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Initial recognition failure of spontaneous spinal epidural hematoma in emergency care: symptom pattern and first-department allocation in a two-center cohort

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Abstract

Background

Spontaneous spinal epidural hematoma (SSEH) is a rare, time-sensitive neurological emergency that may initially resemble more common emergency conditions. We evaluated the frequency of initial recognition failure in SSEH and examined its association with presenting symptom pattern and first-department allocation.

Methods

We retrospectively reviewed 51 consecutive patients with SSEH treated at two Japanese neurosurgical centers between 1995 and 2024. Initial recognition failure was defined as failure to recognize SSEH at first medical contact, resulting in a non-SSEH-directed diagnostic workup or treatment. Symptom pattern, initial medical department, diagnostic intervals, clinical severity, and radiological variables were extracted from medical records. Factors associated with initial recognition failure were explored using univariable logistic regression.

Results

Initial recognition failure occurred in 19 patients (37.3%). Initial working diagnoses included cerebral infarction (n = 6), aortic dissection (n = 4), spinal tumor (n = 3), lumbar disc herniation (n = 1), Guillain-Barre syndrome (n = 1), hyperkalemia (n = 1), spinal cord infarction (n = 1), vertebral artery dissection (n = 1), and other lumbar pain disorders (n = 1). Compared with Brown-Sequard pattern, transverse myelopathy was associated with higher odds of initial recognition failure (odds ratio [OR], 7.20; 95% confidence interval [CI], 1.63–31.71). Compared with initial evaluation in a general/emergency department, initial evaluation in a neurological department was associated with lower odds of initial recognition failure (OR, 0.03; 95% CI, 0.005–0.18).

Conclusions

Initial recognition failure was common in SSEH and was associated with both symptom pattern and first-department allocation. These findings suggest that SSEH should be considered early in emergency patients with severe acute neck, back, or truncal pain accompanied by any neurological symptom, even when the presentation appears bilateral, systemic, cardiovascular, or stroke-like. Awareness of this diagnostic pitfall among frontline emergency and non-neurological providers may facilitate earlier spinal cord localization and timely spinal MRI.

Background

Spontaneous spinal epidural hematoma (SSEH) is an uncommon but potentially disabling neurological emergency caused by hemorrhage within the spinal epidural space [1, 2]. Prompt recognition is important because neurological outcome is influenced by neurological severity and the timing of decompression in patients who require surgery [3–5]. However, the first clinical challenge often occurs before treatment selection: the disorder must be recognized among more common emergency presentations.

Early diagnosis is difficult because SSEH can resemble several acute disorders encountered in emergency care. Cervical SSEH may present with hemiparesis and be mistaken for ischemic stroke, sometimes exposing patients to antithrombotic or thrombolytic treatment before spinal pathology is recognized [6–9]. Other presentations, including severe chest, abdominal, neck, or back pain with neurological symptoms, have been reported to mimic acute coronary syndrome or transient ischemic attack [10, 11].

The clinical problem is therefore not limited to imaging availability. The first diagnostic frame applied to the patient may determine whether the patient enters a neurological pathway, where spinal cord localization and spinal MRI are more likely, or a non-neurological pathway, where cardiovascular, systemic, or peripheral neurological disorders may be prioritized. This issue is particularly relevant in systems where ambulance crews coordinate transport to an accepting hospital and where the initial in-hospital evaluation may occur in general emergency, neurological, orthopedic, cardiovascular, or other specialty pathways [12–14]. Although emergency care systems differ across countries, the diagnostic challenge of a rare time-sensitive neurological mimic entering a non-neurological pathway is broadly relevant.

This study aimed to identify clinical and pathway-level factors associated with initial recognition failure in SSEH, with particular attention to symptom pattern and first-department allocation. The long observation period was used to accrue sufficient cases of this rare disorder; unadjusted period-based diagnostic intervals were treated only as descriptive supplementary context and not as evidence of temporal improvement.

Methods

Study design, setting, and ethics

This retrospective two-center cohort study was performed at neurosurgical centers in Japan. The report was prepared with reference to the STROBE recommendations for observational studies. The protocol was approved by the Institutional Review Board of the coordinating center (IRB No. 2023052601). Because of the retrospective design and use of anonymized clinical data, the requirement for additional study-specific written informed consent was waived. The study was conducted in accordance with the Declaration of Helsinki.

Patient selection

All consecutive patients diagnosed with SSEH between January 1995 and December 2024 were screened. SSEH was defined, according to Lonjon et al. [15], as a rapidly accumulating epidural hematoma without traumatic or iatrogenic cause. Diagnosis was confirmed intraoperatively in surgical cases or by computed tomography, magnetic resonance imaging (MRI), and compatible clinical course in conservatively treated cases.

After excluding traumatic or iatrogenic hematomas and secondary epidural hematomas related to systemic bleeding or hematologic disorders, 51 patients were included. Patients receiving ordinary antithrombotic therapy, including antiplatelet or anticoagulant agents, and patients receiving maintenance hemodialysis were retained in the cohort; examples of excluded disorders included hemophilia and leukemia.

This cohort overlaps with and expands a previously published cohort from the same institutions that focused on neurological prognosis in SSEH [16]. The present study addresses a distinct research question focused on emergency diagnostic pathways, first-department allocation, initial recognition failure, and diagnostic intervals. These diagnostic-pathway variables and outcomes were not the subject of the previous prognostic report.

Definitions and variables

Initial recognition failure was defined as failure to recognize SSEH at first medical contact by the first attending physician, resulting in a non-SSEH-directed diagnostic workup or treatment, with the correct diagnosis subsequently established by another physician or department. This term was intended to capture delayed initial recognition, not to imply negligence or avoidable error in every case. First medical contact was defined as the patient's first evaluation at a medical institution rather than prehospital contact with emergency medical services.

Symptom pattern was classified by the most prominent neurological presentation at first medical contact: Brown-Sequard pattern, transverse myelopathy, segmental pattern, or pain-only presentation. Brown-Sequard pattern was defined as unilateral or asymmetric motor deficit with crossed sensory impairment. Transverse myelopathy was defined as bilateral motor and sensory deficits below the lesion. Segmental pattern indicated isolated nerve root- or myelomere-level deficits, and pain-only presentation indicated axial pain without focal neurological deficit at first contact.

Neurological severity was recorded using the American Spinal Injury Association Impairment Scale (AIS) at admission and final follow-up [17]. The following variables were extracted from medical records: age, sex, symptom pattern, spinal shock, AIS grade, number of vertebral levels involved, canal occupancy ratio, initial medical department, initial working diagnosis, initial recognition failure, onset-to-first-contact interval, first-contact-to-diagnosis interval, onset-to-diagnosis interval, and treatment strategy. Initial

medical department was categorized as general/emergency, neurological, or orthopedic. In this cohort, the general/emergency category included non-neurological first-contact services that initially managed undifferentiated emergency presentations or cardiovascular/systemic diagnostic concerns. Diagnosis time was defined as the time at which SSEH was definitively diagnosed.

Use of AI-assisted tools

AI-assisted tools were used to support language editing, manuscript organization, and journal-specific formatting. All analyses, interpretations, and final manuscript content were reviewed, edited, and approved by the authors, who take full responsibility for the content of this manuscript.

Statistical analysis

Continuous variables are presented as median with interquartile range, and categorical variables as number and percentage. The primary analysis focused on overall initial recognition failure and its association with symptom pattern and first-department allocation. Because the number of initial recognition failure events was limited (n = 19), associated factors were evaluated using univariable exploratory logistic regression. Brown-Sequard pattern and the general/emergency department were used as reference categories. Odds ratios (ORs) with 95% confidence intervals (CIs) were reported. For descriptive supplementary summaries only, patients were grouped by calendar period: 1995–2004, 2005–2014, and 2015–2024. Recognition-failure frequencies and diagnostic intervals were summarized by period without trend testing, because unadjusted temporal comparisons over a 30-year observation period are vulnerable to confounding by changes in imaging availability, emergency care organization, referral pathways, clinical awareness, and documentation practices. Analyses were performed using R software version 4.3.2 (R Foundation for Statistical Computing, Vienna, Austria).

Results

Among 51 patients, 22 (43.1%) were male, and the median age was 73 years. Surgical treatment was performed in 29 patients (56.9%). Overall clinicoradiological characteristics are summarized in Table 1. Brown-Sequard pattern was present in 21 patients (41.2%), transverse myelopathy in 22 (43.1%), segmental pattern in 3 (5.9%), and pain-only presentation in 5 (9.8%). The initial medical department was general/emergency in 14 patients (27.5%), neurological in 33 (64.7%), and orthopedic in 4 (7.8%).

Table 1
Overall clinicoradiological characteristics

Characteristic	Overall (n = 51)
Male sex	22 (43.1%)
Age, years	73 [68–79]
Operative management	29 (56.9%)
Vertebral levels	3.0 [3.0-5.5]
Canal occupancy ratio, %	51.4 [44.0-60.6]
Symptom pattern	
Brown-Sequard	21 (41.2%)
Transverse myelopathy	22 (43.1%)
Segmental pattern	3 (5.9%)
Pain only	5 (9.8%)
AIS grade on admission	
A	5 (9.8%)
B	5 (9.8%)
C	21 (41.2%)
D	16 (31.4%)
E	4 (7.8%)
Initial medical department	
General/emergency	14 (27.5%)
Neurological	33 (64.7%)
Orthopedic	4 (7.8%)
Spinal shock	3 (5.9%)

Values are presented as number (%) or median [interquartile range]. AIS, American Spinal Injury Association Impairment Scale.

Initial recognition failure occurred in 19 patients (37.3%) at first medical contact. The initial working diagnoses in these patients were cerebral infarction (n = 6), aortic dissection (n = 4), spinal tumor (n = 3), lumbar disc herniation (n = 1), Guillain-Barre syndrome (n = 1), hyperkalemia (n = 1), spinal cord infarction (n = 1), vertebral artery dissection (n = 1), and other lumbar pain disorders (n = 1).

Symptom pattern was associated with initial recognition failure (Table 2; Fig. 1A). Recognition failure occurred in 3 of 21 patients (14.3%) with a Brown-Sequard pattern, 12 of 22 (54.5%) with transverse myelopathy, 2 of 3 (66.7%) with a segmental pattern, and 2 of 5 (40.0%) with pain-only presentation. Compared with Brown-Sequard pattern, transverse myelopathy was associated with higher odds of initial recognition failure (OR, 7.20; 95% CI, 1.63–31.71). Segmental pattern and pain-only presentation also had higher point estimates, but the confidence intervals were wide because of small subgroup numbers.

Table 2
Key factors associated with initial recognition failure

Factor	Initial recognition failure	OR	95% CI
Symptom pattern			
Brown-Sequard	3/21 (14.3%)	Reference	Reference
Transverse myelopathy	12/22 (54.5%)	7.20	1.63–31.71
Segmental pattern	2/3 (66.7%)	12.00	0.81-177.44
Pain only	2/5 (40.0%)	4.00	0.46–34.92
Initial medical department			
General/emergency	12/14 (85.7%)	Reference	Reference
Neurological	5/33 (15.2%)	0.03	0.005–0.18
Orthopedic	2/4 (50.0%)	0.17	0.01–1.96
Values are presented as number/total (%). OR, odds ratio; CI, confidence interval.			

First-department allocation was also associated with initial recognition failure (Table 2; Fig. 1B). Recognition failure occurred in 12 of 14 patients (85.7%) initially evaluated in general/emergency departments, 5 of 33 (15.2%) in neurological departments, and 2 of 4 (50.0%) in orthopedic departments. Compared with general/emergency departments, initial evaluation in a neurological department was associated with lower odds of initial recognition failure (OR, 0.03; 95% CI, 0.005–0.18).

Descriptive period-based summaries of recognition-failure frequencies and diagnostic intervals are provided in Additional file 1. These unadjusted summaries were used only to characterize the cohort and should not be interpreted as evidence of temporal improvement.

Discussion

This two-center cohort provides three clinically relevant findings for emergency care. First, more than one-third of patients with SSEH were not recognized as having SSEH at first medical contact. Second, recognition failure was more frequent in non-Brown-Sequard presentations, particularly transverse myelopathy. Third, recognition failure was strongly associated with first-department allocation, occurring

most often when patients initially entered a general/emergency pathway rather than a neurological pathway.

The association between symptom pattern and recognition failure is clinically plausible. Brown-Sequard or markedly asymmetric presentations may be interpreted as neurological events, prompting neurological consultation or neuroimaging. In contrast, bilateral weakness, sensory disturbance, severe axial or truncal pain, hypertension, abdominal pain, or systemic features may suggest aortic disease, acute coronary syndrome, metabolic disorders, Guillain-Barre syndrome, spinal cord infarction, or other conditions. This diagnostic ambiguity may delay spinal cord localization and urgent spinal MRI.

The department-level association should not be interpreted as a causal effect of department specialty independent of case mix. Rather, first-department allocation is a pathway-level marker that reflects the initial diagnostic frame applied to the patient. Patients with stroke-like or clearly neurological findings may be routed to neurological care, whereas those with predominant pain, cardiovascular concern, or atypical bilateral symptoms may enter general emergency or cardiovascular pathways. The observed association therefore supports the concept that initial recognition failure in SSEH is partly a pathway-entry problem. It should be acknowledged that first-department allocation and initial recognition failure are not fully independent constructs: routing to a neurological pathway may itself reflect that the presentation had already been recognized as neurological at first contact. The large effect estimate for neurological evaluation should therefore be read as a marker of this shared diagnostic framing rather than as an independent protective effect of department specialty.

Although this cohort was drawn from Japan, the core diagnostic problem is not unique to the Japanese emergency care system. Emergency medical services and hospital triage structures differ across countries, but patients with acute pain and neurological symptoms may initially be evaluated under cardiovascular, neurological, orthopedic, metabolic, or general emergency diagnostic frames in many systems. The practical implication is that emergency clinicians should consider SSEH when severe acute neck, back, or truncal pain is accompanied by any neurological symptom, even if the presentation appears bilateral, systemic, cardiovascular, or stroke-like.

The long observation period should be viewed primarily as a strategy for accruing enough patients with a rare emergency condition. Unadjusted era-based comparisons of diagnostic intervals are vulnerable to substantial temporal confounding, including changes in MRI availability, emergency care organization, referral patterns, clinical awareness, and documentation practices. For this reason, period-based diagnostic intervals were relegated to supplementary descriptive context and were not used to support conclusions about temporal improvement.

Limitations

This study has several limitations. First, it was retrospective and included two neurosurgical centers in one country; therefore, absolute rates of recognition failure and first-department allocation may not

generalize to all healthcare systems. Moreover, because only patients in whom SSEH was ultimately diagnosed at a neurosurgical center were included, cases that were never recognized, such as patients who died undiagnosed or who were managed entirely as an alternative diagnosis, could not be captured; the observed frequency of initial recognition failure may therefore underestimate its true frequency. Second, detailed prehospital emergency medical services records, ambulance crew decision-making, hospital acceptance processes, imaging wait times, and first-institution imaging modality were not available. Third, the number of initial recognition failure events limited multivariable modeling, and residual confounding cannot be excluded. In particular, neurological severity (AIS grade) and symptom pattern are likely correlated with first-department allocation, and these factors could not be disentangled in the univariable analysis. Fourth, symptom pattern and initial recognition failure were classified retrospectively without independent adjudication or formal interobserver agreement assessment, which may introduce classification bias. Fifth, several subgroup estimates had wide confidence intervals because SSEH is rare and subgroup sizes were small. Finally, the 30-year observation period introduced unavoidable changes in imaging technology, emergency care infrastructure, and clinical awareness; therefore, no causal inference regarding temporal changes in diagnostic delay should be made from this cohort.

Conclusions

Initial recognition failure was common in patients with SSEH and was associated with symptom pattern and first-department allocation. Non-Brown-Sequard presentations, especially transverse myelopathy, were more frequently unrecognized at first medical contact, and initial evaluation in a neurological department was associated with fewer recognition failures than initial evaluation in a general/emergency department. SSEH should be recognized as an important diagnostic pitfall in emergency care. Education and awareness among frontline emergency and non-neurological providers may help prompt earlier spinal cord localization and timely spinal MRI in patients with severe acute neck, back, or truncal pain accompanied by neurological symptoms.

List of abbreviations

AIS, American Spinal Injury Association Impairment Scale; CI, confidence interval; CT, computed tomography; CTA, computed tomography angiography; MRI, magnetic resonance imaging; OR, odds ratio; SSEH, spontaneous spinal epidural hematoma.

Declarations

Conflict of Interest:

The authors declare no conflicts of interest.

Ethics approval and consent to participate

This study was conducted in accordance with the Declaration of Helsinki. The protocol was approved by the Institutional Review Board of Nakamura Memorial Hospital (IRB No. 2023052601). Because of the retrospective design and use of anonymized clinical data, the requirement for additional study-specific written informed consent was waived.

Consent for publication

Not applicable. The manuscript does not contain individually identifiable information.

Competing interests

The authors declare that they have no competing interests.

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Author Contribution

YO conceived and designed the study, curated the data, performed the statistical analyses, prepared Figure 1, and drafted the manuscript. MM and MS curated the data, performed the investigation, and critically revised the manuscript. HN supervised the study, provided resources, and critically revised the manuscript. All authors read and approved the final manuscript.

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Not applicable.

Data Availability

The datasets generated and/or analyzed during the current study are not publicly available because they contain patient-level clinical information and public sharing could compromise patient privacy, but they may be available from the corresponding author on reasonable request and with appropriate institutional approval.

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Figures

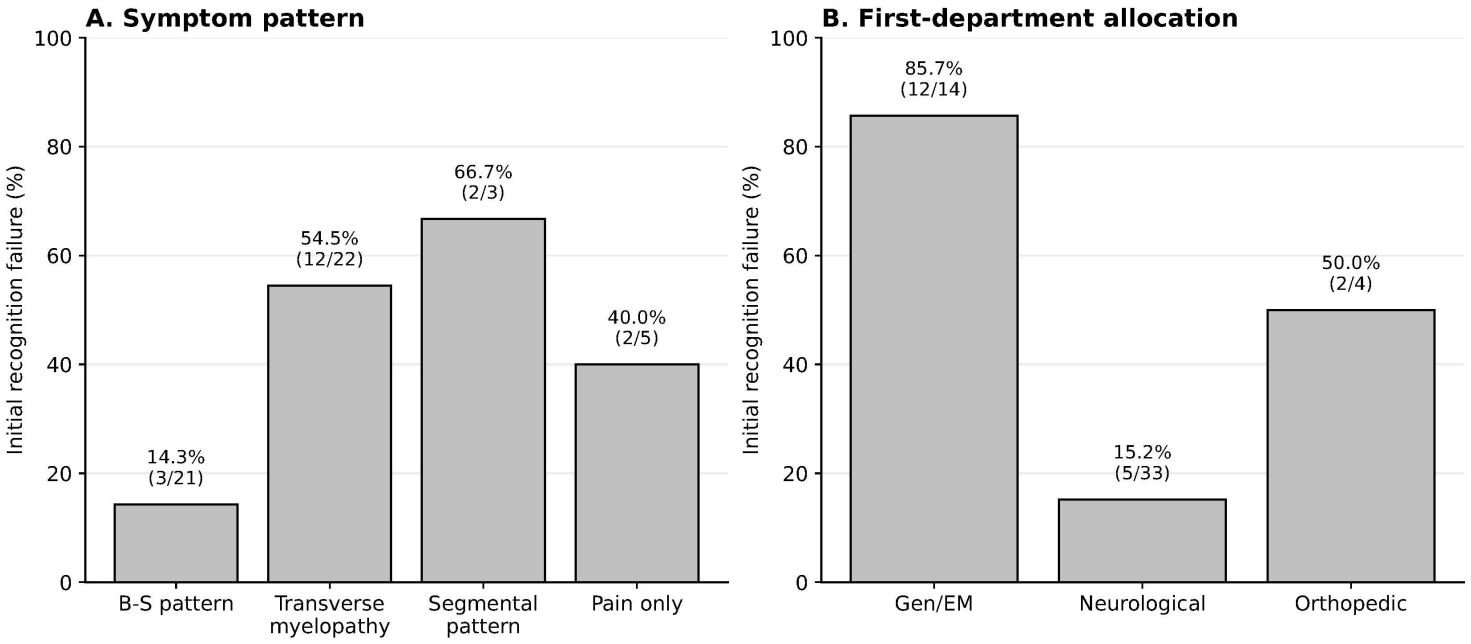


Figure 1

Initial recognition failure by symptom pattern and first-department allocation. (A) Proportion of patients with initial recognition failure according to symptom pattern at first medical contact. (B) Proportion of patients with initial recognition failure according to initial medical department. Bars indicate percentages, and labels indicate number/total. These are descriptive proportions from the cohort; odds ratios are reported in Table 2. B-S, Brown-Sequard; Gen/EM, general/emergency.

Supplementary Files

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- BMCEMAdditionalfile1PeriodSummaries.pdf