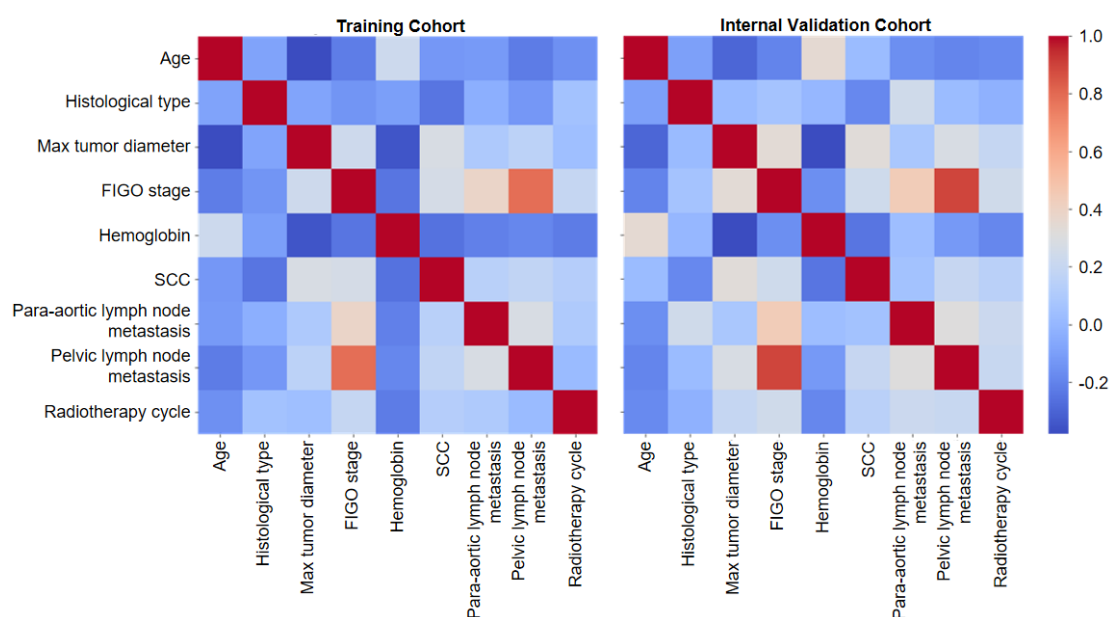
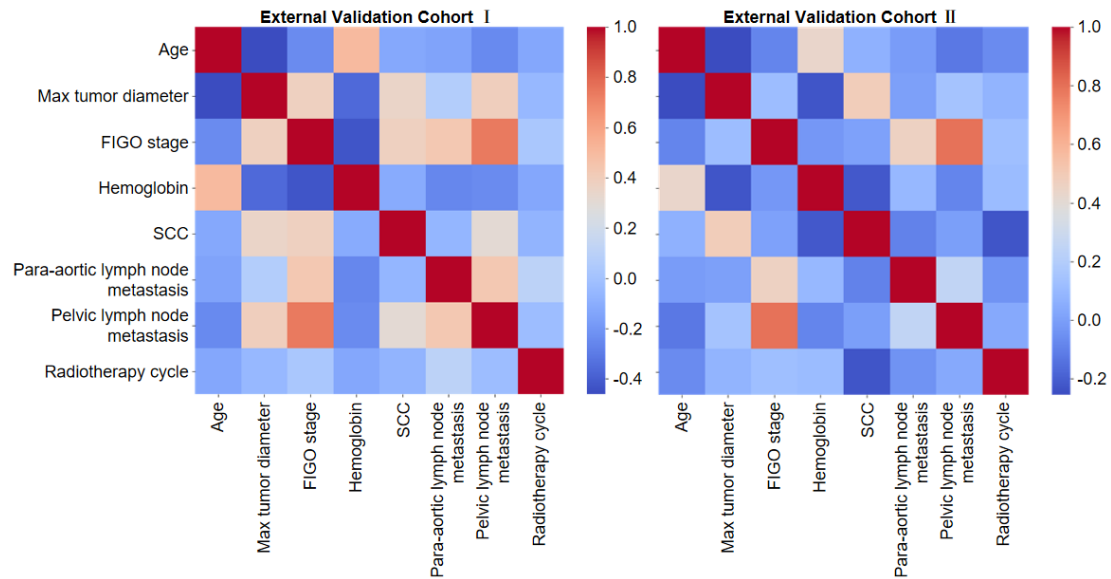


Supplementary Information

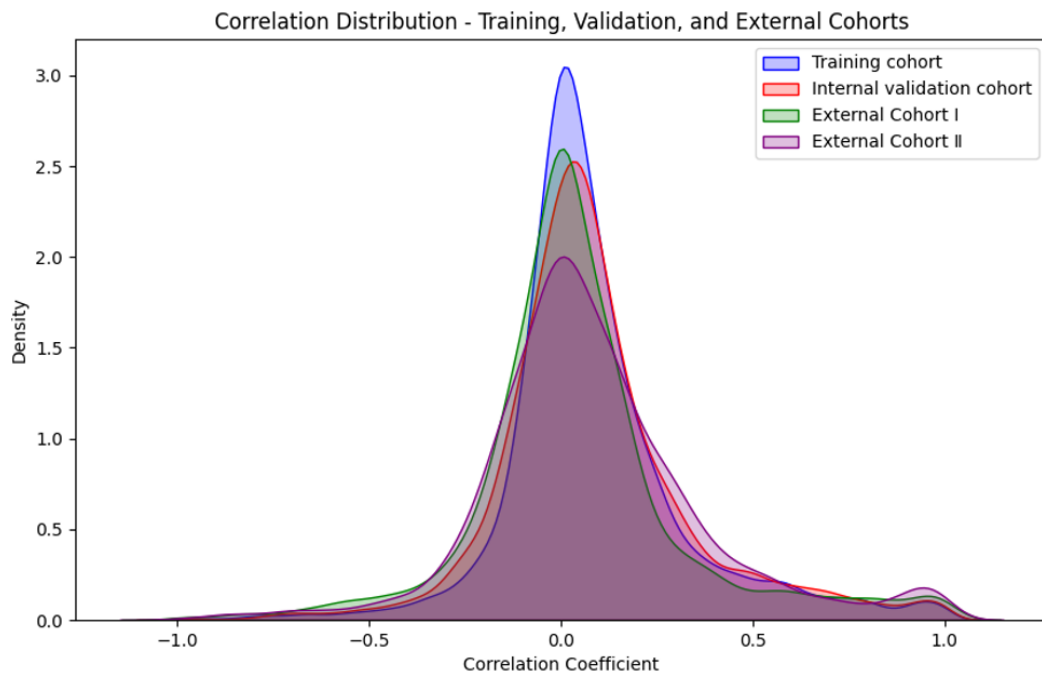
Supplementary Figures



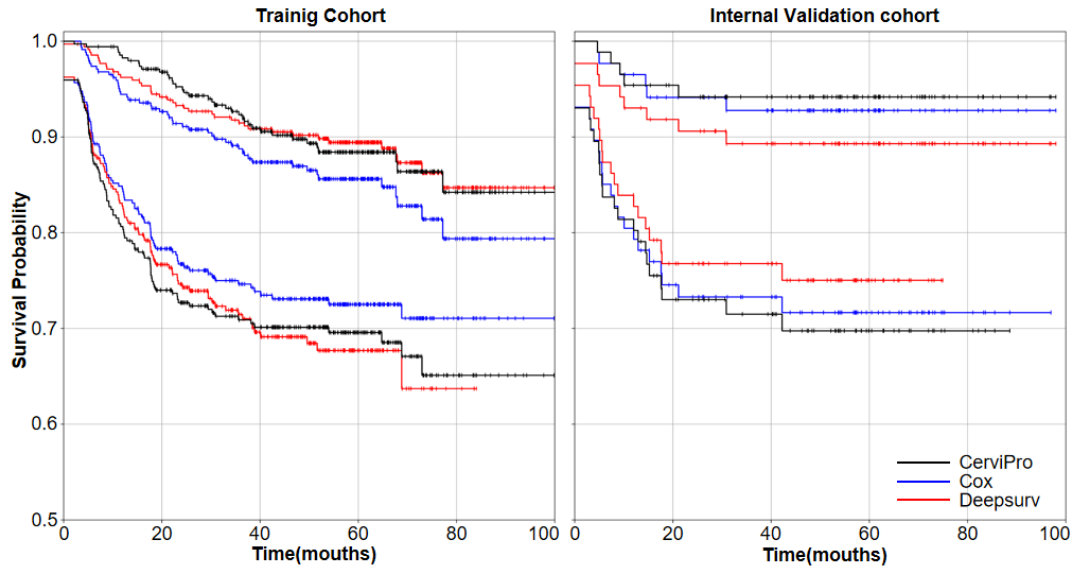
Supplementary Figure 1: Clinical feature correlation of the internal cohort. The heatmaps demonstrate the consistency of correlation patterns across the two cohorts, reflecting the relationships between these clinical features in the study population. The consistency of correlations between features was maintained in both the training and validation cohorts.



Supplementary Figure 2: Clinical feature correlation of the external cohort. The heatmaps demonstrate the consistency of correlation patterns across the two cohorts, reflecting the relationships between these clinical features in the study population. The consistency of correlations between features was maintained in both the external validation cohort I and the external validation cohort II.

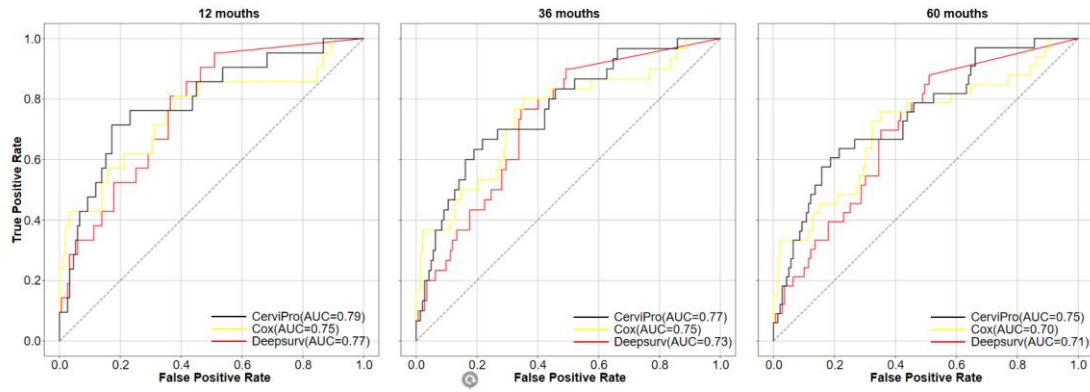


Supplementary Figure 3: Feature Correlation Analysis Across Different cohort. The figure compares the distribution of feature correlation coefficients across the training cohort, validation cohort, and external validation cohorts I and II.



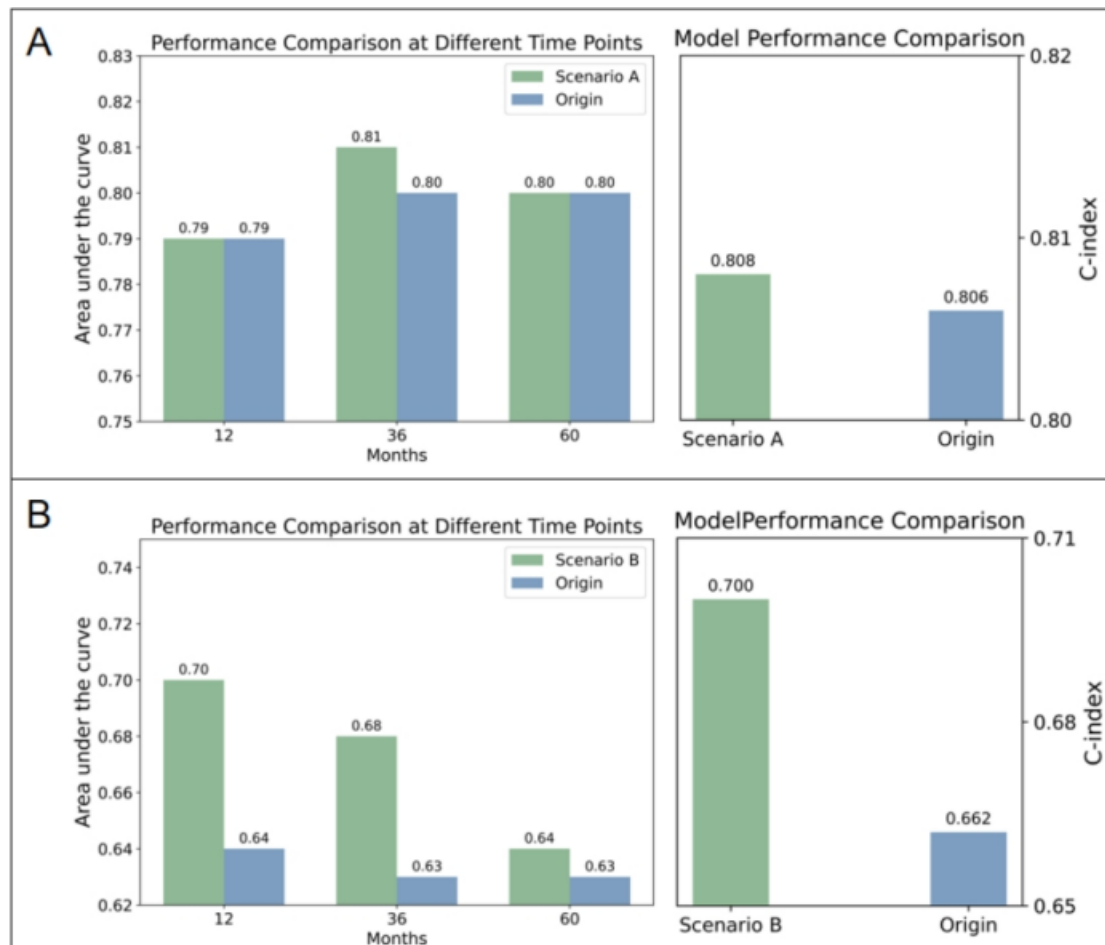
Supplementary Figure 4: Kaplan-Meier analysis of the CerviPro, Cox, and DeepSurv models on the training and internal validation cohort.

This figure illustrates the survival analysis results of three models (CerviPro, Cox regression model, and DeepSurv model) in distinguishing high-risk and low-risk patients, evaluated in the Training Cohort and Internal Validation Cohort. The black curve represents the predictions of the CerviPro model, while the blue and red curves correspond to the Cox model and the DeepSurv model, respectively.

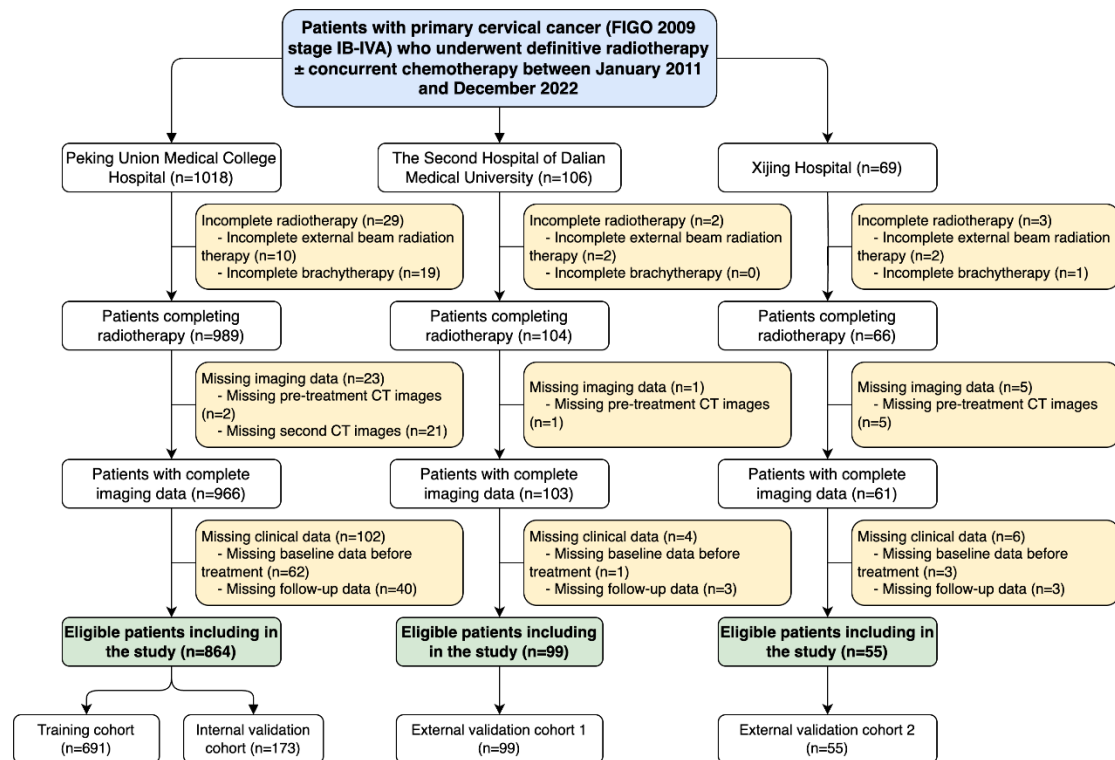


Supplementary Figure 5: Receiver operating characteristic (ROC) curves and area under the curve (AUC) values for DFS prediction at 12, 36, and 60 months of different models on the internal validation set.

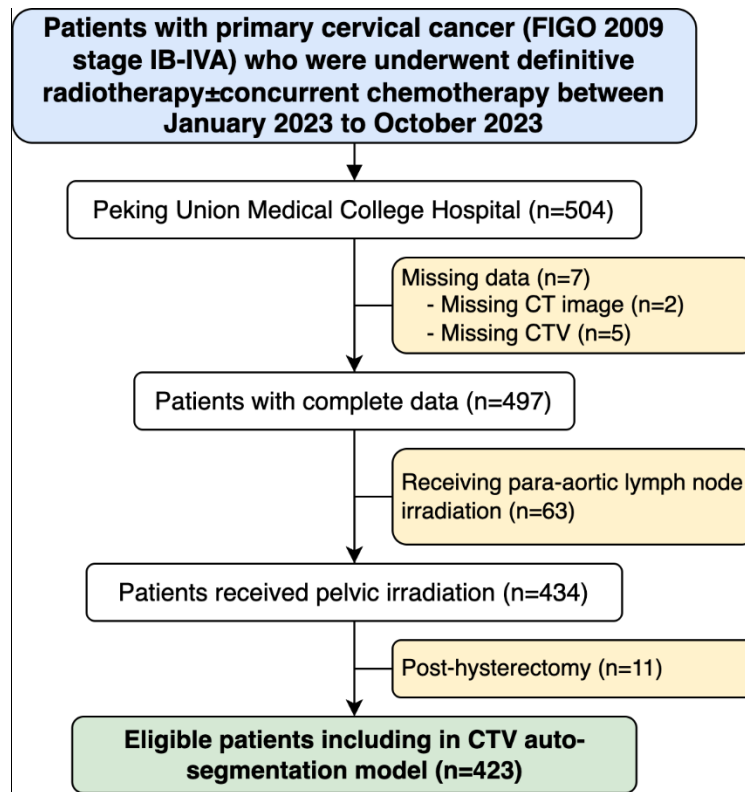
This figure illustrates the receiver operating characteristic (ROC) curves of three predictive models (CerviPro, Cox, and DeepSurv) on the internal validation set at 12 months, 36 months, and 60 months. The horizontal axis represents the false positive rate (FPR), while the vertical axis represents the true positive rate (TPR). The performance of each model is quantified by the area under the curve (AUC), with values indicated in the legend. At all three time points, the CerviPro model demonstrates superior predictive performance, with AUC values of 0.79 (12 months), 0.77 (36 months), and 0.75 (60 months), which are higher than those of the Cox model (AUC = 0.75, 0.75, and 0.70) and the DeepSurv model (AUC = 0.77, 0.73, and 0.71). These results suggest that CerviPro consistently outperforms the other models in predictive accuracy across different time points.



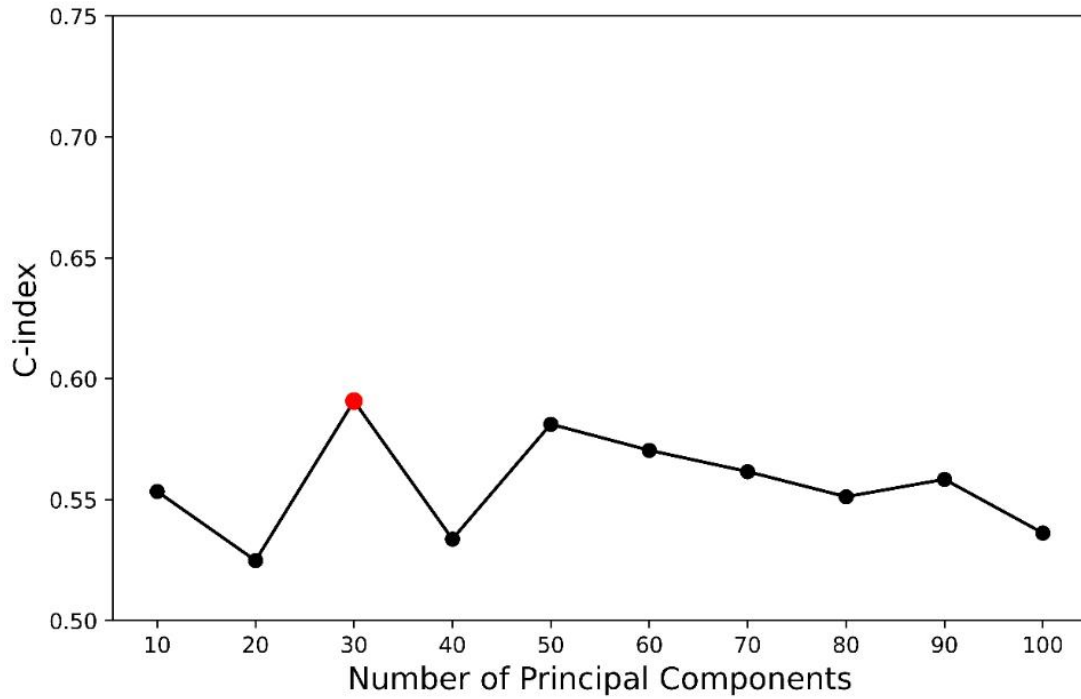
Supplementary Figure 6: Model performance comparison under different training scenarios.



Supplementary Figure 7: Flow chart of patient inclusion.



Supplementary Figure 8: Flow chart of patient inclusion for clinical target volume (CTV) auto-segmentation model training



Supplementary Figure 9: Effect of Number of Principal Components on C-index Performance We applied Principal Component Analysis (PCA) to reduce the dimensionality of the multimodal features. Before model training, the training dataset was further divided into a training subset and a test subset for internal validation. Specifically, we systematically evaluated the prognostic performance of the model (measured by the C-index) by varying the number of principal components from 10 to 100 in increments of 10. When the number of components reached 30, the model achieved the highest C-index of 0.591. Based on this result, we selected the top 30 principal components for downstream analysis.

Supplementary Tables

Supplementary Table 1. Patient Characteristics in center 1 and center 2&3

Characteristics	Center 1 (n=864)	Center 2&3 (n=154)	P value
Age, years	51 (46-59)	57 (50-65)	< 0.001
Histological type, n(%)			< 0.001
Squamous cell carcinoma	780 (90.3)	154 (100)	
Non-squamous cell carcinoma	84 (9.7)	0 (0)	
Follow-up duration, months	50.82 (25.63-64.49)	37.73 (24.72-45.02)	< 0.001
Max tumor diameter, cm	4.04 ± 1.66	5.34 ± 1.66	< 0.001
FIGO stage, n(%)			< 0.001
IB	102 (11.8)	5 (3.7)	
IIA	53 (6.1)	7 (4.5)	
IIB	373 (43.2)	40 (26.0)	
IIIA	18 (2.1)	5 (3.2)	
IIIB	60 (6.9)	35 (22.7)	
IIIC1	204 (23.6)	49 (31.9)	
IIIC2	47 (5.4)	13 (8.4)	
IVA	7 (0.8)	0 (0)	
Hemoglobin, g/L	124.31 ± 20.74	120.90 ± 20.25	0.059
SCC, ng/mL	4.10 (1.50-13.30)	10.83 (3.70-34.33)	< 0.001
Pelvic lymph node metastasis, n(%)	248 (28.7)	62 (40.3)	<0.01
Para-aortic lymph node metastasis, n(%)	49 (5.7)	13 (8.4)	0.19
Overall radiotherapy time, days	51 (49-57)	43 (39-55)	< 0.001

Supplementary Table 2. Patient Characteristics in center 1 and center 2.

Characteristics	Center 1 (n=864)	Center 2 (n=55)	P value
Age, years	51 (46-59)	53 (44-65)	0.927
Histological type, n(%)			0.015
Squamous cell carcinoma	780 (90.3)	55 (100)	
Non-squamous cell carcinoma	84 (9.7)	0 (0)	
Follow-up duration, months	50.82 (25.63-64.49)	27.63 (22.30-35.40)	< 0.001
Max tumor diameter, cm	4.04 ± 1.66	6.02 ± 1.44	< 0.001
FIGO stage, n(%)			< 0.001
IB	102 (11.8)	0 (0)	
IIA	53 (6.1)	0 (0)	
IIB	373 (43.2)	2 (3.6)	
IIIA	18 (2.1)	0 (0)	
IIIB	60 (6.9)	13 (23.6)	
IIIC1	204 (23.6)	32 (58.2)	
IIIC2	47 (5.4)	8 (14.5)	
IVA	7 (0.8)	0 (0)	
Hemoglobin, g/L	124.31 ± 20.74	117.60 ± 21.83	0.021
SCC, ng/mL	4.10 (1.50-13.30)	6.50 (2.30-20.30)	0.067
Pelvic lymph node metastasis, n(%)	248 (28.7)	40 (72.7)	< 0.001
Para-aortic lymph node metastasis, n(%)	49 (5.7)	8 (14.5)	0.016
Overall radiotherapy time, days	51 (49-57)	56 (52-61)	< 0.001

Supplementary Table 3. Patient Characteristics in center 1 and center 3.

Characteristics	Center 1 (n=864)	Center 3 (n=99)	P value
Age, years	51 (46-59)	60 (53-67)	< 0.001
Histological type, n(%)			0.001
Squamous cell carcinoma	780 (90.3)	99 (100)	
Non-squamous cell carcinoma	84 (9.7)	0 (0)	
Follow-up duration, months	50.82 (25.63-64.49)	41.50 (36.07-48.53)	< 0.001
Max tumor diameter, cm	4.04 ± 1.66	4.96 ± 1.66	< 0.001
FIGO stage, n(%)			< 0.001
IB	102 (11.8)	5 (5.1)	
IIA	53 (6.1)	7 (7.1)	
IIB	373 (43.2)	38 (38.4)	
IIIA	18 (2.1)	5 (5.1)	
IIIB	60 (6.9)	22 (22.2)	
IIIC1	204 (23.6)	17 (17.2)	
IIIC2	47 (5.4)	5 (5.1)	
IVA	7 (0.8)	0 (0)	
Hemoglobin, g/L	124.31 ± 20.74	122.73 ± 19.19	0.469
SCC, ng/mL	4.10 (1.50-13.30)	13.88 (5.00-44.56)	< 0.001
Pelvic lymph node metastasis, n(%)	248 (28.7)	22 (21.8)	
Para-aortic lymph node metastasis, n(%)	49 (5.7)	5 (5.0)	
Overall radiotherapy time, days	51 (49-57)	40 (37-42)	< 0.001

Supplementary Table 4. C-index of different models and feature combinations in the internal validation cohort

Feature Set	CerviPro	Cox	DeepSurv
Clinical Variables Only	0.744	0.770	0.768
Deep Learning Features Only	0.659	0.488	0.565
Radiomic (Pre-CT) Only	0.746	0.648	0.667
Radiomic (Post-CT) Only	0.753	0.671	0.668
Radiomic (Pre + Post-CT) Only	0.753	0.647	0.685
Clinical + Radiomic (Pre + Post-CT)	0.772	0.667	0.715
Clinical + Deep Learning Features	0.745	0.643	0.697
All features	0.806	0.663	0.717

Abbreviations: Pre-CT: Radiomic features extracted from pre-treatment CT scans; Post-CT: Radiomic features extracted from post-treatment CT scans; Deep Learning Features: Features extracted by a pre-trained foundational/deep model; Clinical Variables: Such as age, FIGO stage, tumor size, hemoglobin, SCC antigen, etc.

Supplementary Table 5. C-index of CerviPro using different feature combinations in the training and internal validation cohorts

Feature Set	Training cohort	Internal validation cohort
Clinical Variables Only	0.761	0.744
Deep Learning Features Only	0.670	0.659
Radiomic (Pre-CT) Only	0.755	0.746
Radiomic (Post-CT) Only	0.750	0.753
Radiomic (Pre + Post-CT) Only	0.754	0.753
Clinical + Radiomic (Pre + Post-CT)	0.797	0.772
Clinical + Deep Learning Features	0.749	0.745
All features	0.855	0.806

Supplementary Table 6. C-index of CerviPro using different feature combinations in the external validation cohorts

Feature Set	External validation cohort I	External validation cohortII
Clinical Variables Only	0.639	0.676
Deep Learning Features Only	0.549	0.529
Radiomic (Pre-CT) Only	0.617	0.653
Clinical + Radiomic (Pre-CT)	0.641	0.698
Clinical + Deep Learning Features	0.616	0.627
All Features	0.662	0.702

Supplementary Table 7. Patients received para-aortic lymph nodes irradiation in 3 Centers.

	Peking Union Medical College Hospital (Center 1)	Xijing Hospital (Center 2)	Second Affiliated Hospital of Dalian Medical University (Center 3)	p (Center 1 vs Center 2)	p (Center 1 vs Center 3)
Overall	22.6% (195/864)	23.6% (13/55)	16.2% (16/99)	0.855	0.144
With para- aortic lymph nodes metastasis	100% (49/49)	100% (8/8)	100% (5/5)	/	/
Without para- aortic lymph nodes metastasis	17.9% (146/815)	10.6% (5/47)	11.7% (11/94)	0.202	0.131