Proton Therapy for Breast Cancer: Rationale, Indications and Future Direction

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Sr Consultant Radiation Oncology
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The Rationale

Breast cancer: Improvement in outcomes warrants attention to survivorship issues

Nair N et al. Breast cancer in India – An audit, with outcome analysis. Indian J Cancer 2018;55:16-22.

2192 pts treated in Tata Memorial a single year

5 yr DFS
EBC: 85.5%

LABC 67.7%

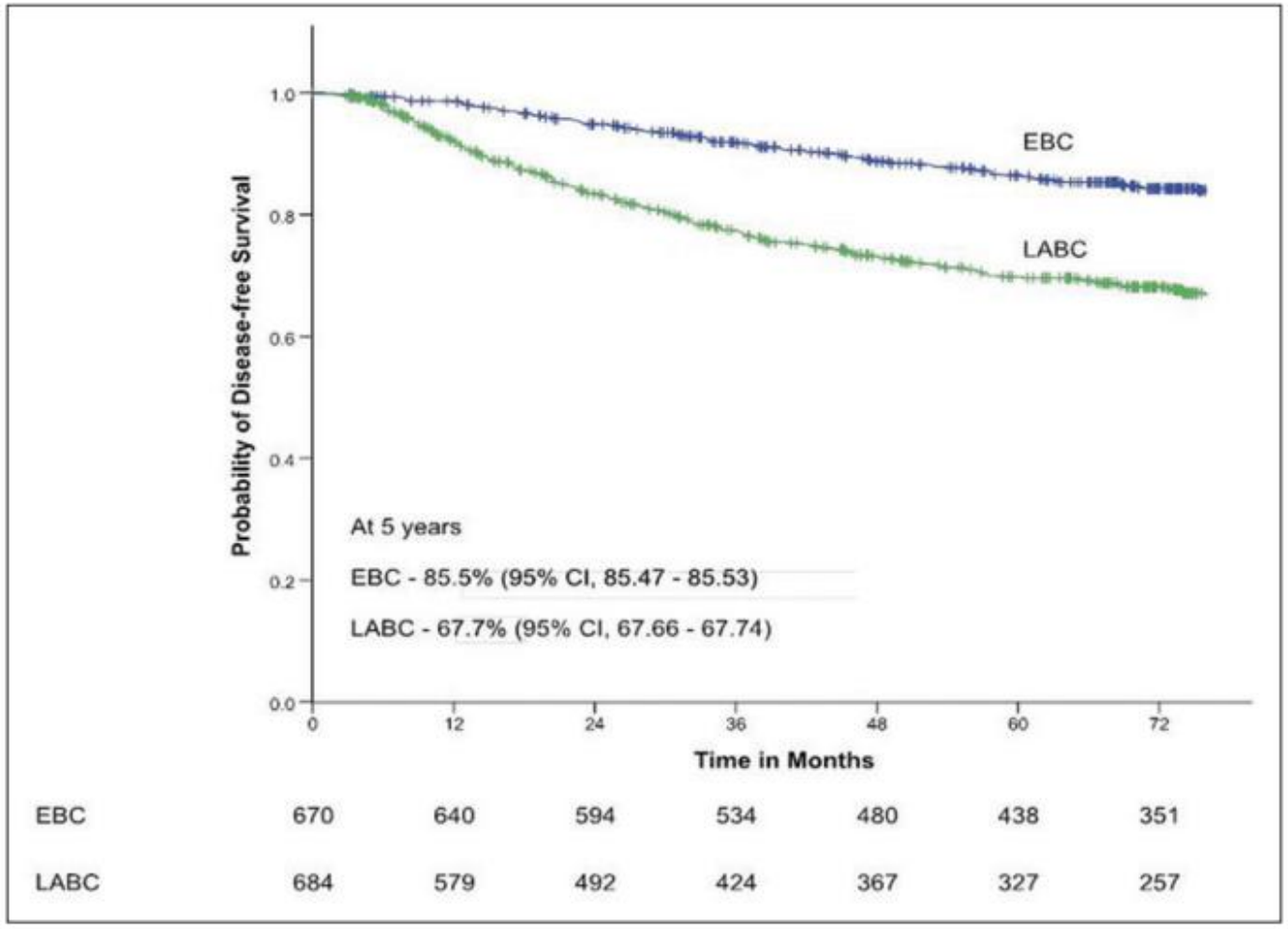


Figure 1: Disease-free survival in early and locally breast advanced breast cancer in the present study

Survivorship in Breast Cancer

The Breast 79 (2025) 103862

Contents lists available at ScienceDirect

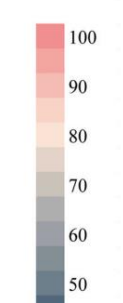
The Breast

journal homepage: www.journals.elsevier.com/the-breast

Survival feature and trend of female breast cancer: A comprehensive review of survival analysis from cancer registration data

Dan-Dan Tang [a,b], Zhuo-Jun Ye [a,b], Wan-Wan Liu [c], Jing Wu [b,c], Jing-Yu Tan [a,b], Yan Zhang [a,b],

		1990-1994	1995-1999	2000-2004	2005-2009	2010-2014
Asia	China		53.8	75.9	80.4	83.2
	China, Hong Kong				82.2	83.3
	China, Taiwan		77.2	80.2	82.2	84.2
	China, Zhongshan		55.0	64.5	65.5	74.5[a]
	Japan	81.6	81.8	85.9	88.9	89.4
	Korea		76.7	79.5	84.0	86.6
	Mongolia				76.7	76.1
	Thailand		65.9	72.9	71.3	
	Malaysia, Penang		64.8	71.1	67.8	
	Singapore			76.3	80.3	80.3
	India		48.1	57.6	59.1	66.1
	Israel		80.9	85.1	87.8	88.0
	Kuwait			68.3	71.0	75.2
	Turkey		72.8	84.8	80.6	82.1
	Cyprus			88.7	90.6	
America	Canada	82.5	83.7	85.9	87.6	88.2
	USA	83.9	86.0	88.9	89.8	90.2
	Argentina			82.3	82.0	84.4
	Brazil	58.4	78.2	86.9	87.4	
	Brazil, Barretos			75.6[b]	74.9[c]	85.0[d]
	Chile		73.3	74.6	73.5	
	Colombia		65.7	72.3	79.1	
	Ecuador		68.9	72.1	75.7	75.5
	Costa Rica			87.0	86.4	86.7
	France, Martinique			78.9	87.8	89.8
	Cuba	84.0	72.8	73.7	81.8	75.1
	USA, Puerto Rico			83.4	83.0	84.1
Oceania	Australia	80.7	84.6	87.0	88.5	89.5
	New Zealand		79.5	82.8	86.1	87.6
Africa	Eastern Cape, South		53.4	37.9	71.5	



frontiers in Oncology

MINI REVIEW
published: 16 June 2020
doi: 10.3389/fonc.2020.00864

Mini Review

Breast Cancer Survivorship, Quality of Life, and Late Toxicities

*Simone Nardin [1,2], Edoardo Mora [1,2], Feba Mariam Varughese [1,2], Francesca D'Avanzo [3], Ajay Ram Vachanaram [1,2], Valentina Rossi [3], Chiara Saggia [3], Sara Rubinelli [3] and Alessandra Gennari [1,2,3]**

- **Cardiotoxicity after adjuvant treatment**
- Ovarian failure and fertility preservation
- Distress, body image, self-esteem, and sexuality
- Osteoporosis and long-term survival
- Host metabolism and lifestyle in breast cancer survivors

Cardiotoxicity of adjuvant systemic treatment

Drug	Incidence	Cardiotoxicity
Adriamycin / Epirubicin	4% @ 900mg/sqm, 15% @ 1000mg/sqm	Cardiomyopathy leading to Congestive heart failure
Docetaxel	2.3 – 8 %	Congestive heart failure
Cyclophosphamide	7-25%	Myocarditis
Letrozole	1-2.5%	Doubling of cardiac events
Traztuzumab	10-14%	Decreased LVEF, Congestive heart failure
5FU	1.2-7.6%	Myocardial ischemia, Arrhythmias

The NEW ENGLAND JOURNAL of MEDICINE

ESTABLISHED IN 1812 MARCH 14, 2013 VOL. 368 NO. 11

Risk of Ischemic Heart Disease in Women after Radiotherapy for Breast Cancer

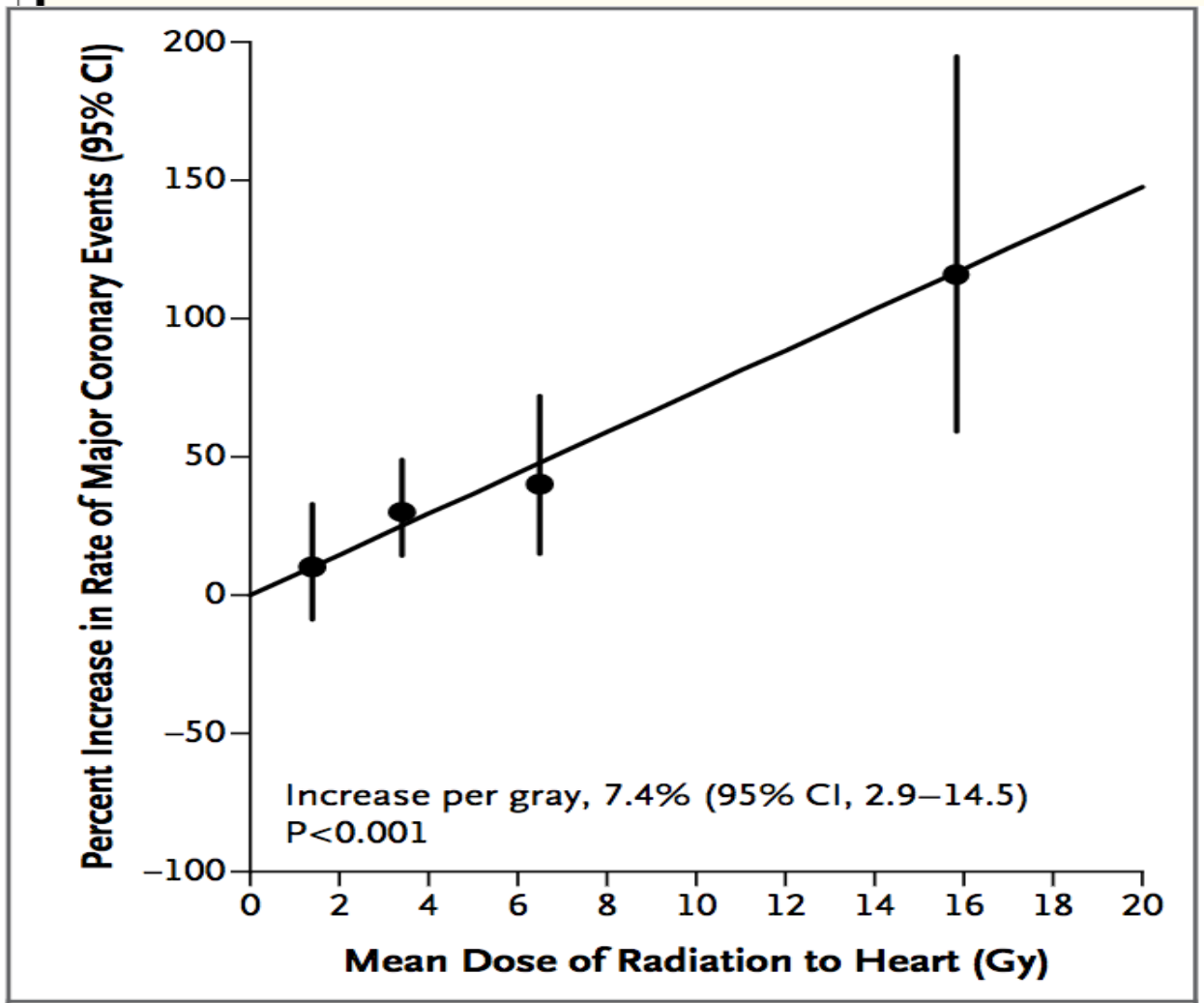
Sarah C. Darby, Ph.D., Marianne Ewertz, D.M.Sc., Paul McGale, Ph.D., Anna M. Bennet, Ph.D.,

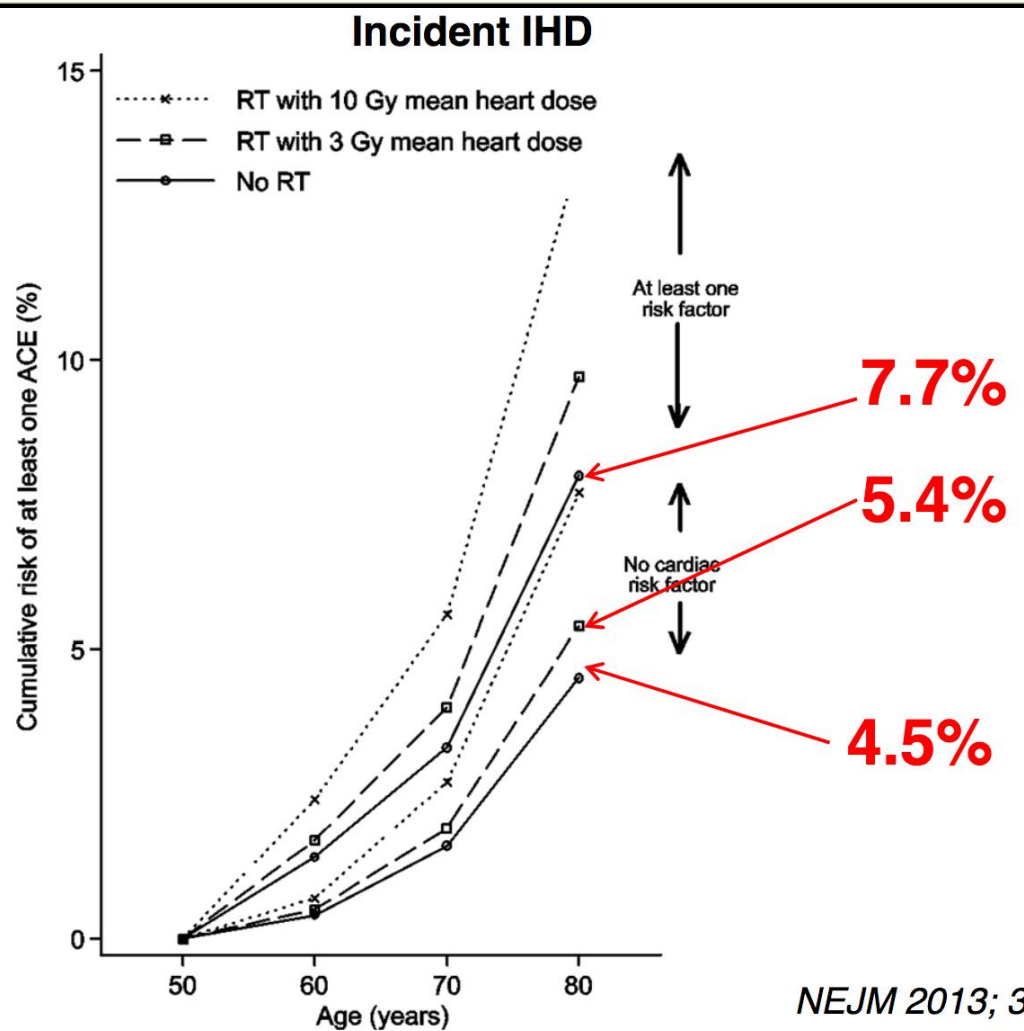
2168 patients, 963 with major coronary event, 1205 controls

Rate of coronary event significantly higher in women treated for left sided lesions, prior diagnosis of IHD (rate ratio 6.67.)

Higher when associated with Diabetes mellitus, COPD, smoking, high BMI (rate ratio 1.9),

The NEW ENGLAND JOURNAL of MEDICINE





NEJM 2013; 368:987-98

What does the 7.4% increase per Gy MHD mean

Study	Type	Event	Outcome
Darby et al 2013	Population based case control study	Major coronary event (MI, coronary revascularization, death from IHD)	2 Gy, - 10% excess 2 to 4 Gy - 30% 5 to 9 Gy – 40% ≥ or 10 Gy – 116% ---------- 0 to 4 years, 16.3% 5 to 9 years, 15.5% 10 to 19 years, 1.2% ≥20 Yrs8.2%
Jacobse et al 2017	Nested case control study of MI in BC survivors	MI	IMC RT – 2.45X HT and BMI > 30, significant factors 6.4% increase in risk for every 1 Gy. Max in women < 45 yrs @ 24.5 % @ 1 yr

Is the estimation by Darby et al valid for modern day radiotherapy techniques?

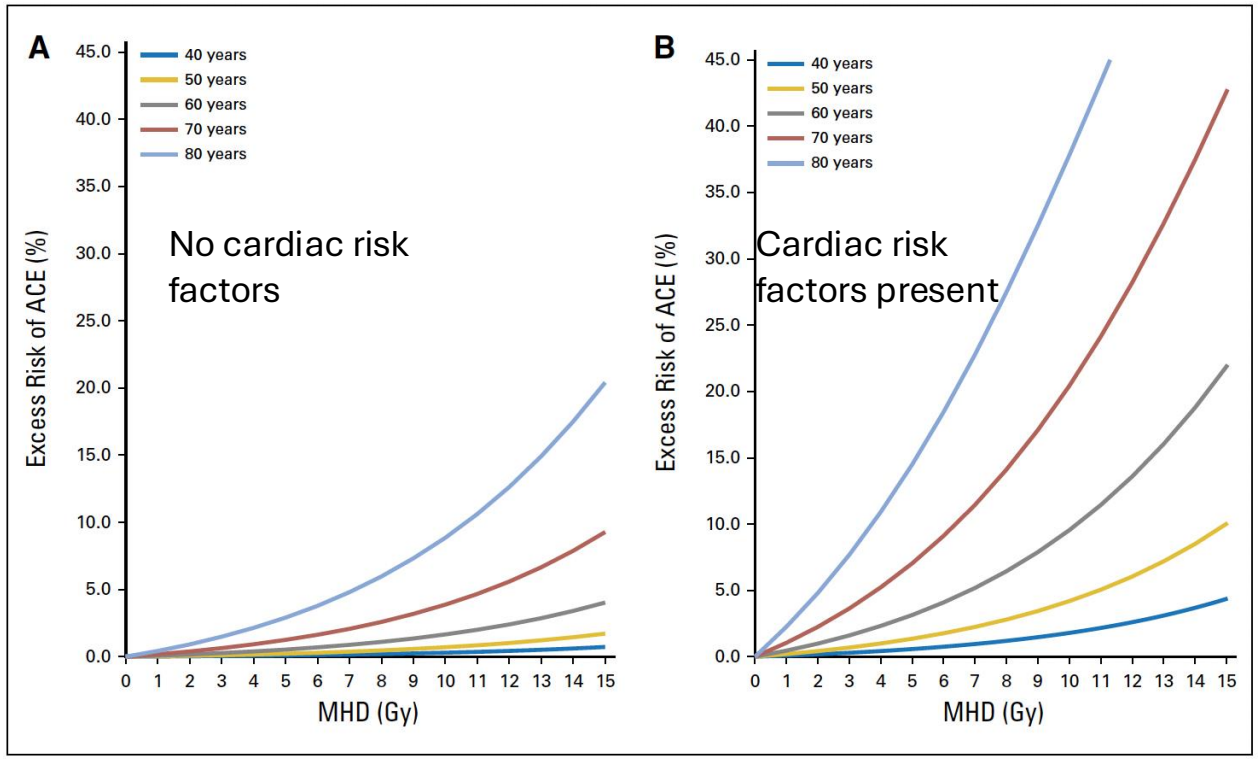


Fig 2. Excess risk of an acute coronary event (ACE) depending on the mean heart dose (MHD) in volume percentage calculated per age category and (A) absence or (B) presence of cardiac risk factors.

Van den Bogaard et al, JCO 2017

910 patients

Best fit model incorporated LV-V5, age and ACE score

Risk of cardiac event 16.5 Gy per Gy in first 9 years after RT

IJC INTERNATIONAL JOURNAL of CANCER | UICC

RESEARCH ARTICLE

Long-term risk of major cardiac events in breast cancer patients treated with intensity-modulated and 3-dimensional conformal radiotherapy: Secondary analysis of a randomized clinical trial

Nam Kyu Kang, Kyu Hye Choi, Jae Uk Jeong, Sung Ja Ahn, Mina Yu, Jin Hee Kim, Bae Kwon Jeong, Han Byul Kang, Hyo Chun Lee, Jong Hoon Lee

First published: 09 May 2025 | https://doi.org/10.1002/ijc.35476

21% increase per Gy increase in MHD in the first 6.5 years

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CLINICAL INVESTIGATION

Is Radiation-Induced Cardiac Toxicity Reversible? Prospective Evaluation of Patients With Breast Cancer Enrolled in a Phase 3 Randomized Controlled Trial

Aswin Abraham, DPhil, MD,* Karan Paul Sanghera, MD,* Farshid Gheisari, MD,† Stella Koumna, MD, FRCPC,†

17.2% any cardiac event @ MFU 127 months

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Clinical Investigation

Dose to the Left Anterior Descending Artery Correlates With Cardiac Events After Irradiation for Breast Cancer

Andrew H. Zureick, MD,* Vincent P. Grzywacz, MD,* Muayad F. Almahariq, MD, PhD,*† Brittany R. Silverman, BS,‡

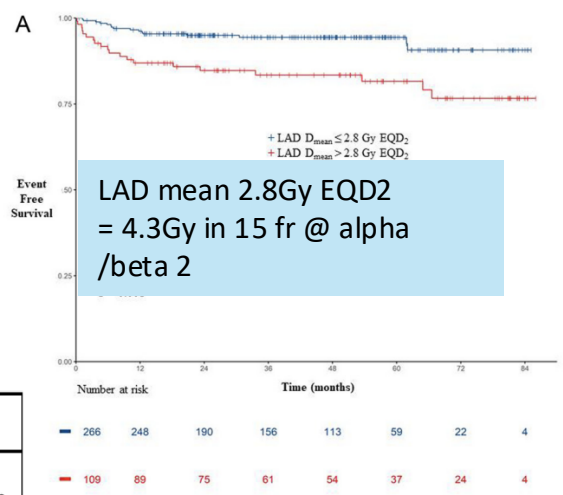
Any Cardiac Event

William Beaumont hospital,
375 consecutively patients 2012 -18 Left sided for intact breast and chest wall +/- RNI
19%recd IMC, 12.5 adriamycin, 7.5% herceptin

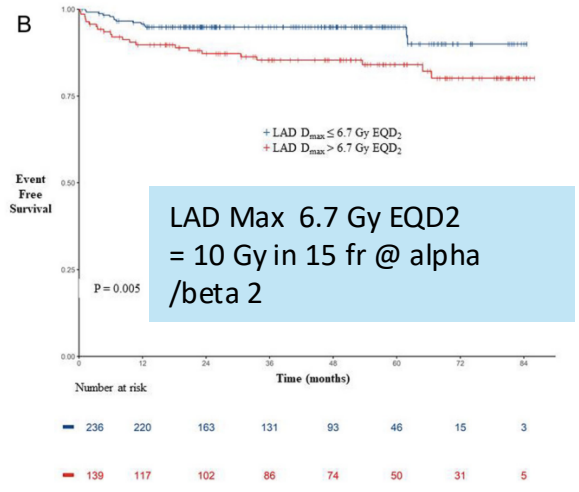
Table 4 Multivariable analyses for each dosimetric parameter versus cardiac toxic effects*

	Any cardiac events			Major cardiac events		
Dosimetric index†	HR	95% CI	*P* value	HR	95% CI	*P* value
LAD D_{mean}	1.09	1.02, 1.17	.006	1.08	1.01, 1.17	.022
LAD D_{max}	1.02	1.01, 1.04	.009	1.02	1.00, 1.04	.12
Heart D_{mean}	1.86	1.12, 3.08	.016	1.68	1.24, 3.77	.007
Heart D_{max}	1.02	1.00, 1.04	.016	1.01	0.99, 1.04	.2

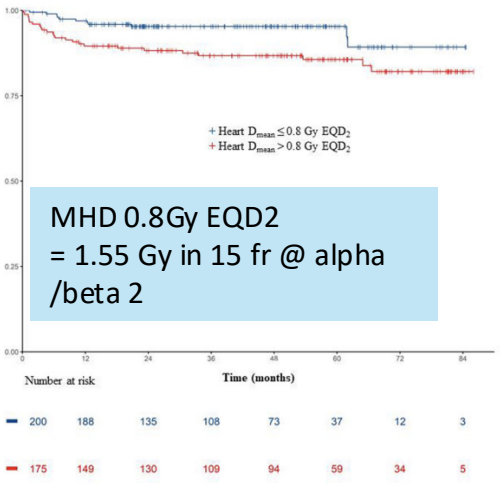
D mean heart dose 0.8Gy, Any cardiac disease, 6.1%, median follow up 48 m.



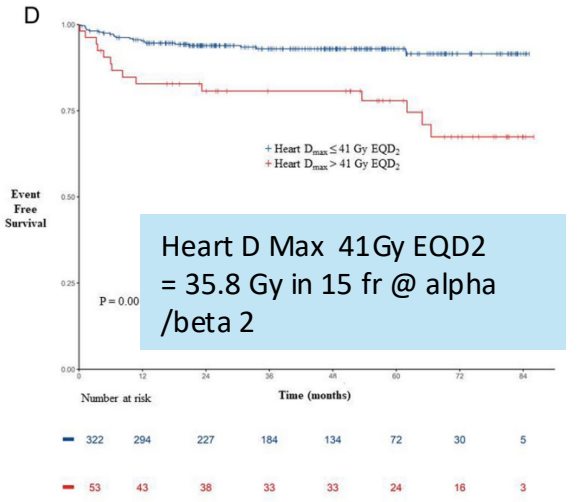
LAD mean 2.8Gy EQD2
= 4.3Gy in 15 fr @ alpha /beta 2



LAD Max 6.7 Gy EQD2
= 10 Gy in 15 fr @ alpha /beta 2

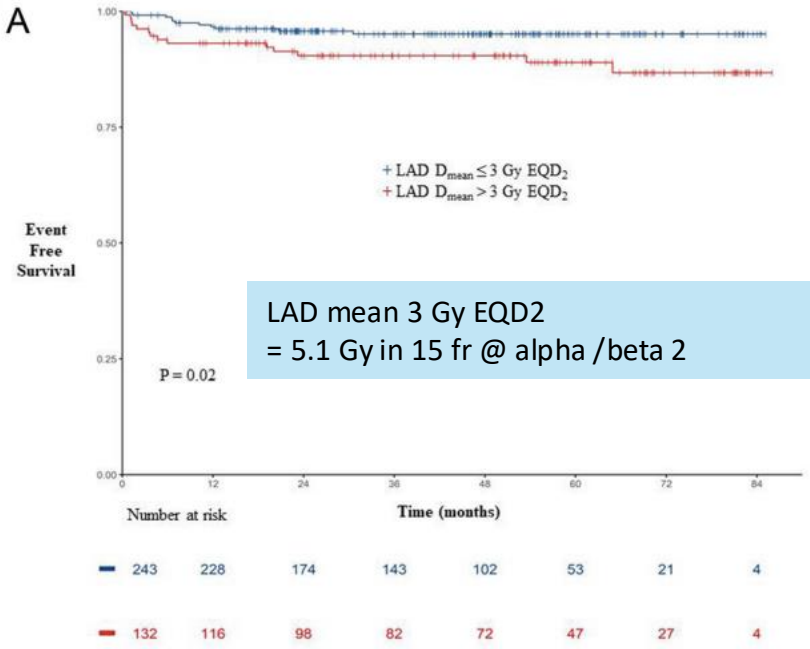


MHD 0.8Gy EQD2
= 1.55 Gy in 15 fr @ alpha /beta 2

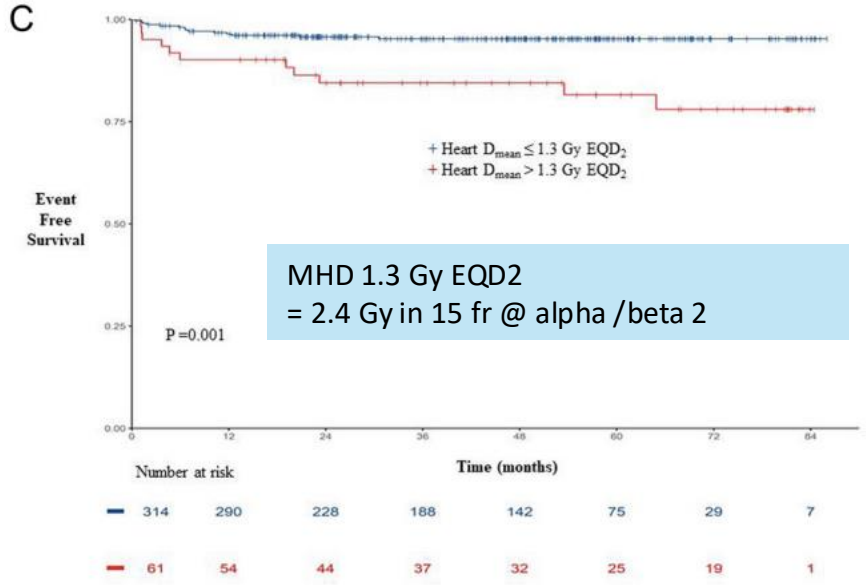


Heart D Max 41Gy EQD2
= 35.8 Gy in 15 fr @ alpha /beta 2

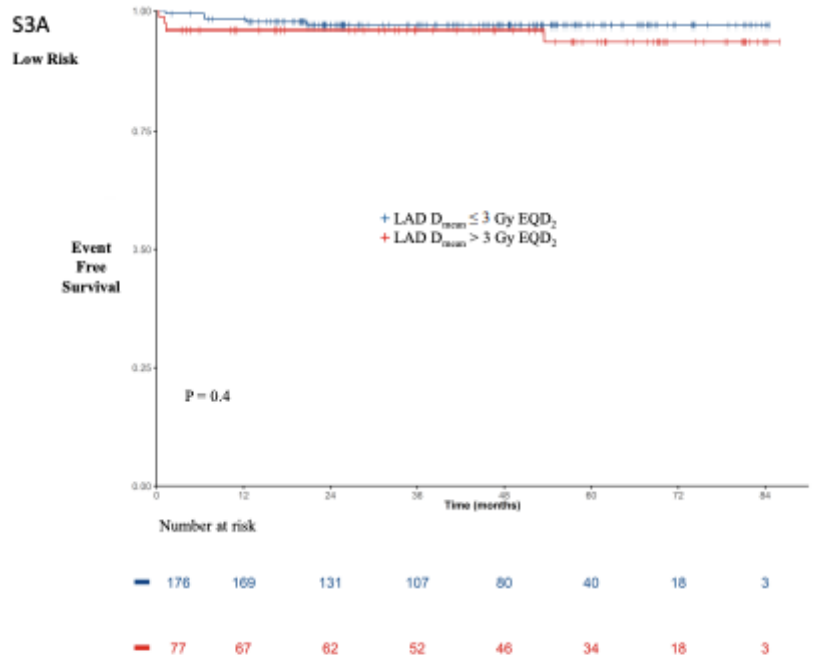
Major Cardiac Event



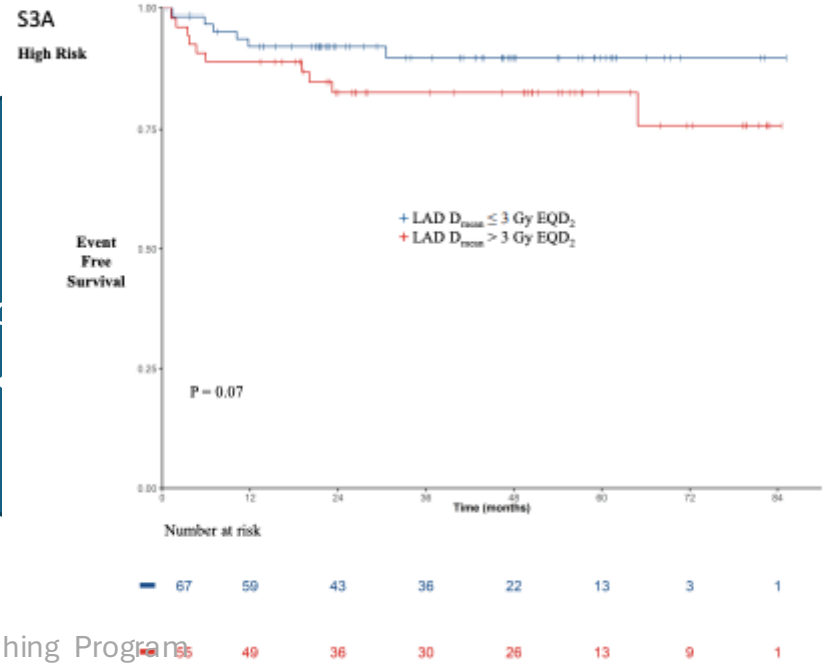
LAD mean 3 Gy EQD2
= 5.1 Gy in 15 fr @ alpha /beta 2



MHD 1.3 Gy EQD2
= 2.4 Gy in 15 fr @ alpha /beta 2

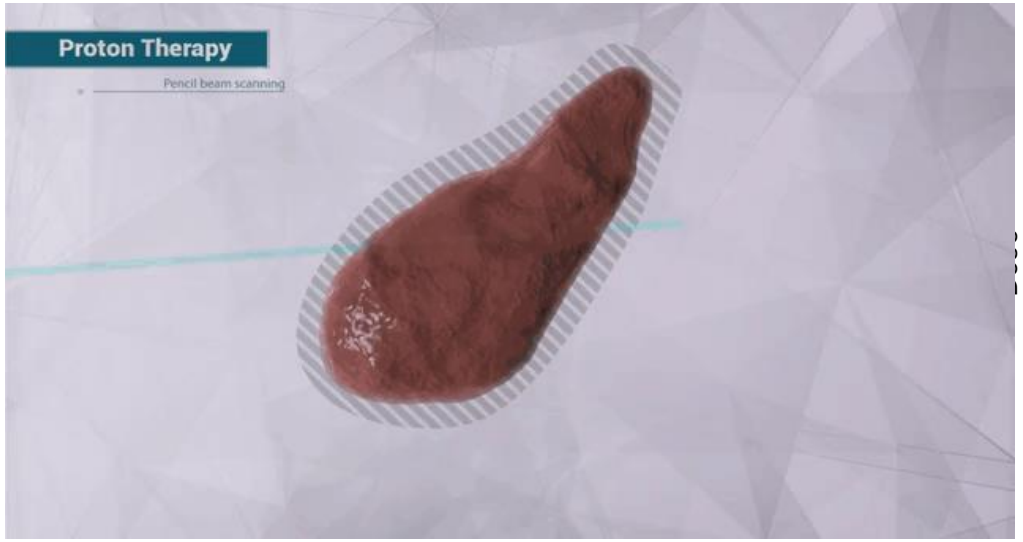


Adriamyc
Traztuzum
CCI≥ 2

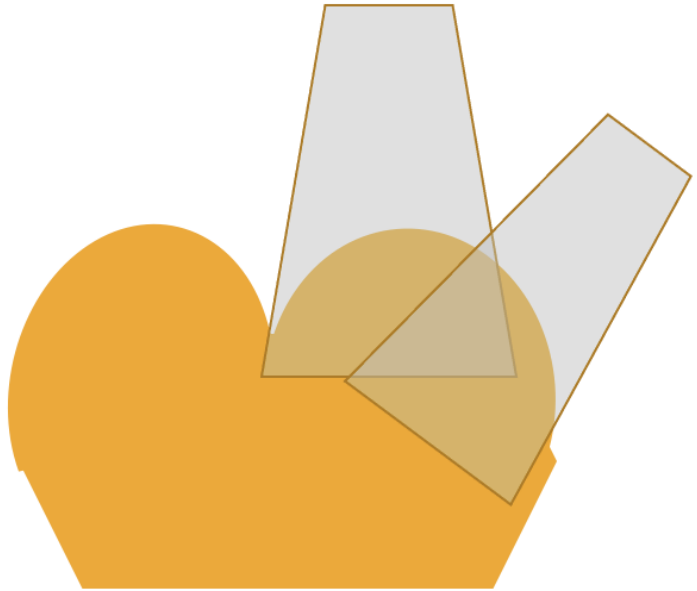


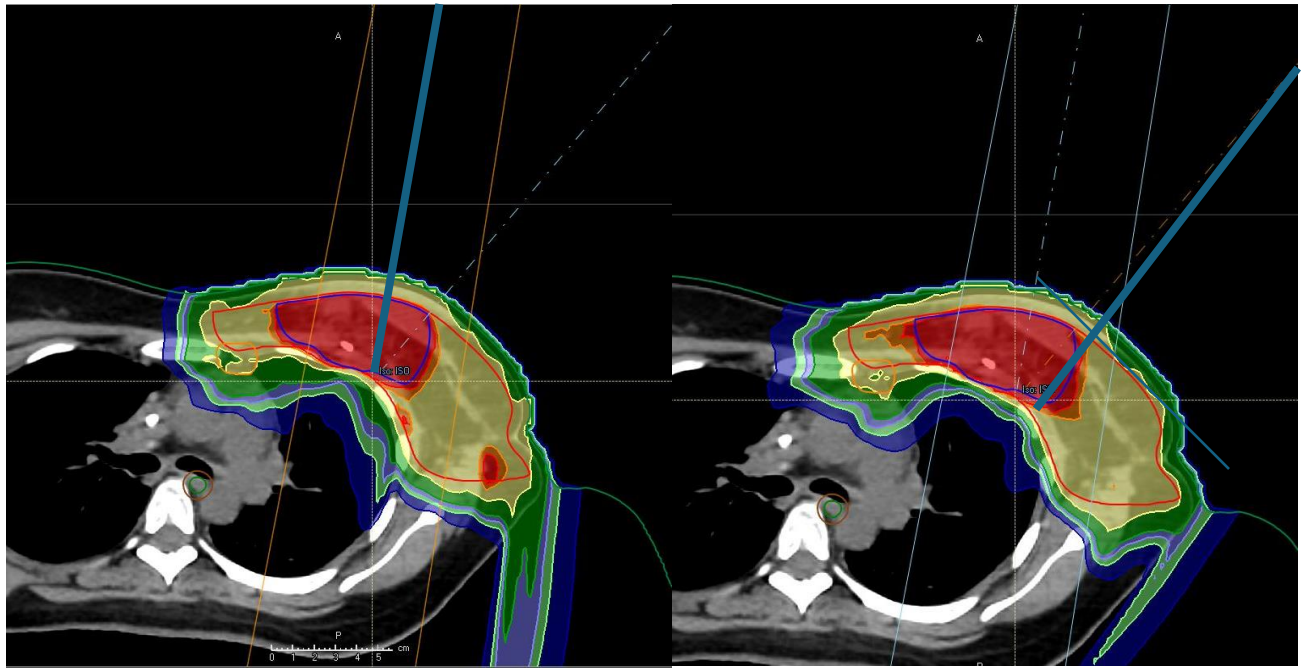
How do protons help reduce risk of RIHD and who benefits the most?

Proton therapy compared with photon therapy



Aim of Proton therapy
MHD < 1Gy





Protons in breast cancer – Clinical Studies – Bradley et al, 2016

Int J Radiation Oncol Biol Phys, Vol. 95, No. 1, pp. 411–421, 2016

Initial Report of a Prospective Dosimetric and Clinical Feasibility Trial Demonstrates the Potential of Protons to Increase the Therapeutic Ratio in Breast Cancer Compared With Photons

Julie A. Bradley, MD, Roi Dagan, MD, MS, Meng Wei Ho, MSc,

Target :=>95% breast receives =>47.5 Gy, nodes =>95% receives => 45 Gy
Dose constraint goals cardiac mean dose <5 Gy, cardiac V20 <10%, IL lung V20 <30%, CL lung V5 <20%.
.

Table 2 Median (range) cardiac dose

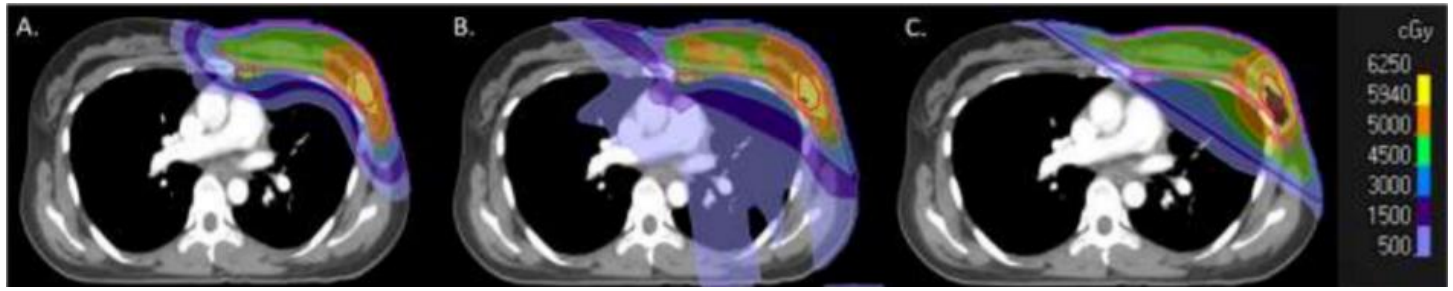
Radiation therapy technique	Heart V5 (%)	Mean heart dose (Gy)	Ventricle V5 (%)	Cardiac V20 (%)	Mean ventricle dose (Gy)
Left-sided patients					
Proton therapy	2.7 (0-12)	0.6 (0-3.2)	0.5 (0-15.6)	1 (0-3.6)	0.1 (0-4)
Conventional therapy	34 (7-60)	5.9 (2-9.1)	31.4 (8.7-79.8)	6.1 (1.4-12.9)	5.4 (2.4-11)
P	.004	.004	.004	.0039	.004
Right-sided patients					
Proton therapy	0.3 (0-2.9)	0.5 (0-0.8)	0 (0-1)	0 (0-1.4)	0.2 (0-0.5)
Conventional therapy	13.2 (0.4-24.7)	2.9 (1-5.1)	3.3 (0-7.1)	1.6 (0-7.7)	1.2 (0.8-1.7)
P	.004	.004	.008	.0078	.004

The risk for developing a secondary cancer after breast radiation therapy: Comparison of photon and proton techniques

Harald Paganetti • Nicolas Depauw • Andrew Johnson • Rachel Beth Forman • Jackson Lau • Rachel Jimenez

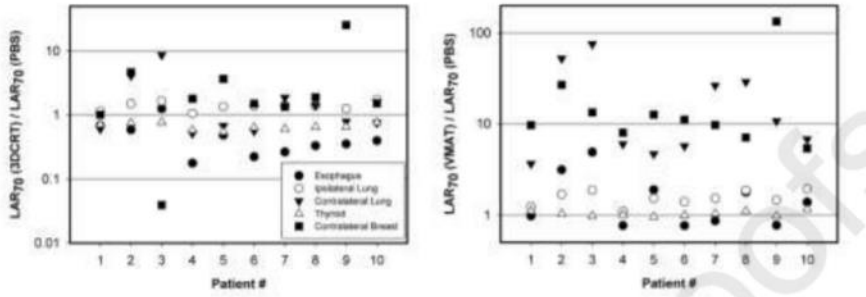
Published: May 24, 2020 • DOI: https://doi.org/10.1016/j.radonc.2020.05.035 • Check for updates

- 10 photon-VMAT
- 10 photon 3DCRT
- 14 pencil beam scanning proton



Protons VMAT 3DCRT

Life-time Attributable Risk (LAR) at 70 yrs age



3DCRT vs Protons VMAT vs Protons

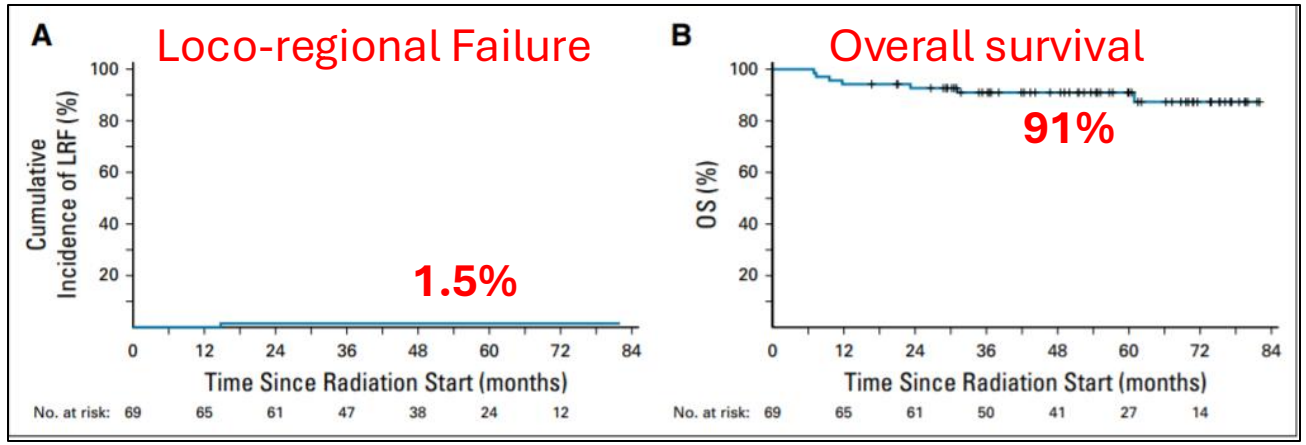
•The secondary malignancy risk in the contralateral lung and breast is less in protons as compared to VMAT, 3DCRT
•Ipsilateral lung, risks were lowest for protons, followed by 3DCRT and VMAT.

original report

Phase II Study of Proton Beam Radiation Therap for Patients With Breast Cancer Requiring Regional Nodal Irradiation

Rachel B. Jimenez, MD[1]; Shea Hickey, BS[1]; Nicolas DePauw, PhD[1]; Beow Y. Yeap, ScD[1]; Estelle Batin, PhD[1]; Michelle A. Gadd, MD[1]; Michelle Specht, MD[1]; Steven J. Isakoff, MD, PhD[1]; Barbara L. Smith, MD, PhD[1]; Eric C. Liao, MD, PhD[1]; Amy S. Colwell, MD[1]; Alice Ho, MD, MBA[1]; James L. Januzzi, MD[1]; Jonathan Passeri, MD[1]; Tomas G. Neilan, MD, MPH[1]; Alphonse G. Taghian, MD, PhD[1]; Hsiao-Ming Lu, PhD[1]; and Shannon M. MacDonald, MD[1]

Non-metastatic breast cancer pts requiring postoperative RT to the breast/chest wall and regional lymphatics
n= 70, Median Follow-up- 55 months



Pre-Proton 5 yrs post-Proton

Proton beam RT for breast cancer has low toxicity rates

Protocols worldwide

Clinical and Translational Radiation Oncology 27 (2021) 126–131

Contents lists available at ScienceDirect

Clinical and Translational Radiation Oncology

journal homepage: www.elsevier.com/locate/ctro

Original Research Article

Selection criteria for early breast cancer patients in the DBCG proton trial – The randomised phase III trial strategy

Line Bjerregaard Stick [a,b,c,*], Ebbe Laugaard Lorenzen [d], Esben Svitzer Yates [e], Carmel Anandadas [f],

Oncology
Protocol

Pragmatic randomised clinical trial of proton versus photon therapy for patients with non-metastatic breast cancer: the Radiotherapy Comparative Effectiveness (RadComp) Consortium trial protocol

Justin E Bekelman [1], Hien Lu [1], Stephanie Pugh [2], Kaysee Baker [3], Christine D Berg [4], Amy Berrington de Gonzalez [4], Lior Z

Editorial

Proton Beam Therapy in Breast Cancer Patients: The UK PARABLE Trial is Recruiting

A.M. Kirby *†, J.S. Haviland *‡, M. Mackenzie §, H. Fleming ¶, C. Anandadas ||, S. Wickers **,

APCC 202003

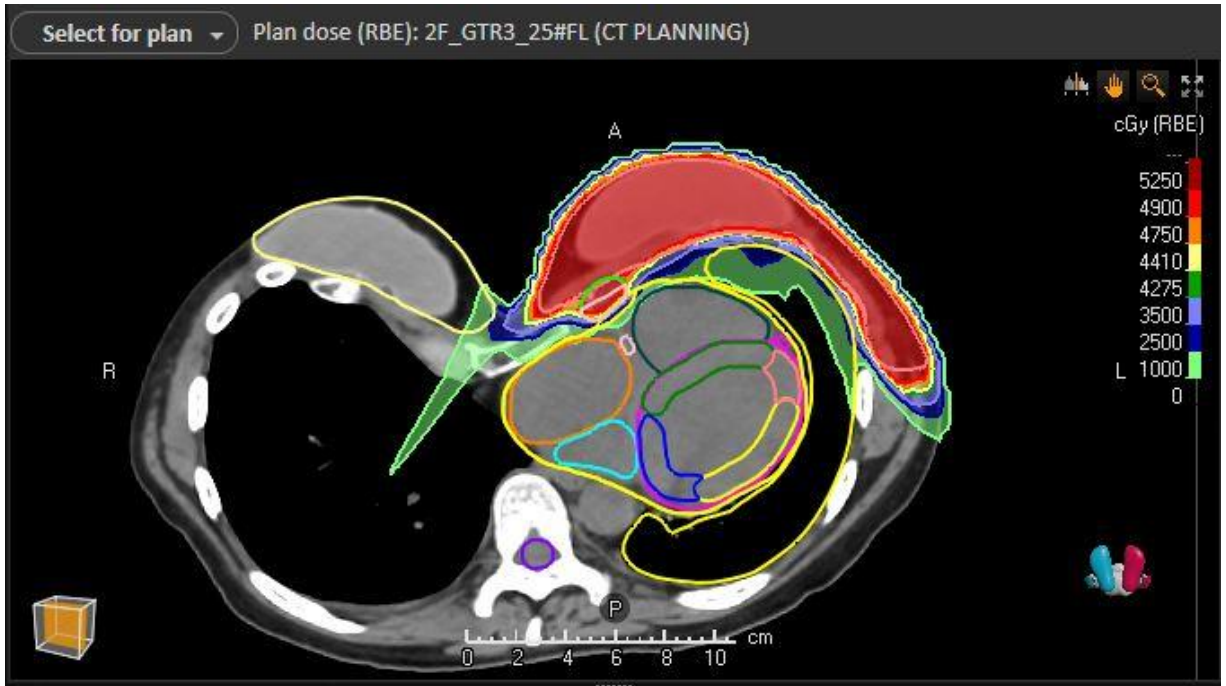
Breast Cancer Proton Registry

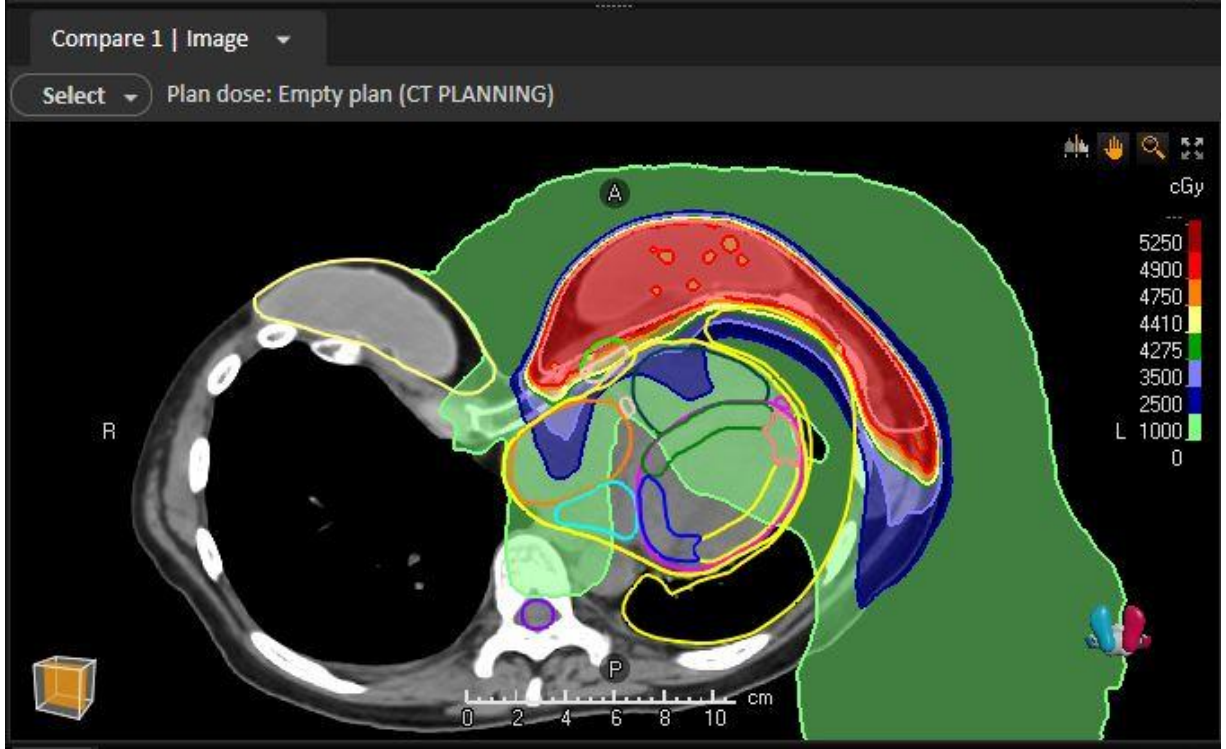
HyPro-B

A mean heart dose of ≥4 Gy and/or ipsilateral lung V17Gy/V20Gy ≥ 37%

All patients who require nodal irradiation.

Age (years) at study registration	Mean heart dose (Gy) needed for ≥2% risk of radiation-related heart disease by aged 80 years	
	No Cardiac Risk Factor	At Least One Cardiac Risk Factor*
≤44¶	≥4Gy	≥2.5Gy
45-54	≥6 Gy#	≥4 Gy
55-64	≥6 Gy#	≥4.5 Gy
65+	≥6 Gy#	≥5.5 Gy

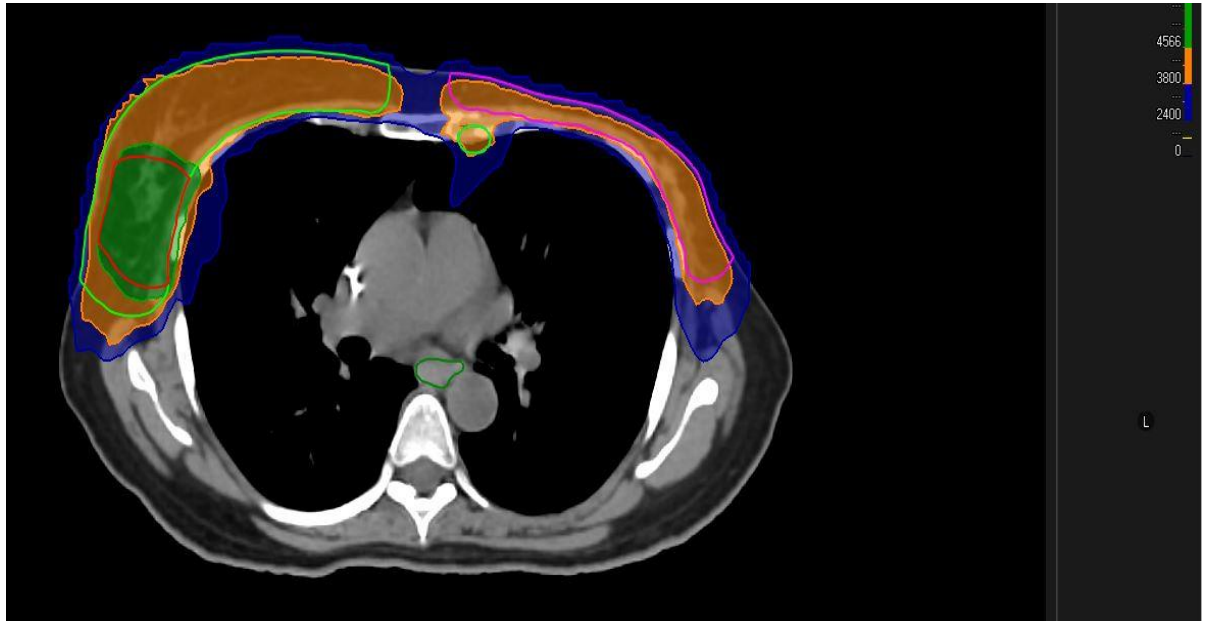




PRT for breast cancer in pectus excavatum

Parameter	Proton	Photon (Tomotherapy)
Mean Heart dose (GyE)	1.12	13.54
Heart V5GyE(%)	5.95	91.43
LAD Dose (GyE), $D_{0.03cc}$	4.0	14.05
LAD Dose (GyE),Mean	0.5	8.66
Mean Dose to LV (GyE)	0.07	10.07
Left Ventricle V5GyE(%)	0.01	92.61
Mean dose to Ipsilateral lung (GyE)	9.18	13.96
V5(%)	41	73
V20(%)	18.5	23.5
Mean dose to C/L Breast (GyE)	1.78	5.36

Special situations: Bilateral breast cancer, reirradiation



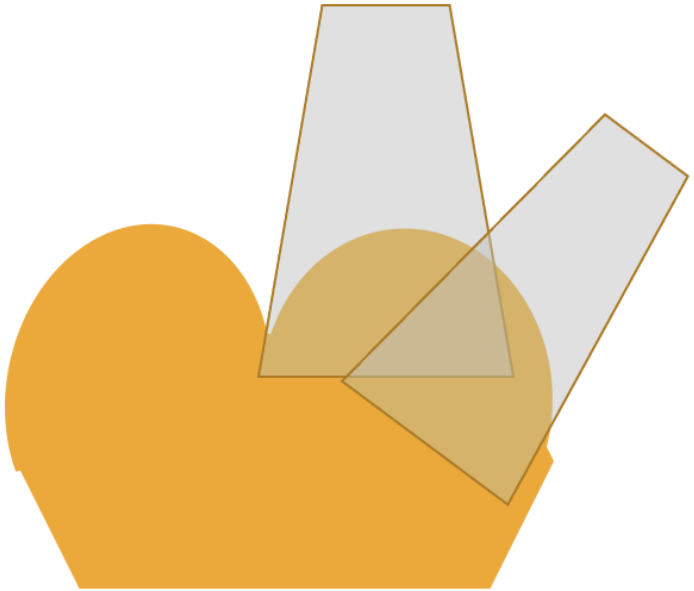
Bilateral Breast Cancer

Reirradiation : Sternal metastasis/ IMC Recurrence

Comparison of Proton therapy with X-Rays + DIBH for breast cancer @APCC- consecutive patients

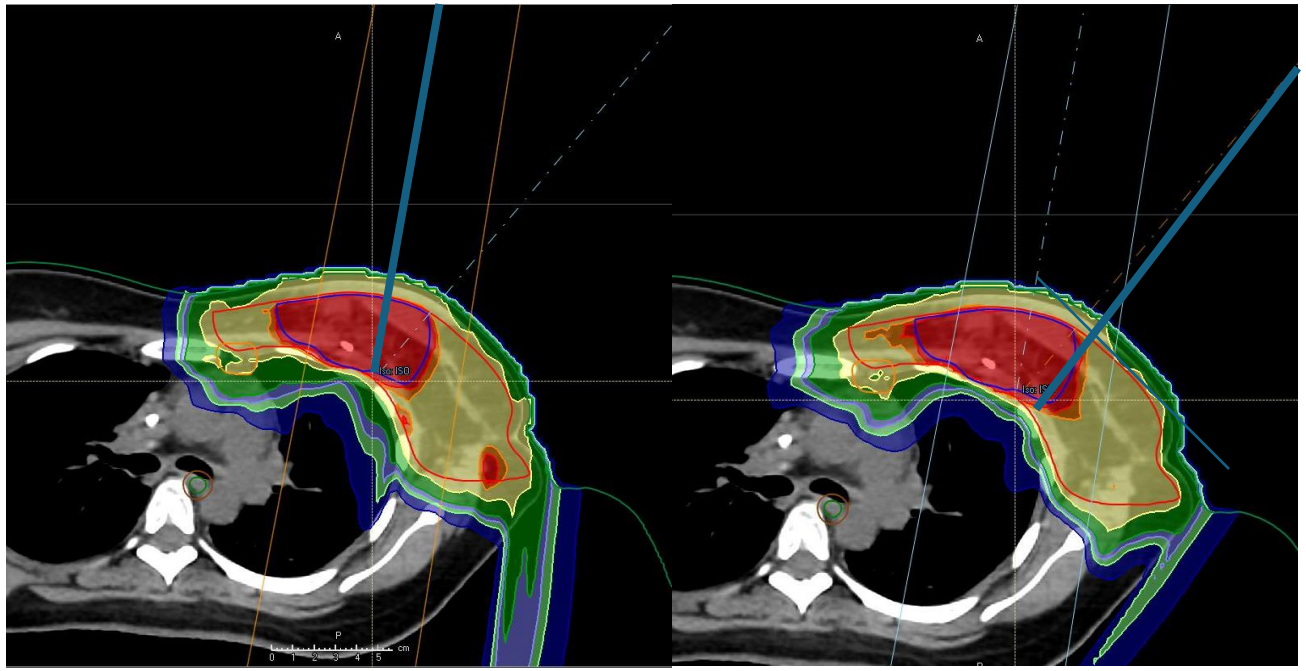
LEFT SIDE Proton Therapy (n=37) Whole Breast -22, Chest Wall -15. Mean			X Rays + DIBH Left side (n=36) Whole Breast -16, Chest Wall -20; Mean	
Heart	0.81	79% ↓	Mean Heart dose	3.92
Heart V5GyE(%)	4.24		` Heart V5GyE(%)	19.1
LAD Dose (GyE), $D_{0.02cc}$	7.89	45% ↓	LAD Dose (GyE), $D_{0.02cc}$	14.35
LAD Dose (GyE),Mean	2.15	69% ↓	LAD Dose (GyE),Mean	6.93
Dose to LV (GyE)	0.24		Dose to LV (GyE)	3.67
Left Ventricle V5GyE(%)	0.64	96% ↓	Left Ventricle V5GyE(%)	15.60
Ipsilateral lung (GyE)	3.11	74% ↓	Ipsilateral lung (GyE)	11.98
V4(%)	18.07		V4(%)	58.10
V17(%)	5.60		V17(%)	24.85
C/L Breast (GyE)	0.33	91% ↓	C/L Breast (GyE)	3.54

Proton therapy planning



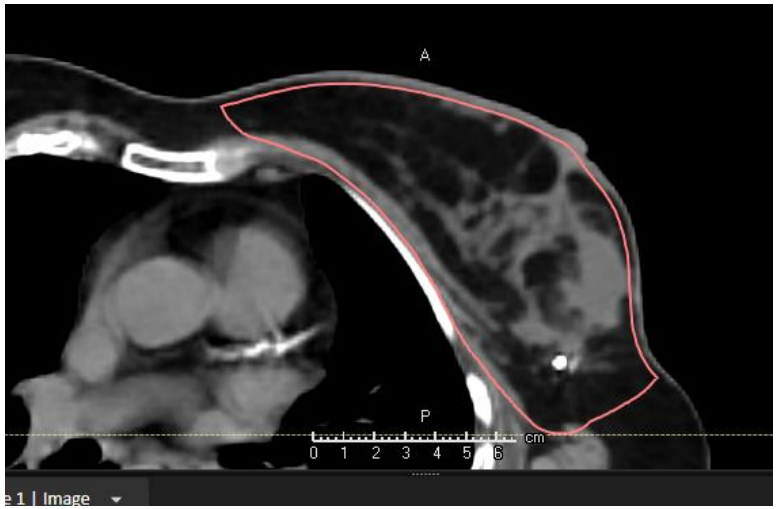
- Wingboard, vaclock
- Face variable
- Scan without contrast
- Create rind for skin and ribs
- Enface beams, two, occasionally one
- Treat implant and metal port thru and thru
- Cool skin and ribs
- Robustness not being applied for range in chest wall, reasoning 3.5 % of 2 cm is too small.
- Use SGRT for positioning, followed by check kvkv CBCT.
- Hypofractionated SIB – 45.6Gy in 15 fr, 40Gy in 15 fr, 37.5Gy in 15 fr
- AIM: Reduction of cardiac dose to 1 Gy, Reduction of second cancer risk

- APBI may also be performed – 7.3Gy X 3
- DIBH has a limited role - ~ 10-15% patients require



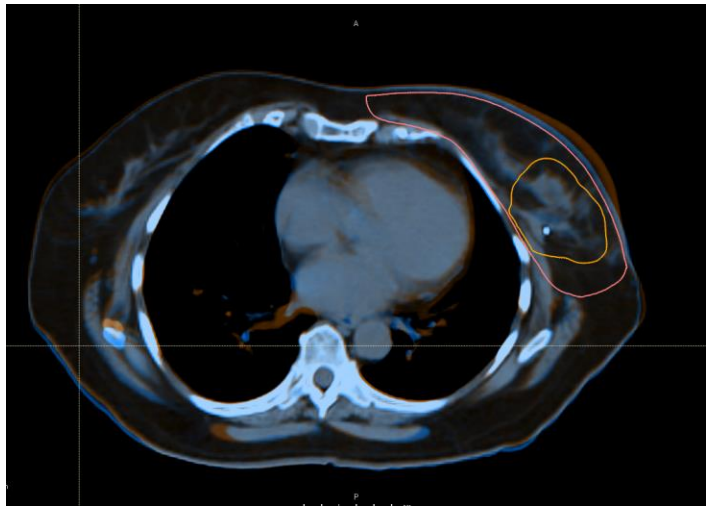
Exacting and labour intensive

Planning CT

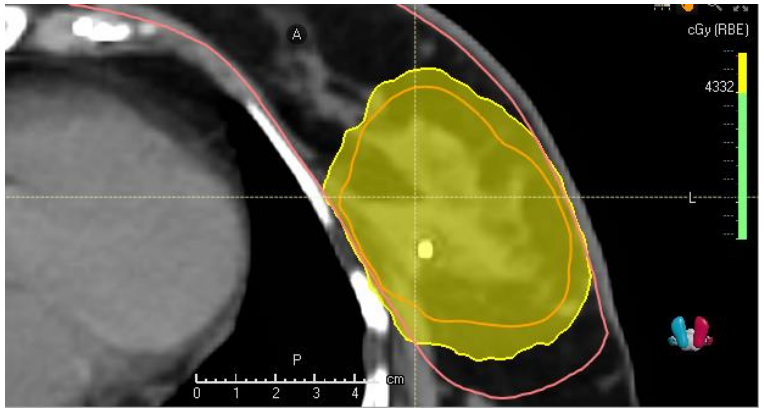


QACT

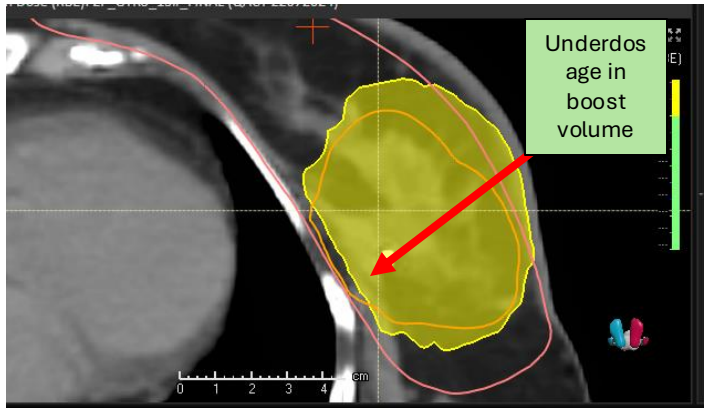
Fusion



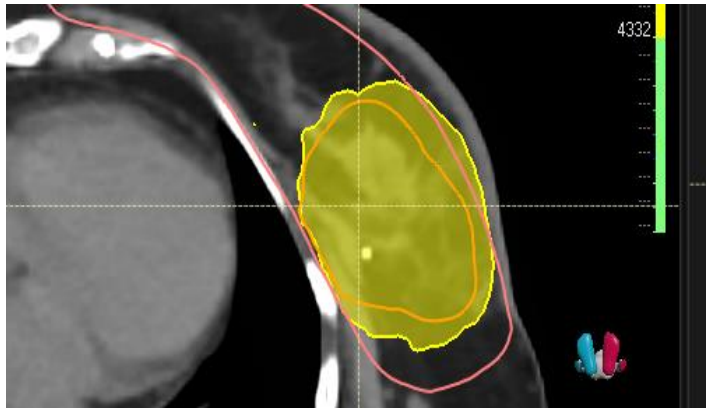
Boost coverage by 95% colour-wash



Underdosage due to change in BPL



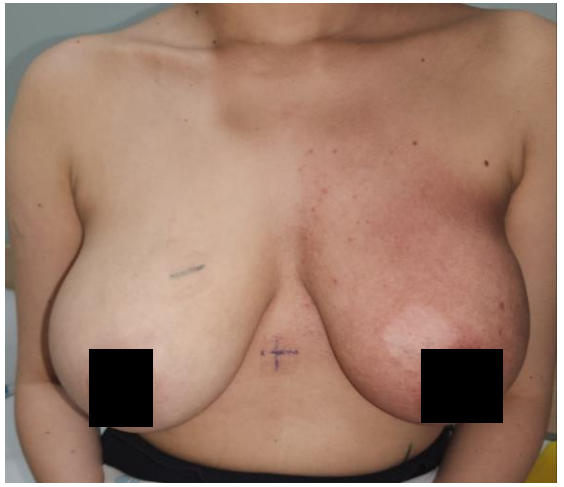
Adaptive plan



Hypofractionated proton therapy with SIB

Grade 3 reactions	2 /48
No locoregional failure	
Rib fractures	2/48
Radiation recall / inflammation	3/48

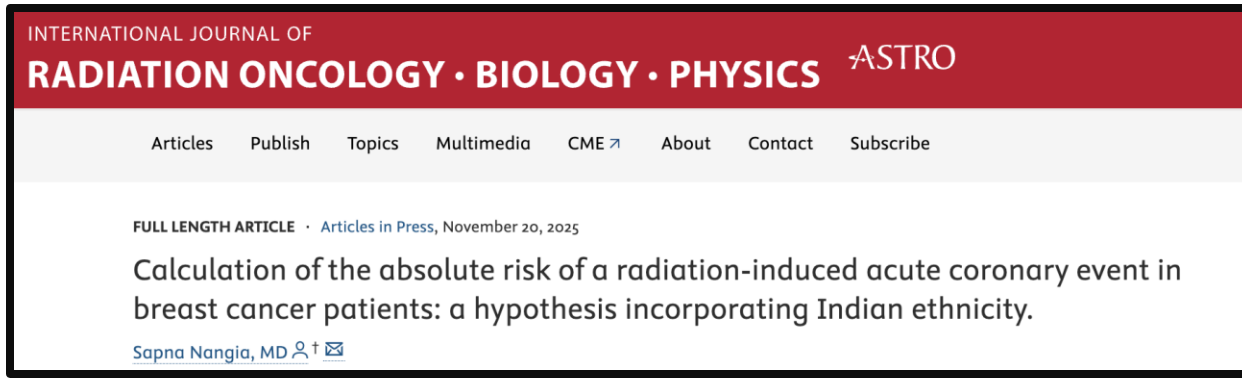
HYPOFRACTIONATED PROTON THERAPY



Grade 3 reactions	2 /48
No locoregional failure	
Rib fractures	2/48
Radiation recall / inflammation	3/48

Who benefits the most

- Left sided breast cancer
- Patients with cardiac risk factors: diabetes, hypertension, obesity, smoking, strong family history, COPD
- Patients who have received cardiotoxic chemotherapy- Adriamycin, trastuzumab
- Patients requiring internal mammary node irradiation
- Young patients, to reduce the integral dose.
- Bilateral breast cancer
- ILD



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FULL LENGTH ARTICLE · Articles in Press, November 20, 2025

Calculation of the absolute risk of a radiation-induced acute coronary event in breast cancer patients: a hypothesis incorporating Indian ethnicity.

Sapna Nangia, MD †

The absolute lifetime risk for MHD, ranging from 1 Gy to 10 Gy, has been calculated using the following formulae:

Estimated Absolute Risk-ACE-Life (EAR-ACE-Life) = Baseline Risk-ACE-Life (BR-ACE-Life) X [1+ (Mean Heart dose X 0.074)]

Radiation Induced Absolute Risk-ACE-Life (RIAR-ACE-Life) = EAR-ACE-Life - BR-ACE-Life

Where

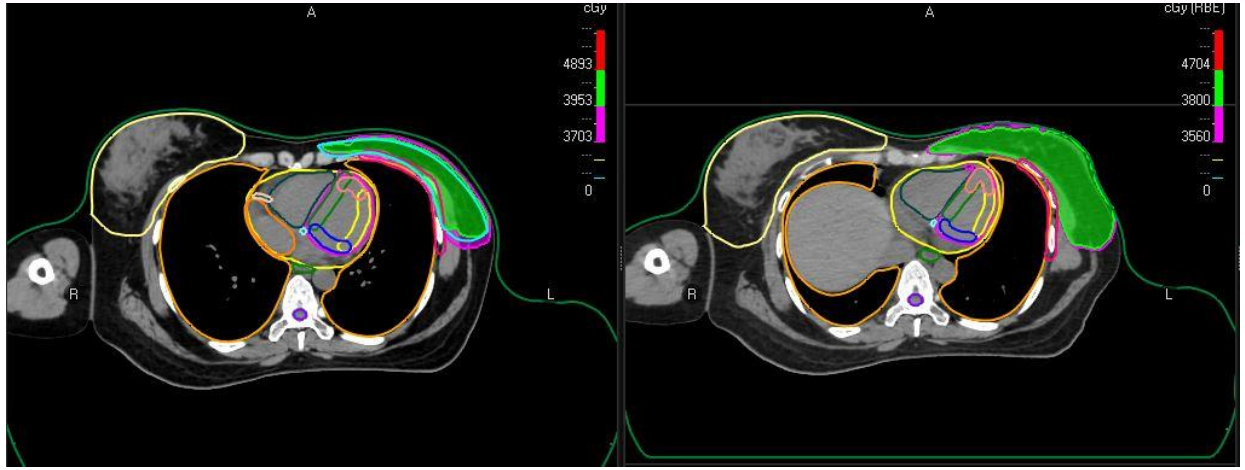
RIAR-ACE-Life
RIAR-ACE-10

EAR-ACE-Life: Estimated absolute risk of Acute Coronary Event for expected life span.

BR-ACE-Life: Baseline risk of Acute Coronary Event for expected life span

RIAR-ACE-Life: Radiation-related increase in absolute risk of Acute Coronary Event for expected life span.

Proton therapy advantage in a ”good” photon DIBH plan



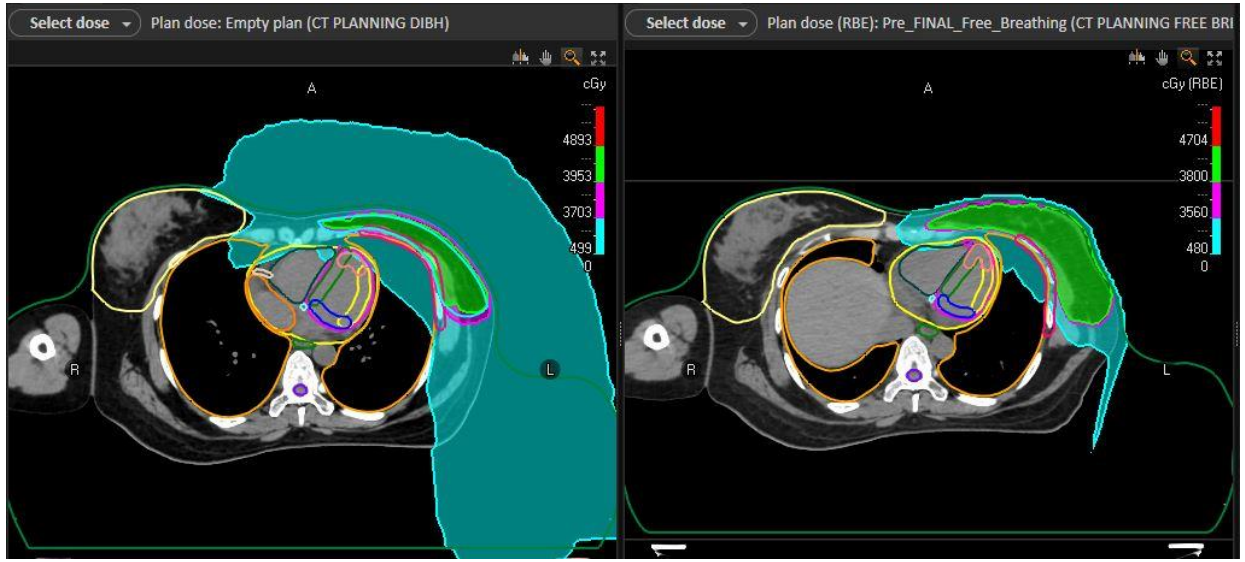
MHD DIBH Photon: **3.08 Gy**

MHD PRT: **0.52 Gy**

23%

3.9%

83%



Mean LAD DIBH Photon: **4.96 Gy**

Mean LAD PRT: **1.17 Gy**

76%

Dutch model for identifying breast cancer patients benefiting from proton therapy

Clinical Oncology 34 (2022) 247–257

Contents lists available at ScienceDirect

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journal homepage: www.clinicaloncologyonline.net

Original Article

Model-Based Selection for Proton Therapy in Breast Cancer: Development of the National Indication Protocol for Proton Therapy and First Clinical Experiences

L.J. Boersma *, M.G.A. Sattler †‡, J.H. Maduro §, N. Bijker ¶, M. Essers ||, C.M.J. van Gestel **,

Table 1B Cumulative risk of acute coronary events (ACE) for WOMEN WITH risk factors for ACE < 80 years of age.

NOTE 1: The row for women aged 40 years should be used for women < 40 years of age.

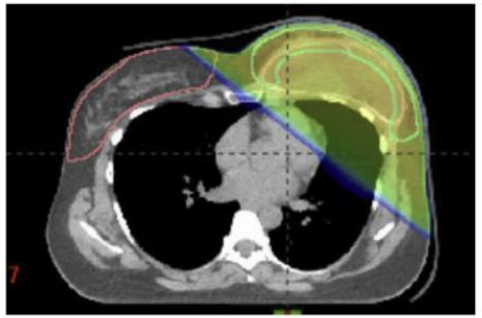
NOTE 2: The row for women aged 70 years should be used for women > 70 years of age.

Age in years	Mean Heart Dose (Gy)											Age in years	Threshold MHD (Gy) for a plan comparison
	0 Gy	1 Gy	2 Gy	3 Gy	4 Gy	5 Gy	6 Gy	7 Gy	8 Gy	9 Gy	10 Gy		
40	11,6%	12,5%	13,4%	14,2%	15,1%	15,9%	16,8%	17,7%	18,5%	19,4%	20,2%	40	2,32
41	11,6%	12,5%	13,3%	14,2%	15,1%	15,9%	16,8%	17,6%	18,5%	19,4%	20,2%	41	2,33
42	11,6%	12,5%	13,3%	14,2%	15,0%	15,9%	16,8%	17,6%	18,5%	19,3%	20,2%	42	2,33
43	11,6%	12,5%	13,3%	14,2%	15,0%	15,9%	16,7%	17,6%	18,5%	19,3%	20,2%	43	2,33
44	11,6%	12,4%	13,3%	14,2%	15,0%	15,9%	16,7%	17,6%	18,4%	19,3%	20,2%	44	2,33
45	11,6%	12,4%	13,3%	14,1%	15,0%	15,9%	16,7%	17,6%	18,4%	19,3%	20,1%	45	2,33
46	11,4%	12,3%	13,1%	14,0%	14,8%	15,7%	16,5%	17,4%	18,2%	19,1%	19,9%	46	2,36
47	11,3%	12,1%	13,0%	13,8%	14,6%	15,5%	16,3%	17,2%	18,0%	18,8%	19,7%	47	2,39
48	11,2%	12,0%	12,8%	13,6%	14,5%	15,3%	16,1%	16,9%	17,8%	18,6%	19,4%	48	2,42
49	11,0%	11,8%	12,7%	13,5%	14,3%	15,1%	15,9%	16,7%	17,6%	18,4%	19,2%	49	2,45
50	11,4%	12,2%	13,1%	13,9%	14,8%	15,6%	16,5%	17,3%	18,2%	19,0%	19,8%	50	2,37
51	11,3%	12,1%	12,9%	13,8%	14,6%	15,4%	16,3%	17,1%	17,9%	18,8%	19,6%	51	2,40
52	11,1%	11,9%	12,8%	13,6%	14,4%	15,2%	16,1%	16,9%	17,7%	18,5%	19,4%	52	2,43
53	11,0%	11,8%	12,6%	13,4%	14,2%	15,0%	15,9%	16,7%	17,5%	18,3%	19,1%	53	2,46
54	10,8%	11,6%	12,4%	13,2%	14,0%	14,8%	15,6%	16,5%	17,3%	18,1%	18,9%	54	2,49
55	10,7%	11,5%	12,3%	13,1%	13,9%	14,7%	15,4%	16,2%	17,0%	17,8%	18,6%	55	2,53
56	10,5%	11,2%	12,0%	12,8%	13,5%	14,3%	15,1%	15,9%	16,6%	17,4%	18,2%	56	2,59
57	10,2%	11,0%	11,7%	12,5%	13,2%	14,0%	14,7%	15,5%	16,3%	17,0%	17,8%	57	2,65
58	10,0%	10,7%	11,4%	12,2%	12,9%	13,7%	14,4%	15,1%	15,9%	16,6%	17,3%	58	2,71
59	9,7%	10,4%	11,2%	11,9%	12,6%	13,3%	14,0%	14,8%	15,5%	16,2%	16,9%	59	2,78
60	8,7%	9,3%	10,0%	10,6%	11,3%	11,9%	12,6%	13,2%	13,8%	14,5%	15,1%	60	3,11
61	8,5%	9,1%	9,7%	10,4%	11,0%	11,6%	12,2%	12,9%	13,5%	14,1%	14,8%	61	3,19
62	8,3%	8,9%	9,5%	10,1%	10,7%	11,3%	11,9%	12,5%	13,1%	13,8%	14,4%	62	3,27
63	8,0%	8,6%	9,2%	9,8%	10,4%	11,0%	11,6%	12,2%	12,8%	13,4%	14,0%	63	3,36
64	7,8%	8,4%	9,0%	9,6%	10,1%	10,7%	11,3%	11,9%	12,5%	13,0%	13,6%	64	3,45
65	7,6%	8,2%	8,7%	9,3%	9,9%	10,4%	11,0%	11,6%	12,1%	12,7%	13,2%	65	3,55
66	7,2%	7,7%	8,3%	8,8%	9,3%	9,9%	10,4%	10,9%	11,5%	12,0%	12,5%	66	3,75
67	6,8%	7,3%	7,8%	8,3%	8,8%	9,3%	9,8%	10,3%	10,8%	11,4%	11,9%	67	3,97
68	6,4%	6,9%	7,4%	7,8%	8,3%	8,8%	9,3%	9,7%	10,2%	10,7%	11,2%	68	4,21
69	6,0%	6,5%	6,9%	7,4%	7,8%	8,3%	8,7%	9,1%	9,6%	10,0%	10,5%	69	4,48
≥70	6,0%	6,4%	6,9%	7,3%	7,7%	8,2%	8,6%	9,1%	9,5%	10,0%	10,4%	70	4,52

A

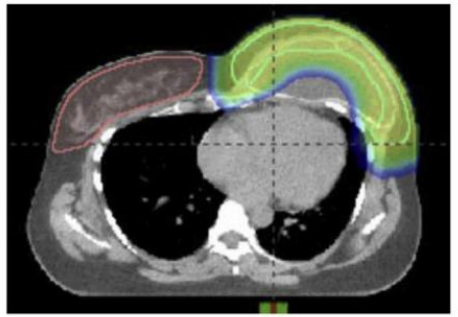
Dose distribution of photon plan (deep inspiration breath hold)

- Mean Heart Dose = 6.0 Gy
- Mean Lung Dose = 6.8 Gy
- Mean Contralateral breast dose = 2.3 Gy



Dose distribution of proton plan (free breathing)

- Mean Heart Dose = 0.1 Gy
- Mean Lung Dose = 3.1 Gy
- Mean Contralateral breast dose = 0.5 Gy



B

Only yellow marked cells are needed as input

Cumulative risk on ACE < 80 years of age	
Gender	female
Age (years)	40
Mean Heart Dose (Gy)	6
Cardiac risk factors	no
NTCP (%)	9,99%

between 40 and 70

between 0 and 10

6,9%

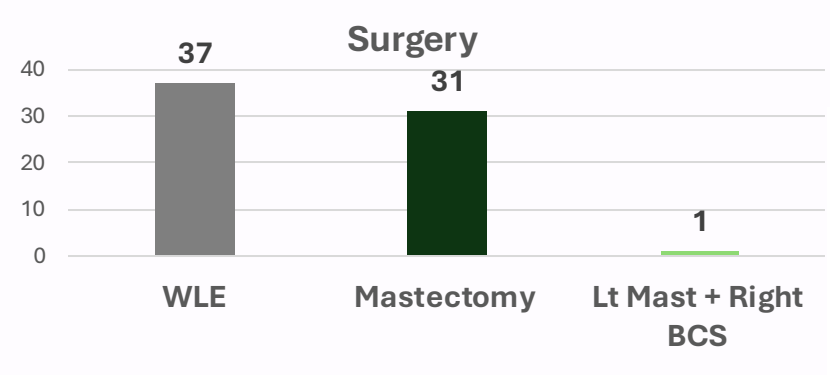
Only yellow marked cells are needed as input

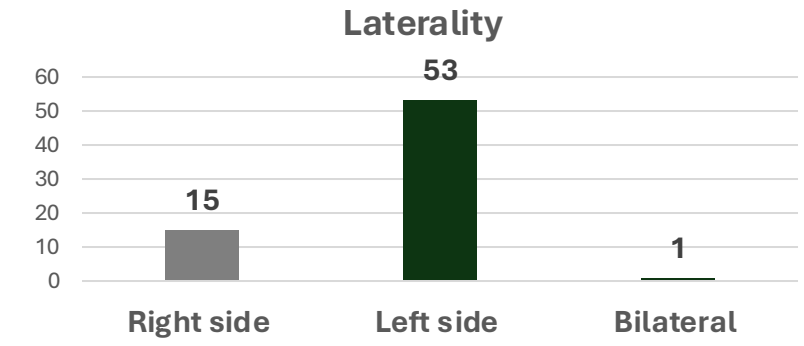
Cumulative risk on ACE < 80 years of age	
Gender	female
Age (years)	40
Mean Heart Dose (Gy)	0,1
Cardiac risk factors	no
NTCP (%)	6,97%

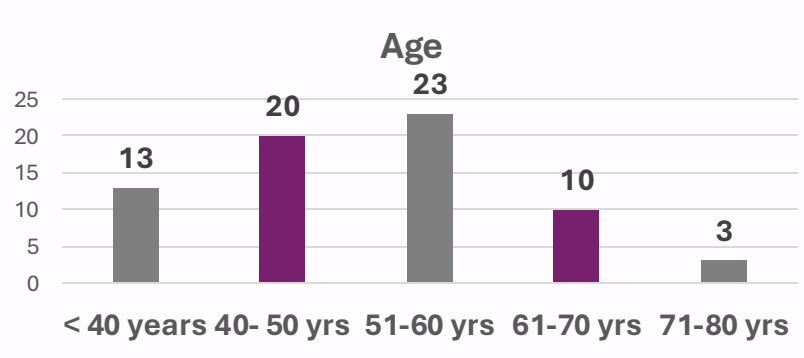
between 0 and 10

DELTA NTCP (%)	3,02%
RESULT	PROTON

Proton Therapy for Breast Cancer @Apollo Proton Cancer Centre, Chennai, India







69 patients analysed , 80 treated

Oncoplasty: 46% BCS patients

Reconstruction : 29% PMRT patients

Regional Nodal Irradiation : 83%

Median Mean Heart Dose : 0.88Gy

Heart and Cardiac Substructure Sparing Intensity-Modulated Proton Therapy for Non-Metastatic Breast Cancer: Real-World Prospective Registry Outcomes

S. Nangia[1], J. Mathew[1], G. Singh[2], T. Anusha[1], A. K. Reddy[1], D. S. Sharma[2], and N. Burela[1]; *[1]Department of Radiation Oncology, Apollo Proton Cancer Centre, Chennai, India, [2]Department of Medical Physics, Apollo Proton Cancer Centre, Chennai, India*

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Proton therapy for reducing heart and cardiac substructure doses in Indian breast cancer patients

Sapna Nangia[1], Nagarjuna Burela[1], M. P. Noufal[2], Kartikeswar Patro[2], Manoj Gulabrao Wakde[2], Dayanada S. Sharma[2]

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Purpose: Indians have a higher incidence of cardiovascular diseases, often at a younger age, than other ethnic groups. This higher baseline risk requires consideration when assessing additional cardiac morbidity of breast cancer treatment. Superior cardiac sparing is a critical dosimetric advantage of proton therapy in breast cancer radiotherapy. We report here the heart and cardiac-substructure doses and early toxicities in breast cancer patients treated post-operatively with proton therapy in India's first proton therapy center.

Materials and Methods: We treated twenty breast cancer patients with intensity-modulated proton therapy (IMPT) from October 2019 to September 2022, eleven after breast conservation, nine following mastectomy, and appropriate systemic therapy, when indicated. The most prescribed dose was 40 GyE to the whole breast/chest wall and 48 GyE by simultaneous integrated boost to the tumor bed and 37.5 GyE to appropriate nodal volumes, delivered in 15 fractions.

Results: Adequate coverage was achieved for clinical target volume (breast/chest wall), i.e., CTV_{40}, and regional nodes, with 99% of the targets receiving 95% of the prescribed dose ($V_{95\%}$ > 99%). The mean heart dose was 0.78 GyE and 0.87 GyE for all and left breast cancer patients, respectively. The mean left anterior descending artery (LAD) dose, LAD $D_{0.02cc}$, and left ventricle dose were 2.76, 6.46, and 0.2 GyE, respectively. Mean ipsilateral lung dose, V_{20Gy}, V_{5Gy}, and contralateral breast dose (D_{mean}) were 6.87 GyE, 14.6%, 36.4%, and 0.38 GyE, respectively.

Conclusion: The dose to heart and cardiac substructures is lower with IMPT than published photon therapy data. Despite the limited access to proton therapy at present, given the higher cardiovascular risk and coronary artery disease prevalence in India, the cardiac sparing achieved using this technique merits consideration for wider adoption in breast cancer treatment.

Keywords: Breast cancer, Pencil beam scanning, Protons, Heart, Proton beam therapy, Toxicity

ENDORSED BY ASCO · Narayana · Apollo · PROTON Cancer Centres

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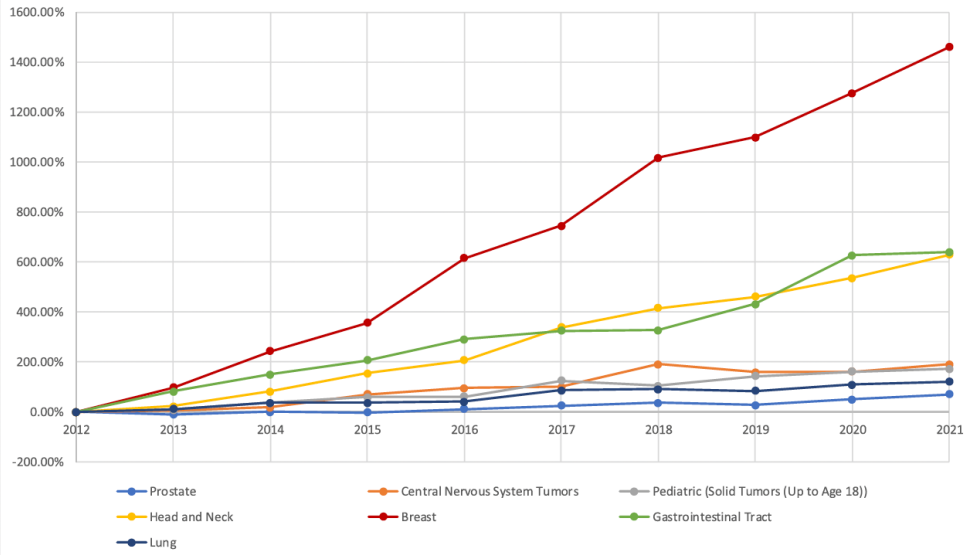
CLINICAL INVESTIGATION

Temporal Evolution and Diagnostic Diversification of Patients Receiving Proton Therapy in the United States: A Ten-Year Trend Analysis (2012 to 2021) From the National Association for Proton Therapy

William F. Hartsell, MD,*† Charles B. Simone, IIMD,‡ Deborah Godes, MBA,§ Jennifer Maggiore, MSW,‖

Increase in Breast Ca -1561%
Number treated in 2021- 1452
Increase in CNS tumours – 291%
Number treated in 2021- 1743

Proportional change in number of patients by diagnosis among the 7 most common diagnoses treat with proton therapy compared to baseline year (2012)



Future direction

Widening application

Clinical and Translational Radiation Oncology 48 (2024) 100847

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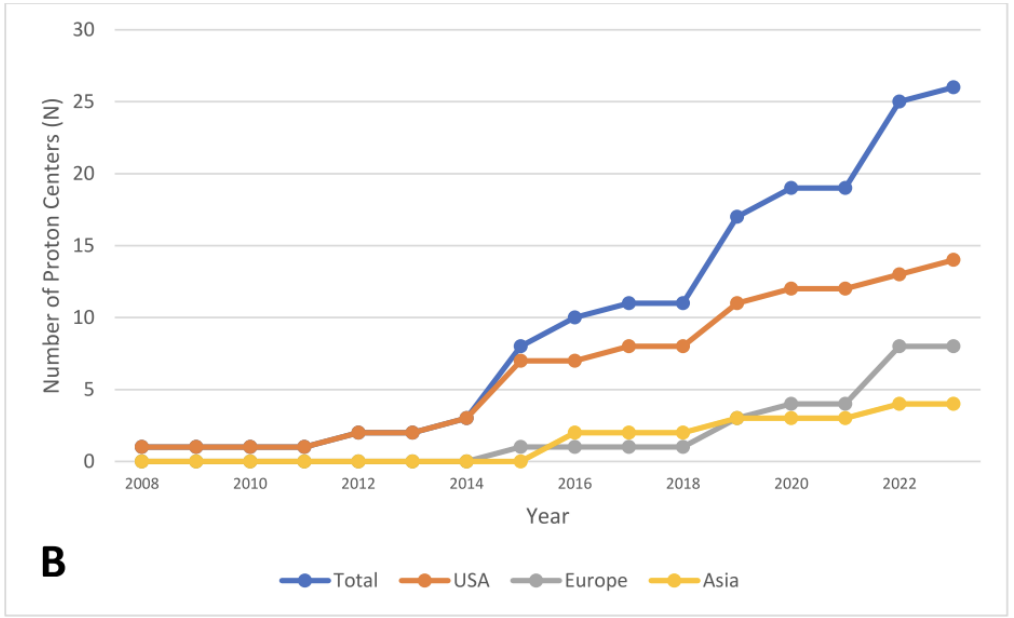
journal homepage: www.sciencedirect.com/journal/clinical-and-translational-radiation-oncology

Original Research Article

PTCOG international survey of practice patterns and trends in utilization of proton therapy for breast cancer

J. Isabelle Choi [a,b,*], Camille Hardy-Abeloos [c], Alicia Lozano [d], Alexandra Hanlon [d],



Access
Upright treatment
Ultrahypofractionation with sequential or simultaneous integrated boost

Thank you