THE CORRELATION OF MATRIX METALLOPROTEINASE-9 WITH STROKE AND PREVALENCE, RISK FACTORS, AND KNOWLEDGE OF STROKE AMONG PALESTINIANS

ROZAN ATTILI, HATEM A HEJAZ

Department of Medical Sciences, College of Pharmacy and Medical Sciences, Hebron University, P. O. Box 40; Hebron, Palestine.
Email: rozana@hebron.edu

ABSTRACT

Objectives: The research study aims to estimate the prevalence of the stroke, to evaluate the stroke associated risk factors, and to determine the factors and symptoms associated with the knowledge of the stroke among the Palestinian population. Furthermore, to find the association between matrix metalloproteinase-9 (MMP-9) levels and the stroke, the concentration of MMP-9 in the serum of stroke patients was measured.

Methods: The research study includes a cross-sectional survey that was conducted. The serum MMP-9 levels were also measured in 11 stroke patients using an ELISA reader. Statistical analysis was performed by GraphPad Prism version 8. Sociodemographic characteristics of stroke patients associated with stroke among the Palestinian population were also obtained and analyzed.

Results: The higher incidence of the stroke was in the patient's ages between 51 and 60 years old, with 30 patients (46%) of the total stroke patients. The majority of the stroke patients 40 (60.6%) were having enough income. Most of the stroke patients (29, 43.9%) were none educated. The majority of the stroke patients 48 (72.2%) had a family member/s who has been diagnosed with a stroke. Most of the stroke patients 60 (90.9%) have sudden numbness, weakness in the face, arms, and legs. All the samples analyzed showed a marked increase in MMP-9 concentration.

Conclusions: The prevalence of stroke and the high risk of stroke were high among adults aged ≥51 years in Palestine. Hypertension was the highest risk factor for stroke. The serum MMP-9 could be an important prognostic factor for the stroke.

Keywords: Matrix metalloproteinase-9, Risk factors, Stroke, MMP-9, Ischemic stroke, Knowledge, Prevalence.

INTRODUCTION

Stroke is the third most common cause of death in most Western countries, after coronary heart disease and cancer. Stroke accounts for 44 million physical disabilities annually, with 5.5 million deaths worldwide. Stroke is the leading cause of death in the United States; stroke kills about 140,000 Americans each year – that is 1 out of every 20 deaths. Someone in the United States has a stroke every 40 s. According to the Centers for Disease Control and Prevention, every 4 min someone dies of a stroke, every year, more than 795,000 people in the United States have a stroke. Blood vessels are required to transport and carry oxygen nutrients electrolytes, etc., throughout the body. Once there is a stroke the blood vessel will be blocked through the formation of a different sized or clot or the leakage of the blood from the body vessels [1-3].

A stroke occurs when oxygen and nutrients are unable to reach the brain due to blockage or rupture of a blood vessel. When this occurs, the deprived part of the brain begins to die. Stroke is classified into two common major types; ischemic stroke and hemorrhagic stroke. Ischemic stroke accounts for 87% of all strokes and occurs when a blood clot or fatty deposit blocks blood flow to the brain. While 13% of all strokes is hemorrhagic stroke which occurs when a blood vessel that supplies blood to the brain ruptures. However, the majorities of the strokes are ischemic stroke [4], where the blood flow is reduced as mentioned and in a long stage leads the cells to lose their proper function [5]. This depends on the type of neurons enrolled in this process and their hetergennicity; therefore, some neurons will be more susceptible to ischemic and some are more resistant [1-3,5]. Hemorrhagic stroke is the second type of stroke and it is the second one in terms of incidences; mainly, it happens because the vessel becomes very fragile which allows the leakage of blood and a high amount of bleeding. As the bleeding happens this interferes with the function of the brain, in which the brain starts to lose its function; in addition to that; the senses neurons are affected too. Multifactors are involved in this process; the most common factor is hypertension. Using blood thinners can cause a high risk of dangerous bleeding after an injury in the head [1-3].

To facilitate health interventions that would reduce mortality and morbidity due to stroke, it is important to assess public awareness about the disease and its risk factors most, especially among the younger population who are still amenable to primordial and primary prevention. This study assessed community knowledge and risk factors of stroke among Palestinian individuals.

This research study aims to investigate the incidence rate of the stroke among the Palestinian population, to identify the risk factors of the stroke, to assess the knowledge of the stroke risk factors, and to determine the factors and symptoms associated with the knowledge of the stroke among individuals. Furthermore, to shows; if the gender is an important factor in stroke prevalence and to investigate whether the matrix metalloproteinase-9 (MMP-9) has a role in the stroke; by measuring its concentration in random blood stroke patient samples; as MMP-9 is presumably a possible marker for acute stroke. In other words, MMP-9 could be an important prognostic factor for stroke. However, identification and interventions of the risk factors could prevent stroke and/or promote stroke prevention strategies. Besides, increasing knowledge about stroke risk factors may lead to improved prevention and treatment of stroke.

METHODOLOGY

The research study consists of two parts: The first part is a cross-sectional track which includes an online questionnaire. The online questionnaire was available to the public and completed electronically by individuals

through Google Forms. The electronic questionnaire was distributed and remains online for about 4 months. The questionnaire includes questions about the stroke risk factors (age, gender, sociodemographic characteristics of stroke patients, income, education, and work), and the knowledge about the risk factors associated with the stroke. The results obtained from the questionnaire were collected and entered into a Microsoft Excel sheet for processing and analysis. The questionnaire has a statement regarding the consent of the individuals to participate in the survey study and to collect and process their data. No questions regarding the identity of the participants were in the questionnaire. Therefore, the identities of the individuals who completed the questionnaire form are unknown; thus, the participant's information remains and is kept confidential and only used for research purposes. All the subjects who participated in the research study could withdraw at any time.

The second part of the research study includes the analysis of the stroke patient's blood samples. The blood samples were collected after getting the consent of the Ministry of Health (MOH). Blood samples of the stroke patients admitted were collected and then were subjected to centrifugation to obtain the serum. All the samples collected were transported rapidly on the ice and kept at −20°C. The serum samples were processed and analyzed using the Human Quantikine ELISA kit (Sigma-Aldrich) according to the manufacture protocol. The ELISA reader is used to measure the concentration of MMP-9 in the corresponding patient's samples. Statistical analysis was carried out using GraphPad prism 8. Sociodemographic characteristics of the stroke patients, the risk factors, and the knowledge about the risk factors associated with the stroke among the Palestinian population were also obtained from an online questionnaire and analyzed. Comparing the prevalence of the stroke between Palestine and other nearby countries was reviewed and discussed.

RESULTS

Two hundred and twenty-six Palestinians individuals with different ages and sex (138 females [~61%] and 88 males [~39%]) were completed the online questionnaire. After a careful assessment to identify the stroke patients, the majority of individuals were found healthy; 160 (70.8%) of participants are non-stroke patients (109 [48.2%] females and 51 [22.5%] males), while 66 (~29%) participants (29 [12.8%] females and 37 [16.3%] males) were diagnosed as stroke patients. The total participants in the survey represented in Fig. 1.

Risk factors of the stroke including age, gender, sociodemographic characteristics of the stroke patients, income, education, work, and the knowledge about the stroke risk factors among the Palestinian population were analyzed. Since age is an important factor in stroke incidence, the outcomes and complications of the stroke were studied on different age groups (1–10, 11–20, 21–30, 31–40, 41–50, and 51–60

years) to see which age group has the highest incidence (Fig. 2). The higher incidence of the stroke was found in the patient's ages between 51 and 60 years old (30 patients, 46% of the total 66 diagnosed stroke patients). The second age groups with stroke were in the patient' ages between 41–50 and 31–40 years, with a total of 11% and 5%, respectively. However, the age groups between 21–30, 11–20, and 1–10 years have the lowest incidence among the age groups with a total of 2%, 1%, and 1%, respectively. Thus, age plays an important role in the incidence and complications of the stroke as the prevalence in younger age is found to be low and the risk increases with age, as shown in Fig. 2. One of the parents was completed the questionnaire for the patients aged between 1 and 10 years old.

The prevalence of the stroke between males and females was analyzed. The gender difference among the individuals of the stroke in our studied group found to be an important factor in the prevalence of the stroke, as the majority of the stroke patients were males with 37 (56%) and 29 females (44%), this indicates that the male gender is at a higher risk of stroke than females, as shown in Fig. 3. The results indicate that male's gender is at a higher risk for stroke than females.

The sociodemographic characteristics of the stroke patients in our study were collected (Table 1); it was found that the majority of the stroke patients were living in villages 37 (56%) and 29 (44%) patients were living in cities, indicating that the incidence of the stroke in the rural area is higher than the cities. The majority of the stroke patients 40 (60.6%) were having enough income, 17 (25.7%) their income were not enough, and only 8 (12.1%) their income were sufficient and more. The majority of the stroke patients were also none educated as 29 (43.9%) have no degree; 20 (30.3%) have secondary school or less and only 17
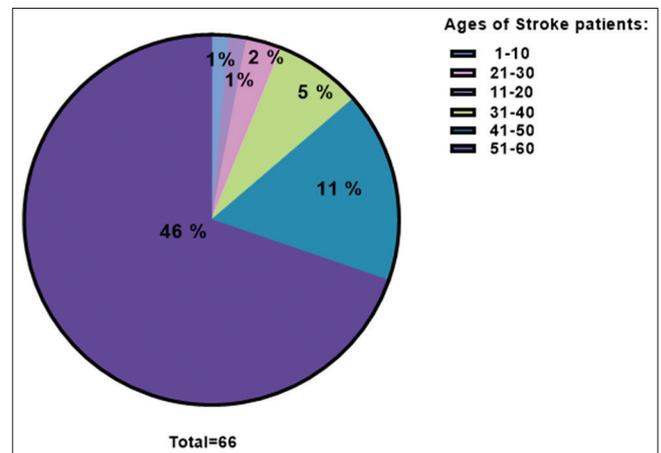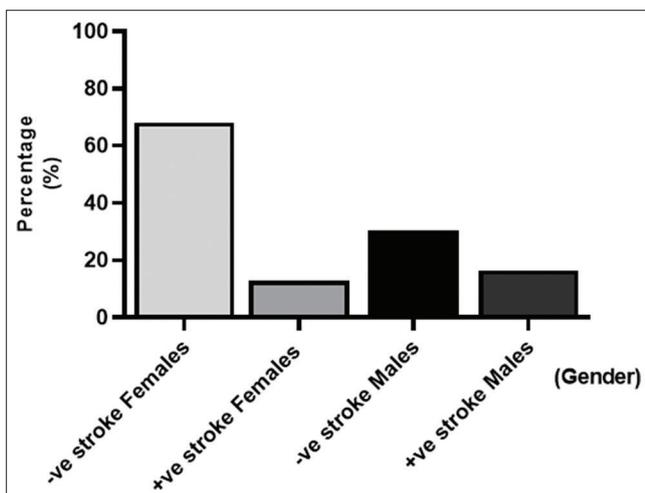
Fig. 2: Incidence of stroke in different age groups
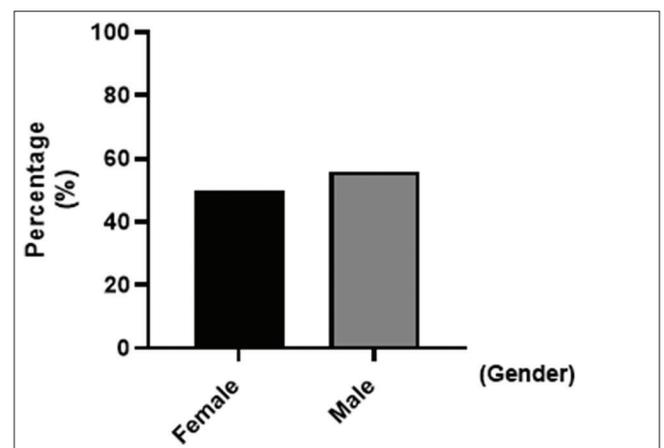
Fig. 1: Prevalence rates for the stroke

Fig. 3: Gender incidence rate of stroke

(25.7.5%) have a university education level or higher degree. Regarding the patients work and profession, most of the stroke patients were either retired 19 (28.7%), or housewives 18 (27.2%), hand workers 11 (16.6%), and another business profession 10 (13.6%), not working 9 (13.6%), and only 4 (6%) are professional workers, as shown in Table 1.

The patients asked about the knowledge, symptoms, the risk factors of the stroke, and the definition of stroke and the results are presented in Table 2. Their knowledge about the stroke was varied and the majority of the stroke patients 32 (48.48%) know that the stroke causes a rapid loss of the brain function, while 10 (15.15) know that it causes accumulation of fluid inside the brain, 10 (15.15%) answered that it causes abnormal growth of tissues in the brain, and 4 (6.06%) said that it causes inflammation of the brain and membranes, as shown in Table 2. Most of the stroke patients know that hypertension is an important risk factor for the stroke as 56 patients (84.8%) mentioned

Table 1: Sociodemographic characteristics of stroke patients

Variables and its categories		Frequency (n)	Percent
Place of residence	City	29	44
	Village (i.e., small communities, rural, urban)	37	56.0
The monthly income of the family	Not enough	17	25.7
	Just enough	40	60.6
	Sufficiency and increase	8	12.1
Education	Secondary school or less	20	30.3
	University or high degree	17	25.76
	Non-educated	29	43.94
Work	Professional worker	4	6
	Housewife	18	27.2
	Hand worker	11	16.6
	Retired	19	28.7
	Other business	10	15.1
	Not working	9	13.6

Table 2: Patients knowledge, symptoms, and risk factors of stroke (symptoms or signs and cause of stroke)

What is a stroke?	Inflammation of the brain and membranes	4	6.06%
	Abnormal growth of tissues in the brain	6	9.09%
	Rapid loss of brain function	32	48.48%
	Accumulation of fluid inside the brain	10	15.15%
	Do not know	11	16.6%
Risk factors for stroke	Hypertension	56	84.8%
	Diabetes	4	6.06%
	Smoking and alcohol	6	9.09%
Is there any of your family member/s who has been diagnosed with stroke?	Yes	48	72.7%
	No	15	22.7%
	Do not know	3	4.5%
Is there any sudden numbness or weakness in the face/arms/legs, esp. in one half of the body?	Yes	60	90.9%
	No	1	1.5%
	Do not know	5	7.57%
Is there any sudden confusion/ trouble speaking/ understanding	Yes	65	98.48%
	No	1	1.51%
	Do not know	0	0.0%
Is there sudden difficulty in seeing in one/both eyes?	Yes	43	65.15%
	No	14	21.2%
	Do not know	9	13.6%
Is there sudden pulsation with chest pains?	Yes	41	62.12%
	No	17	25.75%
	Do not know	8	12.1%
Is there sudden trouble walking, dizziness, loss of balance, or inability to organize the movement?	Yes	59	89.39%
	No	5	7.75%
	Do not know	2	3.03%
Is there shortness of breath or sudden high body temperature?	Yes	43	65.15%
	No	17	25.75%
	Do not know	6	9.09%
Is there a sudden severe headache without a known cause?	Yes	44	66.6%
	No	15	22.72%
	Do not know	7	10.6%
If you notice someone stroke symptoms, what you should do?	Immediately contacts ambulance	59	89.3%
	Do not know	7	10.6%
From where did you get the above information?	The presence of an individual from a family or a sick friend	33	50%
	Network asteroid (internet)	4	6.06%
	Personal experience	14	21.2%
	Media (TV, radio)	5	7.5%
	Books	3	4.54%
	Lectures, courses, workshops	1	1.51%
	Personal experience and books	3	4.54%
	Personal experience and Internet	1	1.51%
	Other	2	3.03%

this, and the least expected risk factor was diabetes 4 (6.06%). The majority of the stroke had a family member/s who has been diagnosed with a stroke. Thus, there is a correlation between the stroke and the family history, as having a family member/s with stroke increases the incidence of the disease. Most of the stroke patients 60 (90.9%) have sudden numbness, weakness in the face, arms, and legs, especially in one half of the body and only 1 (1.5%) answered that there is no such feeling, as shown in Table 2.

Table 3 represents knowledge about the risk factors associated with stroke among patients who are diagnosed with a stroke. These include high blood pressure, diabetes, smoking and alcohol, stress and anxiety, heart and blood diseases, increased fats and cholesterol in the blood, obesity, lack of drive and do not exercise regularly, and some drugs such as contraception. The majority of the patients 57 (86.36%) mentioned that high blood pressure is a risk factor and only 7 (10.6%) patients said that it is not, while 2 (3.03%) patients do not know if it is a risk factor or not. About half of the patients 34 (51.51%) know that diabetes is a risk factor, while 27 (40.9%) patients said that it is not and 5 (7.5%) patients do not know if it is a risk factor or not. The high percent of the patients; 80.30%, 74.12%, 69.69%, and 66.66% know that stress and anxiety, high cholesterol, obesity and sedentary, and heart and blood diseases, respectively, are risk factors, as shown in Table 3.

MMP-9 is known to have a dual effect, elevated, or inhibitory effects. This depends on the type of disease, the stage of the disease, and the dose of the drug used. To establish if there is any correlation between the MMP-9 and the stroke, 11 random serum samples from the stroke patients who were admitted to Hebron Governmental Hospital were collected and analyzed. All the samples of stroke patients showed a marked increase in MMP-9 concentration (7000 pg/ml–9000 pg/ml), in contrast to the negative control (100–150 pg/ml) and positive control (1200 pg/ml–1214 pg/ml), as shown in Fig. 4. However, MMP-9 has a significant effect on stroke. The MMP-9 concentration was compared between different stroke samples by unpaired t-test with Welch correction. Results were considered significant at $p < 0.0001$.

Different articles of stroke published by authors from nearby countries to Palestine were reviewed, for comparing the prevalence and risk factors of the stroke between Palestine and these countries. Our results were consistent and identical to the studies in nearby countries' of the incidence and risk factors of stroke. The data of these countries show that the males and the age group above 51 have a high risk of stroke similar to our research study data; other risk factors were also similar with some exceptions.

DISCUSSION

Stroke is a world-leading cause of mortality worldwide and it is also referred to as a cardiovascular accident. It is a sudden neurologic deficit manifesting either as vascular occlusion from thrombosis or embolism or hemorrhage into the brain due to a blood vessel rupture usually due to hypertension [6]. In our study, 66 patients (29.2%) of a total of 226 samples were stroke patients, from both genders, males and females. The incidence of stroke in our study is consistent with the two hospital-based studies conducted in North Palestine in 2008 and 2009 [7,8]. While the third study in 2019 was conducted in the Gaza strip and showed that the stroke has a lower incidence in this area [9]. Knowledge of stroke risk factors is known to reduce the incidence of stroke. This study assessed the level of knowledge of stroke risk factors among Palestinians individuals with different age groups, stroke patients were between 1 and 60 years old with a mean age of 30.

Associations between the sociodemographic characteristics of the stroke patients and their knowledge were found that almost all these characteristics lack statistical significance; except for education; as most of the stroke patients in this study were non-educated. It seems that education affects knowledge, and higher education is an important factor for the knowledge of stroke and its risk factors. This suggests that better education plays a key role in public health awareness. Interestingly, age was significantly associated with knowledge of stroke risk factors. The result disagreed with a study that indicates no significant relationship between the knowledge of stroke and the age. Our result is consistent with other studies which show that the stroke incidence is higher among non-educated patients [10]. The study shows that the prevalence of stroke and the high risk of stroke were high among adults aged between 51 and 60 years (Fig. 2). However, age plays an important role in the incidence and complications of the stroke; as the prevalence in younger age is found to be low and the risk increases with age, as shown in Fig. 2. This finding is identical to other studies as age was found to be an important factor in stroke incidence, the outcomes, and the complications of the stroke [11].

Table 3: The knowledge about the risk factors associated with stroke among patients

| Variables and its categories leading cause of stroke		Frequency (n)	Percent
High blood pressure	Yes	57	86.36
	No	7	10.6
	Do not know	2	3.03
Diabetes	Yes	34	51.51
	No	27	40.9
	Do not know	5	7.5
Smoking and alcohol	Yes	30	45.45
	No	30	45.45
	Do not know	6	9.09
Stress and anxiety	Yes	53	80.30
	No	9	13.6
	Do not know	4	6.06
Heart and blood diseases	Yes	44	66.66
	No	14	21.21
	Do not know	8	12.12
Increase the fats and cholesterol in the blood	Yes	49	74.12
	No	8	12.12
	Do not know	9	13.6
Obesity, lack the drive, and do not exercise regularly	Yes	46	69.69
	No	18	27.27
	Do not know	2	3.03
Some drugs such as contraception	Yes	21	31.8
	No	25	37.8
	Do not know	20	30.30
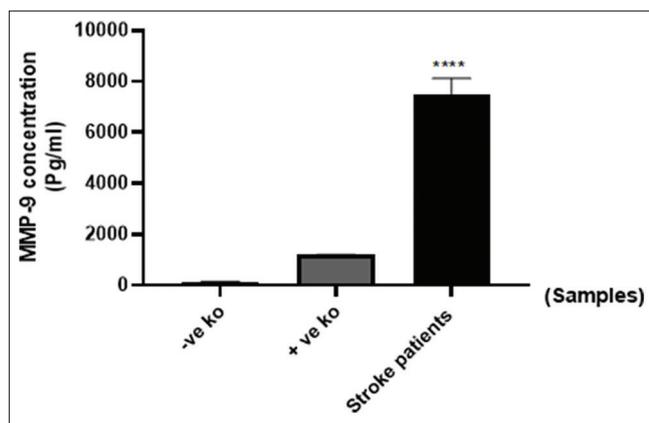
Fig. 4: Significant induction of MMP-9 expression in the serum of stroke patients in Palestine. MMP-9 concentration in serum samples of stroke patients compared by unpaired t-test with Welch correction. Results were considered significant at p<0.0001

The study shows that males have a higher rate of stroke compared to females; this finding is consistent with other studies in different countries (Bahrain, Egypt, and Iran). For examples, a hospital-based study in Bahrain showed that the stroke incidence is higher in males in contrast to females [12], moreover, in Egypt, a prospective study showed that the male-to-female ratio was 1.7:1, this also indicates that a higher rate for stroke occurs in male gender [13], and a third study also agrees with our finding was conducted in Iran, which showed that the rates of the stroke are higher in male gender than the females [14]. According to our knowledge, this is the first study in Palestine that shows that stroke incidence is higher in males than females. This finding can be used for further investigation and to study certain factors such as genetic factors, diet type, lifestyle heterogeneity of neurons or vessels in the male gender, and why the male gender is at higher risk for stroke.

The stroke patients who live in villages (37, 56.06%) are slightly more than those who live in cities (29, 43.94%), as shown in Table 1. The high incident rate of stroke in the villages may be due to different assumptions such as reduced specialized facilities in the villages; difficulty in receiving the rapid and accurate treatment which could cause more subsequent complications among stroke. There are no studies in the Arab regions that studied the incidence of stroke based on the residence or showed living in an urban-rural area increases the incidence of stroke among this group. In the future, it is worth carrying out studies to study the correlation between stroke incidence and living in the village and rural areas, similar to the study conducted in China, which showed that the stroke was higher in the village compared with the city [15]. However, still further studies are needed to check and confirm the incidence rate of stroke among urban areas and rural areas.

Analyzing the other socioeconomic status of stroke patients precisely including their income. The results showed that the patients with an income which is considered as just enough income were the highest group of stroke patients (40, 60.6%); just enough income means that the person can cover the basic living expenses. Our data also represented that the patients with an income that is considered sufficient and more have lower rates of stroke incidence. An economic factor is an important factor in the prevalence and treatment of diseases, in other words, a higher income lowers the stroke rates as shown. This might be due to receiving better treatment and hospitalization scenarios. We are talking about the multifactorial higher income which might help but still, other factors may increase the rate of stroke such as genetic factors or having a first or second-generation family diagnosed with stroke and in addition to many other factors. Still, there is a controversial finding on the correlation between stroke and the socioeconomic status [16-18].

Hypertension was found to be the most commonly identified risk factor in this research study; as represented by the majority of stroke patients (84.8%), who know and have hypertension. In both questions about hypertension, most of the patients answered that hypertension is a risk factor for stroke (84.8%) and (86.36%), respectively (Tables 1 and 2). This finding is identical to other studies as hypertension is the most common cause of stroke worldwide. Many studies showed the impact of hypertension on stroke and proved that hypertension is the most prevalent risk factor for stroke [19-22]. It is also worth mentioning that the type of hypotension can have a kind of clear impact on the etiology of preoperative stroke in which is still unclear and further studies are needed [23].

Although in our research study; it was found that the second most identified stroke risk factor was stress and anxiety (53, 80.30%) Table 3. From our point of view, stress can lead to hypertension, increase sugar and fat, and this gives a chance to the formation of a clot; therefore, it is most likely to cause a stroke. Our results are identical to our assumption that stress is a second important risk factor for stroke. It is also worth mentioning that there are different types of stress (i.e., psychology, emotional, psychosocial, and psychophysiological). However, still studies are controversial, and further research studies needed to study the correlation between different kinds of stress and stroke and to analyze their impact on the stroke. In our study, we did not classify the type of stress, because still there is a low level of knowledge about psychological conditions concerning different diseases [24-26].

The third major risk factor for stroke is increased fat and cholesterol in the blood (74.12%), the forth was obesity (69.69%), then heart and blood (66.66%), diabetes mellitus (51.51%), and the lowest risk factor was smoking or alcohol consumption (45.45%). Since obesity is a common health problem in the Arab region, it represents a range between 25% and 81.9% [27], but still, it is the fourth risk factor for stroke among the Palestinian population. Only about half (51.51%) of stroke patients in our study knew that the disease is a risk factor of stroke. The educational approach about all risk factors is likely to be effective in high-risk individuals of stroke. Therefore, patient education should be provided to persons diagnosed with hypertension and/or to any other risk factors as these risk factors are most likely to increase the incidence of stroke [28].

Having a family member who had a stroke increased the incidence of stroke in our study groups, in which 72.7% of stroke patients had a family member diagnosed with a stroke. These indicate that some patients due to genetic factors and family history are highly susceptible to stroke. In other words, the stroke incidence can be in certain families who are at higher risk, and the patients with no family history of stroke have a low incident rate. Our result agreed with other studies, which showed a linkage between stroke and family history [29]. Thus, screening certain people for stroke is an essential tool to reduce the risk and complications of stroke [30]. The major source of information about stroke in this study was due to the presence of an individual from a family or a sick friend, as about 50% (33) of the patients (Table 2) either they have a family member or a friend with a stroke. In this study, most of the patients had good knowledge about the warning signs of a stroke, as the majority of them (65, 98.48%) known that the main warning signs being sudden confusion/trouble speaking/understanding, while 60 patients (90.9%) mentioned that numbness in the limbs is a warning sign of a stroke. Other warning signs were also known among participants but to less extend (Table 2).

Stroke patients usually take medications either with stroke or post-stroke, the most common medications they take are blood thinners. Two major kinds of blood thinners for stroke patients are given; either antiplatelets and/or anticoagulants. Therefore, to study the link between stroke and the effect of the anticoagulant or antiplatelet given, we measured the concentration of MMP-9 in the serum of stroke patients. Normally and in a healthy state, MMP-9 is presented in an inactive form with low concentration in serum. To link the results obtained with the blood thinner used, and the MMP-9, and to find the role of monocytes in T-cells and the pathophysiology of the stroke and stroke attack; the

concentration of MMP-9 in the corresponding stroke patient's blood samples was measured. We found that in all stroke patients, MMP-9 was markedly elevated and was a significant increase in contrast to the control which showed a non-significant increase. Among our collected stroke samples, the ranges of MMP-9 concentration in the serum were between 7000 pg/ml and 9000 pg/ml, which is considered a significant marked increase in contrast to the negative control (100–150 pg/ml) and positive control (1200 pg/ml–1214 pg/ml), presumably, this may indicate that MMP-9 can be a prediction marker, diagnostic, and prognostic tool of a stroke; but still, further studies must be carried out on a large size sample to confirm this. Our preliminary finding of MMP-9 in the serum of stroke patients can be a method of monitoring the range of MMP-9 concentration levels in stroke patients as a kind of prognostic tool to reduce the side effects and complications of a stroke. Our finding is consistent with other studies which also showed the higher of the serum MMP-9 in stroke patients [31]. Other studies showed that the serum level of MMP-9 in stroke patients is an important prognostic marker [32], as it is correlated with the severity of the disease [33].

One of the important approaches to achieving stroke prevention for high-risk individuals is to be knowledgeable about stroke risk factors. The majority of patients diagnosed with hypertension and/or diabetes in this study knew few risk factors. Thus, the lower level of knowledge of identification of diagnoses of stroke risk factors needs more concentration on patient education and stroke prevention strategies. Furthermore, the level of attention that should be given to any manifestation of stroke symptoms might be reduced due to poor knowledge of stroke risk and prevention and the consequences of non-adoption of necessary stroke preventive strategies. The high serum level of MMP-9 in stroke patients is an important prognostic marker as the concentration increases with the disease. The study has some limitations, including the lack of assessment of the duration of the diagnosis and medical care of individuals before the study which affects the knowledge and further studies needed with a large sample size.

CONCLUSIONS

The prevalence of stroke and the high risk of stroke were high among adults aged ≥51 years in Palestine. Hypertension was the highest risk factor for the stroke, other factors such as age, gender, education, and sociodemographic characteristics of the stroke patients, such as income, education, work, and besides the knowledge about the risk factors associated with the stroke are also important. However, this suggests that at the individual level and population level interventions for these risk factors could prevent stroke and/or promote stroke prevention strategies. Furthermore, increased knowledge of the stroke risk factors in the general population may lead to improved prevention of the stroke and could improve stroke treatment. The serum MMP-9 could be an important prognostic factor for the stroke as higher serum MMP-9 levels in the stroke patients were found.

ACKNOWLEDGMENT

CONFLICTS OF INTEREST AND FINANCIAL DISCLOSURE

The authors declare no competing financial interest and no conflicts of interest concerning the authorship and/or publication of this article.

ETHICAL CONSIDERATIONS

The study was approved by the Palestinian MOH. The identities of patients remained unknown and confidential; the data only used for research purposes. The consent of the individuals to participate in the survey and to collect and process their data was obtained from all participants. All the participants in the research study could withdraw at any time.

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