Not Black or White…

It is Gray – after L.H. Gray (known as “Hal” Gray), a British radiation scientist and researcher (1905-1965), after whom contemporary radiation dose measurement was named in his honor in 1975. The radiation dose in Gray refers to the amount of absorbed radiation energy per unit of mass in the body – one Gray is specifically one joule per kilogram.

Cancers have known dose thresholds at which elimination of the tumor is likely. Normal tissues have thresholds at which toxicity of radiation therapy may ensue. These dose values vary across different organs in the body, and depend on factors such as the absolute and relative volume of the organ under irradiation as well as the orientation of the radiation dose regions to the organ structure. In this discussion we will focus on dose limits of normal tissues as they relate to the treatment of lung cancer.

In and around the lungs are a myriad of critical normal tissues. First of all, there is the lung itself, and the major airways which feed its air supply: the trachea and bronchi. In the middle of the chest between the lungs (this area is known as the “mediastinum”) are found the esophagus (swallowing tube that connects the mouth and stomach), the vertebral column (bones of the spine) and spinal cord (nerves of the spine), and the great blood vessels of the chest: the aorta and vena cava. Adjacent to all of these is the heart (somewhat to the left side as we all know). Wrapping around the outside are the ribs, muscles of the chest wall, skin and breast tissue.

Of all of this relevant anatomy, let’s discuss two of these structures with great importance: the lungs and the spinal cord. These two normal tissues are of interest too in that they are typically representative of side effects profiles which happen in the early-intermediate term, that is within a few weeks or months after radiation (lungs -> pneumonitis), or years after radiation (spinal cord -> myelopathy, or spinal cord dysfunction).

Two decades ago, a consensus panel of experts developed guidelines for radiation therapy doses to various organs of the body – including the lungs and spinal cord. This panel was chaired by Dr. Emami, and these guidelines are often referred to as the “Emami” dose guidelines. The panel stipulated radiation doses typically associated with either a 5% risk or a 50% risk of an adverse effect when a significant volume or length of the tissue/organ was irradiated to a threshold dose. For example, a 5% risk of lung toxicity corresponded to treating the whole lung to 1750 cGy, two-thirds of the lung to 3000 cGy, or one-third of the lung to 4500 cGy. For the spinal cord, it was estimated that 20 cm of the spinal cord could be irradiated to 4700 cGy with a corresponding 5% risk of late spinal cord damage.

Since then, radiation technology has changed to a fairly great extent, and much more is known about actual delivered radiation doses within the body. Targeting of radiation is increasingly sophisticated. In comparison to our knowledge of radiation dose delivery today, the radiation dosing information from 20 years ago was closer to what now would be considered a “rough estimate.” Nowadays we can predict radiation doses to fractions of a cubic millimeter at any point in the body. We now know that the chance of spinal cord damage
at an actual dose of 47 Gy is closer to 0.1% than 5%. Of interest, we still use the guideline of 45-50 Gy for radiation dose tolerance of the spinal cord when radiation therapy is delivered at 180 to 200 cGy per day.

In the modern era, in which we are able to deliver super high doses per treatment – 2000 cGy in a single fraction as example, the relevance of the classic Emami tissue toxicities for the lung continue to evolve. Now that a 2000cGy treatment can be highly focused on a tumor occupying far less than one-third of the lung, our consideration of safe dose thresholds has transitioned to a careful volumetric analysis of lung dose which scrutinizes relative dose thresholds at much smaller volumes than 2 decades ago. We now look small volumes of the lung receiving the full spectrum of possible doses from near nothing to very high dose, and we have an increasing understanding of what these numbers mean in terms of risk for lung toxicity.

As a radiation oncologist, interpreting risk profiles of lung irradiation and applying them in individual patient circumstances is often a gray area of balancing risk and benefit, rather than a set of black and white maximum dose thresholds. At times for example, a risk of lung or spinal cord toxicity exceeding 5% may yield a therapeutic benefit that is worth the risk. In my practice I frequently see patients for whom re-treatment with radiation may not have been considered a possibility. However, with closer examination, and a thorough understanding between myself and the patient, the actually risks and benefits may strongly favor radiation treatment.