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Can the optic nerve sheath diameter in brain magnetic resonance imaging be a predictor of elevated intracranial pressure?

Jeongho Kang[1], Woo Jeong Kim[1], Young Joon Kang[1] , Su Jin Kim[2]

[1] Department of Emergency medicine, Jeju National University Hospital, Jeju, Republic of Korea,
[2]Department of Emergency medicine, Korea University Hospital, Seoul, Republic of Korea
{Youngjoon.Kang}jedarm@jejunu.ac.kr

Abstract.
Elevated intracranial pressure (EICP) is important cause of the mental change. Recent studies by using ultrasound show that optic nerve sheath diameter (ONSD) increase in the patients with EICP. We compared the diameter of optic nerve sheath and mass effect in the magnetic resonance image (MRI). In the T1 weighted image, we measured the optic nerve sheath diameter at the 3 ㎜ posterior of eye glove. 31 patients were involved. 14 patients showed mass effect and were suspicious of EICP. 17 patients showed no mass effect. Based on MR imaging, ONSD of the group with suspicious EICP show 5.06mm±0.55 (Rt), 5.16±0.56mm (Lt) but ONSD of the group with less suspicious EICP show 4.54±0.56mm (Rt), 4.35±0.75mm (Lt). The increase of optic nerve sheath diameter can be a sign of elevated intracranial pressure.

Keywords: Optic nerve sheath diameter, elevated intracranial pressure

1. Introduction

The incidence of mental change in emergency department population is estimated that 10 to 25 percent of elderly hospitalized patients.[1] The causes of mental change are divided to intracranial and extracranial causes. The extracranial causes are metabolic, infectious, cardiac disease and toxin.[2] The intracranial causes are vascular, infectious disease and neoplasm. The metabolic causes such as hypoglycemia, drug intoxication can be diagnosed by glucometer, history taking, and intracranial cause such as hemorrhage, neoplasm can be confirmed by brain computed tomography or magnetic resonance imaging. But these imaging study require a hemodynamic stability and time, so the radiologic examinations are restricted in the stable patients. Elevated intracranial pressure (EICP) is the main cause in the patients with intracranial hemorrhage or neoplasm. The invasive procedures are required to detect the change of intracranial pressure (ICP), but these are difficult in the emergency room setting.

In recent studies, assessing the optic nerve sheath diameter in a patients with severe head injury, intracranial hemorrhage and neoplasm is useful tool for the detection of elevated intracranial pressure. Kho et al. asserted the measurement of optic nerve sheath diameter by ultrasound reflected the prognosis of the patients.[3] But our preliminary study showed the reproducibility and repeatability were low. Ballantyne et al. revealed the intra-observer variations and inter-observer variation in sonographic measurement were decreased after 17 examinations. [4]

2. Methods and materials

This was a retrospective review of Magnetic resonance imaging of patients with mental change in a year. 111 patients were examined the only diffusion MRI, so they were ruled out. 31 patients were involved. We measured the optic nerve sheath diameter at 3mm distant from the exit of optic nerve from the eye globe in a T1-weighted image.

The differences between patients with EICP and those with normal ICP were compared by using a two-tailed Wilcoxon rank-sum test.

3. Results

3017 patients visited emergency department because of mental change from Mars 2005 to December 2006. 142 patients were performed MRI. 111 patients among 142 patients were excluded because they were only diffusion MRI. 31 patients were involved. ONSD was measured by MRI in the both eyes of 31 patients.

3.1 Baseline characteristics

Male patients are 10, female are 21. Mean age was 62.2. The patients with elevated intracranial pressure were 14. The patients without elevated intracranial pressure were 17. Sex ratio and age were not different within two groups.

In a group of increased intracranial pressure, 13 patients had primary or metastatic cancer and a patient had intracranial hemorrhage. 10 patients had cerebral infarct, 3 patients had normal brain image, 4 patients had intracranial hemorrhage. (Table 1.)

Tab. 1 The comparison of mass effect and optic nerve sheath diameter in patients with mental change

Sex	Age	Cause of EICP	Mass effect	Rt optic sheath diameter (mm)	Lt optic sheath diameter (mm)
F	82	Metastatic cancer	+	4.69	4.69
M	69	Metastatic cancer	+	4.69	4.69
F	45	Metastatic cancer	+	5.47	5.93
M	78	meningioma	+	4.19	4.69
F	43	Metastatic cancer	+	6.29	6
F	69	metastatic cancer, multiple lymphoma	+	5.05	4.69
F	62	Subarachnoid hemorrhage	+	4.53	4.53
F	67	Metastatic cancer	+	5.46	5.46
F	55	Metastatic cancer	+	5.63	5.47
F	35	Metastatic cancer	+	4.69	5.93
F	74	Metastatic cancer	+	4.78	4.78
M	23	Metastatic cancer	+	4.78	4.69
F	51	Primary brain cancer	+	5.47	5.7
F	50	Metastatic cancer	+	5.05	5.05
F	71	Normal finding	-	5.47	5.05
M	74	cerebral Infarct	-	4.37	5.03
F	77	cerebral Infarct	-	5.87	5.49
M	5	Intracranial hemorrhage	-	3.49	3.98
M	57	cerebral Infarct	-	5.46	5.41
M	75	cerebral Infarct	-	3.75	3.35
F	71	Intracranial hemorrhage	-	5.05	4.89
F	80	cerebral Infarct	-	4.53	4.53
F	53	Intracranial hemorrhage	-	3.14	2.96
F	68	cerebral Infarct	-	4.45	4.69
F	72	Intracranial hemorrhage	-	4.04	3.56
F	57	Normal finding	-	4.14	4.37
M	68	cerebral Infarct	-	4.62	3.66
M	72	Normal finding	-	4.69	4.19
M	79	cerebral Infarct	-	4.53	3.75
F	73	cerebral Infarct	-	5.47	5.05
F	73	cerebral Infarct	-	4.19	4.01

3.2 Optic nerve sheath diameter

The right and left optic nerve sheath diameter of male patients were 4.45±0.55 and 4.34±0.66. The right and left optic nerve sheath diameter of female patients were 4.93 ±0.73and 4.90±0.78. The difference of right and left optic nerve sheath diameter within male and female were not significant. (p=0.82, p=0.63)

The mean diameter of right and left optic nerve sheath diameter in the patients with mass effect were 5.06±0.55mm, 5.16±0.56mm. But the mean diameter of right and left optic nerve sheath diameter in the patients without mass effect were 4.54±0.56mm, 4.35±0.75mm. Independent two samples T-test of right ONSD between EICP group and normal group was significant. (p=0.42) Independent two samples T-test of left ONSD between EICP group and normal group was significant. (p=0.02)

4. Discussion

ICP is the pressure inside the skull. EICP is a serious medical problem. Primary, EICP lead to damage brain tissue by changing cerebrospinal fluid flow. Secondary, brain herniation can occur. ICP is not constant range, coughing and sneezing can increase ICP 50~60 mmHg. It must measure during 24-48 hour for accurate ICP. ICP measurement by ventricular puncture is used most exactly and standard examination[5]. However, it is difficult in the case of ventricular narrowing. Also, ventricular catheter tip can be occlusion by choroid plexus or epithelial cells. Long term use of a ventricular catheter increase the infection risk. Recently, new measurement methods are being developed, for example subarachnoid screw or bolt, subdural cup catheter, fibrous epidural sensor etc. But It is necessary a less invasive and more fast method for emergency room environment[6].

Clinical features of EICP are headache, nausea or vomiting, papilledema, abducens nerve palsy, tinnitus and dizziness, abnormal breathing etc. Particularly, papilledema is optic disc swelling, it occur bilateral without infection sign in EICP condition. Cause of papilledema is congestion of central retinal vein because of elevated mechanical pressure to central retinal vein in EICP condition[7]. Optic neuritis or papilledema is most common complication of intracranial tumor. It occur because much cerebrospinal fluid in subarachnoid space that increase intracranial pressure[8]. Because EICP influence eye globe condition, so examination of alteration eye globe condition in unconscious patient can be diagnostic clue of EICP. Brodsky and Vaphiades suggest diagnostic factors of EICP by assay magnetic resonance image (MRI) of patients with pseudotumor cerebri[9]. Flattening of the posterior sclera and prelaminar enhancement are definite diagnostic factor of EICP. Also, Distension of the perioptic subarachnoid space, intraocular protrusion of the prelaminar optic nerve, vertical tortuosity of the orbital optic nerve are presumtive factors of ECIP. Gass etc report enlarged subarachnoid spaces around the optic nerves in MR image of benign intracranial hypertension patient[10],[11]. They suggest effectiveness of MRI for diagnosis and treatment of EICP.

Optic nerve sheath enclose optic nerve. Optic nerve sheath is composed three layer membrane, which is continuous with meninges. Each membranes are continuous with dura meter, subarchnoid membrane, pia meter from lateral to median. So Meningitis or encephalitis can easily extend to optic nerve. The optic nerve sheath is anatomically continuous with the dura mater, and has a trabeculated arachnoid space through which cerebrospinal fluid slowly percolates. Helmake and Hansen report that the optic nerve sheath diameter (ONSD) increased by up to 60% at a distance of 3 mm behind the globe compared with only 35% at 10 mm[12]. Therefore anterior optic nerve sheath is most influenced site by EICP. They validated the optic nerve sheath response to changing cerebrospinal fluid pressure. Subarachnoid pressure cannot be predicted exactly by single scan, because the change of optic

nerve sheath diameter are variable within a CSF pressure interval. [13]

The measurement of optic nerve sheath diameter is simple and noninvasive. If small probe is applied to patients who need intensive monitoring because of intracranial hemorrhage, it would be a good embedded patient monitoring system. [14]

5. Conclusion

In the MRI of unconscious patient, the optic nerve sheath diameter of the patient who have elevated intracranial pressure is significant increased than those of the patient who have non-elevated intracranial pressure.

So, optic nerve sheath diameter of unconscious patient can predict the increase of intracranial pressure.

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