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CLINICAL IMAGING

Cerebral pulsatility index by transcranial Doppler sonography predicts the prognosis of patients with fulminant hepatic failure

Manri Kawakami, Masahiko Koda*, Yoshikazu Murawaki

Second Department of Internal Medicine, Faculty of Medicine, Tottori University School of Medicine, Nishimachi 36-1, Yonago 683-8504, Japan

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Abstract

Aim: Cerebral hemodynamic derangement is well known in patients with fulminant hepatic failure. The advent of transcranial Doppler sonography (TCD) enabled noninvasive observation of cerebral hemodynamics. To evaluate its clinical usefulness, we examined longitudinal cerebral hemodynamic parameters in patients with fulminant hepatic failure and severe acute hepatitis. **Methods:** The six subjects were four patients with fulminant hepatic failure, one with severe acute hepatitis and one with severe acute exacerbation on chronic hepatitis. The pulsatility indices of the right middle cerebral artery were used as parameters of cerebral hemodynamics. **Results:** The pulsatility indices of the two patients with a deteriorating course had elevated to >1.00, whereas those of the two patients undergoing recovery were within normal limits, as well as of the patients with acute hepatitis or acute exacerbation on chronic hepatitis. **Conclusion:** Cerebral pulsatility measured by TCD may be a real-time and useful tool to assess and monitor patients with fulminant hepatic failure.

Keywords: Cerebral pulsatility index; Transcranial Doppler sonography; Fulminant hepatic failure

1. Introduction

Acute liver failure rapidly develops cerebral dysfunction including hepatic encephalopathy and cerebral edema. Cerebral edema is reported to occur in more than 80% of patients with hepatic fulminant failure, which is associated with a high mortality rate [1]. However, to evaluate intracranial pressure (ICP), the direct implanting of ICP monitoring devices is involved, which carries a risk of hemorrhage [2]. Recently, transcranial Doppler sonography (TCD) as one of the neuromonitoring systems has become available to help evaluate intracranial disease. TCD is a noninvasive and bedside procedure, which was validated for the measurement of cerebral blood flow [3–6]. We have reported that patients with liver cirrhosis have a higher vascular resistance according to the severity of liver diseases and hepatic encephalopathy [7]. Furthermore, patients with fulminant hepatic failure have been reported to have a cerebral hypoperfusion pattern and an increased pulsatility index [8,9]. TCD monitoring is less invasive and safer than direct ICP monitoring. In this paper, we have reported that TCD is useful to assess the severity and predict the prognosis of patients with fulminant hepatic failure.

2. Patients and methods

2.1. Patients

The present study included four consecutive patients with fulminant hepatic failure, one patient with acute hepatitis and one patient with acute exacerbation of chronic hepatitis, who were admitted to our hospital. Severe acute hepatitis and severe acute exacerbation of chronic hepatitis were defined as having a prothrombin time <40% and no distinct hepatic encephalopathy. None of the patients in this study were hypoglycemic or treated with sedatives before the appearance of hepatic encephalopathy.

* Corresponding author. Second Department of Internal Medicine, Faculty of Medicine, Tottori University, Nishimachi 36-1, Yonago 683-8504, Tottori, Japan. Tel.: +81 859 38 6527; fax: +81 859 38 6529.
E-mail address: masakoda@grape.med.tottori-u.ac.jp (M. Koda).

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2.2. Transcranial Doppler sonography monitoring

Flow velocities in the middle cerebral artery were measured using TCD as follows: the subjects were rested in a supine position and cerebral hemodynamics measurements were carried out by the same observer (MK) by using a duplex Doppler apparatus with color Doppler sonographer and a 2.5-MHz convex transducer (sonolayer SSA-260 A; Toshiba Medical Systems, Tokyo, Japan). The right middle cerebral artery was identified through the temporal ultrasound window with color Doppler ultrasonography (Fig. 1). The sampling volume of the pulsed Doppler system was placed in the right middle cerebral artery at a depth of 45–60 mm, and correlation for the angle of insonation by alignment of a cursor along the direction of blood flow was performed. Velocity measurements were taken from arterial segments in which the vector of blood flow relative to the ultrasound beam was less than 60. The peak systolic velocity, end-diastolic minimum velocity, and time-averaged mean velocity were determined. The pulsatility index was automatically calculated according to the following formula:

$$\text{Pulsatility index} = (\text{peak systolic velocity} - \text{end-diastolic minimum velocity}) / \text{time-averaged mean velocity}.$$

To minimize measurement error, we performed measurements at least seven times and expressed each result as the average of five values excluding maximal and minimal values. To examine the reproducibility of TCD, a single observer (MK) measured the TCD parameters of the middle cerebral artery in the early morning every day for 3 days. The coefficient of variation was 18% for mean cerebral blood velocity and 5% for the cerebral pulsatility index. We found that the cerebral pulsatility index was more reproducible compared with cerebral blood velocity.

3. Results

The clinical courses of the six patients (Cases 1–4: fulminant hepatic failure; Cases 5 and 6: severe acute hepatitis) are shown in Figs. 2–4. Among the four patients with fulminant hepatic failure, two patients (Cases 1 and 2) died (Fig. 2) and two were successfully treated (Fig. 3). Among the recovered patients, one patient (Case 3) underwent transplant on the third day after admission. The standard value (mean±2 S.D.) of the pulsatility index from 25 healthy controls was 0.53–0.97, shown as a dotted area in Figs. 2–4. The two deteriorating patients had elevated pulsatility indices >1.00 (Fig. 2). On the other hand, the pulsatility indices of the two recovering patients were elevated according to the severity of liver function, but not beyond normal limits during the clinical course. The two patients with severe hepatitis with maintained prothrombin time <40% are shown in Fig. 4. Their pulsatility indices were within normal limits during clinical course.

4. Discussion

Cerebral autoregulation is due to the reactive dilatation or constriction of cerebral resistance vessels as a response to alterations in cerebral perfusion pressure. Within a wide range of arterial blood pressure values, cerebral blood flow

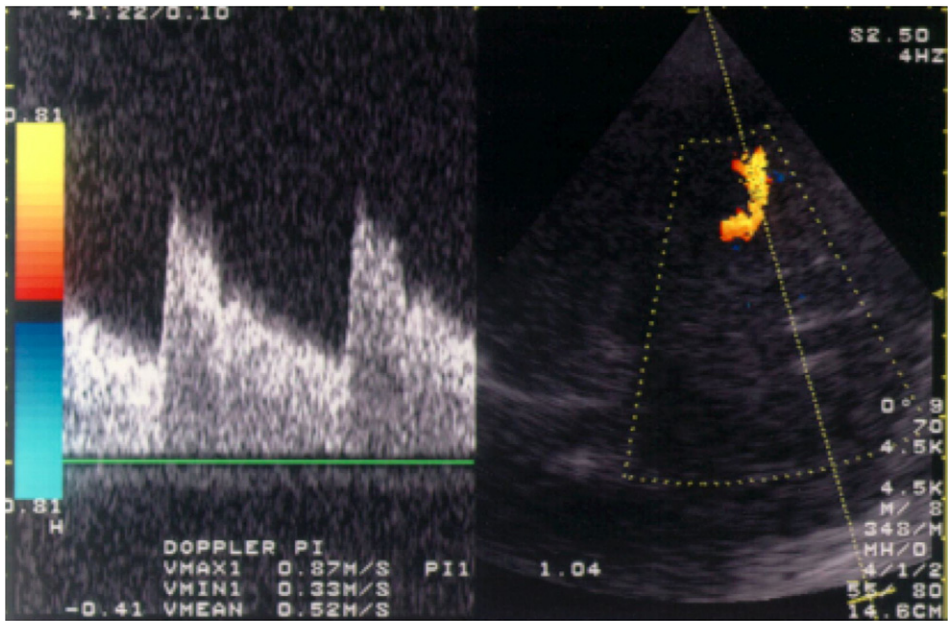

Fig. 1. The image on the right shows the sampling volume positioned within the middle cerebral artery for color Doppler ultrasonography. That on the left shows the time–velocity waveform.