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Assessment of Brain Lesions in Type 2 Diabetes Mellitus and Hypertension using Magnetic Resonance Imaging

Qurain Turki Alshammari[1], Mohammed Salih[1], Moawia Gameraddin[2*], Bushra Abdelmalik[1], Sultan Alshoabi[2], Elfadil Elnour[1], Elgeili Yousif[1]

[1]*Hail University, College of Medical Applied Sciences, Department of Diagnostic Radiology Sciences, Hail, Saudi Arabia*

[2]*Taibah University, Faculty of Applied Medical Sciences, Department of Diagnostic Radiologic Technology, Al-Madinah, Saudi Arabia*

Abstract

Background: Type 2 diabetes mellitus (T2DM) and hypertension (HTN) are risk factors for the spectrum of brain lesions. In this paper, we studied the impact of T2DM and HTN on the incidence of several brain lesions diagnosed with magnetic resonance imaging (MRI).

***Methods and Results*:** This retrospective, single-center study was conducted at Royal Care International Hospital (Khartoum, Sudan) from January 2016 to December 2016 and included 80 patients (40 male and 40 female, aged between 20 years and 90 years) with suspected brain disorders. MRI brain examinations were conducted on a 1.5 Tesla MRI system (Toshiba Medical Systems, Tokyo, Japan). The following sequences were analyzed: T1-weighted imaging (T1WI), T2-weighted imaging (T2WI), fluid-attenuated inversion recovery (FLAIR), and diffusion-weighted imaging (DWI). Brain lesions were characterized by magnetic imaging spectroscopy and histopathological analysis. Binary logistic regression analysis was used to establish a mathematical model of the relationship between T2DM/HTN and the prevalence of brain lesions.

Among 80 patients, HTN, T2DM, and the combination of T2DM and HTN were identified in 18(22.5%), 9(11.2%), and 11(13.8%) patients, respectively. Brain lesions were found in 48(60%) patients and were most prevalent in the age group of 66-80 years. The brain lesions included ischemic brain infarction (22.5%), brain tumors (11.2%), cerebral hemorrhages (6.2%), brain atrophy (1.2 %), ischemic brain infarction with brain atrophy (16.2%), and brain metastases (2.5%). Regression analysis showed that HTN and T2DM were associated with significantly higher ORs for brain lesions ([OR=2.459, 95% CI: 1.673–3.614, P<0.001] and [OR=1.507, 95% CI: 1.067–2.128, P=0.042], respectively). HTN was associated with significantly higher OR for ischemic brain infarction (OR=7.404, 95% CI: 2.600–21.081, P<0.001).

Conclusion: The study showed a significant interaction between HTN and T2DM on the prevalence of brain lesions, especially ischemic brain infarction and brain atrophy.(**International Journal of Biomedicine. 2020;10(4):382-386.**)

Key Words: brain lesions • MRI • ischemic brain infarction • diabetes • hypertension

Abbreviations

BA, brain atrophy**; CH**, cerebral hemorrhages; **DWI**, diffusion-weighted imaging; **FLAIR**, fluid-attenuated inversion recovery; **HTN**, hypertension; **IBI**, ischemic brain infarction; **MRI**, magnetic resonance imaging; **T2DM**, type 2 diabetes mellitus.

Introduction

Type 2 diabetes mellitus (T2DM) and hypertension (HTN) are common risk factors associated with a spectrum of brain lesions such as ischemic brain infarcts (IBI), neurodegenerative outcomes, brain atrophy (BA), late-life cognitive impairment, and others.[1-4]

Magnetic resonance imaging (MRI) is widely used in diagnosing brain ischemic lesions, intracranial tumors, brain metastases, and other lesions. With recent advances in MRI technology, ischemic lesions can be identified with high accuracy using diffusion-weighted image (88%-100% sensitivity and 95%-100% specificity).[5] New diagnostic techniques, such as dynamic color mapping, diffusion-weighted imaging, diffusion

tensor imaging, perfusion-weighted imaging, magnetic resonance spectroscopy, and functional MRI allow us to obtain detailed information about brain lesions.[6-8]

The aim of our study was to study the impact of T2DM and HTN on the incidence of several brain lesions diagnosed with MRI.

Materials and Methods

This retrospective, single-center study was conducted at Royal Care International Hospital (Khartoum, Sudan) from January 2016 to December 2016 and included 80 patients (40 male and 40 female, aged between 20 years and 90 years) with suspected brain disorders. Among 80 patients, HTN, T2DM, and the combination of T2DM and HTN were identified in 18(22.5%), 9(11.2%), and 11(13.8%) patients, respectively.

HTN was diagnosed when a person's systolic blood pressure (SBP) was ≥140 mmHg and/or their diastolic blood pressure (DBP) was ≥90 mmHg following repeated examination.[9] Diabetes was diagnosed when the patient has a fasting blood glucose level of 126 mg per dL (7.0 mmol per L) or greater on two separate occasions.[10]

The data collection sheets completed for each subject included the following variables: sex, age, clinical history of HTN and T2DM, and MRI findings.

This study was approved by the ethics committee of the Royal Care International Hospital. Written informed consent was obtained from each patient.

MRI brain examinations were conducted on a 1.5 Tesla MRI system (Toshiba Medical Systems, Tokyo, Japan). Each patient was scanned supine on the examination couch with his or her head within the head coil. Images were obtained in a plane orthogonal to the long axis of the hippocampus; this plane is orientated parallel to the brainstem. The following sequences (slice thickness/interslice distance of 5mm/1.5mm) were analyzed: T1-weighted imaging (T1WI), T2-weighted imaging (T2WI), fluid-attenuated inversion recovery (FLAIR), and diffusion-weighted imaging (DWI). Brain lesions were characterized by magnetic imaging spectroscopy and histopathological analysis.

Statistical analysis was performed using IBM SPSS Statistics 23. Binary logistic regression analysis was used to establish a mathematical model of the relationship between T2DM/HTN and the prevalence of brain lesions. Odd ratios (OR) and their 95% confidence intervals (95%CI) were calculated. A probability value of $P<0.05$ was considered statistically significant.

Results and Discussion

The demographic, clinical characteristics and medical history of study participants are presented in Table 1. Among 80 patients, HTN, T2DM, and the combination of T2DM and HTN were identified in 18(22.5%), 9(11.2%), and 11(13.8%) patients, respectively. Brain lesions were identified in 48(60%) patients (Table 1) and were most prevalent in the age group of 66-80 years. The brain lesions included ischemic brain infarction (IBI) (22.5%), brain tumors (11.2%), cerebral hemorrhages (CH) (6.2%), brain atrophy (BA) (1.2 %), IBI with BA (16.2%), and brain metastases (2.5%). IBI with and without BA was found in 16.2% and 22.5% cases, respectively, (Fig.1 and Table 2) and accounted for 27.1% and 37.5%, respectively, of all brain lesions. Brain tumors accounted for 18.8% of all brain lesions, whereas cerebral hemorrhage for 10.4%. The other brain lesions were less frequent. IBI was most common in the age groups of 51-65 and 66-80, whereas IBI and BA were most frequent in the age group of 66-80 years (Table 2). The prevalence of brain tumors was most frequently found in the age group of 36-50 years. Figure 2 shows the distribution of brain lesions between males and females. It was observed that IBI and IBI+BA were higher among males than among females (10 vs. 8 and 9 vs. 4, respectively). It was found that IBI+BA was prevalent (63.6%) in patients with T2DM and HTN (Table 3).

Table 1:

The demographic, clinical characteristics and medical history of study participants

Variable	Absolute number	Percent, %
Males	40	50
Females	40	50
Age groups		
20-35 years	19	16.7
36-50 years	18	15.8
51-65 years	16	14.0
66-80 years	23	20.2
81-90 years	4	3.5
Clinical history		
None	42	52.5
T2DM	9	11.2
HTN	18	22.5
T2DM+HTN	11	13.8
MRI Diagnosis of brain lesions		
Yes	48	60.0
No	32	40.0

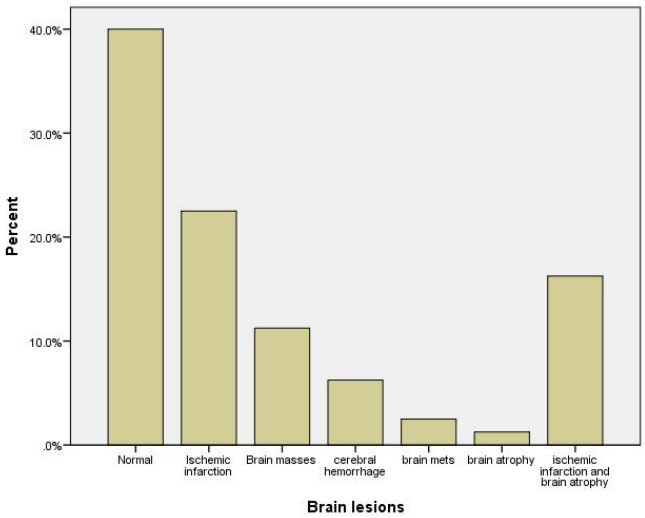

Fig. 1. *Distribution of spectrum brain lesions in the study sample.*

Table2.

Incidence of brain lesions in different age groups

Age groups	No brain lesions	IBI	Brain tumors	CH	Brain Mets	BA	IBI and BA
20-35 yrs (n=19)	15 (78.9%)	2 (10.5%)	1 (5.3%)	1 (5.3%)	-	-	-
36-50 yrs (n=18)	12 (66.7%)	2 (11.1%)	4 (22.2%)	-	-	-	-
51-65 yrs (n=16)	3 (18.8%)	8 (50.0%)	1 (6.2%)	1 (6.2%)	2 (12.5%)	-	1 (6.2%)
66-80 yrs (n=23)	2 (8.7%)	6 (26.1%)	3 (13.0%)	3 (13.0%)	-	1 (4.3%)	8 (34.8%)
81-90 yrs (n=4)	-	-	-	-	--	-	4 (100%)
Total (n=80)	32 (40.0%)	18 (22.5%)	9 (11.2%)	5 (6.2%)	2 (2.5%)	1 (1.2%)	13 (16.2%)

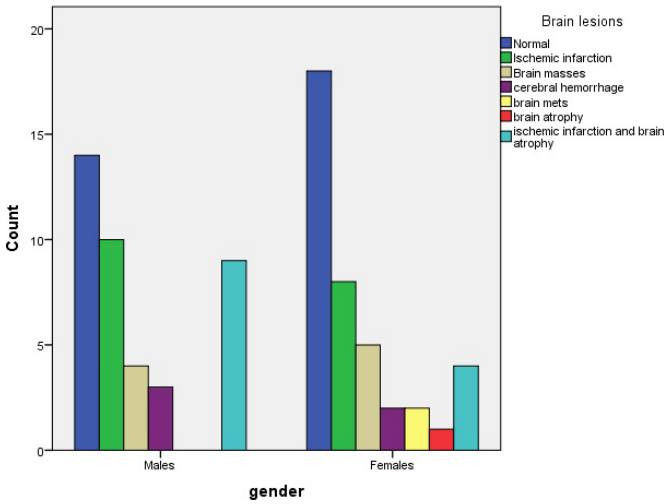

Fig. 2. *Distribution of brain lesions according to gender*

Table 3.

Brain lesions in the study participants

Clinical history	Brain lesions						
	No brain lesions	IBI	Brain tumors	CH	Brain Mets	BA	IBI and BA
No history of T2DM and HTN	25 (59.5%)	7 (16.7%)	5 (11.9%)	1 (2.4%)	2 (4.8%)	-	2 (4.8%)
T2DM (n=9)	4 (44.4%)	3 (33.3%)	1 (11.1%)	1 (11.1%)	-	-	-
HTN (n=18)	2 (11.1%)	7 (38.9%)	2 (11.1%)	2 (11.1%)	-	1 (5.6%)	4 (22.2%)
T2DM and HTN (n=11)	1 (9.1%)	1 (9.1%)	1 (9.1%)	1 (9.1%)	-	-	7 (63.6%)
Total (n=80)	32 (40.0%)	18 (22.5%)	9 (11.2%)	5 (6.2%)	2 (2.5%)	1 (1.2%)	13 (16.2%)

T2DM was associated with a significantly higher OR for cerebral hemorrhage, although the relationship was statistically insignificant (P=0.22) (Fig.3). The associations between brain tumors and T2DM or HTN were of no significance (P>0.05) (Fig.4).

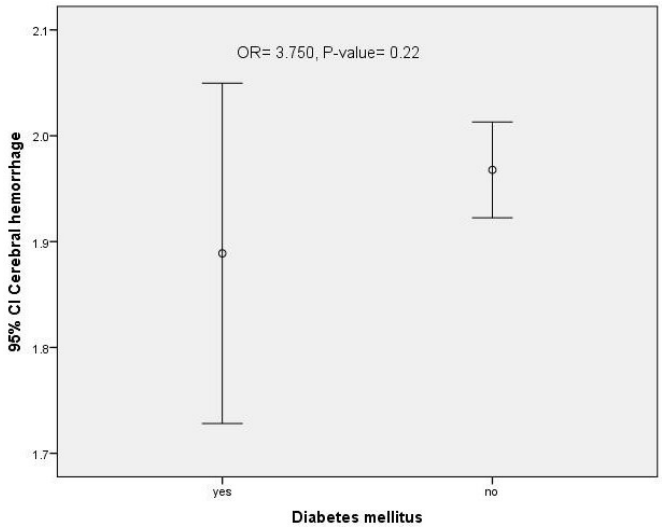

Fig. 3. *Association of T2DM with cerebral hemorrhages*

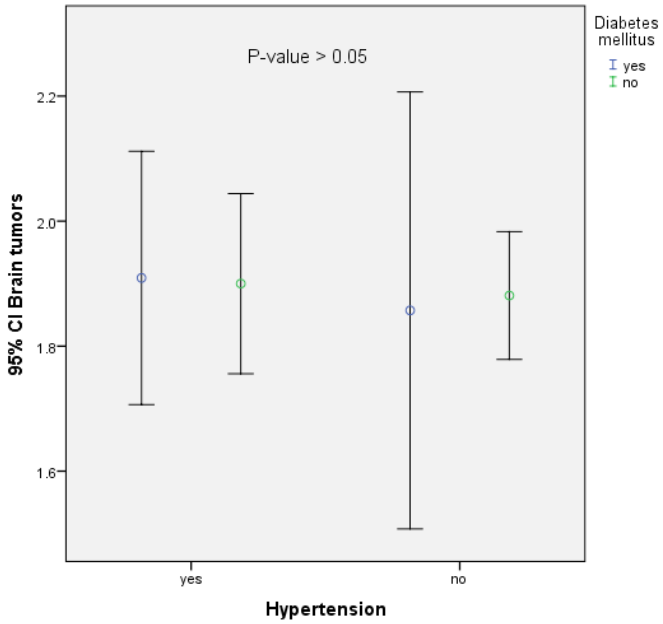

Fig. 4. *Association of T2DM and HTN with brain tumours*

Regression analysis showed that HTN and T2DM were associated with significantly higher ORs for brain lesions ([OR=2.459, 95% CI: 1.673–3.614, P<0.001], [OR=1.507, 95% CI: 1.067–2.128, P= 0.042] (Table 4). Table 5 summarizes the associated factors of ischemic brain infarction. HTN was associated with significantly higher OR for ischemic brain infarction (OR=7.404, 95% CI: 2.600–21.081, P<0.001), while the associations between the risk of ischemic brain infarction and sex or diabetes were of no significance.

T2DM and HTN are potent risk factors for cerebrovascular disease. Brain ischemic lesions are frequently seen on brain MRI especially in the elderly population. Hypertension and

T2DM were reported to be strongly associated with risks of vascular brain lesions, neurodegeneration, IBI, and BA.[11-15] The evidence for the relation between blood pressure and brain atrophy is less clear.[12] Some studies showing that high midlife blood pressure is related to BA later in life,[16-18] while others show that in older individuals, especially low blood pressure levels lead to an increased risk for BA.[19,20]

Table 4.

Binary logistic regression analysis of associated factors for brain lesions

Variable	B	SE	χ^2	Sig.	OR	95%CI
Gender	-0.077	0.635	0.015	0.904	0.926	0.267–3.216
Age	0.075	0.022	12.160	0.001	1.078	1.033–1.124
HTN	-1.565	0.802	22.312	< 001	2.459	1.673–3.614
T2DM	0.109	0.839	3.908	0.042	1.507	1.067–2.128

Table 5.

Binary logistic regression analysis of associated factors for brain ischemic infarction

Variable	B	SE	χ^2	Sig.	OR	95%CI
Gender	0.494	0.601	0.675	0.411	1.639	0.504–5.327
Age	-0.065	0.021	9.457	0.002	0.937	0.900–0.977
HTN	2.002	0.534	14.060	<0.001	7.404	2.600–21.081
T2DM	1.032	0.634	2.646	0.104	2.806	0.810 –9.723

The current study supports the hypothesis that T2DM and HTN increased the risk of various brain lesions. IBI and BA were the most prevalent lesions in the study sample with HTN and T2DM. Our results are in agreement with the data obtained by Roberts et al. [21] Moran et al. reported that T2DM was associated with more cerebral infarcts and lower total gray, white, and hippocampal volumes.[22]

The mechanisms by which T2DM and HTN cause brain lesions are disputed. They may primarily target blood vessel structure and function to cause vascular damage or may interact at the cellular level with neurons or synapses that affect neurodegenerative processes and promote brain neurodegeneration.[21,23,24]

As we age, structural changes occur throughout the brain. Such common brain changes include global atrophy, white matter injury, small-vessel ischemia, and microhemorrhages. (25-29) These changes are more frequent and more severe in HTN and T2DM. The present study revealed that the incidence of brain lesions, especially brain atrophy, increased with age. Our results are consistent with T. Gu et al.[30] who found that age and the number of cardiovascular risk factors are independently associated with the brain atrophy and lesion index score.

Accumulating evidence suggests that a history of diabetes may be involved in the occurrence of various types of cancer.[31-34] The findings of the meta-analysis performed by Tong et al [35] indicate that diabetic individuals have a similar risk of brain tumors as non-diabetic individuals. However, a significant positive correlation between the risk of brain tumors and diabetes mellitus was revealed in females, but not in males. Our study found that DM and HTN were not significantly associated with the incidence rates for brain tumors.

In conclusion, HTN and T2DM are associated with advanced brain damage. The current study showed a significant interaction between HTN and T2DM on the prevalence of brain lesions, especially ischemic brain infarcts and brain atrophy.

Competing Interests

The authors declare that they have no competing interests.

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***Corresponding author**: Associate professor Moawia Gameraddin, Department of Diagnostic Radiologic Technology, Faculty of Applied Medical Sciences, Taibah University, Al-Madinah Al-Munawarah, Saudi Arabia. Email: gameradinm@gmail.com*

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