

# Advanced Technology in Radiotherapy “Improving Treatment while Reducing Side Effects”

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IAEA Scientific Forum

**Nuclear Techniques  
in Human Health**

*Prevention, Diagnosis, Treatment*



## Optimal Radiotherapy Utilization Rate by Cancer Type

Tumor type	Proportion of all cancers	Proportion of patients receiving radiotherapy	Patients receiving radiotherapy (% of all cancers)
Breast	0.13	83	10.8
Lung	0.10	76	7.6
Melanoma	0.11	23	2.5
Prostate	0.12	60	7.2
Gynecologic	0.05	35	1.8
Colon	0.09	14	1.3
Rectum	0.05	61	3.1
Head and neck	0.04	78	3.1
Gall bladder	0.01	13	0.1
Liver	0.01	0	0.0
Esophageal	0.01	80	0.8
Stomach	0.02	68	1.4
Pancreas	0.02	57	1.1
Lymphoma	0.04	65	2.6
Leukemia	0.03	4	0.1
Myeloma	0.01	38	0.4
Central nervous system	0.02	92	1.8
Renal	0.03	27	0.8
Bladder	0.03	58	1.7
Testis	0.01	49	0.5
Thyroid	0.01	10	0.1
Unknown primary	0.04	61	2.4
Other	0.02	50	1.0
Total	1.00	-	52.3

# Radiotherapy



Table 1: Radiotherapy utilisation rate, mean fractions, and outcome benefits (absolute proportional) for top ten cancers globally by incidence.<sup>2</sup>

	Radiotherapy utilisation rate (%)	Mean radiotherapy fractions per course	5-year local control benefit (%)	5-year overall survival benefit (%)
Breast	87	16	15	2
Cervix	71	21	35	20
Colorectal	19	23	5	2
Haematological	48	8	7	4
Head and neck	74	22	34	20
Liver	0	0	0	0
Lung	77	16	9	6
Oesophagus	71	15	5	2
Prostate	58	28	25*	1
Stomach	27	19	2	1
Total	50	18	10	4

1. Cancer 2005; 104(6): 1129-37.
2. Lancet Oncol 2015; 16: 1153-86.

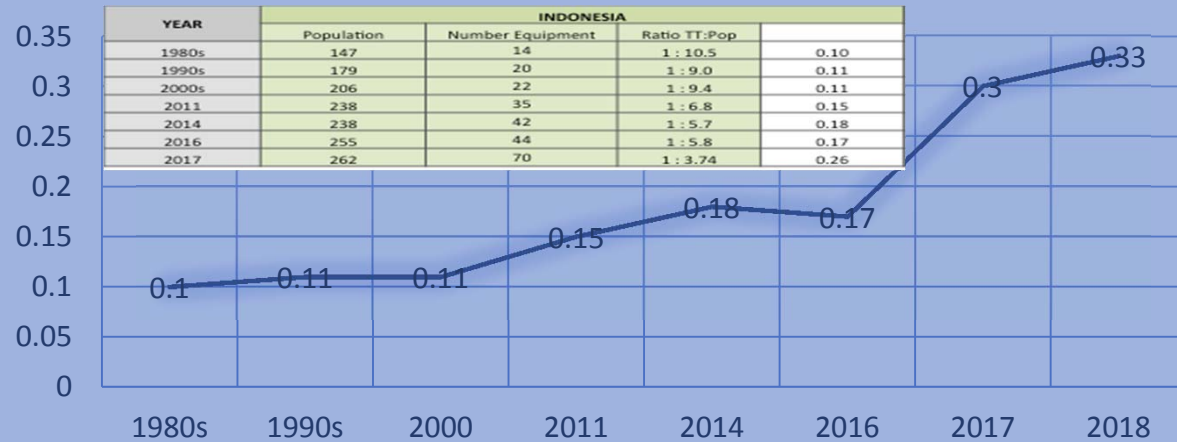
# Radiotherapy In OUR REGION ??



- World Population : 7Billion
- **FARO / ASIAN Population : 3.76 Billion (53% from Global Population)**
- ROs : 13.889
- **Machines : 4033**
- Number of Patients Treated/ year : **1.587.949 Patients**

No	Negara	Population in Million	Total Machines	Ratio TT : Pop 2017
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## Radiotherapy Growth in INDONESIA 1980s - current status 2017 - projection 2018



7	Srilanka	20	14	1 : 1.43	0.699
8	Philippines	103	36	1 : 2.26	0.44
9	India	1.342	589	1 : 2.27	0.44
10	Indonesia	263	80	1 : 3.26	0.30
11	Bangladesh	164	25	1 : 6.56	0.15
12	Pakistan	196	29	1 : 6.89	0.14

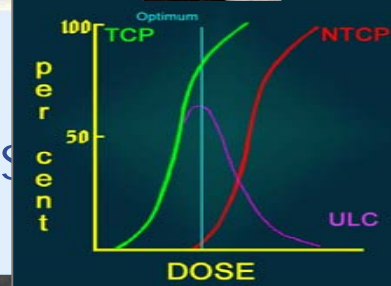
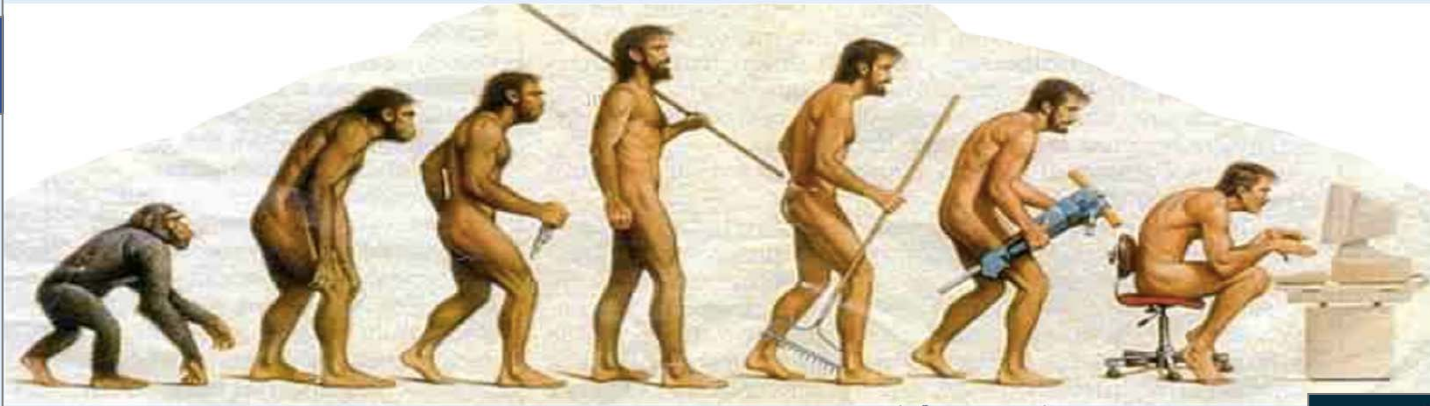
\$96.8 billion. Scale-up of radiotherapy capacity in 2015–35 from current levels could lead to saving of 26.9 million life-years in low-income and middle-income countries over the lifetime of the patients who received treatment. The economic benefits of investment in radiotherapy are very substantial. Using the nominal cost model could produce a net benefit of \$278.1 billion in 2015–35 (\$265.2 million in low-income countries, \$38.5 billion in lower-middle-income countries, and \$239.3 billion in upper-middle-income countries). Investment in the efficiency model would produce in the same period an even greater total benefit of \$365.4 billion (\$12.8 billion in low-income countries, \$67.7 billion in lower-middle-income countries, and \$284.7 billion in upper-middle-income countries). The returns,

2015–35 based on current and projected need, and show substantial health and economic benefits to investing in radiotherapy. The cost of scaling up radiotherapy in the nominal model in 2015–35 is US\$26.6 billion in low-income countries, \$62.6 billion in lower-middle-income countries, and \$94.8 billion in upper-middle-income countries, which amounts to \$184.0 billion across all low-income and middle-income countries. In the efficiency model the costs were lower: \$14.1 billion in low-income, \$33.3 billion in lower-middle-income, and \$49.4 billion in upper-middle-income countries—a total of \$96.8 billion. Scale-up of radiotherapy capacity in 2015–35 from current levels could lead to saving of 26.9 million life-years in low-income and middle-income countries over the lifetime of the patients who received treatment. The economic benefits of investment in radiotherapy are very substantial. Using the nominal cost model could produce a net benefit of \$278.1 billion in 2015–35 (\$265.2 million in low-income countries, \$38.5 billion in lower-middle-income countries, and \$239.3 billion in upper-middle-income countries). Investment in the efficiency model would produce in the same period an even greater total benefit of \$365.4 billion (\$12.8 billion in low-income countries, \$67.7 billion in lower-middle-income countries, and \$284.7 billion in upper-middle-income countries). The returns, by the human-capital approach, are projected to be less with the nominal cost model, amounting to \$16.9 billion in 2015–35 (–\$14.9 billion in low-income countries; –\$18.7 billion in lower-middle-income countries, and \$50.5 billion in upper-middle-income countries). The returns with the efficiency model were projected to be greater, however, amounting to \$104.2 billion (–\$2.4 billion in low-income countries, \$10.7 billion in lower-middle-income countries, and \$95.9 billion in upper-middle-income countries). Our results provide compelling evidence that investment in radiotherapy not only enables treatment of large numbers of cancer cases to avoid dying, but also brings positive economic benefits.

2015, 2016; Francisco Margiles Cancer Centre, Toronto, ON, Canada (Prof D A Jaffray PhD, Prof M Milosevic MD, Prof B O'Sullivan MD, Prof M Gospodarowicz MD); TECHNA Institute, University Health Network, Toronto, ON, Canada (Prof D A Jaffray, T Y M Lui MSc); Department of Radiation Oncology, University of Toronto, Toronto, ON, Canada (Prof D A Jaffray, Prof B O'Sullivan, D L Rodin MD, Prof M Gospodarowicz); Ingham Institute for Applied Medical Research, University of New South Wales, Liverpool, NSW, Australia (Prof M B Barton MBBS, T P Hanna MD, M L Yap MD); International Agency for Research on Cancer, Lyon,

Radiotherapy not only save lives, but also brings positive economic benefits.

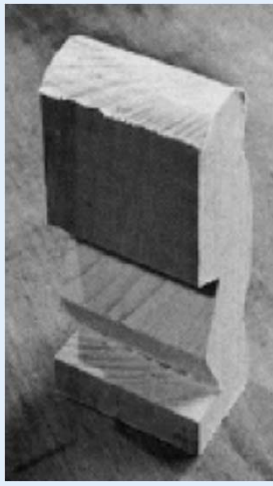
# MILESTONES IN RADIOTHERAPY



2D-  
Conventional



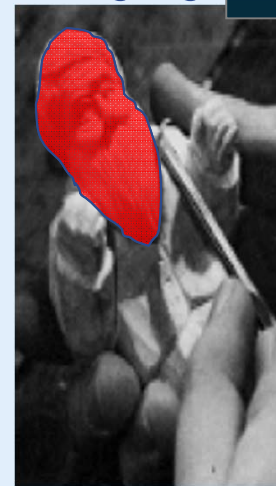
3D-  
Conformal



IMRT

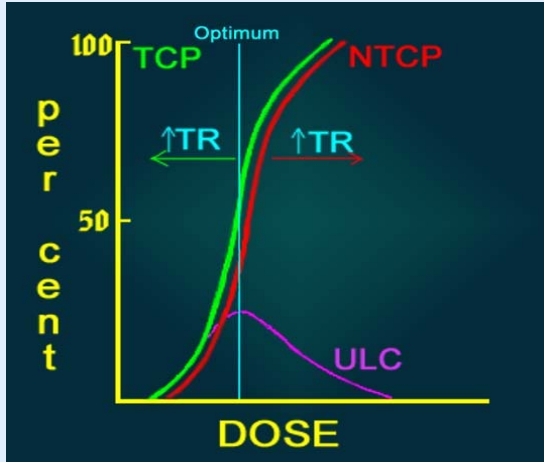


IMRT+  
Theranostics  
Imaging

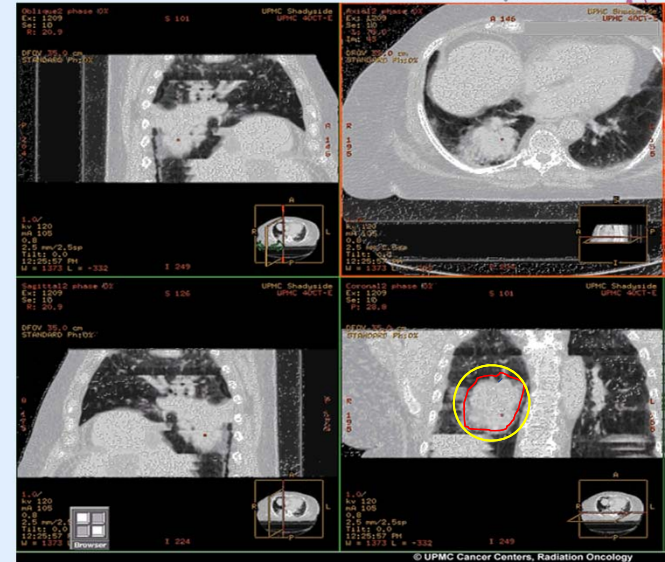
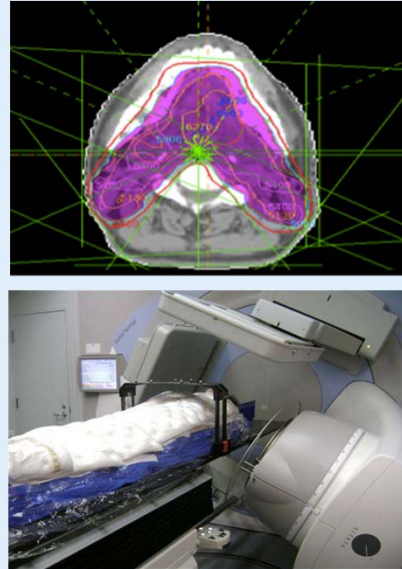


# Therapeutic Ratio

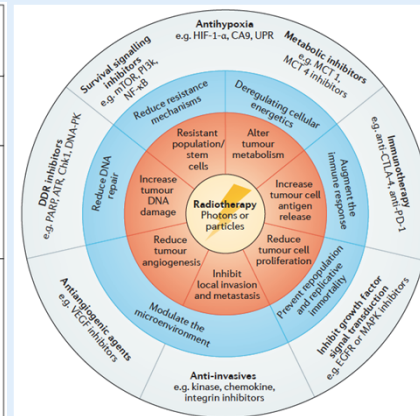
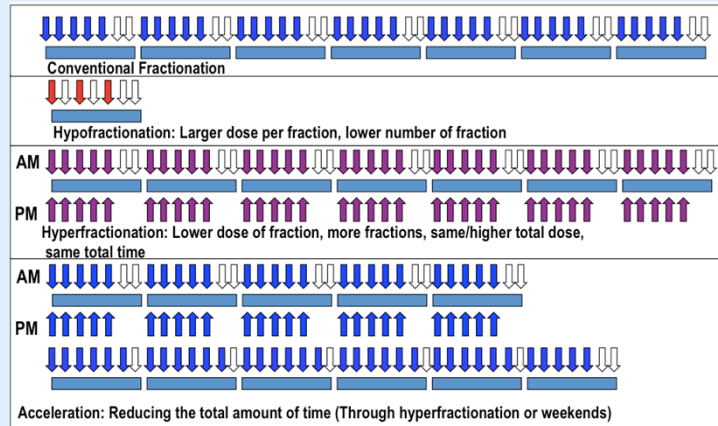
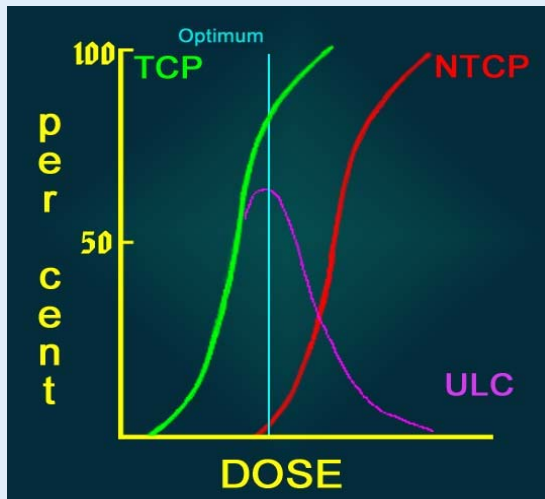
## Physical Aspect



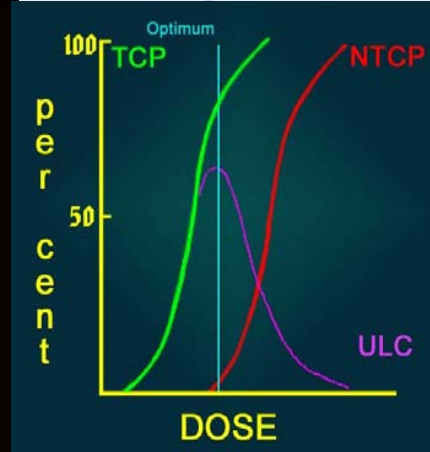
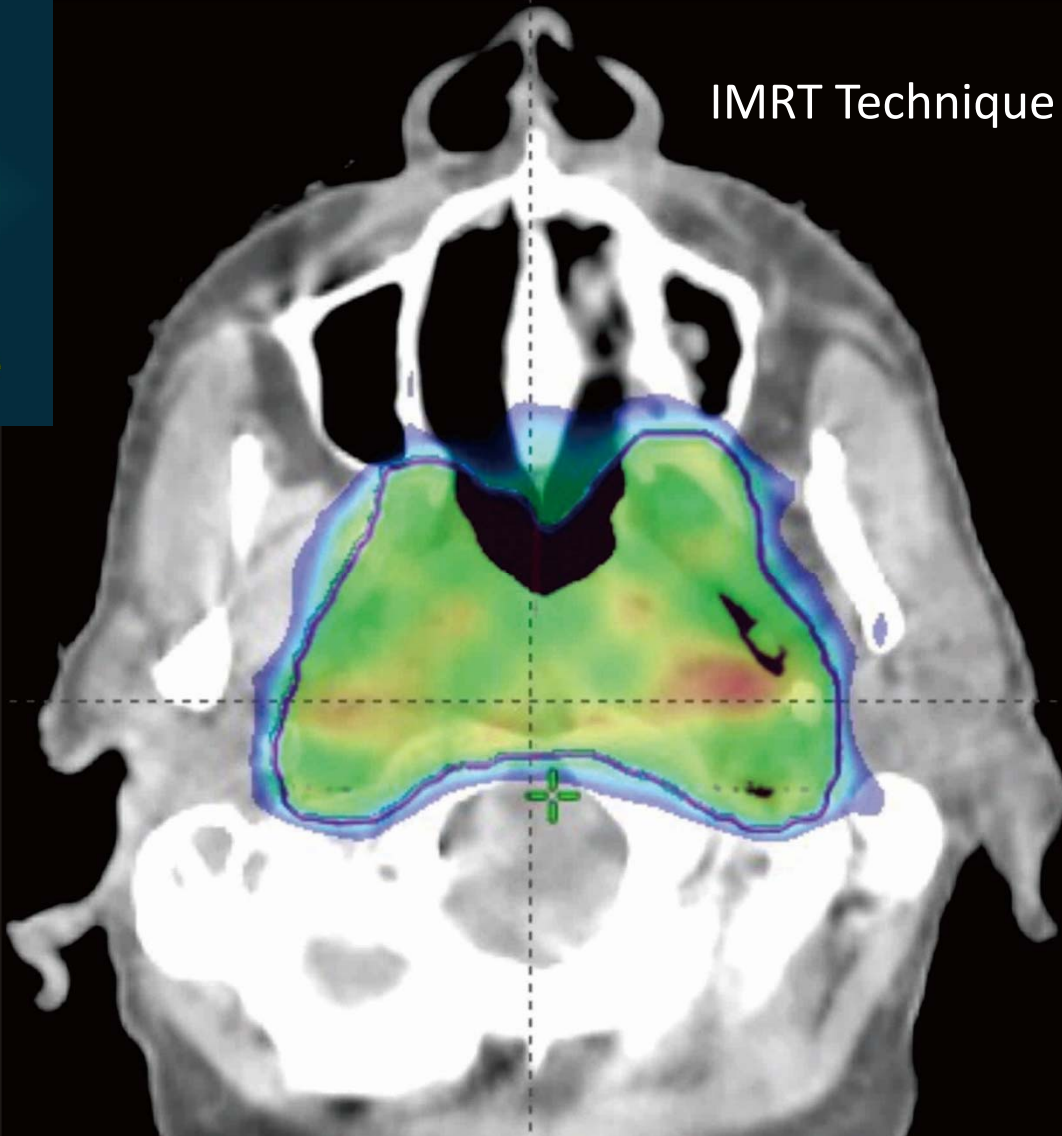
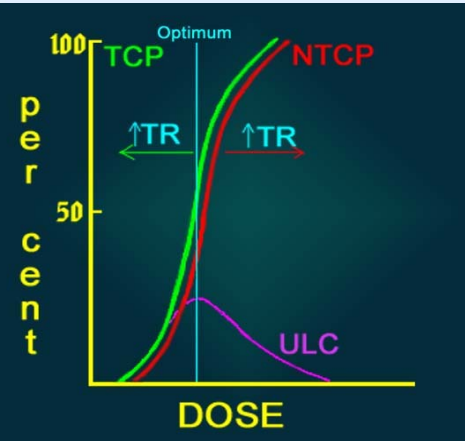
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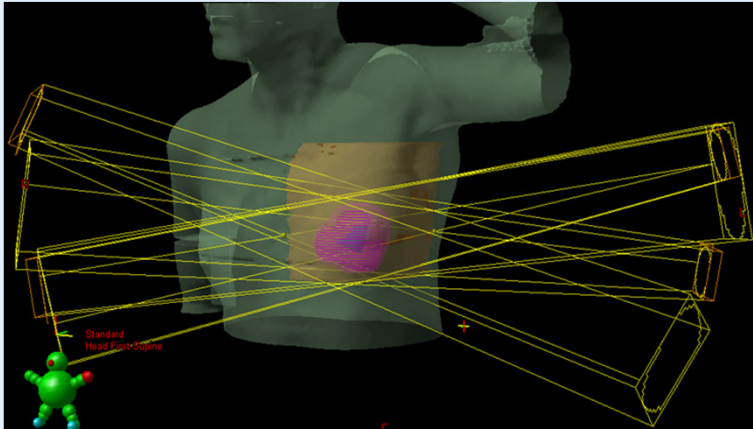
## Biological Aspect



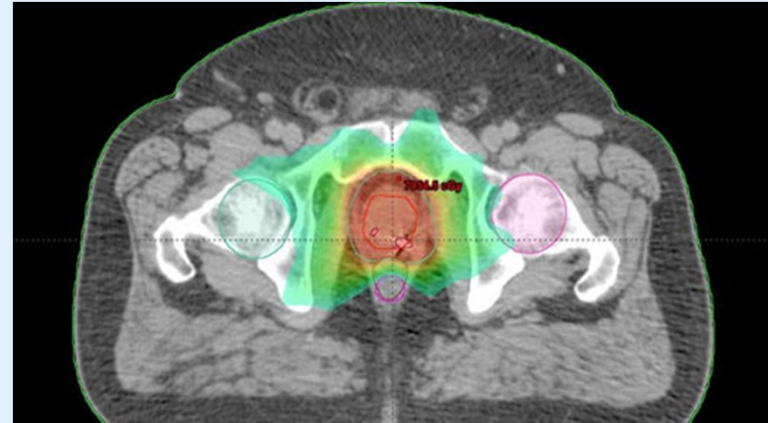
# 2D vs 3D vs IMRT in Head and Neck Cancer Irradiation



# How to reduce side effects?



Less target / HD radiation volume



Dose sculpting by beam arrangement



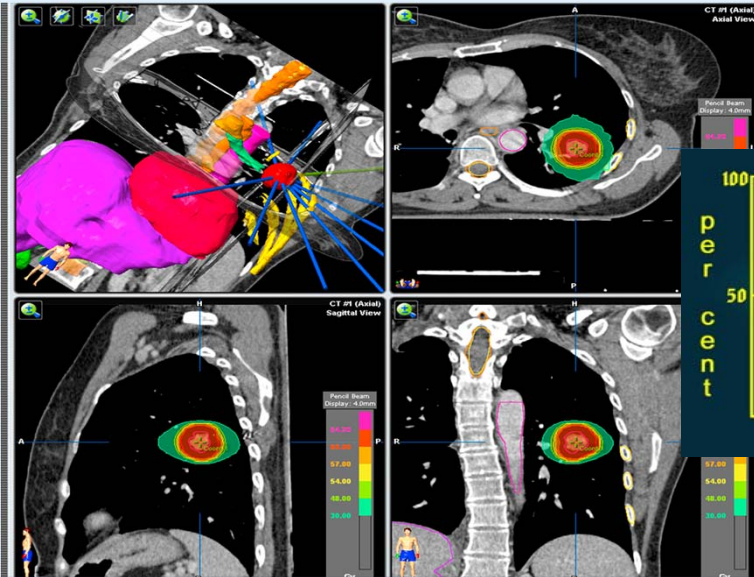
Proton therapy

Dose escalation

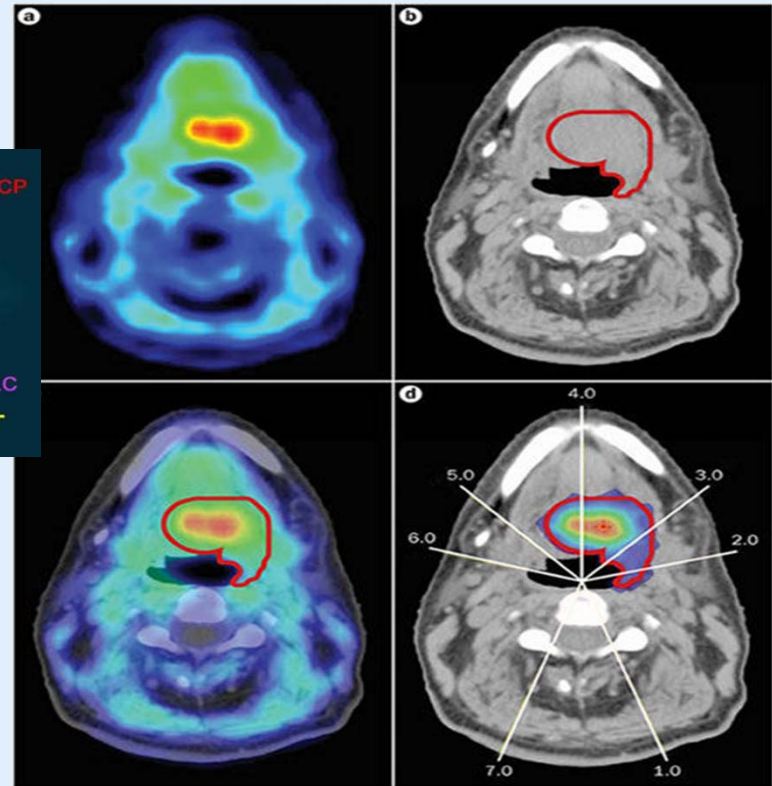
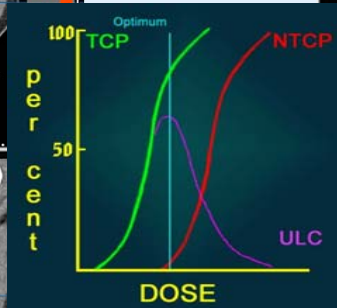
1. <http://columbiasurgery.org/news/2007/11/30/accelerated-partial-breast-irradiation>.
2. [http://www.upstate.edu/cancer/cancer-care/treatment-options/radonc-patientcare/treatment\\_options/external/imrt.php](http://www.upstate.edu/cancer/cancer-care/treatment-options/radonc-patientcare/treatment_options/external/imrt.php)
3. <https://iba-worldwide.com/proton-therapy/proton-therapy-solutions/proteus-plus>.



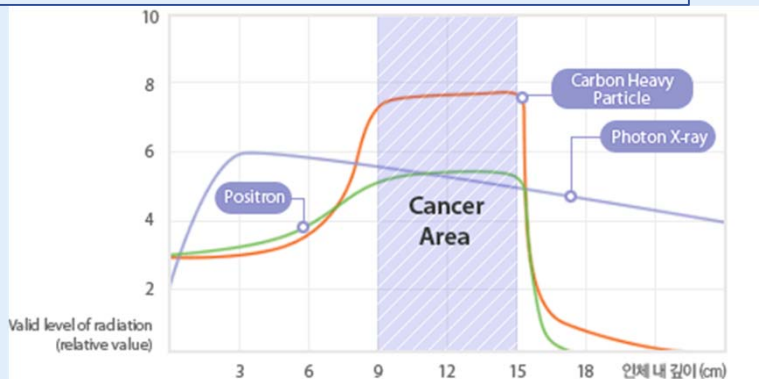
# How to improve outcome?



**Dose escalation**



**Theranostics imaging**



**Particle Therapy**

1. Nat rev clin oncol 2012; 9; 674-687.
2. Radologia 2013; 55(3): 225-232.
3. <http://www.kirams.re.kr/eng/khima/therapy01.do>

# Benefit of Advanced Technology

Intensity-modulated radiation therapy versus 2D-RT or 3D-CRT for the treatment of nasopharyngeal carcinoma: A systematic review and meta-analysis

Binglan Zhang<sup>a</sup>, Zeming Mo<sup>a</sup>, Wei Du<sup>a</sup>, Yan Wang<sup>b</sup>, Lei Liu<sup>a,\*</sup>, Yuquan Wei<sup>a</sup>

This systematic review and meta-analysis demonstrated that IMRT may obtain a better antitumor effect, and significantly decrease the incidence of radiation-induced late toxicities in patients with NPC.<sup>1</sup>

Systematic review

Intensity-modulated radiation therapy for head and neck cancer: Systematic review and meta-analysis



Gustavo Nader Marta<sup>a,b,\*</sup>, Valter Silva<sup>c</sup>, Heloisa de Andrade Carvalho<sup>a,d</sup>, Fernando Freire de Arruda<sup>a</sup>, Samir Abdallah Hanna<sup>a</sup>, Rafael Gadia<sup>a</sup>, João Luis Fernandes da Silva<sup>a</sup>, Sebastião Francisco Miranda Correa<sup>a</sup>, Carlos Eduardo Cintra Vita Abreu<sup>a</sup>, Rachel Riera<sup>c</sup>

IMRT reduces the incidence of grade 2–4 xerostomia in patients with head and neck cancers without compromising loco-regional control and overall survival.<sup>2</sup>

1. Oral Oncol 2015; 51(11): 1041-6.

2. Radiother Oncol 2014; 110: 9–15.

# Take home messages

BETTER TREATMENT RESULT



Radiation Safety



