

Bolus Injection 방법을 이용해서 측정한 정상 성인의 뇌척수액 배출저항*

김은영 · 박현선 · 정종권** · 진태경 · 김재중 · 박형천

= Abstract =

Resistance to Cerebrospinal Fluid Outflow Measured by Bolus Injection Method in Normal Adults

Eun-Young Kim, M.D., Hyun Sun Park, M.D., Chong Kweon Chung, M.D.,**
Tae Kyoung Jin, M.D., Jae Joong Kim, M.D., Hyung Chun Park, M.D.

Department of Neurosurgery, Anesthesiology, ** Inha University Hospital, College of Medicine,
Inha University, Incheon, Korea

Objectives : The measurement of resistance to cerebrospinal fluid outflow(R_o) can clearly delineate cerebrospinal fluid dynamics in patients with ventricular dilatation and can help in selecting patients to undergo shunt placement. With regards to type of infusion method, bolus injection is known to be more practical and safer than continuous infusion. The purpose of this study was to obtain R_o of normal adults using lumbar bolus injection method.

Material and Methods : Twenty adults aged 25 to 52 years were studied using lumbar bolus injection method. Fifteen patients with hemifacial spasm and five with cerebral concussion underwent R_o measurement under propofol general anesthesia and local anesthesia, respectively.

Results : The mean values of R_o determined 1 minute and 2 minutes after bolus injection were 4.8 ± 1.7 and 4.4 ± 1.6 mmHg/ml/min, respectively. There was no significant difference of R_o between propofol general anesthesia group and local anesthesia group. Two patients showed R_o greater than 6 mmHg/ml/min. One patient revealed unexpectedly high level of R_o due to severe spinal stenosis.

Conclusion : Mean R_o in this study was higher than that of Shapiro's study. Borderline R_o near 6 mmHg/ml/min should be regarded with caution and compared with clinical symptoms and results of other studies. Patients with severe spinal stenosis should be evaluated with caution.

KEY WORDS : Resistance to cerebrospinal fluid outflow · Hydrocephalus.

서 론

(normal pressure hydrocephalus)

3)5-7)16), 29), 9), 8)12), 13), 28), (cerebrospinal fluid dynamics) 4)5)14)18)19)21)23)24), 가¹⁰⁾ 60~74% 50% 3)7)20), 가 2)5)14)15)17-19)23) 가 (bolus injection) (continuous infusion) 2)5)15)17-19)21)23)24), 가 15)23-25)27), 가 15)17)23)25), 가 2)11),

2. 방 법 15 2microgram/kg fentanyl 2mg/kg propofol (nitrous oxide) 1 : 1 propofol 100 microgram/kg/min 5 20 3-way stopcock (manometer) (P₀, mmHg) 3~7ml (V, ml) 1ml/sec (P_p, mmHg) t (1 , 2 , 3) (P_t, mmHg) (pressurevolume index, PVI) (resistance to cerebrospinal fluid outflow, R₀) Mar- 18)19)23) 2
$$PVI = \frac{V}{\log \frac{P_p}{P_0}}$$

$$R_0 = \frac{t \times P_0}{PVI \times \log \left[\frac{P_t}{P_p} \times \frac{P_p - P_0}{P_p - P_0} \right]}$$

대상 및 방법

결 과

1. 연구대상 20 15 20 25 52 41

5~11mmHg, 8. 8 ± 1.2mmHg 3~7ml, 5ml 3 1 19 (PVI) 17~83.8ml, 27 ± 8ml 19 1 (R₀) 1.9~6.4mmHg/ml/min, 4.8 ± 1.7mmHg/ml/min, 2

Table 1. Results of resistance to CSF outflow in 20 patients

Patient category	Resistance to CSF outflow(R_o) (mmHg/ml/min)		
	R_o at 1 minute	R_o at 2 minute	R_o at 3 minute
Hemifacial spasm			
Case no.	1	1.7	1.7
	2	5.8	4.9
	3	2.5	1.9
	4	5.7	5.0
	5	5.9	5.4
	6	5.8	5.2
	7	5.8	5.3
	8	3.1	2.7
	9	5.8	5.0
	10	6.15	5.5
	11	3.0	2.2
	12	5.8	5.0
	13	2.1	1.7
	14	5.7	5.1
	15	6.4	5.6
Cerebral concussion			
Case no.	16	5.8	5.1
	17	2.0	1.9
	18	5.6	5.2
	19	5.9	5.4
	20	Failed	Failed
Mean \pm SD*	4.8 \pm 1.7	4.4 \pm 1.6	4.2 \pm 1.5

* : SD = standard deviation

(R_o) 1.7~5.72mmHg/ml/min,
 4.4 \pm 1.6mmHg/ml/min, 3
 (R_o) 1.7~5.6mmHg/ml/min, 4.2 \pm
 1.5mmHg/ml/min

가
 . 2 1
 6.4, 6.15mmHg/ml/min 6mmHg/
 ml/min (Table 1).

Propofol nitrous oxide 14
 5 1
 4.9 \pm 1.3mmHg/ml/min, 4.6 \pm 1.8mmHg/
 ml/min 가

3
 1 12
 42.9mmHg/ml/min .

20

고찰

가 2)5)14)15)17-19)23),
 (idiopathic) 가
 3)5-7)29),
 5)8)14)17)22)23),
 Glasgow Coma Scale 8
 44%가 1
 (>0.3),
 56% , 24%
 , 21% 가 26%

17).
 (arrested hydrocephalus)
 (compensated hydrocephalus)

4)27)30).
 가

가
 가

가
 ,
 4)27)30).

(con-
 tinuous infusion), (bolus injection)
 (cerebrospinal fluid space)

가

• : 2000 2 7
 • : 2000 6 29
 • :
 400 - 103 371 7 - 206
 : 032) 890 - 2373, 2370, 3507
 : 032) 890 - 2947
 E - mail : nskey@inha.ac.kr

References

- 1) Adams RW, Cucchiara RF, Gronert GA, Messick JM, Michenfelder JD : *Isoflurane and cerebrospinal fluid pressure in neurosurgical patients. Anesthesiology* 54 : 97-99, 1981
- 2) Albeck MJ, Skak C, Nielsen PR, Olsen KS, Bgesen SE, Gjerris F : *Age dependency of resistance to cerebrospinal fluid outflow. J Neurosurg* 89 : 275-278, 1998
- 3) Benzel EC, Pelletier AL, Levy PG : *Communicating hydrocephalus in adults : Prediction of outcome after ventricular shunting procedures. Neurosurgery* 26 : 655-660, 1990
- 4) Bird MT, Ratcheson RA, Seigel BA, Fishman M : *The evaluation of arrested communicating hydrocephalus utilizing cerebrospinal fluid dynamics : a preliminary report. Develop Med Child Neurol* 15 : 474-482, 1973
- 5) Boon AJ, Tans JT, Delwel EJ, Egeler-Peerdeman SM, Hanlo PW, Wurzer HA, et al : *Dutch normal-pressure hydrocephalus study : prediction of outcome after shunting by resistance to outflow of cerebrospinal fluid. J Neurosurg* 87 : 687-693, 1997
- 6) Boon AJ, Tans JT, Delwel EJ, Egeler-Peerdeman SM, Hanlo PW, Wurzer HA, et al : *Dutch normal-pressure hydrocephalus study : randomized comparison of low- and medium-pressure shunts. J Neurosurg* 88 : 490-495, 1998
- 7) Boon AJ, Tans JT, Delwel EJ, Egeler-Peerdeman SM, Hanlo PW, Wurzer HA, et al : *Dutch normal-pressure hydrocephalus study : the role of cerebrovascular disease. J Neurosurg* 90 : 221-226, 1999
- 8) Bradley WG Jr, Scalzo D, Queralt J, Nitz WN, Atkinson DJ, Wong P : *Normal pressure hydrocephalus : evaluation with cerebrospinal fluid flow measurements at MR imaging. Radiology* 198 : 523-529, 1996
- 9) Foltz EL, Aine C : *Diagnosis of hydrocephalus by cerebrospinal fluid pulsewave analysis : A clinical study. Surg Neurol* 15 : 283-293, 1980
- 10) Haan J, Thomeer RTWM : *Predictive value of temporary external lumbar drainage in normal pressure hydrocephalus. Neurosurgery* 22 : 388-391, 1988
- 11) Henriksson L, Voigt K : *Age-dependent differences of distribution and clearance patterns in normal RIHSA cisternograms. Neuroradiology* 12 : 103-107, 1976
- 12) Kitagaki H, Mori E, Ishii K, Yamaji S : *Spaces in idiopathic normal pressure hydrocephalus : morphology and volumetry. AJNR Am J Neuroradiol* 19(7) : 1277-1284, 1998
- 13) Kosteljanetz M, Ingstrup HM : *Normal pressure hydrocephalus : correlation between CT and measurements of cerebrospinal fluid dynamics. Acta Neurochir* 77 : 8-13, 1985
- 14) Kosteljanetz M, Nehen AM, Kaalund J : *Cerebrospinal fluid outflow resistance measurements in the selection of patients for shunt surgery in the normal pressure hydrocephalus syndrome. A controlled trial. Acta Neurochir* 104 : 48-53, 1990
- 15) Kosteljanetz M : *Resistance to outflow of cerebrospinal fluid determined by bolus injection technique and constant rate steady state infusion in humans. Neurosurgery* 16 : 336-340, 1985
- 16) Krauss JK, Droste DW, Vach W, Regel JP, Orszagh M, Borremans JJ, et al : *Cerebrospinal fluid shunting in idiopathic normal-pressure hydrocephalus of the elderly : effect of periventricular and deep white matter lesions. Neurosurgery* 39 : 292-300, 1996
- 17) Marmarou A, Foda MA, Bandoh K, Yoshihara M, Yamamoto T, Tsuji O, et al : *Posttraumatic ventriculomegaly : hydrocephalus or atrophy? A new approach for diagnosis using CSF dynamics. J Neurosurg* 85 : 1026-1035, 1996
- 18) Marmarou A, Shulman K, LaMorgese J : *Compartmental analysis of compliance and outflow resistance of the cerebrospinal fluid system. J Neurosurg* 43 : 523-534, 1975
- 19) Marmarou A, Shulman K, Rosende RM : *A nonlinear analysis of the cerebrospinal fluid system and intracranial pressure dynamics. J Neurosurg* 48 : 332-344, 1978
- 20) Meyer JS, Kitagawa Y, Tanahashi N, Tachibana H, Kandula P, Cech DA, et al : *Evaluation of treatment of normal-pressure hydrocephalus. J Neurosurg* 62 : 513-521, 1985
- 21) Park YK, Oh WS, Chong YG, Chung HS, Suh JK, Lee HK, et al : *Review of constant infusion method of cerebrospinal fluid outflow resistance study. J Korean Neurosurg Soc* 21 : 420-427, 1992
- 22) Portnoy H : *Comment. In Morgan MK, Johnston IH, Spittaler PJ : A ventricular infusion technique for evaluation of treated and untreated hydrocephalus. Neurosurgery* 29 : 832-837, 1991
- 23) Shapiro K, Marmarou A, Shulman D : *Characterization of clinical CSF dynamics and neural axis compliance using the pressure-volume index : I the normal pressure-volume index. Ann Neurol* 7 : 508-514, 1980
- 24) Sullivan HG, Miller JD, Griffith RL 3d, Carter W Jr, Rucker S : *Bolus versus steady-state infusion for determination of CSF outflow resistance. Ann Neurol* 5 : 228-238, 1979
- 25) Takizawa H, Gabra-Sanders T, Miller JD : *Validity of measurement of cerebrospinal fluid outflow resistance estimated by the bolus injection method. Neurosurgery* 17 : 63-66, 1985
- 26) Talke P, Caldwell J, Dodsont B, Richardson CA : *Desflurane and isoflurane increase lumbar cerebrospinal fluid pressure in normocapnic patients undergoing transspenoidal hypo-*

Bolus Injection

- physectomy. Anesthesiology 85 : 999-1004, 1996*
- 27) Tans JTJ, Poortvliet DCJ : *Comparison of ventricular steady-state infusion with bolus infusion and pressure recording for differentiating between arrested and non-arrested hydrocephalus. Acta Neurochir 72 : 15-29, 1984*
- 28) Vanneste J, Augustijn P, Davies GA, Dirven C, Tan WF : *Normal pressure hydrocephalus. Is cisternography still useful in selecting patients for a shunt? Arch Neurol 49 : 366-370, 1992*
- 29) Vassilouthis J : *The syndrome of normal-pressure hydrocephalus. J Neurosurg 61 : 501-509, 1984*
- 30) Whittle IR, Johnston IH, Besser M : *Intracranial pressure changes in arrested hydrocephalus. J Neurosurg 62 : 77-82, 1985*