# Brain and Neck Tumors Among Physicians Performing Interventional Procedures

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**Physicians performing interventional procedures are chronically exposed to ionizing radiation, which is known to pose increased cancer risks. We recently reported 9 cases of brain cancer in interventional cardiologists. Subsequently, we received 22 additional cases from around the world, comprising an expanded 31 case cohort. Data were transmitted to us during the past few months. For all cases, where possible, we endeavored to obtain the baseline data, including age, gender, tumor type, and side involved, specialty (cardiologist vs radiologist), and number of years in practice. These data were obtained from the medical records, interviews with patients, when possible, or with family members and/or colleagues. The present report documented brain and neck tumors occurring in 31 physicians: 23 interventional cardiologists, 2 electrophysiologists, and 6 interventional radiologists. All physicians had worked for prolonged periods (latency period 12 to 32 years, mean 23.5 ± 5.9) in active interventional practice with exposure to ionizing radiation in the catheterization laboratory. The tumors included 17 cases (55%) of glioblastoma multiforme (GBM), 2 astrocytomas (7%), and 5 meningiomas (16%). In 26 of 31 cases, data were available regarding the side of the brain involved. The malignancy was left sided in 22 (85%), midline in 1, and right sided in 3 operators. In conclusion, these results raise additional concerns regarding brain cancer developing in physicians performing interventional procedures. Given that the brain is relatively unprotected and the left side of the head is known to be more exposed to radiation than the right, these findings of disproportionate reports of left-sided tumors suggest the possibility of a causal relation to occupational radiation exposure.**  **(Am J Cardiol 2013;111:1368−1372)**

Orthopedic complications and radiation exposure have become major occupational health concerns among interventional physicians. Interventionists are chronically exposed to ionizing radiation, which can pose increased cancer risks. Numerous publications have emphasized the potential hazards of accumulated radiation exposure for oncogenesis and cataracts.[1−14] We recently reported a collection of 9 cases of brain cancers in interventional cardiologists.[15] That report documented that the preponderance of tumors developed on the left side of the brain, the part of the interventionists' body most directly exposed and often poorly protected. In response to that report, we received numerous additional unsolicited reports of cases. An update was published as a "letter to the editor" a few weeks later.[16] The cohort of reported cases has increased to 31 cases of interventionists with brain cancer.

The aim of the present report was to increase the awareness and request the creation of a large-scale registry.

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## Methods

The present study included data from 31 interventional physicians with brain and neck cancer. We previously published an initial first small report and a subsequent update as a "letter to the editor."[15,16] The present study reports the most updated data on previously published cases gathered since publication and information on 13 additional reported cases transmitted to us during the previous few months.

For all cases, where possible, we endeavored to obtain the baseline data, including age, gender, tumor type and side involved, specialty (cardiologist vs radiologist), and number of years in practice. These data were obtained from the medical records (when available), published studies of previous cases, and interviews with patients, when possible, or with family members and/or colleagues.

## Results

The demographic variables (age, gender, specialty, and years in practice) and tumor type and clinical outcomes are summarized in Table 1. The age range of the patients was 49 to 67 years (median 54, mean 54.7 ± 7.1). Only 1 of the patients in the present series of malignancies was a woman.

The most common offending tumor type was glioblastoma multiforme, identified in 17 of 31 cases (55%), with 2 cases of astrocytoma and 5 of meningioma.

A striking finding was the disproportionate occurrence of tumors on the left side of the brain. Anatomic localization data were available for 26 cases, and in 22 (85%), the

0002-9149/13/$ - see front matter 
http://dx.doi.org/10.1016/j.amjcard.2012.12.060

Table 1
Patient characteristics

| | Country | Year Diagnosed | Age at Diagnosis (yrs) | Gender | Radiation Exposure (Latency Period) (yrs) | Tumor Type | Side Involved | Occupation | Prognosis | Age at Death (yrs) | Survival After Diagnosis | Reference |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | Toronto, Canada | 1997 | 62 | M | 20 | GBM | Left side | IC | Died in 1999 | 64 | 2 yrs | 13,15 |
| 2 | Toronto, Canada | 1997 | 53 | M | 20 | GBM | Left side | IC | Died in 1999 | 55 | 4 yrs | 13,15 |
| 3 | Haifa, Israel | 1998 | 48 | M | 12 | Meningioma | Left temporal | IC | Alive | | | 15 |
| 4 | Paris, France | 2001 | 56 | M | 25 | GBM | Left temporal | IC | Died in 2005 | 59 | 4 yrs | 15 |
| 5 | Paris, France | 2005 | 49 | M | 22 | GBM | Left temporo-occipital | IC | died in 2006 | 50 | 16 mo | 15 |
| 6 | Haifa, Israel | 2009 | 62 | M | 32 | GBM | Left frontal | IC | Died in 2010 | 63 | 11 mo | 15 |
| 7 | Sweden | NA | | M | 20 | Acoustic neurinoma | NA | IR | | | | 14,15 |
| 8 | Sweden | NA | | M | 28 | Meningioma | NA | IR | | | | 14,15 |
| 9 | Sweden | NA | | M | 31 | Oligodendroma | NA | IR | | | | 14,15 |
| 10 | London, UK | 2009 | 62 | M | 27 | Parotids | Left | IC | | | | 16 |
| 11 | Zürich, Switzerland | 2009 | 53 | M | 20 | GBM | Left frontal | Pediatric EP | Died in 2010 | 54 | 14 mo | 16 |
| 12 | Virginia | 2009 | 67 | M | 29 | GBM | Left | EP | Alive | | | 16 |
| 13 | Dundee, Scotland | 2007 | 59 | M | 29 | Astrocytoma | Left | IC | Died in 2009 | 61 | 2 yrs | 16 |
| 14 | Kentucky | 2008 | 54 | M | 22 | GBM | Left | IC | Died in 2010 | 56 | 2 yrs | 16 |
| 15 | Illinois | 2003 | 65 | M | 32 | GBM | Midline | IC | Died in 2005 | 67 | 2 yrs | 16 |
| 16 | Gainesville, Florida | 1990s | ~40 | M | ~10 | GBM | Left occipital lobe | IC | | NA | | 16 |
| 17 | West of Scotland | 2008 | 52 | Female | NA | GBM | Left frontal | Radiologist | Died in 2009 | 53 | 1 yr | 16 + new data |
| 18 | West of Scotland | 2011 | NA | M | NA | GBM | Left temporal | IR | Alive | | | 16 + new data |
| 19 | Leipzig, Germany | 2005 | 55 | M | 20 | GBM | Right | IC | | 56 | 1 yr | New |
| 20 | Homburg, Germany | 2010 | 54 | M | 25 | Astrocytoma (grade III) | Left | IC | Alive | | | New |
| 21 | Linköping, Sweden | 2009 | 49 | M | 12 | GBM | Left frontal lobe | IC | Died in 2011 | 49 | 2 yrs | New |
| 22 | Santa Monica, California | 2006 | 52 | M | 21 | GBM | Left | IC | Died in 2007 | 53 | 2 yrs | New |
| 23 | California | 2008 | 71 | M | 22 | Glioma | Left temporal | IC | Alive | | | New |
| 24 | Maryland | 2012 | 57 | M | 26 | Meningioma | Right | IR | Alive | | | New |
| 25 | Belgium | 1990s | NA | M | NA | GBM | NA | IC | Died | NA | | New |
| 26 | Belgium | 1990s | NA | M | NA | GBM | NA | IC | Died | NA | | New |
| 27 | Ireland | 2011 | 55 | M | 31 | Neck lymphoma | Left | IC | Alive | | | New |
| 28 | Israel | 2012 | 62 | M | 32 | Parotids | Right | IC | Alive | | | New |
| 29 | Germany | 2003 | 49 | M | 19 | Meningioma | Left | IC | Alive | | | New |
| 30 | Middle East | 2009 | 62 | M | 30 | Meningioma | Left | IC | Alive | | | New |
| 31 | Middle East | 2009 | 52 | M | 19 | Tonsillar tumor | Left | IC | Alive | | | New |

EP = electrophysiologist; F = female; GBM = glioblastoma multiforme; IC = invasive cardiologist; IR = invasive radiologist; M = male; NA = not available.

malignancy was left sided. The tumor was midline in 1 interventional cardiologist (who had performed most cases using the Sones technique in which the head was typically centered nearest the x-ray source). The tumor was right sided in 3 operators (2 cardiologists and 1 radiologist).

The mean number of years in active interventional practice was 23.5 ± 5.9 years. The latency period from the start of work until the cancer diagnosis was 12 to 32 years (median 22). Data were unavailable regarding the years in practice for 5 patients.

## Discussion

The present observations have expanded those of recent previous reports of brain and neck cancer in interventional physicians.[13–16] Occupational radiation exposure and the orthopedic complications from wearing the heavy leaded aprons necessary to limit such exposure risk have become major concerns among physicians performing interventional procedures.[6–9,17–20] The present findings raise additional concern regarding occupational radiation exposure-induced malignancies.[21–29] Furthermore, the preponderance of tumors were glioblastoma multiforme, meningiomas, or astrocytomas, all malignancies known to be associated with radiation exposure.[30–33]

The most striking finding in the present report was the disproportionate number of tumors on the left side of the brain, the region of the head known to be more exposed to radiation and least protected by traditional shielding. The incidence in Europe and North America for glioblastoma multiforme has been 2 to 3 cases per 100,000 and for symptomatic meningioma has been approximately 2 cases per 100,000. All these malignancies have an equal distribution between the left and right sides. Performing Fisher's exact test to compare the 22 left- and 4 nonleft-sided tumors to the normal expected distribution in the general population (50% for each side) revealed, for a population of 26 subjects, a p value of 0.0176.

The limitations of interpreting observations from a "cluster" of cases for which the true "numerator and denominator" of cases within the total population is unknown must be emphasized. Regardless, these observations suggest, although they do not establish, the possibility of a causal connection between occupational radiation exposure and the development of brain cancer.

Interventionists are chronically exposed to ionizing radiation, which poses increased cancer risks.[18,19,34] Several reports have documented that the dosage of ionizing radiation among interventional cardiologists is the greatest registered by any medical staff using x-rays.[8,12] Recent studies reporting the occupational doses from fluoroscopy-guided interventional procedures calculated an increased cancer risk caused by professional radiation exposure in modern invasive cardiology practice.[8]

To mitigate the risk of radiation exposure, the use of shielding equipment is mandatory. Direct personal leaded aprons fully protect the trunk and thyroid gland. However, despite the use of additional indirect table-side and drop-down shields, the operators' legs, arms, neck, and head are not fully protected. Recognition of the sensitivity of the eyes to radiation damage has led to mandatory use of leaded glasses; however, even this strategy has failed to fully protect physicians from occupational x-ray exposure, as emphasized by recent reports of an alarming dose-dependent increased risk of radiation-induced cataracts in interventional cardiology staff.[7]

The operators' brains are even less protected than their eyes. Given that the operators' head is at best incompletely protected by drop-down shielding, it would not be surprising that the left side of the brain, that closest to radiation exposure in most interventional procedures, would be at greater risk of the induction of radiation-associated tumors. The present results support this concept, documenting that fully 85% of brain cancers were left sided, because random chance would have resulted in a more equal distribution.

We can only speculate that this disproportionate pattern of left-sided lesions reflects the effects of a differential dose distribution of radiation exposure in interventionists who typically work with the left side of the head in closest proximity to the primary x-ray beam and scatter. These observations are also consistent with previous reports that cardiologists' annual head exposure (ranging from 20 to 30 mSv/year ) is nearly 10 times greater than their whole body exposure,[11] with the left side of the head experiencing twice the exposure levels of the right side.[12]

Several previous studies have implicated occupational exposure to radiation as a risk factor for the induction of brain tumors, although studies have also been published in which a causal link was not firmly established. In the general population, similar to the findings from the present study, glioma has been the most common brain tumor type in adults. The prognosis has generally been poor. It has been postulated that in some cases, gliomas might be related to radiation exposure.[30] The other tumor types observed in the present study (astrocytomas, meningiomas, and parotid malignancies) have also been associated with radiation exposure.[31–33]

The present observations support those of previous studies, which, in aggregate, provide the basis for speculation regarding a causal relation between chronic radiation exposure and brain tumors of the cell types associated with such exposure.[21–29,34–36]

The present study had important limitations pertinent to the methods used; therefore caution must be taken in the interpretation of the present results. First, to firmly establish a causal relation between any factor (e.g., smoking) and cancer induction (e.g., lung cancer) is challenging and requires large population studies in which the numerator (number of cancers) and denominator (total population at risk) can be accurately ascertained. The present observations were derived from a very small number of anecdotally reported and, therefore, highly selected, cases that neither reflect the true population numerator (all brain cancers in interventionists) nor denominator (all interventional physicians). Furthermore, to draw firm conclusions regarding a causal effect between radiation exposure and brain cancer, an accurate measure of the total radiation exposure would be important (measured exposure for total years active in the fluoroscopy laboratory). We were not available to obtain the radiation exposure levels for the present analysis. In addition, in any future retrospective collection of information, such data would be difficult to obtain.

Although the anecdotal nature of the present report has substantially limited firm conclusions, the present cohort undoubtedly represents the minimal number of true brain cancer cases in interventionists. Therefore, at the very least, the present observations should serve to further heighten concerns regarding the safety of chronic occupational radiation exposure and the necessity for additional action on this important issue.

The Multispecialty Occupational Health Group, a joint effort of professional societies dedicated to the study of occupational hazards to interventional physicians has affirmed that the interventional laboratory poses occupational health hazards that must be "acknowledged, better understood, and mitigated to the greatest extent possible."[18–20,34] The Multispecialty Occupational Health Group is presently engaged in epidemiologic studies designed to assess the lifetime cancer risks for interventional physicians. Recognition of the potential harm of radiation has led to long-established standards for occupational exposure, emphasized by the policy of "as low as reasonably achievable." However, recent reports have reaffirmed the hypothesis of a linear-no-threshold model of radiation risk for solid cancers. That hypothesis states that any radiation dose carries with it an associated risk of cancer induction and that the risk increases linearly with an increasing dose[18]; clearly, improved fluoroscopic laboratory radiation safety equipment that affords more complete operator and staff protection is needed. Enhanced awareness, training, and practice of optimal radiation protection methods is essential.

New cases can be reported by contacting the corresponding author, Dr. Roguin (E-mail address: aroguin@technion.ac.il).

## Disclosures

Dr. Goldstein is an owner of equity in ECLS, Inc., which develops shielding devices for radiation protection. The other authors have no conflicts of interest to disclose.


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