



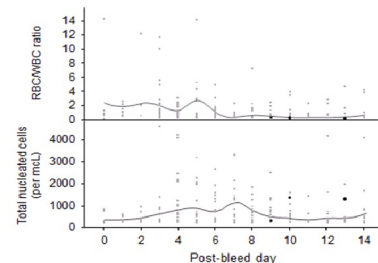
Introduction

Preferred detection of aneurysmal subarachnoid hemorrhage (aSAH) consists of head computed tomography (CT), followed by cerebrospinal fluid (CSF) analysis. There is no consensus for routine CSF analysis following temporary CSF diversion. Without established CSF parameters following aSAH, the clinical utility of CSF interpretation is unclear. CSF analysis is an established means to detect infection using gram stain and culture, but the utility of protein, glucose, total nucleated cell (TNC) and red blood cell (RBC) counts are unknown. Previous studies have shown elevated CSF levels of pro-inflammatory cytokines and biomarkers to be associated with delayed cerebral ischemia (DCI), but it is not known whether there is an association of DCI with the components of routine CSF values, such as: glucose, TNCs, RBCs, and protein. We sought to determine the diagnostic value of routine CSF analysis in the setting of aSAH.

Methods

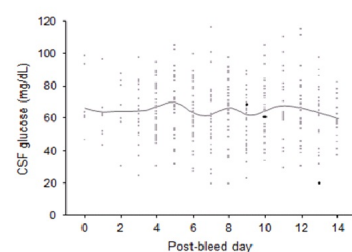
Retrospective review of consecutive adult patients diagnosed with aSAH from 1/2000 to 12/2013 at Mayo Clinic, Rochester, MN with cerebral aneurysm(s) identified by vascular imaging, and CSF drawn within 14 days of the date of hemorrhage. Primary outcomes assessed for were infection (meningitis/ventriculitis) and DCI.

TNC and TNC/RBC Ratio



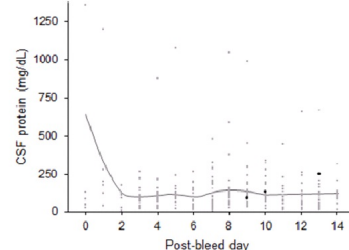
TNC over time and TNCs adjusted for RBC over time with infectious cases shown as black dots, gray dots indicating non-infections.

CSF Glucose



CSF glucose over time with black dots indicating infections.

CSF Protein



CSF protein over time with 3 infections shown as black dots.

Results

We identified 741 patients during the study period, 167 met inclusion criteria and 356 samples were collected. First Median CSF samples were taken 5 (4-8) days post-bleed. Indications for CSF samples varied: fever 81 (22.8%), altered mental status 79 (22.2%), new onset headache 56 (15.7%), development of a new neurological deficit 38 (10.7%) elevated peripheral white blood cell (WBC) count 17 (4.8%), surveillance 42 (11.8%) and undocumented 43 (12.0%). Ventriculitis, confirmed by growth of organism from CSF culture, present in 2 (1.2%) patients. One patient (0.6%) suffered post-hospitalization meningitis. CSF WBC count remained elevated throughout the 14 days, even when corrected for RBC. Peak CSF RBCs occurred 2-4 days post bleed, and then tapered toward normal limits. Maximum CSF RBCs did not correlate to modified Fisher grades ($p=0.42$). DCI was present in 86 (51.5%) patients and there was no difference in the CSF profile of patients with DCI compared with those without.

Conclusions

Routine CSF sampling for cell count and chemistry in the setting of temporary diversion following aSAH appears to have little clinical benefit beyond the evaluation for infection. Larger prospective studies would be needed to elucidate any diagnostic utility beyond CSF gram stain and culture.

CSF Profile with and without DCI

CSF Component	No DCI (n=81)	DCI (n=86)	p-value
Glucose	63.0 (49.8-73.3)	60.5 (48.3-76.8)	0.771
Protein	102.0 (55.8-158.0)	119.5 (68.5-214.8)	0.564
RBC	40000.0 (8215.0-90000.0)	25500 (5378.3-80000.0)	0.506
WBC	155.0 (55.0-568.0)	250.0 (50-910.0)	0.091
Neutrophils	64.0 (36.0-80.0)	70.0 (45.0-80.0)	0.261
Lymphocytes	15.0 (8.0-40.0)	15.0 (6.0-28.0)	0.096
Monocytes	12.0 (7.0-25.0)	13.0 (8-25.0)	0.624
Eosinophils	0(0-0)	0(0-1)	0.208

No significant difference was seen with the CSF profile of patients with and without the development of DCI.

Learning Objectives

By the conclusion of this session, participants should be able to:

- 1) Describe the limited importance of CSF analysis following SAH, except for infection analysis.
- 2) Discuss, in small groups, individual practice patterns at home institutions regarding CSF analysis following subarachnoid hemorrhage.
- 3) Identify an effective means of diagnosis and treatment for ventriculitis/meningitis following SAH.

References

1. Vergouwen MD, Vermeulen M, van Gijn J, Rinkel GJ, Wijndicks EF, Muizelaar JP, et al: Definition of delayed cerebral ischemia after aneurysmal subarachnoid hemorrhage as an outcome event in clinical trials and observational studies: proposal of a multidisciplinary research group. *Stroke*; 41:2391-2395, 2010
2. Zingale A, Ippolito S, Pappalardo P, Chibbaro S, Amoroso R: Infections and re-infections in long-term external ventricular drainage. A variation upon a theme. *J Neurosurg Sci* 43:125-133, 1999.
3. Pfisterer W, Mühlbauer M, Czech T, Reinprecht A: Early diagnosis of external ventricular