Dosimetric Comparison of HDR Interstitial Brachytherapy and SBRT as Alternative Treatment Methods for Advanced-Stage Cervical Cancer

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STUDY AT A GLANCE

18 Patients (n)

III–IVA Stage

28 Gy / 4 fx (both arms) Boost dose

Retrospective, single-institution Design

1 Introduction

- Cervical cancer caused an estimated 604,000 new cases and 342,000 deaths globally in 2020, with the greatest burden in low-resource settings.
- Locally advanced cervical cancer (LACC, FIGO IIB–IVA) is treated with EBRT + concurrent cisplatin followed by a brachytherapy boost — the established standard of care.
- Image-guided HDR interstitial brachytherapy (HDR-IBT) delivers highly localized dose escalation with rapid fall-off near OARs, but requires specialized applicators, anesthesia, and a trained multidisciplinary team.
- Stereotactic body radiotherapy (SBRT) has emerged as a non-invasive alternative boost with steep dose gradients, but its ability to reproduce brachytherapy-like heterogeneity is unproven.
- Global infrastructure data (IAEA DIRAC) show LINAC teletherapy is roughly 4× more available worldwide than HDR brachytherapy — nearly half of centers offer no brachytherapy service at all.

PURPOSE

To retrospectively compare the dosimetric performance of Syed-template HDR-IBT and SBRT boost plans for LACC patients, and to evaluate SBRT's potential as a non-invasive alternative when brachytherapy is not feasible.

IMAGE-GUIDED HDR-IBT vs. SBRT

- HDR-IBT: intracavitary/interstitial needles placed via Syed–Neblett template; steep, heterogeneous dose fall-off.
- SBRT: external-beam VMAT delivery; highly conformal but more homogeneous dose distribution.

2 Methods

PATIENT COHORT (n = 18)

Characteristic	Value
Median age (range)	49 y (34–67)
Stage IIIB / IIIC1 / IIIC2 / IVA	2 / 9 / 5 / 4 pts
EBRT dose	45 Gy ± nodal boost (55–57.5 Gy)
Syed HDR-IBT dose	28 Gy / 4 fx (100%)
Median CTV_HR / CTV_IR	43.5 cc / 107.6 cc
Concurrent chemo (cisplatin)	14 / 18 (78%)

SYED HDR-IBT PLANNING

- Needles placed via Syed–Neblett template under anesthesia; CT/MRI fusion for GTV, CTV_HR, CTV_IR, and OAR contouring.
- TG-43 planning in BrachyVision; EQD2 (α/β = 10 tumor, 3 OAR) combines EBRT + brachytherapy dose.
- EMBRACE-II–based goals: CTV_HR D90 target ≈ 85–90 Gy EQD2 cumulative.

SBRT PLANNING

- Syed CT rigidly fused to EBRT CT; CTV_HR, CTV_IR, and OAR contours copied over.
- 3-mm margin added to CTV_HR → PTV_SBRT.
- 4-arc VMAT (RayStation, Monte Carlo dose engine); 28 Gy/4 fx prescribed to D95 of PTV_SBRT, using patient-specific goals mirroring Table 2.

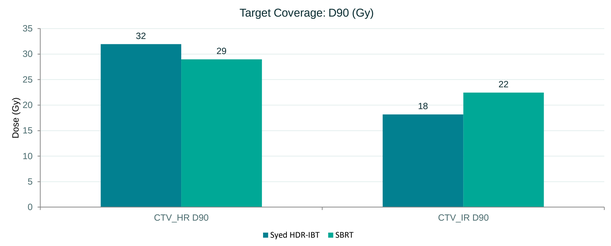
STATISTICAL ANALYSIS

- Wilcoxon signed-rank test (two-sided), significance at $p < 0.05$.
- Linear mixed-effects models (random patient intercept) tested whether CTV_HR / CTV_IR volume modified the treatment effect.

3 Results

CTV_HR D90
32.0 vs 29.0 Gy
Syed > SBRT ($p < 0.001$)

CTV_IR D90
22.5 vs 18.2 Gy
SBRT > Syed ($p < 0.001$)



CONFORMITY & HOMOGENEITY

- SBRT: higher conformity index (CI 0.7 vs 0.5) and lower homogeneity index (HI 1.2 vs 3.4) for CTV_HR — more homogeneous, less "hot-spot" dose (both $p < 0.001$).
- Syed: greater dose heterogeneity and steeper fall-off — desirable for the boost given OAR proximity.

ORGAN-AT-RISK DOSE (mean ± SD, cGy)

OAR / Metric	Syed	SBRT	p
Bladder mean	920 ± 226	1108 ± 281	**<0.001**
Bladder max	3809 ± 948	3063 ± 286	**<0.001**
Bowel D2cc	798 ± 438	1019 ± 664	**0.04**
Rectum D2cc	1636 ± 288	1515 ± 264	**0.04**
Sigmoid D2cc	1528 ± 299	1557 ± 323	0.67

4 Discussion

- Syed HDR-IBT retains superior CTV_HR coverage and the steep spatial dose gradients that underlie brachytherapy's strong local-control record (e.g., >90% 5-yr local control in EMBRACE-I).
- SBRT achieved better CTV_IR coverage and comparable OAR sparing, with a more homogeneous dose distribution — but does not fully replicate brachytherapy's dose heterogeneity.
- No significant treatment × volume interaction was found for CTV_HR or CTV_IR, though outcome literature still links larger tumors to greater benefit from interstitial technique.
- Global infrastructure gaps (fewer HDR units than LINACs, especially in LMICs) and strict chemoradiation timelines (≈49–56 days) support considering SBRT when brachytherapy access or timing is a barrier.
- SBRT may suit smaller, well-defined HR-CTVs; bulky or parametrially extensive disease still favors interstitial HDR-IBT.

CONCLUSION

HDR-IBT remains superior for CTV_HR dose escalation, but SBRT achieves acceptable coverage and OAR sparing — a practical option when brachytherapy is not feasible. Prospective trials are needed to optimize SBRT planning and define patient-selection criteria.

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Acknowledgement: Supported by the American Cancer Society (RSG-22-030-01-CTPS).

Conflicts of interest: None declared.

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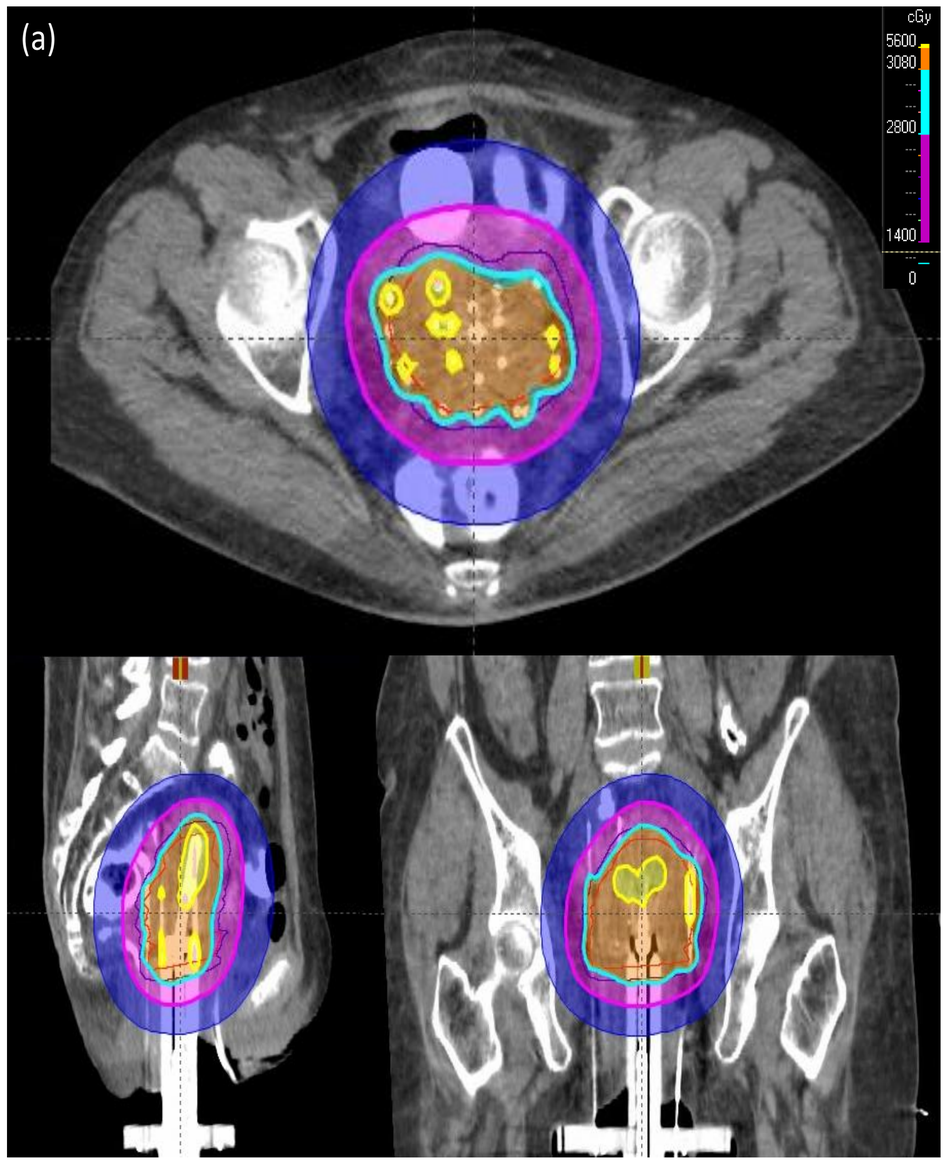

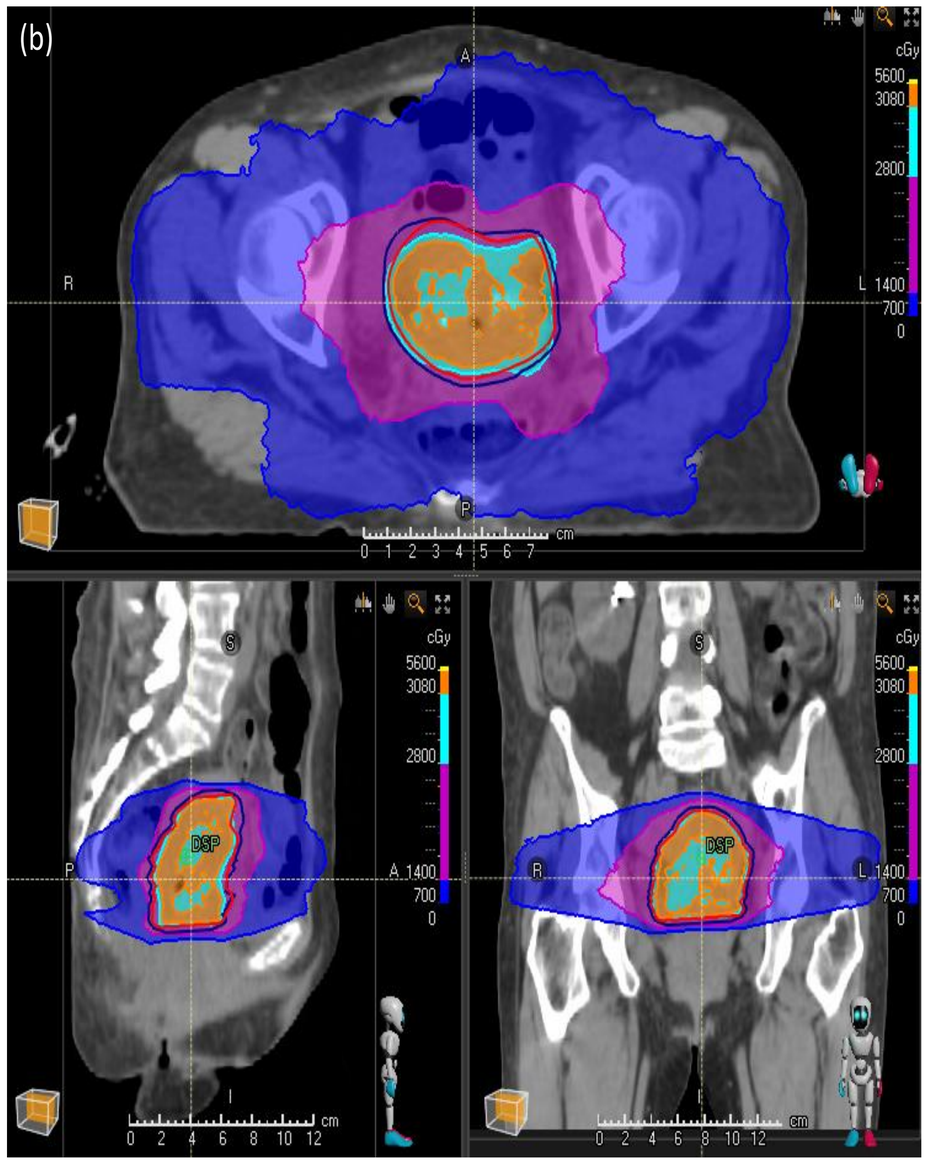

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