

# Correlation Between Change in Air Humidity and the Incidence of Stroke

Enes Slatina<sup>1</sup>, Miralem Music<sup>2</sup>, Nermina Babic<sup>3</sup>, Amela Dervisevic<sup>4</sup>, Ekrema Mujaric<sup>4</sup>, Mirhan Salibasic<sup>5</sup>, Enes Tuna<sup>6</sup>, Jasmina Corovic<sup>6</sup>

Institute for Emergency Medical Services (EMS) Sarajevo, Bosnia and Herzegovina<sup>1</sup>

Department of Pathophysiology, Faculty of medicine, University of Sarajevo, Sarajevo, Bosnia and Herzegovina<sup>2</sup>

Department of Physiology, Medical Faculty, University of Sarajevo, Sarajevo, Bosnia and Herzegovina<sup>3</sup>

Cantonal Hospital Zenica, Zenica, Bosnia and Herzegovina<sup>4</sup>

Clinical Center University of Sarajevo, Sarajevo, Bosnia and Herzegovina<sup>5</sup>

Faculty of Dental medicine, University of Sarajevo, Sarajevo, Bosnia and Herzegovina<sup>6</sup>

Corresponding author: Enes Slatina, MD, EMS, Sarajevo. E-mail: enes.slatina@gmail.com

## ABSTRACT

**Introduction:** According to the World Health Organization estimates annually in the world die due to CVI every sixth women and 10<sup>th</sup> man. This paper is the research of the correlation between changes in relative air humidity and stroke (CVA) in the Sarajevo Canton. Included are patients who experienced an acute stroke in the Canton of Sarajevo and treated in the pre hospital phase by the staff of the Institute for Emergency Medicine. Days with stroke and those without cases of stroke were compared within three years and meteorological data for those days were obtained by the Weather Bureau of Federation of Bosnia and Herzegovina. Meteorological data include measurements of average humidity every day at 7, 14 and 21 o'clock in three years. **Aim:** To evaluate the significance of the influence of humidity on the incidence of CVI's. Show the trend towards CVI in the reporting period and is it correlated with the trend of change in relative humidity in those days. Correlate the incidence of stroke as determined in relation to gender, age and selected climatic parameter. **Material and Methods:** This article presents a retrospective study. Subjects were patients of Emergency Medical Care Institute in Sarajevo, which in the period from 2004 to 2006 had a CVI. Included are patients who had a working diagnosis of stroke for the first time or as a repeated stroke. Analysis of cases of stroke was carried out by gender, age, days and seasons by descriptive-analytical epidemiological methods. **Results:** In total were registered 1930 patients during three years period. According to years of research in 2004-635, 2005-616 and 2006 - 679. It was found that when testing the null hypothesis about the effects of humidity in two months with a maximum stroke in the year and days without CVI and relative humidity only in 2005 had a statistically significant effect on the incidence of stroke, while during the other two years of the study there was no impacts. It turned out that the extreme values of relative humidity of the day whether there was a rapid increase or decreases in humidity increases the incidence of stroke in all three years of research. **Conclusion:** Patients gender had no effect on the incidence of CVI. Seasons had no effect on the incidence of CVI. Most CVI in all three years of research was in relation to the old age and occurred in the older age group 70-79 (41.35%), where it was shown that the age of the patient influences the incidence of CVI. Extremely low relative humidity and extremely high, influence on the increase in the number of CVI. Determined is a slight correlation between the average relative humidity and CVI in single day.

**Key words:** ER, air humidity, the incidence of stroke.

## 1. INTRODUCTION

"CVI is characterized by sudden neurological dysfunction resulting from insufficient blood supply to brain tissue. Stroke can be divided into two groups depending on the etiology: ischemic (83%) and hemorrhagic (17%)" (1). "Thrombosis is a blood clot that obstructs a blood vessel or develops in the cavity of the heart. Thrombus can originate from anywhere in the cardiovascular system. Often there is damage to the wall of the vessel, with subsequent accumulation of blood platelets" (2). Transient ischemic attack (TIA) or stroke before the brain. "By definition, a TIA is a short-term disturbance of neurologic function, which is accompanied by disruption of regional cerebral

blood flow that may only last a few seconds or that its duration is up to 24 hours. Signs and symptoms of TIA also will depend on which part of the brain is deprived of blood supply" (3).

Good training of pre hospital services is essential factor in early diagnosis of cerebrovascular stroke, rapid transport to appropriate institutions and thus facilitates early reperfusion brain. Hence there is the need for education of family physicians and the nurses (technicians) as well as emergency medical unit's staff. After receiving a call about the incident, when examining the patient, it is necessary to determine whether this is really the CVI or some other neurological disorder. There are two screening scales for pre hospital stroke identification Cincinnati

hospital scale and Los Angeles hospital scale (LAPSS).

In the pre hospital treatment assistance is provided to all those who suffer a stroke and as a first level of urgency. In order to adequately treat the patient with stroke, it is necessary to reach the patient as soon as possible. To such patients then is needed to provide rapid transport to the hospital with a diagnostic CT capabilities and department of neurosurgery (optimum time for the possibility of thrombolytic therapy in indicated patients is up to 3 hours).

### 1.1. CLIMATE CONCEPTS

“Persons with impaired health, in which some mechanisms do not operate well, have difficulties to adapt to changing weather conditions. In this sense different health problems may arise, sometimes even including myocardial infarction, stroke, perforation of stomach ulcer, etc.” (4). Climate is Sarajevo has mild continental characteristics. “The average altitude of the Sarajevo valley is about 500 meters above sea level. Valley occupies an area of approximately 31.7 km<sup>2</sup> with a center in the area of Ilidza and Plandiste. It is located in the area of Bosnia river springs in which flows Zujevina and Rakovica, Zeljeznica with Kasindolka, Dobrinja with Tilava and river Miljacka. Average annual relative humidity is 71.6% and varies within the range from 66.3% to 74.8% (5).

## 2. GOALS

The goals of this study are as follows:

- Identify the importance of the influence of humidity on the stroke incidence;
- Determine the trend of CVI occurrence in the reporting period and correlate these findings with the trend of change in relative humidity during those days;
- Correlate the incidence of stroke in relation to gender, age, and selected climatic parameter.

## 3. MATERIAL AND METHODS

This paper presents a retrospective study. Subjects were patients of Institute for Emergency Medical Care in Sarajevo, which in the period from 2004 to 2006 have been diagnosed as CVI. Patients with a first episode of CVI or as a repeat stroke, which were included in this study, were analyzed in relation to age, gender, time of diagnosis (day, season and year) and the basic meteorological parameter—relative humidity. Basic meteorological data for days, months and years of the study period was provided by the Federal Meteorological Institute of the Sarajevo Canton (Decision No. 04-33-2-197/06). Relative humidity measurements were performed at 7, 14 and 21 o'clock every day during the investigated period from beginning of 2004 until the end of 2006. Statistical analysis was done in Microsoft Excel and Microsoft Access. Results obtained in the study were statistically analyzed and for all analyzed parameters are

Period 2006.		Males			Females			Total		Weekly mean		
From	To	N	% for males	% of total.	N	% for females	% of total	N	%	T(°C)	Bar	V.%
01.01.	01.01.	1	0.56	0.26	0	0.00	0.00	1	0.50	8.00	935.00	68.00
02.01.	08.01.	7	3.93	1.84	13	6.44	3.42	20	9.90	0.50	943.25	86.00
09.01.	15.01.	3	1.69	0.79	9	4.46	2.37	12	5.94	-3.42	953.67	68.50
16.01.	22.01.	2	1.12	0.53	10	4.95	2.63	12	5.94	-0.83	945.33	76.17
23.01.	29.01.	5	2.81	1.32	7	3.47	1.84	12	5.94	-5.00	952.75	63.67
30.01.	31.01.	4	2.25	1.05	4	1.98	1.05	8	3.96	0.50	948.75	94.00
01.10.	01.10.	3	1.69	0.79	1	0.50	0.26	4	1.98	15.53	943.59	75.06
02.10.	08.10.	6	3.37	1.58	11	5.45	2.89	17	8.42	15.53	943.59	75.06
09.10.	15.10.	7	3.93	1.84	8	3.96	2.11	15	7.43	11.13	948.20	69.20
16.10.	22.10.	11	6.18	2.89	8	3.96	2.11	19	9.41	8.89	942.79	68.89
23.10.	30.10.	9	5.06	2.37	5	2.48	1.32	14	6.93	13.00	942.93	61.14
30.10.	31.10.	3	1.69	0.79	0	0.00	0.00	3	1.49	7.00	943.00	54.00

  

Testing zero hypothesis:	T(°C)	P(mbar)	V(%)
Mean: for selected days	5.08	945.69	74.46
for days without CVI	8.23	943.39	71.71
Standard error: for selected days	7.27	5.17	8.78
for days without CVI 8,56	6.68	13.34	
Coefficient of variation: for selected days 1.43	0.01	0.12	
for days without CVI 1.04	0.01	0.19	

Standard error of difference; Mean: 2,37 1,74 2,84; Accordance with normal distribution: Z= 1,33 1,32 0,97; For the threshold of 0.0. the hypothesis is: not rejected not rejected not rejected

Table 1. Selected days in the typical months

made tables and chart with a comment for better visibility of individual factors and their relationships. In the study was used the normal distribution test to test the hypothesis.

## 4. RESULTS

During the three-year study (2004, 2005 and 2006) was registered in the working protocols 1930 patients who experienced an acute or recurrent stroke. From these 1930 patients, there were 924 (48.88%) males and 1006 (51.12%) females. Results are grouped according to the analysis of certain parameters that were studied. In a survey for each year are taken two months with the highest stroke incidence and compared the mean relative humidity with the same parameters when there were no strokes. For the sake of precision, were separated two weeks, with the most impact from the given month with the average values of relative humidity and tested the null hypothesis. Also are correlated changes in relative humidity at the day when CVI occurred and the day before. The incidence of patients who experienced an acute stroke by years of research in relation to the total population of the Sarajevo Canton: (2004) 151/100,000, (2005) 147/100,000 (2006) 162/100,000. (Table 1).

Tabulation for testing of the null hypothesis for selected days from two months with the most strokes in the 2006 and analyzed climate parameters with average values of climatic parameters without CVI in the three-year study. Months with the highest CVI incidence are January and October of the 2006. It was found that at the significance level of 0.05 relative humidity has no influence on the incidence of stroke.

From Table 2 can be seen that the largest number of stroke patients is aged 70-79 years or 801 (41.35%), then in the 60-69 decade 469/24.30%. Separately, men are more represented at the decade 60-69 yrs., and later women. The average age for a three-year period (2004-2006) was 69.31 for men, for women 72.53 and 70.92 for the total sample. Average per day most CVI

Age	Males	%	Females	%	Total	%
20 to 29	2	0.10	3	0.15	5	0.26
30 to 39	7	0.36	4	0.20	11	0.57
40 to 49	33	1.70	31	1.08	64	3.31
50 to 59	124	6.42	69	3.57	193	10.00
60 to 69	259	13.41	210	10.88	469	24.30
70 to 79	363	18.80	438	22.69	801	41.35
80 to 89	126	6.52	225	11.65	351	18.19
90 to 99	10	0.51	26	1.34	36	1.87
Mean age	69.31	72.53	70.92	100%		

Table 2. Number of strokes by gender and age in 2004-2006.

occurs primarily at very low relative humidity of 43%, then 61%, 75% and a very high of 96%. Average the largest number of stroke per day occurred at a very low relative humidity of 41%, and elevated at 83% in the 2005. The highest average of the CVI per day occurs at extremely lowered average relative humidity of 38% and an extremely increased to 98% and at least with humidity of 50%. The highest number of CVI's has been recorded in winter (26.16%) and the lowest in autumn (22.69%) for the period 2004-2006. By sex, there is a visible deviation by seasons. Number of males with stroke is highest in the spring with 256 cases or 13.26%, and the woman in the winter with 281 cases or 14.55%. Also, women in autumn and spring had a little more CVI's than men. The average number of CVI's in the day increases as the air is extremely dry (38%), and extremely humid (98%). For 60 occurrences of different numbers of strokes classified by grades in the table correlation coefficient is  $r = 0.29$ , which makes a slight correlation between CVI and the average humidity during the day. For 21 occurrence of different numbers of strokes classified by grades in the table correlation coefficient is  $r = -0.07$ , which makes a slight correlation between CVI and changes in the relative humidity of the day. (Table 3, Table 4).

## 5. DISCUSSION

During the three-year study carried out in EMS Sarajevo during the 2004, 2005 and 2006th, there was a homogeneous group of patients, and the total number of people who experienced acute stroke (CVI), and who are registered in the operating protocols is 1930. This represents a very large sample survey which was used for test of normal distribution. CVI was diagnosed from adolescents to elderly usually between 70 and 79 years in all three years of the study (2004 – 40.31%, 2005 – 41.88%, 2006 – 42.26%), followed by age group 60 -69 years also in all three years of the study: 2004 – 27.24%, 2005 – 24.51% and in 2006–21.35%. The youngest patient was 24 years old and the oldest 99 years. The average age of patients in all three years of the study was 70.92 years and separately by gender male–69.31 and female 72.53 years. To the patient's emergency medical assistance was provided by the staff of EMS Sarajevo.

Detailed neurological examinations used by medical doctors in the pre hospital phase are not practical because they delay transport of the patient. Once the acute stroke is suspected time spent outside of the hospital must be minimized. The presence of an acute stroke is an indication for "load and go", because the therapy window is limited. Pre hospital treatment consists of the ABC management and close monitoring of vital signs. Studies worldwide show that more than 20% of the population has

metropathy, or persons who with difficulties tolerate changes in the weather, in which changes provoke the emergence of new or worsening of already present illness. Healthy people have mechanisms that can adapt to the changes in the atmosphere: the autonomic nervous system, skin, endocrine system and balance of body fluids. Disruption of these mechanisms in some chronic disease causing deterioration during weather changes. Positive weather conditions in which a person feels good are mix of multiple climate parameters, and of the investigated ones are the temperature 17-25°C, ideal average temperature of 21°C, barometric pressure in the Sarajevo area of 943 mbar, and at the sea level of 1013 mbar with daily relative humidity below 65% to 50% average relative humidity as it is set also in the air conditioning units. Feigin and colleagues (2001) published the results of a study based on a population that was done in the southern hemisphere (Australia, Oakland) to 783 cases (from 1981 to 1997). This was the first study to show a significant seasonal fluctuations occur in hemorrhagic stroke with the highest number of cases in young people <65 in the spring and in the elderly  $\geq 65$  in the winter. During the day the highest incidence is between 8 and 12h and the lowest between midnight and 6am. High blood pressure and low atmospheric temperatures is possible trigger SAH. The results are similar to studies in the Northern Hemisphere (6). Jakovljevic et al. (1996) published the results of stroke research in Finland based on population  $n=15449$  (period from 1982 to 1992), which was conducted in three areas of Finland: Kuopio, S. Karelia and Turku/Loimaa. The emergence of CVI was usually higher in the winter than during other seasons, but the study could not detect a significant difference between the seasons (7). Oberg et al. (2000) from University of S. Carolina, USA in research conducted on 72,779 patients over 10 years (1986-1995), found clear evidence of occurrence of ischemic stroke caused by weather. The highest incidence is in mid-May. There is no connection between CVI and the seasons. Area and race did not have any effect (8). In our study, as in study of Jakovljevic et al. winter was with the most cases of stroke (27%) and there was no significant difference between the seasons in the CVI incidence. As for seasonal fluctuations, as in study by Feign et al., hemorrhagic stroke among young people in spring and elderly people in the winter, when we could not determine because this pre hospital study included all types of stroke, and certain types of stroke may only be determined in hospital studies. In our study was also recorded the highest incidence of stroke in the morning and the lowest after midnight.

In our study, women were also more represented in total (1006) or 52.12% then men 924 or 47.87% as well as in all three years of research individually, but without substantial statistical significance in terms of gender influence on the incidence of CVI. Strokes are more common over 65 years of age and make up 76.17% (1470), while they are the highest in the decade between 70-79 years–801 or 41.50%. Men over 65 are represented with 648 cases or 44.09% and 822 women or 55.91%. In earlier research by Bokonjic R. (9), most cases were in the 60-69 decade of life, indicating that the extended age by a decade due to the consequences of stroke and its frequency, and that the medicine has advanced in its development, diagnosis and treatment.

Laad et al. (2004) in France analyzed the seasonal variations in the appearance of the stroke and the influence of meteorological factors on their appearance. The study was a population-based

No. of CVI occurrence	Mean air humidity (%) at 7,00; 14,00;21,00h							
No. of CVI	x1÷x2	30-40	40-50	50-60	60-70	70-80	80-90	90-100
y1÷y2	Yrs. \ Xsr	35	45	55	65	75	85	95
0-20	10	2	9	0	0	0	1	3
20-40	30	0	0	8	3	2	8	4
40-60	50	0	0	2	6	8	1	2
60-80	70	0	0	0	1	0	0	0
80-100	90	0	0	0	0	0	0	0
100-120	110	0	0	0	0	0	0	0
120-140	130	0	0	0	0	0	0	0
140-160	150	0	0	0	0	0	0	0

Table 3. Correlation of the number of strokes and the average humidity during certain day

No. of CVI occurrence	Mean air humidity (%) at 7,00; 14,00;21,00h									
No. of CVI	x1÷x2	-60-50	-50-40	-40-30	-30-20	-20-10	-10-0	0-10	10-20	20-30
y1÷y2	Yrs. \ Xsr	-55	-45	-35	-25	-15	-5	5	15	25
0-20	10	1	1	0	0	0	0	0	1	0
20-40	30	0	0	0	0	0	0	2	0	0
40-60	50	0	1	0	0	0	1	0	0	0
60-80	70	0	0	0	0	0	0	0	0	0
80-100	90	1	0	0	2	0	0	0	0	0
100-120	110	0	2	1	0	0	0	0	0	0
120-140	130	0	1	2	0	0	1	0	0	1
140-160	150	0	1	0	0	1	1	0	0	0

Table 4 Correlation of the number of strokes and humidity changes in a day

Dijon registry of stroke and included 3287 patients from 1985 to 1998. The difference from one season to another was significant only for the total number of strokes, with a minimum from July to September and a maximum in October. Detected are correlations with meteorological data for the total number of strokes. They pointed to the influence of temperature and relative humidity on days with stroke or 1-5 days earlier (10). In our study, when testing the null hypothesis about the effects of relative air humidity on days with and without CVI's, (where the null hypothesis denies the influence of the fact and working confirms the influence of humidity) compared to the average values of relative humidity is monitored in two months with the highest stroke incidence and four weeks with most strokes within these months, there was no effect of the average relative humidity on the incidence of stroke. It was found only by this test in 2005 the average relative humidity had influence on the incidence of CVI's. The influence of relative humidity showed the increased incidence of stroke and at extreme values: first at a very low average humidity (38%), followed by a very high (98%). The influence of fluctuations in relative humidity is negligible during the day  $r = 0.07$  (7 am to 14 pm), and there is a mild correlation compared to the average humidity of the day  $r = 0.29$  to the emergence of CVI when we include all the cases. In extreme situations, with an increased number of stroke and no significant correlation between relative humidity, but only a mild correlation with changes in the average humidity of the day in relation to the previous day. Fluctuations for all analyzed parameters during the day was analyzed by comparing measurements in the period from 7 am to 14 pm, when it was most strokes during a three-year research and where it is found that there is no significant correlation between relative humidity and CVI's. Given that the measurements made in terms of 7h, 14h and 21h, analyzes were performed in these terms, but without significant results.

## 6. CONCLUSIONS

Patients gender in all three years of the study did not significantly influence the incidence of CVI's, women were represented slightly more (1006) or 52.12%, and men 924 or 47.87% of the cases. When testing the existence of statistical differences in CVI incidence by seasons it showed no statistically significant differences between seasons on the incidence of stroke and individually by years of research and in all three years of research together. During the study from the 2004 to 2006, when testing the null hypothesis for specific days with stroke compared to days without CVI and relative humidity this showed no statistically significant effect on the incidence of stroke, except in the year 2005 in two months with the highest CVI in years of research in relation to values of humidity in the days without CVI's. We found that the incidence of stroke in three years combined 2004-2006 and individually for each year of research increases at extremely low or high values of relative humidity. Age of the patient affected the incidence of stroke and stroke occurred the most, as far as age concerned, in the older age group in the three-year of study at age from 70-79 years (41.31%) in 2004, (41.88%) in 2005, (42.26%) in 2006 and for all three years combined at average of 41.35%. The correlation between CVI and the average relative humidity of the day in all cases was determined a slight correlation with  $r = 0.29$  for the average humidity of the day. In examining the correlation of CVI and changes in the relative humidity of the day (7 am to 14 pm) when most strokes occurred were found insignificant correlation  $r = 0.07$ .

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