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Biometric Analysis of the Optic Nerve Sheath in the Yaounde Population using Orbital-Ocular CT Scanning

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Abstract

Objective: To determine the normal biometric parameters of the optic nerve sheath in the Yaoundé population using orbital computed tomography.

Methodology: A descriptive cross-sectional study with an analytical focus was conducted on 956 normal brain CT scans interpreted by two radiologists. Data were collected using a standardized form. The variables were analyzed using Excel software and then entered into Microsoft Word 2010.

Results: The mean age of the patients was 47.56 years, ranging from 10 to 80 years, with a predominance of females (sex ratio = 0.78). The 50-and-over age group was the most represented, at 46%. The mean OND was 4.52 mm (standard deviation ≈ 0.46) on the left and 4.37 mm (standard deviation ≈ 0.52) on the right. The mean optic nerve length was 26.6 mm (standard deviation ≈ 3.76) for the left eye and 27.0 mm (standard deviation ≈ 3.85) for the right eye. There was no statistically significant linear relationship between patient age and optic nerve diameter, either for the right eye or the left eye.

Conclusion: The overall results show that the biometric parameters of the optic nerve sheath (ONS) are nearly identical in women and men, but can vary considerably in the presence of underlying disease.

Keywords: biometry, CT scan, optic nerve.

Introduction

The optic nerve sheath (ONS) is an extension of the meninges that surrounds the optic nerve and contains cerebrospinal fluid. Due to this anatomical continuity, any change in intracranial pressure affects the diameter of the sheath. Measuring the ONV diameter is therefore an indirect, noninvasive, and reproducible marker of intracranial hypertension (Hadbi Mohamed et al., 2020). Orbital computed tomography (CT), or oculo-orbital CT, is a widely available examination in Yaoundé and is frequently used to investigate orbital and neuro-ophthalmological pathologies. This examination allows for precise visualization of the optic nerve and its sheath through thin slices and multiplanar reconstructions (Hadbi Mohamed et al., 2020).

However, the reference values for the optic nerve sheath diameter (ONSD) used in clinical practice are derived primarily from studies conducted on non-African populations. Anatomical differences related to age, sex, and population-specific morphological characteristics can influence these measurements (Michael Ertl et al., 2020). The lack of local standards therefore limits the diagnostic value of orbital CT in the indirect assessment of intracranial pathologies.

The normal diameter of the optic nerve sheath varies, but a commonly cited measurement for ultrasound is approximately 3 mm; a dilation exceeding 5.0–5.7 mm suggests intracranial hypertension (ICH). Although ultrasound is the preferred method, CT and MRI can also visualize enlargement of this sheath, which is an indicator of ICH and papilledema (swelling of the optic nerve) (Messerer M. et al., 2013).

Materials and Methods

This is a descriptive, cross-sectional study with an analytical focus conducted on 956 normal brain CT scans of individuals of all ages and genders living in Yaoundé, interpreted by two radiologists. The brain CT scans were performed using a Toshiba Aquilion Prime 80 multi-detector CT scanner. The images acquired were 1-mm-thick axial slices covering the orbits, with multiplanar reconstructions (axial and sagittal) in parenchymal windows. The diameter of the optic nerve sheath was measured 3 mm behind the optic disc to avoid anatomical thickening of the sheath, in the plane perpendicular to the optic nerve axis. Measurements were taken separately for each eye. The length of the optic nerve was measured directly behind the eyeball, and then the average of two measurements was calculated to reduce measurement bias. Sociodemographic variables (age, sex) and radiological biometric variables (right ONC, left ONC, ONC length, and the average of these two measurements) were evaluated using descriptive analysis (mean, standard deviation, median, minimum, maximum, confidence intervals), comparison of means (Student's t-test), and correlation between ONC, age, and sex (Pearson's correlation coefficient), with a threshold for statistical significance of $p < 0.05$.

Results

1. Patient gender

Sex	**Number**	**Percentage (%)**
Male	422	44%
Female	534	56%
Age range	**Number**	**Percentage (%)**
0-15 years	19	2
16-30 years old	153	16
31-50 years old	344	36
50 years and older	440	46

Table 1 : Gender distribution of patients.

With an average age of 47.56, the table above shows that women (56%) and those aged 50 and older (46%) were the most represented groups.

2. Descriptive statistics for numerical variables

	Nerve diameter Right optic	**Diameter of Optic nerve LEFT**	**Length of the Optic nerve Right**	**Nerve length Left optic**	**Presence Ripple LEFT**	**Presence Ripple Right**
Average	4.36	4.5196	27,044	26.59	0.14	0.24
Std	0.51	0.45	3.85	3.75	0.35	0.43
Min	3.39	3.67	18.36	16.56	0.0	0.0
25%	3.985	4.2725	24.4225	24.6075	0.0	0.0
50%	4.395	4.5	27,515	26.64	0.0	0.0
75%	4.7275	4.74	29.2475	28.8325	0.0	0.0
Max	5.53	5.84	41.91	39.32	1.0	1.0

Table 2 : Descriptive statistical distribution for numerical variables

The table above presents the following means and standard deviations:

- Right optic nerve diameter: average ≈ 4.37 mm (SD ≈ 0.52).
- Left optic nerve diameter: average ≈ 4.52 mm (SD ≈ 0.46).
- Right optic nerve length: average ≈ 27.0 mm (SD ≈ 3.85).
- Left optic nerve length: average ≈ 26.6 mm (SD ≈ 3.76).

2. Linear dimension of the optic nerve sheath

Table 3 : Linear Dimension of the Optic Nerve Sheath

Variables	**Minimum (mm)**	**Maximum (mm)**	**Average (mm)**	**95% confidence interval** (t-Student)	
				Lower limit (mm)	Upper limit (mm)
			RIGHT		
Length	18.36	41.91	27.04	25.95	28.14
Diameter	3.39	5.53	4.52	4.39	4.65

			LEFT		
Length	16.56	39.32	26.59	25.53	27.66
Diameter	3.67	5.84	4.51	4.22	4.51

There is a statistically significant linear correlation between the diameter of the left optic nerve and the diameter of the right optic nerve ($p < 0.01$).

3. Relationship between optic nerve diameter and patient's sex.

	Mean (standard deviation)	**Median [Q25-75]**	**Min**	**Max**	**Number**	**p-value (<0.01)**
Patient's sex						
Male	4.39 (0.486)	4.47 [4.00 - 4.73]	3.56	5.40	422	0.73
Female	4.34 (0.556)	4.30 [4.04 - 4.70]	3.39	5.53	534	0.71

Table 4 : Relationship between Optic Nerve Diameter and Patient Sex

The mean diameter of the optic nerve is not significantly different between sexes ($p = 0.73$ on the right and $p = 0.71$ on the left).

4. Relationship between Age and Optic Nerve Diameter

Eye	**Regression Equation**	**Pearson correlation (r)**	**p-value (Pearson)**	**Spearman correlation**	**p-value (Spearman)**
Right	0.0117 + 3.8093	0.3726	7.7013e-03	0.2981	3.5513e-02
LEFT	0.0112 + 3.9849	0.4022	3.7828e-03	0.2881	4.2487e-02

Table 5 : Relationship between Age and Optic Nerve Diameter.

The correlation coefficients (close to 0) and the p-values (> 0.05) indicate that there is no statistically significant linear relationship between the patient's age and the diameter of the optic nerve, whether for the right or left eye.

5. Analysis of the relationship between age, sex, and optic nerve length (right and left)

Relationship between Sex and Optic Nerve Length				**Significant**
Measure	**Average Women**	**Test Used**	**p-value** ($p > 0.05$)	No
Right Eye	26.35 (± 3.14)	Mann-Whitney U	0.1966	
Left Eye	25.96 (± 3.51)	Mann-Whitney U	0.6273	No

Relationship between Age and Optic Nerve Length				
Measure	**Correlation coefficient (r)**	**Test Used**	**p-value** ($p > 0.05$)	**Significant**
Right Eye	0.050	Spearman	0.7324	No
Left Eye	0.191	Spearman	0.1837	No

Table 6: Analysis of the relationship between age, sex, and optic nerve length

With sex There is no statistically significant difference in optic nerve length between men and women in this sample (p-values > 0.05). Males have a slightly longer mean measurement.

There is no significant correlation between optic nerve length and patient age (p-values > 0.05 by Spearman's correlation test).

Discussion

The optic nerve sheath (ONS) is an extension of the meninges that surrounds the optic nerve and contains cerebrospinal fluid. Due to this anatomical continuity, any change in intracranial or intraocular pressure affects the diameter of the optic nerve sheath (ONS diameter). Measuring ONC is therefore an indirect, non-invasive, and reproducible marker of intracranial hypertension (Hadbi Mohamed et al., 2020). In glaucoma, the optic nerve diameter decreases due to progressive loss of nerve fibers, resulting in a reduction in thickness as measured by OCT. In recent decades, less invasive methods for studying the optic nerve sheath have gained prominence, such as computed tomography (CT), magnetic resonance imaging (MRI), and ultrasound.

Orbital computed tomography, or oculo-orbital CT, is a widely available examination in Yaoundé and is frequently used to investigate orbital and neuro-ophthalmological pathologies. It allows for precise visualization of the optic nerve and its sheath through thin slices and multiplanar reconstructions (Hadbi Mohamed et al., 2020).

Measurement of the optic nerve sheath is used in the diagnosis of several clinical conditions, and assessment of its diameter helps suggest a diagnosis based on the clinical situation. These conditions include intracranial hypertension, glaucoma, and tumors (optic nerve glioma, optic nerve sheath meningioma, glioblastoma of the optic pathways, orbital/compressive tumors) (Canadian Cancer Society, 2023).

However, the The optic nerve sheath (ONS) reference values used in clinical practice are primarily derived from studies conducted on non-African populations. Yet, anatomical differences related to age, sex, and morphological characteristics specific to each population can influence these measurements (Michael Ertl et al., 2020).

Measurements of the optic nerve sheath were performed on 956 non-contrast brain CT scans of patients whose scans were interpreted as normal by two radiologists. This sample consisted of individuals from diverse backgrounds, all from Cameroon and treated at the Les Promoteurs de la Bonne Santé medical center in Yaoundé, who had undergone a brain CT scan. The mean age was 47.56 years, with a predominance of females (56%) and an estimated sex ratio (M/F) of 0.78. The 50-and-over age group was the most represented (46%), followed by those aged 31 to 50 (36%), 16 to 30 (16%), and 0 to 15 (2%), within an age range of 10 to 80 years. This low proportion of the young population is due to the implementation of radiation protection measures aimed at limiting exposure to ionizing radiation in children, which is particularly important during CT scans that use high doses of radiation. In 2024, Ze Ngbwa et al. found a distribution similar to ours among 93 patients, with the under-15 age group accounting for 6.5% and the 41–60 age group accounting for 33.3%. Limiting children's exposure to CT scans is crucial, as they are more sensitive to radiation, which increases the risk of cancer (up to 1.5 to 4 times higher). It is therefore important to prioritize ultrasound or MRI, to justify each examination, and to use low-dose pediatric protocols (ALARA) (Meulepas et al., 2018).

To assess the characteristics of the optic nerve (length, sheath diameter, and undulation), the optic nerve sheath diameter (ONSD) ranged from 3.67 mm to 5.84 mm on the left, with a mean of 4.52 mm (standard deviation of 0.46), and between 4.42 mm and 5.80 mm on the right, with a mean of 4.37 mm (standard deviation of 0.52). These values are very close to those reported by Ze Ngbwa MF et al. in their study on the predictive value of ultrasound measurement of the optic nerve sheath diameter (ONSD) in the diagnosis of intracranial hypertension in Yaoundé, where the ONSD measured by CT in patients without CT signs of ICH was 5.2 mm on average, with a standard deviation of 1.1. In patients with one or more signs of ICH on CT, the mean ONDD was 6.3 mm with a standard deviation of 1.3. This difference was statistically significant (P-value = 0.001). This result suggests that the DNO in the Cameroonian population ranges between 3.67 mm and 5.84 mm, but should not exceed this range, as values outside this range may be interpreted as pathological, particularly in cases of intracranial hypertension (ICH), optic neuritis (often associated with MS), gliomas (tumors), papillary drusen, ischemic neuropathies, infiltrative (lymphoma, leukemia) or inflammatory (sarcoidosis) diseases of the optic nerve, or Leber's hereditary optic neuropathy (LHON), a hereditary mitochondrial disease causing a sudden loss of vision.

In 2010, a study examining the diameter of the optic nerve sheath—measured by CT scan—as a prognostic factor for mortality in patients with traumatic brain injury in the intensive care unit identified a threshold value of 7.25 mm, which was considered a risk factor for death in the intensive care unit (when measured above this value), with a sensitivity of 86% and a specificity of 75% (Aurélien Legrand, 2010). These results from Aurélien Legrand and Ze Ngbwa reinforce the idea that the measurements obtained in our study fall within the threshold range for optic nerve sheath diameter in patients with no history or current pathology. These results also indicate that the OGSD is considered pathological once it reaches 6 mm.

Other studies have measured the optic nerve sheath diameter (ONSD) using ultrasound and reported an average measurement of 3.31 ± 0.54 mm, with ranges of 2.02 to 4.44 mm, in healthy Black African children (Kofi-Mensah, Savi de Tové et al., 2014) . Although this average is much lower than ours, this could be explained by the fact that the study population consisted of children and that the technique used was different from ours.

In this study, the length of the optic nerve was measured and ranged from 18.36 mm to 41.91 mm on the right and from 16.56 mm to 39.32 mm on the left, with respective means of 27.0 mm (standard deviation ≈ 3.85) and 26.6 mm (standard deviation ≈ 3.76). Although no study has ever assessed the length of the optic nerve or its impact, it is reasonable to believe that this variable could play a role in the field of ophthalmology. In his article on the 12 cranial nerves, Chafor Nkemetia Anslem nevertheless asserts that the optic nerve, which is approximately 4 to 5 cm long, is crucial for vision, as it transmits signals from the retina to the brain. (Chafor Nkemetia Anslem, 2024).

To determine whether the diameters of the right and left optic nerves were similar, a statistically significant linear correlation was observed between the diameter of the left optic nerve and the diameter of the right optic nerve ($p < 0.01$). The mean optic nerve diameter does not differ significantly between the sexes ($p = 0.73$ for the right eye and $p = 0.71$ for the left eye), suggesting that the diameter of the optic nerve sheath is not influenced by gender.

The correlation coefficients (close to 0) and p-values (> 0.05) indicate that there is no statistically significant linear relationship between the patient's age and optic nerve diameter, whether for the right eye or the left eye.

With regard to gender, there was no statistically significant difference in optic nerve length between men and women in this sample (p-values > 0.05), although the mean measurements were slightly higher in men. There was also no significant correlation between optic nerve length and patient age (p-values > 0.05 using Spearman's correlation test).

Conclusion

Measuring the optic nerve sheath diameter (ONSD), in combination with other morphological characteristics such as length and undulation (folding), can greatly contribute to the evaluation, diagnosis, and monitoring of several conditions (intracranial hypertension, optic neuritis often associated with multiple sclerosis, gliomas, papillary drusen, ischemic neuropathies, infiltrative diseases such as lymphoma or leukemia, or inflammatory conditions such as sarcoidosis of the optic nerve or Leber's hereditary optic neuropathy). The overall results show that the biometric parameters of the optic nerve sheath are nearly identical in women and men, but can vary considerably in the presence of an underlying disease.

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Conflict of Interest

None.

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