COMPARISON OF Co-60 AND LINAC TREATMENT PLANNING FOR PATIENT WITH DIFFERENT DIAGNOSES

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Abstract

Radiotherapy with external beams widely uses photon-like radiation produced by linear accelerators. The method for constructing the treatment plans (Treatment Planning System - TPS) is the three-dimensional conformal radiation therapy (3D-CRT). This is one of the most commonly used methods for radiotherapy patients at the University Hospital Center "Mother Theresa", Tirana. The aim of this study is the comparison of TPS with the Cobalt-60 and Linear Accelerator for patients with different diagnoses and stages, by analysing dose-volume histograms (DVH) as well as dose distribution in the tumor volume (Planning Target Volume - PTV) and organs at risk (Organs At Risk - OAR). The plans that are constructed and analysed in this study are planned for tumor-like patients in the head, breast and pelvis. The comparison showed that the most efficient way to treat patients is the one with accelerator because the combination of energies and since the use of Multi Leaf Collimator (MLC) makes it possible to cover the target volumes better and diminishes the dose for OAR. Comparative results are respectively: for the head tumor Linac realizes PTV 98.6% versus 97.2% of Co-60; for breast cancer, Linac realizes PTV 95.49% versus 61.96% of Co-60; for the pelvis tumor, Linac realizes PTV 96.04% versus 72.16% of Co-60.

Key words: Treatment planning system, 3D conformal radiation therapy, dose volume histogram, planning target volume, organs at risk.

Introduction

Treatment Planning is used in external radiation therapy to create herds of radiation, dose distribution, to increase control and to minimize complications in healthy tissues. For creating a three-dimensional (3D) treatment planning and for determining an accurate dose of treatment it is important to determine the main volumes linked to a treatment planning, which are [International Commission on Radiation Units and Measurements (1993); Report 50, ICRU, Bethesda, Maryland, USA (1978)]:

- *Gross Tumor Volume* (GTV), which includes the mass of visible malignant cells*;*

- Clinic Tumor Volume (CTV), that is includes GTV plus a high probability volume that has diseased cells [Holland, Veling, MravunacM *et al. (*1985)];

- *Planning Target Volume* (PTV), - the volume to be irradiated taking into account the changes of CTV [McKenzie, van Herk, Mijnheer (2002)].

Figure 1. View of PTV, CTV and GTV

Schematic presentation of volumes shown in Figure 1.

To determine the main volume, first is provided a detailed anatomy views. Three dimensional tumor information is provided by computerized tomography (CT) scanner. These images is provided data for density of different organs that help for calculations of radiation dose. The CT scanner images are transferred digitally in the contouring system. The GTV, CTV, PTV, contour of the body and normal organs are contoured by the oncologist.

Preparing a treatment planning involves contouring in three dimensions not just the tumor and the possibility of its spread but also of the organs at risk (OAT). In addition, doses per fraction, volume for treatment or parallel therapy affect the probability of late effects occurring in each individual patient. Therefore it is necessary to determine the allowable doses [Lee, Leu, Smathers *et al*. (1995)]. Dose given to a tissue volume in a three dimensional plane, is described in the form of a dose-volume histograms (DHV). The dose is calculated through the treatment planning system for each pixel of the contoured organ generating the dose-volume histogram. [Bentel, Nelson, Noell, (1989)].

The method for constructing the TPS is the three-dimensional conformal radiation therapy (3D-CRT) [Van Dyk,, Barnett, Battista, (1999)]. This is one of the most commonly used methods for radiotherapy patients at the University Hospital Center “Mother Theresa”, Tirana. The aim of this study is the comparison of TPS with the Cobalt-60 and Linear Accelerator for patients with different diagnoses and stages, by analysing DVH as well as dose distribution in PTV and OAR.

Materials and methods

The plans that are constructed and analysed in this study are planned for tumor-like patients in the head, breast and pelvis.

Each patient, positioned with the help of immobilization equipment, is scanned with CT scaner with cut thickness 0.5 cm. Images from CT-Simulator are sent to the Focal system, which is the system in which radiation oncologist contour PTV, CTV, GTV and OAR. Then the images pass in the treatment planning system XiO 4.70. Treatment plans, in all three cases have been realized using the Co-60 device as well as the Linear Accelerator.

The dose prescribed by the doctor for each case is;

- 3000 cGy – for the treatment of head tumor,
- 4005 cGy – for the treatment of breast tumor,
- 5040 cGy – for the treatment of tumors in the pelvis.

The treatment methods are different for different diagnoses, but we have used conventional techniques with four main areas (Ant- Post, Post- Ant, Lat-Lat S, Lat –La D). In addition to the main areas are also used small auxiliary fields for treatment plans in Linear Accelerator. All tumor site of treatment plan with Linear Accelerator are realized with a margin of 0.7 cm from the PTV. To protect organs at risk and healthy tissues from unnecessary radiation, for areas of cobalt treatment are used standard blocks of different sizes and shapes, which are manually placed at the head of the device, while to the Linear Accelerator are used Multi Leaf Colimator (MLC). For any occasion are presented PTV, CTV, OAT and the doses they receive. Based on international protocols is defined maximum and minimum doses which are allowed for radiation. For organs that are closer to the tumor, if this dose is exceeded, damage and complications can be enormous. [Adams, Warrington (2008)].

In the Co-60 units (1.25 MV beam, Best theratronix), treatment plan has been realized using two laterally opposite fields with gantry angles respectively the first with 90^o and the second with 270^o. In Linear Accelerator Elekta synergy (6 MV and 18 MV) the treatment plan is constructed with two lateral fields along with auxiliary fields.

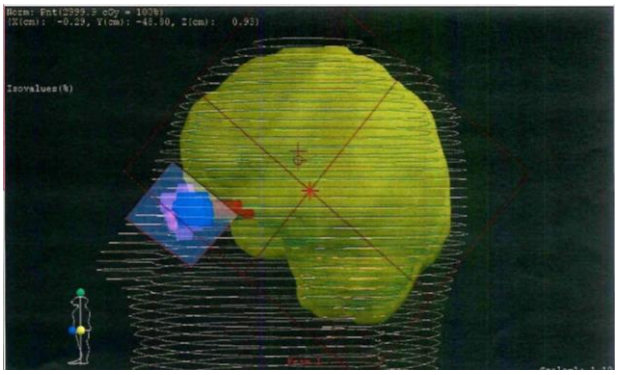
Data are presented in the dose-volume histogram DVH, where seen (in percentwhat is the dose taken by tumor measures and the dose which it is irradiated any organ around the tumor. DVH is the important data in the treatment plan, by which they are valued OAR and PTV. DVH is the best way to evaluate the treatment plan as well as to compare different plans.

Experimental Measurements and Results

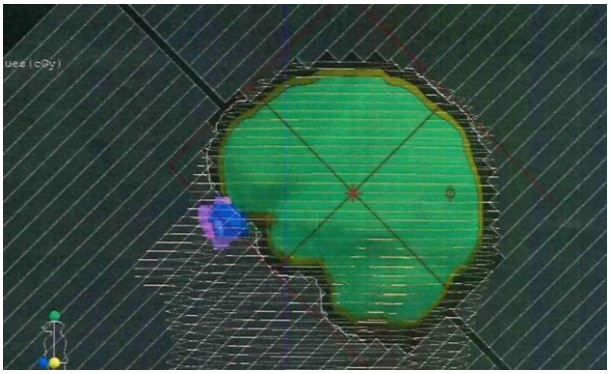
Case 1. Head Tumor Treatment.

Plans were performed using the three-dimensional conformal radiotherapy method (3D–CRT). The dose for this case is 3000 cGy, that was accomplished with 10 sessions, 300 cGy dose for each session.

Figure 2 shows a picture of the organ to be protected (the eye), realized with the Co-60 device as well as with the Linear Accelerator.



a) Co-60



b) Linac

Figure 2. View of eye organ protection. a) with Co-60, b) with Linac

Figure 3 shows the comparison of DVH, realized with Co-60 (presented with dashed lines) well as with the Linear Accelerator.

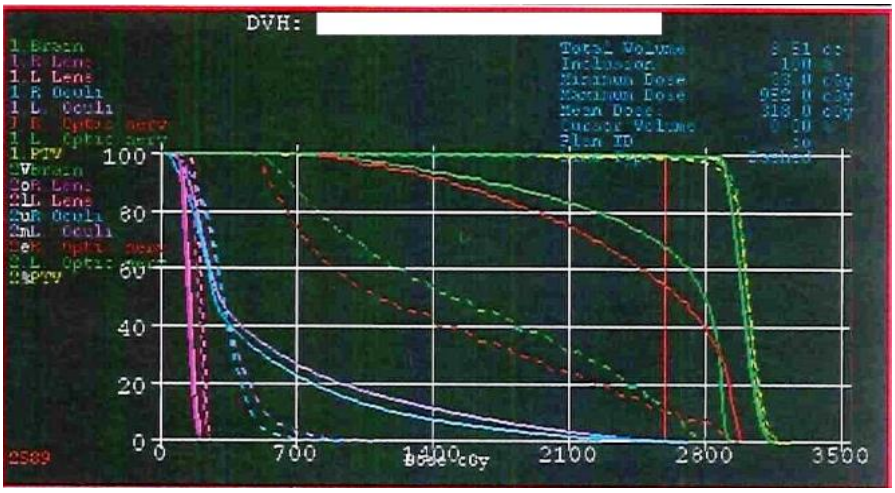


Figure 3 Comparison of DVH (Co-60 is presented with dashed lines)

In Figure 4 is presented isodose distribution for the head tumor case for both treatment plans, realized with Co-60 and Linear Accelerator.

We note that the best isodose dispersion is done by the Linear Accelerator, as we have better protection of the organs at risk and a combination of the two energies, whereas in the Co device is used only one energy.

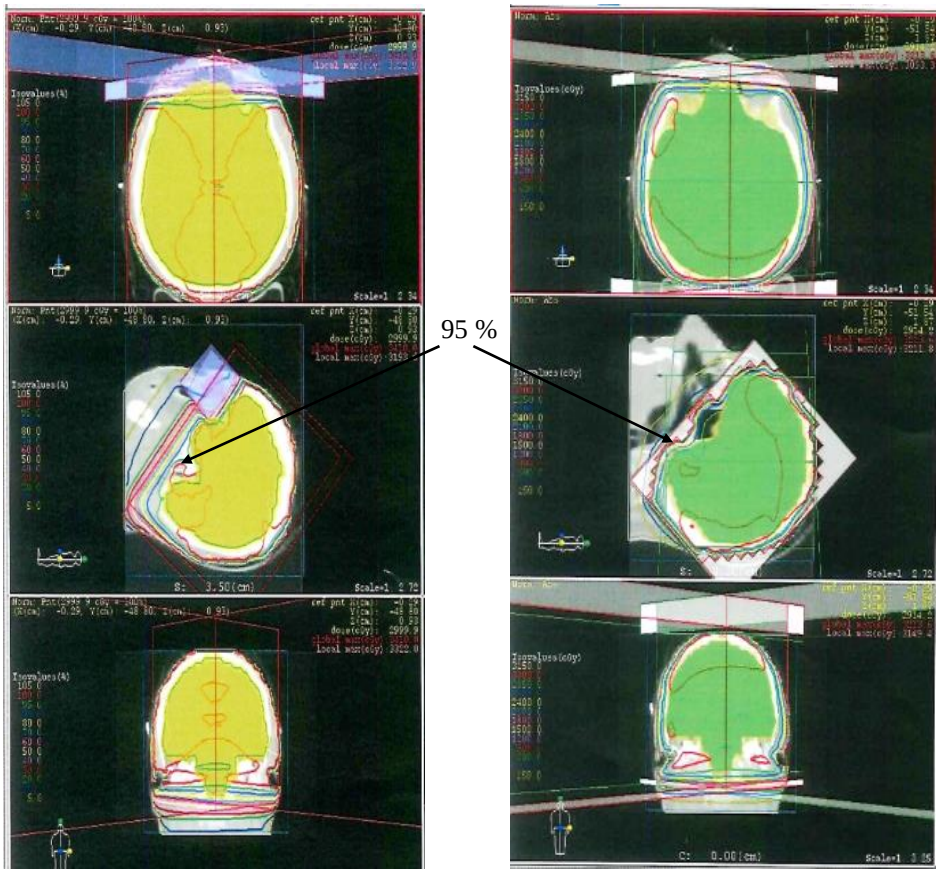


Figure 4. Comparison of dose distribution for the two treatment plans in the case of the head

In Table 1 have been compared the maximum doses in cGy and PTV coverage for the two treatment plans, respectively with Co-60 and Linear Accelerator for the head tumor case.

Table 1. Maximum dose comparison in cGy and PTV coverage for the head tumor treatments

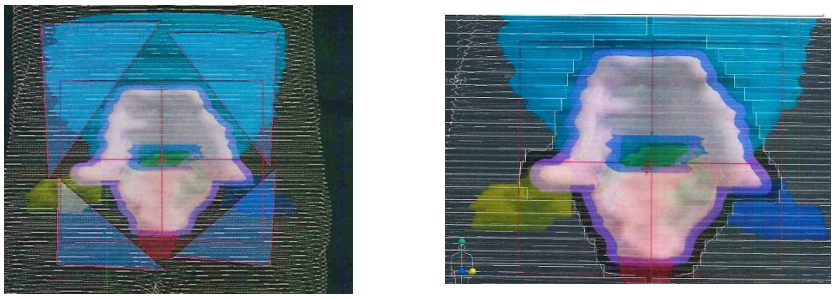
Treatment / OAR	Co-60	Linac
Brain	3210	3157
Right Lens	253	201
Left Lens	234	202
Right Eye	1501	1710
Left Eye	1797	1710
Right Optical Nerve	3025	2982
Left Optical Nerve	2926	2925
PTV	97.2 %	98.6 %

It is noted that maximum dose has higher value in Co-60 treatment plan compared to Linear Accelerator. Regarding some organs that receive more dose with Linear Accelerator, compared to Cobalt, - means that the energy used in cobalt is more favorable for tumors that are contoured near the skin. PTV is 98.2% realized with Linear Accelerator versus 97.2% realized with Co-60.

Case 2. Pelvis Tumor Treatment

Plans were performed using the three-dimensional conformal radiotherapy method (3D – CRT). The dose for this case is 5040 cGy, that was accomplished with 28 sessions, 180 cGy dose for each session

Figure 5 shows a picture of the organ to be protected intestine, and two femoral heads, realized with the Co-60 device as well as with the Linear Accelerator.



a) Co-60, b) Linac

Figure 5. View of eye organ protection. a) with Co-60, b) with Linac

Figure 6 shows the comparison of DVH, realized with Co-60 (presented with dashed lines) well as with the Linear Accelerator.

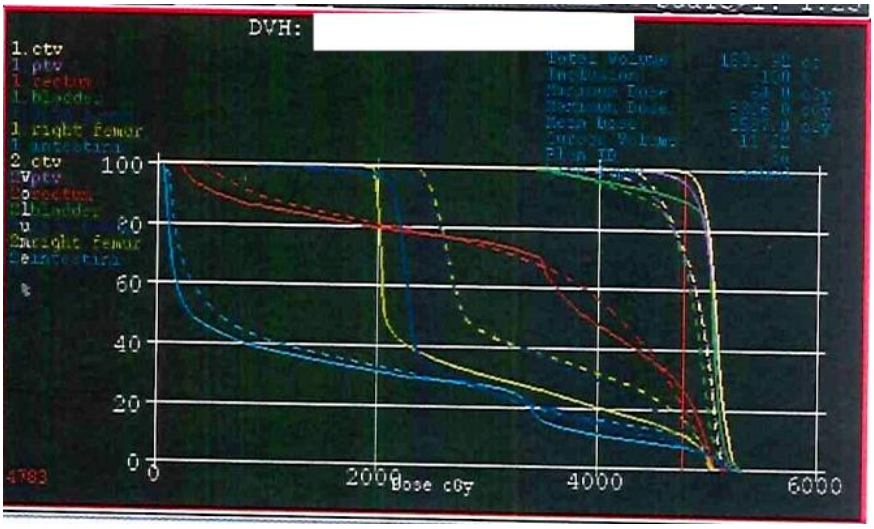
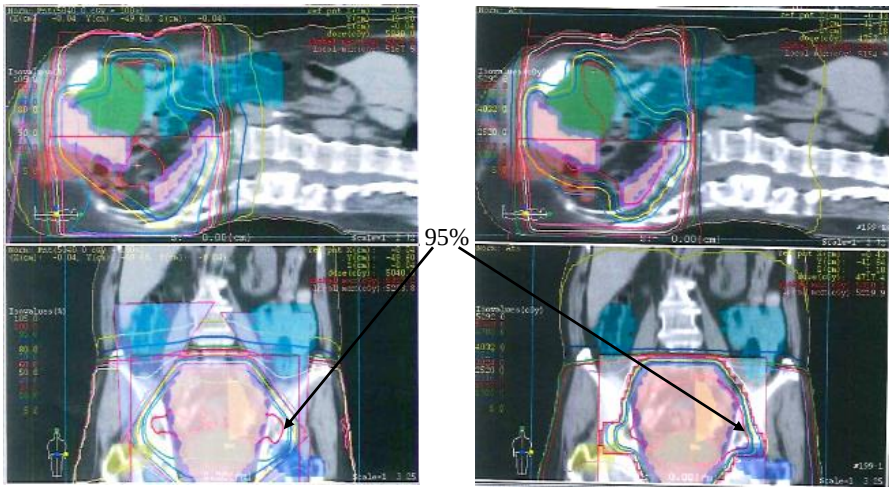


Figure 6. Comparison of DVH (Co-60 is presented with dashed lines)

In Figure 7 is presented isodose distribution for the pelvis tumor case for both treatment plans, realized with Co-60 and Linear Accelerator.



Co-60 Linac

Figure 7. Comparison of dose distribution in the case of pelvis

We note that the best isodose dispersion is done by the Linear Accelerator, as we have better protection of the organs at risk and a combination of the two energies, whereas in the Co device is used only one energy.

In Table 2 have been compared the maximum doses in cGy and PTV, CTV coverage for the two treatment plans, respectively with Co-60 and Linear Accelerator for the case of pelvis tumor

Table 2. Maximum dose comparison in cGy and PTV, CTV coverage, for pelvis tumor treatments

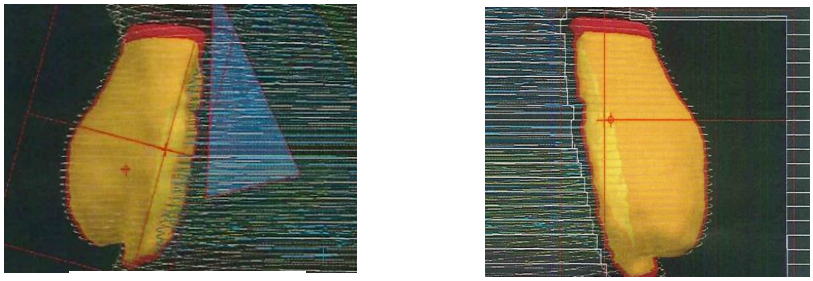
Treatment / OAR	Co-60	Linac
Rectum	5159	5185
Bladeri	5239	5279
Left Femur	5075	5222
Right Femur	5070	5076
Intestini	5306	5304
PTV	72.16	96.04%
CTV	73.3%	99.77%

It is noted that maximum dose has higher value in Co-60 treatment plan compared to Linear Accelerator. Regarding some organs that receive more dose with Linear Accelerator, compared to Cobalt, - means that the energy used in cobalt is more favorable for tumors that are contoured near the skin. PTV is 96.04 % and CTV is 99.77 % realized with Linear Accelerator versus respectively 72.16 % for PTV and 73.3% for CTV realized with Co-60.

Case 3. Breast cancer tumor treatment

Plans were performed using the three-dimensional conformal radiotherapy method (3D – CRT). The dose for this case is 4005 cGy, that was accomplished with 15 sessions, 267 cGy dose for each session.

Figure 8 shows a picture of the organ to be protected (lungs), realized with the Co-60 device as well as with the Linear Accelerator.



a) Co-60 b) Linac

Figure 8. View of eye organ protection. a) with Co-60, b) with Linac

Figure 9 shows the comparison of DVH, realized with Co-60 (presented with dashed lines) well as with the Linear Accelerator.

In Figure 10 is presented isodose distribution for the breast tumor case for

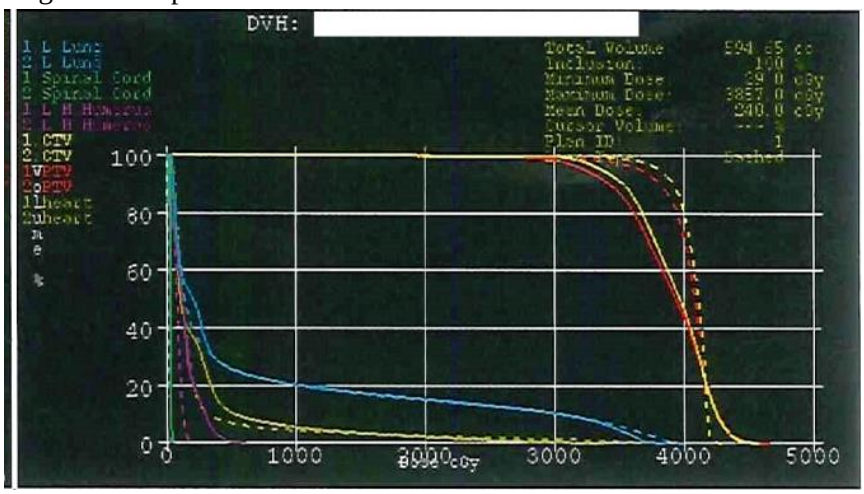


Figure 9. Comparison of DVH (Co-60 is presented with dashed lines)

both treatment plans, realized with Co-60 and Linear Accelerator.

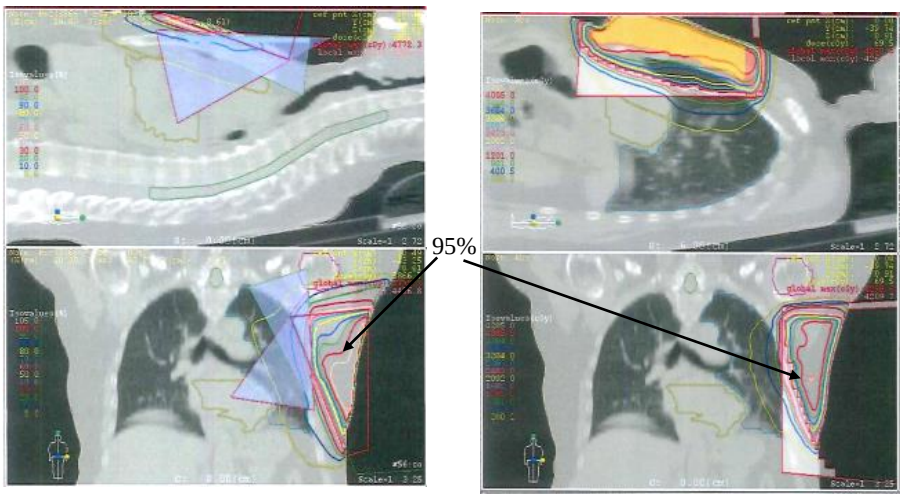


Figure 10. Comparison of dose distribution in the case of breast.

In this case it can be seen that distribution of isodoses around the tumor is better with Linear Accelerator than with cobalt.

In Table 3 have been compared the maximum doses in cGy and PTV, CTV coverage for the two treatment plans, respectively with Co-60 and Linear Accelerator for the breast tumor case

Table 3. Maximum dose comparison in cGy and PTV, CTV coverage for the breast tumor treatments

Treatment / OAR	Co-60	Linac
Spinal cord	41	33
Left Lung	3784	4014
Left Humerus	554	198
Heart	3311	3857
PTV	61.96 %	95.49 %
CTV	66.31 %	90.11 %

It is noted that maximum dose has higher value in Co-60 treatment plan compared to Linear Accelerator. Regarding some organs that receive more dose with Linear Accelerator, compared to Cobalt, - means that the energy used in cobalt is more favorable for tumors that are contoured near the skin. PTV is 95.49 % and CTV is 90.11 % realized with Linear Accelerator versus respectively 61.96 % for PTV and 66.31 % for CTV realized with Co-60.

From the above treatment it is noted that in all three cases examined 95% PTV coverage is better in handling with the Linear Accelerator.

Conclusions,

In all three cases examined above were presented maximum dose comparisons, OAR, PTV coverage dhe CTV, of which it is noted that the best treatment is provided by the use of the Linear Accelerator.
Regarding some organs that receive more dose with Linear Accelerator, compared to Cobalt, - means that the energy used in cobalt is more favorable for tumors that are contoured near the skin.
Since in the design of treatment plans, PTV coverage and CTV is very important, for organs at risk, summary results presented in Tables 1, 2, 3, indicate that treatment with the Linear Accelerator provides better PTV coverage rather than cobalt treatment of these volumes**.**
Based on the experimental results and the corresponding calculations, we affirm that:
• Radiotherapy conformal plan using Linear Accelerator allows the delivery of high doses to the target and low doses in the organs around it;
• Tracking plans with the Linear Accelerator improve homogeneity in target dose distribution and protect organs at risk;
• Use of small extra fields in the Linear Accelerator provides better dose distribution and uniformity;
• In the Linear Accelerator, the combination of energies and the use of MLC gives less dose to the critical structures, as a result, the Linear Accelerator may allow the use of high doses for the treatment of tumor diseases;
• In therapy with Cobalt - 60, using only one energy favors better treatment of tumors that are contoured closer to the skin.

Acknowledgements

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