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## External ventricular drain management in neuro-intensive care units: a french survey

Béranger Beaufile

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UNIVERSITE DE MONTPELLIER  
FACULTE DE MEDECINE MONTPELLIER-NÎMES

**THESE**

Pour obtenir le titre de

**DOCTEUR EN MEDECINE**

Présentée et soutenue publiquement

Par

**Béranger BEAUFILS**

Le 9 septembre 2019

**"EXTERNAL VENTRICULAR DRAIN MANAGEMENT  
IN NEURO-INTENSIVE CARE UNITS: A FRENCH SURVEY"**

Directeur de thèse : Dr Kévin CHALARD

**JURY**

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## **INTRODUCTION**

The placement of an external ventricular drains (EVD) is the most performed neurosurgical procedure<sup>1</sup>. This device is widely used in neuro intensive care units (ICU) as a way of controlling acute hydrocephalus and monitoring intracranial pressure. Patients with diffuse subarachnoid haemorrhage (SAH) or intraventricular haemorrhage are almost always concerned by cerebrospinal fluid (CSF) removal using an EVD<sup>2,3</sup>.

However, despite their widespread use, catheter malposition, haemorrhage and ventriculostomy related infection (VRI) remain common complications of EVDs<sup>4</sup>. Previous studies have examined how to reduce these risks but have not provided strong conclusions about the best method for insertion and management of EVDs. For this reason, the Neurocritical Care Society published, in 2016, a consensus statement to address the absence of high level evidence and to suggest a thoughtful use of this device<sup>5</sup>.

However, considering the relative lack of comprehensive evidences, a previous American survey highlighted the expected discrepancies in the management of EVDs between institutions<sup>6</sup>. The heterogeneity of practices tends to persist and an optimal EVD management remains controversial. The aim of this study was to determine the baseline current clinical practices of EVD management in French neuro-ICUs.

## **MATERIALS AND METHODS**

An online survey (*Supplemental Data S1*) was used to determine the EVD management practices at the institutional level in twenty-five French neuro-ICUs registered to the “Association de Neuro-Anesthésistes-Réanimateurs de Langue Française” (ANARLF). A detailed survey with multiple-choice questions was sent to practitioners working in the neuro-ICUs. Only one response per institution was counted. The survey was designed in order to reflect the predominant approach of each unit to EVD management. In order to simplify the reading of this report, answers to some questions with the four choices *always*, *often*, *sometimes* and *never* were transduced in two

dichotomised categories: “YES” (*always* or *often*) and “NO” (*sometimes* or *never*). Detailed answers are available in *Supplemental Data S2*.

The survey contained twenty-three questions on four main topics: (1) overall use of EVDs; (2) maintenance practices and management of VRIs; (3) specific use of EVDs in patient suffering from a SAH and (4) EVD weaning. In part (1), respondents were asked whether the EVD was placed under general anaesthesia or not; whether they monitored the intracranial pressure (ICP) using the EVD or not; and which unit of measure was used to determine the EVD level (cm d’H<sub>2</sub>O or mmHg). In part (2), we examined the maintenance practices that could impact the incidence of a VRI (e.g. management of an EVD obstruction, injections on the EVD, sampling of CSF). In part (3), we were focused on specific adjustments of EVD in patients suffering from a SAH. Respondents were asked if they maintained the EVD open or closed in the situation of unsecured and secured aneurysm, at which level was positioned the EVD from the level of the tragus, if the drainage was continuous or intermittent and if they used a systematic intraventricular fibrinolytic therapy. In part (4), we studied EVD weaning criteria and the method used (rapid or gradual). Respondents were asked which clinical signs they were monitored during the weaning phase. They were also asked whether they performed a systematic CT scan to determine shunt dependency.

Answers were collected between November 2017 and January 2018. Individuals within each neuro-ICU were contacted based on prior communication with the last author or from their directory listing from the ANARLF. Implied consent was obtained by taking part in the survey. The survey was performed using the online software SurveyMonkey. In addition, we sent follow-up emails to non-respondents for up to two attempts. Analyses were performed using Microsoft Excel and GraphPad Prism.

## RESULTS

We received completed surveys from each of the 25 neuro-ICUs in France and Belgium for a response rate of 100% (*Supplemental Data S2*). The majority of responding institutions were university hospitals (23/25).

### **Part (1): Overall use of EVD**

In the situation where patients did not need sedation for other reason, 84% (21/25) of respondents still favoured EVD insertion under general anaesthesia versus local anaesthesia. In brain injured patients with a need for ICP monitoring, an EVD allows a monitoring of intraventricular pressure (IVP), which reflects ICP. In this case, 52% (13/25) favoured intermittent monitoring of IVP using a bypass transducer connected to the EVD whereas 44% (11/25) used a supplemental intraparenchymal transducer in order to have a continuous measure of ICP. The last institution used a continuous measure of IVP using a transducer integrated into the EVD. Eighty-four percent (21/25) of centres used cmH<sub>2</sub>O units rather than mmHg units to set the EVD drainage level from the level of the tragus.

### **Part (2): Maintenance practices and management of VRIs**

We retrieved, in this part of the survey, some details about habits and routines of institutions used to reduce the risk of VRIs. Firstly, we highlighted that 84% (21/25) of institutions never used antibiotic prophylaxis at the EVD insertion time. Secondly, practitioners were asked how they manipulated the EVD in case of an obstruction of the catheter: suction of the CSF at the distal or the proximal stopcock were performed by 24% (6/25) and 40% (10/25) of centres, respectively; injection of a saline solution was performed by 36% (9/25) of respondents and injection of fibrinolytic agents by 60% (15/25) of respondents. When the latter techniques were conducted and failed, one attitude made consensus: respondents mostly changed EVD (20/25, 80%). Thirdly, we pointed out that 68% (17/25) of institutions realized ad hoc CSF sampling in case of a VRI



suspicion whereas 32% (8/25) made systematic and periodic sampling of cerebral spinal fluid in order to screen for VRI occurrence.

Finally, when a VRI was diagnosed, approximately 68% (17/25) of centres systematically changed the intraventricular catheter (if a CSF drainage was needed).

### **Part (3): Specific use of the EVD in patients suffering from a SAH**

In this part, we focused on the use of EVDs in patients with a SAH. Adjustments of the EVD before aneurysm exclusion, after aneurysm exclusion and during the weaning phase were examined.

Concerning the type of drainage, 76% and 96% of institutions kept the EVD continuously opened before and after aneurysm exclusion, respectively (*Figure 1*). Other institutions used an intermittent drainage.

The EVD level of drainage changed throughout the hospitalisation (*Figure 2*). The mean level of drainage was  $17 \pm 3.46$  cmH<sub>2</sub>O from the level of the tragus before aneurysm exclusion and  $13 \pm 3.74$  cmH<sub>2</sub>O after aneurysm exclusion ( $p$ -value = 0,0013). During the weaning phase, the mean level was  $13.4 \pm 4.63$  cmH<sub>2</sub>O.

In the situation of an important intraventricular bleeding obstructing the third and fourth ventricles, 96% (24/25) of respondents did not administer an intraventricular fibrinolytic therapy systematically (56% *never* and 40% *sometimes*).

### **Part (4): EVD weaning**

#### *Weaning criteria*

Respondents defined the following conditions as incompatible with an EVD weaning: non-control of the intracranial hypertension (25/25, 100%), persisting high volume of CSF drained (19/25, 76%), persistence of blood in the subarachnoid space on a cerebral CT-scan (5/25, 20%) or a hematic aspect of the CSF drained (14/25, 56%).

During the weaning phase, physicians monitored the following clinical events: consciousness disorders (25/25, 100%), CSF leakage (22/25, 88%), headache (17/25, 68%), Transcranial Doppler abnormalities (15/25, 60%) and occurrence of pseudomeningocele (11/25, 44%).

Concerning medical imaging, 92% (21/25) of institutions performed a systematic cerebral CT-scan before EVD withdrawal: 44% after 24h of clamping and 44% after 48h (*Figure 3*).

#### *Gradual versus rapid weaning*

Gradual weaning consists in sequentially increasing the level of the drainage day after day; this is a multistep approach. Rapid weaning consists in immediately closing the EVD when the decision is taken. In this survey, 76% (19/25) favoured a gradual weaning versus 24% (6/25) a rapid weaning (*Figure 4*).

#### *Permanent shunt placement*

Eighty-four percent of respondents (21/25) did not systematically place a permanent shunt after the first weaning failure. However, a permanent shunt could be inserted without attempting EVD weaning for 68% of respondents (17/25), if conditions suggested that the EVD weaning would not be possible. Finally, physicians were asked which was the appropriate moment for inserting a permanent shunt. The appropriate delay considered by respondents was: 7 to 14 days for 16% (4/25) of them, 14 to 21 days for 52% (12/25) of them, 21 to 28 days for 28% (7/25) of them and more than 28 days for 4% (1/25) of them.

## **DISCUSSION**

The present survey represents the current practices concerning EVD management by neuro-intensivists in French neuro-ICUs. We observed an overall heterogeneity concerning the daily management of EVDs. These findings are similar to the latest American survey concerning the management of EVD in SAH<sup>6</sup>.

The management of the infectious risk is probably the most debated subject in the literature. The prevalence of VRIs is relatively important<sup>7</sup> but its management remains controversial.

An antibiotic prophylaxis is not recommended by the French Society of Anaesthesia and Intensive Care (SFAR) for the surgical insertion of an EVD<sup>8</sup>. However, such a prophylaxis is recommended by American guidelines<sup>9</sup>. In this survey, intensivists followed French national recommendations. Others answers concerning VRIs were heterogeneous. Definitions of contamination, colonization, ventriculitis and VRI has been proposed by Lozier et al.<sup>10</sup>. But, the debate on screening and a consensus definition of VRI still remains<sup>11</sup>. For example, a diagnosis can be made by systematic CSF sampling. An EVD care bundle, including routine daily CSF sampling, could lower the incidence of VRIs<sup>12</sup>. However, approximately 2/3 of the centres prefer to wait for a clinical suspicion of infection to sample CSF. This could be explained by the fact that, despite an intense research, no clear biomarker has been found<sup>13</sup>, unlike for community-acquired meningitis<sup>14</sup>.

Intraventricular fibrinolytic agents, administered via the EVD are intended to accelerate the clot lysis and to reduce the inflammatory response<sup>15</sup>. Their use was not a common practice in our survey. Studies have shown a safe use without leading to an improvement in the functional outcome<sup>16</sup>. It should remain a targeted therapy for a limited number of patients.

In this survey, we studied the EVD level of drainage set for patients suffering from a SAH. We observed that the level decreased over time. Before securing the aneurysm, the aim of the EVD is to control the acute hydrocephalus but can be associated with an increased risk of aneurysm rebleeding<sup>17</sup>. Drainage is thus kept at a low flow rate. After aneurysm exclusion, the drainage flow can be enhanced in order to lower the intracranial pressure. During the weaning phase, practices are more heterogeneous. This is probably due to the lack of evidence concerning weaning.

Concerning the type of drainage, we opposed continuous versus intermittent drainage. Most centres favoured a continuously opened drain before and after securing the aneurysm. Continuous drainage may limit blood in the subarachnoid space, which is associated with vasospasm<sup>18</sup>, thus theoretically decreasing the risk of delayed cerebral ischemia. Intermittent drainage may be more "physiological", by promoting the natural absorption of CSF. However, the literature is scarce concerning the subject. Moreover, a randomised controlled trial showed a benefit of intermittent drainage, with fewer drain complications such as haemorrhage, EVD malfunction and ventriculitis<sup>19</sup>.

Concerning the method of weaning, a gradual method was historically supposed to prevent long-term shunt placement in SAH. In 2004, Klopfenstein et al. showed that a rapid weaning could lead to a reduction in ICU and hospital lengths of stay, but there was no difference in the rate of permanent shunt placement<sup>20</sup>. However, most centres favoured a gradual weaning, even with the current evidence. Again, this discrepancy could be due to the lack of evidence.

In order to look for the recurrence of hydrocephalus during the weaning phase, centres monitored more or less the same clinical events and Transcranial Doppler. We suggest that the measure of third ventricle by transcranial ultrasonography could be useful in this situation. Indeed, Widehem et al. showed that sonography is reliable as CT to measure the third ventricle diameter in neuro ICU patients<sup>21</sup>.

The main force of our study was the number of participating centres, with a response rate of 100%. Thus, it may accurately represent current practices in neuro-ICUs in university hospitals of the ANARLF group. The representative value of our descriptive survey is strong.

However, some limitations must be underlined. Only intensivists were questioned, whereas other specialties also deal with EVDs (neurologists, neurosurgeons, neuroradiologists). Moreover, only

one person per centre replied to the survey. Results thus represent the practice of institutions and does not show differences between intensivists in a same centre.

## **CONCLUSION**

From EVD insertion to its weaning, we noticed some disparities concerning the management between centres. Different attitudes are sometimes contrary to the best available evidences.

Given the potential impact on the prognosis, EVDs are a central topic for randomised controlled trials in neuro-ICUs in the next few years. Once done, French or European recommendations are needed in order to standardise the use of EVDs.

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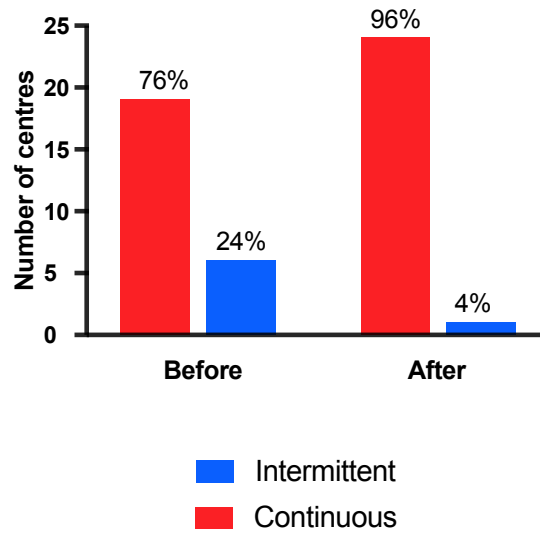
## **CONFLICTS OF INTEREST**

No conflict of interest

Preliminary results from this survey were presented at the 60<sup>th</sup> SFAR congress in september 2018.

## FIGURES

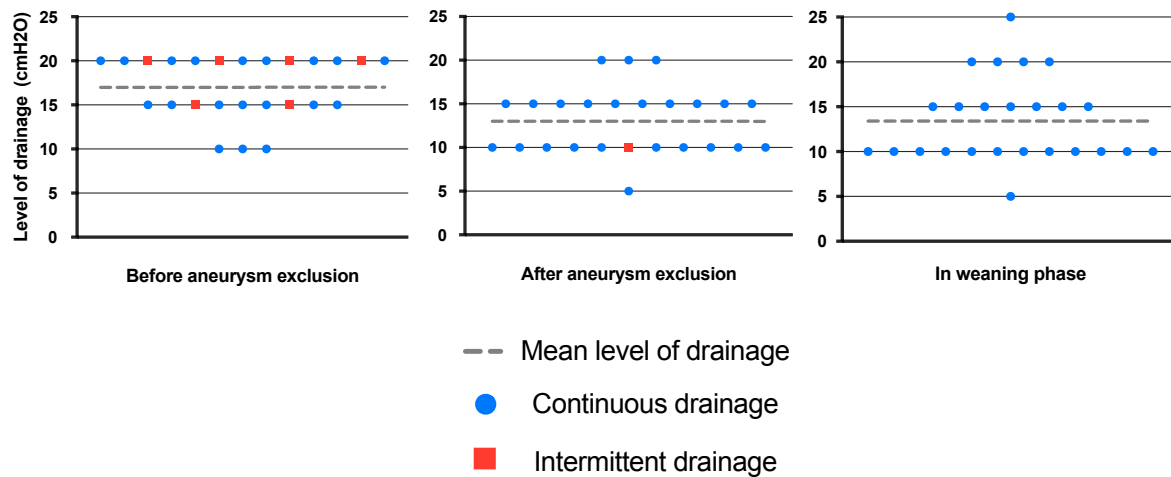
**Figure 1.** Type of drainage



The majority of neuro-ICUs used a continuous drainage and this proportion increased after aneurysm exclusion.

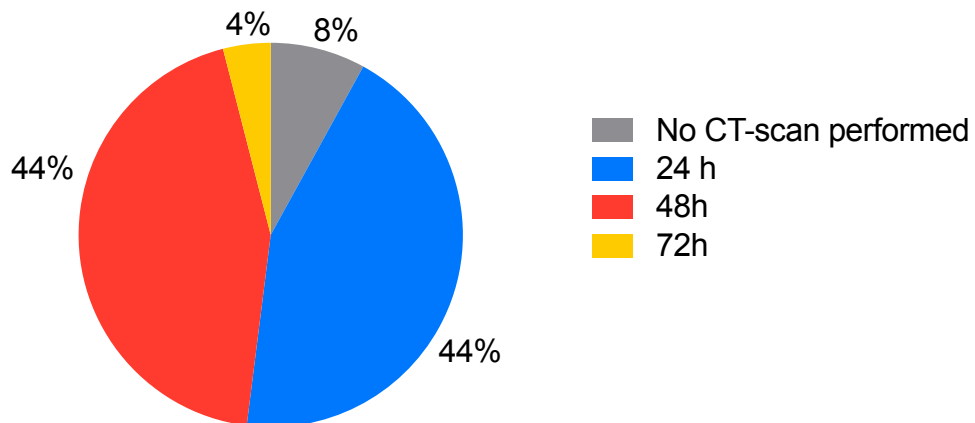


**Figure 2. Levels of EVD drainage set in patients with aneurysmal subarachnoid haemorrhage**



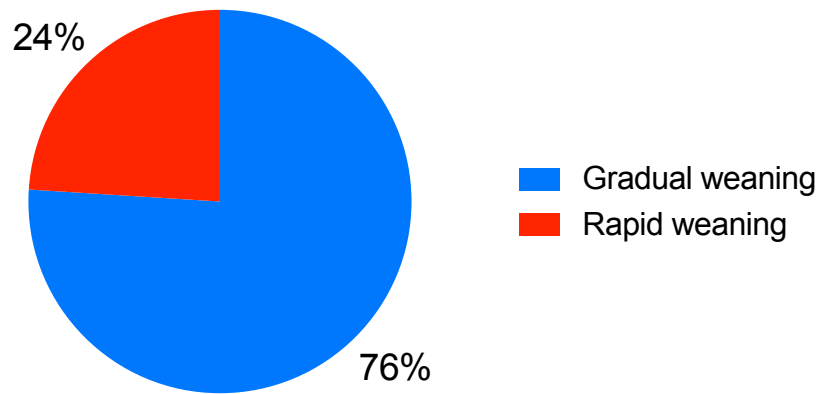
We noted a trend to lower the level of drainage throughout the hospitalisation. Before aneurysm exclusion, the mean level was  $17 \text{ cmH}_2\text{O} \pm 3.46 \text{ cmH}_2\text{O}$  and after aneurysm exclusion, the mean level was  $13 \pm 3.74 \text{ cmH}_2\text{O}$  ( $p\text{-value} = 0,0013$ ). During the weaning phase, the mean level was  $13.4 \pm 4.63 \text{ cmH}_2\text{O}$  and levels were more heterogeneous, varying from  $5 \text{ cmH}_2\text{O}$  to  $25 \text{ cmH}_2\text{O}$

**Figure 3. Delays between EVD clamping and CT scan control**



Ninety-two percent of centres performed a systematic cerebral CT-scan before EVD withdrawal, even without any clinical sign of hydrocephalus. Approximately one half performed the scan at 24 hours (44%) and the other half at 48 hours (44%).

**Figure 4: Type of weaning**



There are 2 opposite strategies in the timing of the weaning. Around 3/4 of centres favoured a gradual weaning, others institutions chose a rapid strategy.

## SUPPLEMENTAL DATA

### ***Supplemental data S1: e-mail survey***

#### **(1) Overall use of EVD**

- 1) In the situation where patients do not need sedation for another reason, how often do you perform EVD insertion under local anaesthesia (versus general anaesthesia)?
  - a. Never
  - b. Sometimes
  - c. Often
  - d. Always
- 2) In brain injured patients, which technique of ICP monitoring do you use?
  - a. None
  - b. Continuous monitoring of ICP by a supplemental intraparenchymal transducer
  - c. Intermittent monitoring of IVP with measurement of the height of the water column
  - d. Intermittent monitoring of IVP by a bypass transducer connected to EVD
  - e. Continuous monitoring of IVP by a transducer integrated into the EVD
- 3) Which unit do you use to set the EVD drainage level from the level of the tragus?
  - a. cmH<sub>2</sub>O
  - b. mmHg

#### **(2) Maintenance practices and management of VRI**

- 4) How often do you administer an antibiotic prophylaxis for an EVD insertion?
  - a. Never
  - b. Sometimes
  - c. Often
  - d. Always
- 5) In order to screen for VRI occurrence, do you perform periodic and systematic CSF sampling (more than once a week with no clinical sign of infection)?
  - a. Yes
  - b. No
- 6) When a VRI has been diagnosed and the patient still needs a continuous CSF drainage, do you systematically change the EVD?
  - a. Yes
  - b. No

- 7) When the drainage has become impossible (obstructed EVD), which action(s) do you take after checking the tubing, valves and clamps?
- Suction of CSF at the distal stopcock
  - Suction of CSF at the proximal stopcock
  - Injection of saline solution
  - Injection of fibrinolytic agents
  - EVD change in case of failure of the previous actions
  - Systematic EVD change without any of the previous actions

**(3) Specific use of EVD in SAH patients**

- 8) Before aneurysm exclusion, which drainage technique do you use?
- Continuous
  - Intermittent
- 9) After aneurysm exclusion, which drainage technique do you use?
- Continuous
  - Intermittent
- 10) Before aneurysm exclusion, when the EVD is opened, at which level from the level of the tragus do you set the drainage (in cmH<sub>2</sub>O)?
- 0
  - 5
  - 10
  - 15
  - 20
  - 25
- 11) Just after aneurysm exclusion, when the EVD is opened, at which level do you set the drainage (in cmH<sub>2</sub>O)?
- 0
  - 5
  - 10
  - 15
  - 20
  - 25

- 12) During EVD weaning phase, when the EVD is opened, at which level do you set the drainage (in cmH<sub>2</sub>O)?
- 0
  - 5
  - 10
  - 15
  - 20
  - 25
- 13) In the case of a SAH with an important intraventricular bleeding obstructing the third and fourth ventricles, how often do you administer an intraventricular fibrinolytic therapy?
- Never
  - Sometimes
  - Often
  - Always

**(4) EVD weaning**

- 14) Which item(s) seem incompatible with an EVD weaning trial?
- Persistence of an intracranial hypertension
  - Persistence of blood in the sub-arachnoid space on the cerebral CT scan
  - Clear drained CSF
  - Hematic drained CSF
  - High CSF protein concentration
  - Persisting high volume of CSF drained
- 15) Which item(s) do you monitor during the weaning phase?
- Consciousness disorders
  - Headaches
  - CSF leakage
  - Occurrence of pseudomeningocele
  - Haemodynamic parameters by Transcranial Doppler
- 16) Do you perform a systematic cerebral CT scan before EVD withdrawal?
- Yes
  - No

- 17) What is the optimal moment after clamping the EVD for performing this cerebral CT-scan?
- a. no systematic CT-scan
  - b. 24h
  - c. 48h
  - d. 72h
- 18) Which method of EVD weaning do you perform?
- a. Gradual
  - b. Rapid
- 19) In the case of a VRI diagnosis, which attitude do you have after 24 to 48 hours of efficient antibiotic therapy?
- a. Delayed weaning
  - b. Standard weaning
- 20) Do you insert a permanent shunt after the first weaning failure?
- a. Yes
  - b. No
- 21) In some cases, do you insert a permanent shunt without attempting an EVD weaning trial?
- a. Yes
  - b. No
- 22) Before inserting a permanent shunt, do you systematically sample CSF to measure the protein concentration?
- a. Yes
  - b. No
- 23) In the case of an EVD weaning failure, which period for inserting a permanent shunt seems appropriate?
- a. 7-14 days
  - b. 14-21 days
  - c. 21-28 days
  - d. > 28 days

## Supplemental data S2: detailed answers

Centre	OVERALL USE OF EVD	1) In the situation where patients do not need sedation for another reason, how often do you perform EVD insertion under local anaesthesia (versus general anaesthesia)?	2) In brain injured patients, which technique of ICP monitoring do you use?	3) Which unit do you use to set the EVD drainage level from the level of the tragus?
1		Sometimes	Intermittent monitoring of IVP by a bypass transducer connected to the EVD	cmH2O
2		Often	Intermittent monitoring of IVP by a bypass transducer connected to the EVD	cmH2O
3		Sometimes	Continuous monitoring of ICP by a supplemental intraparenchymal transducer	mmHg
4		Sometimes	Intermittent monitoring of IVP by a bypass transducer connected to the EVD	cmH2O
5		Sometimes	Continuous monitoring of ICP by a supplemental intraparenchymal transducer	cmH2O
6		Sometimes	Intermittent monitoring of IVP by a bypass transducer connected to the EVD	cmH2O
7		Never	Continuous monitoring of ICP by a supplemental intraparenchymal transducer	cmH2O
8		Never	Intermittent monitoring of IVP by a bypass transducer connected to the EVD	cmH2O
9		Never	Continuous monitoring of IVP by a transducer integrated into the EVD	cmH2O
10		Always	Continuous monitoring of ICP by a supplemental intraparenchymal transducer	cmH2O
11		Never	Intermittent monitoring of IVP by a bypass transducer connected to the EVD	mmHg
12		Sometimes	Continuous monitoring of ICP by a supplemental intraparenchymal transducer	cmH2O
13		Always	Intermittent monitoring of IVP by a bypass transducer connected to the EVD	cmH2O
14		Never	Continuous monitoring of ICP by a supplemental intraparenchymal transducer	mmHg
15		Sometimes	Continuous monitoring of ICP by a supplemental intraparenchymal transducer	cmH2O
16		Sometimes	Intermittent monitoring of IVP by a bypass transducer connected to the EVD	cmH2O
17		Sometimes	Continuous monitoring of ICP by a supplemental intraparenchymal transducer	cmH2O
18		Never	Intermittent monitoring of IVP by a bypass transducer connected to the EVD	cmH2O
19		Never	Intermittent monitoring of IVP by a bypass transducer connected to the EVD	cmH2O
20		Sometimes	Continuous monitoring of ICP by a supplemental intraparenchymal transducer	cmH2O
21		Sometimes	Intermittent monitoring of IVP by a bypass transducer connected to the EVD	mmHg
22		Often	Intermittent monitoring of IVP by a bypass transducer connected to the EVD	cmH2O
23		Never	Intermittent monitoring of IVP by a bypass transducer connected to the EVD	cmH2O
24		Never	Continuous monitoring of ICP by a supplemental intraparenchymal transducer	cmH2O
25		Never	Continuous monitoring of ICP by a supplemental intraparenchymal transducer	cmH2O



MAINTENANCE PRACTICES AND MANAGEMENT OF VRI	4) How often do you administer an antibiotic prophylaxis for an EVD insertion?	5) In order to screen for VRI occurrence, do you perform periodic and systematic CSF sampling (more than once a week with no clinical sign of infection)?	6) When a VRI has been diagnosed and the patient still needs a continuous CFS drainage, do you systematically change the EVD?
	Sometimes	No	Yes
	Never	Yes	Yes
	Never	No	Yes
	Never	No	No
	Never	No	Yes
	Never	No	No
	Never	Yes	No
	Never	No	Yes
	Never	Yes	Yes
	Never	Yes	Yes
	Sometimes	No	No
	Never	No	Yes
	Never	No	Yes
	Never	No	Yes
	Never	No	Yes
	Never	Yes	Yes
	Never	No	Yes
	Never	No	Yes
	Never	No	No
	Sometimes	No	Yes
	Never	No	Yes
	Always	Yes	No
	Never	No	No
	Never	Yes	Yes
	Never	Yes	No

7) When the drainage has become impossible (obstructed EVD), which action(s) do you take after checking the tubing, valves and clamps?						
Suction of CSF at the distal stopcock	Suction of CSF at the proximal stopcock	Injection of saline solution	Injection of fibrinolytic agents	EVD change in case of failure of the previous actions	Systematic EVD change without any of the previous actions	
X	X	X	X	X		
X		X	X	X		
		X		X		
			X	X	X	
X	X		X	X		
			X	X	X	
X					X	
X			X	X		
			X	X		
			X	X		
				X		
X		X		X		
		X		X		
		X		X		
			X	X		
		X		X		
				X		
	X	X	X	X	X	
	X		X	X		
	X		X	X		

SPECIFIC USE OF EVD IN SAH PATIENTS	8) Before aneurysm exclusion, which drainage technique do you use?	9) After aneurysm exclusion, which drainage technique do you use?	10) Before aneurysm exclusion, when the EVD is opened, at which level from the level of the tragus do you set the drainage (in cmH2O)?	11) Just after aneurysm exclusion, when the EVD is opened, at which level do you set the drainage (in cmH2O)?	12) During the EVD weaning phase, when the EVD is opened, at which level do you set the drainage (in cmH2O)?
	Continuous	Continuous	15	10	10
	Intermittent	Continuous	20	10	15
	Continuous	Continuous	20	15	20
	Continuous	Continuous	15	10	10
	Continuous	Continuous	15	10	10
	Intermittent	Continuous	15	15	10
	Continuous	Continuous	10	10	5
	Continuous	Continuous	20	20	10
	Continuous	Continuous	15	15	15
	Continuous	Continuous	20	10	10
	Intermittent	Continuous	20	15	15
	Continuous	Continuous	20	15	10
	Continuous	Continuous	20	20	20
	Continuous	Continuous	20	20	15
	Continuous	Continuous	20	15	15
	Continuous	Continuous	10	10	20
	Continuous	Continuous	15	15	15
	Continuous	Continuous	20	15	20
	Continuous	Continuous	20	15	25
	Continuous	Continuous	15	10	10
	Continuous	Continuous	10	10	10
	Intermittent	Intermittent	15	10	10
	Intermittent	Continuous	20	10	10
	Continuous	Continuous	15	5	10
	Intermittent	Continuous	20	15	15

13) In the case of a SAH with an important intraventricular bleeding obstructing the third and fourth ventricles, how often do you administer an intraventricular fibrinolytic therapy?	EVD WEANING	14) Which item(s) seem incompatible with an EVD weaning trial?						
		Persistence of an intracranial hypertension	Persistence of blood in the sub-arachnoid space on the CT scan	Clear drained CSF	Hematic drained CSF	High CSF protein concentration	Persisting high volume of CSF drained	
Sometimes		X			X		X	
Never		X					X	
Never		X					X	
Never		X					X	
Sometimes		X	X		X			
Never		X			X		X	
Never		X					X	
Never		X	X		X			
Never		X			X		X	
Never		X			X		X	
Sometimes		X			X	X	X	
Often		X	X		X		X	
Sometimes		X					X	
Never		X						
Sometimes		X	X		X			
Never		X					X	
Never		X			X		X	
Never		X			X		X	
Sometimes		X					X	
Sometimes		X			X			
Never		X						
Never		X			X		X	
Never		X			X		X	
Sometimes		X						
Sometimes		X			X			
Never		X			X		X	
Never		X					X	
Sometimes		X						
Sometimes		X	X		X		X	
Sometimes		X					X	

15) Which item(s) do you monitor during the weaning phase?				16) Do you perform a systematic cerebral CT scan before EVD withdrawal?	17) What is the optimal moment after clamping the EVD for performing this cerebral CT-scan?	18) Which method of EVD weaning do you perform?	
Consciousness disorder	Headaches	CSF leakage	Occurrence of pseudomeningocele	Haemodynamic parameters by Transcranial Doppler			
X	X	X	X		Yes	48h	Gradual
X		X		X	Yes	48h	Gradual
X	X	X	X	X	Yes	24h	Gradual
X				X	Yes	48h	Gradual
X	X	X	X		No	48h	Gradual
X		X		X	Yes	48h	Gradual
X	X			X	Yes	24h	Rapid
X	X	X		X	Yes	24h	Gradual
X	X	X			Yes	24h	Gradual
X		X	X		Yes	48h	Gradual
X	X	X	X		Yes	24h	Gradual
X	X	X	X	X	No	48h	Rapid
X	X	X	X	X	Yes	24h	Gradual
X		X		X	No	No systematic CT scan	Gradual
X	X	X			Yes	48h	Gradual
X	X	X	X	X	Yes	24h	Gradual
X		X	X		Yes	24h	Gradual
X	X	X		X	Yes	24h	Gradual
X	X	X		X	Yes	48h	Rapid
X		X	X	X	No	No systematic CT-scan	Gradual
X	X				Yes	48h	Gradual
X	X	X	X	X	Yes	24h	Gradual
X		X			Yes	48h	Rapid
X	X	X		X	Yes	72h	Rapid
X	X	X		X	Yes	24h	Rapid

19) In the case of a VRI diagnosis, which attitude do you have after 24 to 48 hours of efficient antibiotic therapy?	20) Do you insert a permanent shunt after the first weaning failure?	21) In some cases, do you insert a permanent shunt without attempting an EVD weaning trial?	22) Before inserting a permanent shunt, do you systematically sample CSF to measure the protein concentration?	23) In the case of an EVD weaning failure, which period for inserting a permanent shunt seems appropriate?
Standard weaning	No	No	Yes	14-21 days
Standard weaning	No	No	Yes	14-21 days
Standard weaning	No	No	No	14-21 days
Standard weaning	No	No	Yes	14-21 days
Standard weaning	No	No	Yes	14-21 days
Standard weaning	No	No	No	21-28 days
Standard weaning	No	Yes	No	7-14 days
Standard weaning	No	No	Yes	14-21 days
Standard weaning	No	Yes	Yes	21-28 days
Delayed weaning	No	Yes	Yes	21-28 days
Delayed weaning	No	No	Yes	14-21 days
Standard weaning	No	No	Yes	7-14 days
Standard weaning	No	No	Yes	14-21 days
Standard weaning	Yes	Yes	Yes	14-21 days
Standard weaning	Yes	Yes	No	14-21 days
Delayed weaning	No	No	No	14-21 days
Delayed weaning	No	No	Yes	21-28 days
Standard weaning	No	No	Yes	14-21 days
Standard weaning	No	Yes	Yes	14-21 days
Standard weaning	No	No	Yes	21-28 days
Standard weaning	No	No	Yes	21-28 days
Delayed weaning	No	No	Yes	> 28 days
Delayed weaning	Yes	Yes	Yes	7-14 days
Delayed weaning	No	No	Yes	21-28 days
Standard weaning	No	Yes	Yes	21-28 days
Delayed weaning	Yes	No	Yes	7-14 days

## SERMENT

- *En présence des Maîtres de cette école, de mes chers condisciples et devant l'effigie d'Hippocrate, je promets et je jure, au nom de l'Être suprême, d'être fidèle aux lois de l'honneur et de la probité dans l'exercice de la médecine.*
- *Je donnerai mes soins gratuits à l'indigent et n'exigerai jamais un salaire au-dessus de mon travail.*
- *Admis dans l'intérieur des maisons, mes yeux ne verront pas ce qui s'y passe, ma langue taira les secrets qui me seront confiés, et mon état ne servira pas à corrompre les mœurs, ni à favoriser le crime.*
- *Respectueux et reconnaissant envers mes Maîtres, je rendrai à leurs enfants l'instruction que j'ai reçue de leurs pères.*
- *Que les hommes m'accordent leur estime si je suis fidèle à mes promesses. Que je sois couvert d'opprobre et méprisé de mes confrères si j'y manque.*

## **ABSTRACT**

**Background and objective:** External ventricular drains (EVD) are widely used in neuro-intensive care units (ICU) but, in a relative deficiency of comprehensive evidences, heterogeneity of practices tend to persist and optimal EVD management remains controversial. In this study, we aimed to determine the baseline current practices of EVD management in French neuro-ICUs.

**Methods:** We conducted an online survey in the 25 neuro-ICUs registered to the “Association de Neuro-Anesthésistes-Réanimateurs de Langue Française” (ANARLF). Only one response was counted per institution. Answers from a 23-questions survey were collected from November 2017 to January 2018. We focused on 4 main topics: (1) overall use of EVD; (2) management of ventriculostomy related infections (VRI); (3) use of EVD in patients suffering from a subarachnoid haemorrhage (SAH) and (4) EVD weaning.

**Results:** The response rate was 100%. The majority of institutions used the same conditions for EVD insertion: placement under general anaesthesia (84% of respondents) and no antimicrobial prophylaxis use (84%). However, we found differences in the way to monitor intracranial pressure following EVD insertion: 52% of institutions used a bypass transducer connected on the EVD whereas 44% of them used a supplemental intraparenchymal transducer. We also showed strong heterogeneities concerning the screening of VRI: two-thirds of responders realized ad hoc cerebral spinal fluid sampling in case of VRI suspicion whereas the third left realized systematic and periodic sampling of cerebral spinal fluid. Concerning the EVD drainage in SAH, 76% kept the EVD continuously open before aneurysm exclusion and 96% after aneurysm exclusion. The institutions left used intermittent drainage. The EVD level of drainage changed with time course: mean level of drainage was  $17\pm 3.46$  cmH<sub>2</sub>O above the level of the tragus before aneurysm exclusion,  $13\pm 3.74$  cmH<sub>2</sub>O after aneurysm exclusion and  $13.4\pm 4.63$  cmH<sub>2</sub>O in the weaning phase. EVD weaning was done gradually most of the time (76%) and 92% of institutions performed a systematic CT-scan after EVD clamping.

**Conclusion:** From EVD insertion to EVD weaning, we noticed some disparities between institutions concerning EVD management. Given the potential impact on the prognosis, more trials are needed in order to standardize EVD use.

**MeSH Keywords:** external ventricular drain, neurocritical care, survey, subarachnoid haemorrhage



## RESUME

**Introduction :** La dérivation ventriculaire externe (DVE) est un dispositif grandement utilisé en neuroréanimation mais, dans un contexte de manque de données scientifiques fortes, une hétérogénéité des pratiques persiste et la gestion optimale de la DVE reste controversée. Dans cette étude, nous avons déterminé les pratiques actuelles concernant la DVE dans des neuroréanimations françaises.

**Matériels et méthodes :** Nous avons mené une enquête en ligne dans les 25 services de neuroréanimation membres de l'Association de Neuro-Anesthésistes-Réanimateurs de Langue Française (ANARLF). Une seule réponse était comptée par centre. Les réponses du questionnaire comportant 23 questions ont été collectées de novembre 2017 à janvier 2018. Nous nous sommes concentrés sur 4 sujets : (1) utilisation générale de la DVE; (2) gestion de la méningite nosocomiale; (3) utilisation de la DVE dans l'hémorragie sous-arachnoïdienne et (4) sevrage de la DVE

**Résultats :** Le taux de réponse a été de 100%. La plupart des services avaient les mêmes pratiques concernant la mise en place : insertion sous anesthésie générale (84% des centres), sans antibioprophylaxie (84%). Cependant, nous avons trouvé des différences concernant la manière de monitorer la pression intracrânienne : 52% des centres utilisaient un capteur de pression intégré au cathéter intraventriculaire alors que 44% utilisaient capteur intraparenchymateux supplémentaire. Nous avons également montré une forte hétérogénéité des pratiques à propos du dépistage de la méningite nosocomiale : 2 tiers des centres réalisaient des prélèvements de liquide céphalorachidien seulement en cas de suspicion clinique alors que l'autre tiers réalisait des prélèvements réguliers et systématiques sans point d'appel. Concernant le drainage dans l'hémorragie sous arachnoïdienne, 76% des centres laissaient la DVE ouverte de manière continue avant exclusion anévrismale et 96% après, le reste utilisant un drainage intermittent. Le niveau de drainage changeait au cours du temps : les niveaux moyens étaient de  $17 \pm 3.46$  cmH<sub>2</sub>O au-dessus du niveau du tragus avant exclusion anévrismale,  $13 \pm 3.74$  cmH<sub>2</sub>O après exclusion and  $13.4 \pm 4.63$  cmH<sub>2</sub>O dans la période de sevrage. Le sevrage de la DVE était effectué progressivement la plupart du temps (76%) et 84% des centres réalisaient un scanner cérébral systématique après le clampage.

**Conclusion :** de la mise en place au sevrage de la DVE, nous avons constaté des disparités entre les centres concernant la gestion de la DVE. Etant donné l'impact potentiel sur le pronostic, des essais supplémentaires sont nécessaires pour standardiser les pratiques.

**Mots clefs :** dérivation ventriculaire externe, neuroréanimation, enquête de pratique, hémorragie sous-arachnoïdienne