Characterizing canine dose from computed tomography imaging

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Introduction

In response to growing concern of low dose radiation effects from computed tomography (CT) medical imaging, a study was developed at Colorado State University to better model stochastic effects in dogs which set the foundation for a canine translational model.

Effects from radiation are projected to follow a linear no threshold model which was developed by the Biological Effects of Ionizing Radiation (BEIR) VII committee from the Lifetime Survival Studies. Data support strong implications at the high dose ranges, but little evidence supports the theory at low doses. Research is needed to better link stochastic effects to levels of low doses of radiation.

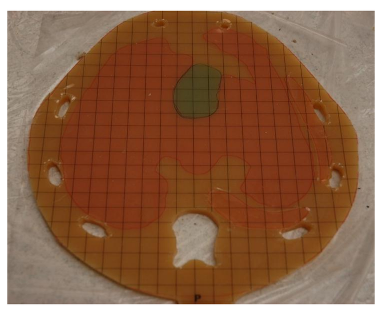
Studies from a variety of scientific fields show a unique parallel between the evolution of a disease in a human and their pet dog. An example is the well documented development of mesothelioma in both a pet and its owner for humans whose hobbies involved asbestos (Paoloni and Khanna 2008). It was hypothesized that a model relating the radiation response between a dog and human could be created which later utilizes canine data for human implications.

Materials and Methods

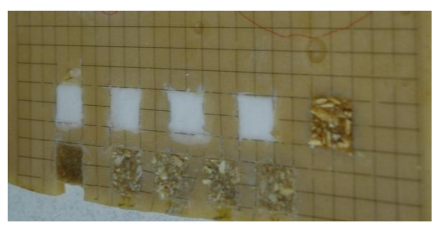
The first step to building a model required the construction of a physical canine phantom with identifiable organs of interest. A full-scale phantom was created in slices crafted after a CT scan from a research foxhound. Tissue-equivalent materials for the phantom were fabricated from recipes (Winslow et. al 2009) and real canine bones.





The soft tissue and lung were fabricated from a recipe developed by Winslow et al. at the University of Florida.



A new material was created and tested for bone and a real skull was used for the head.

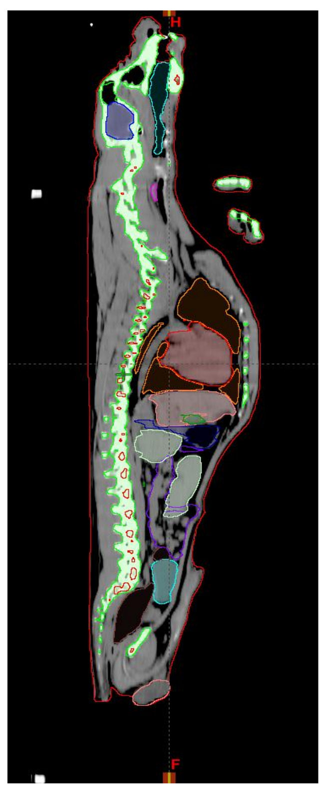
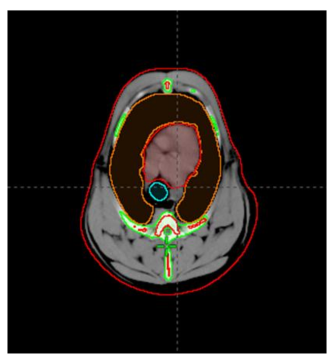
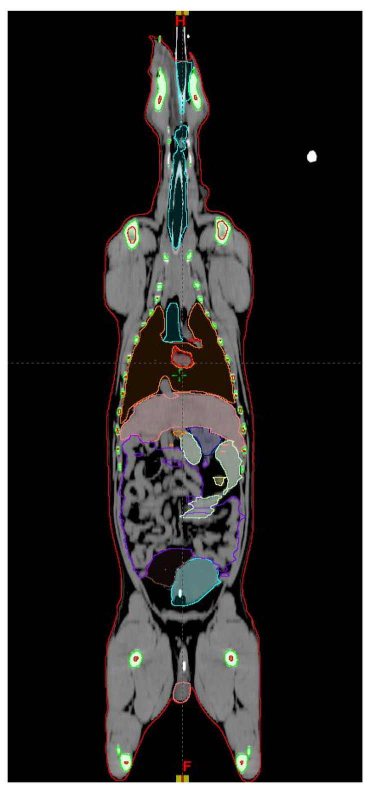
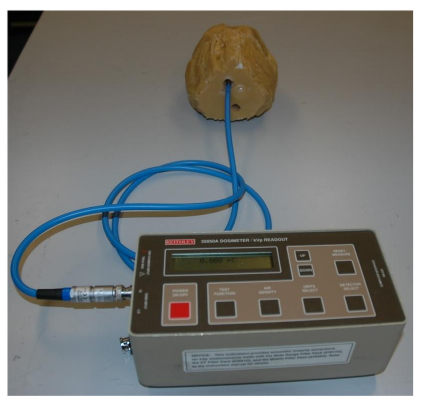




Figure 1. Images taken from Eclipse, Varian Treatment Planning Software. The full body CT was acquired from a research foxhound.



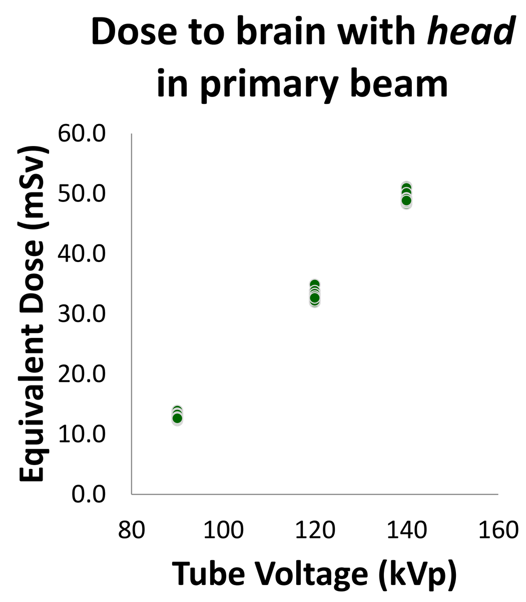

A 0.125 cc PTW pencil ion chamber (right bottom) and Keithley 35050A dosimeter (right top) were used to measure the air kerma in pico-coulombs. Once the phantom was created, dose data were collected in the brain of the canine phantom for two configurations: (1) with the head in the primary beam, (2) with the chest in the primary beam. The doses were measured at commonly practiced CT parameters of 90, 120, and 140 kVp at 300 mAs.

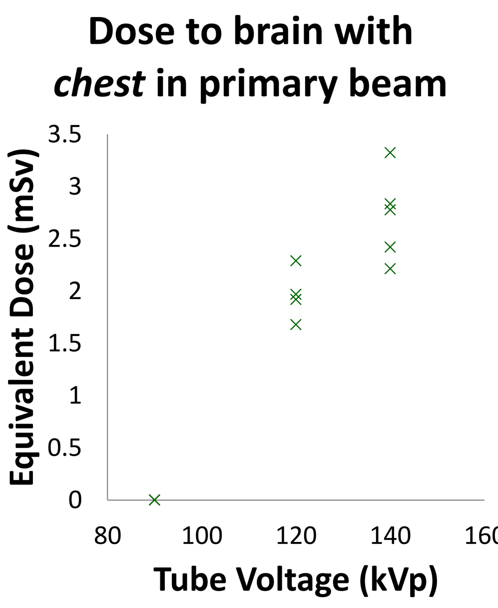
Brain dose data were compared to Monte Carlo generated human data for an adult and a ten year old child from ImPACT software (Shrimpton and Jones 1993).

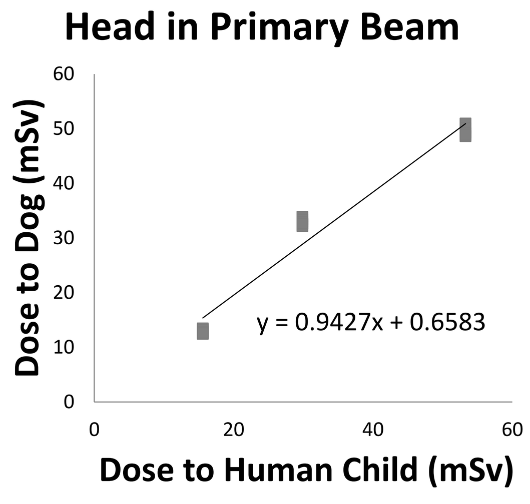
Results

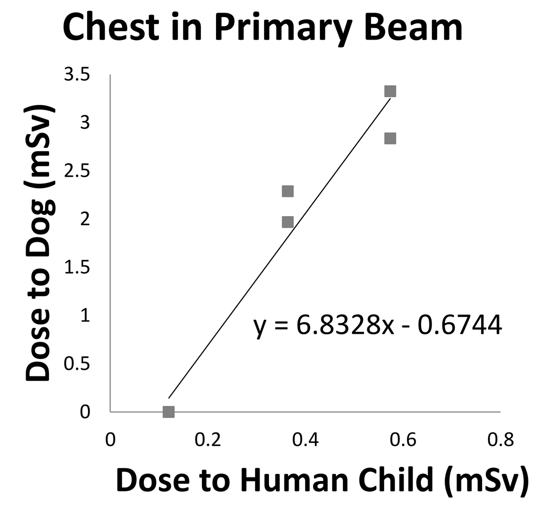
Successful completion of the torso and head of the phantom allowed measurements to be taken in the brain with the primary beam on both the head and chest.

Doses to the center of the brain, shown below, were calculated from the measured air kerma. Scattered radiation from the chest to the brain and direct radiation were measured to better characterize a clinical setting.









A desired ratio of one for the measured dose to the dog brain over the model-generated dose to a human child was seen in the data of the head in the primary beam.

Conclusions

The measurements with the head in the primary beam showed a ten year old human is comparable to a foxhound in dose received to the brain during a head CT scan for a range of kVp.

Data indicate a need for further study into the dispersal of scattered radiation in a dog in relation to a human. It is postulated that the difference in body structure may have an effect on how the radiation is scattered to the brain, and the geometrical distortion may carry to other parts of the body. The scattered radiation is an area that will need more extensive research to complete the model.

The canine species is ideal for translational research due to size, sensitivity to radiation and shortened latency periods for stochastic effects to form (Shearin and Ostrander 2010). More research is required to complete the model and develop a system for translational medicine.

References

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