

DID CHERNOBYL ACCIDENT CONTRIBUTE TO THE RISE OF THYROID CANCER IN TURKEY?A. Kocakusak^{1,*}*Haseki Education and Research State Hospital, General Surgery, Istanbul, Turkey***Abstract**

Context. Radioactivity has been known to be a causative factor for thyroid cancer.

Objective. To answer whether the Chernobyl nuclear accident had any harmful effect on the rate of thyroid cancers after a wait-and-see period.

Background. The Chernobyl accident in 1986 was chosen as a milestone because of its close proximity to the geographical area studied.

Design. The time periods chosen were: I. 1990-1996 (latent period), II. 1997-2003 (sensitive period), III. 2004-2015 (control period).

Subject and Methods. A retrospective study was conducted in a teaching and reference state hospital. The statistical analysis of the data of 4251 patients was made by chi-square and Fisher exact tests.

Results. A total of 4251 patients were operated on because of thyroid diseases between 1990-2015. The number of patients in regard to the three time periods were 817, 1141 and 2293, respectively. Statistically significant rise of thyroid cancer and significant geographic vulnerability among different parts of the country were detected between the first two periods, but not between the second and third. The rising rates of malignancy were 1.71% (14/817), 6.83% (78/1141) and 8.59% (197/2293). The mean ages of malignant cases were 51.07 years, 46.2 years and 41.8 years although the mean ages of benign cases were 47.91, 60.2, and 61.3 years according to groups, respectively.

Conclusion. The Chernobyl nuclear accident seemed to have harmful effect on the rate of thyroid cancer or at least contributed to its increase.

Key words: nuclear, papillary, radiation, thyroid cancer.

INTRODUCTION

During the last decades thyroid malignancies gained more attention than before as one of the most commonly rising types of cancers worldwide and radioactivity especially the Chernobyl nuclear disaster has been blamed (1, 2). In addition to publications related to increased rates of benign diseases caused

by environmental and genetic factors, Turkey, as one of the leading countries with thyroid malignancy globally, also reported its data in relation to Chernobyl in some studies since ionizing radiation occurring from nuclear accidents has been considered as a part of the environmental causes (3-5). Although the interest of researchers for thyroid cancer has always been very high, differences between countries and investigators have resulted in difficulties to create a real consensus. Thyroid cancer has been reported as the second common cancer among women after breast cancer and the seventh common cancer when both sexes are evaluated in Turkey according to Globocan 2012 reports (6). The mostly blamed reason both for benign and malignant diseases of thyroid has been iodine deficiency, which has been a fate in some geographical areas such as Turkey (7). The cancer types related to iodine deficiency are follicular and undifferentiated malignancies of the thyroid (8, 9). However, thyroid papillary carcinoma has significantly increased following Chernobyl disaster according to publications in Turkey (5, 10, 11).

Many factors have been cited in regard to the increasing trend of thyroid cancer. Global disasters sometimes create big questions which disguise real opportunities to answer some medical dilemmas, since disasters have a strong ability to transform a local geographic area to a large laboratory. Unfortunately, decades are necessary to get a correct answer and almost nobody will be interested to evaluate the outcomes since all data get outdated after those decades. The relative shortness of the professional working time of the investigators also does not help the situation. However, some slow developing malignancies such as thyroid cancers necessitate delayed evaluations, since at least decades are necessary for such studies. Increased number in thyroid cancer is a real observation all over the world. Causes contributing to this fact are not only radioactive fallout. Endemic iodine deficiency, changes in indications for surgery,

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changes and improvement in diagnostic tools because of the evolved technology, treatment options which transformed into total thyroidectomies when compared to other surgical methods resulted in higher rates of thyroid cancers worldwide. Many factors meanwhile change the laboratory environment of populations when time passes and an outcome of non-standard data is inevitable. The necessary latent period after radioactivity can be as long as 10 years. The rate of thyroid cancer has increased in Turkey during the last decades. Whether Chernobyl, with its 1150 km distance to the geographic area studied, had any effect on thyroid cancers is a doubtful question but it surely has lost its importance. Turkey has been affected by radioactive clouds of the nuclear reactor by two fronts. The first impact was on the western parts of Turkey including Istanbul and Western Black Sea coast beginning from April 30th 1986. Eastern Black Sea coast was affected by a second cloud at the beginning of May 1986. As the whole Black Sea coast has been the region with highest volume of rainfall of the whole country, almost all year round, the clouds left their radioactive content with heavy rains to those geographic areas (12-15).

Retrospective data divided in three consecutive time periods was studied and it resulted in a very interesting result to report. We could not answer why there was a difference between the first and second periods, but the second and the third, many years after the Chernobyl accident. The difference between the first two periods might only be answered by the mass disaster of radioactivity. A retrospective view of the data of 4251 patients consecutively operated on in a teaching hospital is reported to enlighten the latter observation.

PATIENTS AND METHODS

The present study retrospectively evaluates the patients who were operated on because of thyroidal

diseases during the last 26 years to focus surgical interventions and for the comparison of the related data. The Chernobyl accident in 1986 was chosen as a milestone because of its close proximity to the geographical area studied. The time periods chosen were:

- I. 1990-1996 (latent period),
- II. 1997-2003 (sensitive period),
- III. 2004-2015 (control period).

Patients' files, pathology reports, online hospital records, reports of surgical interventions of all surgically treated patients including all benign and malignant cases were used to see whether there had been any difference between the periods given (Table 1).

Age, gender, geographical area within the country, preoperative evaluations and diagnostic tools, postoperative hospitalization time, postoperative follow-up results, early and late complications, extent of surgical interventions, hormonal status, external hormone usage were recorded. The statistical analyses were made by using chi-square and Fisher exact tests with level of significance $p < 0.05$.

RESULTS

A total of 4251 patients were operated on because of thyroidal diseases in our surgical clinic between 1990-2015. Between 1990-1996 (latent period) a total of 817, between 1997-2003 (sensitive period) 1141, and between 2004-2015 (control period) 2293 patients were surgically treated.

The rising rates of malignancy were 1.71% (14/817), 6.83% (78/1141) and 8.59% (197/2293) according to time intervals, Table 2.

The results of age, gender, preoperative evaluations and diagnostic tools, postoperative hospitalization time, postoperative follow-up results, early and late complications, hormonal status, external hormone usage were not statistically different among

Table 1. Demographics

Time Period	I (1990-1996)	II (1997-2003)	III (2004-2015)
Number of patients operated	817	1141	2293
Benign	803	1063	2096
	627 (78.09%) females 176 (21.91%) males Mean age: 47.91 years	923 (86.3%) females 140 (13.7%) males Mean age: 60.02 years	1785 (85.1%) females 311 (14.9%) males Mean age: 61.3 years
	14 (2)	78 (34)	197
Malignant (Black Sea area vs other areas)	8 (57.1%) females 6 (42.9%) males Mean age: 51.07 years	60 (76.9%) females 18 (23.1%) males Mean age: 46.2 years	166 (84.3%) females 31 (15.7%) males Mean age: 41.8 years

Table 2. Thyroid surgery in study periods

Time Period	Malignant (PTC)	Benign	Number of patients operated
I (1990-1996)	14 (8)	803	817
II (1997-2003)	78 (57)	1063	1141
Total	92	1866	Chi-square: 27.899 p< 0.0001 Fisher's exact test: p<0.0001
Thyroid cancer cases between the second and third periods			
Time Period	Malignant (PTC)	Benign	Number of patients operated
II (1997-2003)	78 (57)	1063	1141
III (2004-2015)	197 (168)	2096	2293
Total	275	3159	Chi-square: 3.186 P: 0.0743 Fisher's exact test: 0.0825

Table 3. Significant rise of papillary thyroid cancer between the second and third periods

Time Period	Papillary cancer	Other types	Number of patients operated on
II (1997-2003)	57	21	78
III (2004-2015)	168	29	197
Total	225	50	Chi-square: 5.593 P: 0.01 (p< 0.05) Fisher's exact test: 0.0238 (p< 0.05)

groups. Another evidence to blame the Chernobyl disaster to contribute to the rising trend of thyroid malignancies was the mean age of patients at diagnosis. The mean ages of malignant cases were 51.07 years, 46.2 years, and 41.8 years according to the consecutive time intervals studied, where malignant cases are now younger than before, although the population is now older and the mean life expectancy in Turkey has increased from 74 in 1990 to 85 years in 2016. The patients of today were the children of the year 1986. Moreover, another fact supporting this evidence was the mean age of the patients with benign thyroid diseases. The mean age of benign goiters were 47.91, 60.2, and 61.3 years according to the same consecutive time intervals. Hence the mean ages of benign and malignant cases were found to be inversely proportional to each other in all time intervals.

Statistically significant rise of thyroid cancer and significant geographic vulnerability among different parts of the country were detected between the first two periods (chi-square: 4.279, p=0.0386), but not between the second and the third. Insignificant rise of papillary cancer between the first two periods gained significance in the last period (Table 3).

The study was not about the surgical methods used because of very confusing surgical interventions since even solitary adenectomy, solely isthmectomy or recurrent subtotal thyroidectomy had been used in the first period, which later on, more or less transformed into lobectomies. Therefore, one of the rationale was to express the changing face of thyroidectomy by giving

the changing rates of completion thyroidectomies which was a good mirror of previous surgical method. According to the comparison of the first and second time periods, completion thyroidectomy was employed in 2 (14.28%) of 14 patients in the first and 37 (47.7%) of 78 patients in the second time periods. However, the rate decreased to 15.22% (30/140) in the third period. Papillary cancer in 8 (57.2%), follicular cancer in 4 (28.6%) and anaplastic cancer in 2 (14.2%) were the malignant subgroups of the first period. Papillary cancer in 57 (73.1%), anaplastic cancer in 9 (11.5%), follicular cancer in 8 (10.2%), Hürthle cell cancer in 2 (2.6%), medullary cancer in 1 (1.3%), and metastatic cancer from lung in 1 (1.3%), were the malignant subgroups of the second period. Statistically significant rise of thyroid cancer was detected between the first two periods. There was not any significant difference between the second and third periods considering malignant cases compared to benign goiters. The third time period had more or less similar results compared to studies worldwide (8, 9).

DISCUSSION

Thyroid cancer seemed to increase in number one decade earlier in Turkey when compared to other studies worldwide. The significant increase in thyroid cancer incidence was during the second time period, although it globally was the third time period which had a peak in thyroid cancer worldwide according to similar studies (8). Our patients seemed to have entered

the vulnerable period one decade earlier than the other geographical areas worldwide. Hence, there was not a real difference between the second and third periods according to the present study. The patients who came from the Black Sea coast as the nearest area of Turkey to Chernobyl significantly dominated in number, which was another strong evidence to blame the Chernobyl accident.

Another, though insignificant rise was the ratio of papillary cancers *versus* the other types. However, a significant difference was detected in regard to papillary cancer in the comparison of second and third decades. When the patients were distributed according to the seven existing geographical areas of the country and compared to each other, patients from the Black Sea coast had been significantly more in number when compared to other areas between the 1st and 2nd periods, but the 2nd and 3rd. Distribution of the cases in regard to 7 geographical areas of the country did not differ significantly between the last two periods although patients still mostly came from the northern cities. We believe that an evaluation of the geographical distribution of any disease can only be studied in a large country such as Turkey with an area of more than 780.000 km², almost one third of the area of entire Europe. The data of the present study are listed in Tables 1-3.

Radiation is a well-known risk factor for thyroid cancer especially for papillary carcinoma. Many diseases such as leukemia, lymphoma, liver, nasopharynx, lung, breast and oesophagus carcinomas and neural tube defects also increased after the disaster. The legislative mandatory iodization of the household salt since 1999 in the country studied may have decreased the rate of follicular carcinoma. The increased ratio of papillary cancer can be attributed to the delayed iodine prophylaxis in iodine deficient areas of the geography studied. Increased incidence of thyroid cancer has been recognized by the neighbouring countries of Turkey in Europe (16-18). During the last decades papillary cancer showed a marked increase in Turkey (5, 11). Since the children of 1986 have been operated on because of thyroid malignancies as adults nowadays, dramatic increase of papillary thyroid cancer can be attributed to the radioactive dispersion happened in the same period. Caesium 137 isotope distribution along the Black Sea coast was most remarkable in 1986 according to the measurements of the prime minister records when compared to other areas of the country (15). Loss of significance between second and third periods of the present study in regard

to geographical area can be attributed to the movement of patients from one area to another within 25 years. Besides, in another study reported in Turkey, regional differences could not be found in regard to Chernobyl in patients from Aegean region only, which is far away from the Black Sea coast (11). Radiation-induced carcinogenesis especially affects vulnerable organs such as the thyroid gland. Long half-lives of some radioactive isotopes still continue their harmful effects on sensitive organs in some geographic areas. Major radioactive substances released by Chernobyl accident were caesium-137 (half-life: 30 years), strontium-91 (half-life: 29.2 years), plutonium-241 (half-life: 14.4 years), (which decays into americium-241 (half-life: 430 years), Iodine-131 (half-life: 8.04 days), Xenon 133 (half-life: 5 days), and Tellurium-132 (half-life: 78 hours) (19). Since those radioactive isotopes are reported to have been spread out by the disaster, their effects could have been speculated even nowadays. While heavier radioactive elements such as Strontium fell down to areas near Chernobyl, elements lighter in weight such as Iodine and Caesium became scattered around 75% of European countries. Scattered radioactive elements affected humans through air, water, or foods ingested. Rainy weather almost every day of the year deteriorated the situation of the whole Black Sea coast. The relationship between radioactivity and thyroid cancer is a real observation in Turkey (20). Although completion thyroidectomy was employed in 2 (14.28%) of 14 patients in the first and 37 (47.7%) of 78 patients in the second time periods, the rate was 15.22% (30/140) in the third period. Moreover, completion thyroidectomy was following always after lobectomies in the third period instead of following bilateral subtotal thyroidectomy unlike the first and second periods, which reflected the changing face of the thyroid surgery. Preference for total thyroidectomy after 2003 instead of other lesser surgical interventions by the surgeons and increased diagnostic techniques such as ultrasonography and fine needle aspiration cytology in addition to changes in histological criteria making them more strict, all have some effects on the increased incidence of thyroid cancer; however, such a rise as reported in this present study contains the most remarkable data and our results cannot be explained without the effect of the Chernobyl disaster.

Our rate of cancer plotted against benign surgical reasons to operate on may seem to be not so high when compared to studies of the Western Europe. The rising rates of malignancy in this present study were 1.71% (14/817), 6.83% (78/1141) and 8.59%

(197/2293) according to time intervals. The reason of this condition can be attributed to the thyroid nodule incidence of Turkish population, which is over 70% because of being a country with endemic goitre diseases of benign origin leading to surgical interventions.

In regard to the time periods, the rates of benign disorders leading to surgery were almost similar such as 803/817 (98.28%), 1063/1141 (93.16%) and 2096/2293 (91.4%) according to groups, respectively. However, surgical interventions for benign thyroid diseases were almost doubled in number in our hospital between the last two periods. Presence of nodular goitre in more than half of the whole population in a country of endemic thyroidal diseases resulted in an increased number of surgical interventions because of using the guidelines of western countries which are non-endemic in regard to goitre. Unfortunately, Turkey as an endemic goitre country lacks its own guidelines for its own surgical indications. Moreover, the domino effect of high rates of thyroid cancer reported at to 35.6 % in consecutive autopsy series who did not die of thyroid cancer might have resulted in high rates of surgical interventions because of benign thyroid diseases in the present study (21).

The limitation of the study was the absence of molecular studies which would be helpful for detecting the effect of ionizing radiation in the development of thyroid papillary cancer. However, decades before, a meta-analysis in a pooled evaluation helped to answer the question whether age at irradiation had any effect on thyroid cancer showed that the most excessive relative risk began to decline about 30 years following exposure but it was still elevated at 40 years. Decreased significant risk with increasing age at exposure was also reported (22). Age at diagnosis in this present study was supporting the relationship between thyroid cancer and ionizing radiation. The unequal time period of the 3rd part (12 years) when compared the first two periods of 7 years did not create any problem since we used the rates (percentages) only (not the numbers) which avoided the differences among the time intervals. Hence the number of surgical interventions doubled during time intervals of 7 and 12 years.

In conclusion, one can claim that the study results over-emphasized Chernobyl disaster as the causative factor for the increased rate of thyroid cancer, but according to the results gained, it would be speculation not to do so. The reported data showed that the Chernobyl nuclear accident had harmful effects on the rate of thyroid cancers or at least contributed to its increase after a wait-and-see period. However,

changes in diagnosis and surgical treatment options leading to an increased number of patients to deal with, in addition to genetics and environmental factors, all resulted in the increased rates of thyroid cancer worldwide and transformed the face of it almost into another. Whether the Chernobyl nuclear disaster had any effect on thyroid cancers is a doubtful question to answer but it surely has lost its importance.

Conflict of interest

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