

Spontaneous Spinal Epidural Hematoma: A Retrospective Study on Prognostic Factors and Review of the Literature

Mark Fedor¹, Eric S. Kim¹, Kai Ding², J. Paul Muizelaar¹, Kee D. Kim¹

¹Department of Neurological Surgery, University of California, Davis Medical Center

²Division of Biostatistics, Department of Public Health Sciences, University of California, Davis

Objectives: The spontaneous spinal epidural hematoma (SSEH) is a rare clinical entity. Patients typically present with sudden onset back pain followed by neurological deficits.

Methods: Diagnosis of SSEH is usually made with MRI and standard treatment is surgical evacuation. In 1996, Groen published the most comprehensive review on the SSEH in which he analyzed 333 cases. We review 104 cases of SSEH presented in the English literature since the last major review and add three of our own cases, for a total of 107 cases.

Results: Our patients presented with back pain and neurologic deficits. Two made excellent functional recovery with prompt surgical decompression while one continued to have significant deficits despite evacuation. Better postoperative outcome was associated with less initial neurological dysfunction, shorter time to operation from symptom onset and male patients.

Conclusion: We discuss the etiology of SSEH and report current trends in diagnosis, treatment, and outcome.

Key Words: Spinal epidural hematoma • Back pain • Neurological deficits • MRI

INTRODUCTION

1. Case 1

1) History

The patient is a 71 year-old right handed man who presented to the emergency room with sudden onset of upper back pain, just below his neck, associated with right arm weakness. Within hours, he developed weakness of his legs associated with paresthesia that progressed to paralysis of bilateral lower extremities. Past medical history is significant for arthritis, restless leg syndrome diagnosed six days prior to presentation, and history of syncope.

2) Examination

He had 4+/5 strength in the left upper extremity and 4/5

strength in the right upper extremity with complete paralysis of bilateral lower extremities. Although sensation to light touch was preserved, he had decreased pin-prick sensation and proprioception starting at the cervicothoracic level, worse on the right side than the left. Deep tendon reflexes were brisk and the Babinski reflexes were up-going. He had normal coagulation values.

3) Imaging

MRI showed large posterolateral extradural mass extending from C2 to T4 with marked spinal cord compression. T1-weighted images showed low signal intensities and T2-weighted images showed heterogeneous intermediate to high signal intensities. No contrast enhancement was found except for a small nodular enhancing focus at the C7-T1 junction to the right of the midline (Fig. 1).

4) Operation

The patient was taken urgently to the operating room for a C3 to T1 laminectomy. A dark blood clot was noted in the epidural space and was evacuated. Portions of the epidural clot were sent to pathology whose report confirmed the presence of hematoma with no evidence of vascular malformation.

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Corresponding Author: **Kee D. Kim, MD**

Department of Neurological Surgery, University of California Davis
School of Medicine, 4860 Y St. Suite 3740, Sacramento, CA 95817

Tel: +916-734-3102, Fax: +916-703-5368

Email: kdkim@ucdavis.edu



Fig. 1. T2-weighted sagittal magnetic resonance (MR) image showing large posterolateral extradural mass extending from C2 to T4 with marked spinal cord compression.



Fig. 2. Postoperative magnetic resonance image shows complete resolution of the hematoma.

5) Postoperative Course

Postoperative MRI showed complete resolution of the hematoma (Fig. 2). The patient recovered well with prompt return of neurologic function. On two-year follow up, he was doing well with no residual neurological deficits, only occasional spasms in his trapezius muscle.

1. Case 2

1) History

Patient is a 78 year-old woman who awoke early in the morning with low back pain. Soon afterwards, she presented to the emergency room with additional complaint of right lower extremity pain and weakness with difficulty ambulating. Her past medical history was significant for hypertension, type II diabetes and distant history of TB, previously treated. She had normal coagulation values.

2) Examination

On neurological examination, she had 4/5 right dorsiflexion weakness but otherwise had good motor strength. She had diminished sensation to light touch in her right lower extremity.



Fig. 3. T1-weighted sagittal MR image showing epidural mass from T10 to L4.

3) Imaging

Initial MRI showed epidural mass from T10 to L4 (Fig. 3).

4) Operation

Patient was taken to the operating room 16 hours after



Fig. 4. Postoperative MR image revealed complete resolution of the hematoma.

the initial symptom of low back pain. She underwent T10 to L4 laminectomy and was noted to have significant compression of the thecal sac from epidural blood clot. The hematoma was evacuated and portions of the specimen were sent to pathology, where findings were consistent with hematoma with no evidence of vascular malformation.

5) Postoperative Course

Postoperative MRI showed complete resolution of the hematoma (Fig. 4). Patient showed progressive improvement and eventually gained return of full strength in her right leg. She however, continued to have right leg pain and numbness

3. Case 3

1) History

A 42 year old woman was gardening when she suddenly developed severe low back pain with nausea. The day prior she had been engaged in heavy physical work. Soon after lying down she noticed she could not move her legs and could not feel anything from the waist down. Past medical history is significant for Aspirin use.

2) Examination

Both legs were completely flaccid. There were absent re-

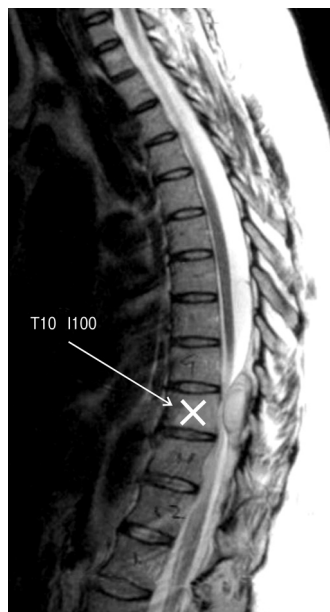


Fig. 5. T2-weighted sagittal MR image shows an extradural mass compressing the spinal cord from T9 to T11.

flexes in her legs. She also could not feel anything below the T11 sensory level. She had urinary retention as well.

3) Imaging

MRI showed an extradural mass compressing the spinal cord from T9 to T11. It was hyperintense to the spinal cord on T2 imaging. The signal was heterogeneous in character (Fig. 5).

4) Operation

She had a T9 to L1 laminectomy performed within 24 hours of symptom onset. The hematoma was found to extend down to L1 intraoperatively. Pathological analysis revealed only blood clot.

5) Postoperative Course

The patient had no improvement. She remained paraplegic and has made little improvement with rehabilitation.

MATERIALS AND METHODS

The last major review on SSEH was reported by Groen in 1996⁴¹). Therefore, our literature search was limited to cases reported since 1996 coinciding with the widespread acceptance and use of MRI. A PubMed literature search for "spon-

taneous spinal epidural hematoma" was conducted and the reports from the English literature were collected. Hematomas associated with vascular malformations, spinal surgery, trauma, spinal tumors, or any spinal procedures such as diagnostic lumbar punctures were excluded. Patients on anti-coagulation medication and those with hypertension were included since they were part of the past reviews on SSEH. The diagnosis was made with an imaging study and confirmed in most cases by surgery.

We statistically investigated the effect of time to surgery (before or after 24 hours of hospital admission) on neurological outcome. Because the literature accounts were inconsistent in their clinical descriptions of initial and final neurological status, the Frankel grading system was used to provide a standardized assessment of neurological dysfunction. The initial and final Frankel grade for each patient was assigned based on symptomatic reports (Table 1). For quantitative analysis, the Frankel grade scale of A-E was converted to a 1-5 scale, respectively. We used linear regression to investigate the relationship between final Frankel grade and time to surgery. Initial Frankel grade, age, sex, time to surgery, size of

hematoma, history of hypertension, and use of anticoagulants were included as covariates. We first considered the effects of time to surgery, initial Frankel grade, age, and sex and then sequentially added two-way interactions as well as effects associated with size of hematoma, hypertension and use of anticoagulants. Four age categories were used: less than 20 years, 20 to 40 years, 40 to 60 years and 60 years of age and older. Statistical analyses were conducted using R version 2.12.1 and a significance level of 0.05 was used to determine significant effects.

RESULTS

We identified 104 cases of SSEH in the literature and added our three patients for a total of 107 cases (Table 2). Nineteen patients had no significant past medical history. Fourteen patients had a history of anticoagulation (including use of Aspirin and Ibuprofen) and thirteen had a history of hypertension and five patients had hemophilia. Other past medical histories of significance included previous stroke, pregnancy, amyloidosis, renal transplant, epilepsy, and a prior history of SSEH. In thirteen patients the past medical history was not presented. The neurological deficits varied in severity from minor sensory abnormalities to complete paralysis. In four patients, severe neck pain or headache was the only presenting symptom. The majority of patients (93/107) presented with neurological impairment leading to loss of function (Table 3).

In 98 cases, MRI was used to make the diagnosis of SSEH. A CT scan was performed in five and a CT myelogram was performed in three of the cases. A conventional myelogram was used in one case. The average number of spinal segments

Table 1. Frankel grade system

Frankel Grade	Description
A	Complete motor and sensory loss
B	Complete motor loss and incomplete sensory loss
C	Incomplete motor loss, with "useless" or non-functional strength
D	Incomplete motor loss, with "useful" or functional strength
E	No motor or sensory abnormalities

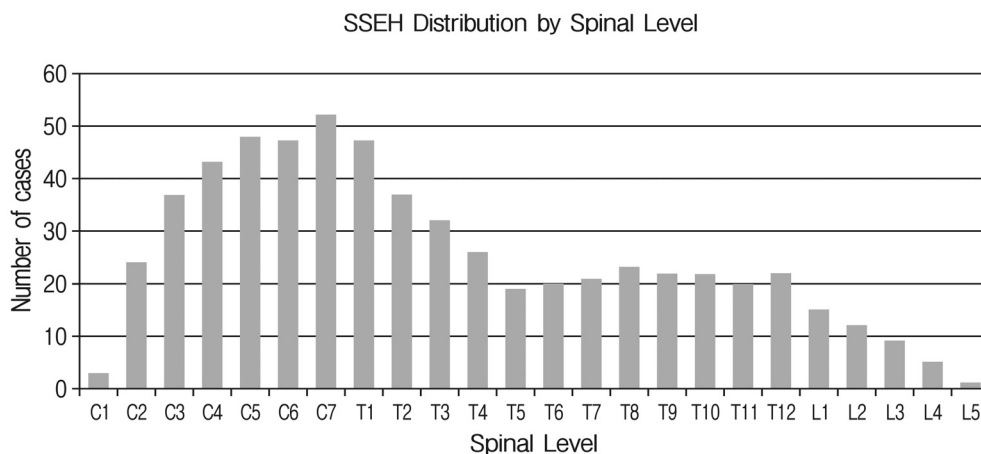


Fig. 6. Distribution of spinal segments involved in all reviewed cases of SSEH. There is increased frequency in the cervico-thoracic and to a less degree, the thoraco-lumbar regions. Overall there is increased involvement of the cervical and upper thoracic regions.

Table 2. Demographics of SSEH patients

Author	Year	Age	Gender	Level	Position	Initial Frankel	Time to Operation (hrs)	Final Frankel	Duration of Symptoms	PMH
Alabedeen ²⁾	1996	79	M	T6-T8	P	D	>48	E	hrs	None
Wagner ³⁾	1996	74	M	C2-C6	PL	A	No OR	E	min	spasticity
Silber ⁴⁾	1996	51	M	C5-T4	PL	A	No OR	E	2h	Ibuprofen
Chen ⁵⁾	1997	50	M	T4	A	A	<24	C	min	None
Kotilainen ⁶⁾	1997	13	M	L4-L5	PL	D	<24	E	min	None
Lonjon ⁷⁾	1997	61	M	C5-C7	PL	D	<24	E	min	None
Carroll ⁸⁾	1997	26	F	T5-T8	A	C	<24	D	min	pregnant
Lonjon ⁷⁾	1997	73	M	L3-L4	P	C	>48	C	1wk	None
Lonjon ⁷⁾	1997	76	F	C2-C5	A	A	>48	C	min	AntiCoag
David ²⁾	1997	23	M	T4-T9	PL	A	No OR	E	1d	None
Alexiadou ¹⁰⁾	1998	66	M	T12-L1	P	A	<12	D	Unk	AntiCoag
Pecha ¹¹⁾	1998	13	M	T1-T4	P	A	8	E	2d	None
Schaeybroeck ¹²⁾	1998	75	F	T1-T5	P	A	18	D	18h	TPA
Awada ¹³⁾	1998	14	M	C2-T2	A	A	9	C	min	seizure
Henderson ¹⁴⁾	1998	77	F	T6-L3	A	A	11	D	min	None
Alexiadou ¹⁰⁾	1998	51	M	T12	P	C	>48	E	Unk	AntiCoag
Schaeybroeck ¹²⁾	1998	46	M	T11-T12	P	C	>48	E	3 d	AntiCoag
Meena ¹⁵⁾	1998	26	M	C5-T1	P	C	>48	D	15d	Hemophelia B
Patel ¹⁶⁾	1998	1.83	F	C7-T10	P	C	>48	E	6d	None
Alexiadou ¹⁰⁾	1998	71	F	T12-L1	P	A	>12	A	Unk	alcohol
Alexiadou ¹⁰⁾	1998	87	M	C5-T3	P	A	>12	A	Unk	AntiCoag
Patel ¹⁶⁾	1998	1.5	M	C1-T1	P	A	24	D	5d	None
Pahapill ¹⁷⁾	1998	30	M	T3-T4	PL	D	No OR	E	hrs	None
Fukui ¹⁸⁾	1999	67	M	C3-C5	PL	C	10	D	Unk	Unk
Fukui ²⁴⁾	1999	73	M	T6-L3	P	C	23	D	Unk	Unk
Fukui ²⁴⁾	1999	40	M	L3-L4	AP	A	50	D	Unk	Unk
Cirak ¹⁹⁾	1999	8	M	C3-C7	A	A	>48	E	9d	None
Fukui ²⁴⁾	1999	81	F	T7-L3	P	C	26	E	Unk	Unk
Fukui ²⁴⁾	1999	31	F	C1-C3	AL	E	No OR	E	Unk	Unk
Fukui ²⁴⁾	1999	54	F	C6-T1	A	D	No OR	E	Unk	Unk
Fukui ²⁴⁾	1999	76	M	C2-C6	P	E	No OR	E	Unk	Unk
Fukui ²⁴⁾	1999	42	M	C2-T6	P	E	No OR	E	Unk	Unk
Gaffney ²⁰⁾	2000	70	M	C3	PL	D	<24	E	Unk	HTN
van Heesewijk ²¹⁾	2000	4	F	C2-C6	PL	C	<24	E	15d	None
Inamasu ²²⁾	2000	50	M	C3-C6	P	C	No OR	E	4h	None
Borges ²³⁾	2000	74	M	C4-T1	PL	A	No OR	E	hrs	AntiCoag
Duffill ²⁴⁾	2000	64	F	C2-T1	P	A	No OR	E	30 min	None
Duffill ²⁴⁾	2000	28	M	C7-T6	P	C	No OR	E	min	None
Duffill ²⁴⁾	2000	72	M	C2-T2	PL	C	No OR	E	hrs	None
Duffill ²⁴⁾	2000	68	F	T4-T11	P	A	No OR	E	min	HTN
Hentschel ²⁵⁾	2001	68	M	C7-T1	P	B	No OR	E	10h	HTN
Hentschel ²⁵⁾	2001	65	F	T7-T12	A	A	No OR	E	20 min	HTN
Kim	2002	78	F	T10-L4	P	C	16	D	hrs	HTN, DM
Kim	2002	71	M	C2-T4	PL	C	<24	E	hrs	syncope
Steinmetz ²⁶⁾	2003	27	F	T1-T2	A	C	<24	E	1wk	pregnant
Rosenberg ²⁷⁾	2003	14	F	T3-T5	PL	C	<24	E	min	None
Kong ²⁸⁾	2003	52	F	T8-T10	P	D	15	E	min	Renal failure
Muizelaar	2003	42	F	T9-T12	P	A	<24	A	hrs	Aspirin
Kong ²⁸⁾	2003	77	F	C7-T3	P	A	34	A	2h	HTN

Table 2. Demographics of SSEH patients (continue)

Author	Year	Age	Gender	Level	Position	Initial Frankel	Time to Operation (hrs)	Final Frankel	Duration of Symptoms	PMH
Muthukumar ²⁹⁾	2003	19	M	C2-C7	A	C	No OR	E	30d	None
Kirazli ³⁰⁾	2004	22	M	T9-T10	P	A	10	E	4d	AntiCoag
Masski ³¹⁾	2004	27	F	C7-T2	A	A	12	A	5d	Pregnant
Cywinsky ³²⁾	2004	27	F	T1-T2	A	C	36	E	10d	Pregnant
Jea ³³⁾	2005	24	F	T1-T2	PL	A	8	E	2wk	pregnant
Song ³⁴⁾	2005	51	M	T8-L2	PL	A	28	A	hrs	MI, Aspirin
Hsieh ³⁵⁾	2006	75	F	C2-C5	PL	A	>4	D	Unk	HTN
Hsieh ³⁵⁾	2006	20	M	C5-C7	PL	B	>8	E	Unk	None
Hsieh ³⁵⁾	2006	62	F	C3-C5	PL	C	No OR	C	2wk	Unk
Hsieh ³⁵⁾	2006	54	M	C3-C5	PL	B	6h	E	Unk	Type II Diabetes
Villas ³⁶⁾	2006	64	M	C4-C5	PL	B	Unk	E	unk	None
Pai ³⁷⁾	2006	1.25	M	C4-T3	A	C	48	E	Unk	Unk
Shin ³⁸⁾	2007	16	F	C7-T2	A	B	<24	C	Unk	None
Abram ³⁹⁾	2007	10	F	C7-T1	P	B	42	B	42	None
Park ⁴⁰⁾	2007	68	F	T7-T12	P	A	12	A	Unk	None
Helmy ⁴¹⁾	2007	65	F	C3-C4	P	A	<24	C	Unk	None
Lee ⁴²⁾	2007	0.33	M	C4-T4	PL	C	>48	E	Unk	None
Poonai ⁴³⁾	2007	0.92	F	C4-T3	P	C	>48	D	Months	None
Kalina ⁴⁴⁾	2007	0.58	M	C2-L4	P	C	No OR	E	Days	Severe Hemophilia
Bose ⁴⁵⁾	2007	24	F	C4-C7	P	A	>48	A	Unk	Post-Partum
Riaz ⁴⁶⁾	2007	52	M	C6-T1	P	C	>36	E	Unk	HTN, Smoker
Bisson ⁴⁷⁾	2007	7	M	C2-T3	P	D	No OR	E	5 days	Hemophilia B
Fok ⁴⁸⁾	2007	1.25	M	C3-T8	P	B	>48	E	2 days	None
Sakakibara ⁴⁹⁾	2008	55	M	C2-C7	A	B	Unk	D	Unk	Unk
Ramelli ⁵⁰⁾	2008	13.5	M	C6-C7	P	A	Unk	D	Unk	Unk
Ramelli ⁵⁰⁾	2008	0.58	F	C6-T7	P	A	>36	A	Unk	None
Liu ⁵¹⁾	2008	50	M	T6-T8	P	B	Unk	D	Unk	None
Thiele ⁵²⁾	2008	55	F	C4-C7	PL	D	Unk	E	Unk	None
Morales Ciancio ⁵³⁾	2008	78	F	T1-T12	P	C	>48	C	>48	Clopidogrel
Vitali ⁵⁴⁾	2008	15	M	C5-C6	L	C	No OR	E	Days	None
Halim ⁵⁵⁾	2008	25	M	C2-T1	P	A	No OR	D	10 days	None
Aksay ⁵⁶⁾	2008	32	M	C7-T3	P	A	<24	D	1 week	None
Baek ⁵⁷⁾	2008	69	F	C2-C5	L	C	>2	D	1 week	None
Baek ⁵⁷⁾	2008	64	M	T5-L2	L	C	>2	E	Unk	None
Baek ⁵⁷⁾	2008	19	M	C3-C7	PL	C	>4	E	Unk	None
Lim ⁵⁸⁾	2008	1.66	F	C7-T4	P	C	>48	D	2 weeks	None
Oh ⁵⁹⁾	2008	62	M	T9-T12	P	A	10	E	10	HTN
Hussenbocus ⁶⁰⁾	2009	36	M	C7-T4	P	A	<12	A	5	None
Forsnes ⁶¹⁾	2009	32	F	T12-L2	P	C	16	D	2 days	Pregnant
Nojiri ⁶²⁾	2009	55	M	C5-T3	L	B	>24	D	>24	None
Nourbakshs ⁶³⁾	2009	75	M	C3-T2	L	C	50	D	3 months	None
Kunizawa ⁶⁴⁾	2009	63	F	C3-T5	PL	A	7	D	6 months	None
Woon ⁶⁵⁾	2009	33	FF	T2-T4	P	A	14h	E	8h	HTN
Aoki ⁶⁶⁾	2009	82	F	T10-T12	P	C	8	D	2 days	Anticoag
Aoki ⁶⁶⁾	2009	64	M	C2-T3	P	B	No OR	E	5	Anticoag
Chen ⁶⁷⁾	2009	25	M	C6-T1	P	B	16	E	36	None
Deger ⁶⁸⁾	2009	77	F	C2-T9	P	B	4	C	Unk	HTN, renal failure
Muizelaar	2003	42	F	T9-T12	P	A	<24	A	hrs	Aspirin
Kong ²⁸⁾	2003	77	F	C7-T3	P	A	34	A	2h	HTN

Table 2. Demographics of SSEH patients (continue)

Author	Year	Age	Gender	Level	Position	Initial Frankel	Time to Operation (hrs)	Final Frankel	Duration of Symptoms	PMH
Miller ⁶⁹⁾	2010	58	M	T8-L2	P	A	>48	A	4 days	HTN, diabetes
Tagaya ⁷⁰⁾	2010	0.33	M	C2-L2	P	C	No OR	E	Unk	Hemophilia
Subbiah ⁷¹⁾	2010	65	M	C4-T1	A	C	No OR	E	24 hours	LMWHT
Kiehna ⁷²⁾	2010	0.42	M	C1-L4	P	D	No OR	E	4 hours	Hemophilia
Hosoki ⁷³⁾	2010	0.92	M	T9-L1	P	D	48	E	2 days	None
Kumchev ⁷⁴⁾	2010	55	M	C2-C4	PL	B	<24	E	Hrs	None
Sirin ⁷⁵⁾	2010	77	M	C6-T3	P	C	No OR	E	40 minutes	HTN
Fleager ⁷⁶⁾	2011	22	M	C2-L3	A	A	4	E	2 days	None
Badar ⁷⁷⁾	2011	35	F	T2-T8	A	C	>24	E	3 days	None
Matsubara ⁷⁸⁾	2011	36	F	C3-C7	P	B	9h	C	9h	None
Chang ⁷⁹⁾	2011	32	F	C3-C7	P	B	<12	C	Unk	Renal failure

Table 3. Number of patients who presented with varying degrees of neurological dysfunction, as described by the Frankel grade

Frankel Grade at Presentation:	Number of Cases:
A	39/107 (36%)
B	16/107 (15%)
C	38/107 (36%)
D	11/107 (10%)
E	3/107 (3%)

involved was 5.4 with a range of 1 to 23. The distribution of segments showed increased involvement at the cervicothoracic junction (Fig. 6). The majority (53%) of hematomas were located posterior to the spinal cord, whereas 23% were located posterolateral, 18% were anterior, 5% were lateral and 1% were circumferential to the cord.

Overall, 60/107 (56%) of the patients had complete recovery. Of the 80 operative cases, 35 (43.75%) experienced complete recovery, 22 (27.5%) had incomplete motor recovery with good functional outcome, 10 (12.5%) had incomplete motor recovery with poor functional outcome, 2 (2.5%) had preserved sensation without motor function and 11 (13.75%) had no motor or sensory recovery. No patients suffered from worse neurological outcome after treatment.

For the statistical analysis investigating the effect of surgical timings on patient outcome, 43 of the 107 patients were excluded from the analysis for the following reasons: twenty-three patients were managed conservatively and thus would not provide any information on the effect of delayed surgery. We also excluded nine infants (<2 years old) from the analysis due to considerable delays in diagnosis, and consequently, substantially late presentation to the OR. As a result, age and time of surgery would be confounded. Finally, for six patients, missing data precluded analysis.

Of the 64 patients analyzed, 31 (48%) were female and 33

(52%) were male. The mean age of the patients was 48 (±24) with the following distribution among the four age categories: less than 20 years (n=9), 20 to 40 years (n=16), 40 to 60 years (n=12) and over 60 years (n=27). Forty-nine patients had surgery within 24 hours and 19 patients had surgery after 24 hours. The number of patients with an initial Frankel grade of A, B, C and D were 28, 9, 22 and 5, respectively.

Initial Frankel grade (F(1, 60)=23.15, p=0.001) and sex (F(1, 60)=4.41, p=0.040) were statistically significant to final Frankel grade. For every one grade increase in the initial grade, the final grade increased by 0.69. After controlling for initial Frankel grade, male patients had better outcomes from surgery than female patients. The final Frankel grade of male patients averaged 0.63 points higher than female patients after adjusting for initial Frankel grade and time to surgery.

Although the timing of the surgery after admission was not statistically significant (F(1, 60)=3.18, p=0.079) to final Frankel grade, early surgery (within 24 hours) yielded better outcomes than delayed surgery (after 24 hours) (Fig. 7). On average, patients who received surgery within 24 hours had a final Frankel grade 0.60 points higher than those receiving later surgery (Fig. 8).

On the other hand, age (F(3, 57)=0.96, p=0.42), past history of hypertension (F(1,57)=0.0013, p=0.97), use of anti-coagulants (F(1, 57)=0.57, p=0.45), and the number of spinal segments in the hematoma (F(1, 57)=0.99, p=0.32) were not significant predictors of final Frankel grade. In addition, no two-way interactions were significant.

DISCUSSION

The first reported case of SSEH was by Jackson in 1869. Since then, over 400 cases have been described in the world literature. MRI has emerged as the diagnostic study of choice

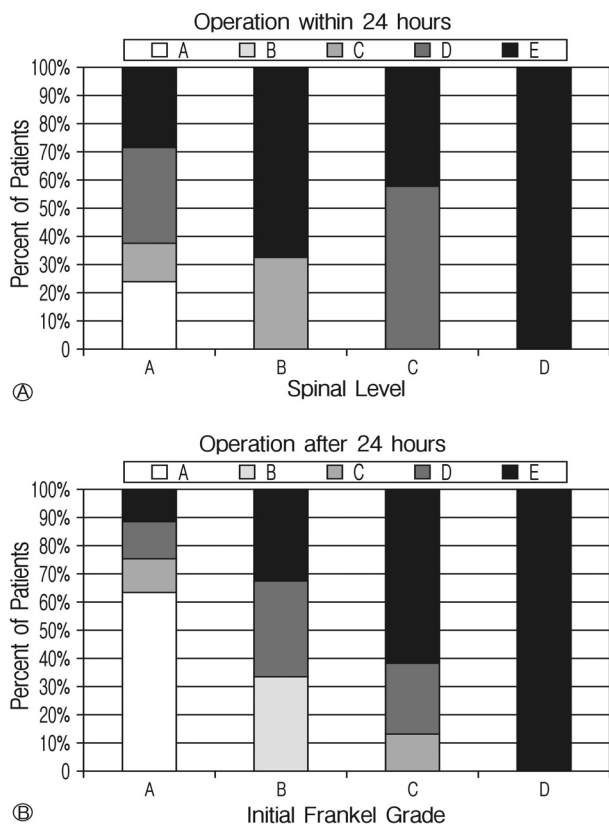


Fig. 7. Approximately 62% patients with an initial Frankel grade of A that had surgery after 24 hours do not improve. In contrast, only about 24% of Initial A; grade patients operated within 24 hours failed to improve. All patients with an initial Frankel grade of B; improved when operated on within 24 hours while 33% of those operated on after 24 hours remained without motor function.

for SSEH. A T2-weighted scan showing an epidural mass hyperintense to the spinal cord with focal areas of hypointensity (consistent with the presence of deoxyhemoglobin) highly suggests the presence of an epidural hematoma^{26,27}. No MRI characteristic that may predict outcome currently exists²⁷.

In the majority of reports, the hematoma is considered to be "spontaneous" if it develops without known cause (i.e. trauma, fracture, spinal lesion or medical procedure). Hence, some refer to SSEH as idiopathic spinal epidural hematoma⁴¹. In most cases, however, patients have some history (i.e. anticoagulation use, bleeding diathesis, hypertension, straining) that may contribute to the bleeding. Some case reports include SSEH due to vascular malformations, whereas most authors do not consider these to be spontaneous in origin. Following a variable time interval anywhere from minutes to weeks, neurological dysfunction develops ranging from mild weakness to complete paralysis. Past reviews found that better prognosis is associated with less severe initial neurological dysfunction and with

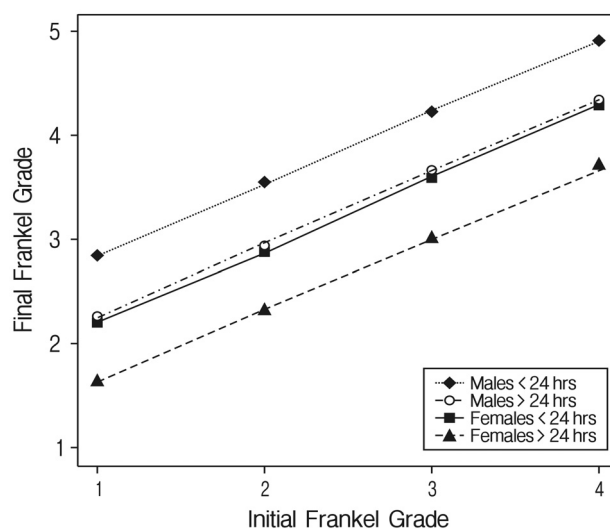


Fig. 8. Initial and final Frankel grades.

faster time to operation^{30,36,41,50}. However, reported cases of SSEH managed non-surgically with steroids²¹ or only observation also exist¹⁷.

Past reviews found that pediatric patients presented with longer and more variable times to neurological symptom onset¹⁷. We believe this is due to difficulty in assessing pain and performing accurate neurologic examination in this group. Children under two years of age presented to surgeons after days, and sometimes weeks after symptoms eventually alerted parents or caregivers. Such symptoms included chronic irritability, crying and inability to ambulate or stand. Elderly patients, on the other hand, had faster onset to deficits varying from minutes to hours.

Treatment consisted of either decompressive laminectomy or conservative management with or without steroids. In our study, conservative management was employed in 23 patients. In one of these, neurological improvement occurred following a lumbar puncture (LP), which drew 20 ml of clear cerebrospinal fluid (CSF)³. In this case, the LP was performed to rule out infection before MRI diagnosis of the epidural hematoma. The remaining 84 patients were treated surgically. Of these, 47 were operated within 24 hours of symptom onset and 37 were operated 24 hours after symptom onset.

1. Prognostic Factors

For those cases treated surgically, the literature reports that post-operative recovery is based both on pre-operative neurological function as well as time to operation after the onset of these symptoms^{30,41,50}. Our review also illustrates that patients with a higher pre-operative Frankel grade, functional recovery

was more likely. Also, those patients with a shorter interval to operation had better recovery than those with longer intervals. Especially in cases of complete neurological dysfunction, a timely operation may be of great benefit, and even in cases of delayed surgery, good functional outcome can be achieved. In contrast to Groen's review and for unknown reason, recovery was greater in males than in females after surgery.

A past medical history that may have contributed to bleeding is associated with a worse neurological presentation and may indirectly influence eventual recovery. In 10 of the 26 cases of complete initial motor deficit, patients had a history of anticoagulation such as aspirin or ibuprofen use.

However, even patients with significant comorbidities did achieve functional recovery comparable with patients without comorbidities. Hence, a relevant past medical history does not predict poor outcome, but may be associated with worse initial neurological dysfunction than others.

Initial neurological dysfunction was the strongest predictor for a patient's outcome. Patients presenting with severe and/or worsening conditions typically did not recover as well as those presenting with minor symptoms. Furthermore, the timing of a decompressive laminectomy was more significant factor in patients initially presenting with Frankel grades of A or B. Patients presenting with better neurologic function (scores of D or E) frequently showed substantial improvement regardless of time to operation. With the exception of patients showing significant neurologic improvement before surgery, a prompt evacuation of an epidural hematoma should be attempted. Even in the case of complete or severe neurologic deficit and lengthy symptom duration, functional recovery may be achieved through surgical intervention.

2. Pathophysiology

Groen speculated that bleeding most likely arises from the posterior epidural venous plexus³³. This plexus lies directly between the dura and ligamentum flavum making rupture more likely than in the anterior venous plexus which is covered by the posterior longitudinal ligament. Communication between the venous plexus and the intrathoracic veins allows for transfer of pressures from one compartment to another. Given that the epidural venous plexus is devoid of valves, it may be particularly vulnerable to sudden changes in pressure, especially at the cervicothoracic and thoracolumbar junctions where resistance is minimal. Cases of SSEH associated with heavy lifting, straining, pregnancy and hypertension further supports the venous theory.

In contrast, Beatty suggested that bleeding occurs from epidural arteries¹⁶. He argued that hemorrhage from an epidural vein would not create enough pressure to compress the spinal

cord, observing that the normally expanded epidural sac may tamponade epidural bleeding encountered during surgical procedures. There are also reports of SSEH located anteriorly for which the posterior venous plexus theory would not apply^{4,5,11,12,19,20,24,26,28,29,34,37,44,51}. With few exceptions, SSEH arises from a venous bleed rather than an arterial bleed.

3. Treatment

In recent years, there have been increased reports of spontaneously resolving spinal epidural hematomas. This may be due to quick diagnosis by higher resolution MRI when a patient presents with sudden onset of neurological deficits. Even in the face of improving neurological condition, MRI is performed to evaluate the size and location of the hematoma³². It is important to stress that by the time of diagnosis with MRI, the patients managed conservatively were already improving clinically. Thus, conservative management is only appropriate in the face of improving neurological status.

Four of the five hemophilic patients in our review were treated conservatively with either Factor VIII or Factor IX? both of which are clotting-related proteins. All four of these patients recovered to an "E" Frankel grade. Although the number of hemophilic patients is relatively small, there has been substantial success of conservative management in these patients.

In a review by Groen, conservatively treated SSEH had more spinal levels involved than those treated operatively. Similarly in our review, the mean spinal levels of SSEH managed conservatively was seven as opposed to five for surgical cases. The total length of involvement was not a dependent factor predicting outcome.

CONCLUSION

Both the venous and arterial theories provide plausible explanations for SSEH with most cases probably resulting from a venous bleed. Our review of SSEH presented in the English literature since 1996 is consistent with previously published reviews with regard to clinical presentation, spinal segment involvement and factors predicting neurological outcome except males as a group did better than females for unknown reason. Patients with less initial neurological deficit and those with shorter time to operation show better neurological improvement. Those who present with a past medical history are more likely to have greater initial neurological deficit with tendency to greater bleeding, especially in the case of anticoagulation use. An increasing number of conservatively treated SSEH cases have been reported. In all such cases, patients presented with improving neurological status. Although high resolu-

tion MRI has improved the accuracy of SSEH diagnosis, no imaging characteristics serve to predict the eventual outcome. Expedient decompressive laminectomy continues to be the treatment of choice for patients with SSEH.

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