



Consensus statement by the Belgian Society of Neurosurgery and literature review on the diagnosis and management of postoperative spinal epidural hematoma

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ABSTRACT

Introduction: Postoperative spinal epidural hematoma (SEH) is a potentially devastating complication for patients and caregivers, and a leading cause for litigation in spine surgery. This article provides a literature review and the consensus statement of the Belgian Society of Neurosurgery (BSN) on the management of postoperative SEH. **Research question:** Can we implement current evidence to establish a framework on the management of postoperative SEH?

Material and methods: Based on a Pubmed search, abstracts were screened for topics covering incidence, pathophysiology, risk factors, surveillance, diagnosis, treatment, and outcome. Relevant topics are presented in a narrative review format, followed by a consensus statement of the BSN with emphasis on rapid diagnosis and treatment.

Results: Symptomatic SEH is rare (0.3–1%) and can have an insidious onset with rapid progression to neurological deficits. Recurring risk factors are coagulation deficiencies and multilevel surgery. The protective effect of a postoperative drainage system is uncertain, and early thrombo-embolic prophylaxis does not increase the risk of SEH. Prognosis is dependent on residual neurological function and critically, on the time to reintervention. There is a need for structured neurological observation formats after spine surgery.

Discussion and conclusion: Symptomatic SEH after surgery is an unpredictable and severe complication requiring rapid action to maximize outcomes. The BSN proposes three nuclear terms central to SEH management, converging on a triple 'S': 1) high level of suspicion 2) speed of diagnosis and 3) immediate surgery. All spine centers can benefit from an institutional protocol in which SEH should be treated as an emergency.

1. Introduction

Postoperative epidural bleeding with neurological deficits after spinal procedures is one of the most disappointing complications for patients and caregivers, and a leading cause for litigation in spine surgery (Butler et al., 2022; Daniels et al., 2017; Agarwal et al., 2018). During a

recent meeting of the Belgian Society of Neurosurgery (BSN) on medico-legal aspects in spine surgery, several points in current practice were delineated that lack documentation and have to be scrutinized in order to improve patient care. Even in high-volume centers, attention for this complication needs to be rekindled because of the low incidence and the variable presentation and experience of bedside caregivers. After

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clinical suspicion, diagnostic measures and subsequent interventions risk to be delayed in function of ongoing daily planning, leading to delays in diagnosis and treatment, and higher risk of permanent disability. Postoperative hemorrhage with resulting neurological decline cannot be completely prevented and even after rapid diagnosis and treatment incapacitating deficits can persist. Logically, litigation frequently ensues, detrimental for the wellbeing of patients and caregivers. To establish a contextual framework, the current article outlines the consensus statement of the Belgian Society of Neurosurgery (BSN) based on an updated literature review on the incidence, pathophysiology, clinical course, risk factors, preventive measures, and strategies for early diagnosis and treatment. As such we aim to improve patient safety while ensuring an evidence-based medicolegal environment for caregivers.

2. Methods

A PubMed search was performed including articles until February 2024 using the terms epidural hematoma AND spinal OR spinal surgery. All abstracts were screened and potentially included based on the following subjects: incidence, pathophysiology, clinical course, risk factors, surveillance, diagnosis, treatment, and prognosis on postoperative SEH. Reviews and meta-analyses on subtopics were included to improve the level of evidence. We present a narrative review concerning these topics. After completion of the review, all topics were presented in a plenary discussion with the board members of the Belgian Neurosurgical Spine Society (BNSS), the spine subsection of the BSN. The aim was to provide an evidence-based text with recommendations that could serve as a framework for institutional protocols in Belgian or European spine centers, and as a medicolegal reference for litigation cases. All members were asked to give input on the presented topics. Recommendations were formulated after reaching consensus on each topic. This consensus statement was then approved by the BSN board. In the discussion, the consensus statement of the BSN for the perioperative management and postoperative surveillance, diagnosis, and treatment is provided. Lastly, we added a potential screening tool for postoperative surveillance by the paramedical team for early detection of SEH.

3. Results

3.1. Incidence, pathophysiology, and clinical course

Globally, spine surgery rates have drastically increased in the last two decades in both frequency and extent. In current practice it has become necessary to meet the challenging goal of improving the success rate of spine surgery while minimizing postoperative complications. SEH consists of a bleeding in the epidural space along the spinal canal. Asymptomatic SEH (accumulation of blood and fluids in the subfascial space) is common after spinal surgery (33–100%) and will spontaneously absorb postoperatively as seen in postoperative MRI studies (Shin et al., 2017; Sokolowski et al., 2008a) (Ikuta et al., 2006). As such, blood in the tissue cavity after surgery is a normal finding. A symptomatic compressive SEH causing neurologic deficits, however, rarely develops with a reported incidence rate varying between 0.3 and 1% (for all spinal locations) based on more than 150,000 surgeries in a recent systematic review, meta-analysis and large databases (Glottzbecker et al., 2010) (Park et al., 2020; Chen et al., 2022) (Abola et al., 2021). Surgery on the thoracic spine seems to exhibit a slightly higher incidence of symptomatic SEH compared to cervical or lumbar areas (Chen et al., 2022; Aono et al., 2011) (Masuda et al., 2020).

The pathophysiology of compressive, nontraumatic cauda equina syndrome (CES) might be representative for the evolution of neurological deficits caused by a postoperative hematoma in the lumbar spine. In a systematic review and meta-analysis of animal studies, the degree of compressive pressure influences effects and outcomes of CES (Pronin et al., 2019). Neurological outcome was most strongly associated with residual pre-decompression function. Different pathophysiological

mechanisms seem at play in CES, one being direct mechanical compression with reversible effect, the other being the development of neuronal ischemia if the compressive pressure of the hematoma exceeds mean arterial blood pressure driving the perfusion of neural elements, with rapid subsequent irreversible deficits. In many instances a combination of compression and secondary ischemia induced effects probably exist (Pronin et al., 2019). The spinal canal is an enclosed space in which any additional volume can rapidly increase intraspinal pressure, with similar mechanisms at play as seen in the intracranial compartment (Monro-Kellie doctrine). The cross-sectional area of the spinal canal is larger in the lumbar spine than in the cervical and thoracic spine, and most of the neural tissue in the lumbar canal consists of nerve roots, which may be less vulnerable to mechanical trauma than the spinal cord. This likely accounts for the lower incidence of new onset major neurologic deficit after lumbar spinal surgery compared with cervical and thoracic spinal surgery (Butler et al., 2022; Glottzbecker et al., 2010).

Symptoms of SEH usually occur within 24h after the initial surgery, however delayed presentations are not rare (Butler et al., 2022; Chen et al., 2022; Aono et al., 2011; Lawton et al., 1995) (Amiri et al., 2013) (Wang et al., 2020). Symptomatic lumbar SEH presents with a combination of sharp back pain, irradiating leg pain and neurological deficits as seen in a classic CES. Severe lumbar or radicular pain have been described as the predominant symptom in lumbar SEH (Anno et al., 2019). A characteristic progression from low back pain to bilateral neurological deficits in the lower extremities is often seen, but others report painless motor deficits as frequent (Scavarda et al., 1997; Kao et al., 2015). In contrast, symptomatic cervical or thoracic SEH resulting in spinal cord compression more likely developed tetra- or paraparesis (motor weakness as the predominant symptom), sometimes in combination with sensory disturbances and sometimes (local or radicular) pain (Anno et al., 2019) (Goldstein et al., 2015) (Masuda et al., 2020). In the specific case of cervical SEH, acute airway dysfunction can additionally be present (Masuda et al., 2020; Goldstein et al., 2015; Schroeder et al., 2017).

3.2. Risk and protective factors

Risk factors are difficult to establish due to the low incidence of symptomatic SEH and vary between studies, but recurrent factors include coagulation deficiencies and multilevel surgery (Chen et al., 2022; Amiri et al., 2013) (Abola et al., 2021) (Butler et al., 2022) (Awad et al., 2005). In a large retrospective nationwide Korean study, intraoperative blood loss, prolonged surgical time, high blood pressure, use of nonsteroidal anti-inflammatory drugs and concurrent coagulation factor deficiencies were found to be independent risk factors of SEH (Park et al., 2020). Additionally, >10 units alcohol consumption per week and previous spinal surgery have been identified as risk factors (Amiri et al., 2013). Anterior approaches and open surgery showed a protective effect as compared to posterior spinal decompressions and minimally invasive surgical approaches respectively (Chen et al., 2022). Kou et al. found that patients who require multilevel lumbar procedures or have a preoperative coagulopathy are at a significantly higher risk for developing SEH (Sokolowski et al., 2008b). Saitta et al. suggested that pre-operative antiplatelet medication in the form aspirin increases the risk of SEH, even when appropriately discontinued (Saitta et al., 2023), but this finding has not been replicated in a review on aspirin use in spinal surgery (Zhang et al., 2017). Mirzai et al. evaluated postoperative lumbar SEH formation in 50 patients randomly assigned to drain insertion or no drain insertion (Mirzai et al., 2006). Postoperative MRIs performed on the first post-operative day showed a statistically significant decrease in hematoma incidence and size with drain placement. However, this study highlights the group of non-symptomatic SEH, a physiological event that is frequently seen. There is currently no convincing evidence that epidural subfascial drains effectively reduce the incidence of symptomatic SEH and there is no convincing data showing potentially harmful effects of drain insertion (e.g., surgical site

infection) (Butler et al., 2022; Aono et al., 2011) (Awad et al., 2005). Similarly, the intraoperative use of tranexamic acid does not seem to reduce to incidence of symptomatic SEH, based on small randomized controlled trials (Colomina et al., 2017; Elmore et al., 2019). Early postoperative use of prophylactic anticoagulation (<24h) does not seem to increase the risk of postoperative SEH and is deemed safe (Glotzbecker et al., 2010; Chen et al., 2022; Dhillon et al., 2017) (Awad et al., 2005). Lastly, studies highlight sudden hypertension after extubating as a risk factor for developing SEH and maintenance of normotension in the postoperative period should be considered important (Yamada et al., 2015) (Butler et al., 2022) (Liao et al., 2020) (Tsuge et al., 2019).

3.3. Screening and diagnosis

Regarding early screening, a systematic review investigating which clinical screening instruments might be appropriate for evaluating postoperative patients, could find no existing validated scales in spinal surgery.⁴⁰ Five scales appeared to be applicable in the postoperative stage: the American Spinal Injury Association-score (ASIA score), the Oswestry Disability Index (ODI), the Japanese Orthopaedic Association-score (JOA score), the Medical Research Council-score (MRC score) and the Short Form 36. Twelve experts were involved to evaluate these scales, only the ASIA-score and the MRC received the label useable and objective. The study showed the need for uniformity in the execution of structured clinical neurological observations throughout the patient's hospital admission. In any case, when confronted with a suspicion of SEH during neurological screenings of the (para)medical team, urgent evaluation by a spine surgeon is warranted.

When confronted with a clinical suspicion of postoperative SEH, the question is whether and how this diagnosis should be confirmed. First, as described in the next section, outcome is dependent on time to re-intervention (Lawton et al., 1995; Kebaish and Awad, 2004). As such, additional imaging could result in time delay to surgery. A next consideration is the diagnostic value of imaging. As previously described, postoperative MRI very often shows accumulation of blood in the epidural space in asymptomatic patients (33–100%) (Shin et al., 2017; Sokolowski et al., 2008a) (Ikuta et al., 2006; Sokolowski et al., 2008b), and clinicians are less familiar with the interpretation of postoperative CT or MR imaging (since this is not routinely performed in a clinical setting). As such, it can sometimes be difficult to attribute certain radiological findings (false positives) to the clinical findings, the latter which can also prove difficult to interpret (neurological exam dominated by pain, residual effects of anesthesia after long procedures and 'psychogenic or functional' contamination of the clinical exam). One study showed that 60% of asymptomatic subjects after lumbar decompression showed a postoperative epidural hematoma with thecal sac compression beyond its preoperative state (Sokolowski et al., 2008b). A challenging grey zone of uncertainty persists, even with rapid MR imaging, whether a certain amount of epidural blood requires re-intervention in the presence of a new neurological deficit (Butler et al., 2022). A small hematoma is often present and could not be the cause of the new deficit, for which re-intervention is riskier than observation and will not benefit the patient. This also highlights the importance of involving the treating surgeon, as intraoperative findings could explain a postoperative neurological deficit. Thirdly, most studies highlight the advantage of MRI compared to CT in delineation of a postoperative hematoma, its extent and location, and the degree of spinal cord or cauda equina compression (Butler et al., 2022; Ikuta et al., 2006). CT imaging is often dubious and does not provide a clear delineation of blood and neural elements (but can be first choice when hardware is present) (Butler et al., 2022). Immediate MRI 24/7 is, however, still often not available in most centers. In most cases of surgically treated SEH, an MRI was performed prior to surgery (Leroy et al., 2021) (Goldstein et al., 2015) (Zeng et al., 2017; Yi et al., 2006). Imaging was performed in 32 out of 42 operated SEH subjects. In 23 out of these 32

patients the imaging modality was specified, with MRI performed in 20/23 and CT in 3/23 subjects (Goldstein et al., 2015; Leroy et al., 2021; Zeng et al., 2017; Yi et al., 2006). Lastly, when confronted with a severe neurological deficit or rapid neurological decline (or combined with acute respiratory distress after anterior cervical spine surgery), especially early after surgery (without an intraoperative explanation), the suspicion of a postoperative SEH is high and immediate re-intervention without imaging is the preferred option by some authors (Butler et al., 2022; Goldstein et al., 2015; Leroy et al., 2021).

When confronted with new neurological symptoms after spinal surgery, the differential diagnosis of postoperative SEH is guided by the timeline of symptom development. Immediate onset of new symptoms is most often attributed either to direct neurological injury during surgery (e.g., mechanical or ischemic injury) or early postoperative SEH. Other possible etiologies of new (or recurrent) postoperative neurological symptoms are direct mechanical compression due to hemostatic material, delayed SEH, recurrent disc herniation, postoperative epidural abscess, or pseudomeningocele. Timeline of symptom development, clinical signs and imaging can confirm the differential diagnosis of SEH.

3.4. Treatment and outcome

Neurological outcome after evacuation of a postoperative SEH is critically dependent on the time to re-intervention (Butler et al., 2022; Amiri et al., 2013; Wang et al., 2020; Liao et al., 2020; Zeng et al., 2017; Yi et al., 2006) (Schroeder et al., 2017) and the residual neurological function (Butler et al., 2022; Zeng et al., 2017; Yi et al., 2006), both for cauda equina compression (Butler et al., 2022; Kao et al., 2015) and spinal cord compression (Aono et al., 2011; Masuda et al., 2020; Anno et al., 2019; Schroeder et al., 2017; Liao et al., 2020). As such, rapid diagnosis and treatment are crucial when an SEH is suspected. Long term outcome studies after cauda equina syndrome from other causes highlight a high incidence of persisting symptoms: in 30–40% bowel or bladder dysfunction, in 40–50% sexual impairment, 50% experienced residual genital numbness or sensory deficits, in 40% motor weakness, and 67% reported significant back pain. Quality of life was lower than expected when corrected for age and sex. Furthermore, half of the patients reported moderate or worse depression, and 40% of patients of working age could no longer work due to problems attributable to CES. Urinary and fecal incontinence, catheter use, sexual dysfunction, and genital numbness were significantly more common in patients with a complete cauda equina syndrome (with urinary and bowel dysfunction) (Kumar et al., 2022; Srikandarajah et al., 2015). Specifically for postoperative lumbar SEH, permanent deficits are frequent (sometimes even after fast re-intervention) and expected rates for complete neurological recovery range from 33% to 95% across all symptoms and speed of intervention according to a recent review (Butler et al., 2022). For spinal cord compression after postoperative SEH, complete recovery across all symptoms and speed of intervention ranges between 50 and 70% (based on small series) (with the remaining deficits often being motor weakness), again with significant better outcomes without delay in diagnosis and surgery (Masuda et al., 2020; Anno et al., 2019; Schroeder et al., 2017; Liao et al., 2020).

In studies published on the matter of timely intervention in cauda equina syndrome in general, a tendency from surgery within 48 h evolved over a time frame of 24 h to an acceptance of 'the sooner the better' as the current standard of care (Lawton et al., 1995; Kumar et al., 2022; Srikandarajah et al., 2015; Thakur et al., 2017; Hogan et al., 2019; Epstein, 2022). For SEH, Kebaish et al. for instance concluded that rapid surgical evacuation of the hematoma within 6h of symptom onset of postoperative deficit resulted in better neurologic outcomes, confirmed by others (Kebaish and Awad, 2004) (Amiri et al., 2013). It is important to note that in most of these studies, evacuation of the hematoma improved the neurological status (e.g., in one study 35 of 43 symptomatic SEH patients had an improvement of at least one point on the Frankel grade scale) (Masuda et al., 2020). Lastly, SEH by itself seems a

risk factor for additional complications such as postoperative infections (surgical site infection, respiratory and urinary tract infections) and deep venous thrombosis (Butler et al., 2022) (Abola et al., 2021).

4. Discussion

Postoperative symptomatic SEH can lead to permanent neurological deficits and is one of the most disappointing complications for patients and caregivers, and a major cause for litigation in spine surgery. In the above sections we highlighted aspects regarding clinical management important for caregivers and litigation cases. In the discussion, we provide an overview of the BSN/BNSS consensus statement and recommendations on the perioperative management of symptomatic SEH.

4.1. Prevention

Based on the evidence on risk and protective factors, several perioperative considerations can be made. Firstly, regarding aspects of coagulation, aspirin could be continued with an acceptable risk:benefit in selected cases with a high cardiovascular risk. The surgeon should be vigilant with these patients in the post-operative period to observe for signs and symptoms of SEH. Likewise, if safety allows, the surgeon might consider an extended aspirin drug vacation in certain patients to decrease the chances of a post-operative bleeding e.g., in high-risk spinal procedures. There are no guidelines published on best timing to restart postoperative anticoagulant use, although it is a known risk factor of SEH. The administration of postoperative anticoagulants in patients undergoing spine surgery is therefore left to the discretion of clinicians who need to balance the risks of thromboembolic events against symptomatic postoperative bleeding. For thrombo-embolic prophylaxis, current evidence does not show an increased incidence of SEH after early start (<24h) and is considered safe, for which we recommend its use. We found no evidence on the use of preoperative prophylaxis and SEH. Furthermore, we cannot recommend the routine use of tranexamic acid for the prevention of symptomatic SEH based on current evidence.

Secondly, the tendency in current practice is to decrease the use of postoperative drainage systems. Postoperative drainage decreases the amount of asymptomatic SEH, but there is no conclusive evidence of an effect on symptomatic SEH. The decision whether to place an epidural drain is left to the treating surgeon. After surgery for SEH or for certain high-risk procedures (e.g., multilevel surgery) use of a subfascial drain should be preferred.

Lastly, general considerations such as rigorous intraoperative hemostasis and avoiding postoperative hypertension are mandatory.

4.2. Postoperative surveillance, diagnosis, and treatment

4.2.1. Clinical surveillance

The presentation of symptoms and signs related to SEH can be acute or insidious with slow progression and is often masked by local or irradiating pain. Even for an experienced clinician, early-stage suspicion can be difficult, only to be later confronted with the appearance of an obvious neurological deficit and, from that point on, recovery may be incomplete. Progressing radicular pain and new sensorimotor deficits suspected for cauda equina or spinal cord compression should warrant workup to exclude SEH both in the immediate and delayed postoperative period. Postoperative follow-up after spinal surgery is based mainly on clinical parameters documented by the paramedical team. Scoring of patients after neurosurgical procedures rely not only on the vital parameters and pain scores but also on neurological findings, that might not be obvious unless specifically checked. Although it can be expected that standard paramedical training incorporates documenting basic neurological parameters, in daily practice it remains a challenge to score these parameters and to communicate findings efficiently and reliably. As neurological scores can be quite complex for caregivers not continuously involved in the field, a scoring system for neuromonitoring

should not only be sensitive but also feasible to implement in an environment with no experienced neuro nurses. From a safety as well as medicolegal standpoint, the evaluation and documentation of neurological parameters should be as explicit as those of vital parameters and communication of any change needs to be documented. Urgent medical attention by the on-call physician in the case of abnormally increasing pain or new neurological findings is warranted.

Before discharge from the recovery room, reevaluation needs to confirm absence of deficits and adequate pain control. This should be documented and communicated to the nursing staff on the ward who must check it again at ward intake. Patients should be encouraged to self-monitor for pain and sensorimotor changes and to alert nursing staff earlier than the fixed moment. Neurologic examination upon awakening is mandatory for detecting a new-onset neurological deficit. During the consensus meeting, a comprehensive follow-up form (IMPOSE guideline) that had been successfully incorporated in certain Belgian spine centers, was proposed as a general outline to guide routine neurological assessments by the paramedical team in the postoperative period (see appendix for the IMPOSE form) (Van Parys et al., 2020). The IMPOSE ('Immediate Postoperative Spine Evaluation') form incorporates the major clinical features that should be repeatedly checked after any spinal procedure (respiratory function, motor and sensory function in upper and lower limbs, bladder function, pain, drain output and wound checks). There is, however, no evidence showing that the use of a standard neurological screening tool on fixed timepoints after surgery improves neurological outcome by earlier detection of complications, but it could at least inform caregivers on important neurological signs and stress attention on repeated observations to early detect important complications. Secondly, the IMPOSE form advises routine checks every 2 h, which can be difficult in resource-limited care settings. This highlights the importance of patient education to early report any change in neurological function or pain. When a deficit is suspected, the threshold for bedside evaluation by the treating physicians (or their on-call colleagues) should be low. In cases of abnormal pain increase, clinical assessment of the patient is mandatory before and after pain interventions.

Ambulatory surgery is becoming increasingly popular for certain spinal procedures. As postoperative SEH is a rare complication, ambulatory surgery with early hospital discharge should be feasible after a certain observation period with a reassuring neurological examination in competent patients. An acceptable strategy would be to inform and educate the patient and to emphasize to take immediate action if any change in neurological symptoms should occur.

4.2.2. Early diagnosis and intervention

As earlier recognition and subsequent intervention correlates with better functional outcomes, urgent surgical evacuation should be performed as soon as possible when neurological deterioration is detected, and postoperative SEH is suspected. As such, postoperative SEH with neurological symptoms should be treated as an absolute medical emergency with immediate diagnosis and subsequent surgery. When confronted with severe or rapidly progressing neurological symptoms in the early postoperative period, without clear intraoperative cause, the case can be made for immediately proceeding with surgery without additional imaging since the suspicion is high and imaging would result in time delay. In other cases, or when in doubt, immediate imaging should be performed. An urgent MRI is the modality of choice as visualization of the epidural bleeding, the neural elements and degree of compression is superior as compared to CT. MRI can additionally differentiate between different causes of a new postoperative neurological symptoms, both in early and delayed cases (mechanical/ischemic neural injury, compressive hemostatic material, epidural abscess, pseudomeningocele, recurrent disc herniation ...). It is highly advised to incorporate the use of MRI in an institutional protocol to ensure the possibility of rapid imaging. A significant challenge can be to determine what degree of compression or what size of hematoma can explain a new postoperative neural deficit

and needs reoperation. There is a grey zone for reintervention and a decision should always be made based on a risk-benefit assessment of reintervention.

4.3. Medicolegal aspects

Postoperative CES due to SEH should be regarded as unforeseeable and is impossible to completely prevent even with maximal effort during surgery. As such, postoperative SEH is regarded as a therapeutic risk. Even with fast reintervention, clinical deficits can be permanent. Since serial clinical evaluations are the only way to screen for this type of complication, a high level of awareness and a clear protocol with delineation of the responsibilities of the involved personnel could maximize safety. From the moment a clinical suspicion is established, care should parallel the treatment of acute stroke, with the same time demands for imaging and reintervention (immediate action as opposed to as soon as possible can be organized in the schedule). All personnel involved in spinal care must understand the severity of this condition to minimize time lost before reintervention. A legal database of spine surgery malpractice cases showed that a failure to adequately diagnose or treat SEH were more common the cause for litigation as compared to procedural errors (Agarwal et al., 2018). Moreover, in the US, a delay in diagnosis more often resulted in a plaintiff ruling as compared to cases in which no delay occurred (Daniels et al., 2017). As such, a key element in medicolegal decisions is the reaction time of caregivers and time to surgical revision (Leroy et al., 2021).

4.4. Consensus based recommendations by the BSN/BNSS

Symptomatic SEH is a severe complication that often remains unpredictable. Institutional protocols in spine centers and awareness of all involved caregivers could help to establish the necessary means for urgent diagnosis and treatment to maximize outcomes. The BSN/BNSS proposes nuclear terms central to the management of symptomatic postoperative SEH converging on a 'triple S': Suspicion, Speed and Surgery (Fig. 1.)

1. High level of suspicion

All caregivers should be aware of SEH, the disastrous effects of permanent neurological deficit and the importance of early diagnosis and intervention.

Paramedical competence should be guaranteed by the hospital at every ward where patients after spine surgery might reside, even in case of emergency planning. Paramedics should be fully up to date in the scoring of patients as based on standard training requirements.

Recording of neurological findings in the medical file is mandatory and a low threshold of alarm should be stressed. A dedicated follow-up chart (e.g., IMPOSE guidelines, see appendix) could be followed and

5. Appendix

IMPOSE guideline (Immediate Postoperative Spine Evaluation) (2014)

This follow-up form is intended for nurses to use after cervical, thoracic or lumbar spinal procedures.
General considerations.



Fig. 1. Flowchart. Management of postoperative symptomatic SEH is centered around three nuclear terms: Suspicion, Speed and Surgery.

explicitly communicated when discussing any patient. The time of clinical suspicion and alerting the responsible physician should be logged in the medical records.

2. Speed of diagnosis

It is highly advisable that on call physicians have full knowledge of and access to the medical file and they should appear at the bedside to evaluate the patient themselves as fast as possible if called upon.

The type of imaging must be decided by the on-call physician depending on the clinical findings, patient or surgery specifics and availability. Rapid MRI is the modality of choice, otherwise a CT can be performed. A clear protocol for 24/7 immediate availability of imaging must be guaranteed by the hospital and radiological department, initiated by the on-call surgeon who should be able to decide for rapid transfer and/or scan no matter which elective program is running. Routine radiological schedules made to optimize efficiency do not weigh up to his type of surgical emergency and are to be regarded as a remnant of the past. If imaging would result in significant time delay and suspicion of SEH is high in the early postoperative setting, immediate proceeding to surgery should be strongly considered.

3. Surgery as soon as possible

The credo in this specific complication remains 'Time is Nerve'. Any relevant neurological deficit caused by a postoperative hematoma should be treated as soon as possible. Without discussion, elective programs should be interrupted acutely and clear agreements with the operating room organization must be in place before agreeing to perform spinal surgery in a hospital. Monitoring of the time trajectory to start of surgery as is performed in stroke patients might be a way to improve motivation of imaging and anesthesiologic departments.

5. Authorship statement

Authorship criteria are based on those outlined by the International Committee of Medical Journal Editors' (ICMJE) Uniform Requirements for Manuscripts Submitted to Biomedical Publications.

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Declaration of Competing Interest

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- The surgeon should mention any preoperative deficits.
- A score used by nurses should be easy to use, fast and feasible.
- Adequate scoring is only possible with an awake and alert patient. Consciousness should be scores as: normal, drowsy, or deeply sleeping.
- Respiratory distress: a rare but severe complication after anterior cervical procedures is a retropharyngeal hematoma which can present with acute respiratory distress.
- Motor: if the patient can show that he/she can easily move both hands, arms, legs and feet, this will suffice.
- Sensory: testing sensory functions by touching or pinching the patient will suffice.
- Wound: swelling of the wound can be a sign of an underlying hematoma and loss of fluid from the wound can indicate a cerebrospinal fluid leak.
- Drain: a high flow can indicate persistent bleeding.
- Bladder function: both retention and incontinence can be an alarm sign.
- Frequency: in the first 2 h, an evaluation is done every 30 min. If after 2 h no alarming signs are present, subsequent evaluations should only be performed every 2 h.
- If doubt, consult the treating surgeon.

Follow-up form after back surgery.

Preoperative deficit: (to be completed by MD) Recovery ward: every 30min. After recovery every 2h for a total of 10h. Starting hour recovery:h												
Cervical = Lumbar + arms	0'	30'	60'	90'	120'	150'	180'	5h	7h	9h	11h	13h
Consciousness (nl-drowsy- sleeping)												
Breathing (distress)												
Squeezing hands												
Flexion arms												
Extension arms												
Sensory arms: pinching												
Uncontrollable pain												
Raising legs												
Moving feet up-down												
Sensory legs: pinching												
Drain: flow (ml)												
Wound observation:												
Swelling:												
Fluid leakage:												
Urine flow if no bladder tube (±)	Bladder scan after 5h if no miction											

If there are any deviations from recovery or if you have any doubts, inform the surgeon.
This form has been developed in hospital AZ Sint-Blasius (Dendermonde, Belgium, 2014)

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