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HIRSLANDEN
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Quality Assessment of Automatically Planned O-ring Linac SBRT Plans for Pelvic Lymph Node and Lung Metastases. Evaluating the optimal minimum target size

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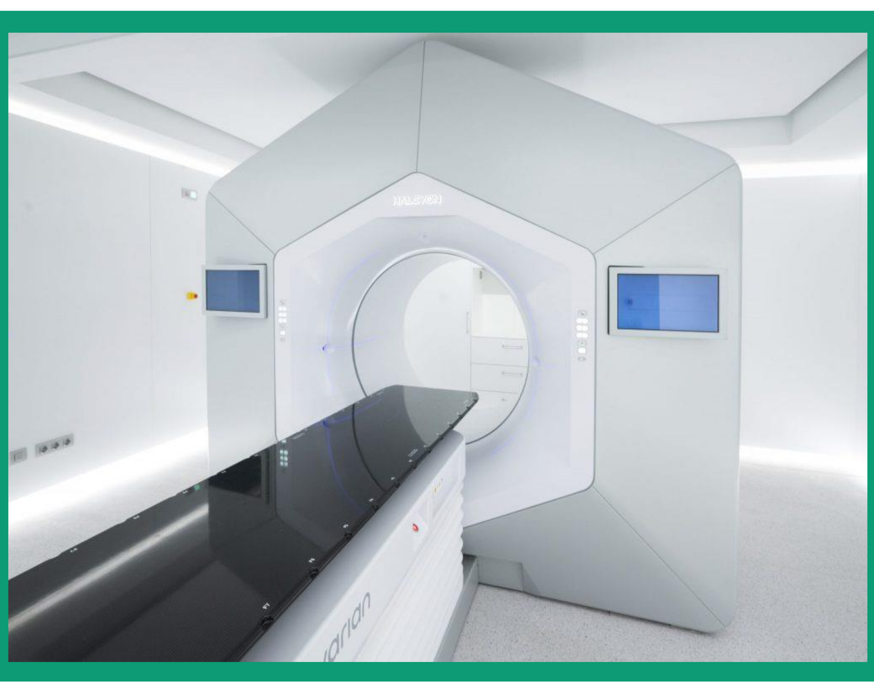
SUMMARY



GOAL: assessing the influence of Planning Target Volume (PTV) on the quality of automatic planned O-ring Halcyon linac stereotactic body radiation therapy (SBRT) plans of pelvic lymph node and lung metastases and evaluating an absolute PTV volume threshold as a plan quality prediction criterion.

SAMPLE

18 SBRT lung plans
+
21 SBRT pelvic Lymph Node (LN) plans
↓
Automatically replanned for Halcyon (HAL)

METHODS

Plan quality evaluation
↓
By using indices for:
- Conformity
- Coverage
- Dose fall-off

Plan quality improvement threshold
↓
K-means
+
Mann-Whitney U tests

RESULTS

- Plans met tolerance criteria
- Found quality improvement threshold for HAL plans

↓
4.0 cm³ PTV

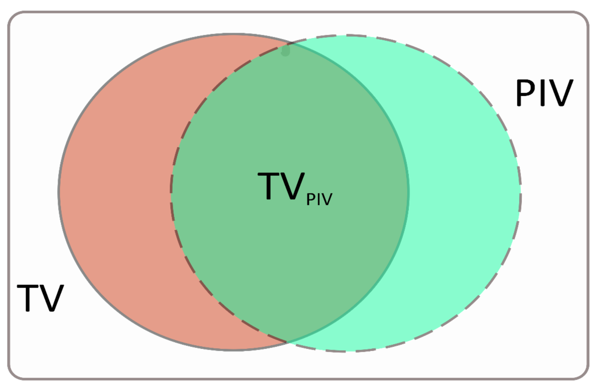
MATERIAL & METHODS

Sample:

- ✓ Patients: 21 SBRT pelvic LN & 18 lung SBRT treatment plans replanned in HAL
- ✓ Prescription dose: 7.5 - 13 Gy (LN) and 10 - 18 Gy (lung) in 3-fractions
- ✓ %Prescription isodose: 66 - 75% (LN) & 65.7 - 70% (lung)
- ✓ Mean PTV 4.0 cm³ (range: 1.1 - 10.7 cm³) for LN and 4.9 cm³ (range: 1.0 - 17.1 cm³) for the lung

The quality of the HAL plans is assessed by:

✓ **Dose metrics:**



- NCI = $\frac{TV}{TV_{PIV}}$*spillage → Conformity, Coverage, Dose fall-off
- CI = $\frac{PIV}{TV}$ → Conformity
- MGI = $\frac{PIV_{50\%}}{TV_{PIV}}$ → Dose fall-off
- Spillage = $\frac{PIV}{TV_{PIV}}$ → Dose fall-off
- %PIV → Coverage

TV: Target Volume; PIV: Prescription Isodose Volume; TV_{PIV} :TV∩PIV; NCI: New Conformity Index; CI: Conformity Index; MGI: Modified Gradient Index

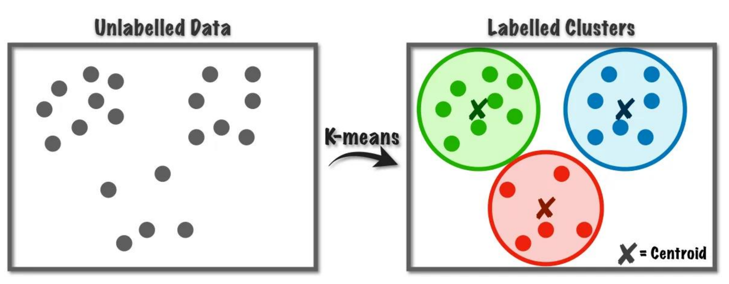
✓ **NTCP evaluation Lymann model:**

$$EUD = \left(\sum_i v_i D_i^{1/n}\right)^n \rightarrow t = \frac{EUD - TD_{50}}{m\, TD_{50}} \rightarrow NTCP = \frac{1}{\sqrt{2\pi}}\int_{-\infty}^{t} e^{-\frac{x^2}{2}} dx$$

EUD: equivalent uniform dose; TD_{50}: the tolerance dose at which NTCP after irradiation of a reference volume is 50%; *m*: the slope of the NTCP curve; (D_i, v_i): bins of a differential DVH; *n*: indicates serial/parallel nature of the structure.

The HAL *quality* PTV threshold was found by using:

✓ **K-means:**



→ *Best* threshold ≡ $\overline{PTV_1} + 2\sigma_1$

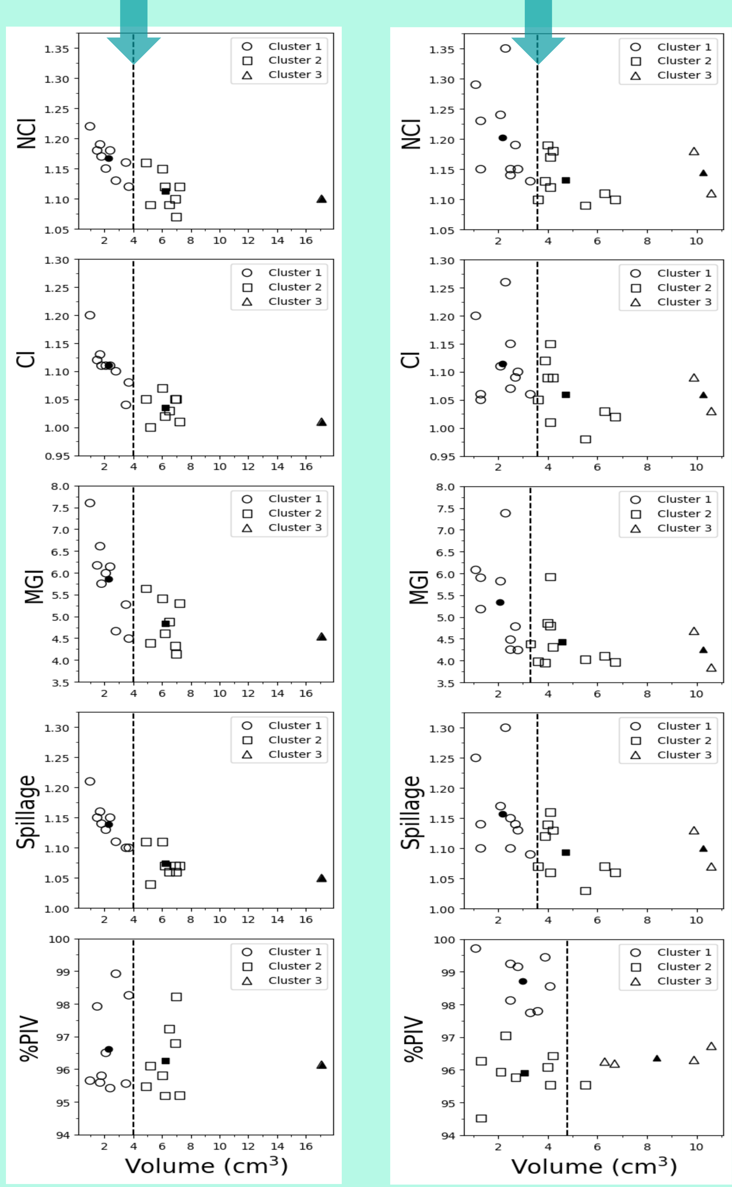
Properties of cluster i :
* $\overline{PTV_i}$: centroid i
* σ_i: standard deviation i

✓ **Mann-Whitney U test:** a set of these tests were performed taking the PTV values in the PTV sample range as test threshold. The PTV volumes with significant outcome were called: *significant* thresholds

Quality threshold ≡ best threshold ∩ significant threshold

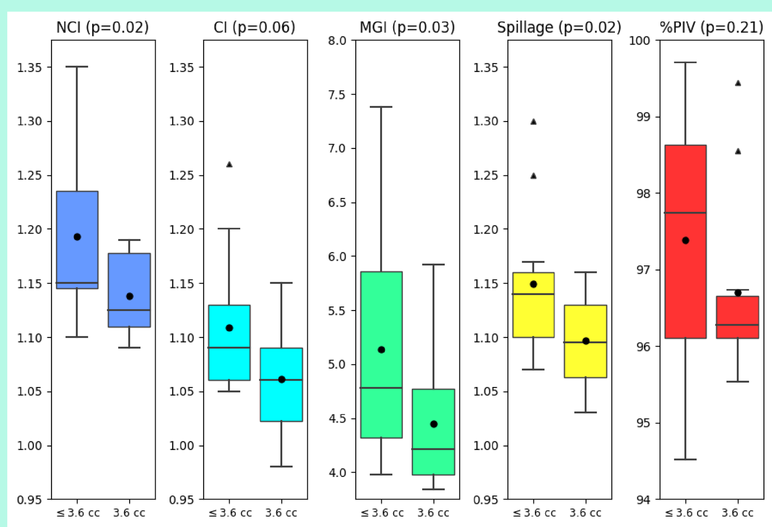
From **K-means analysis**: a systematic PTV threshold is obtained in most dosimetric indices of both groups of plans, 3.6 cm³ for pelvic LN and 4.0 cm³ for lung plans.

***Best* threshold** for each dose index:

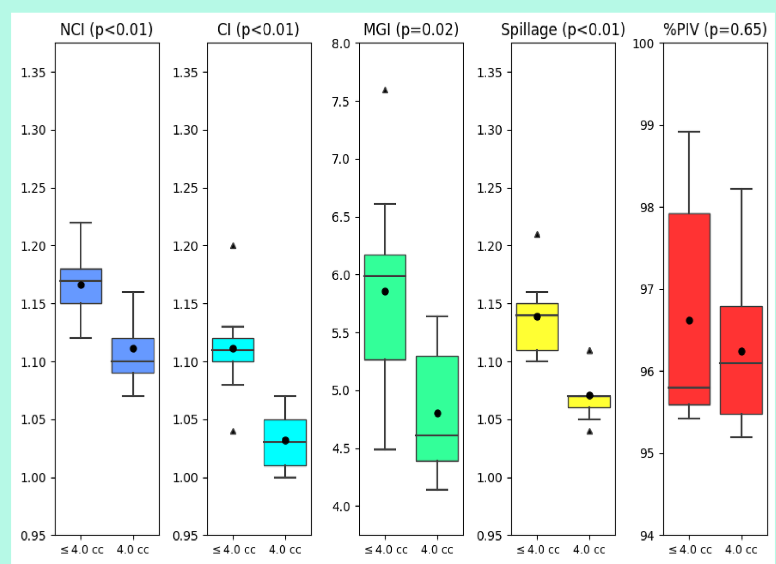


Among the set of **Mann-Whitney tests** that were significantly different having the PTV as threshold, 3.6 cm³ and 4.0 cm³ PTV thresholds for pelvic LN and lung plans respectively, were contained.

Pelvic LN



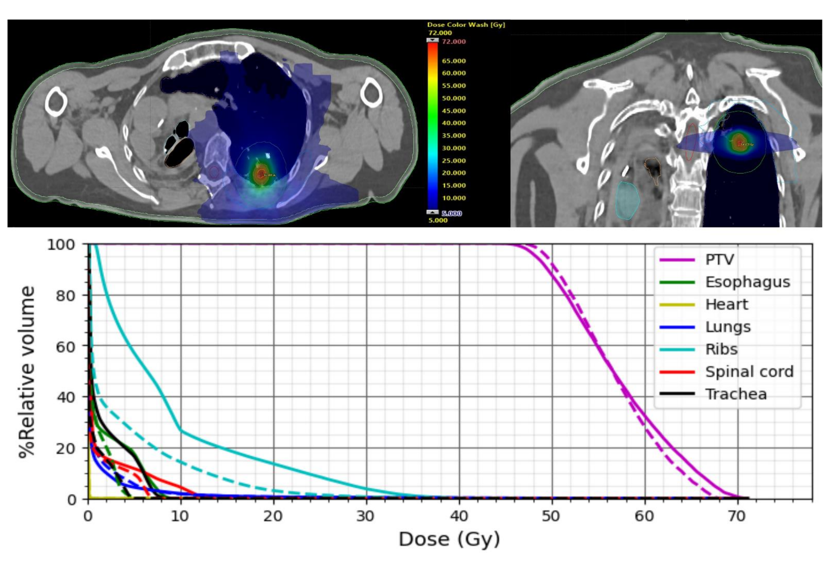
Lung

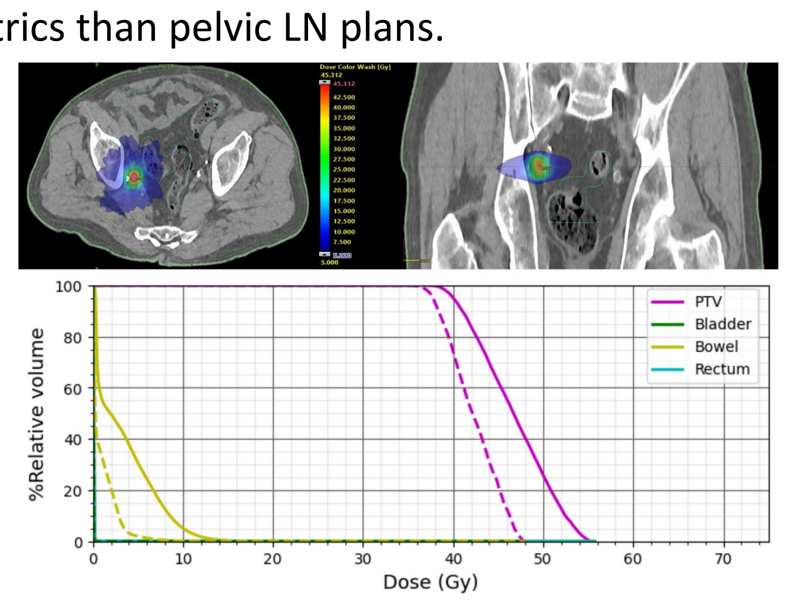


Found *quality* thresholds:
- ✓ Lung plans: 4.0 cm^3
- ✓ Pelvic LN plans: 3.6 cm^3

RESULTS

- ✓ 95% (n=20) pelvic LN and 100% (n=18) lung plans met tolerance criteria of institutional requirements.
- ✓ Low healthy tissue toxicity prediction: NTCP below reported values in literature for similar dose schema and endpoints.
- ✓ In general, lung plans exhibit better dose metrics than pelvic LN plans.





CONCLUSION

This study has highlighted the clinical feasibility of the HAL system for lung and pelvic LN treatment plans. HAL plans successfully adhered to the institutional requirements. A reference for achievable plan quality was established by comparison with literature data. HAL plans demonstrated improved quality for target volumes larger than the identified PTV volume *quality* threshold of 4.0 cm³ in both, pelvic LN and lung plans. This parameter found holds promise as a potential criterion for determining the achievable dose metric quality based on the target size.

DISCLOSURE STATEMENT

This study was partially supported by Varian, a Siemens Healthineers Company.

SOURCES

https://towardsdatascience.com/k-means-a-complete-introduction-1702af9cd8c
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