Development of Reference Values of Evans Index Using Computerized Tomographic Scan in Healthy Individuals and Comparison with Hydrocephalous Patients of Saudi Origin

Bayer SB¹, Algowiez R², Shetty AC³

¹Assistant Professor, Department of Anatomy, College of Medicine, Imam Abdulrahman Bin Faisal University, Dammam, Kingdom of Saudi Arabia; ²Assistant Professor, Department of Radiology, College of Medicine, Imam Abdulrahman Bin Faisal University, Dammam, Kingdom of Saudi Arabia; ³Assistant Professor, Vice Deanship for Postgraduate Studies and Scientific Research, College of Dentistry, Imam Abdulrahman Bin Faisal University, Dammam, Kingdom of Saudi Arabia.

ABSTRACT

Introduction: Evan's Index is one such ventriculography index, which is useful in a wide range of clinical conditions. Development of baseline reference data is necessary when such data is unavailable.

Objectives: Evan's Index is useful in various clinical conditions. This study aimed to establish reference values for Evans index in the Saudi healthy population.

Methods: We retrospectively evaluated 150 computed tomography (CT) scans, 100 were normal, and 50 were having hydrocephalous. Evan's index (EI) ratio was obtained by measuring the maximum frontal horn width to the maximum transverse diameter of the inner table in the same section on a computer monitor using a meter rule.

Results: All scans were age and gender-matched. There is no statistical significance in EI values between males and females in both adult and children groups ($p > 0.05$). The mean EI value ranged from 0.23 to 0.28. We found an apparent increase in EI values with increasing age. However, it was not statistically significant ($p > 0.05$).

Conclusion: Our data will be useful in a variety of clinical situations.

Key Words: Adults, Children, Evans Index, Gender, Healthy population, Hydrocephalous

INTRODUCTION

Evans index (EI) is a direct marker of ventricular size. It also serves as an indirect marker of ventricular volume.¹ It is the ratio that compares the maximum width of the frontal horns of lateral ventricles to the maximum transverse diameter of the inner table of the skull at the same level. EI can be measured from both CT and Magnetic resonance imaging (MRI) methods.² Measurement of EI is instrumental in the diagnosis of idiopathic normal pressure hydrocephalus, the prognosis of the ventriculoperitoneal shunt and the evaluation of visual outcomes in childhood hydrocephalus.^{3,4} Thus, developing a baseline reference data of Evan's index will be useful in a wide range of clinical conditions for this population where such data is unavailable. To this purpose, we aimed to establish typical values for the Evans index in the Saudi population.

MATERIALS AND METHODS

The present retrospective study was conducted between 2017 to April 2019 at Imam Abdulrahman Bin Faisal University, Dammam, Saudi Arabia.

The CT images included in this study were those of Saudi patients who had brain CT for several medically or surgically indicated reasons in the Department of Radiology, King Fahd Hospital of the University located at Al Khobar. Subjects with tumours and injuries were excluded. The CT images were retrospectively viewed after obtaining approval from the Institutional Review Board at Imam Abdulrahman Bin Faisal University. Images were reviewed by the radiologist. Images with motion artefacts, major head tilt, were excluded from the study. Images with a minor degree of head tilts/obliquity were included after doing data correction by the

Corresponding Author:

Dr. Bayer SB, Assistant Professor, Department of Anatomy, College of Medicine, Imam Abdulrahman Bin Faisal University, Dammam, Kingdom of Saudi Arabia.

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swivel tool. The various radiological measurements of the brain were measured in a total of 150 Saudi origin subjects, including 100 normal (50 adults and 50 children) and 50 with hydrocephalus (25 adults and 25 children) between January 2017 and April 2019. The measurements were made using a multi-detector row computed tomography scan (MDCT Scan, Somatom Definition, Siemens Healthcare, Forchheim, Germany). CT imaging parameters were as follows: 5- and 1-mm section thickness, 100-120 KVp, 250-350 mA. Siemens syngo. plaza (version VA20D) picture archiving and communication system (PACS) software was used to perform the measurements. The following measurements of the brain were taken through axial images: Maximum width of the frontal horns of the lateral ventricles, Maximal internal diameter of the skull at the same level and Evan's index (EI) ratio were obtained by measuring the maximum frontal horn width to the maximum transverse diameter of the inner table in the same section on a computer monitor using a meter rule. $EI = a/b$, as seen in Figure 1. Evans index value 0.3 or higher signifies ventriculomegaly. At the start of the study, Evans index was calculated by the radiologist from twenty normal CT scans selected randomly and assessed the Inter-observer variability.

Figure 1: Calculation of Evans Index in Normal CT Scan.

Statistical analysis

The data was entered in Microsoft excel spreadsheet 2016, and Statistical analysis was performed using IBM SPSS Statistics for Windows, Version 21.0. Armonk, NY: IBM Corp. Results were tabulated as mean, standard deviation and actual numbers. Interobserver variability was assessed by calculating the coefficient of variation of the Evans index. The coefficient of variation in the Evans index calculated by

radiologist one and two were 3% and 4% respectively. An unpaired t-test was used appropriately. A P-value of less than 0.05 was considered statistically significant.

RESULTS

There were 50 adults 25 female and 25 males, similarly 50 children 25 female and 25 males without hydrocephalous. There were 25 adults and 25 children in patients with hydrocephalus. Demographic and Evans index values were shown in Table 1. All scans were age and gender-matched. It can be appreciated from Tables 1 and 2, that there is no statistical significance in EI values between males and females in both adult and children groups ($p>0.05$). Additionally, we also noticed that the EI values between normal adult and children were also statistically similar ($p>0.05$). The mean EI value ranged from 0.23 to 0.28. We found a linear trend in EI values with increasing age; however, it was not statistically significant ($p>0.05$).

DISCUSSION

The EI has been commonly used in diagnostic imaging for years for the assessment of the ventricular size and is also used to detect ventriculomegaly due to cerebral atrophy. The broader availability of CT makes it easy to measure the ventricular system. EI value >0.3 is considered as ventricular enlargement according to international guidelines even in normal pressure hydrocephalus.⁵ A recent report found that EI measured by using CT agrees with EI measured using the MRI scan.⁶ However, magnetic resonance imaging (MRI) scanning is time-consuming and partially operator dependent.⁷ We retrospectively calculated Evans index from both healthy and hydrocephalous CT brain images and found that the average values obtained in this study were in line with those reported in the literature.⁸ Kosourov et al. reported a mean EI value ranging from 0.22 to 0.28 in adults; our patient EI values were also similar.⁹ We also found that there was an apparent increase in EI values with increasing age, similar to a study that evaluated Evans index across gender and age.^{10,11} Even With this physiologic ventricular enlargement, the Evans ratio does not exceed 0.3. It is well known that index values >0.30 indicate progressive hydrocephalus,¹² our hydrocephalous also had EI values >0.3 . We did not notice any significant difference in EI values between males and females in the normal population as well as patients with hydrocephalus. Measurement of EI is less time consuming and can be used in routine practice. However, the isolated use of EI does not give the extent of cerebral atrophy.

CONCLUSION

We report the normative values of the Evans Index across age and gender. This data about ventricles in the general population is useful for the early diagnosis of hydrocephalus or the follow-up of shunt therapy.

Conflict of interest: Nil

Source of finding: self

Author's Contribution

SB- investigation

AR- data analysis

ACS- manuscript writing

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Table 1: Distribution of Evans Index across age and gender in normal individuals and hydrocephalus patients

	Females			Males			P-value
	n	Mean	SD	n	Mean	SD	
Normal adults							
Age (years)	25	43	21	25	44	19	P>0.05
Evans Index	25	0.25	0.02	25	0.26	0.03	
Normal children							
Age (years)	25	6	3	25	6	4	P>0.05
Evans Index	25	0.25	0.02	25	0.25	0.03	
Hydrocephalous adults							
Age (years)	11	43	21	13	36	16	P>0.05
Evans Index	11	0.41	0.08	13	0.42	0.05	
Hydrocephalous children							
Age (years)	13	4	4	12	6	4	P>0.05
Evans Index	13	0.49	0.11	12	0.50	0.10	

Table 2: Distribution of Evans Index across age and gender in normal individuals

Age Group (years)	Gender	Evans Index	P value
<= 1	Female	0.23±0.01	P.0.05
	Male	0.23±0.03	
2-11	Female	0.25±0.02	
	Male	0.25±0.03	
12-21	Female	0.24±0.02	
	Male	0.25±0.03	
22 - 31	Female	0.25±0.01	
	Male	0.25±0.02	
32 - 41	Female	0.25±0.03	
	Male	0.25±0.03	
42 - 51	Female	0.24±0.05	
	Male	0.26±0.02	
52 - 61	Female	-	
	Male	0.27±0.03	
62 - 71	Female	0.27±0.01	
	Male	0.25±0.01	
72 - 81	Female	0.27±0.01	
	Male	0.28±0	
82 - 91	Female	0.25±0	
	Male	0.28±0	