Available online at www.sciencedirect.com

ScienceDirect

journal homepage: www.JournalofSurgicalResearch.com

Intrathecal lactate predicting hydrocephalus after aneurysmal subarachnoid hemorrhage

Kuo-Chuan Wang, MD,[a,b] *Sung-Chun Tang, MD, PhD,*[c] *Jing-Er Lee, MD, PhD,*[d] *Jiann-Shing Jeng, MD, PhD,*[c] *Dar-Ming Lai, MD, PhD,*[a] *Sheng-Jean Huang, MD,*[a] *Sung-Tsang Hsieh, MD, PhD,*[c,e] *and Yong-Kwang Tu, MD, PhD*[a,*]

[a] *Division of Neurosurgery, Department of Surgery, National Taiwan University Hospital, National Taiwan University College of Medicine, Taipei, Taiwan*

[b] *Graduate Institute of Clinical Medicine, College of Medicine, National Taiwan University, Taipei, Taiwan*

[c] *Department of Neurology, National Taiwan University Hospital, National Taiwan University, College of Medicine, Taipei, Taiwan*

[d] *Department of Neurology, Taipei Medical University-Wan Fang Hospital, Taipei, Taiwan*

[e] *Department of Anatomy and Cell Biology, College of Medicine, National Taiwan University, Taipei, Taiwan*

ARTICLE INFO

Article history:
Received 30 May 2014
Received in revised form
29 August 2014
Accepted 18 September 2014
Available online 28 September 2014

Keywords:
Cerebrospinal fluid
Hydrocephalus
Lactate
Shunting
Subarachnoid hemorrhage

ABSTRACT

Background: Evidence shows possible benefits from continuous drainage by lumbar drain after aneurysmal subarachnoid hemorrhage (SAH). Under the hypothesis that compartmentalization occurs between the ventricle and subarachnoid space after massive SAH, this study aimed to evaluate the biochemical differences between ventricular and intrathecal cerebrospinal fluid (CSF) and assess the role of CSF lactate in shunt-dependent hydrocephalus (SDHC) after aneurysmal SAH.

Materials and methods: Patients with modified Fisher grade III/IV aneurysmal SAH who underwent early obliteration were evaluated. Intrathecal and intraventricular CSF were obtained on day 7 post-SAH to measure their biochemical composition in terms of total protein, glucose, ferritin, and lactate. The associations of SDHC with the clinical parameters and CSF data were analyzed.

Results: There were 28 patients (mean age, 55.4 y; males, 46.6%), including 18 (64.3%) with SDHC. Intrathecal CSF had significantly higher levels of total protein, ferritin, hemoglobin, and lactate but lower glucose level than intraventricular CSF (all $P < 0.0001$). By multivariate analysis of clinical and CSF parameters, elevated intrathecal CSF lactate ($P = 0.036$) and the presence of intraventricular hemorrhage ($P = 0.05$) were independent factors associated with SDHC. Moreover, intrathecal lactate >5.5 μM effectively predicted the occurrence of SDHC (odds ratio: 32, 95% confidence interval: 3.8–270.8; $P = 0.0015$).

Conclusions: By compartmentalization of the subarachnoid space after SAH, intrathecal lactate level is a useful predictive parameter for long-term SDHC in patients with aneurysmal SAH patients.

* *Corresponding author*. Division of Neurosurgery, Department of Surgery, National Taiwan University Hospital, 7 Chun-Shun South Road, Taipei 100, Taiwan. Tel.: +886 2 2312 3456x65078; fax: +886 2 23915292.

E-mail address: yktu@ntu.edu.tw (Y.-K. Tu).

0022-4804/$ – see front matter © 2015 Elsevier Inc. All rights reserved.
http://dx.doi.org/10.1016/j.jss.2014.09.022

1. Introduction

Shunt-dependent hydrocephalus (SDHC) is a frequent complication after aneurysmal subarachnoid hemorrhage (SAH), with a reported incidence of 6%–67% [1–4]. Its occurrence significantly affects long-term morbidity among survivors of SAH. Numerous associated factors have been reported, including age >50 y, female gender, high neurologic severity, large amount of blood in the subarachnoid space, intraventricular hemorrhage (IVH), acute hydrocephalus requiring external ventricular drainage (EVD), symptomatic vasospasm, and meningitis [4–7]. In addition to these clinical parameters, high cerebrospinal fluid (CSF) levels of ferritin or tenascin-C have been reported to be surrogate indicators for the occurrence of SDHC [8,9].

EVD is frequently used as initial treatment for acute hydrocephalus after SAH. However, evidence shows a higher complication rate in patients receiving continuous drainage from EVD [3]. Several studies also show decreased neurologic complication after SAH by continuous drainage through lumbar drain [3,4]. This study hypothesized that massive hemorrhage within the subarachnoid space may obstruct CSF outflow to the subarachnoid space and fresh CSF will no longer be flushed into the subarachnoid space though the openings in the fourth ventricle. Hematoma metabolism and inflammation reaction must be separated between the ventricles and subarachnoid space. As such, the subarachnoid space may be compartmentalized and intrathecal CSF maybe more representative of the microenvironment of the subarachnoid space than intraventricular CSF.

The level of CSF lactate increases after anaerobic metabolism in cells of the central nervous system (CNS) [10,11]. It may also increase if the red blood cells in the subarachnoid or ventricular spaces increase secondary to head trauma or SAH [12]. Studies from the clinical or basic aspect suggest that the degree of CSF lactic acidosis is an important biomarker of outcome in a variety of neurologic and neurosurgical diseases [11,13,14]. In SAH, high CSF lactate in the acute stage has been associated with the occurrence of vasospasm [15,16] but its role in the development of SDHC has not been investigated. If the subarachnoid space is compartmentalized after SAH, lactate may accumulate. This study aimed to determine the biochemical differences between ventricular and intrathecal CSF and the relationship between CSF lactate and SDHC in patients with modified Fisher grades III and IV aneurysmal SAH.

2. Materials and methods

2.1. Patients

Patients with modified Fisher grades III and IV angiography-confirmed aneurysmal SAH and aged 18–80 y were enrolled. The exclusion criteria were patients with arterial dissection or infectious aneurysm, massive IVH in the third and fourth ventricle causing obstructive hydrocephalus, massive intracerebral hemorrhage (defined as >30 mL) or brain edema causing uncal herniation, documented meningitis or brain tumor, end-stage renal disease, and spinal cord tumor or previous spinal surgery.

This study was approved by the National Taiwan University Hospital Committee on Human Research and conducted in accordance with the Helsinki Declaration of 1975. Each patient or a next of kin of patients with decreased consciousness provided written informed consent.

2.2. Study design

Standard treatment of the SAH patients was provided by an integrated team that included neurosurgeons, neurointensivists, and interventional neuroradiologists. The management protocol consisted of resuscitation, early surgical or endovascular obliteration of the aneurysm, aggressive management of intracranial pressure (ICP), comprehensive intensive care, and aggressive medical or endovascular therapy for vasospasm. An EVD was inserted during operation for CSF drainage to assist the surgery. For cases of severe acute hydrocephalus with impaired consciousness, an EVD was inserted before angiography. ICP was monitored through the EVD, which was released only with signs of increased ICP.

Patients were monitored postoperatively in the neurointensive care unit. Transcranial color-coded sonography examination was performed daily to detect vasospasms. Head computed tomography or conventional angiography was performed once vasospasm was suspected on transcranial color-coded sonography [17,18] or if there was neurologic deterioration. Chronic hydrocephalus was defined as clinical deterioration with no detectable cause other than hydrocephalus occurring after day 14 posthemorrhage and with progressively increased ventricular size and the Evans index became greater than 0.30 [19]. Chronic hydrocephalus was treated with ventriculoperitoneal (VP) shunting. Clinical outcome was evaluated using the Glasgow Outcome Scale at 3 mo after the onset [20]. Glasgow Outcome Scale ≤3 was defined as an unfavorable functional outcome.

2.3. CSF sample collection, preparation, and analysis

Ventricular CSF was obtained via the EVD on day 7 post-SAH. Lumbar puncture was performed on the same day to obtain intrathecal CSF. The concentrations of proteins, glucose, and lactate in the CSF samples were determined using an automatic chemistry analyzer. The level of ferritin was determined by quick auto-neo-Fe (K) (Toshiba-2000FR; Toshiba, Tokyo, Japan). The concentration of oxyhemoglobin was determined by spectrophotometry. Briefly, the CSF samples were measured three times at each wavelength (A577 and A630), and the mean values of the measurements were used to calculate the oxyhemoglobin concentrations.

2.4. Statistical analysis

Statistical analyses were performed using the SAS software, version 9.1.3 (SAS Institute Inc, Cary, NC). Statistical significance was set at a two-sided $P \leq 0.05$. The distributional properties of continuous variables were expressed as mean ± standard deviation and interquartile range, whereas