FETAL RADIATION SHIELD
FOR PREGNANT PATIENTS RECEIVING RADIATION THERAPY

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Abstract

One in every 1500 pregnancies in the United States is complicated by radiation therapy. Therapy often affects patients must be adjusted in order to reduce the fetal radiation dose. Typically, the angle of treatment is altered to accomplish this as there is currently no standard protocol to physically shield the fetus. The Department of Human Oncology at University Hospital has requested that a shield be designed that will block leakage from the head of the radiation machine as well as radiation scatter to the sides of the abdomen. Although several shield designs have been developed, they were discontinued due to safety and cost concerns. A shield that is 5.6 cm in width and made of lead will be fabricated that is safe for the patient and medical personnel, mobile, and able to shield 50% of radiation leakage and scatter. In order to construct this device, a SolidWorks model and non-functional prototype will be created to evaluate the design before final fabrication will be completed, likely by a third-party source. Mechanical and clinical testing will also be necessary to evaluate the safety and effectiveness of the device.

Problem Definition

The main concern pregnant women face when receiving radiation therapy is the potential for their child to develop serious malformation. Without a shield, this risk is already quite low at approximately 0.5% chance [1], with the risk being greatest during the first week of pregnancy, when radiation effects can be lethal. After this, concerns mostly include increased risk of growth retardation, childhood cancer and microcephaly [2, 3].

The main sources of radiation that can interact with the fetus include photon leakage through the head of the machine, radiation scatter from the collimators, and radiation scattered within the patient from the treatment beams [2].

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Testing & Results

Material and Shield Thickness

Figure 1: Radiation scatter explained, derived from [4].

Lead is the material most commonly used to block radiation [4]. The generally accepted thickness of lead required to block 90% of all radiation is roughly 5.7 cm [4], as depicted in Figure 2. Reported values for the half-value layer of lead, the thickness required to block 50% of radiation, vary, but are less than 5.7 cm. Thus, in order to block at minimum 50% of radiation reaching the fetus, the team decided to design a shield that is 5 cm thick.

RADIATION TESTING

- Most important part of testing in order to confirm efficacy of the design in shielding
- Impossible to do without physical lead shield
- Monte Carlo Radiation Simulation – only models targeted beam, not scatter or leakage
- No software modeling of scattered radiation due to variability/uncertainty

STRESS TESTING

- Linear static test for identifying most likely points of failure
- Expected maximum displacement of the shield 2.9985E-5 near 0, as expected
- Most likely to fail at corners, especially during movement
- Further stress testing will be necessary with support mechanism as failure is more likely

Surface Area

- Surface area of the shield is used as an estimate correlated to body covered, 596.82cm²
- Difficulty in determining actual percentage of surface area of bodies, as patient size will vary

Future Work

The team will be working with Swift Engineering and Manufacturing to manufacture the final shield. We are currently awaiting a quote.

TASkS FOR SUBSEQUENT SEMESTERS

- Finalize support design – materials selection and SolidWorks testing
- Manufacture shield
- Test efficacy of shield to block radiation using phantom
- Manufacture support
- Assembly of shield and support
- Additional testing and implementation

References