



Rapid versus gradual external ventricular drain weaning: a general review of best practices

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Rapid versus gradual external ventricular drain (EVD) weaning methods have been widely debated, aiming to establish a standard clinical practice. The techniques used in each approach offer their own set of benefits and associated risks. Many published works continue to deliberate and dispute each other on the topic, as many believe gradual weaning is preferable due to its perceived potential to decrease ventriculoperitoneal shunt (VPS) dependency. In contrast, rapid weaning is known to have benefits such as a reduction in ventriculostomy-associated infections. Additionally, both weaning methods have been further debated due to the perception of the risks associated, which for gradual weaning includes a longer hospital stay. This literature review explores both sides of this debate, providing pros and cons to each weaning method to better unify the disconnect within the field. Based on the current research available, it is clear that due to a lengthy and more consistent list of benefits as well as overall decreased associated risks, rapid weaning is the superior form of EVD treatment method and should become the standard for clinical practice when performing EVDs on patients suffering from aneurysmal subarachnoid hemorrhages.

Keywords: External ventricular drain; Neurology; Neurosurgery; Weaning; Rapid weaning; Gradual weaning

INTRODUCTION

An external ventricular drain (EVD), is a method used to drain cerebrospinal fluid (CSF) from a patient in order to alleviate hydrocephalus and reduce increased intracranial pressures (ICP) [1]. This technique is often used in patients who have suffered from an aneurysmal subarachnoid hemorrhage (aSAH), as up to 37% of these patients develop chronic hydrocephalus [2,3]. Many patients with aSAH face long stays in the intensive care unit (ICU) [2,3]. With an increased risk of refractory hydrocephalus, a significant number of individuals require a permanent diversion

of CSF via a ventriculoperitoneal shunt (VPS) [2,3]. The management of the EVD for temporary CSF diversion influences the need for a VPS in some patients, the duration of ICU stay, and the likelihood of certain drain-related complications [4,5]. Despite the critical nature of EVD management, the most effective approach remains a topic of debate, with no consensus on the method that best enhances the safety of EVD discontinuation and minimizes the need for a VPS [2,6]. Currently, two primary techniques are employed: a gradual weaning process, which involves incrementally increasing the drainage resistance over several days, and a rapid weaning process, which entails promptly closing the

EVD [1-2,6].

Gradual weaning involves incrementally raising the drain height by 5 cm every 24 hours until it reaches a final level of 25 cm H₂O, with the drain being closed on day 4 [1,7]. The drain is typically re-opened only if the ICP > 20 cm H₂O for 5 minutes, the patient shows clinical signs of neurologic deterioration, or if the computed tomography brain scan on the following day shows hydrocephalus or ventricular enlargement [1,7]. In contrast, rapid weaning entails immediately closing the drain within 24 hours. Reopening the drain in this method also occurs only under the same conditions as mentioned above (i.e., ICP > 20 cm, neurologic deterioration, or hydrocephalus/ventricular enlargement) [1,7].

Elevated ICP is often a primary clinical indication for using an EVD, considering many essential factors such as compliance, hemodynamic strain, and metabolic dysfunction, among others. [8]. Compliance, in particular, is a crucial indicator of ICP, as a decrease in intracranial compliance (the cranial vault's adaptive ability to increase in volume) indicates an elevated ICP [8]. Compliance provides clinicians with an essential foundation for EVD use, as it is not only a highly reliable option for measuring intracranial compliance but also serves as a method for administering intrathecal drugs, such as antibiotics and thrombolytics, in addition to their drainage properties [9].

The current body of literature shows a lack of consensus on whether gradual or rapid weaning of CSF is the safest and most productive method for treating patients [10,11]. As things stand, many researchers and clinicians advocate for gradual weaning, highlighting its potential to decrease shunt dependency without increasing the risk of infections [10]. Many, however, believe that both approaches are comparable and possess desirable benefits and equal risks [2,6,12]. By a seemingly wide margin, many support the use of rapid weaning due to its apparent long list of benefits and a subsequent shorter list of associated risks, including decreased risk of meningitis and ventriculitis, better ventricular compliance, lower risk of infection, shortened hospital stays, lower treatment costs, and more [4,6,12]. Additionally, the current Neurocritical Care Society guidelines on EVD weaning states recommend that the process be completed as quickly as clinical conditions allow, in order to minimize the total duration of EVD monitoring and reduce the risk of ventriculostomy-related infections [4].

Arguably, a primary factor contributing to the differing opinions on EVD weaning in clinical practice is the risk of shunt requirement, a supplementary method for draining CSF, that introduces its own set of potential complications, such as pseudocysts, perforations, hernias, etc. [1,10]. In the event of the EVD being

unsuccessful, a feared complication is the potential for patients to become shunt-dependent after an aSAH [10]. This risk of shunt dependency is a central point of debate over the optimal EVD management strategy. The current literature on this topic is quite divided, with some articles explicitly stating that gradual weaning decreases shunt dependency, and others asserting that rapid weaning reduces shunt dependency [4,10]. This division has led to confusion among healthcare providers about the safest approach to EVD weaning for their patients. Given this situation, there is a need for an explicitly stated and agreed-upon method for EVD weaning, that should become established as standard practice, providing clinicians with a reliable guideline to follow.

GRADUAL WEANING

When determining the optimal management for acute brain injury, there is ongoing debate over specific treatments choices. Currently, this is particularly true for the use of EVDs in the management of subarachnoid hemorrhage (SAH). The two procedures at the center of the debate are gradual and rapid weaning of EVDs. EVDs have been a tool in the treatment of acute SAH for over 50 years, with many institutions traditionally favoring gradual weaning. However, the growing body of research suggests that gradual weaning may not always be the superior option [13].

Pros

One advantage of gradual weaning over rapid weaning is the reduced likelihood of shunt dependency [10]. Through multivariate analysis, one study found that patients undergoing gradual weaning were less likely to develop shunt dependency [10]. Symptomatic vasospasm and ventriculostomy-associated infections are also a concern for this treatment, yet there appears to be no significant difference in their incidence between gradual and rapid weaning [10]. Although one trial indicated that the length of stay (LOS) was longer for patients undergoing gradual weaning, the findings were not significant and did not favor one treatment modality over the other [2]. Another advantage of gradual weaning is linked to the increased time during which the EVD remains in place. Many physicians prefer to maintain the EVD inserted during the period of vasospasm following an aSAH [5]. The gradual weaning protocol offers more flexibility in managing the duration the EVD stays in, as it is progressively adjusted until full weaning is achieved.

Cons

Gradual weaning has been associated with a significant increase in the length of hospital stays compared to rapid weaning [2,12,14].

Longer hospitalizations are linked to increased mortality rates, adverse patient outcomes, and a considerable financial burden on both the patient and the hospital [15]. Gradual weaning also requires the EVD to be inserted for a longer period of time, which may lead to complications and a higher risk of EVD malfunction [1]. The same study that found gradual weaning to be associated with a lower risk of shunt dependency also reported that an incremental weaning protocol was more likely to result in secondary shunt placement after a successful initial weaning, further extending the hospital stay [10]. This increased risk of secondary shunt dependency requires adequate neurological care following hospital discharge [10]. While gradual weaning remains the standard protocol in most institutions, the accumulating evidence of potential complications may shift preference towards a rapid weaning protocol.

RAPID WEANING

Pros

Although gradual weaning has been the predominant choice among physicians, rapid weaning of EVDs may be a better alternative. One study highlighted rapid weaning's advantage over gradual weaning in terms of VPS placement. When comparing intermittent drainage and rapid weaning with continual drainage and gradual weaning, a significant reduction in the need for shunt placement was found, with insertion rates of 13% for rapid weaning versus 35% for gradual weaning [1]. Arguably the biggest difference between gradual and rapid weaning is the impact on the length of hospital stay. Multiple studies have demonstrated that rapid weaning significantly reduces the LOS in both the ICU and hospital in general [1,4,10]. Beyond reducing hospitalization time, rapid weaning has also been associated with a lower incidence of non-functioning EVD, showing a rate of 15% compared to the 30% observed with gradual weaning [1].

Another potential advantage of rapid weaning is an increased chance of successful removal of the drain [5]. Early removal of the drain can lead to a reduced duration for which patients require the EVD, resulting in shorter hospital and ICU stays, and with no deleterious effects on safety or clinical outcomes [5,12]. Although infections are a common concern for both rapid and gradual weaning protocols, one study showed that rapid weaning could decrease the risk of ventriculostomy-associated infections [5]. A multicenter observational study that reviewed practices across six neurocritical care units in the United States found that rapid weaning was associated with fewer EVD complications, a shorter ICU LOS by approximately 2.1 days, and lower rates of shunt placement [4].

Cons

Although much of the current research on this topic suggests that rapid weaning has advantages over gradual weaning, complications can still occur. While one study reported a decrease in ventriculostomy-associated infections with rapid weaning, the majority consensus indicates no significant benefit of rapid vs gradual weaning in the context of infection [1,10]. Additionally, rapid weaning may be associated with a higher likelihood of developing shunt dependency; however, most studies have reported non-significant differences in shunt dependency rates between the two approaches [10].

POTENTIAL CHALLENGES IN GRADUAL VERSUS RAPID WEANING

Similar to the challenges of gradual weaning, one potential issue with the rapid weaning protocol for EVDs is the need for shunt placement. Any patient who cannot tolerate weaning from an EVD will need a shunt [16]. While one prospective randomized control trial (RCT) found no significant differences in the rate of shunt placement between different treatments approaches [12], another multicenter study found that rapid weaning was associated with a decreased rate of shunt placement, indicating conflicting evidence in current research [4].

Another problem that physicians can face with respect to EVDs is morbidity. It has been found that a longer duration of EVD placement leads to a higher chance of unwanted health concerns, such as infection or recurrent hydrocephalus [17]. With this consideration, rapid weaning could potentially reduce the time an EVD is in place, thereby eliminating unwanted ICU complications, such as hemorrhage, meningitis, ventriculitis, brain abscess, empyema, and dislodgement [1,18]. However, comparisons between different weaning protocols have not shown a statistically significant difference in infection rates [10].

The medical community faces a challenge in identifying the definitive best practice for weaning EVDs: the lack of multicenter prospective studies. Most current research consists of RCTs confined to a single care center [1,2,12]. These studies yield results that are difficult to apply to a larger population. Thus, there is a need for more multicenter prospective studies to ascertain the most effective and efficient weaning method for EVDs [5].

DISCUSSION

Gradual EVD weaning has been the method of choice for decades, with many institutions favoring it due to its supposed lower risk of shunt dependency and possibly a reluctance to adopt the

newer rapid EVD weaning strategy. Indeed, a survey on EVD management approaches conducted in 2017 revealed that 78% of the participating institutions used a gradual weaning approach [19]. Although gradual weaning was found to be the predominantly preferred method, the steadfast belief in its superiority may not always align with the best practice or prove to be the most effective. Recent studies and clinical trials have introduced rapid weaning as a promising alternative that merits consideration from healthcare institutions, given its extensive benefits and comparatively few risks. To make well-informed clinical decisions, healthcare providers must understand both the medical complications and the outcomes associated with each EVD weaning method.

While both gradual and rapid EVD weaning are associated with complications, rapid weaning has fewer complications and, hence, should generally be the preferred method. Ventriculitis, a CSF infection within the ventricles, is a potential complication of EVD weaning [20]. A 2020 study supported by the American Heart Association, American Stroke Association, and National Institutes of Health further explored the rate of ventriculitis among patients who underwent gradual and rapid weaning and found that the rates of infection were significantly higher in patients undergoing gradual weaning [1]. Such a critical complication as ventriculitis, which can result from gradual weaning, demands careful attention from clinicians. If not adequately treated, ventriculitis can lead to neurological deterioration, hydrocephalus, and death [20]. Additionally, meningitis, cerebral abscesses, and subdural empyemas are other serious complications associated with gradual EVD weaning. Clinicians should be aware of these complications when choosing an EVD weaning approach [2,21]. Collectively, these findings underscore that rapid weaning is linked to a reduced complication rate and support its consideration as the preferred treatment method for EVD management.

For healthcare providers to decide on the most beneficial EVD approach for patients, it is crucial to balance complications against outcomes to achieve the best results. These outcomes include LOS in the hospital, LOS in the ICU/Neuro ICU, overall EVD duration, and EVD failure rate [1]. LOS in the hospital is an important outcome as not only does it minimize hospital-related complications, but also reduces costs for patients and institutions [22]. In an RCT of 81 aSAH patients who underwent either gradual or rapid weaning, those in the gradual weaning group spent an average of 2.8 more days in the ICU and 2.4 more days in the hospital compared to the rapid weaning group [12]. A similar difference in LOS was shown in pediatric patients in the neonatal ICU where average LOS was 14.1 days in the rapid weaning group and 16.9 days in the gradual weaning group [2]. A larger study of 200 aSAH patients who underwent EVD placement found that those

who had a rapid EVD weaning approach experienced shorter ICU LOS and shorter hospital LOS [1]. The study also concluded that the rapid EVD approach was associated with a shorter mean EVD duration, which substantially reduced the risk of a ventriculostomy-associated infection [1]. Together, these studies show that by reducing the overall LOS and the associated consequences, rapid weaning is a more efficient strategy compared to gradual weaning. Finally, it is important for clinicians to understand that the EVD system can fail due to mechanical issues, obstruction of the catheter, or a defect in the apparatus [23]. The rate of EVD failure is notably higher with gradual weaning, as the drain remains in place for 4 days or more, increasing the chance of mechanical issues such as tubing twists and shifts in the apparatus [1,7,18]. Rapid weaning minimizes the occurrence of these complications since the drain is removed within 24 hours, and it is associated with a substantially lower incidence of non-functioning EVD [1,7].

As discussed above, rapid EVD weaning is superior to gradual weaning for two primary reasons. First, it minimizes infectious complications, such as ventriculitis, meningitis, and abscess formation. Second, it improves patient outcomes by decreasing the ICU LOS, hospital LOS, overall EVD duration, and EVD failure rate. Given these advantages, rapid weaning is the favored approach in the field, as its benefits significantly outweigh the risks.

CONCLUSIONS

Undoubtedly, rapid weaning emerges as the superior and more efficient method for EVD weaning in numerous clinical scenarios. By being associated with an overall lower VPS placement rate, shorter hospital stay, decreased drain complications, improved functional outcomes, and better ventricular compliance, rapid weaning provides a long list of benefits that are simply not as prominently or consistently seen in gradual weaning. Almost every aspect reviewed here demonstrates numerous instances where rapid weaning should be the preferred method of EVD management. The literature is brimming with evidence to support this, as seen with lower EVD failure rates, reduced risk of infection, a higher chance of successful removal, and more. The prevailing belief among many institutions that gradual weaning is the better option is often contradicted by what is identified as best practice or most effective in numerous cases. With an increasing number of studies published each year, there is a clear shift that is firmly tipping the scales towards the recognition that gradual weaning may no longer be the most effective method. Rapid weaning should, unquestionably, become the standard clinical practice when managing EVDs in patients with aSAH over gradual wean-

ing, as there are an increased number of benefits for the patient and an overall reduction in risks that gradual weaning simply cannot match.

ARTICLE INFORMATION

Ethics statement

Not applicable.

Conflict of interest

No potential conflict of interest relevant to this article.

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