# Measuring blood glucose before or after lumbar puncture

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Background: The ratio of cerebrospinal fluid (CSF) to peripheral blood glucose at the same period is an important index for diagnosing and monitoring the efficacy of central nervous system infection, especially bacterial meningitis. Some guidelines refer that blood glucose measurement should be carried out before lumbar puncture. The main reason is to avoid possible effect of stress response induced by lumbar puncture on the level of blood glucose. However, there is no consensus on whether it should be followed in actual clinical work, since up to now no research work having been published on whether lumbar puncture will induce the changes on blood glucose. Our study aimed to investigate the changes of peripheral blood glucose before and after lumbar puncture. Methods: In order to clarify the influence of timing of peripheral blood glucose measurement at the same period of lumbar puncture, a prospective study was conducted including children with an age range from 2 months to 12 years old in the neurology department of a medical center. For those children who need lumbar puncture due to their illness, their blood glucose was measured within 5 minutes before and after lumbar puncture respectively. The blood glucose level and the ratio of CSF to blood glucose before and after lumbar puncture were compared. Meanwhile, the patients were divided into different groups according to the factors of sex, age and sedation or not for further comparison. All statistical analyses of the data were performed using SPSS version 26.0 for Windows. Results: In total, 101 children who needed lumbar puncture during hospitalization from January 1, 2021, to October 1, 2021, were recruited with 65 male and 36 female respectively. There was no significant difference on the level of blood glucose, CSF to blood glucose ratio before and after lumbar puncture among the children (p>0.05). No differences were observed within different groups (sex, age, sedation or not) either. Conclusion: It is unnecessary to emphasize blood glucose measurement should be carried out before lumbar puncture, especially for pediatric patients. From the perspective of facilitating smoother cerebrospinal fluid puncture in children, blood glucose measurement after lumbar puncture might be a better choice.

1       **Measuring blood glucose before or after lumbar puncture**

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23  **Abstract**

24  Background:The ratio of cerebrospinal fluid (CSF) to peripheral blood glucose at the same

25  period is an important index for diagnosing and monitoring the efficacy of central nervous

26  system infection, especially bacterial meningitis. Some guidelines refer that blood glucose

27  measurement should be carried out before lumbar puncture. The main reason is to avoid possible

28  effect of stress response induced by lumbar puncture on the level of blood glucose. However,

29  there is no consensus on whether it should be followed in actual clinical work, since up to now

30  no research work having been published on whether lumbar puncture will induce the changes on

31  blood glucose. Our study aimed to investigate the changes of peripheral blood glucose before

32  and after lumbar puncture.

33  Methods: In order to clarify the influence of timing of peripheral blood glucose measurement at

34  the same period of lumbar puncture, a prospective study was conducted including children with

35  an age range from 2 months to 12 years old in the neurology department of a medical center. For

36  those children who need lumbar puncture due to their illness, their blood glucose was measured

37  within 5 minutes before and after lumbar puncture respectively. The blood glucose level and the

38  ratio of CSF to blood glucose before and after lumbar puncture were compared. Meanwhile, the

39  patients were divided into different groups according to the factors of sex, age and sedation or

40  not for further comparison. All statistical analyses of the data were performed using SPSS

41  version 26.0 for Windows.

42  Results: In total, 101 children who needed lumbar puncture during hospitalization from January

43  1, 2021 to October 1, 2021, were recruited with 65 male and 36 female respectively. There was

44  no significant difference on the level of blood glucose, CSF to blood glucose ratio before and

45  after lumbar puncture among the children (p>0.05). No differences were observed within

46  different groups (sex, age, sedation or not) either.

47  Conclusion: It is unnecessary to emphasize blood glucose measurement should be carried out

48  before lumbar puncture, especially for pediatric patients. From the perspective of facilitating

49    smoother cerebrospinal fluid puncture in children, blood glucose measurement after lumbar

50    puncture might be a better choice.

51    Key words: lumbar puncture, blood glucose, cerebrospinal fluid glucose (CSF glucose)

52    **Introduction**

53    Acute bacterial meningitis (ABM) is one of the top ten causes of infection-related death

54    worldwide [1]. About 30–50% of people who survived after ABM have permanent neurological

55    sequelae [2, 3]. Early use of antibiotics can reduce the incidence and mortality of severe

56    suppurative meningitis. This means early diagnosis is particularly important in clinical work.

57    Cerebrospinal fluid(CSF)detection, such as cell count, glucose, total protein, chloride and

58    culture of CSF, are the most crucial diagnostic basis for suppurative meningitis. The typical

59    abnormalities of CSF in purulent meningitis are mainly the increase of multinucleated

60    leukocytes, the decrease of CSF glucose concentration, the decrease of CSF glucose to blood

61    glucose ratio and the increase of CSF protein level [4]. The diagnosis of suppurative meningitis

62    traditionally depends on cerebrospinal fluid culture, although it may take a long time to obtain

63    the bacterial culture. Up to now, Gram staining needs 8-24 hours and bacterial culture needs

64    about 72 hours. Prolonged diagnosis time is likely to bring adverse consequences to children. In

65    order to make an early diagnosis of suppurative meningitis, perform early treatment, reduce the

66    incidence of sequelae and help the patients to get antibiotics as soon as possible, some

67    researchers suggested to use the CSF/blood glucose ratio, which might be more efficient. It was

68    demonstrated that the CSF/blood glucose ratio may predict the presence of bacterial meningitis

69    more precisely than other routinely measured markers in CSF [5]. In addition, during the

70    treatment of suppurative meningitis, CSF culture will turn negative. Thus, corresponding

71    indicators are needed to monitor the curative effect. The effect of the treatment can be evaluated

72    by the CSF / blood glucose ratio through continuous lumbar puncture (LP). Therefore, it is

73    essential to obtain blood glucose of the same period of LP appropriately. In 2008, The European

74    Federation of Neurological Societies stated out that blood glucose needs to be obtained before

75     LP in the "EFNS guideline on the management of community-acquired bacterial meningitis:

76     report of an EFNS Task Force on acute bacterial meningitis in older children and adults"[6].

77     Why is it emphasized to obtain blood glucose values before LP? One main reason might be

78     that obtaining blood glucose before LP could exclude the stress response caused by LP that leads

79     to blood glucose increase. Lumbar puncture is a kind of traumatic stress for the human body,

80     which may rise blood glucose. Is it necessary to emphasize obtaining blood glucose before LP?

81     There is no relevant research so far. This guideline is mainly based on theoretical reasoning.

82     That's why there is no consensus for this guideline in many countries. At present, for example, in

83     China some medical institutions follow this guidance strictly, while many others regard it as

84     unnecessary. There is no standardized rule to follow. The purpose of this study was to investigate

85     whether collecting the blood before and after lumbar puncture would cause difference in blood

86     glucose level, and thereby affecting the ratio of CSF glucose/blood glucose. What 's more, we

87     aimed to further clarify whether it is really necessary to measure blood glucose before LP for

88     pediatric patients and thereby    providing basic information for actual clinical work.

89     **Materials & Methods**

90     This study was conducted in the Department of Neurology, Guangzhou Women's and

91     Children's Hospital from January 1, 2021 to October 1, 2021. Totally 101 children who needed

92     LP during hospitalization were included. This selection was based on the following inclusion

93     criteria: children with no contraindications for LP. Exclusion criteria: patients with endocrine-

94     related diseases; measuring capillary blood glucose for more than 5 minutes before or after LP;

95     children with sedation failure.

96     Capillary blood glucose was obtained within 5 minutes before and after LP by the same

97     person. The blood glucose was measured on the same fingertip of the left ring finger before and

98     after the LP. The same blood glucose meter was used for measurements. The position was

99     sterilized with 75% ethanol and blood glucose measurement was performed after drying. The

100     first drop was discarded and extrusion was minimized. The CSF samples were sent for

101  examination immediately after lumbar puncture in order to avoid degradation of glucose during

102  CSF storage [7]. The name, inpatient number, sex age, time of capillary blood glucose

103  measurement before and after LP, blood glucose values measured before and after LP, start time

104  of LP, CSF glucose value, state of the patients at the time of puncture (drug sedation, awake)

105  were recorded in detail. All participating researchers have been trained and are qualified.

106  Data analysis was performed using SPSS statistical software version 26.0. Continuous

107  variables were presented as mean $\pm$ SD if normal distribution was established, whereas non-

108  normally distributed measures were expressed as M (P25,P75). To compare changes of blood

109  glucose before and after LP in different age, sex, and conscious state groups, paired t test was

110  applied. Wilcoxon signed-ranks test was used for comparing CSF /blood glucose ratio within the

111  groups before and after LP. P values less than 0.05 were considered as statistically significant.

112  This study conforms to the relevant requirements of the Helsinki declaration of the World

113  Medical Association. It was approved by the Ethics Committee of Guangzhou Women's and

114  Children's Hospital (Approval Number: [2022]201A01). Written informed consent for the

115  research was given by the children's guardians in accordance with the recommendations of the

116  biomedical research ethics committees.

117

118  **Results**

119  A total of 101 cases, 65 male and 36 female were included in the study, with the age ranged

120  from 2 months to 12 years . The children were divided into four groups according to their age:

121  group A (n=51): age<3y; group B (n=15): 3y≤age<6y; group C (n=12): 6y≤age<9y; group D

122  (n=23): 9y≤age≤12y.

123  1.  First of all, we compared  capillary blood glucose and the CSF/blood glucose ratio of

124     the 101 patients before and after LP (Table 1). There were no significant differences in both

125     blood glucose levels and the ratio of CSF /blood glucose before and after LP (p＞0.05). The

126     trend of blood glucose changes before and after lumbar puncture was shown in Figure 1.

127     2.      For different age groups, there were no significant differences of blood glucose and the

128     CSF/blood glucose ratio before and after LP (p>0.05) (Table 2).

129     3.      No significant differences in the blood glucose level and the CSF/blood glucose ratio

130     before and after LP were observed for different sexes (p>0.05) (Table 3).

131     4.      The patients were divided into two groups according to their state of consciousness at

132     the time of lumbar puncture, drug sedation and awake group. No significant changes in blood

133     glucose and the CSF/blood glucose ratio were found before and after LP between the groups

134     (p>0.05) (Table 4).

135     **Discussion**

136     Analysis of CSF is a crucial tool for the diagnosis of central nervous system infections,

137     especially suppurative meningitis. CSF glucose is one of the most important indicators for CSF

138     analysis. It plays an irreplaceable role in the diagnosis and identification of infectious diseases of

139     the nervous system. In bacterial meningitis, the bacteria multiply and consume the glucose of the

140     CSF. In addition, the impaired function of the glucose transport system also results in a decrease

141     in CSF glucose [8, 9]. However, CSF glucose mainly comes from blood through the blood-brain

142     barrier. Plasma glucose has a significant impact on CSF glucose [9, 10]. The CSF glucose levels

143     are directly proportional to the plasma levels. It means that we should not assess CSF glucose

144     levels only, simultaneous measurement of blood glucose is required [7]. Studies have shown that

145     the CSF/blood glucose ratio is an effective indicator for the diagnosis of bacterial meningitis,

146     thereby could be used as a marker and speed up the physician's decision to administer antibiotics

147     [5, 11-13]. The CSF/ blood glucose ratio could be used for differential diagnosis and efficacy

148     evaluation as well. Obtaining the correct ratio of CSF to blood glucose is critical.

149     The article 'EFNS guideline on the management of community-acquired bacterial meningitis:

150     report of an EFNS Task Force on acute bacterial meningitis in older children and adults' by the

151     European Federation of Neurological Societies in 2008 declared that blood glucose should be

152     obtained before LP[6]. The stress response caused by LP may affect blood glucose. It is well

153     known that acute injury can produce stress response to body and lead to increasing blood glucose

154     [14].When the body subjected to traumatic stimulation, it will induce series of complex

155     microcirculation, neuroendocrine and other pathophysiological changes. Regulation of

156     neuroendocrine system manifested as sympathetic-adrenal medulla and the hypothalamic-

157     pituitary-adrenal cortex system caused excessive gluconeogenesis, glycogenolysis and insulin

158     resistance, resulting in elevated blood glucose [14-17]. As a stimulus, will LP cause stress

159     response and increase blood glucose? Should we measure blood glucose before LP as suggested

160     in the guideline [6]?

161     Based on our results, there were no significant differences in capillary blood glucose levels

162     and the ratio of CSF /blood glucose before and after LP for children between 2 months to 12

163     years old. Considering that age, sex and state of consciousness may have different response to

164     stress, the tested patients were grouped and compared. None of these factors have affected the

165     measured results. The stress stimulation of LP was not able to cause changes in capillary blood

166     glucose. Blood glucose measurement after LP did not alter the blood glucose level and the ratio

167     of CSF /blood glucose. Regarding to the applicability, for pediatric patients, LP is usually

168     performed under drug sedation. Measuring blood glucose before LP may wake up the sedated

169     children and will increase the difficulty of LP, hence increase the failure rate of LP. From the

170     perspective of facilitating smoother cerebrospinal fluid puncture in children, blood glucose

171     measurement after lumbar puncture might be a better choice. Additionally, our results could also

172     provide useful information in the diagnosis of other neurological and genetic pathologies, such as

173     the glucose transporter type 1 deficiency syndrome.

174     **Conclusions**

175     It is unnecessary to emphasize the obtention of peripheral blood glucose of pediatric patient

176 before lumbar puncture, especially for the patient who are sedated before LP. Taken together,

177 our study provides a basis for the formulation of relevant guidelines.

178 **Acknowledgments**

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# Figure 1

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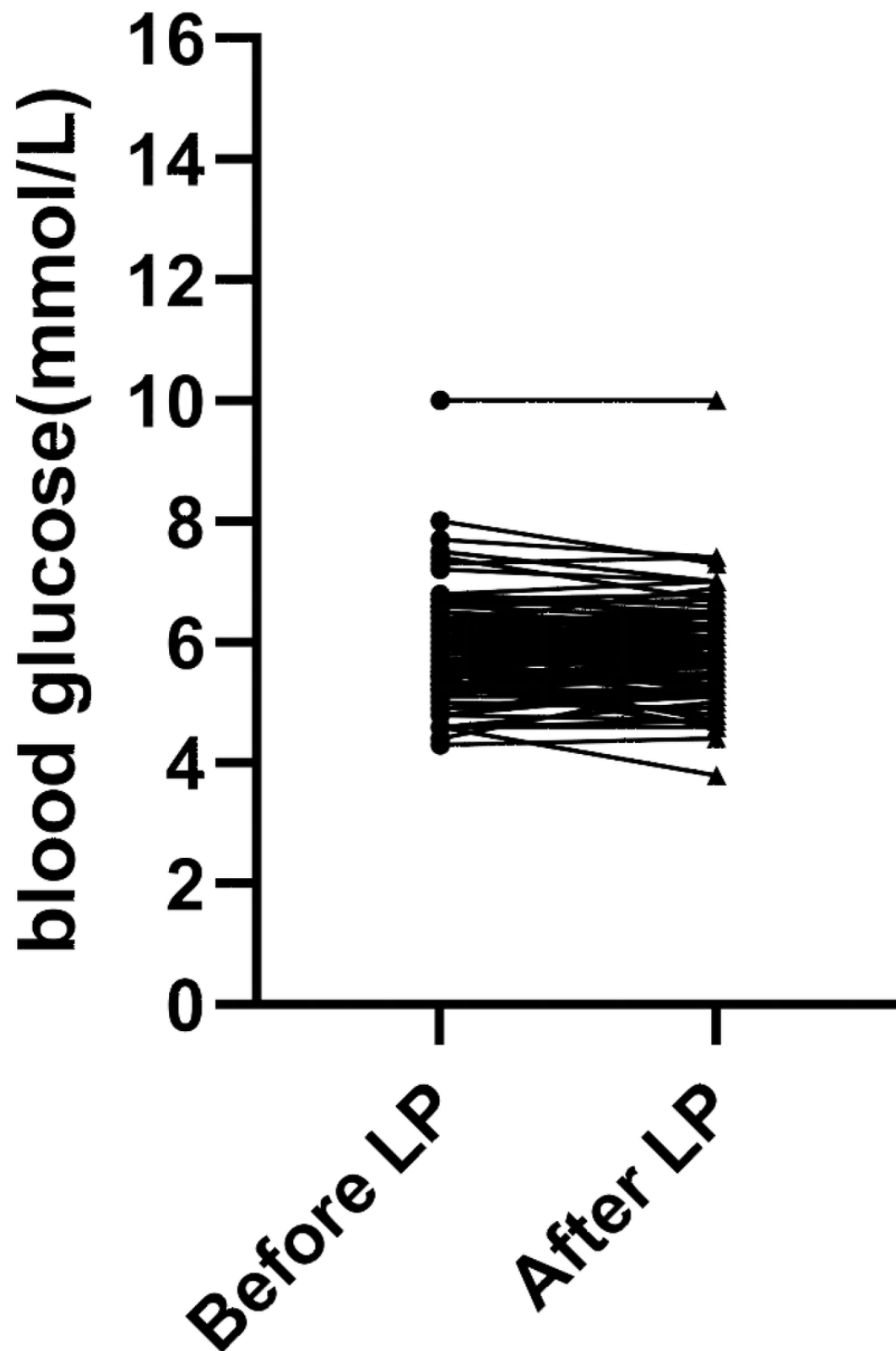
Comparison of blood glucose and ratio before and after LP

1    Table 1

2            Comparison of blood glucose and the CSF/blood glucose ratio before and after lumbar puncture(LP)

|  | Before LP | After LP | z/t Value | P Value |
|---|---|---|---|---|
| Blood glucose mean ± SD (mmol/L) | 5.89±0.86 | 5.83±0.83 | -1.47 | 0.15 |
| CSF/blood glucose ratio M (P25, P75) | 0.51 (0.44, 0.60) | 0.52 (0.44, 0.60) | -1.43 | 0.15 |

3    Notes:

4    Normal distributed data are presented by mean ± SD and non-normally distributed measures are expressed as M (P25, P75). Paired t test and Wilcoxon
5    test were used to analyze the normal distributed and non-normal distributed data, respectively.

Comparison of blood glucose and the ratio before and after LP in different age groups of children.

1    Table 2

2    Comparison of blood glucose and the CSF/blood glucose ratio before and after lumbar puncture (LP) in different age groups of children

| Group | Number | Blood glucose | | | | CSF/Blood glucose ratio | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | Before LP mean ±SD (mmol/L) | After LP mean ±SD (mmol/L) | t Value | P Value | Before LP M (P25, P75) | After LP M (P25, P75) | z Value | P Value |
| A (age<3y) | 51 | 5.81±0.63 | 5.80±0.61 | -0.13 | 0.90 | 0.49 (0.42,0.54) | 0.48 (0.43,0.56) | -0.26 | 0.80 |
| B (3y≤age<6y) | 15 | 5.71±0.90 | 5.61±0.98 | -0.97 | 0.35 | 0.60 (0.53,0.65) | 0.60 (0.52,0.70) | -0.56 | 0.57 |
| C (6y≤age<9y) | 12 | 6.10±1.09 | 5.92±0.86 | -1.88 | 0.09 | 0.60 (0.49,0.65) | 0.60 (0.50,0.67) | -1.49 | 0.14 |
| D ( 9y≤age≤12y) | 23 | 6.08±1.12 | 6.01±1.10 | -1.08 | 0.29 | 0.52 (0.40,0.59) | 0.49 (0.38,0.60) | -1.19 | 0.24 |

3    Notes:

4    Normal distributed data are presented by mean ± SD and non-normally distributed measures are expressed as M (P25, P75). Paired t test and Wilcoxon

5    test were used to analyze the normal distributed and non-normal distributed data, respectively.

Comparison of blood glucose and CSFblood glucose ratio before and after LP in different gender groups of children

1  Table 3

2  Comparison of blood glucose and the CSF/blood glucose ratio before and after lumbar puncture(LP)in different sex groups of

3  children

| Group | **Number** | Blood glucose | | | | CSF/blood glucose ratio | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | Before LP mean ±SD (mmol/L) | After LP mean ±SD (mmol /L) | t Value | P Value | Before LP M (P25, P75) | After LP M (P25, P75) | z Value | P Value |
| Males | 65 | 5.88±0.82 | 5.82±0.83 | -1.28 | 0.21 | 0.50  (0.45,0.58) | 0.51 (0.46,0.59) | -1.58 | 0.11 |
| Females | 36 | 5.91±0.94 | 5.86±0.83 | -0.74 | 0.46 | 0.56(0.40,0.62) | 0.56 (0.41,0.64) | -0.48 | 0.63 |

4  Notes:

5  Normal distributed data are presented by mean ± SD and non-normally distributed measures are expressed as M (P25, P75). Paired t test and Wilcoxon
6  test were used to analyze the normal distributed and non-normal distributed data, respectively.

Comparison of blood glucose and the ratio before and after LP in sedated and awake children

1   Table 4

2   Comparison of blood glucose and the CSF/blood glucose ratio before and after lumbar puncture (LP) in sedated and awake children

| Group | Number | Blood glucose | | | | CSF/blood glucose ratio | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | Before LP<br>mean ± SD (mmol/L) | After LP<br>mean ± SD (mmol /L) | t Value | P Value | Before LP<br>M (P25, P75) | After LP<br>M (P25, P75) | z Value | P Value |
| Drug sedation | 59 | 5.93±0.77 | 5.87±0.73 | -1.26 | 0.21 | 0.50 (0.43,0.60) | 0.52 (0.43,0.60) | -1.35 | 0.18 |
| Awake | 42 | 5.84±0.98 | 5.78±0.96 | -0.83 | 0.41 | 0.51 (0.45,0.58) | 0.52 (0.45,0.61) | -0.94 | 0.35 |

3   Notes:

4   Normal distributed data are presented by mean ± SD and non-normally distributed measures are expressed as M (P25, P75). Paired t test and Wilcoxon
5   test were used to analyze the normal distributed and non-normal distributed data, respectively.