# Treatment Plan Evaluation **by Radiobiological Model in Radiotherapy** Treatment Planning Computer

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**Abstract**

The purpose of radiotherapy treatment planning is to design the best irradiation technique for the patient. After the treatment plans are performed by medical physicists, the oncologist evaluates the plan. In physical evaluation, the criteria are determined in terms of doses and irradiated volumes by using the evaluation tools such as dose distribution, dose volume histogram (DVH) and dose statistics. This is insufficient to predict any biological end point of radiotherapy. Recently, the radiobiological models are introduced in commercial treatment planning. The purpose of this study was the use of radiobiological model in treatment planning system to evaluate treatment plan. The plans of 34 patients treated with 3D-CRT were irradiated. The biological index such as TCP, NTCP, EUD and P+ were calculated for each treatment plan and the P+ values were then compared. In each case, the best plan with highest P+ value was examined whether it was chosen for patient treatment. The results revealed that of 16 patients (47 percents) the plan with highest P+ value was selected. Statistical analysis showed significant difference between the treatment plan evaluation by using radiobiological model and without using radiobiological model (p value $\leq 0.05$). The radiobiological model can help choosing the best treatment plan, therefore, the treatment outcome and a quality of life will be improved as a consequence.

**Keywords :** radiobiological model, TCP, NTCP, EUD, P+

## I. INTRODUCTION

Radiotherapy is the major treatment modality for cancer patients.[1] When cells are exposed to radiation, the physical phenomenons between radiation and cells occur first following by biological effect to cells. The tissue responses of radiation depend on many factors such as irradiated volume, normal tissue architecture and the amount of tumor clonogenic cells.[2] In external beam radiotherapy, 3-dimensional technique is commonly used to treat the patients. The technique is based on 3-dimensional anatomic information and the dose distribution conforming to the target volume in terms of adequate dose to tumor and minimum dose to normal tissue. After the treatment plan is performed, it is evaluated by the oncologist. The physical evaluation of the treatment plan is based only on doses and irradiated volumes. It is insufficient to predict any biological end point from radiation. Recently, the radiobiological models have become available in commercial treatment planning system to evaluate and optimize the treatment plan. The aim of this study was the use of radiobiological model in treatment planning to evaluate treatment plan.

## II. MATERIALS AND METHODS

This study was the retrospective study. The inclusion criteria were as followed; the treatment plans were performed in radiotherapy treatment planning software Pinnacle version 7.6c, the patients were treated with 3D-CRT plan with curative intend and they had at least 2 plans or 2 trials, and the stages of

cancers were well defined. Totally 94 treatment plans of 34 patients at Maharaj Nakorn ChiangMai Hospital, Faculty of Medicine, Chiang Mai University, were investigated.

The selected treatment plans were imported to the radiotherapy treatment planning software Pinnacle version 8.0d. The importing data was verified by comparing the dose volume histogram (DVH) from treatment planning software Pinnacle version 7.6c and version 8.0d. Then treatment planning software Pinnacle version 8.0d was used to calculate the biological index of these plans.

The index in the biological model such as tumor control probability (TCP), normal tissue complication probability (NTCP), equivalent uniform dose (EUD) and complication free tumor control (P+) were calculated for each region of interest. TCP and NTCP were calculated by using Källman-S model, the biological model using in Pinnacle system.[3] EUD was calculated using generalized EUD (gEUD).[4] Finally the treatment plans were evaluated by comparing P+ value of each plan. In each case, the best plan with highest P+ value was examined whether it was chosen to treat the patient. Statistical analysis in this study was performed using dependent t-test for the highest P+ value plan and the plan chosen for treatment.

## III. RESULTS

The 34 patients were enrolled in this study with 94 treatment plans. The results showed 16 patients (47 percents) whose best plan with highest P+ value was chosen for treatment.

**Table 1** P+ values of the best plan (highest P+) and the chosen plan for patient treatment

| Patients | Chosen plan | Highest P+ plan |
|---|---|---|
| 1 | -0.21 | -0.21 |
| 2 | -0.981 | -0.98 |
| 3 | -0.296 | -0.296 |
| 4 | 0.15 | 0.15 |
| 5 | 0.051 | 0.051 |
| 6 | 0.184 | 0.184 |
| 7 | 0.678 | 0.678 |
| 8 | -0.315 | -0.315 |
| 9 | 0.966 | 0.966 |
| 10 | 0.001 | 0.003 |
| 11 | 0.37 | 0.37 |
| 12 | 0.059 | 0.101 |
| 13 | -0.167 | -0.144 |
| 14 | 0.251 | 0.254 |
| 15 | -0.238 | -0.238 |
| 16 | 0.248 | 0.248 |
| 17 | 0.277 | 0.277 |
| 18 | 0.284 | 0.284 |
| 19 | 0.614 | 0.616 |
| 20 | 0.499 | 0.499 |
| 21 | 0.278 | 0.348 |
| 22 | 0.083 | 0.104 |
| 23 | 0.259 | 0.291 |
| 24 | 0.376 | 0.457 |
| 25 | 0.293 | 0.404 |
| 26 | -0.043 | -0.043 |
| 27 | 0.327 | 0.471 |
| 28 | 0.168 | 0.407 |
| 29 | 0.054 | 0.06 |
| 30 | 0.139 | 0.213 |
| 31 | -0.185 | -0.172 |
| 32 | 0.36 | 0.468 |
| 33 | 0.283 | 0.283 |
| 34 | 0.123 | 0.172 |

Statistical analysis in this study was performed using t-test for dependent samples. There was significantly difference between the treatment plan evaluation by using radiobiological model and without using radiobiological model ($p$ value $\leq 0.05$).

## IV. DISCUSSION AND CONCLUSIONS

Radiobiological model has the potential to distinguish between the treatment plans which from the physical dose would be considered equal. It is used to evaluate the treatment plans by biological index. The radiobiological model may reveal radiation effects which might be difficult to assess by using the DVH alone. The model can help choosing the best treatment plan, and as a consequence the treatment outcome and a quality of life for the patient will be improved. However the biological indexes depend on the parameters used in the model which should be implemented with caution. These parameters using in this study are based on the clinical data from reviewed literatures and some are in the database of Pinnacle system. In Thailand, as the other countries, radiobiological models are a new tool. It is still in the early phase, therefore, it's application should be performed by the expertise either for evaluation or optimization the treatment plans.

## ACKNOWLEDGMENT

We would like to sincere thank Supreme Products Company for their kindly support of radiotherapy treatment planning computer and Mr. Anirut Watcharawipha for his contribution in this study.

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