Workflow Optimization in Cervical Cancer Radiotherapy Planning Using AI/Scripts in Middle-Income Countries

Diego Aguilar [1]; Ricardo Escobar [1]; Alexandra Tellez [1]; Kevin Vega, MSc. [1]; Eduardo Florián, MSc. [1]; Otto Hurtarte, BSc. [1]; Erick Montenegro [1]; Mariluna García, M.D.[1]; Melissa Castellanos, M.D.[1]; Milton Ixquiac, PhD [1]
[1]Liga Nacional Contra el Cáncer

2026 JULY 19–22 VANCOUVER, BC
JOINT AAPM | COMP MEETING

ABSTRACT

Purpose: The purpose of this work was to optimize the radiotherapy treatment planning workflow for cervical cancer using artificial intelligence-based tools and optimization through scripts, with the goal of reducing planning time and improving the implementation of clinical protocols in a middle-income country.
Methods: CT images acquired with intracavitary brachytherapy applicators in place, including fletcher, ring, cylinder, central tandems or aarurhus (for interstitial technique), were imported into Eclipse (v18) for treatment planning of cervical cancer patients. An AI-assisted and script-based workflow was implemented for cervical cancer external beam radiotherapy, focusing on automated structure generation and standardized plan initialization and dose calculation using the RapidPlan model, where it was also adapted for SIB and non-SIB treatment techniques. Brachytherapy treatment plans were subsequently generated and evaluated. The combined external beam and brachytherapy dose distributions were assessed using Radformation tools by evaluating the biologically effective dose (BED) to the target volumes and compliance with dose limits for organs at risk. Planning efficiency and workflow performance were evaluated by comparing planning time and manual interactions with the conventional manual planning process.
Results: The AI-assisted workflow along with the scripts reduced median treatment planning time compared to manual planning. Plan to plan variability was reduced, while target coverage and OAR dose constraints remained clinically acceptable and comparable to the conventional workflow.
Conclusion: The use of scripting and artificial intelligence resulted in improved efficiency in structure generation, treatment planning, and plan approval for cervical cancer brachytherapy. When integrated with prior external beam radiotherapy planning, the proposed workflow demonstrated reduced planning time while maintaining clinically acceptable plan quality, supporting its applicability in resource-limited clinical settings.

RAD formation

CONTACT

Ricardo J. M. Escobar Matzir
ECFM-USAC / INCAN
Email: ricardoemf03@gmail.com
Guatemala, 2026

INTRODUCTION

High-dose-rate (HDR) brachytherapy combined with external beam radiotherapy (EBRT) is an essential component of treatment for locally advanced cervical cancer. According to EMBRACE II recommendations, treatment planning requires accurate target delineation, organ-at-risk (OAR) dose evaluation, and assessment of the cumulative biological dose delivered by EBRT and HDR brachytherapy. Conventional cervical cancer planning workflows include multiple manual steps, such as contour delineation, plan review, dose constraint verification, and biological dose assessment. These tasks are time-consuming and may introduce interobserver variability, limiting efficiency and standardization in routine clinical practice.
To address these challenges, Liga Nacional Contra el Cancer (Guatemala) implemented RadFormation tools into the clinical workflow. The implementation included AI-assisted auto-contouring, automated plan quality review using ClearCheck, and cumulative biological dose evaluation using BED and EQD2.
Because HDR brachytherapy delivers large doses per fraction, EBRT and brachytherapy physical doses cannot be directly added. Biological dose was therefore assessed using the linear-quadratic model:

$$BED = D\left(1 + \frac{d}{\alpha/\beta}\right), \qquad EQD2 = \frac{BED}{1 + \frac{2}{\alpha/\beta}}.$$

This work evaluates whether the implementation of AI-assisted contouring and automated plan review reduced contouring time and standardized the cervical cancer treatment planning workflow.

METHODS AND MATERIALS

Patient selection. Fifteen cervical cancer patients previously treated with EBRT, including SIB and non-SIB techniques, were retrospectively selected.
Image datasets. CT images acquired with the brachytherapy applicator in place were imported into Eclipse Treatment Planning System (V16) for HDR brachytherapy planning.
Contouring-time evaluation. For each patient, physician contouring time was recorded using the conventional manual workflow. The same datasets were then processed using the AI-assisted AutoContour workflow. With AutoContour, OARs were automatically segmented, while physicians manually delineated the CTV-HR and CTV-IR target volumes. Contouring time was defined as the interval from opening the CT dataset to completion of physician contour approval.
Workflow standardization. After contour approval, HDR brachytherapy plans were generated by the medical physics team. ClearCheck was used to verify BED and EQD2 for the individual brachytherapy plan and for the cumulative plan sum combining EBRT and HDR brachytherapy. Compliance with institutional target and OAR constraints implemented at INCAN was verified, based on EMBRACE II recommendations.

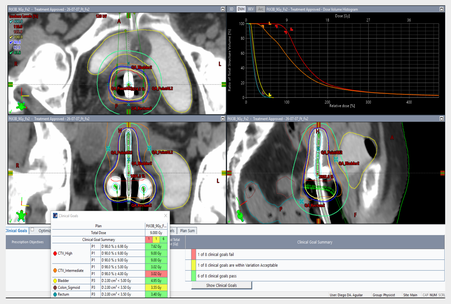


Figure 1. Example of a patient's CT with a ring applicator.

Brachy Total Constraints

Unapproved

Priority	Structure Template	Structure Plan	Type	Prescription	Constraint	Goal	Plan Sum	Pass/Fail
1	CTV	CTV_High	Target	CTV_85 Gy: 85Gy	(EQD2 α/β = 10) D90% ≥	100%	102.279%	✓
2	CTV_IR	CTV_Intermediate	Target	CTV_85 Gy: 85Gy	(EQD2 α/β = 10) D90% ≥	71-59%	76.436%	✓
3	CTV	CTV_High	Target		(EQD2 α/β = 10) D90%	Gy	86.938Gy	
4	CTV_IR	CTV_Intermediate	Target		(EQD2 α/β = 10) D90%	Gy	64.971Gy	
5	Rectum	Rectum	OAR		(EQD2 α/β = 3) D2cc ≤	70-75Gy	61.743Gy	✓
6	Bladder	Bladder	OAR		(EQD2 α/β = 3) D2cc ≤	80-90Gy	71.861Gy	✓
7	Colon_Sigmoid	Colon_Sigmoid	OAR		(EQD2 α/β = 3) D2cc ≤	70-75Gy	59.913Gy	✓

Figure 2. Pass/Fail review in the Plan Sum of ClearCheck.

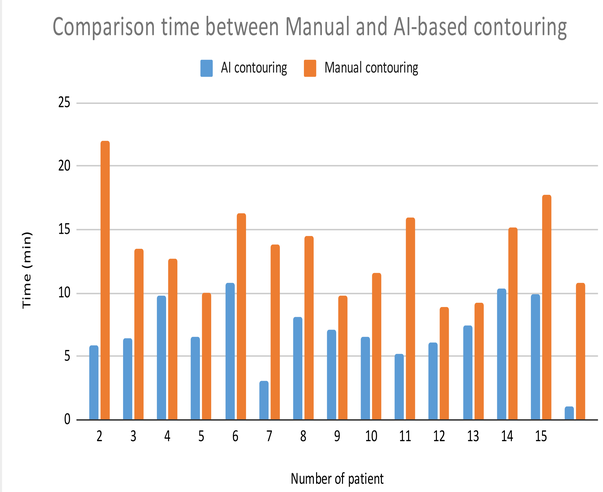
RESULTS

Manual physician contouring time was evaluated in 15 cervical cancer patients previously treated with EBRT. The initial analysis showed an average manual contouring time of:

	Manual	AutoContour
Patients (n)	15	15
Mean contouring time (min:sec)	13:46	6:56

After implementation of the AI-assisted workflow, OARs were automatically generated using AutoContour, while physicians manually delineated the CTV-HR and CTV-IR. The resulting contours and treatment plans were reviewed and approved by the physicians.
ClearCheck was used to standardize plan evaluation by automatically assessing EQD2 for both the individual brachytherapy plan and the cumulative Plan Sum, which combines EBRT and HDR brachytherapy. All evaluated plans were approved according to the institutional dose constraints implemented at INCAN.
A standardized workflow diagram was generated to summarize the implemented clinical process, including AutoContour-based structure generation, physician review, treatment planning, ClearCheck evaluation, EQD2 assessment, and final plan approval.

Chart 1. Comparison times



Brachy Total Constraints

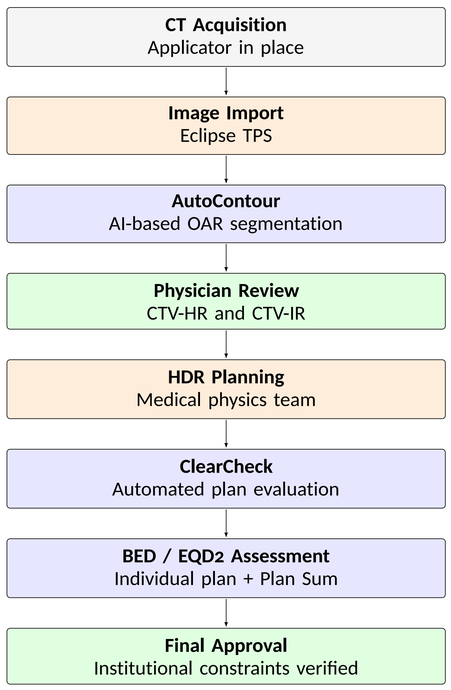
Unapproved

Priority	Structure Template	Structure Plan	Type	Prescription	Constraint	Goal	Plan Sum	Pass/Fail
1	CTV	CTV_High	Target	CTV_85 Gy: 85Gy	(EQD2 α/β = 10) D90% ≥	100%	103.159%	✓
2	CTV_IR	CTV_Intermediate	Target	CTV_85 Gy: 85Gy	(EQD2 α/β = 10) D90% ≥	71-59%	72.366%	✓
3	CTV	CTV_High	Target		(EQD2 α/β = 10) D90%	Gy	87.685Gy	
4	CTV_IR	CTV_Intermediate	Target		(EQD2 α/β = 10) D90%	Gy	61.511Gy	
5	Rectum	Rectum	OAR		(EQD2 α/β = 3) D2cc ≤	70-75Gy	58.057Gy	✓
6	Bladder	Bladder	OAR		(EQD2 α/β = 3) D2cc ≤	80-90Gy	69.641Gy	✓
7	Colon_Sigmoid	Colon_Sigmoid	OAR		(EQD2 α/β = 3) D2cc ≤	70-75Gy	59.72Gy	✓

Figure 3. Plan Sum of ClearCheck

DISCUSSION

The implementation of the RadFormation platform into the HDR brachytherapy workflow at Liga Nacional Contra el Cáncer improved both contouring efficiency and biological dose evaluation. AI-assisted auto-contouring reduced physician contouring time by approximately 50%.
In addition to improving contouring efficiency, workflow standardization simplified the evaluation of cumulative biological dose. ClearCheck enabled automated assessment of EQD2 for both the individual brachytherapy plan and the cumulative Plan Sum.
Compared with the previous workflow, which required manual EQD2 calculations performed by the medical physics team, the implemented process reduced manual interactions while providing a more consistent and reproducible plan review prior to physician approval.



CONCLUSIONS

AI-assisted auto-contouring reduced physician contouring time by approximately 51.6%, improving the efficiency of the HDR brachytherapy planning workflow.

- The implementation of RadFormation standardized the clinical workflow by integrating AI-based contour generation with automated EQD2 evaluation through ClearCheck, simplifying plan review for both individual brachytherapy plans and cumulative Plan Sum analysis.
- The proposed workflow reduced manual interactions while maintaining physician oversight, providing a reproducible and clinically efficient approach for cervical cancer brachytherapy planning.
- This implementation demonstrates the feasibility of integrating commercially available AI-assisted planning tools into routine clinical practice in a middle-income country.

REFERENCES

1. Dale, R., Plataniotis, G., & Jones, B. (2024). A generalised method for calculating repopulation-corrected tumour EQD2 values in a wide range of clinical situations, including interrupted treatments. Physica Medica, 118, 103294. https://doi.org/10.1016/j.ejmp.2024.103294
2. Pötter, R., Tanderup, K., Schmid, M. P., Jürgenliemk-Schulz, I., Haie-Meder, C., Fokdal, L. U., Sturdza, A., Hoskin, P., Mahantshetty, U., Kirisits, C., et al. (2021). EMBRACE II study protocol: The outcome and prospect of two decades of evolution within the GEC-ESTRO GYN working group and the EMBRACE studies. Clinical and Translational Radiation Oncology, 9, 48–60.