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SUMMARY

Computed Tomography and Its Carcinogenic Effects in Children and Youth in Québec:

Scope of the Issue and Proposed Strategies

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SUMMARY

Developments in diagnostic radiology have made it possible not only to perform increasingly precise scans and but also to reduce their associated radiation doses. Yet the growing use of these scans in medical practice and the advent of new technologies expose the population to an increasingly high collective dose. Computed tomography (CT) has been estimated to account for roughly 50% of diagnostic medical radiation in the general public, with another 25% due to nuclear medicine, and the remaining 25% due to all the other radiological tests (conventional radiography, fluoroscopy, PET, etc.) [Fazel et al., 2009; Mettler et al., 2008a].

This report was prepared at the request of the Direction québécoise du cancer (DQC), which was especially interested in several issues: the cancer-related risks of diagnostic CT in children and young adults; available imaging options; and the means taken to reduce CT-related risks. The DQC asked us to focus on children and youth, given their increased sensitivity to radiation, their longer life expectancy, and the possibility that absorbed doses may be higher in these patients.

The aspects studied concerned the link between cancer and radiation from diagnostic medical procedures. Our examination of the link between radiation and cancer development, and of the quantification of absorbed doses (dosimetry), raised the following questions:

What is the best estimate of the extent of CT use in children and youth in Québec? What information is there on (i) the number of scans per age group; (ii) the effective dose associated with these scans; (iii) the contributions of the different CT scans; and (iv) radiation doses delivered in CT compared with those from other radiation sources?

What is the estimated carcinogenesis, specifically, the number of new cancer cases (incidence) and deaths (mortality) associated with CT in children and youth below the age of 20 years in Québec?

This review summarizes the literature on the link between ionizing radiation and cancer. It presents relevant concepts and measurement units, along with epidemiological evidence on the causal link between radiation and cancer. To clearly highlight the areas of consensus or debate, we performed a literature search in the databases containing primary scientific articles and systematic reviews published from 2000 to 2010, with no restriction as to language of publication. Special attention was paid to studies addressing CT-related radiation in children and youth below the age of 20 years. An estimate of different exposures to natural radiation sources is provided based on information available worldwide, in Canada and in Québec. A similar estimate was produced for artificial radiation sources, primarily from medical procedures.

We used data supplied by the RAMQ for 2009 and a dose-effect relationship model published in the literature to estimate the number of new cancer cases and cancer-related deaths potentially occurring during the lifetime of those exposed to CT radiation. These estimates were compared with others previously produced for Québec, the rest of Canada and the United States.

It was found that less than 4% of the CT scans done in Québec in 2009 were performed in children and youth aged 0 to 19 years, from a total of approximately 888,000 scans. This percentage varied with the anatomical site examined. Data indicate that 35% of CT procedures in adults were abdominal (26% for abdomen and pelvis, 8% for chest and abdomen, 1% for abdomen alone), whereas the head was the most common area of investigation in children and youth below the age of 20 years.

No matter how small, the risk associated with the thousands of scans performed each year suggests that a certain number of cancers are likely to occur. By applying a risk model adjusted for age distribution and for the health status of people undergoing CT scans, Berrington de González et al. [2009] derived an estimate of 14,500 deaths per year in the U.S. (equal to approximately 360 deaths in Québec). An analogous calculation was applied here to derive a more appropriate estimate for Québec in 2009, based on information on CT scan volume per anatomical site and per age-sex distribution.

For estimating carcinogenesis in children, the number of scans and the effective doses associated with

different pediatric CT scans were used under the basic assumption that pediatric doses are similar to adult doses. In 2009, 1.7 million children and youth below the age of 20 years accounted for 22% of the Québec population. The 32,668 CT scans in these children and youth accounted for 3.7% of those performed for all ages, and for 2.5% of the effective doses associated with these scans.

The link between radiation and cancer is well established, but the exact quantification of its effects remains a topic of controversy, especially for doses less than 100 mSv, which are typical in medical practice. For our estimates, we used the BEIR model [NRC, 2006], which assumes a linear relationship between the doses received and the probability of developing cancer. The application of these doses to a patient population may overestimate the carcinogenic effect produced in people who may sometimes have limited life expectancies. Berrington de González et al. [2009] reduced their cancer risk estimate by 11%, accounting for people who die from cancer within five years of their scans, and by 9% by eliminating the scans performed in people who had already been diagnosed with cancer. By applying the 20% reduction proposed by Berrington de González, we obtained an estimate on the order of 300 new cancer cases (estimate produced with our model: 286 new cancer cases and 184 deaths), including twenty or so in children and youth below the age of 20 years (estimate produced with our model: 24 cancer cases and 11 deaths in children and youth below the age of 20 years).

By comparison, we estimated that in 2009 there would have been 44,200 new cancer cases in Québec and 20,100 cancer deaths, accounting for 35% of the 57,200 deaths from all causes in Québec. Changing demographics will cause these figures to rise rapidly over the next two or three decades. The number of potential CT-induced cancers in Québec therefore accounts for only a small proportion of the total number of cancers.

Estimates of the number of cancer cases and the number of cancer-related deaths are dependent upon various assumptions, and reasonable variations in these assumptions may easily generate estimates roughly twice as high or twice as low. This quantitative analysis considered only the negative effects of CT imaging, which may be quantified by estimation. However, it is much more difficult to measure the morbidity and mortality that these 32,668 CT scans may have prevented, owing to earlier or more accurate diagnoses of serious diseases.

In the case of CT scans, the conventional medical attitude is to expect positive effects to significantly outweigh negative effects. This attitude should perhaps be tempered by recognizing the cancer risk associated with these scans, while emphasizing the importance of the diagnostic information they yield. The challenge of implementing best practices in CT is to make sure that this is the case for each clinical indication for which it is used. Two major strategies may help ensure the preponderance of positive effects: **optimization** of CT performance and **justification** of the use of CT scans.

Internationally, the risk associated with diagnostic radiation has been recognized since the advent of radiology and nuclear medicine. Historically, risk control, through radiation protection and the judicious use of these technologies, has kept pace with developments in the available techniques. The advent of CT, which delivers much higher radiation doses than conventional radiography, has led to new initiatives for aligning practices with this new reality, especially for pediatric patients. Examples include the Image Gently movement launched in 2006, the FDA's collaborative initiatives with manufacturers early in 2010, and Health Canada's Security Code 35 introduced in 2009. The present analysis provides an overview of the measures found in the medical literature that are designed to limit radiation-related dangers, while preserving the many benefits that these technologies offer to patients. These measures include:

- providing professional training and awareness about the issues;
- producing information to help physicians make decisions about the use of CT scans;
- developing dose-rate standards;
- developing guidelines on the indications for the different imaging techniques; and
- implementing quality-assurance measures in clinical and radiology facilities.

In this dynamic environment, these measures must be developed and supported to allow patients to take full advantage of the promising benefits of these technologies and to reduce the risk of inducing cancers that is inevitably linked to ionizing radiation.