Intensive Care Med
https://doi.org/10.1007/s00134-026-08342-4

WHAT'S NEW IN INTENSIVE CARE

Going with the flow: lumbar cerebrospinal fluid drainage after aneurysmal subarachnoid hemorrhage: indications, safety, and practical considerations

Giuseppe Citerio[1,2], Katharina M. Busl[3] and Stefan Wolf[4*]

Why drain cerebrospinal fluid after subarachnoid hemorrhage?

With the onset of subarachnoid hemorrhage (SAH), a large amount of red blood cells (RBCs) enters the cerebrospinal fluid (CSF) space. While natural processes set in to clear the blood, spanning many days, blood cells break down and release hemoglobin in the CSF space. These blood-breakdown products have increasingly been recognized as toxins for neurons and cerebral arteries [1]. SAH burden, especially in form of thick clots and cisternal blood, directly correlates with development of cerebral vasospasm and delayed cerebral ischemia. Hence, accelerating removal of blood from the CSF space is compelling, albeit not new: the idea of early blood removal as strategy to prevent cerebral vasospasm was originally introduced in the late 1950s.

External ventricular drainage (EVD) is the most commonly employed method of CSF diversion after SAH: it not only drains CSF but allows for measurement and management of high intracranial pressure (ICP) and relieves obstructive hydrocephalus. Lumbar drainage (LD) also has a long history as CSF diversion method. It was first described in 1960 for reduction of intracranial pressure, treatment of hydrocephalus, and management of CSF leaks [2]. However, it only reemerged as an attractive modality for CSF drainage after SAH in 2004, following the observation of a striking reduction in rate of vasospasm in patients undergoing LD when compared with EVD or no CSF diversion [3]. Since then, observational studies corroborated this finding, and now, randomized trials and consecutive meta-analyses support the efficacy of LD as adjunctive therapy in the management of SAH [4–7]. In the recent EARLYDRAIN trial, prophylactic LD initiated within 72 h reduced secondary infarctions and improved 6-month outcomes across the whole range of SAH severity grades [5]. This constitutes the first therapeutic trial in the field of SAH resulting in improvement in outcomes, since the British Nimodipine trial in 1989 by Pickard and the ISAT collaborative establishing coiling as preferred method compared to clipping if both are feasible [8, 9]. Two meta-analyses conducted after EARLYDRAIN show that the use of LDs decreases vasospasm incidence and mortality without added morbidity [6, 7]. A trial sequential analysis further provided robust evidence to support the use of LD for risk reduction of secondary infarctions [10].

How is lumbar drainage different than external ventricular drainage?

In contrast to EVDs, LD promotes gravity-assisted drainage of blood products from basal cisterns and the spinal compartment—yielding a bloodier output and faster clearance of blood and breakdown products [11] (see Fig. 1). Communicating CSF pathways are a prerequisite for safe LD use. Compressed or absent basal cisterns, visible on CT, are a firm contraindication, as impaired CSF communication can precipitate downward brain displacement

*Correspondence: stefan.wolf@charite.de
[4] Department of Neurosurgery, Charité Universitätsmedizin Berlin, Corporate Member of Freie Universität Berlin, Humboldt-Universität zu Berlin and Berlin Institute of Health, Berlin, Germany
Full author information is available at the end of the article

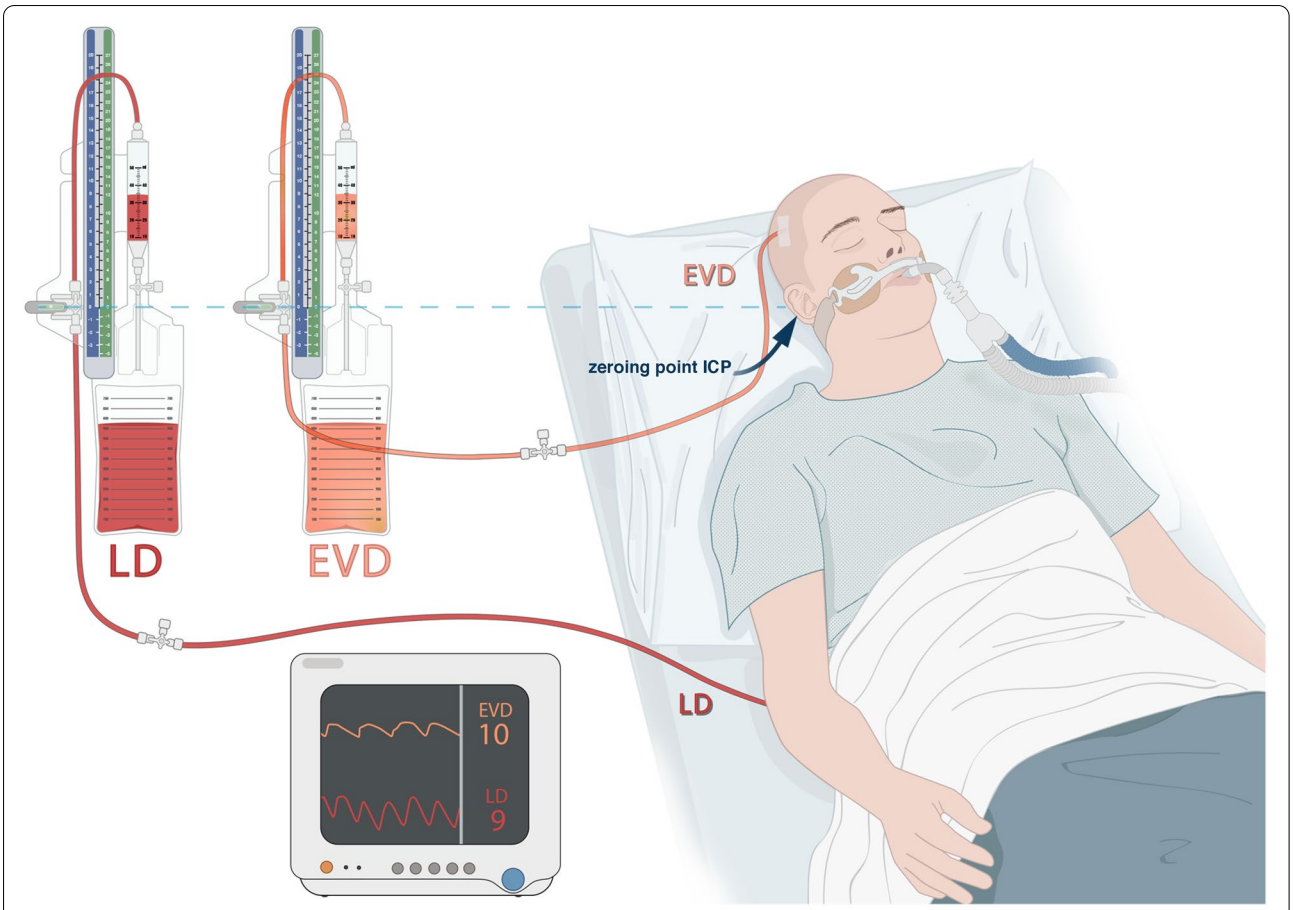

Fig. 1 LD is inserted with the patient in lateral decubitus to reduce the risk of abrupt initial overdrainage (compared with the sitting position). A dedicated lumbar catheter is introduced at the L3–L4 or L4–L5 interspace and advanced 10–20 cm into the subarachnoid space, and then connected to a closed sterile drainage system with an integrated pressure transducer. The transducer is zeroed at the level of the external auditory meatus to harmonize with standard intracranial pressure (ICP) monitoring. When pressure transducers are zeroed at the same level, similar EVD and lumbar ICP readings support CSF pathway patency, whereas a cranio-lumbar gradient > 5 mmHg suggests impaired CSF equilibration and constitutes a safety warning that should prompt immediate interruption of lumbar drainage. Contraindications include radiological and clinical features suggestive of obstructed CSF circulation or high herniation risk, such as compressed/absent basal cisterns or tonsillar descent, and space-occupying lesions. A high load of ventricular blood with suspected obstructive hydrocephalus warrants particular caution, as ventricular CSF may not equilibrate with the lumbar compartment, requiring meticulous gradient monitoring. Additional contraindications include coagulopathy/anticoagulation, local infection at the puncture site, systemic sepsis, aqueduct stenosis, and spinal deformities preventing safe placement. Stop criteria/safety considerations: LD must be paused immediately in case of neurological deterioration, new pupillary abnormalities, unexpected severe headache, or if the EVD–lumbar gradient exceeds 5 mmHg. Infection prevention: sterile insertion technique, minimal subsequent manipulation, and daily site inspection. Routine CSF sampling should be minimized, as excessive sampling increases infection risk and lumbar versus ventricular CSF composition may differ. Drains should remain in place only as long as clinically required (typically ≤ 7–14 days after ictus). As drain-related infections are predominantly associated with EVDs, EVD removal should be prioritized when no longer indicated

despite controlled ICP [12, 13]. As the prediction of open CSF pathways is difficult to be judged from imaging only, practical safety centers on monitoring the cranio-lumbar difference in ICP. This requires pressure transducers on both EVD and LD lines; with ventricular and lumbar pressures being equal according to the physical law of communicating pipes when CSF communication is present [14, 15]. It is essential to avoid creating a pathological downward pressure gradient, and lumbar drainage must be stopped if the difference exceeds 5 mmHg, indicating impaired CSF circulation.

A cranio-lumbar gradient > 5 mmHg is commonly used as a pragmatic safety cutoff in experienced centers. LD should also be avoided when intracranial pressure (ICP) exceeds 20 mmHg unless an EVD is in place and gradients are monitored. At current, no substitute for gradient monitoring is available, although

on-line analysis of pressure waveforms may represent a promising option [15]. In awake, closely monitored patients, lumbar drainage can often be managed without an EVD. In sedated or comatose patients, EVD-based monitoring is strongly recommended to detect an unsafe cranio-lumbar gradient.

EVDs are the appropriate measure for CSF diversion in obstructive hydrocephalus, global cerebral edema or space-occupying lesions limiting CSF communication between compartments. On the other hand, CSF drainage via EVD limits CSF circulation, and thus, the washout of blood products and toxins. Accordingly, higher drainage rates via EVD are related to worse outcome, contrary to a higher amount of drainage by LD [16]. Additionally, rates of chronic hydrocephalus have been reported higher for EVD-drainage than after LD [11, 17].

Independent of modality, drainage should be cautious when the aneurysm is unsecured, as rapid CSF removal can increase transmural aneurysmal pressure and precipitate rebleeding. Notably, the LUMAS trial found no increased risk of rebleeding, even though half of the patients received LD before aneurysm treatment [4].

Indications and drainage protocols

Ideal candidates for LD alone are good-grade patients (Hunt-Hess 1–3, WFNS 1–3) with a thick subarachnoid clot (modified Fisher grade 3 or 4) and patent basal cisterns on computed tomography (CT). Patients with suspected obstructive hydrocephalus or requiring mechanical ventilation due to coma or sedation should receive an EVD first, to address potentially elevated ICP.

LD may then serve as an adjunct to ventricular drainage, and combining LD with EVD has been reported to enhance clearance of subarachnoid blood [18].

Drainage protocols emphasize gradual and controlled CSF removal. Importantly, EARLYDRAIN was pragmatic: EVD placement followed clinical indication and local practice rather than a trial-mandated protocol.

In EARLYDRAIN, most patients were treated with intermittent drainage, removing 5–10 mL/h (120–240 mL/day) at the top of every hour, with the drain closed and lumbar ICP (and the EVD–LD pressure gradient, if present) monitored for the remainder of the hour. This rate effectively clears blood-stained CSF while balancing the risk of overdrainage. Lumbar ICP alarms generally mirror standard ICP thresholds (e.g., sustained ICP > 20 mmHg), while gradient-based stop criteria are emphasized.

The way forward

Lumbar CSF drainage is a physiologically grounded and evidence-based adjunct in SAH management. Its benefits are clearest in patients with thick cisternal clot and patent CSF pathways after definitive aneurysm treatment. Proper technique, controlled drainage protocols, meticulous monitoring, including lumbar–ventricular pressure gradients, and strict adherence to contraindications are essential to ensure safety. Integrated into comprehensive neurocritical care pathways, LD contributes to reduced DCI, fewer infarctions, and improved long-term outcomes. Beyond subarachnoid hemorrhage, the value of adjunctive LD is currently being investigated in patients with severe ventricular hemorrhage of non-aneurysmal origin (DRAIN IVH, NCT 06510842). A second ongoing RCT investigates the value of LD in ICP control after traumatic brain injury (ELASTIC, NCT 05889650). In summary, "The real voyage of discovery consists not in seeking new landscapes but in having new eyes" (Marcel Proust). It is time we open our eyes to the value of lumbar drainage.

Author details
[1] School of Medicine and Surgery, University of Milano-Bicocca, Milan, Italy. [2] NeuroIntensive Care Unit, Department Neuroscience, IRCCS Fondazione San Gerardo dei Tintori, Monza, Italy. [3] Department of Neurology, College of Medicine, McKnight Brain Institute, University of Florida, Gainesville, USA. [4] Department of Neurosurgery, Charité Universitätsmedizin Berlin, Corporate Member of Freie Universität Berlin, Humboldt-Universität zu Berlin and Berlin Institute of Health, Berlin, Germany.

Author contributions
Conceptualization: all authors. Writing—review & editing: all authors. All authors had full access to the text and take responsibility for its integrity and accuracy.

Funding
Open Access funding enabled and organized by Projekt DEAL.

Data availability
There was no data analysis presented in the paper. Therefore, a data availability statement is not applicable.

Declarations

Conflicts of interest
None of the authors have any conflicts to disclose related to the content of this article.

Ethical approval
This article does not report on primary data collected from human participants. All data cited and discussed are derived from previously published studies with appropriate ethical approval. No new patient data were collected or analyzed for this manuscript, and ethics approval was therefore not required.

Publisher's Note

Received: 29 November 2025 Accepted: 6 February 2026
Published online: 25 February 2026

References

1. Bandyopadhyay S, Schwendinger N, Jahromi BR et al (2025) Red Blood cells in the cerebrospinal fluid compartment after subarachnoid haemorrhage: significance and emerging therapeutic strategies. Transl Stroke Res 16:133–146. https://doi.org/10.1007/s12975-024-01238-9
2. Vourc'h G (1963) Continuous cerebrospinal fluid drainage by indwelling spinal catheter. Br J Anaesth 35:118–120. https://doi.org/10.1093/bja/35.2.118
3. Klimo P, Kestle JRW, MacDonald JD, Schmidt RH (2004) Marked reduction of cerebral vasospasm with lumbar drainage of cerebrospinal fluid after subarachnoid hemorrhage. J Neurosurg 100:215–224
4. Al-Tamimi YZ, Bhargava D, Feltbower RG et al (2012) Lumbar drainage of cerebrospinal fluid after aneurysmal subarachnoid hemorrhage: a prospective, randomized, controlled trial (LUMAS). Stroke J Cereb Circ 43:677–682. https://doi.org/10.1161/STROKEAHA.111.625731
5. Wolf S, Mielke D, Barner C et al (2023) Effectiveness of lumbar cerebrospinal fluid drain among patients with aneurysmal subarachnoid hemorrhage: a randomized clinical trial. JAMA Neurol 80:833–842. https://doi.org/10.1001/jamaneurol.2023.1792
6. Lee KS, Chari A, Motiwala M et al (2024) Effectiveness of cerebrospinal fluid lumbar drainage among patients with aneurysmal subarachnoid hemorrhage: an updated systematic review and meta-analysis. World Neurosurg 183:246-253.e12. https://doi.org/10.1016/j.wneu.2024.01.062
7. Musmar B, Abdalrazeq H, Roy JM et al (2025) Outcomes of external ventricular drainage and lumbar drainage in aneurysmal subarachnoid hemorrhage: a systematic review and meta-analysis. Int J Stroke Off J Int Stroke Soc. https://doi.org/10.1177/17474930251361211
8. Pickard JD, Murray GD, Illingworth R et al (1989) Effect of oral nimodipine on cerebral infarction and outcome after subarachnoid haemorrhage: British aneurysm nimodipine trial. BMJ 298:636–642. https://doi.org/10.1136/bmj.298.6674.636
9. Molyneux A, Kerr R, Stratton I et al (2002) International Subarachnoid Aneurysm Trial (ISAT) of neurosurgical clipping versus endovascular coiling in 2143 patients with ruptured intracranial aneurysms: a randomised trial. Lancet 360:1267–1274
10. Chen I-W, Lin H-J, Hung K-C (2024) Letter to the editor regarding "Effectiveness of cerebrospinal fluid lumbar drainage among patients with aneurysmal subarachnoid hemorrhage: an updated systematic review and meta-analysis." World Neurosurg 187:259–260. https://doi.org/10.1016/j.wneu.2024.04.134
11. Busl KM, Wolf S, Zanier ER, Citerio G (2025) Beyond pressure control: external ventricular drains, the glymphatic system, and brain pulsatility. Neurocrit Care. https://doi.org/10.1007/s12028-025-02401-2
12. Staykov D, Speck V, Volbers B et al (2011) Early recognition of lumbar overdrainage by lumboventricular pressure gradient. Neurosurgery 68:1187–1191. https://doi.org/10.1227/NEU.0b013e31820c0274. (**discussion 1191**)
13. Komotar RJ, Ransom ER, Mocco J et al (2006) Critical postcraniotomy cerebrospinal fluid hypovolemia: risk factors and outcome analysis. Neurosurgery 59:284–290. https://doi.org/10.1227/01.NEU.0000223340.89958.8D. (**discussion 284-290**)
14. Speck V, Staykov D, Huttner HB et al (2011) Lumbar catheter for monitoring of intracranial pressure in patients with post-hemorrhagic communicating hydrocephalus. Neurocrit Care 14:208–215. https://doi.org/10.1007/s12028-010-9459-6
15. Früh A, Wolf S, Wessels L et al (2023) Oscillation analysis as a supporting element toward safe and reliable lumbar catheter intracranial pressure monitoring. J Neurosurg 139:1180–1189. https://doi.org/10.3171/2023.1.JNS2336
16. Früh A, Truckenmüller P, Wasilewski D et al (2024) Analysis of cerebral spinal fluid drainage and intracranial pressure peaks in patients with subarachnoid hemorrhage. Neurocrit Care 41:619–631. https://doi.org/10.1007/s12028-024-01981-9
17. Zhou Y, Liu Z, Yan H et al (2025) Different cerebrospinal fluid drainage methods and chronic hydrocephalus in patients with aneurysmal subarachnoid hemorrhage. Front Neurol 16:1564927. https://doi.org/10.3389/fneur.2025.1564927
18. Palermo M, D'Arrigo S, Albanese A, Sturiale CL (2025) Enhancing cerebrospinal fluid clearance in subarachnoid hemorrhage: a systematic review of combined ventricular and lumbar drainage. J Clin Neurosci Off J Neurosurg Soc Australas 139:111442. https://doi.org/10.1016/j.jocn.2025.111442