

# EVAN'S INDEX IN ADULT NEPALESE POPULATION: A COMPUTERIZED TOMOGRAPHIC STUDY

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## ABSTRACT

### Introduction

Evan's Index is a linear measurement of the ventricular size which is used as an indirect marker of ventricular volume. It is used widely as a screening tool to rule out ventricular enlargement. As the ventricular enlargement indicates the neuropathological state of the brain, Evan's Index serves as the quick and reliable method to assess ventricular size.

### Objectives

The study aims to generate a baseline value of Evan's Index among the Nepalese population and also investigates the effect of age and gender on Evan's Index.

### Methodology

A quantitative study was conducted in the Department of Anatomy, Kathmandu University School of Medical Sciences and data was collected from the Department of Radiodiagnosis, Dhulikhel Hospital, Kathmandu University Hospital. The study was done on 385 head computed tomography scans of the individuals of mean age of  $45.44 \pm 19.27$  years. The ratio of inter anterior horns distance of the lateral ventricles and maximal internal diameter of the skull at the same level was taken to calculate Evan's Index.

### Result

The mean value of Evan's index in the present study was  $0.25 \pm 0.03$ . The study did not report gender-wise variation in Evan's Index ( $p > 0.05$ ). Evan's index was minimum at the age group of 20-29 and maximum at the age group of 80-89. The value of Evan's Index showed a significant increase with the age ( $p < 0.05$ ).

### Conclusions

The study provides the mean value of Evan's Index among the Nepalese population. Even though Evan's Index is not influenced by gender, the value increases with normal aging.

### KEYWORDS

Hydrocephalus, lateral ventricle, neuropathological changes



## INTRODUCTION

The Evan's Index (EI) was given by Willams Evan in 1942 that is used as a method to measure ventricles of the human brain. EI is calculated as the ratio of inter anterior horns distance of the lateral ventricles (IAHDLV) to the maximal internal diameter of the skull (MIDS) at the same level.<sup>1</sup>

The ventricles are the series of intercommunicating cavities within the brain filled with cerebrospinal fluid (CSF) namely; two laterals, third and fourth ventricle.<sup>2</sup> The symptomatic accumulation of CSF is called hydrocephalus which may be due to obstruction, hypersecretion, or disturbed absorption of CSF. It is also seen in old age which has the idiopathic cause known as Normal-pressure hydrocephalus.<sup>3</sup>

Ventricular enlargement warns about the neurological changes of the brain. Quick and reliable assessment of ventricular size in routine radiological evaluation is inevitable.<sup>4</sup> Studies have shown a strong correlation between the linear indices and volume of the brain.<sup>5,6</sup> As the volumetric analysis of the ventricle is technique sensitive and laborious the linear evaluation of ventricle size by the EI is used as a surrogate marker of ventricular volume.<sup>5</sup> The study claimed the EI value 0.30 to represent the cut-off value, above which indicates ventricular enlargement.<sup>1</sup>

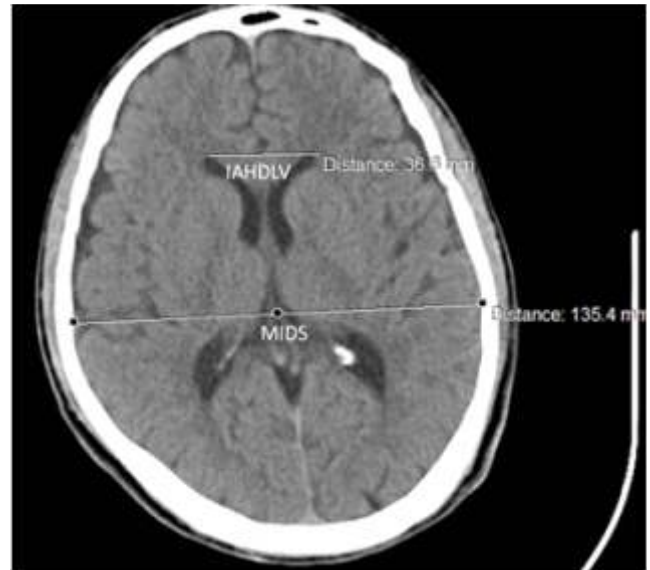
Although many authors raise the question about the reliability of EI in the assessment of ventricular size, it is still used in clinical routine as it is feasible. Furthermore, it precludes the need for special software that may be inaccessible especially in developing countries.<sup>7</sup>

Research in different parts of the world has shown variations in the reference value of EI.<sup>5,7</sup> The ventricular volume is influenced by age, sex and ethnicity.<sup>8</sup> There are only a few studies to generate mean EI value among the Nepalese population. So, this study aims to provide the baseline value of EI in the adult Nepalese population and also probes into the effect of age and gender on EI.

## METHODOLOGY

The present study was a quantitative study which was conducted in the Department of Anatomy, Kathmandu University School of Medical Sciences and Department of Radiodiagnosis, Dhulikhel Hospital/ Kathmandu University Hospital, Kavre, Nepal. The study was done from July 2021 to January 2022 after the approval from IRC/KUSMS (Ref. No. 88/2021). The study was conducted on the head CT scans of the individuals that were reported normal by the Radiologist. The CT scans with traumatic and pathological conditions were excluded from the study.

The study was performed on Siemen Somatom Perspective 128 slice machine. Axial, coronal, and sagittal reconstructed images of the head were obtained from software Syngovia. The axial section of 5 mm slice thickness was obtained and reconstruction was done at 0.625 mm. IAHDLV and MIDS were measured in axial and transverse sections and recorded in mm. Coronal and sagittal sections were used for comparison.



**Figure 1:** Axial CT scan showing measurement of IAHDLV and MIDS

The sample size was calculated as:

$$n = Z^2 \times p \times q / e^2$$

$$= (1.96)^2 \times (0.5) \times (0.5) / (0.05)^2 = 384.16$$

Where, n= minimum required sample size

Z= 1.96 at 95% Confidence Interval (CI)

p= past prevalence (0.5)

q= 1-p

e= margin of error, 5%

The sample size obtained was 384.16 and the study was conducted on 385 images of the individuals. The study participants were between the age of 20-89 years and were divided into seven groups at the interval of nine years. The data management was done in SPSS 16.0 version. Descriptive analysis was used (means and standard deviation) for demographic details. The difference between continuous variables among groups was assessed by independent sample t-test and one-way ANOVA, the p-value of <0.05 was considered significant. An independent sample t-test was used to find the correlations between the gender and one-way ANOVA was used to find the correlations between different age groups.

## RESULTS

The study was conducted on 385 CT scans obtained from the Department of Radio-diagnosis, Dhulikhel hospital/ Kathmandu University Hospital, out of which 207(53.8%) were male and 178(46.2%) were female.

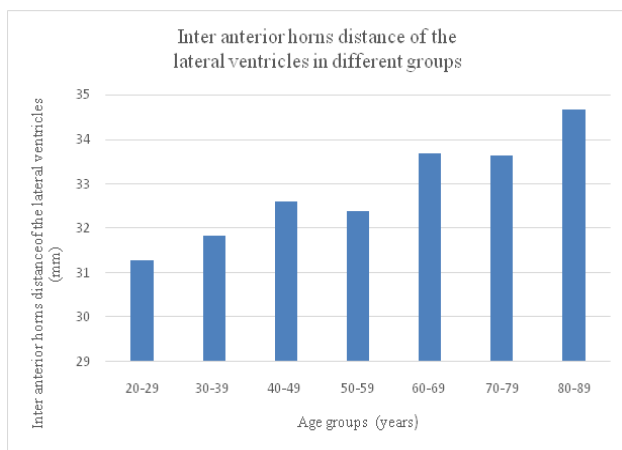
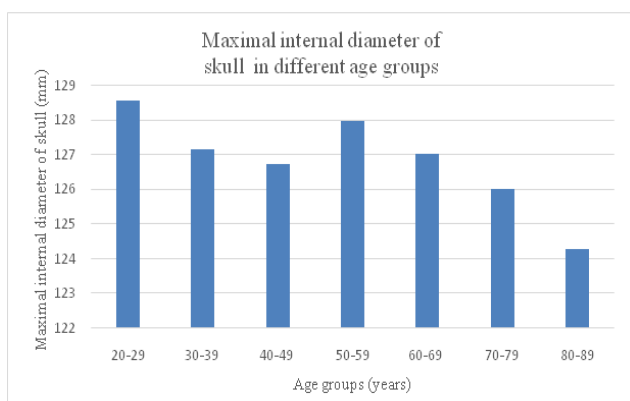
The mean IAHDLV was 32.38±3.93mm and the mean MIDS is 127.34±6.13 mm. The IAHDLV and MIDS between the male and the female revealed a significant difference (p<0.05). The value of EI of total participants was 0.25±0.03, of the male was 0.25±0.03 and of the female was 0.25±0.03. The result showed an insignificant difference in the value of EI for males and females (p>0.05). (Table 1)

**Table 1:** Mean IAHDLV, MIDS, and Evan's Index based on gender

	Total	Male	Female	p-value
IAHDLV (mm)	32.38±3.93	32.86±4.07	31.83±3.69	0.01
MIDS(mm)	127.34±6.13	128.82±6.04	125.60±5.79	0.00
Evan's index	0.25±0.03	0.25±0.03	0.25±0.03	0.58

The age of the participants was between 20 to 89 years with a mean of  $45.44 \pm 19.27$  years. The participants were divided into seven age groups in the range of nine years.<sup>9</sup> The minimum IAHDLV was present in the age group of 20-29 years range and maximum in the age group of 80-89.

There is a significant difference in IAHDLV between the age groups ( $p < 0.05$ ). (Figure 2). The MIDS was minimum in the age group of 80-89 years and maximum 20-29 years. There is no significant difference in MIDS between the age groups ( $p < 0.05$ ). (Figure 3)

**Figure 2:** Inter anterior horns distance of the lateral ventricles in different groups**Figure 3:** Maximal internal diameter of the skull in different age groups

The value of the EI index was minimum in the age group of 20-29 years and it showed a progressive increase in the value with advancing age and was maximum at the age group of 80-89 years. One-way ANOVA shows the value of EI increases significantly with the age ( $p < 0.05$ ). (Table 2)

**Table 2:** Evan's Index among different age groups

Age Groups (years)	Evan's index Total	Evan's Index Male	Evan's Index Female
20-29	0.24 ± 0.02	0.24 ± 0.03	0.24 ± 0.02
30-39	0.25 ± 0.01	0.25 ± 0.02	0.25 ± 0.01
40-49	0.25 ± 0.02	0.25 ± 0.02	0.25 ± 0.03
50-59	0.25 ± 0.03	0.25 ± 0.03	0.25±0.03
60-69	0.26 ± 0.03	0.26 ± 0.02	0.26±0.03
70-79	0.26 ± 0.02	0.26 ± 0.03	0.26±0.02
80-89	0.27 ± 0.02	0.28 ± 0.03	0.27±0.02
p-value	0.00	0.00	0.00

## DISCUSSION

Evans Index is an indirect method of measurement of ventricular size.<sup>1</sup> Research has confirmed the strong correlation between the linear indices using Evan index and the volume of the ventricle.<sup>5,6</sup> As volumetric analysis of the ventricle is complex; simple linear measurements using Evan's Index give fast and reliable, methods for determining ventricular size.<sup>7</sup> Ventricular enlargement indicates neuropathological changes, so early diagnosis of the enlargement is crucial in treatment planning.<sup>10</sup>

The present study reported the mean value of IAHDLV and MIDS to be  $32.38 \pm 3.93$  mm and  $127.34 \pm 6.13$  mm respectively which is similar to the study of Pradhan et al. among the Nepalese population.<sup>11</sup> In contrast to this, the mean value of IAHDLV and MIDS among the Ghanaian population and Central Indian population is higher than the present study.<sup>9,12</sup>

The potential cause for this variation might be various genetic and environmental factors affecting the morphology of the different populations.

A computerized tomographic study in the Nigerian population by Hamidu et al. emphasized significant sexual variation in the mean IAHDLV.<sup>13</sup> The present study is in congruence with the study of Hamidu et al. Likewise, the study among the Indian population by Kumar et al. also reported that male had significantly wider IAHDLV compared to female.<sup>14</sup> This could be further supported by the study of Fjell et al. who investigated the effect of sex on the volume of different brain structures. The study affirmed that men had significantly larger volume of the lateral ventricle than women.<sup>15</sup>

The study by Dzeffi-Tetty et al. reported the mean MIDS value of male to be  $127.6 \pm 0.50$  and female to be  $123.2 \pm 0.48$  mm comparable to the present study.<sup>11</sup> The study by Dhok et al. reported the mean value of MIDS among male and female  $122.85 \pm 0.52$  mm and  $117.73 \pm 0.50$  mm respectively which are less than the present study.<sup>9</sup> The possible explanation for this discrepancy could be racial and ethnic variations. The present study confirmed a significant difference in MIDS between male and female. This difference is attributed to the craniometric sexual dimorphism which expresses that male had significantly larger cranial dimensions than female.<sup>16</sup>

Studies show variations in the value of mean EI ranging from 0.23 – 0.3.<sup>4,17</sup> A CT scan study on 18-76 years individuals of

Andhra Pradesh, India reported the mean value  $0.25 \pm 0.02$  which is alike the present study.<sup>18</sup> However, a study conducted by Lohani et al. among the North Indian population of age range of 18-76 years reported the mean EI value  $0.23 \pm 0.02$  which is lesser than the present study.<sup>17</sup> The possible explanation for this discrepancy could be ethnic and geographical variations.

On the contrary, Liu et al. conducted a study among the Chinese population of age above 70 years to evaluate the effectiveness of EI as a screening tool.<sup>19</sup> The EI value of the study was  $0.27 \pm 0.04$  which is more than the value of the present study. Likewise, in the study of Takeda et al. among the Japanese population of mean age of  $57.3 \pm 20.8$  years, the mean EI value was  $26.6 \pm 2.95$  which is higher than the present study.<sup>20</sup> This observed increase in value of EI could be accredited to the inclusion of more elderly individuals in both studies.

Even though the mean IAHDLV and MIDS had significant gender-wise variation, the value of EI presented an insignificant gender-wise variation. This postulates that EI is not affected by the size of the skull as shown in the study of Evan.<sup>1</sup> Correspondingly, Dzefti-Tetty et al. also concluded that the mean EI value between male and female revealed no significant variation.<sup>12</sup> Whereas a study by Brix et al. highlighted the EI value of female to be notably lower than male.<sup>4</sup> Similarly, the study by Jaraj et al. among older individuals reported a higher value of mean EI among male than female. The authors also postulate that with aging ventricular morphology is affected differently among the sexes by genetic and environmental factors.<sup>21</sup>

A Magnetic Resonance Imaging Study by Coffey et al. reported that age was significantly related to increased volumes of the lateral ventricles (coefficient = 0.95,  $P < .001$ ).<sup>22</sup> This paper also delves into the effect of aging on EI value and discloses that the value increases with the advancing age.<sup>22</sup> Correspondingly, authors from different part of the world support this finding.<sup>13,17</sup> The longitudinal study by Resnick et al. stated substantial decrease in gray and white matter with normal aging causes an increase in the size of the ventricle. This increased ventricular size may contribute to an increase in the value of EI with advancing age.<sup>23</sup>

Conversely, the study by Lohani et al. among the North Indian population revealed no relation between EI and age.<sup>17</sup> Interestingly, the study by Polat et al. among the Turkish population revealed the minimum value of EI at the age group of 61 to 70 years.<sup>24</sup>

Evan did an encephalographic study to estimate the size of the ventricle and proposed the value above 0.3 as pathologic ventricular dilatation.<sup>1</sup> Although the value of EI

increases with the advancing age, the mean EI value of the present study was below the cut-off value of 0.3. Similarly, Ambarki et al. conducted a study in healthy elderly individuals of mean age  $71 \pm 6$  years and obtained the value below the cut-off value.<sup>8</sup> Apostolova et al. suggested that only a mild degree of ventricular enlargement is seen with the advancing age which is different from that case of Alzheimer's disease.<sup>25</sup>

However, another study on the elderly population by Brix et al. reported the upper limit of EI to be higher than 0.3.<sup>4</sup> Thus clinicians need to be aware of this fact as well before considering it as pathological.<sup>21</sup>

## CONCLUSION

In conclusion, the paper establishes the mean value of Evan's Index among the Nepalese population as  $0.25 \pm 0.02$ . Despite the fact there is significant gender-wise variation in mean IAHDLV and MIDS, the study revealed no significant gender-wise variation in the mean value of EI. The evidence from this study suggests that EI value increase with the advancing age. As volumetric analysis of ventricle is laborious and technique sensitive, the EI can serve as quick and reliable alternative method of assessment.

## RECOMMENDATIONS

We recommend studies in a larger sample size including populations of different parts of the country. Future studies on the relationship between this linear index and ventricular volume among the Nepalese population need to be evaluated.

## LIMITATIONS OF STUDY

The study has some limitations. Firstly, the study is confined to the CT scans available from Dhulikhel hospital with a limited number of subjects. Secondly, the study was conducted on the linear indices of the ventricle, correlation of this linear index to the volume was not done.

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## CONFLICT OF INTEREST

The author declares no conflict of interest.

## FINANCIAL DISCLOSURE

None



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