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INFLUENCE OF SEISMOLOGICAL ACTIVITY IN GUBA REGION OF AZERBAIJAN ON MORTALITY FROM CARDIOVASCULAR PATHOLOGIES

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The purpose of the study was to access the dependence of mortality from cardiovascular diseases on helioseismic indicators in the Guba region of Azerbaijan. To analyze the fatal outcomes of diseases in the Guba region, 653 case histories of patients who died in 2013 from various diseases were studied. The causes of deaths, distribution by sex and age, and a relationship between death accidents and the magnitude of earthquakes, the depth of the epicenter and seismological activity by months were established. The largest percentage of patients died from heart failure 44.9 %, then from acute coronary syndrome (22.1 %), from acute cerebrovascular accident (19.1 %) and from hypertensive crisis (2.9 %). The maximum number of deaths was at a magnitude of 1.1–2.0 ml (34.8 %). Depending on the depth of earthquakes, the maximum number of deaths was at the process depth less than 10 km (34.2 %). Thus, the study of seismological activity makes it possible to assess environmental and emergency situations with a high probability, to provide for preventive measures.

Keywords: acute coronary syndrome, cerebral stroke, hypertensive crisis, earthquake, magnitude

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ВПЛИВ СЕЙСМОЛОГІЧНОЇ АКТИВНОСТІ У ГУБІНСЬКОМУ РАЙОНІ АЗЕРБАЙДЖАНУ НА СМЕРТНІСТЬ ВІД КАРДІОВАСКУЛЯРНОЇ ПАТОЛОГІЇ

Метою дослідження було вивчити залежність смертності від серцево-судинних захворювань від геліосейсмічних показників у Губинському районі Азербайджану. Для аналізу летальних наслідків хвороб у Губинському районі вивчено 653 історії хвороби хворих, які померли у 2013 році від різних захворювань. Встановлено причини загибелі, розподіл за статтю та віком, а також зв'язок між смертельними випадками та магнітудою землетрусів, глибиною епіцентру та сейсмологічною активністю за місяцями. Найбільше хворих померло від серцевої недостатності 44,9 %; потім, від гострого коронарного синдрому (22,1 %), від гострого порушення мозкового кровообігу (19,1 %) і гіпертонічного кризу (2,9 %). Максимальна кількість смертей була при магнітуді 1,1–2,0 мл (34,8 %). Залежно від глибини землетрусів, максимальна кількість загиблих була за глибини процесу менше 10 км (34,2 %). Таким чином, вивчення сейсмологічної активності дозволяє з високою ймовірністю оцінювати екологічні та надзвичайні ситуації, передбачати профілактичні заходи.

Ключові слова: гострий коронарний синдром, мозковий інсульт, гіпертонічний криз, землетрус, магнітуда.

Cardiovascular diseases (CVD), being, first of all, an indicator of uncomfortable living conditions for people of various age groups, reduce the quality of life, labor productivity, are accompanied by economic losses due to early disability [1, 4, 9].

So far, isolated seismopathological studies have been carried out in cardiology, which has made it possible to assess the influence of the seasons of the year, some solar activity factors, and geomagnetic disturbances on the mortality rates of the population from myocardial infarction (MI) and cerebral strokes (CS) [5, 12]. At the same time, there is no bioindicative methodology for organizing observations of the features of the impact on the health of the population, methods for predicting the states of seismic lability, as well as the degree of risk of complications of cardiovascular diseases, depending on the ecological characteristics of the region of residence [6, 14, 15].

There are several unresolved issues in applied seismopathology, including identifying the meanings of “medical” types of ecology, their geographical mapping, and the role of seismological and geophysical characteristics in shaping the life environment of patients with cardiovascular diseases. So, for example, myocardial infarctions that occur on days of geomagnetic disturbances are more severe and can be fatal [4, 8, 10].

As is known, the territory of Azerbaijan and the adjacent water area of the Caspian Sea are seismically active regions, and significant earthquakes occur here from time to time. This dictates the need to assess the state of morbidity and mortality according to CVD in various regions of the country and its relationship with individual indicators of earthquakes to identify characteristic patterns.

The purpose of the study was to assess the dependence of mortality from cardiovascular diseases on helioseismic indicators in the Guba region of Azerbaijan.

Materials and research methods. In 2013, seismological information was received from 35 telemetry stations, which included an overview of the seismic regime of the republic, the distribution of seismic waves, the dynamics of seismic processes, the intensity of the earthquake, the magnitude, etc. Also, at 9 geophysical and 5 geochemical stations, the strength of the geomagnetic field and the force of attraction were studied.

To analyze the fatal outcomes of diseases in the Guba region, 653 case histories of patients who died in 2013 from various diseases were studied. The causes of deaths, distribution by sex and age, and a relationship between death accidents and the magnitude of earthquakes, the depth of the epicenter and seismological activity by months were established. The obtained data were statistically processed using the Statistica 12.0 for Windows application package (Statsoft Inc., USA). The Kruskal-Wallis analysis of variance was used to compare three or more samples, the results were considered significant at $p < 0.05$.

Results of the study and their discussion. Of the 653 case histories in the Guba region, 308 patients were men (47.2 %) and 345 were women (52.8 %). Comparative analysis showed that among men 42.5 % died from acute heart failure, 28.2 % from acute coronary syndrome, 16.2 % from acute cerebrovascular accident and 2.9 % from hypertensive crisis. Among women, 47.0 % also died from heart failure, 16.5 % from acute cerebrovascular accident and 21.7 % from acute coronary syndrome, and 2.9 % from hypertensive crisis. Depending on the nosology, the largest percentage of patients died from heart failure 44.9 %, 22.1 % from acute coronary syndrome, 19.1 % from acute cerebrovascular accident and 2.9 % from hypertensive crisis. Data on the distribution of patients by age, gender, nosological and seasonal characteristics are presented in table 1.

Table 1

Distribution of patients by age, gender, nosological and seasonal (month of death) characteristics

		Sex			
		Male		Female	
		Abs. number	%	Abs. number	%
Diseases	Hypertensive crisis	9	2.9	10	2.9
	Acute cerebrovascular accident	50	16.2	75	21.7
	Acute coronary syndrome	87	28.2	57	16.5
	Acute heart failure	131	42.5	162	47.0
	Others	31	10.1	41	11.9
Months	January	34	11.0	37	10.7
	February	24	7.8	35	10.1
	March	24	7.8	26	7.5
	April	19	6.2	33	9.6
	May	29	9.4	31	9.0
	June	29	9.4	25	7.2
	July	21	6.8	27	7.8
	August	30	9.7	24	7.0
	September	25	8.1	25	7.2
	October	31	10.1	27	7.8
	November	18	5.8	28	8.1
	December	24	7.8	27	7.8
Age	0–9	1	0.3	1	0.3
	10–19	0	0.0	1	0.3
	20–29	0	0.0	0	0.0
	30–39	7	2.3	2	0.6
	40–49	16	5.2	10	2.9
	50–59	50	16.2	21	6.1
	60–69	43	14.0	21	6.1
	70–79	99	32.1	100	29.0
	80–89	81	26.3	155	44.9
	90–99	11	3.6	31	9.0
≥100	0	0.0	3	0.9	
Earthquakes	Absence	92	29.9	107	31.0
	Presence	216	70.1	238	69.0

Depending on the months, the largest percentage of deaths was in January 10.9 %, minimum – in September and March (7.7 %). Statistically, in a comparative analysis, on the days of earthquakes for all months there were more deaths than on quiet days, in particular, the most were in May 83.3 %, August 85.2 % and December 86.3 %. Further 75.0 % in July and April and 70.4 % in January. It is also statistically significant that in all months of the year there were more deaths from heart failure.

In the age range, a largest percentage (36.1 %) is in 80-89 years old, in the others age groups: 70–79 years old – 30.5 %, 50–59 years old – 10.9 %, 60–69 years old 9.8 %. In gender features, 77.8 % of men and 22.2 % of women died from the age of 30–39 years, 70.4 % of men and 29.6 % of women aged 40–49, and 70.4 % of 50–59 years men and 29.6 % of women, 60–69 years old 67.2 % of men and 32.8 % of women, and after 70–79 years more women 50.3 % and men 49.7 % died, 80–89 years of women 65.7 % and 34.3 % men.

In a comparative analysis among men, more died at the age of 70–79 32.1 %, further 80–89 26.3 %, 50–59 16.2 %, 60–69 14.0 %, further as they decrease. Among women, it is more at 80–89 years 44.9 %, 70–79 29.0 %, the same (6.1 %) – in age groups 50–59 and 60–69.

At the age of 30–39 years, 66.7 % died from acute coronary syndrome, 22.2 % – from acute heart failure. Among 40–49 years old patients 34.2 % died from acute coronary syndrome, 23.1 % – from acute heart failure, 19.2 % – from acute cerebrovascular accident and 3.8 % – from hypertensive crisis. At the age of 50–59 years, 38.0 % of patients died from acute heart failure, 25.4 % – from acute coronary syndrome, 18.3 % – from acute cerebrovascular accident and 7.0 % – from hypertensive crisis. 60–69 years old persons most of all died from heart failure 37.5 %, 28.1 % – from acute coronary syndrome, 18.8 % – from acute cerebrovascular accident and 1.6 % – from hypertensive crisis. 70–79 years from heart failure 47.7 %, from acute heart failure 21.6 % and 16.1 % from acute coronary syndrome and 3 % from hypertensive crisis. Among 80–89 years old patients from heart failure died 49.2 %, 22.5 % from acute coronary syndrome, 16.9 % from acute cerebrovascular accident and 2.5 % from hypertensive crisis.

In all age groups, more people died on earthquake days than on quiet days. In particular, at the age of 40–49 years 69.2 % and 30.8 %, 50–59 years old 64.8 % and 35.2 %, 60–69 years old 65.6 % and 34.4 %, 70–79 years old 66.8 % and 33.2 % and 80–89 years old 73.3 % and 26.7 %.

When distributing deaths by age and nosology of the disease, it was determined that in hypertensive crisis the same number of deaths (31.6 %) were registered at the age of 70–79 years and 80–89 years, at the age of 50–59 years it was 26.3 %, at the age of 40–49 years and 60–69 years – 5.3 %. From acute cerebrovascular accident, a greater number of deaths (34.4 %) was at the age of 70–79 years, further were data of 80–89 years old patients 32.0 %, at 50–59 years 10.4 %. 36.8 % died from acute coronary syndrome at the age of 80–89, 22.2 % at the age of 70–79, 12.5 % at the age of 50–59 and 60–69. The data of death rate from heart failure were as following: at the age of 80–89 years – 39.6 %, 70–79 years – 39.4 %, 50–59 years – 9.2 %.

The study also studied deaths on the days of earthquakes and without them, so 30.5 % died in the absence, 69.5 % on the days of earthquakes. Depending on the nosology of deaths on days and in the absence of earthquakes, the following results were statistically significantly obtained: 78.9 % died from a hypertensive crisis on the days of earthquakes, and in the absence of 21.1 %, from acute cerebrovascular accident, respectively, 68.0 % and 32.0 %, from acute coronary syndrome 67.4 % and 32.6 %, respectively, from acute heart failure 70.6 % and 29.4 %, respectively.

Depending on the depth of the seismic process, a largest number of deaths was when the depth of the process was less than 10 km (34.2 %), at 11–20 km was 12.4 %, at 31–40 km was 8.1 % and at 21–30 km was 6.1 %.

In a comparative analysis of deaths and magnitude, a large percentage of deaths was with a low magnitude: with 0.1–1.0 ml (24.5 %) and 1.1–2.0 ml (34.8 %). The other magnitudes were characterized by less numbers of patient deaths: 2.1–3.0 ml – 8.1 % and 3.1–4.0 ml – 1.7 %. With a magnitude of earthquakes 1.1–2.0 ml, more women died – 54.2 %, men – 45.8 %, with 2.1–3.0 – 49.1 % and 50.9 % and 3.1–4.0 – 54.5 % and 45.5 %.

With a magnitude of 0.1–1.0 ml more patients (42.5 %) died at the age of 80–89 years and at the age of 70–79 years (24.4 %). Further, 11.3 % at 50–59 years, 10.0 % at 60–69 years. With a process magnitude of 1.1–2.0 ml, 70–79 years old – 34.4 %, 80–89 years old – 33.9 %, 60–69 years old – 9.3 %. With a magnitude of 2.1–3.0 ml, 80–89 years old is 39.6 % and 70–79 years old is 26.4 %. With a magnitude of 3.1–4.0 ml, the maximum was 80–89 years old – 45.5 % and 50–59 years old – 18.2 %. With a magnitude greater than 4.0 ml, 80–89 years old 66.7 % and 70–79 years old 33.3 %. As can be seen from the results, more deaths are distributed at low magnitudes.

In a comparative analysis of the magnitude and nosology, with a magnitude of 0.1–1.0 ml more died from heart failure – 46.3 %, 18.8 % from acute coronary syndrome, 18.1 % from acute cerebrovascular accident and 3.1 % from hypertensive crisis. With a magnitude of 1.1–2.0 ml, 46.7 % died from heart failure, 20.7 % from acute coronary syndrome, 20.3 % from acute cerebrovascular accident and 4.0 % from hypertensive crisis. With a magnitude of 2.1–3.0 ml, 45.3 % died from heart failure, 26.4 % from acute coronary syndrome, 13.2 % from acute cerebrovascular accident and 1.9 % from hypertensive crisis. With a magnitude of 3.1–4.0 ml, the maximum deaths were 54.5 % from acute coronary syndrome, 18.2 % from heart failure, 9.1% from acute cerebrovascular accident. With a magnitude higher than 4, 66.7 % were from acute cerebrovascular accident and 33.3 % from acute heart failure.

We also studied the dependence of the depth of the seismic process on gender differences, the age of patients and the nosology of the disease.

At a process depth of less than 10 km, 56.1 % of women and 43.9 % of men died; at a process depth of 11–20 km, 54.3 % of men and 45.7 % of women died. At a depth of 21–30 km 52.5 % of women and 47.5 % of men, at 31–40 km 58.5 % of women and 41.5 % of men, at a depth of more than 40 km 42.1 % of women and 57.9 % of men.

With a process depth of less than 10 km, maximum death rate was at the age of 80–89 years (41.3 %), minimum – in the 40–49 years group (5.8 %). At 11–20 km process 32.1 % of patients died both in the 80–89 and 70–79 years groups. At a depth of 21–30 km, maximum death rate was at the age of 70–79 years old (45.0 %), at a depth of 31–40 km – in the same age group – 70–79 years (41.5 %). With a seismic process depth of more than 40 km, 80–89 years old – 36.8 %, 70–79 years old – 22.8 %, 50–59 and 60–69 years old – 12.3 %.

Depending on the nosology, at a depth of less than 10 km more deaths were from acute heart failure (41.7 %), from acute coronary syndrome 23.3 %, from acute cerebrovascular accident 18.8 % and from hypertensive crisis 4.5 %. At a depth of 11–20 km, 46.9 % died of heart failure, 21.0 % of acute cerebrovascular accident, 17.3 % of acute coronary syndrome, and 2.5 % of hypertensive crisis. At a depth of 21–30 km from acute heart failure – 60.0 %, from acute cerebrovascular accident – 22.5 %, from acute coronary syndrome – 10.0 %. At a depth of 31–40 km from acute heart failure – 49.1 %, from acute coronary syndrome – 26.4 %, from acute cerebrovascular accident – 15.1 %. At a depth of more than 40 km from acute heart failure – 45.6 %, from acute coronary syndrome – 22.8 %, from acute cerebrovascular accident – 15.8 %. As can be seen in all processes, the largest percentage of deaths was in all seismic processes from heart failure.

When analyzing all the studied indicators on the days of earthquakes, a larger percentage of deaths compared to other groups was from heart failure – 45.6 %, further – from acute coronary syndrome – 21.4 %, from acute cerebrovascular accident – 18.7 % and from hypertensive crisis – 3.3 %. During the absence of earthquakes, 43.2 % died from heart failure, 23.6 % from acute coronary syndrome, 21.1 % from acute cerebrovascular accident and 2.0 % from hypertensive crisis.

We also studied the influence of the magnetic field on the mortality of the population. No serious fluctuations depending on gender were found, 308 men died at a voltage of 49679 T, and 345 women at a voltage of 49678 T. Depending on age magnetic activity did not statistically significantly differ from the initial ones: a greater number of deaths (236) were with a magnitude of 49678 T at the age of 80–89 years, then, 199 people at the age of 70–79 years with a magnitude 49677 T, 71 people 50–59 years old – 49679 Tl, 64 people 60–69 years old – 49681 Tl.

Depending on the nosology, 293 people died from heart failure with a magnitude of 49680 T, 144 people – from acute coronary syndrome with a magnitude of 49675 T, 125 people – from acute cerebrovascular accident of 49675 T and 19 – from hypertensive crisis with a magnitude of 49671 T.

Our study revealed exacerbation of CVD in patient, depending on characteristics of earthquakes in Guba region of Republic of Azerbaijan. These results are very useful to find out the mechanisms of human reaction on seismic activity. The largest number of deaths was noted in our patients at the age of 80–89 from the heart failure. The similar results we found in Nakamura A, et al work. So, authors revealed that the incidence and in-hospital mortality rate of heart failure increased after the Great East Japan Earthquake (2011) [3, 11].

Some researchers, in addition to the relationships we studied, pointed to the influence of additional factors, in particular, the time of the earthquake. So, comparing the earthquake in Loma Prieta (1989), which occurred at 17:04, and another earthquake in Los Angeles (1994), which occurred at 4:31 am, the authors found an increase in the frequency of AMI by 110 % in the second case. They believed that the reason for this is an additional stress factor. But in this study the dependence of CVD mortality on age, magnitude of earthquake and other important factors was not studied [4].

According to our results increase of death rate occurred in short time after earthquake. It is interesting fact that Huang K, et al, by evaluation of 19,083 hospitalizations after the 2008 Sichuan earthquake showed a significantly lower (27.81 %, $P < 0.001$) number and cost (32.53 %, $P < 0.001$) of hospitalizations of patients related to ischemic heart disease, in the 60 days after the earthquake, but in the 5 years after the earthquake, the age-adjusted annual incidence of hospitalization increased significantly ($P < 0.001$) [7].

We also evaluated impact of magnitude on death cases number, and according to our results maximum was in low magnitude (1.1–2.0 ml). But the population-based study (2010–2011) of Tanaka F. et al. suggests that the increase in AMI events after a major earthquake varies depending on the seismic scale of the initial shock and each aftershock. The authors revealed that incidence of AMI was positively correlated with the seismic scale of the earthquake ($r = 0.75$, $P < 0.01$) [13]. In our study the results were opposite, and we supposed that it might be related to effect of age, nosological features (the greatest percentage in our study was from heart failure 46.3 %)

Conclusions

1. The largest percentage of patients died from heart failure 44.9 %, then from acute coronary syndrome (22.1 %), from acute cerebrovascular accident (19.1 %) and from hypertensive crisis (2.9 %).
2. The maximum number of deaths was at a magnitude of 1.1–2.0 ml (34.8 %).
3. Depending on the depth of earthquakes, the maximum number of deaths was at the process depth less than 10 km (34.2 %)

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