Simultaneous Integrated Boost vs. Sequential Boost in Breast Cancer Radiotherapy: A Comprehensive Analysis of Dosimetric, Radiobiological, and Cost-Effectiveness

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Outline

Breast Cancer & Radiotherapy Context
Overview of breast cancer as a global health issue and the role of radiotherapy.

Methodology
Study design, patient cohort, and treatment planning for comparing SIB and SeqB.

Dosimetric Analysis
Comparison of target coverage and organ-at-risk sparing between techniques.

Radiobiological Assessment
Evaluation of tumor control and normal tissue complication probabilities.

Cost-Effectiveness Evaluation
Analysis of treatment costs, resource utilization, and patient benefits.

Conclusion
Summary of findings and implications for breast cancer radiotherapy.

“Asia is rich in people, rich in culture, and rich in resources. It is also rich in trouble”

Hubert H. Humphrey

American politician and pharmacist & the 38th vice president of USA

Breast Cancer: A Global Public Health Concern

5TH BBCC
BANGLADESH BREAST CANCER CONFERENCE 2025

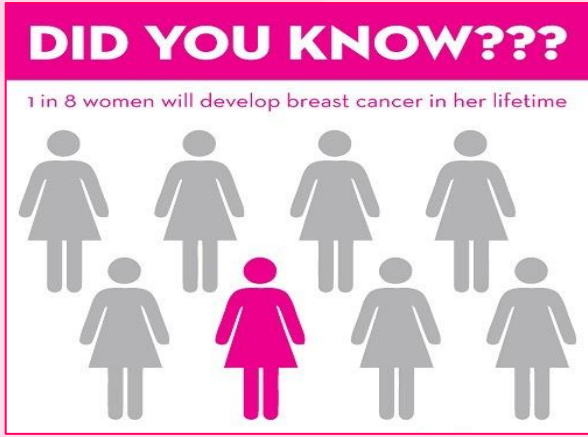
Breast cancer: a major global health issue and top cause of cancer deaths in women.

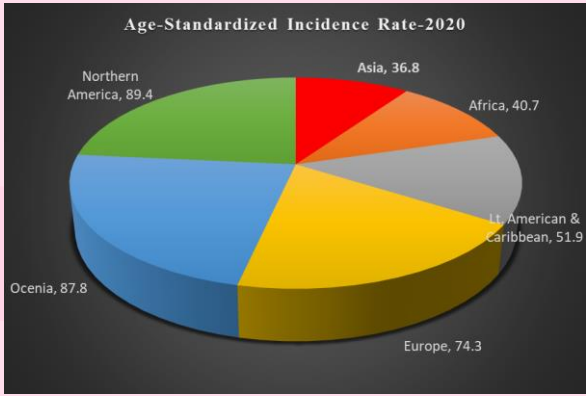
Almost half (45.4%) of breast cancer patients are in Asia.

Over 13,000 women diagnosed annually with over 7,000 deaths (IARC data).

Bangladesh has one of Asia's highest breast cancer rates.

Highest Prevalence Rate: 19.3 per 100,000 among young women aged 15 to 44





Precision and Priority: The Indispensable Role of Radiotherapy in Cancer Care

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- Radiation therapy is an integral part of the treatment of breast cancer.
- Radiotherapy reduces local recurrence by 50–70% post-surgery.
- Tumor bed boost further lowers recurrence risk (5–10% absolute benefit).
- Proven to reduce local recurrence and risk of death from breast cancer.

Breast Cancer Boost Radiotherapy – Why It Matters

Development of refined surgical techniques has made breast-conserving surgery (BCS) the most common approach, preserving breast anatomy while minimizing deformity.

With 70-90% of local recurrences occurring at the original tumor site, a focused high-dose boost to the tumor bed eradicates microscopic residual disease.

Boost radiotherapy reduces the 10-year local recurrence risk from 10% to 6% (40% relative risk reduction

Two types of radiotherapy boosts are available

Source: Early Breast Cancer Trialists' Collaborative Group (EBCTCG) Meta-Analysis, 2021.

Boost Strategies Overview: SeqB

Traditional sequential tumor bed boost (40/42.46 Gy whole breast → 10-16 Gy per boost).

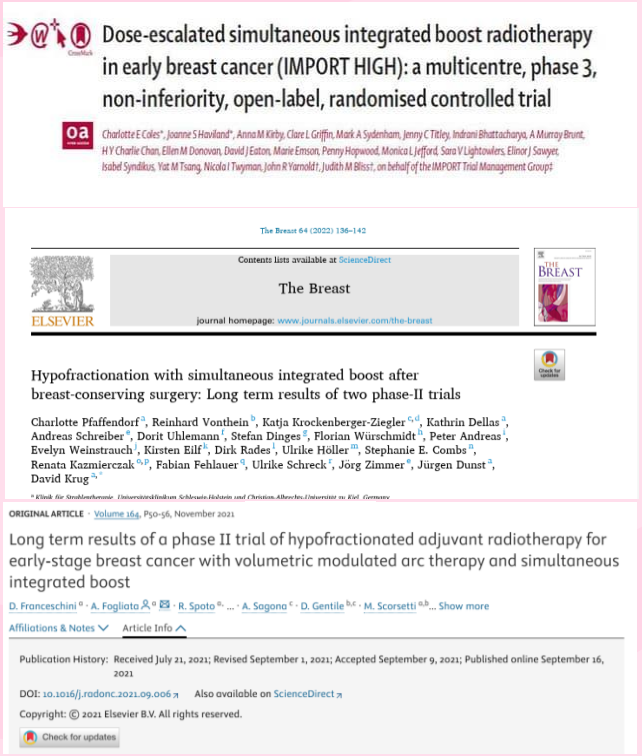
Delivers a sequential boost after whole-breast irradiation, typically in 5–8 additional sessions.

Pros: Simpler planning, widely accessible.

Cons: Prolonged treatment, potential for dose overlap in OARs.

Boost Strategies Overview: SIB

- **Simultaneous integrated boost** (53/48 Gy tumor bed + 40 Gy whole breast in 15 fractions).
- Delivers a higher dose to the tumor bed simultaneously with whole-breast irradiation in a single plan.
  - ***Pros*:** Shorter treatment duration, reduced patient burden & optimized OAR sparing.
  - ***Cons*:** Requires advanced planning (e.g., IMRT/VMAT) to avoid hotspots.



Dose-escalated simultaneous integrated boost radiotherapy in early breast cancer (IMPORT HIGH): a multicentre, phase 3, non-inferiority, open-label, randomised controlled trial

Charlotte E Coles*, Joanne S Haviland*, Anna M Kirby, Clare L Griffin, Mark A Sydenham, Jenny C Titley, Indrani Bhattacharya, A Murray Brunt, H Y Charlie Chan, Ellen M Donovan, David J Eaton, Marie Emson, Penny Hopwood, Monica L Jefford, Sara V Lightowlers, Elinor J Sawyer, Isabel Syndikus, Yat M Tsang, Nicola I Twyman, John R Yarnold†, Judith M Bliss†, on behalf of the IMPORT Trial Management Group‡

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Hypofractionation with simultaneous integrated boost after breast-conserving surgery: Long term results of two phase-II trials

Charlotte Pfaffendorf, Reinhard Vonthein, Katja Krockenberger-Ziegler, Kathrin Dellas, Andreas Schreiber, Dorit Uhlemann, Stefan Dinges, Florian Würschmidt, Peter Andreas, Evelyn Weinstrauch, Kirsten Eilf, Dirk Rades, Ulrike Höller, Stephanie E. Combs, Renata Kazmierczak, Fabian Fehlauer, Ulrike Schreck, Jörg Zimmer, Jürgen Dunst, David Krug

ORIGINAL ARTICLE · Volume 164, P50-56, November 2021

Long term results of a phase II trial of hypofractionated adjuvant radiotherapy for early-stage breast cancer with volumetric modulated arc therapy and simultaneous integrated boost

D. Franceschini · A. Fogliata · R. Spoto · ... · A. Sagona · D. Gentile · M. Scorsetti ... Show more

Affiliations & Notes · Article Info

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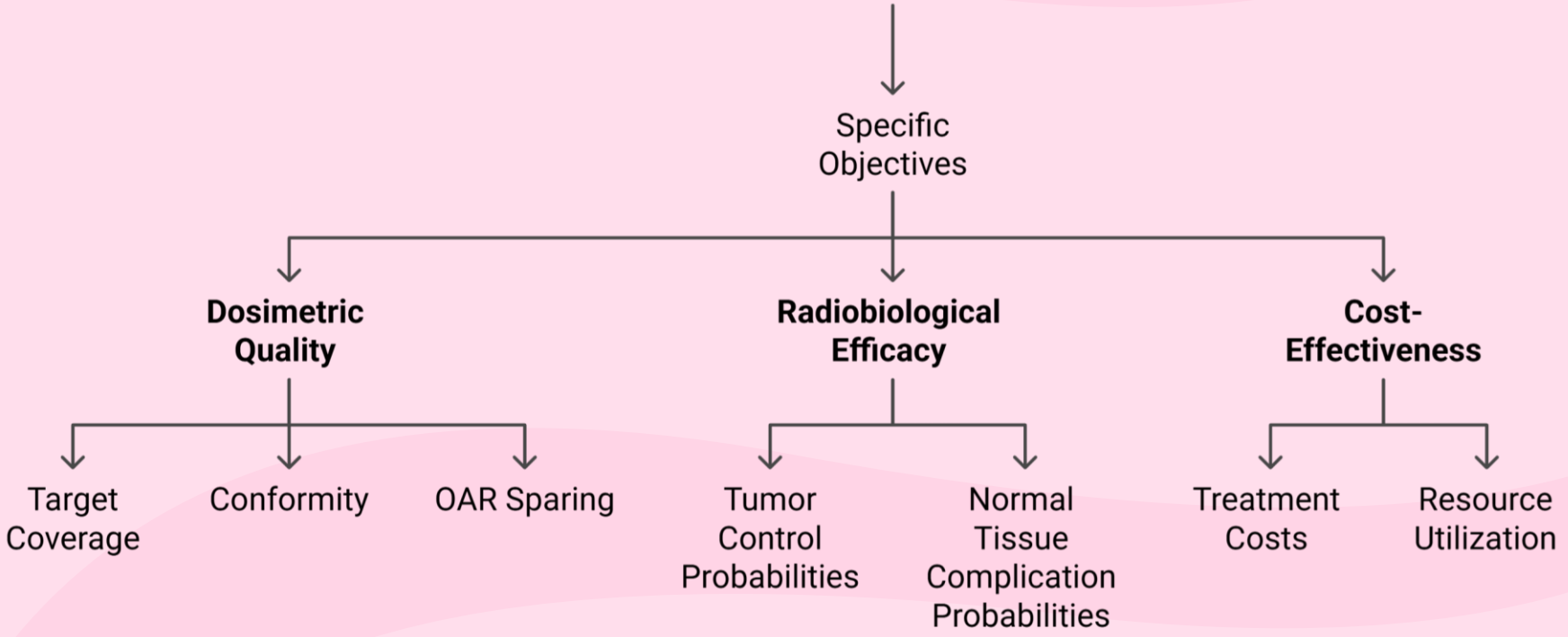
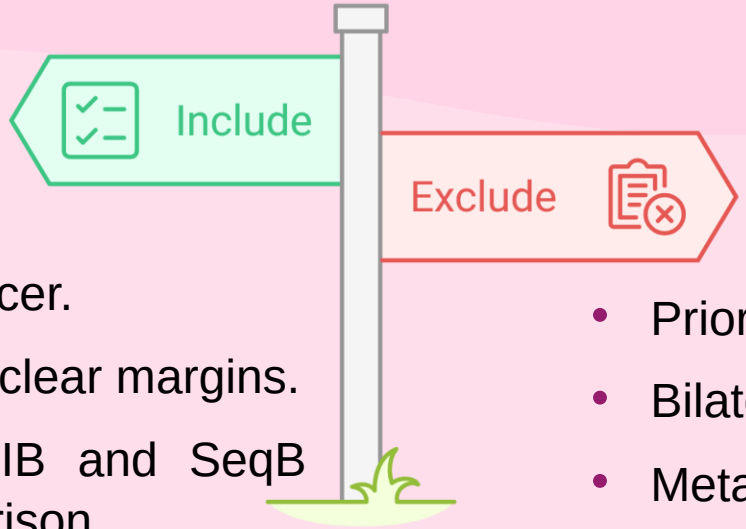
Objectives

Purpose:
Compare SIB and SeqB Techniques



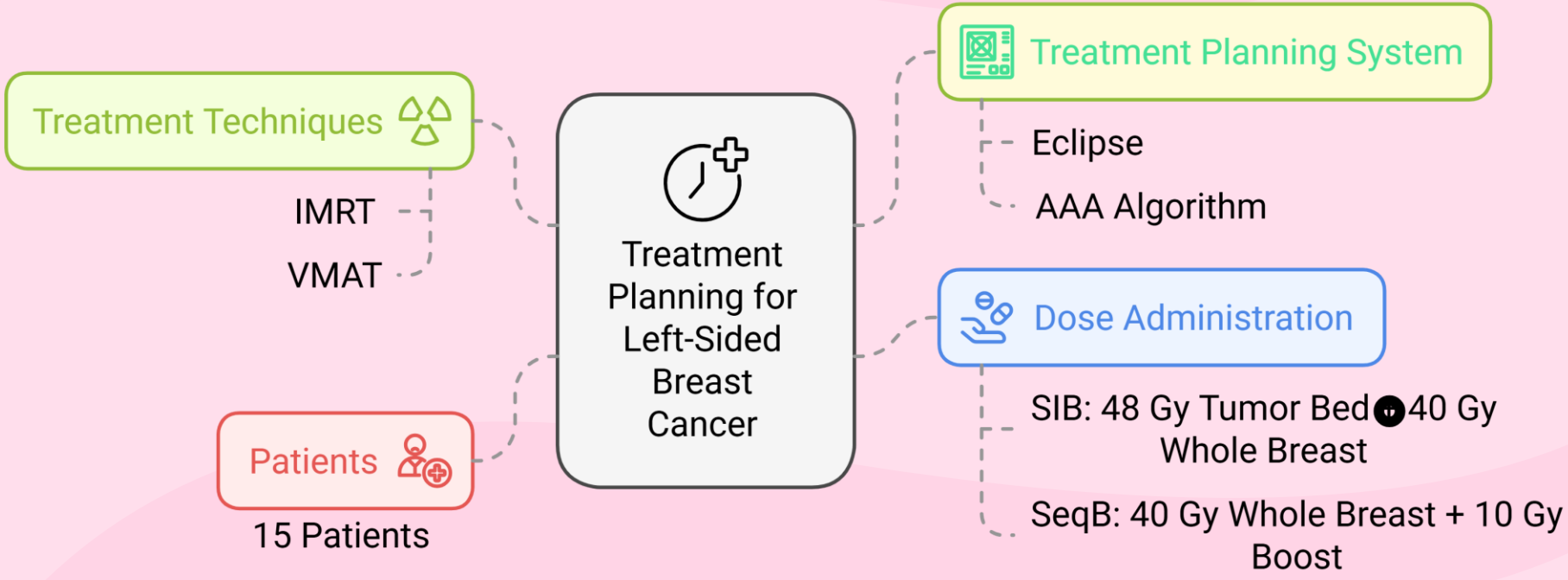
Determine participant eligibility for the study



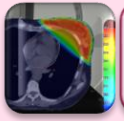
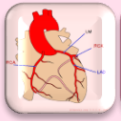
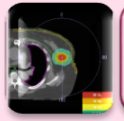
- Early-stage breast cancer.
- Post-lumpectomy with clear margins.
- Availability of both SIB and SeqB plans for direct comparison.
- Dosimetric Data for PTV and OARs.

- Prior Radiotherapy
- Bilateral Cancer
- Metastatic Disease
- Incomplete Data
- Reconstruction
- Non-Standard Protocol

Methodology – Patient Cohort



Plan Evaluation

Target Volume	OAR
 ≥ 95% of the breast PTV will receive ≥ 95%	 Heart: Mean ≤4 Gy
 Under dose to any part of PTV shall not exceed 93% of prescription dose.	 Ipsilateral Lung: V20 <20%
 Overdose to any part of PTV shall not exceed ~~115%~~ 110% of prescription dose.	 LAD: Mean (As low as possible)
 Volume covered by 107% of isodose line should be less than 2cc.	 Contralateral Lung: : Mean≤ V2
	 Contralateral Breast: Mean≤ V2

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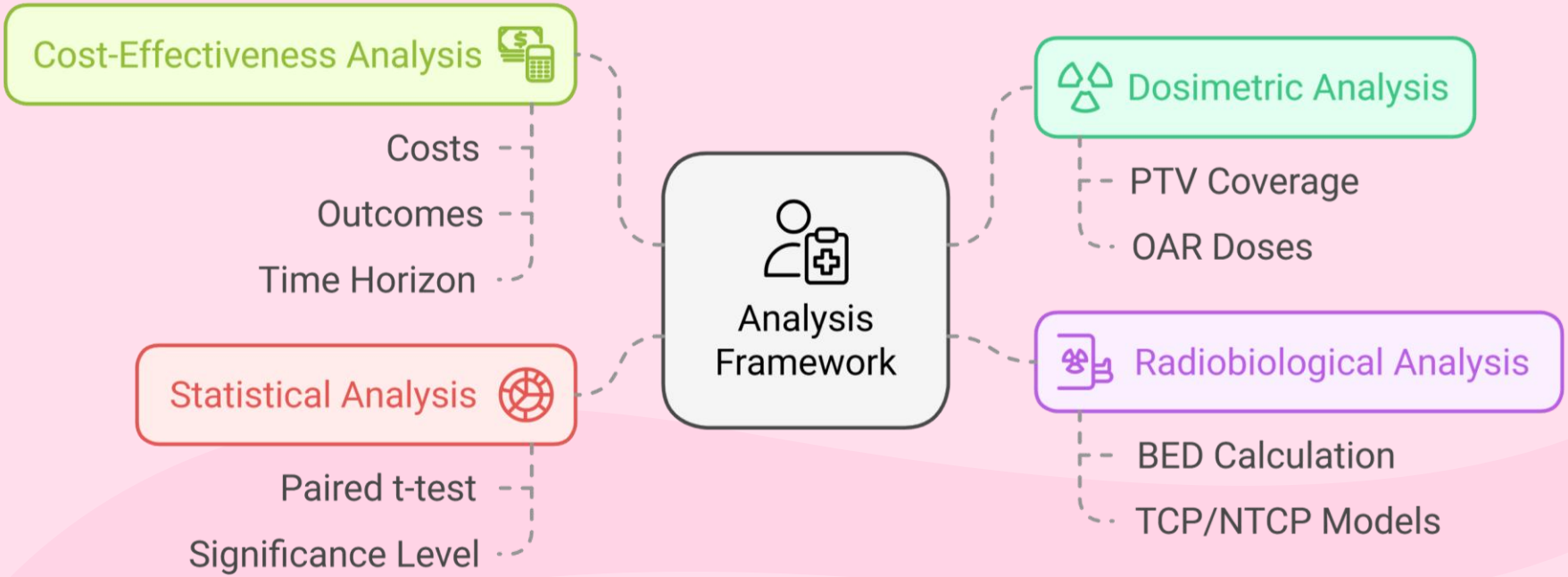
Comprehensive Analysis Framework for Treatment Plans



Methods - Radiobiological Assessment

- **Biologically Effective Dose (BED):**
  - α/β ratios:
    - Tumor: 4 (breast cancer).
    - Organs-at-risk: 3 (heart and lungs).

$$BED = \frac{E}{\alpha} = D \cdot \left(1 + \frac{d}{(\alpha / \beta)}\right)$$

- **Tumor Control Probability (TCP):**
  - Estimated using the Poisson model based on BED.

Poisson LQ Model:

$$\mathrm{TCP} = \exp\left(-N_0 \cdot \exp\left(-\alpha \cdot \mathrm{BED}\right)\right)$$

- **Normal Tissue Complication Probability (NTCP):**

  Lyman-Kutcher-Burman Model

Lyman-Kutcher-Burman (LKB) Model:

$$\mathrm{NTCP} = \frac{1}{\sqrt{2\pi}} \int_{-\infty}^{t} e^{-x^2/2} dx, \quad t = \frac{\mathrm{EUD} - \mathrm{TD}_{50}}{m \cdot \mathrm{TD}_{50}}$$

Results

Dosimetric Analysis of PTV

Parameter	SIB (Mean)	SeqB (Mean)	P- Value
V95% (%)	98.97	99.33	0.09
CI	1.128	1.128	0.995
Max Dose (Gy)	105.46	108.27	0.004
Monitor Units (MU)	890.22 ± 57.33	1387.11 ± 146.2	<0.0001

Organs at Risk (OARs)

Ipsilateral Lung

Parameter	SIB (Mean ± SD)	SeqB (Mean ± SD)	Difference (%)	p-value
V20 (%)	13.42 ± 3.5	14.38 ± 4.0	-6.68%	0.03
V8 (%)	36.99 ± 10.5	38.29 ± 11.0	-3.40%	0.05
V4 (%)	64.37 ± 20.0	65.73 ± 20.5	-2.07%	0.15

Heart

Parameter	SIB (Mean ± SD)	SeqB (Mean ± SD)	Difference (%)	p-value
D5 (Gy)	8.05 ± 1.68	8.52 ± 2.01	-5.52%	0.425
D30 (Gy)	3.82 ± 0.8	3.97 ± 0.9	-3.78%	0.15
Mean Dose (Gy)	3.50 ± 0.8	3.78 ± 0.9	-2.91%	0.05

Organs at Risk (OARs)

Contralateral Lung

Parameter	SIB (Mean ± SD)	SeqB (Mean ± SD)	Difference (%)	p-value
Mean Dose (Gy)	2.77 ± 0.9	2.85 ± 0.9	-2.81%	0.15

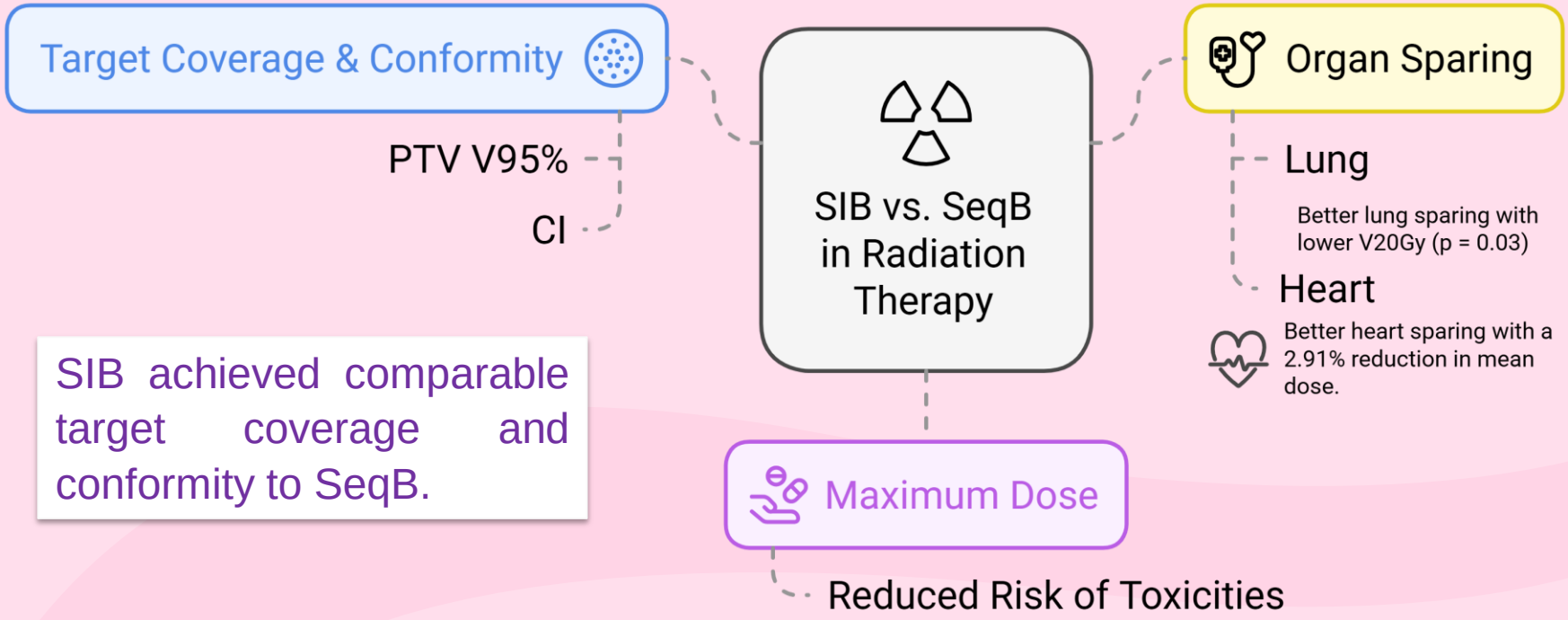
Contralateral Breast

Parameter	SIB (Mean ± SD)	SeqB (Mean ± SD)	Difference (%)	p-value
Mean Dose (Gy)	2.14 ± 1.5	2.45 ± 1.6	-8.99%	0.03

Radiobiological Analysis: Statistical Comparison

Metric	SIB	Seq	Difference	p-Value
Tumor Bed BED (Gy_4)	86.4	81.7	+4.7	<0.001
Whole Breast BED	66.7 Gy_4	66.7 Gy_4	NA	NA
TCP (%)	93.2%	89.6%	+3.6	0.01
TB Normal BED (Gy_3)	96	92.27	+3.73	0.004
NTCP Heart (%)	0.14%	0.18%.	-0.04%	*0.05*
NTCP Lung (%)	2.7 ± 1.5	3.0 ± 2	+0.3	0.57

Discussion - Dosimetric Advantages of SIB



SIB achieved comparable target coverage and conformity to SeqB.

Discussion – Radiobiological Implications

Tumor Control Probability

SIB shows a significant advantage in tumor control probability compared to SeqB.

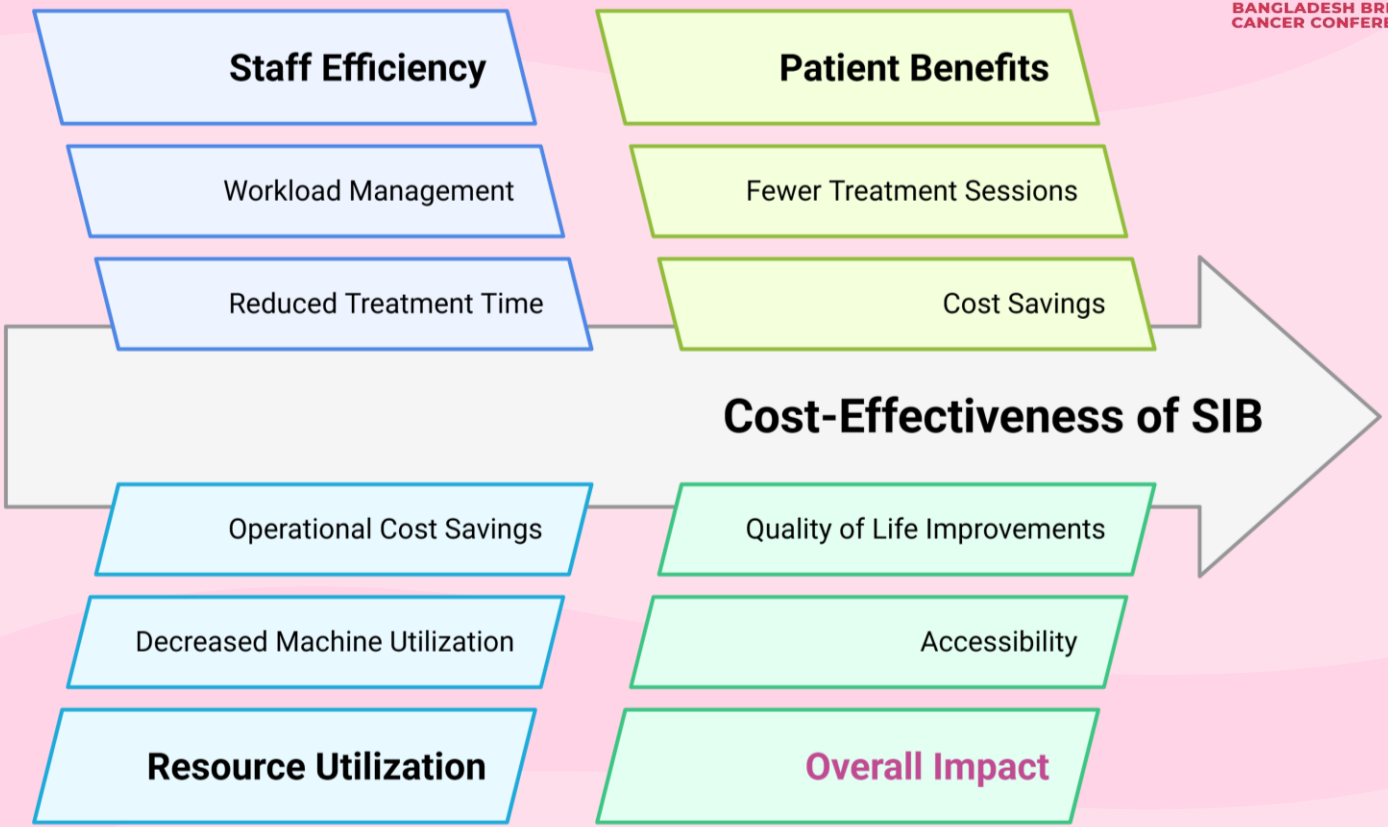
SIB demonstrates lower risk for lung complications, protecting normal tissues effectively.

Normal Tissue Protection

Long-Term Outcomes

The benefits of SIB may lead to improved long-term patient survival and control.

Discussion – Cost-Effectiveness



Discussion: IMPORT HIGH Trial

- IMPORT HIGH is the largest randomised study of SIB, increasing precision of confidence limits for study outcomes.
- Simultaneous integrated boost in IMPORT HIGH was safe and reduced patient visits.
- Moderate or marked late normal tissue adverse events were low across all assessments, with no significant differences between trial groups.
- Increasing the boost dose beyond a higher equivalent dose in 2Gy fractions of around 60 Gy causes increased fibrosis with no benefit.

Conclusion

SIB Advantages: Precision dosimetry, shorter treatment, and cost savings. Ideal for tech-enabled centers.

SeqB Strengths: Simplicity, adaptability, and lower fractional doses. Preferred in resource-limited settings.

C**linical Recommendation:** Adopt SIB where feasible; retain SeqB for high cardiac-risk cases or institutional constraints.

Research Imperative: Prioritize long-term toxicity data and cost models for LMICs.

Takeaway Message

In the BCS era, SIB integrates innovation for modern radiotherapy: Optimize outcomes where technology allows. SeqB remains a pragmatic fallback for equitable care.

SIB maximizes tumor control (↑TCP) while minimizing toxicity (↓NTCP) through radiobiologically optimized dosing, balancing efficacy and safety in breast cancer radiotherapy.

Choose SIB for breast cancer boost—save 33% cost per patient, reduce treatment by 5 days, and optimize resources while enhancing outcomes.

Thank You

Alone we can do so little; together we can do so much.
– Helen Keller

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