2011 International Nuclear Atlantic Conference - INAC 2011
Belo Horizonte,MG, Brazil, October 24-28, 2011
ASSOCIAÇÃO BRASILEIRA DE ENERGIA NUCLEAR - ABEN
ISBN: **978-85-99141-04-5**

DEVELOPMENT OF IRRADIATOR ^{60}CO SOURCES

Rodrigo C. Mosca[1], Eduardo S. Moura[1], Carlos A. Zeituni[1] and Monica B. Mathor[1]

1 Instituto de Pesquisas Energéticas e Nucleares (IPEN/CNEN-SP),
Av. Prof. Lineu Prestes 2242
CEP 05508-000 São Paulo, S.P.
rcmosca@usp.br

ABSTRACT

According to a recent report by the International Agency for Research on Cancer (IARC) / WHO (2008-2010), the global impact of cancer more than doubled in 30 years. In this report, it was estimated that occurred about 12 million new cancer cases and 7 million deaths. In Brazil in 2010, with estimates for the year 2011, point to the occurrence of 489,270 new cases of cancer. Among the possibilities for cancer treatment, radiotherapy is one of the most important therapeutic and resources used to combat it. However, inherent complications of treatment can occur such as tiredness, loss of appetite, radiodermatitis and in more extreme cases late radionecrosis. In order to reproduce a point of radionecrosis in the vicinity of radiodermatitis to mimic these effects in animals, producing a model for assessment of tissue repair, we propose the setting up of an irradiator source of collimated ^{60}Co. The development of was based on 11 sources of ^{60}Co with 1 mm thickness that were inserted by inference in stainless steel "gate-source" screw (patent pending) and later adjusted in a cross-shaped arrangement reinforced so that the beam radiation is directed to a target point, saving for other regions around this target point. The main use of this irradiator with sources of ^{60}Co is just one cause radionecrosis point (target point) of approximately 5 mm^2 with a surrounding and adjacent area of radiodermatitis around about 8 to 10 mm^2 in laboratory animals for subsequent coating with epidermal-dermal matrix populated by a cell culture of human fibroblasts, keratinocytes and mesenchymal stem cells. With that said, its use will be valuable for evaluation of curative treatments against the bone and radionecrosis or palliative treatment rather than as it is currently assumed.

Key Words - Irradiator, ^{60}Co, Radionecrosis, Stem Cells.

1. INTRODUCTION

According to a recent report by the International Agency for Research on Cancer (IARC) / WHO (2008-2010), the global impact of cancer more than doubled in 30 years. In this report, it was estimated that occurred about 12 million new cancer cases and 7 million deaths. In Brazil in 2010, with estimates for the year 2011, point to the occurrence of 489,270 new cases of cancer. The continued population growth, as well as their aging, affects significantly the impact of cancer in the world. This impact will fall primarily on the countries of medium and low development where, according to IARC / WHO, will be half of new cases and about two thirds of cancer deaths. [1]

Among the possibilities to cancer treatment, radiotherapy is one of the treatment modalities used during the period of its evolution. Treatment with radiotherapy can be divided into two methods, brachytherapy and external beam radiation. External radiation therapy uses different sources of radiation such as X-rays and photons emission (linear accelerators, and ^{60}Co). [2] The purpose of applying ionizing radiation is in the region where we want to treat the cancer by increasing cell death and thus eliminating the existing tumor mass. However, in addition to the therapeutic effects of radiation, there are specific complications in different regions of the human body that are related to the response of tissues to radiation and the cell's ability to repair or not radiation-induced lesions. The rapid response of tissues are those with clinical manifestations of injury, after irradiation, in a short period of time, such as skin, mucous membranes, hematopoietic tissue, lymphoid tissue and certain tumors. The slow responses of tissues are those with more delayed. Examples are bone tissue, connective, muscular and nervous systems, which have low proliferative activity. [3]

The biological effects of gamma radiation by ^{60}Co sources have not been fully elucidated on mesenchymal stem cells cultured in epidermal-dermal matrix. In this longing for a better understanding of the radiotherapy effects, it is necessary to reproduce this problems in animal models to obtain results of faced by this type of therapy.

In order to better study of the adverse effects of radiotherapy treatment and how to lead, a prototype of irradiator, with ^{60}Co sources, was designed with reduced dimensions, capable of causing approximately 5 mm^2 radionecrosis point (target point) with a surrounding and adjacent area of radiodermatitis around about 8 to 10 mm^2 in animal.

2. DEVELOPMENT OF PROTOTYPE

For the development stage of irradiator with ^{60}Co sources (including transport cart and support for the animal), a project was designed using the software Solid Edge ST (Siemens®).

The whole development project was executed in the Department of Development (DD / IPEN-CNEN / SP). Initially, for the development stage for irradiator with ^{60}Co sources, was designed a project where 21 sources were aligned with each other, forming cross is collimated so that they could produce electron beams directed at a single focal point located on the back of animal **Figure 1**, using a lead slug with 40 cm thickness. The slug thickness

due to the preliminary calculations that would ensure the shielding required for there was no contamination of both the operator and the environment.
The ^{60}Co sources has 1 mm thickness and will be encapsulated in "gate-sources" screw produced in stainless steel (patent pending) that will be inserted into specific sites previously designed **Figure 2**. Assessing the activity of each source required to cause a radiodermatitis of 5 mm^2 to 20 mm^2 and necrosis in the animal's back, it was decided to use only 11 sources instead of the initial 21 (patent pending).

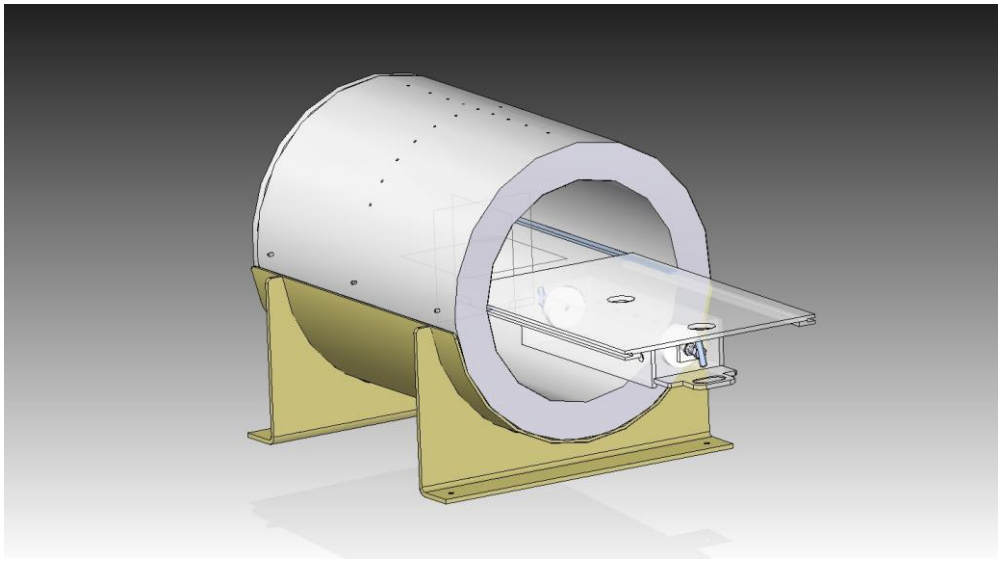

Figure 1 - Initial design of the irradiator sources of ^{60}Co.

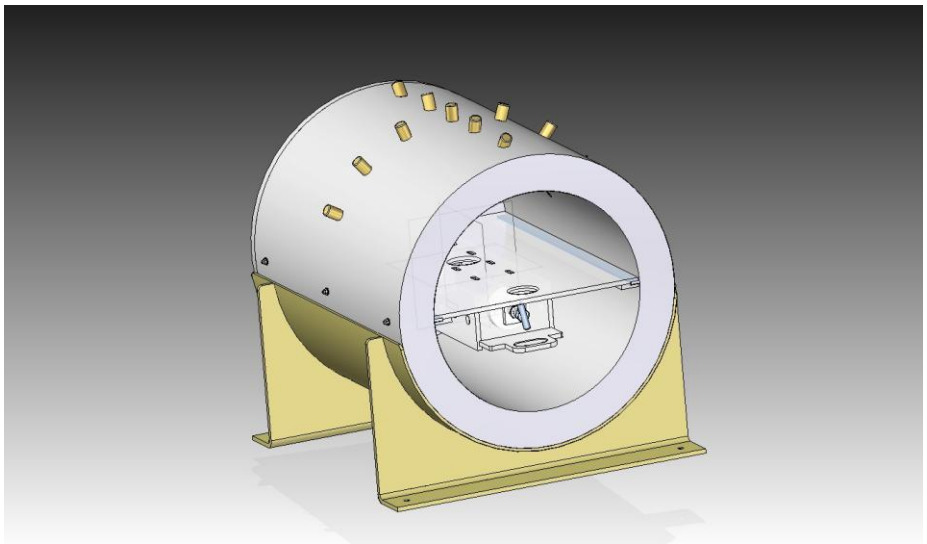

Figure 2 - Initial project with the "gate-sources" screw in position and relocated quantities.

For seeking additional protection to both the operator and the work environment, on these ^{60}Co sources, outside the "gate-source" screw was created a kind of cross-head with lead, bi-articulated with 40 cm^2 thickness, to ensure always specifies shield and avoid direct contact and accident with ^{60}Co sources (**Figure 3**). Still, two doors made out in lead, close the ends of the irradiator, with also 40 cm^2 thickness, and at one end, a cut was made for the support of animals could be inserted without an operator accidentally enter the hand inside the irradiator (see **Figure 3**). For added security, a double lock system was created, and to access ^{60}Co sources, it is necessary supervision of radiation protection and also the operator (see **Figure 3**). The handling and insertion of the ^{60}Co sources in "gate-source" screw will take in a controlled and supervised environment place.

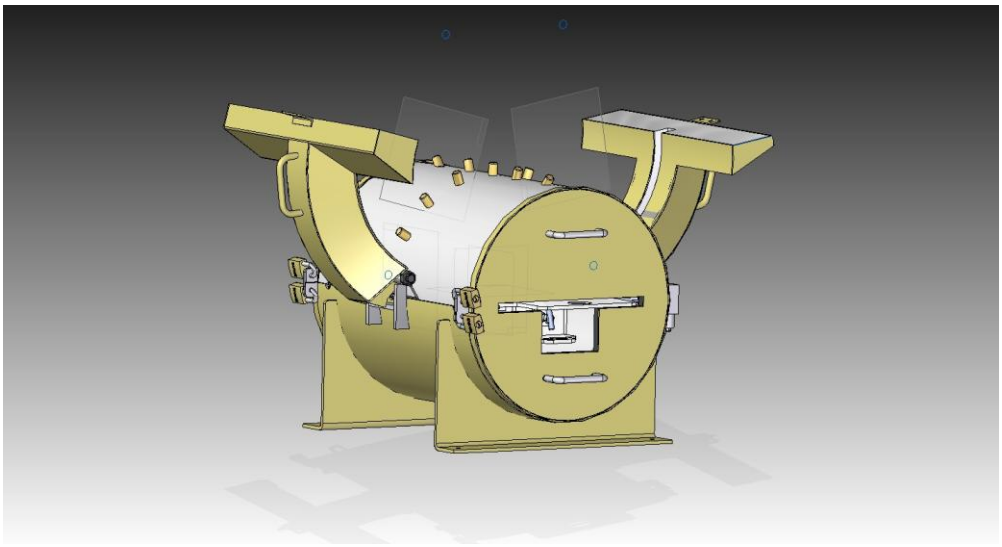

Figure 3 – Bi-articulated additional protection for the "gate-source" screw with the double lock, as the same at as the doors in the irradiator ends. In one of the ends, it may see the cut for the support of animals' insertion, to preventing the insert of hand operator accidentally inside the irradiator.

For the insertion of the animal in the irradiator, it was created an animal support system, made of an acrylic plate with 30 cm long and 5 mm thickness, having a hole with 5 cm^2 in the center, where the collimated beams collide with the back of the animal. This acrylic support has a rectangular format, containing eight holes around the hole center to vent, and at one end a screw press system, which will ensure that the animal remains motionless and the radiation beams collide in a single target point rather than spread (**Figure 4**). This support will slide on a rail, mounted inside the irradiator, at its core, based on calculations for the radiation generated by the ^{60}Co sources causes the focal target point of necrosis and radiodermatitis in back of animal.

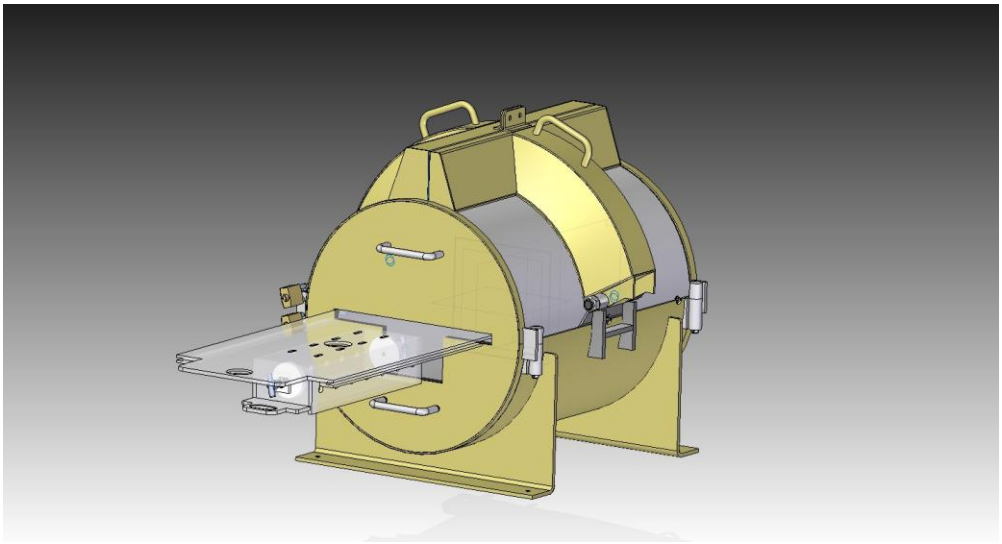

Figure 4 - Drawing of the animal support had already been adapted into a hole cut through the one ends of the irradiator.

With the irradiator finished a stainless steel transport cart was made out, with rounded corners and a handle support, thus aiming at a facility for cleaning and sanitizing, with four casters support up to 250 Kg each, sufficient to support the irradiator (**Figure 5-A** and **B**).

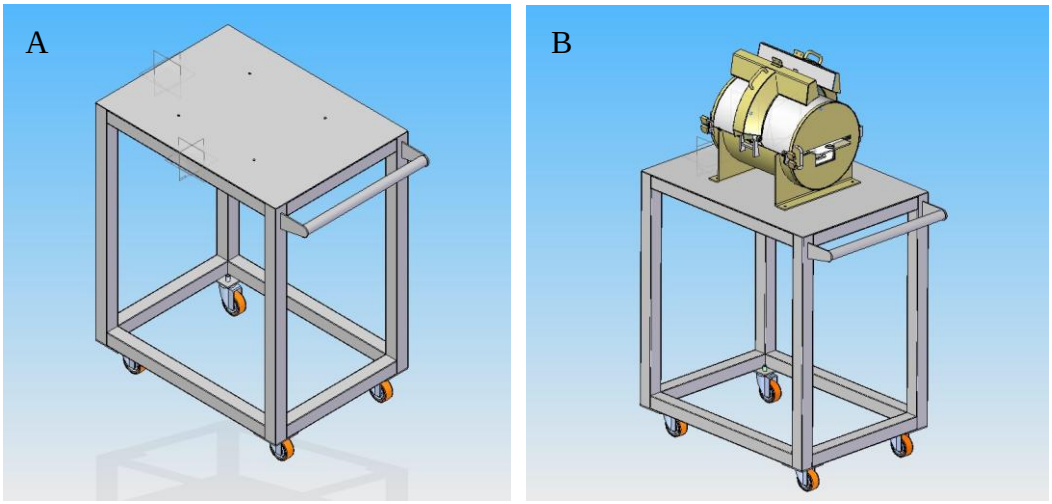

Figure 5 - Transport cart finalized (A) and with the irradiator installed (B).

After all the finished designs was initiated production of the radiator as shown in **Figures 6** to **8**.

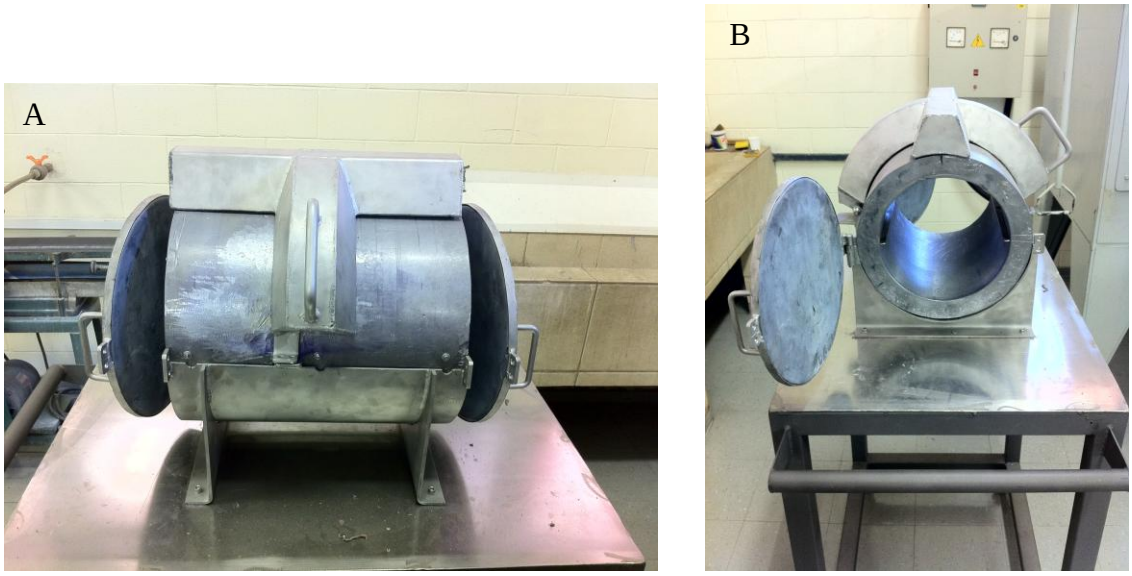

Figure 6 - Side view of the ^{60}Co irradiator completed (A). Frontal view of the ^{60}Co irradiator with de lateral doors opens (B). Note that the ^{60}Co irradiator is supported on the transport car.

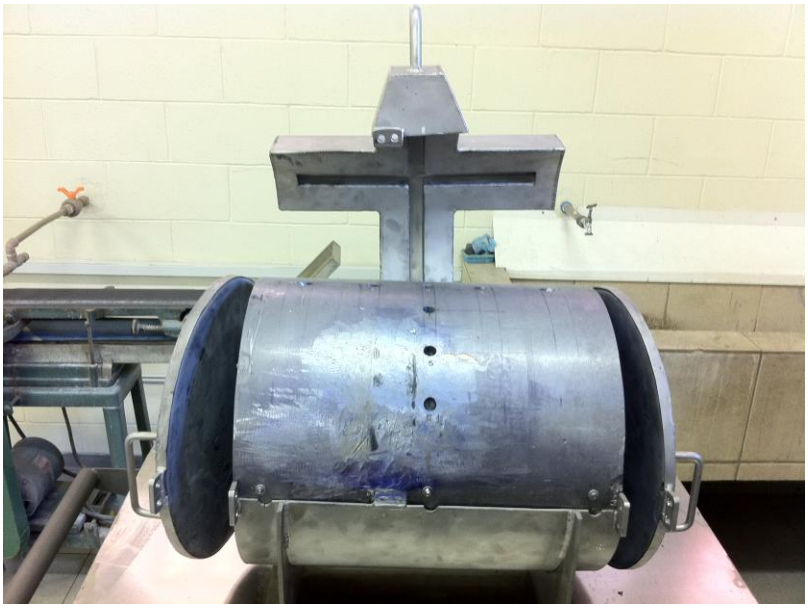

Figure 7 – Lateral view of ^{60}Co irradiator with articulated additional protection for the "gate-source" screw open. Despite the initial design to present bi-articulated additional protection

for the “gate-source” screw, it could not be built due to dosimetric calculations, which could leak radiation beans precisely because the protection it is bi-articulated. Note the roles that will be insert the “gate-source” screw.

Figure 8 - The “gate-source” screw, it was used to insert the ^{60}Co sources, that will be inserted into specific sites previously designed (see **Figure 7**).

3. CONCLUSION

The development of irradiator sources of ^{60}Co capable to creating a single point of radionecrosis and a surrounding and adjacent area of radiodermatitis, can bring significant advances in the study of late lesions caused by radiotherapy and curative solutions also for these complications.

ACKNOWLEDGMENTS

This work was prepared jointly with the Department of Development (IPEN - CNEN / SP) and with financial support from the IAEA through the RC project (Research Contract No. 15333/R0), with the support of CNPq Universal Project - 480390/2010-0 and CNEN to grant the doctoral scholarship for the student Rodrigo Crespo Mosca.

REFERENCES

1. Brasil. Ministério da Saúde. Instituto Nacional de Câncer. *Estimativa 2010: incidência de câncer no Brasil* / Instituto Nacional de Câncer. – Rio de Janeiro: INCA, 2009.
2. Scaff, L.A.M., *Física da Radioterapia*, Ed Sarvier, São Paulo, Brasil (1997).

3. Pelisser, A., Vier-Pelisser, F.B., Fontanella, V.R.C., de Figueiredo, M.A.Z. “Análise Microscópica do Efeito da Radioterapia Fracionada por Cobalto-60 em Mandíbula de Rato.” *Radiol Bras* Vol. 40, n. 2, pp. 113-118 (2007).