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Reference Range for Cerebrospinal Fluid Opening Pressure in Children

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To the Editor: A reference range for cerebrospinal fluid (CSF) opening pressure in children undergoing diagnostic lumbar puncture has not been established.[1] The influence of age, body-mass index (BMI), and depth of sedation on opening pressure in children is also uncertain.[2]

We conducted a 2-year, single-center prospective study of CSF opening pressure in children undergoing lumbar puncture as part of their routine clinical care. Our objective was to establish a useful, clinically relevant reference range for opening pressure and a threshold value for abnormally elevated opening pressure (in the 90th percentile or higher, defined a priori). Our reference group consisted of children between 1 and 18 years of age, none of whom was taking a medication or had signs of a disease or condition that would alter opening pressure on lumbar puncture (e.g., papilledema, hydrocephalus, cerebral edema, Chiari malformation, meningitis, or use of diuretics). The procedure was performed with subjects in the lateral recumbent position, and the opening pressure was measured with the use of a standard manometer. (For enrollment criteria, methods, and results, see the Supplementary Appendix, available with the full text of this letter at NEJM .org.) Reference-range parameters for opening pressure were determined with the use of standard descriptive statistics, whereas associations between age, BMI, and depth of sedation were determined using linear regression analysis.

We enrolled 472 subjects during the study period, and 197 (41.7%) met the inclusion criteria for the reference-range population. The threshold for an abnormally elevated opening pressure, determined on the basis of the 90th percentile for all patients in the reference population, was 28 cm of water (Fig. 1A). The threshold for an abnormally reduced pressure in the 10th percentile was 11.5 cm of water. Subjects placed under moderate to deep sedation during lumbar puncture had a slightly higher opening pressure as compared with those not receiving any sedative medication ($\beta = 3.459$, $P = 0.002$) (Fig. 1B). Similar to studies in adults,[3,4] our study showed a small yet statistically significant positive relationship between opening pressure and BMI ($\beta = 0.313$, $P = 0.002$) (Fig. 1C). Subject age was not associated with increased opening pressure ($P = 0.43$) (Fig. 1D). Given the significant association between depth of sedation and BMI on opening pressure, a post-hoc analysis of opening pressure percentiles was calculated for the 52 subjects who received

minimal or no sedation and were not classified as obese, resulting in a 90th percentile of 25 cm of water.

This study systematically defined the reference range for CSF opening pressure and the threshold value for abnormally elevated opening pressure in a representative pediatric population (in whom evident pathology was excluded) undergoing diagnostic lumbar puncture. It is our opinion that previous estimates of what constitutes an “abnormal” opening pressure, such as 20 cm of water,[1,5] should be reconsidered, and that for most children an opening pressure above 28 cm of water should be considered elevated.

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References

1. Rangwala LM, Liu GT. Pediatric idiopathic intracranial hypertension. Surv Ophthalmol. 2007; 52:597–617. [PubMed: 18029269]
2. Friedman DI, Jacobson DM. Idiopathic intracranial hypertension. J Neuroophthalmol. 2004; 24:138–145. [PubMed: 15179068]
3. Corbett JJ, Mehta MP. Cerebrospinal fluid pressure in normal obese subjects and patients with pseudotumor cerebri. Neurology. 1983; 33:1386–1388. [PubMed: 6684240]
4. Whiteley W, Al-Shahi R, Warlow CP, Zeidler M, Lueck CJ. CSF opening pressure: reference interval and the effect of body mass index. Neurology. 2006; 67:1690–1691. [PubMed: 17101909]
5. Nechyba, C. Blood chemistries and body fluids. In: Gunn, VL.; Nechyba, C., editors. The Harriet Lane handbook: a manual for pediatric house officers. 16th ed.. Philadelphia: Mosby; 2002. p. 549-559.

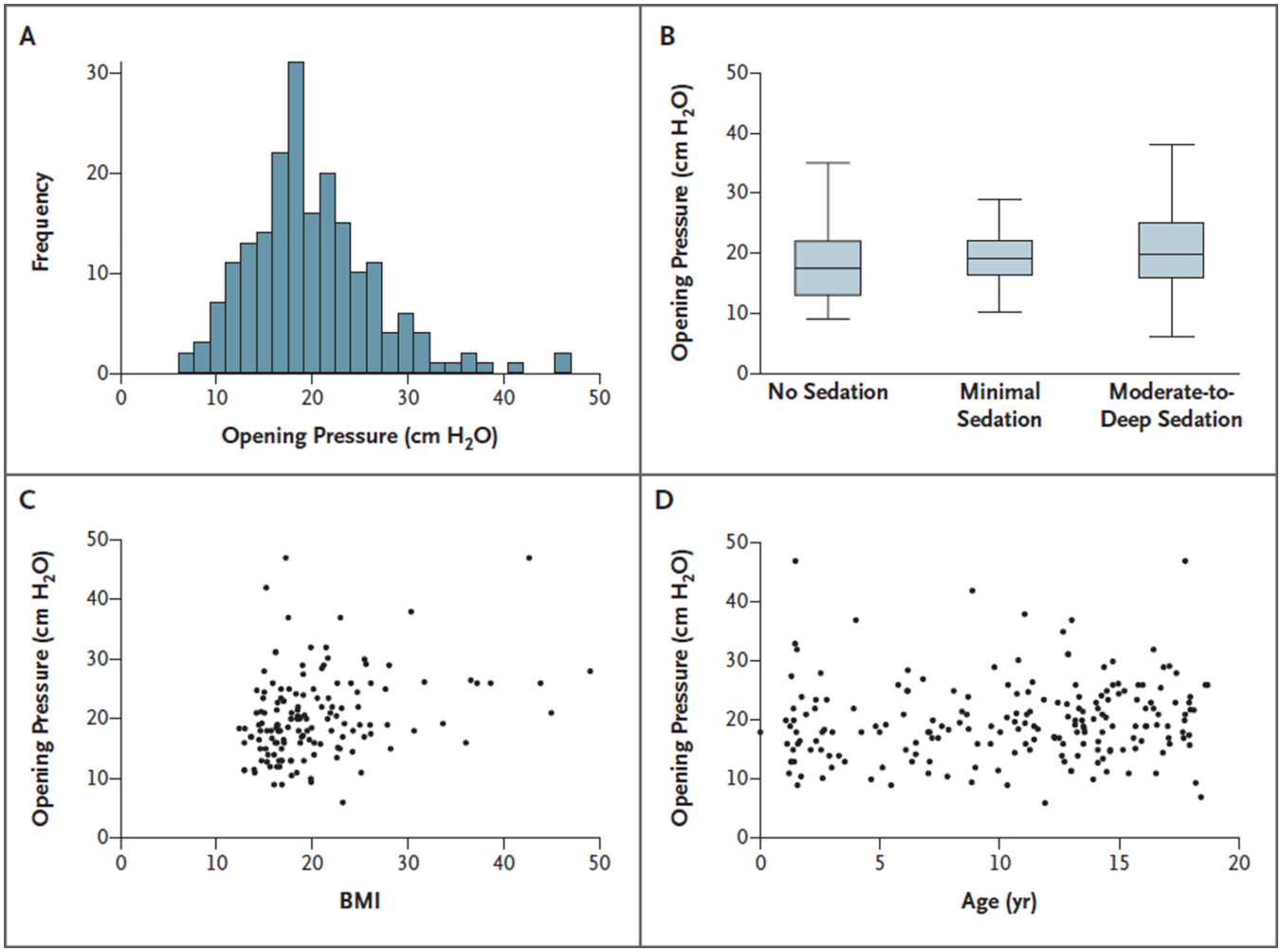

Figure 1. Distribution of CSF Opening Pressure and Effects of Sedation, Body-Mass Index, and Age

Panel A shows the distribution of the cerebrospinal fluid (CSF) opening pressure for 197 study subjects who met the inclusion criteria for the reference group. The mean (±SD) CSF opening pressure was 19.8±6.8 cm of water. The values ranged from 6 to 47 cm of water and were similar in subjects 10 years of age or older and those younger than 10 years. The threshold for an abnormally elevated opening pressure, which was based on subjects with opening pressures in the 90th percentile or higher, was 28 cm of water. The threshold for an abnormally low opening pressure, based on subjects in the 10th percentile, was 11.5 cm of water. Panel B shows the results of an unadjusted linear regression analysis of the relationship between opening pressure and sedation ($\beta = 3.459$, $P = 0.005$). The relationship between opening pressure and body-mass index (BMI, the weight in kilograms divided by the square of the height in meters) is shown in Panel C ($\beta = 0.138$, $P = 0.12$) and that between opening pressure and age in Panel D ($\beta = 0.328$, $P<0.001$). Statistically significant associations between opening pressure and moderate-to-deep sedation ($\beta = 4.990$, $P = 0.002$) and opening pressure and BMI ($\beta = 0.313$, $P = 0.002$) remained in multivariable analysis adjusted for age. In a multivariable linear regression model, no significant association was found between age ($\beta = 0.097$, $P = 0.42$) and opening pressure, even when age was categorized as 10 years or more or as less than 10 years ($\beta = 1.141$, $P = 0.30$). No significant association was found between opening pressure and sedation with ketamine ($\beta = 3.080$; 95% confidence interval, −0.551 to 6.712; $P = 0.10$).