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Letter

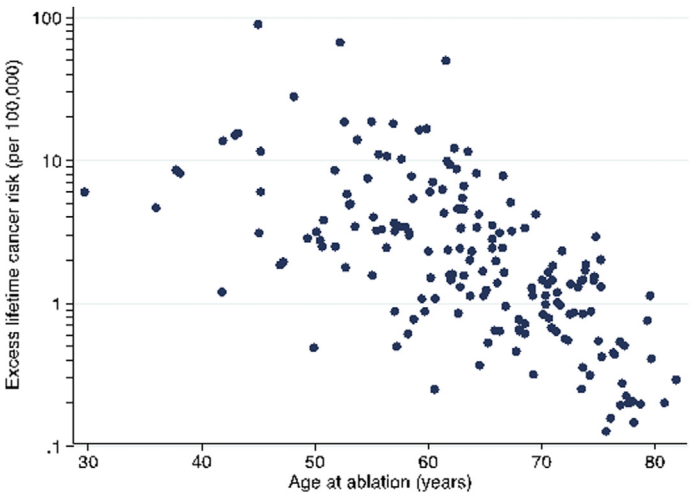
TO THE EDITOR

Estimating Cancer Risk Associated With Ionizing Radiation Exposure During Atrial Fibrillation Ablation

Catheter ablation for the treatment of symptomatic drug refractory atrial fibrillation (AF) is a well-established therapeutic option for management of AF. The long-term risk of radiation exposure in patients undergoing AF ablation is poorly characterized but important when counseling of patients on its risk. The goal of this study was to measure the radiation exposure and estimate the excess lifetime cancer incidence associated with radiation exposure in a cohort of patients undergoing a single catheter ablation for AF.

Between November 2014 and April 2016, 178 consecutive patients undergoing AF ablation at the University of North Carolina at Chapel Hill were included in a cohort for retrospective analysis. Ablation was performed using a standard protocol including antral pulmonary vein isolation and ancillary lesions at the discretion of the operating electrophysiologist with an open-irrigated radiofrequency ablation catheter and utilizing 3-dimensional mapping with CARTO (Biosense Webster, Diamond Bar, California), EnSite NaVX (St. Jude Medical, St. Paul, Minnesota), or Rhythmia (Boston Scientific, Marlborough, Massachusetts) technology. The 3-dimensional map was used to guide lesion placement with supplemental fluoroscopy as required using the Allura Xper monoplane fluoroscopy system (Philips Healthcare, Andover, Massachusetts). Demographic variables (age, gender, comorbidities, body mass index, $CHADS_2$ [congestive heart failure, hypertension, age ≥75 years, diabetes mellitus, prior stroke or transient ischemic attack or thromboembolism] and CHA_2DS_2-VASc [congestive heart failure, hypertension, age ≥75 years, diabetes mellitus, prior stroke or transient ischemic attack or thromboembolism, vascular disease, age 65 to 74 years, sex category] scores—measures of risk for thromboembolism), procedural variables (operator, procedural tools, lesion set), and radiation exposure variables (air kerma, kerma-area product [KAP], frame rate, beam energy) were collected by retrospective chart review. A Monte Carlo simulation program (PCXMC version 2.0.1.3, STUK, Helsinki, Finland) was used to estimate organ-specific radiation doses for the lungs, esophagus, stomach, and liver for all patients, and also to both breasts of female patients. Organ doses determined by Monte Carlo simulation were used to estimate radiation-induced lifetime attributable risks, based on the methods developed by the Committee on the Biological Effects of Ionizing Radiation (1,2). Because patients treated by catheter ablation of AF can have much shorter life expectancy than the general U.S. population, we estimated patient-specific age-dependent survival using published data on the dependence of mortality rates on the CHA_2DS_2-VASc score (3). The mortality hazard due to the CHA_2DS_2-VASc score was combined with the sex- and age-specific hazard for the general U.S. population taken from life tables, producing a survival function for each patient after catheter ablation of AF. For each year after the procedure, the excess cancer risk was estimated by the models described by the Committee on the

FIGURE 1 Estimated Excess Lifetime Cancer Risk by Age at Ablation



Estimated excess lifetime cancer risk (per 100,000) for 178 patients undergoing catheter atrial fibrillation ablation, adjusting for life expectancy by age at ablation and by CHA_2DS_2-VASc (congestive heart failure, hypertension, age ≥75 years, diabetes mellitus, prior stroke or transient ischemic attack or thromboembolism, vascular disease, age 65 to 74 years, sex category) score.

Biological Effects of Ionizing Radiation (1,2) and multiplied by the patient-specific probability to survive up to the given year. Integration of this product of cancer risks and survival probabilities over time after ablation until the maximum possible life span (assumed to be 120 years) produced an estimate of lifetime attributable risk for each patient. More details on this methodology are provided in Brenner et al. (4).

Median fluoroscopy time was 27.5 min with significant variation by operator. Median total organ-specific radiation dose was 3.9 (interquartile range [IQR]: 2.3 to 7.9) mGy for lung, 1.4 (IQR: 0.9 to 2.1) mGy for breast, 0.9 (IQR: 0.5 to 1.6) mGy for esophagus, 0.2 (IQR: 0.2 to 0.4) mGy for stomach, and 5.9 (IQR: 2.5 to 13.6) mGy for liver. In multivariable analyses, increased body mass index, operator, and mapping system (EnSite NaVX or Rhythmia compared with CARTO) were associated with increased KAP. However, there was significant collinearity of operator and mapping system variables such that their independent effect could not be determined. Overall estimated lifetime risk for cancer from a single AF ablation was 4.6 ± 9.7 per 100,000 patients (IQR: 0.8 to 4.5) (i.e., 1 in 21,700). Excess cancer risk ranged from approximately 1 in 1,000,000 in a 78-year-old man to 1 in 1,100 in a morbidly obese 45-year-old man. Lung cancer made the largest contribution (63%) to overall excess cancer risk. The excess lifetime risk for cancer was significantly dependent on the age at which AF ablation was performed (**Figure 1**).

Few studies have estimated the cancer risk associated with radiation exposure in cardiac diagnostic tests and therapeutic procedures using state-of-the-art methods (5). Prior studies were limited in that AF ablation was not guided by electroanatomic mapping, KAP meters were not available, and potential lifetime cancer risk of this radiation exposure was based on older methodology. The risk of low-dose ionizing radiation exposure on lifetime cancer risk is an estimation based on extrapolation of large epidemiologic studies. As such, the estimates rely on several assumptions that result in approximations, which carry a great deal of uncertainty. Nevertheless, proper cohort studies to assess the lifetime cancer risk from medical radiation exposure and specifically catheter AF ablation are impractical, so we are limited to the use of these projection models to assess risk. In addition, many patients undergoing catheter AF ablation will require a second or third procedure in follow-up, though the linear no-threshold model of risk supported by epidemiologic studies would suggest an additive additional risk of repeat procedures. Regardless, our study should help patients and their providers to understand all the potential risks of catheter ablation using modern techniques, which is important to the selection of treatment strategies of AF.

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REFERENCES

1. National Research Council (US) Committee on Health Effects of Exposure to Low Levels of Ionizing Radiations (BEIR VII). Health Effects of Exposure to Low Levels of Ionizing Radiations: Time for Reassessment? Washington, DC: National Academies Press, 1998.

2. Berrington de Gonzalez A, Iulian Apostoaei A, Veiga LH, et al. RadRAT: a radiation risk assessment tool for lifetime cancer risk projection. J Radiol Prot 2012;32:205–22.

3. Olesen JB, Lip GY, Hansen ML, et al. Validation of risk stratification schemes for predicting stroke and thromboembolism in patients with atrial fibrillation: nationwide cohort study. BMJ 2011;342:d124.

4. Brenner DJ, Shuryak I, Einstein AJ. Impact of reduced patient life expectancy on potential cancer risks from radiologic imaging. Radiology 2011;261:193–8.

5. Lickfett L, Mahesh M, Vasamreddy C, et al. Radiation exposure during catheter ablation of atrial fibrillation. Circulation 2004;110:3003–10.