NATURAL IONIZING RADIATION AND BREAST CANCER IN GUARAPARI, STATE OF ESPÍRITO SANTO, BRAZIL

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ABSTRACT

Aim: To evaluate exposure to natural ionizing radiation from monazite sand and breast cancer mortality in Guarapari, state of Espírito Santo, Brazil. **Methodology:** This retrospective study compared breast cancer mortality per 100,000 inhabitants in the municipalities of Guarapari (ES), Ilhéus (BA), Campos de Goytacazes (RJ), and Rio Grande (RG), coastal cities with similar socioeconomic profiles and population pyramids. Data from the Brazilian Institute of Geography and Statistics (IBGE) and DATASUS (Ministry of Health) collected between 2002 and 2008 were used. Radiometric surveys were conducted by the Applied Physics Group of UFES for Guarapari, while the other locations followed CNEN recommendations. Statistical analysis considered $p \geq 0.05$. **Results:** Accumulated natural radiation levels in Guarapari result in doses ranging from 3.65 mSv/year to 10.95 mSv/year, while in other locations, it is 1 mSv/year. The average breast cancer mortality rate between 2002 and 2008 was: Rio Grande = 26.7; Campos = 17.1; Ilhéus = 8.8; and Guarapari = 8.4. This indicates lower incidence of the disease in Guarapari, a fact that contradicts the theory of cancer induction even with low ionizing radiation levels; therefore, it is possible that there is a stimulating effect on the human biological process, resulting in a protective response. **Conclusion:** In this approach, the induction of malignant tumors was not confirmed; but the opposite appears to occur: ***hormesis of breast cancer in Guarapari***, the most common tumor among Brazilian women.

Keywords: breast cancer, natural ionizing radiation, hormesis

INTRODUCTION

Ionizing radiation is considered one of the factors that promotes cancer induction (1). This is a debatable and controversial topic because there are no defined limits to this occurrence, with radiodiagnosis, for example, being widely used in the diagnosis of malignant tumors. It should be highlighted that radiotherapy is an important therapeutic agent in their control.

This approach demonstrates the experience with chronic ionizing radiation caused by monazite sands of Guarapari, state of Espírito Santo, and the occurrence of breast cancer.

METHODOLOGY

This is a retrospective study with data collected between 2002 and 2008 from DATASUS, an agency of the Ministry of Health, and IBGE (Brazilian Institute of Geography and Statistics). The municipalities analyzed were Guarapari (ES), Campos de Goytacazes (RJ), Rio Grande (RS), and Ilhéus (BA), coastal locations with similar socioeconomic profiles and equivalent population pyramids.

The variable used was the breast cancer mortality rate in Guarapari compared to that in the other locations evaluated, recorded in the municipal health records annually prepared by DATASUS.

The natural ionizing radiation levels were established by the Applied Physics Group of the Federal University of Espírito Santo for Guarapari, considering values found in indoor and outdoor environments originating from ^{222}Th present in monazite sands, a radioactive element that decays to stable ^{209}Pb. Further details of this measurement are shown in a previous study (2). The levels in the other locations followed recommendations of the National Nuclear Energy Commission (CNEN) for areas located at sea level, with comparable atmospheric pressure and relative humidity (3).

A one-way fixed-effects Analysis of Variance model was used to compare the average cancer mortality rates in the four Brazilian municipalities. The Dunett's multiple comparison test was used to determine whether the average mortality rate in Guarapari differed significantly from the other locations. To ensure that the distribution of residuals from the ANOVA model was Gaussian and homoscedastic, a Box and Cox[1] logarithmic transformation was applied to data. Since the sample was small, with only 28 observations, the test power was calculated, and the value of 99.97% was found. $P \leq 0.05$ was considered significant (4).

RESULTS

Irradiation doses for the population of Guarapari ranged from 3.65 mSv/year to 10.95 mSv/year, considering a daily exposure of 1 hour during 365 days. The irradiation considered for the populations of Campos, Rio Grande, and Ilhéus was 1 mSv/year.

Table I shows the populations of the four locations measured by the 2010 IBGE census, with Guarapari having the lowest. Regarding neonatal mortality, Guarapari was also lower. Ilhéus showed the lowest Human Development Index, with the others being equivalent.

Table II shows breast cancer mortality rates, with lower values for Guarapari. The mean mortality rates differ significantly between at least two locations ($p < 0.0001$). According to the Dunnett's test results, which compared Guarapari with the other municipalities, it was found that: the mean breast cancer mortality rate is significantly lower in Guarapari than in Campos ($p = 0.0025$) and significantly lower than the mean rate in Rio Grande ($p < 0.0001$). On the other hand, the average breast cancer mortality rates in the municipalities of Guarapari and Ilhéus do not differ significantly ($p = 0.9358$), although the former tends to be lower.

DISCUSSION

The occurrence of harmful health effects at low doses or dose rates caused by ionizing radiation, such as those found in nature or even occupational radiation, has been emphasized in theory, as initially pointed out (1). These aspects are concerning, but epidemiological information may be of significant importance because they can provide more conclusive results in humans, both somatic and germinal aspects. International organizations already recognize that there is a dose threshold for the occurrence of damage (5). The information available shows that cancer is not this type of damage (2,5,6).

Ionizing radiation causes interactions with cytoplasmic elements, the most abundant of which is water, resulting in the formation of oxidative radicals, which react with the production of antioxidants to preserve homeostasis. This mechanism occurs in approximately 60% of cellular aggression, while the interaction in the nucleus, at DNA level, causes single strand breaks, double strand breaks, and cross-links in the helix bands, which can result in chromatid and chromosomal aberrations, accounting for approximately 40% of this effect. DNA alteration repair mechanisms are highly elaborate in cellular metabolism, especially in humans, and are activated and maintained at low dose rates. Furthermore, cell apoptosis (death) and intervention by the body's autoimmune

response can occur (7-10). This explains why populations occupationally exposed or exposed to natural radiation levels have lower cancer rates than the general population, due to biological adaptation, also known as hormesis (11).

The analysis of breast cancer mortality data conducted here shows lower rates in Guarapari compared to other coastal locations in the country (Campos, Rio Grande, and Ilhéus). These findings are consistent with other morbidity studies carried out by Orlando et al., who found lower incidence of the disease in Guarapari compared to other locations in the state of Espírito Santo (12), and this epidemiological information is consistent.

CONCLUSION

The lower incidence of breast cancer in Guarapari may be linked to existing natural ionizing radiation levels, due to biological adaptation. It is possible to consider this as a ***hormesis*** of this radiation.

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Declaration - For all purposes, we declare that there is no conflict of interest in the presentation presented here.

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TABLE I – Information on the compared municipalities – 2010 census

	Ilhéus (BA)	Guarapari (ES)	Campos (RJ)	Rio Grande (RS)
Population	162,334	105,286	463,731	197,228
HDI	0.690	0.731	0.716	0.744
Neonatal Mortality rate	17.97	10.72	13.74	11.44

TABLE II- Breast cancer mortality rate

MORTALITY PER 100,000 INHABITANTS								
	2002	2003	2004	2005	2006	2007	2008	Mean
Ilhéus (BA)	5.4	5.4	18.0	5.4	6.3	10.7	10.8	8.8
Campos (RJ)	15.0	17.7	18.0	17.3	16.7	19.1	16.1	17.1
Rio Grande (RS)	13.3	26.4	27.2	28.8	23.6	31.2	36.7	26.7
Guarapari (ES)	4.2	4.1	14.1	3.8	5.5	12.5	15.3	8.4