13 (5/8)	20 (8/12)	127 (57/70)

The number of males/females is in parentheses.

The 30 departments that had denied complications in the first survey were not contacted again during the second survey. Search in the administrative files revealed that 13 complications had occurred in 12 of these departments. The 13 nonresponding departments in the first survey were again contacted. One department answered, denying complications. No answers were obtained from the remaining 12 departments, but according to the administrative files, 10 complications had occurred in five of these departments.

Spinal Hematoma

A total of 33 cases of spinal hematoma were found; of these, 24 cases had occurred during the last 5 yr of the decade under investigation (72%). The departments reported 25 of all cases, of which six were also found in the administrative files (table 1). There were 24 females (age, 20–92 yr; median age 77 yr) and nine males (age, 20–75 yr; median, 63 yr) (table 5). In the 25 cases in which spinal hematoma occurred after EB, indwelling catheters had been used in 24 patients; information regarding catheter use was missing in one patient. Pathology of the spine was known in six patients, including two cases of ankylosing spondylitis.

The presence of coagulopathy or thromboprophylaxis administered in close time relationship with CNB was documented in 11 patients. Two obstetric patients were severely affected by the syndrome of hemolysis, elevated liver enzymes, and low platelets; one patient received SB and the other had her epidural catheter removed, both with apparent signs of coagulopathy. Within 2 h after the administration of thromboprophylaxis, five patients were given CNB and another three patients had their epidural catheters removed. These include the four patients who received heparin 5,000 IE during vascular surgery.

One patient suffered renal failure postoperatively and developed spinal hematoma during hemodialysis 1 day after catheter removal.

Difficulties in performing the CNB was reported in 10 cases, whereas in 16 patients the blockades were reported to have been easily performed. Acknowledged risk factors were absent in 11 of these cases. Information concerning the CNB was insufficient in seven cases.

The first symptoms, when reported, were severe back pain in five cases and reduced motility of the lower limbs in 18 patients, of which nine patients were paraplegic. One patient was discharged with a catheter à demeure. Two weeks later she returned paraplegic. In six cases only sensory loss was the initial sign.

The time interval from administration of CNB, or removal of epidural catheter, to first appearance of symptoms was clearly stated in 20 cases. Symptoms appeared in the immediate postoperative period or shortly after removal of epidural catheter in five patients. In 14 cases

Table 3. Complications According to Type of Central Neuraxial Blockade

	EB	CSE	SB	Continuous SB	Total
Spinal hematoma	21 (7/14)	4 (1/3)	7 (0/7)	1 (1/0)	33 (9/24)
Cauda equina syndrome	8 (4/4)	4 (0/4)	18 (13/5)	2 (1/1)	32 (18/14)
Purulent meningitis	5 (1/4)	1 (0/1)	20 (14/6)	3 (2/1)	29 (17/12)
Epidural abscess	12 (5/7)		1 (0/1)		13 (5/8)
Traumatic cord lesion	8 (3/5)		1 (0/1)		9 (3/6)
Cranial subdural hematoma	3 (1/2)		2 (2/0)		5 (3/2)
Paraparesis	3 (1/2)		1 (1/0)		4 (2/2)
Other	2 (0/2)				2 (0/2)
Total	62 (22/40)	9 (1/8)	50 (30/20)	6 (4/2)	127 (57/70)

The number of males/females is in parentheses.

CSE = combined spinal epidural blockade; EB = epidural blockade; SB = spinal blockade.

Spinal hematoma followed thoracic EB in eight cases and lumbar EB or CSE in 17 cases.

Table 4. Neurological Complications Related to Outcome

Complication	Full Recovery	Permanent Neurological Damage	No Information	All
Spinal hematoma	6	27	–	33
Cauda equina syndrome	–	32	–	32
Purulent meningitis	21	6	2	29
Epidural abscess	7	4	2	13
Miscellaneous				
Traumatic cord lesion	–	9	–	9
Cranial subdural hematoma	4	1	–	5
Paraparesis	–	4	–	4
Other	–	2	–	2
Total	38	85	4	127

time interval varied from 6 h to 3 days (median 24 h). In one last patient pain and paraparesis appeared 2 weeks after a technically difficult SB.

Among the six restituted patients, five were treated conservatively and one was laminectomized. However, among the 27 patients that did not recover, 11 had been subjected to laminectomy and in a further six cases laminectomy was considered but not performed because of diagnostic delay (table 4). The sequelae were in 13 cases paraparesis, associated with severe pain in one patient, and one patient partially recovering was left with hemiparesis. Cauda equina syndrome was reported in three patients. Three patients were left with sensory deficit, which was accompanied by pain in one case. Three patients died shortly after the complication occurred. The only information regarding five cases was lack of recovery.

Cauda Equina Group and Spinal Stenosis

The cauda equina syndrome was reported in 32 patients and paraparesis was reported in four patients. The condition was permanent in all patients (table 4). In the cases after SB, hyperbaric 5% lidocaine was used in eight cases, bupivacaine 0.5% in 11 cases (six hyperbaric and five isobaric), and in one case a mixture of both drugs was used. One patient received mepivacaine through a spinal catheter. Arachnoiditis after SB was diagnosed in two male patients (table 3).

Preoperatively spinal stenosis was known in one case only. The remaining 13 were diagnosed in the subsequent investigation of the complication, defined as cauda equina syndrome in nine patients and solely paraparesis with no sacral root deficit in four patients (table 5). In six of the patients with spinal stenosis, the complications occurred after EB; in three cases the complications occurred after CSE. Spinal stenosis was most frequently found among orthopaedic patients (six females and one male).

Infectious Complications

In all, 42 infectious complications were reported. Epidural abscess occurred in 13 patients, eight females (age, 17–82 yr; median, 62 yr) and five males (age, 44–76 yr; median, 51 yr). In the 12 cases in which epidural abscess occurred after EB, three patients were reported as healthy. Of the remaining, four patients were diabetic, three patients had cancer, one patient suffered from chronic alcohol abuse, and one patient with rheumatic arthritis received systemic steroid treatment (tables 3, 6). Six patients received EB for pain relief after trauma; of these, five received thoracic EB for pain relief after thoracic trauma. The time interval between catheter insertion and first symptoms varied from 2 days to 5 weeks (median, 5 days). In two cases, the epidural catheter had been removed before development of the first symptoms. The prevailing symptom was fever and, of-

Table 5. Spinal Hematoma, Spinal Stenosis, and Cauda Equina Syndrome Related to Age

	Patient age					
	≤50	50–59	60–69	70–79	≥80	All
Spinal hematoma	**4 (1/3)***	**4 (3/1)**	**4 (2/2)**	**11 (3/8)**	**10 (0/10)**	**33 (9/24)**
Paraparesis and spinal stenosis	**1 (0/1)†**	**1 (0/1)‡**	**–**	**1 (1/0)**	**1 (1/0)**	**4 (2/2)**
Cauda equina syndrome, all cases	**8 (4/4)**	**8 (7/1)**	**3 (2/1)**	**7 (2/5)**	**6 (3/3)**	**32 (18/14)**
Pre-existing spinal stenosis	–	–	2 (1/1)	5 (0/5)	2 (1/1)	9 (2/7)
Local anesthetic neuronal toxicity	8 (4/4)	8 (7/1)	1 (1/0)	2 (2/0)	4 (2/2)	23 (16/7)
Total	**13**	**13**	**7**	**19**	**17**	**69**

The number of males/females is in parentheses. The number of spinal hematoma and cauda equina syndrome in patients with coexisting spinal stenosis increase with age. When local anesthetic neuronal toxicity is considered the cause of damage, the cauda equina syndrome does not show the same increase with age.

* Including two obstetric patients with the syndrome of hemolysis, elevated liver enzymes, and low platelets. † Patient with corrected heart disease, fiberoptic intubation warranted by severe neck disorder. Epidural blockade placed under general anesthesia. ‡ Patient with severe rheumatism, previously operated for spinal stenosis, epidural blockade performed under general anesthesia.

Table 6. Types of Complications after Central Neuraxial Blockade in Obstetric Patients

Complication	Causative or contributing mechanism	EB	SB
Spinal hematoma	HELLP	1	1
Epidural abscess	Technical difficulties	1	–
Miscellaneous			
Cord lesion	Needling	2	1
Intracranial subdural hematoma	Accidental dural puncture	2	–
Permanent abducens paresis	Accidental dural puncture	1	–
Horner's syndrome with facial pain	Accidental dural puncture	1	–
Total		8	2

EB = epidural blockade; HELLP = syndrome of hemolysis, elevated liver enzymes, and low platelets; SB = spinal blockade.

ten, severe backache, in five cases with progression to neurologic symptoms. Magnetic resonance imaging was used for diagnosis in 10 cases; in one patient this was preceded by normal computer tomography.

All seven positive cultures showed *Staphylococcus* species. Laminectomy was performed in six patients, giving full restitution in three. Altogether seven patients were completely restituted, whereas four of the five patients who developed neurologic symptoms did not recover. The sequelae were reported as cauda equina syndrome in two patients, paraparesis in one, and tetraplegia in one patient. The last patient, severely affected by vascular disease, died (table 4).

Meningitis was found in 29 cases, 12 females (age, 32–79 yr; median age, 62 yr) and 17 males (age, 21–74 yr; median, 62 yr). Spinal blockade preceded meningitis in 24 cases, including one case of CSE (table 3). In one case meningitis occurred after EB and myelography. Thus, meningitis occurred after a documented perforation of the dura in 25 of 29 cases. The overall incidence of meningitis after SB was 1:53,000; however, in one department the incidence was 1:3,000 as a result of the clustering of four cases.

In the cases that occurred after single-shot SB, all but two patients were reportedly healthy. Of these, one patient was diabetic and a second patient was under steroid substitution therapy for Addison disease.

Three cases occurred after treatment of chronic pain with indwelling spinal catheter. One patient was diabetic and another patient with disseminated cancer was under systemic steroid treatment.

Of the four patients developing meningitis after continuous infusion through an epidural catheter, the indication was thoracic trauma in one patient and terminal cancer pain in another patient. Two diabetic patients were treated for postoperative and back pain respectively.

Time interval between CNB and symptoms varied from 8 h to 8 days (median, 24 h). The symptoms varied greatly: Headache was always present, often accompanied by fever, even if slight. Absentmindedness, urinary retention, and vomiting were also reported. Classic symptoms of meningitis with high fever, severe headache, and nuchal rigidity were present in 14 patients. Unspecific and less alarming early symptoms led to an initial misinterpretation of the condition in some patients, and four patients were erroneously given the diagnosis of postdural puncture headache. In the 12 cases where positive cultures were obtained, α-hemolytic streptococci were found in 11 cases and *Staphylococcus aureus* in one. Meningitis resulted in partial sequelae in six patients, described as minor neurologic deficit (table 4).

One patient died during terminal treatment for malignant pain complicated by meningitis that was not considered the primary cause of death.

Intracranial Subdural Hematoma and Accidental Dural Puncture

Two patients developed intracranial subdural hematoma after SB, and three cases were observed after accidental dural puncture (tables 3, 6). No coagulation disorders were found in any patient. Three of the patients were treated with craniotomy and one was conservatively handled. These four all had complete recovery. The only information obtained about the fifth patient was that he did not recover (table 4).

Traumatic Cord Lesions

Traumatic lesioning of the spinal cord or cauda occurred in nine patients. Only in one patient was the level of needle insertion believed to have been in the interspace L1–L2. In the remaining eight cases, the anesthesiologist believed to perform the block at a lower level (tables 3, 6). In all cases but one, difficulties in performing the block, and even pain on injection, were encountered. All patients were left with sequelae, defined as severe pain in five cases and cauda equina syndrome in three cases, of which one patient also suffered chronic pain. Information was incomplete for the ninth patient (table 4).

Discussion

The current study is probably the most comprehensive retrospective study performed to detect serious neurologic complications after CNB. Information regarding both the complications and patient subgroups was obtained from a multiple of sources. In our preliminary survey the departments reported an even larger number of complications, but despite our efforts, not all cases could be related to identified patients. None of the administrative files registers their cases according to medical diagnosis of the complication. Several cases might therefore have been overlooked. Thus, this material is released with the knowledge of a probable underestima-

Table 7. Complications (all) and Incidences

	Epidural Blockade Including CSE				Spinal Blockade			
	Patients (× 1000)		Cases and Incidence		Patients (× 1000)		Cases and Incidence	
	M	F	M	F	M	F	M	F
Knee arthroplasty	9	18	2 **[0–7]** 1:4 500	10 **[5–18]** 1:1 800	7	14	–	1 **[0–6]** 1:14 000
Hip arthroplasty	14	29	–	2 **[0–7]** 1:14 500	27	56	–	–
Hip fracture	–	–	–	–	38	111	–	5 **[2–12]** 1:22 000
Obstetric pain relief during labor	–	200	–	8† **[3–16]** 1:25 000	–	–	–	–
Cesarean sections	–	5	–	–	–	50	–	2 **[0–7]** 1:25 000
Subtotal	275		22 (2/20)		303		8 (0/8)	
General population (M/F)	175		49 (21/28)* **[36–65]** 1:3 600		957		48 (34/14) **[35–64]** 1:20 000	
Total	450		71 (23/48)		1 260		56 (34/22)	

CSE = combined spinal epidural blockade; EB = epidural blockade; F = females; M = males; SB = spinal blockade.

95% Confidence Intervals are given in brackets.

* EB versus SB in general population $P < 0.0001$; † EB in obstetric patients versus EB in general population $P < 0.0001$.

The numbers of orthopaedic surgical procedures were reported by national registers. The numbers of CNB are obtained by calculations according to a national survey[14]: Surgery for hip fracture was performed under SB in 86% of all cases, 130 000 females and 45 000 males. Hip arthroplasty was performed under SB in 59%, CSE 24%, EB 9%, of all 95 000 females and 46 000 males. Knee arthroplasty was performed under SB in 38%, CSE 31%, EB 20% of all 36 000 females and 18 000 males.

tion of the number of complications that actually occurred. Cross-checking permitted validation of the information obtained from the departments. Most cases had occurred in the departments initially reporting complications, and the nonresponding departments did not seem to conceal large number of complications.

The information regarding the total number of CNB performed is less accurate. However, the patient subgroups identified permit calculations of incidence in these subgroups.

Only serious neurologic complications were included; thus the incidences found cannot be directly compared with other studies. These often include less serious and transient complications, as well as complications attributable to systemic local anesthetic toxicity and cardiovascular side effects.[5–8]

Retrospective studies relying on few sources of information or calculation of incidences based on case reports underestimate the incidence of even severe neurologic complications. For example, only two of our 33 cases of spinal hematoma were found in the Swedish Patient Insurance Claims. A recent meta-analysis of the world literature disclosed only 63 cases of spinal hematoma after CNB.[15] Only seventeen of the 127 cases included in the current study have previously been described in international papers.[4,13,16–20]

The obstetric population constitutes a large, homogenous group of young healthy patients receiving CNB, offering the possibility of studying the "inborn risk" of the technique as such. The complications observed are typically caused by direct traumatic injury[21–23] (table 6). It is important to acknowledge that neurologic complications associated with pregnancy and labor are considerably more common than complications after CNB.[24] In the current study, spinal hematoma occurred in obstetric patients only in the presence of severe coagulopathy. The overall incidence of serious neurologic complications after CNB is low in obstetric patients.[25,26] Consequently, the unspecified inclusion of obstetric patients will distort any analysis. Therefore, studies must distinguish patient subgroups, as done by Auroy *et al.*[7] and in the current study (tables 7, 8).

Spinal Hematoma, Spinal Pathology and the Cauda Equina Syndrome

Spinal hematoma after CNB is considered extremely rare; incidence has been quoted as 1:150,000 after EB, and 1:220,000 after SB.[9,27–29] In the current study, the incidence of spinal hematoma after EB in obstetric patients was 1:200,000 compared with 1:3,600 in female patients subject to knee arthroplasty (table 8).

The calculation of incidence in orthopedic patients is

Table 8. Cases and Incidences of Spinal Hematoma

	Epidural Blockade Including CSE				Spinal Blockade			
	Patients (× 1000)		Cases and Incidence		Patients (× 1000)		Cases and Incidence	
	M	F	M	F	M	F	M	F
Knee arthroplasty	9	18	1 **[0–6]** 1:9 000	5* **[2–12]** 1:3 600	7	14	–	–
Hip arthroplasty	14	29	–	1 **[0–6]** 1:29 000	27	56	–	–
Hip fracture	–	–	–		38	111	–	5† **[2–12]** 1:22 000
Obstetric pain relief during labor	–	200	–	1 **[0–6]** 1:200 000	–	–	–	–
Cesarean sections	–	5	–	–	–	50	–	1 **[0–6]** 1:50 000
Subtotal (M/F)	275		8 (1/7)		303		6 (0/6)	
General population (M/F)	175		17 (7/10) **[10–27]** 1:10 300		957		2 (1/1) **[0–7]** 1:480 000	
Total (M/F)	450		25 (8/17)		1 260		8 (1/7)	

CSE = combined spinal epidural blockade; EB = epidural blockade; F = females; M = males; SB = spinal blockade.

95% Confidence Intervals are given in brackets.

* EB in female knee arthroplasty patients versus obstetric EB ($P < 0.0001$); † SB in female hip fracture patients versus general group of patients ($P < 0.0001$); EB in male and female knee arthroplasty patients, versus EB in general group of patients: not significant.

The numbers of orthopaedic surgical procedures were reported by national registers. The numbers of CNB are obtained by calculations according to a national survey[14]: Surgery for hip fracture was performed under SB in 86% of all cases, 130 000 females and 45 000 males. Hip arthroplasty was performed under SB in 59%, CSE 24%, EB 9%, of all 95 000 females and 46 000 males. Knee arthroplasty was performed under SB in 38%, CSE 31%, EB 20% of all 36 000 females and 18 000 males.

based on information from a national survey regarding CNB performed in 1993.[14] Most spinal hematomas occurred in later years. Although not documented, we believe that the use of EB has increased among the orthopaedic patients. We could therefore overestimate the incidence, even assuming underreporting. Despite this reservation, the incidence of spinal hematoma in these patients should be recognized as much higher than previously considered. A national survey published in 1992 showed that 95% of Swedish anesthesiologists believed the association of CNB with LMWH to be safe.[30] The occurrence of spinal hematoma after CNB was believed too rare to motivate more extensive observation routines.[10] The first Swedish guidelines were established in 2001. Thus, the high number of spinal hematoma reported in the current study occurred during a period when less strict regimens were applied. However, one third of all spinal hematomas were seen in patients receiving thromboprophylaxis in association with CNB in accordance with the current guidelines and in the absence of any previously known risk factors. Consequently, adherence to guidelines regarding LMWH and CNB may reduce but not completely abolish the risk of spinal hematoma after CNB.

The association of spinal hematoma and LMWH has brought forward recommendations for safe practice in several European countries. Tryba and Wedel proposed that the high number of spinal hematomas reported in the United States was caused by the lack of such recommendations together with the higher doses of LMWH used.[31] In Sweden, enoxaparin is administered as 40 mg given once daily, whereas the dosage in the United States was 30 mg given twice daily. The reporting rate of spinal hematoma in the United States has been calculated as 1:6,600 females undergoing lower limb arthroplasty under EB; with indwelling catheters the rate was estimated as 1:3,100.[32] The higher risk of female orthopaedic patients developing spinal hematoma is confirmed in the current study, despite the lower dosage regime of LMWH adopted in Sweden. Only females developed spinal hematoma after single-shot SB, and 70% of all patients with spinal hematoma were female (tables 2, 3, 8). In 75% of all cases spinal hematoma occurred after EB or CSE; in one case spinal hematoma occurred after SB with an indwelling catheter. Thus, these more traumatic techniques caused most cases of spinal hematoma, in accordance with previous observations.[29]

Pathology of the spine has been proposed as a risk factor for complications after CNB,[27,33] other proposed risk factors include technical difficulties and bloody taps.[33] The prevalence of osteoporotic, degenerative, and other pathologic processes of the spine increases with age[34,35]. Usubiaga *et al.* showed how the ageing of the spine implies a reduction of the epidural space and closure of the intervertebral foramina. In their study, after 10 ml of local anesthetic was epidurally injected, the epidural pressure increased more in elderly than in younger persons and the longitudinal spread was larger, causing a more widespread anesthesia in the elderly. The same would apply to any volume introduced in the epidural space and could possibly explain the occurrence of cauda equina syndrome after otherwise uncomplicated EB (table 5).

Scandinavian females in postmenopausal age have the world's highest incidence of osteoporosis,[36] and in the United States white females also show a high incidence.[37] More females than males suffer osteoporotic hip fractures, and more females need knee or hip arthroplasty. Osteoporosis not only causes a higher number of hip fractures; the spine is also affected, with vertebral deformities and fractures. Moreover, the osteoporotic vertebra is enlarged, causing narrowing of the spinal canal.[38] A large number of female patients with pathologically altered spines are therefore subject to CNB. The correlation between spinal hematoma and thromboprophylaxis might not necessarily be the only important cause-effect relationship. This might also be associated with age-induced spinal and vascular pathology, as illustrated by the obvious difference in age between the obstetric population and the orthopaedic patients who developed spinal hematoma after CNB.

Incomplete documentation regarding the time relationship between CNB and first symptoms could reflect inadequate surveillance in the postoperative period. Also, the poor outcome for the majority of the patients was often related to delay in correct diagnosis. Expectancy instead of immediate investigation might have been supported by the belief that the occurrence of spinal hematoma is highly improbable.

Infectious Complications

Only 13 cases of epidural abscess were found, indicating an incidence significantly lower than previously reported.[39,40] We might underestimate the incidence of epidural abscess, as these late complications were the ones the clinicians most often failed to identify (table 1). Risk factors for infection was present in 75% of the patients.

The diagnosis was in many cases initially overlooked, causing delay in appropriate treatment. Our study also seems to include an overrepresentation of cases after thoracic EB for pain relief after trauma, confirming the findings of Kindler *et al.*[40] The same degree of hygienic standard should be observed when performing CNB in trauma patients as in patients scheduled for elective surgery.[41]

Meningitis occurred almost exclusively after SB, and perforation of the dura was documented in at least one of the cases after EB. Most patients were healthy, subject to minor surgical procedures often performed on out patient basis. All positive cultures but one showed growth of α-hemolytic streptococci. Upper airway floral bacteria are usually seen when meningitis occurs after SB.[42,43] The use of face mask when performing a spinal block is still a matter of debate, but it is our opinion that the appliance of aseptic technique certainly involves the use of face masks.[44] The occurrence of iatrogenic meningitis should lead to a thorough and relentless scrutiny of the hygienic routines applied when performing CNB.[45]

Postdural Puncture Headache

With modern needles used for SB, postdural puncture headache most often occurs after accidental dural puncture with larger gauge needles. Accidental dural puncture can be expected to occur in 1% of all patients receiving EB for pain relief during labor.[46] Our results indicate that cranial subdural hematoma can be expected in approximately one of 1,000 patients after accidental dural puncture. When the headache is atypical or prolonged, the possibility of meningitis or cranial subdural hematoma should be remembered. The patient suffering postdural puncture headache should be followed by the anesthesiologist until full restitution.

Conclusion

The occurrence of any complication implies an interaction of factors related to the blockade itself and known or unknown preexisting conditions in the patient. Iatrogenic meningitis is located at one extreme of this scale, as the introduction of bacteria to the spinal fluid probably causes meningitis in any patient, however healthy. At the other end of the scale we find paraparesis after the mere administration of an otherwise uncomplicated EB in a patient with undiagnosed spinal stenosis. Spinal hematomas occupy an intermediary position where several independent factors may contribute to the development of the complication. Epidural blockades are more likely than SB to cause spinal hematomas. Pharmacological interference in patient coagulation or bleeding conditions may favor the development of hematomas, as do pathologic conditions of the spine. We propose osteoporosis as an important risk factor. In the presence of spinal stenosis, CNB, and particularly EB, should be performed only after careful consideration. Spinal stenosis can by itself cause spontaneous paraplegia, but if preceded by CNB, the blockade will most probably be blamed. Peripheral nerve blockades or intrathecal opioids could be a prudent alternative to EB for postoperative analgesia in these patients.

Guidelines regarding thromboprophylaxis, coagulation disorders, and CNB are continuously updated, and the anesthesiologist should always follow these recommendations. Above all, anesthesia should be individualized.

The concept of inherent risk linked to CNB can not be expressed by a mere number for the technique as a whole, as different patients carry markedly different risk factors. However, our study shows that complications occur four to five times more frequently after EB than after SB, and the complications are different. Predisposing conditions are more often present in the patients suffering complications after EB, but unpredictable complications do occur. The anesthesiologist must assume the whole responsibility of diagnosing neurologic conditions after CNB, whether caused by the anesthetic, or merely occurring in concomitance with the blockade.

The individual risk for each single patient is low. However, for the anesthesiologist the probability of encountering a severe complication after CNB is not negligible, as demonstrated by this article. Patient safety can be increased by careful preoperative evaluation of risk factors and scrupulous postoperative surveillance.

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