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CASE REPORT

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Prognostic implications of tumor volume reduction during radiotherapy in locally advanced cervical cancer: a risk-stratified analysis

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Abstract

Background This study aimed to identify key risk factors in locally advanced cervical cancer (LACC) patients receiving radical radiotherapy and to evaluate the prognostic significance of MRI-determined tumor volume regression (TVR) among varying risk groups.

Methods We retrospectively analyzed a cohort of 176 cervical cancer patients (stages IIA-IVA) treated with intensity-modulated radiotherapy from January 2012 to December 2020. Three-dimensional MRI scans were utilized to measure TVR and lymph node volume regression (NVR). Kaplan-Meier analysis was employed to assess overall survival (OS), progression-free survival (PFS), local relapse-free survival (LRFS), and distant metastasis-free survival (DMFS). Prognostic factors were further analyzed using Cox proportional hazards models.

Results A tumor TVR of ≥ 94% was significantly associated with improved 5-year overall survival (OS; 82.7% vs. 49.8%, $p < 0.001$) and progression-free survival (PFS; 82.5% vs. 51.1%, $p < 0.001$). Patients with TVR ≥ 94% also demonstrated superior LRFS and DMFS compared to those with TVR < 94% ($p < 0.001$ and $p = 0.012$, respectively). In the concurrent chemoradiotherapy (CCRT) subgroup, higher TVR correlated with better prognosis, whereas in patients receiving radiotherapy alone, an increased TVR did not significantly impact OS. Notably, the prognostic value of TVR was most evident in patients with CYFRA21-1 levels below 7.7 ng/ml. In the NVR ≥ 94% subgroup, OS, PFS, and LRFS were significantly better than in patients with NVR < 94% ($p < 0.01$), with a trend towards improved DMFS observed ($p = 0.138$).

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Conclusion TVR serves as a pivotal prognostic marker in LACC patients with CYFRA21-1 levels below 7.7 ng/ml undergoing CCRT. Additionally, within the lymph node metastasis subgroup, patients achieving a NVR of ≥ 94% demonstrated a notably improved prognosis.

Keywords Cervical cancer, Radiotherapy, Chemoradiotherapy, Tumor volume reduction, Prognosis

Introduction

Cervical cancer (CC), recognized as the most prevalent malignancy in the female reproductive system [1], is diagnosed as locally advanced cervical cancer (LACC) in approximately two-thirds of the cases [2]. The integration of concurrent radiotherapy and chemotherapy (CCRT), comprising external beam radiotherapy (EBRT) and intracavitary brachytherapy (ICBT), constitutes the cornerstone of LACC treatment [3, 4]. Advances in magnetic resonance imaging (MRI) have profoundly changed CC assessment, enabling precise quantification of tumor volume (TV) and metastatic lymph node volume (NV) at critical stages. Tumor volume regression (TVR) and lymph node volume regression (NVR) were calculated by assessing tumor and metastatic lymph node volumes before EBRT and ICBT [3, 4]. Oncologic has notably advanced with the application of three-dimensional (3D) volume analysis, focused on regions of interest (ROI) [5]. This technique not only enhances the precision of volume measurements but also demonstrates a significant correlation with clinical outcomes [5–7]. Nonetheless, establishing an optimal TVR threshold for predictive accuracy is challenging, given the substantial variability in thresholds reported across different studies [7]. This variation may stem from differences in baseline patient characteristics and treatment protocols within the study cohort [8–10]. Furthermore, limited research has been conducted on the prognostic significance of NVR in LACC.

While the prognostic significance of TVR in CC is well-established, a standardized treatment approach has yet to be defined in previous studies. Further subgroup analyses are crucial to evaluate the sustained prognostic value of TVR across various treatment regimens [11]. Additionally, CC demonstrates significant heterogeneity, even among patients with comparable TVR levels [12, 13]. The effectiveness of CC treatment is influenced by multiple factors, including FIGO staging, patient age, nutritional status, and, most notably, tumor marker levels [14, 15]. Cytokeratin fragments, particularly cytokeratin 19 fragment antigen 21 – 1 (CYFRA21-1), have emerged as critical prognostic markers in cervical cancer [16]. CYFRA21-1 levels are strongly associated with level is closely related to the stage, tumor size, and other clinical disease parameters of CC [17]. However, current research, however, has yet to explore the interaction between CYFRA21-1 levels and TVR, particularly its impact on prognosis across patients with different CYFRA21-1 levels.

This study aims to identify independent factors influencing survival outcomes in LACC patients with LACC. It seeks to elucidate the prognostic significance of TVR in the context of radical radiotherapy, both as an independent marker and in combination with chemotherapy, while examining its variability among patients with differing risks of recurrence and mortality risks.

Materials and methods

Patient selection

Between January 2012 and December 2020, we identified 176 patients with histopathologically confirmed CC who were restaged to FIGO stages IIA-IVA according to the 2018 FIGO Version 8 system [18] (Supplementary Fig. 2). All patient data were sourced from the First Hospital of Longyan City, Longyan, Fujian, China. Inclusion criteria were: (1) histopathological confirmation of cervical squamous cell carcinoma or adenocarcinoma and (2) completion of pelvic MRI scans pre-radiotherapy and mid-therapy (prior to ICBT) following an EBRT dose of 40–45 Gy). Exclusion criteria were: (1) prior antitumor treatments before initial evaluation at our facility, (2) incomplete radical radiotherapy, and (3) tumor volumes unsuitable for accurate 3D imaging due to fewer than three ROI layers. This study was approved by the Institutional Review Committee of the First Hospital of Longyan ([2020] Research Ethics No. 08), and informed consent was obtained from all participants.

Treatment approach

Participants underwent a combination of EBRT and high-dose rate brachytherapy. The EBRT clinical target volume (CTV) included the cervical mass, entire cervix, uterus, a portion of the vagina, parametrium, and relevant draining lymph nodes, such as the internal iliac, external iliac, common iliac, presacral, and obturator nodes. A total dose of 4860–5040 cGy was delivered to the CTV across 27–28 fractions, supplemented with a Simultaneous Integrated Boost (SIB) to involved lymph nodes, delivering 5670–6160 cGy within the same fractionation schedule. Brachytherapy was initiated after 20 EBRT fractions, delivering 2600–2800 cGy to point A of the pelvic dose reference over four weekly sessions. Concurrent chemotherapy

Table 1 Clinical characteristics of cervical cancer patients

	N (%)	TVR < 94%	TVR ≥ 94%	*p*-value
		N = 42(23.9%)	*N* = 134 (76.1%)	
Age(years)				0.891
Median		58	57	
Range		38–81	35–87	
< 60	98(55.7%)	23(54.8%)	75(56.0%)	
≥ 60	78(44.3%)	19(45.2%)	59(44.0%)	
ECOG Score				0.115
0–1	122(69.3%)	25(59.5%)	97(72.4%)	
2–3	54(30.7%)	17(40.5%)	37(27.6%)	
FIGO stage				0.853
IIA-IIB	86(48.9%)	20(47.6%)	66(49.3%)	
IIIA-IVA	90(51.1%)	22(52.4%)	68(50.7%)	
Pathological type				0.106
SCC	166(94.3%)	37(88.1%)	129(96.3%)	
Adenocarcinoma	10(5.7%)	5(11.9%)	5(3.7%)	
Hemoglobin				0.667
< 90 g/l	20(11.4%)	4(9.5%)	16(11.9%)	
≥ 90 g/l	156(88.6%)	38(90.5%)	118(88.1%)	
Albumin				0.436
< 37 g/l	30(17.1%)	9(20.9%)	21(15.8%)	
≥ 37 g/l	146(82.9%)	34(79.1%)	112(84.2%)	
Tumor type				0.887
Rape blossom type	133(75.6%)	31(73.8%)	102(76.1%)	
Nodule type	34(19.3%)	9(21.4%)	25(18.7%)	
Endogenous type	9(5.1%)	2(4.8%)	7(5.2%)	
Tumor size				0.285
< 5.35 cm	118(67.1%)	31(73.8%)	87(64.9%)	
≥ 5.35 cm	58(32.9%)	11(26.2%)	47(35.1%)	
CYFRA 21 – 1				0.927
< 7.7ng/ml	138(84.1%)	33(84.6%)	105(84.0%)	
≥ 7.7ng/ml	26(15.9%)	6(15.4%)	20(16.0%)	
Lymph node positive				0.904
Yes	49(27.8%)	12(28.6%)	37(27.6%)	
No	127(72.2%)	30(71.4%)	97(72.4%)	
Concurrent chemotherapy				0.001
No	65(36.9%)	25(59.5%)	40(29.9%)	
Yes	111(63.1%)	17(40.5%)	94(70.1%)	

Abbreviation: TVR: tumor volume reduction; SCC: squamous cell carcinoma; FIGO: Federation International of Gynecology and Obstetrics. Tumor size: the largest diameter of the tumor. The FIGO stages are based on the 8th edition of the FIGO staging

consisted of weekly cisplatin (40 mg/m²) for six cycles or a dual-agent regimen of cisplatin (75 mg/m²) and paclitaxel (175 mg/m²) every three weeks for 2–3 cycles. Of note, 111 patients (63% of the cohort) received combined cisplatin and EBRT, categorized as CCRT.

Assessment of cervical TV and NV

TV and NV were precisely measured using the ROI method. The cervical primary tumor and pelvic metastatic lymph nodes were delineated on the axial plane of the T2-weighted MRI sequence, referencing the T2-FS-FRFSE sequence, using AccuContour V3.02 software (Manteia Technologies, Xiamen, China), as illustrated in Supplementary Fig. 1. NV assessment focused exclusively on pelvic positive lymph nodes, defined as those with a short axial length greater than 8 mm, particularly round, needle-shaped, or foliated nodes, whose signal intensity was comparable to that of primary cervical tumors [19]. Notably, necrotic areas within the tumor were excluded from these measurements. TV and NV were assessed calculated before radiotherapy (TVp, NVp) and mid-treatment during radiotherapy (TVmid, and NVmid), with the latter recorded recording pre-brachytherapy TV and NV after an EBRT dose of 40–50 Gy and prior to brachytherapy. Tumor volume regression and nodal volume regression (NVR) were calculated using the following formulas: TVR = (TVp -TVmid) / TVp × 100%, and the formula for NVR is: NVR = (NVp -NVmid) /NVp × 100%. All volumetric evaluations assessments were independently performed by two experienced oncologist radiologists, with discrepancies resolved by and a third reviewer doctor was requested to reevaluate the results when the two doctors did not agree.

Statistical analysis

The receiver operating characteristic (ROC) curve was utilized to determine the optimal cutoff value for the study variable. The primary endpoint was overall survival (OS), while secondary endpoints included progression-free survival (PFS), local relapse-free survival (LRFS), and distant metastasis-free survival (DMFS). Survival probabilities were estimated using Kaplan-Meier analysis, and the effects of various factors on these endpoints were evaluated through univariate and multivariate Cox proportional hazards models.

Results

Patient characteristics

Table 1 summarizes the baseline characteristics of the 176 patients with LACC included in this study. ROC curve analysis identified the cutoff values for each variable, as illustrated in Supplementary Fig. 3. Of the cohort, 134 patients (76.1%) achieved a TVR of ≥ 94%, while 42 patients (23.9%) had a TVR below this threshold. Among the 176 patients, 49 (27.8%) had lymph node metastasis, and 127 (72.2%) did not. No significant differences were observed between these groups in terms of age, FIGO stage, pathological type, initial TV, or CA125 and CYFRA21-1 levels (all $p > 0.05$).

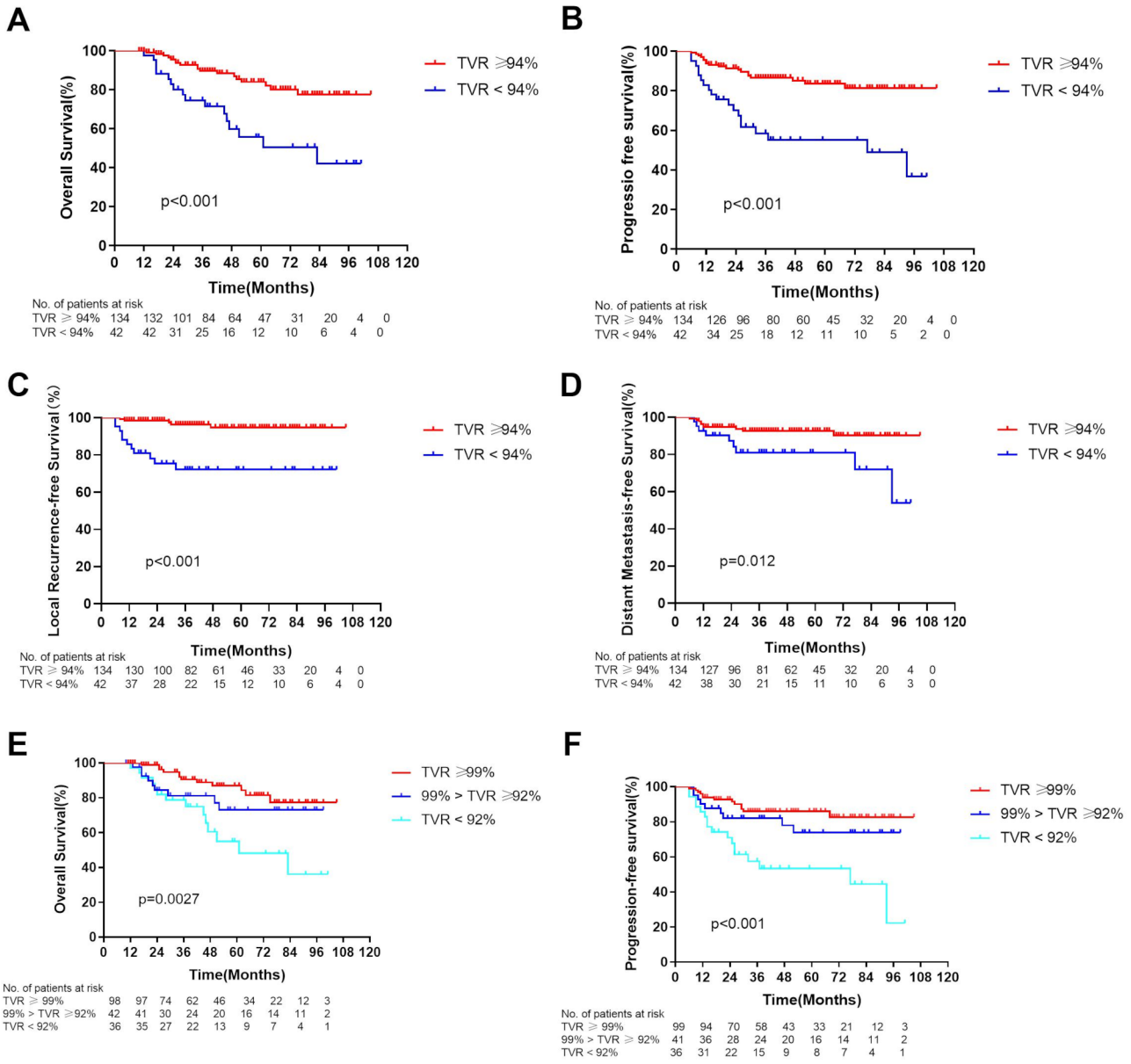

Fig. 1 Kaplan-Meier survival charts **A**, **B**, **C**, and **D** show the effects of tumor volume regression (TVR) on overall survival (OS), progression-free survival (PFS), local relapse-free survival (LRFS), and distant metastase-free survival (DMFS), respectively. Figures **E** and **F** show the impact of survival on OS and PFS as TVR values rise

Notably, a significantly higher proportion of patients in the CCRT group achieved a TVR ≥ 94% compared to those undergoing radiotherapy alone (70.1% vs. 40.5%, $p < 0.05$). Furthermore, the CCRT group demonstrated a significantly higher rate of complete tumor response (73.0%, 81/111) compared to the RT-only group (52.3%, 34/65).

Survival analyses

The median follow-up period for the cohort was 52 months, ranging from 20 to 105 months. Disease progression occurred in 39 of 176 patients (22.2%), with 35 deaths recorded. Patients with a TVR of ≥ 94% demonstrated significantly better 5-year OS (82.7%) and PFS (82.5%) compared to those with a TVR < 94% (49.8% and 51.1%, respectively; $p < 0.001$ for both), as shown in Fig. 1A and B. Furthermore, LRFS and DMFS were significantly improved in the TVR ≥ 94% group compared to the TVR < 94% group ($p < 0.001$ and $p = 0.012$, respectively; Fig. 1C and D).

Stratification of the cohort into three TVR subgroups (cut-offs: 92% and 99%) revealed a consistent association of higher TVR with improved OS and PFS ($p < 0.05$; Fig. 1E and F). Univariate Cox regression

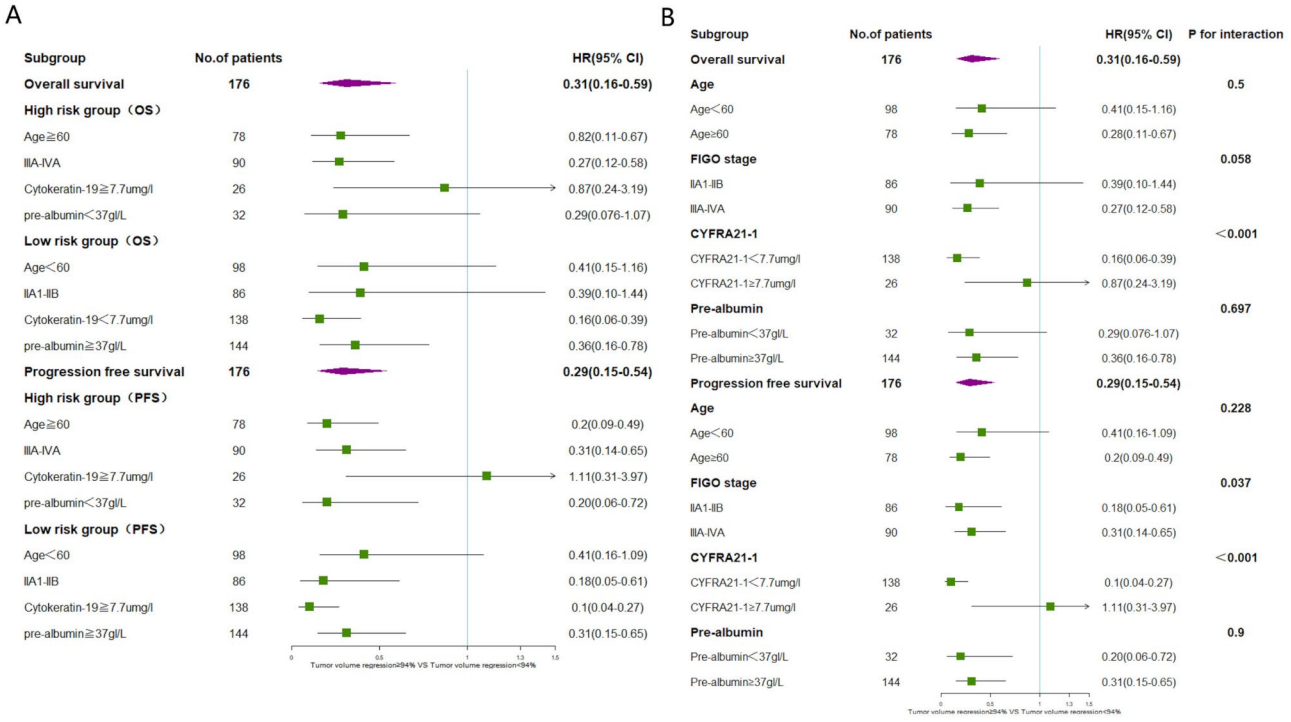

Fig. 2 (**A**) Prognostic Significance of Tumor Volume Reduction (TVR) across Various Subgroups; (**B**) Correlation of TVR with Different Risk Subgroups in Cervical Cancer

analysis identified several significant predictors for both OS and PFS, including ECOG performance status, FIGO stage, tumor size, CYFRA21-1 levels, pre-treatment serum albumin, concurrent chemotherapy, and TVR (all $p < 0.05$). While trends toward decreased OS were observed with increasing age and elevated CA125 levels, these were not statistically significant ($p > 0.05$), nor was anemia ($p > 0.05$), as detailed in Table 2. Multivariate Cox regression analysis identified FIGO stage (IIIA-IVA vs. IIA-IIB), CYFRA21-1 levels (≥ 7.7 ng/ml vs. <7.7 ng/ml), and TVR (≥ 94% vs. <94%) as significant independent predictors of OS. For PFS, age, FIGO stage, CYFRA21-1 levels, and TVR were identified as significant independent factors (Table 2).

Analysis of different risk subgroups of LACC patients

Patients were stratified into high-risk and low-risk groups based on key prognostic factors. The high-risk group included individuals aged ≥ 60 years, with FIGO stage IIIA-IVA, CYFRA21-1 levels ≥ 7.7 ng/ml, and pre-treatment albumin levels < 37 g/L, while all other patients were classified as low-risk. Elevated TVR was associated with improved outcomes in both groups (Fig. 2A).

Among the 111 patients undergoing CCRT, those with a TVR ≥ 94% exhibited significantly better OS and PFS compared to patients with a TVR < 94% (Fig. 3A and B). Conversely, in the 65 patients receiving radiotherapy alone, a TVR ≥ 94% was linked with improved PFS but showed no significant association with OS (Fig. 3C and D).

In patients with CYFRA21-1 levels < 7.7 ng/ml ($n = 138$), a TVR ≥ 94% correlated with better prognosis (Fig. 3E and F). However, in those with CYFRA21-1 levels ≥ 7.7 ng/ml, TVR was not a significant prognostic factor (Fig. 4G and H). Subgroup analyses further demonstrated that CYFRA21-1 levels had a significant interaction with TVR, influencing both OS and PFS (interaction $p < 0.001$). Additionally, FIGO stage significantly impacted the relationship between TVR and PFS (interaction $p = 0.035$), as shown in Fig. 2B.

Survival of lymph node positive subgroup

ROC analysis identified 94% as determined that best cutoff value for NVR was 94%. Compared with patients with node-positive (N+), patients with node-negative (N-) had significantly improved OS and PFS ($p < 0.01$), as shown in Fig. 4A, B. Patients with NVR ≥ 94% demonstrated had significantly improved OS, PFS and LRFS compared to those than patients with NVR < 94% ($p < 0.01$), as illustrated shown in Fig. 4C, D, and E. Although In addition, patients with NVR ≥ 94% showed had a favorable better trend in DMFS compared to those in patients with NVR < 94%, this difference did but it was not reach statistical significance statistically significant ($p = 0.138$), as shown in Fig. 4F.

Table 2 Cox proportional hazards regression models of variables associated with survival outcomes

	Overall survival						Progression free survival					
	Univariate analysis			Multivariate analysis			Univariate analysis			Multivariate analysis		
	HR	95% CI	*P* value	HR	95% CI	*P* value	HR	95% CI	*P* value	HR	95% CI	*P* value
Age (age ≥ 60 vs. < 60 years)	1.86	0.96–3.69	0.064				1.78	0.93–3.38	0.08			
ECOG score (2–3 vs. 0–1)	2.60	1.34–5.10	0.005	1.585	0.989–2.54	0.055	2.90	1.53–6.12	0.001	1.86	1.14–3.05	0.013
FIGO stage (III-IVA vs. IIA-IIB)	3.55	1.66–7.58	0.001	2.79	1.22–6.38	0.015	3.03	1.50–17.0	0.002	2.34	1.07–5.10	0.032
Tumor size (≥ 5.35 cm vs. <5.35 cm)	2.30	1.19–4.48	0.014	1.29	0.59–2.78	0.513	2.29	1.21–4.33	0.011	1.33	0.65–2.74	0.429
TVR (≥ 94% vs. <94%)	0.31	0.16–0.59	< 0.001	0.24	0.11–0.52	< 0.001	0.29	0.15–0.54	< 0.001	0.24	0.12–0.49	< 0.001
CYFRA 21 − 1 (≥ 7.7ng/ml vs. <7.7ng/ml)	2.81	1.34–5.90	< 0.001	3.66	1.64–8.18	0.002	6.66	3.37–13.2	< 0.001	3.77	1.77–8.03	0.001
CA125 (≥ 14.6umol/l vs. <14.6umol/l)	2.06	0.90–4.73	0.089				3.12	1.30–7.49	0.011			
Hemoglobin (< 90 g/l vs. ≥ 90 g/l)	1.94	0.80–4.70	0.141				1.57	0.65–3.75	0.314			
Albumin (< 37 g/l vs. ≥ 37 g/l)	2.81	1.34–5.90	0.006	2.43	0.72–8.18	0.523	2.18	1.05–4.52	0.036	1.56	0.50–4.88	0.443
Concurrent chemotherapy (yes vs. no)	0.48	0.24–0.96	0.039	1.01	0.40–2.54	0.978	0.48	0.25–0.92	0.027	1.15	0.48–2.73	0.745

Abbreviation: HR: Hazard ratio; CI: Confidence interval; TVR: tumor volume reduction; FIGO: Federation International of Gynecology and Obstetrics

Discussion

This study sought to identify risk factors in LACC patients undergoing radiotherapy with and without CCRT, and to explore the prognostic influence of MRI-based TVR across diverse patient risk profiles. Our findings underscore the significance of FIGO stage, CYFRA21-1 levels, and TVR as key independent predictors of LACC treatment outcomes. This investigation uniquely evaluates the predictive value of TVR across different LACC risk categories, highlighting its prognostic relevance particularly in patients with CYFRA21-1 levels below 7.7 ng/ml undergoing CCRT. In the lymph node metastasis subgroup, patients with NVR ≥ 94% demonstrated still had a better prognoses prognosis.

Using MRI, we assessed TV and NV before treatment and mid-RT to calculate TVR and NVR. While previous studies have established the prognostic value of TVR in cervical cancer, the significance of NVR in cervical cancer prognosis has been less explored. Additionally, reported TVR cutoff values vary widely across studies [8–10].

This study found that in the node-positive subgroup, patients with NVR ≥ 94% demonstrated better survival outcomes, indicating that NVR, like TVR, is a valuable prognostic marker for cervical cancer. Sun et al. [20] applied the Youden index to identify an optimal TVR cutoff of ≥ 82.19%, correlating with improved outcomes in LACC patients undergoing CCRT. Using a similar approach, our study identified a distinct TVR cutoff, likely influenced by differences in patient demographics and treatment protocols. Variations in results may also reflect regional and ethnic differences.

LACC exhibits significant heterogeneity, even among patients with similar TVR levels, indicating diverse characteristics of residual disease. FIGO stage, a well-established prognostic factor, remains pivotal in guiding treatment stratification [12, 13]. Wagner et al. [21] retrospectively analyzed 18,649 CC cases from the SEER database, confirming TV as a consistent prognostic indicator across all FIGO stages. This underscores the importance of assessing TVR's prognostic value within each FIGO stage category. Additionally, serum albumin levels, which reflect nutritional status, are recognized as significant prognostic factors in advanced cancers [22–24]. Our findings reaffirm the independent prognostic significance of FIGO stage and pre-treatment albumin levels in LACC, further validating the role of TVR in prognostication across different FIGO stages and in the context of albumin levels.

While CCRT demonstrated prognostic significance in univariate analyses, its effect was less pronounced in multifactorial analyses that included TVR, likely

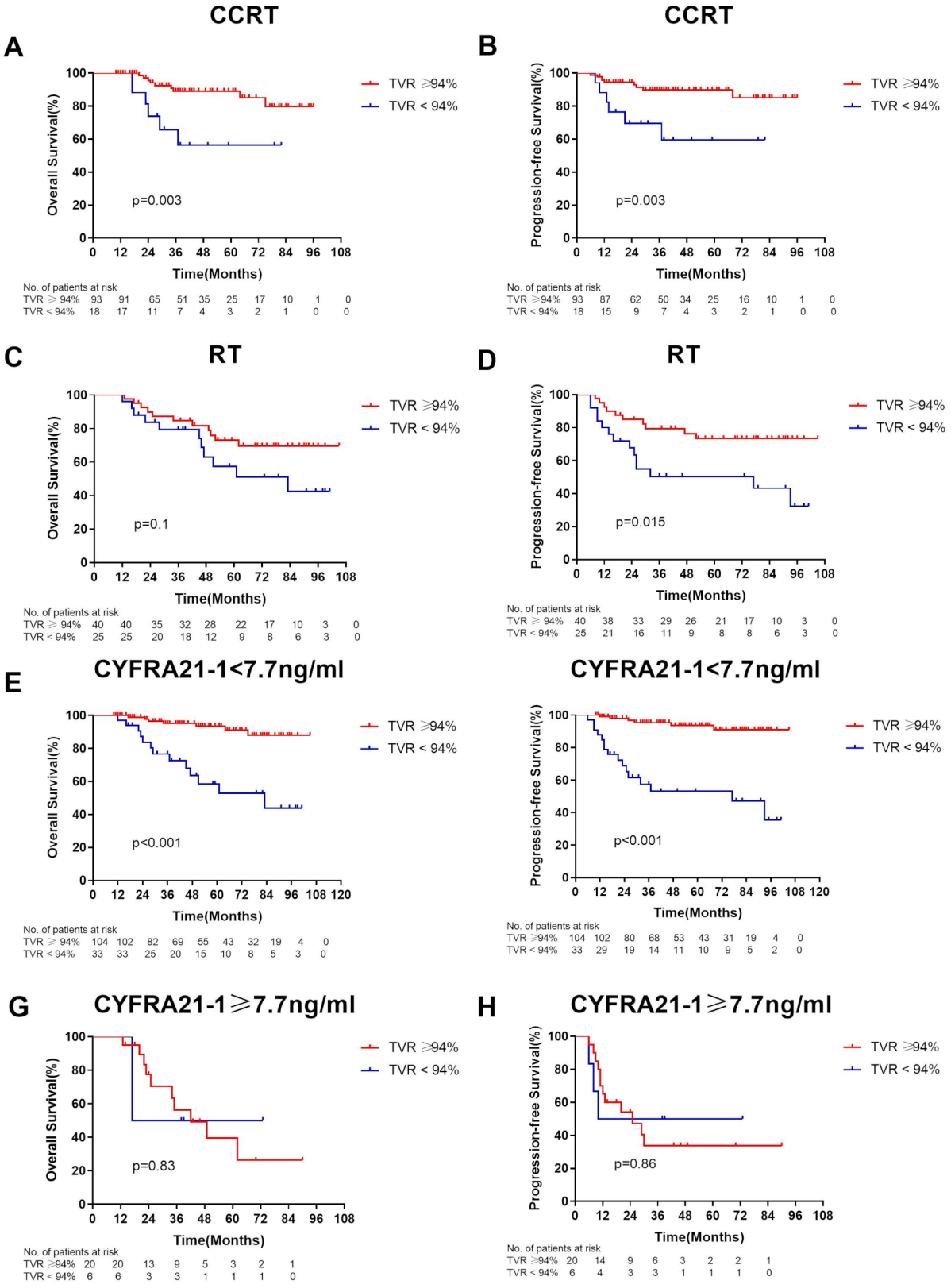

Fig. 3 Survival Analysis based on Treatment Modality and CYFRA21-1 Levels: (**A & B**) Overall Survival (OS) and Progression-Free Survival (PFS) in Patients Undergoing Concurrent Chemoradiotherapy; (**C & D**) OS and PFS in Patients Receiving Radiotherapy Alone; (**E & F**) OS and PFS in Patients with CYFRA21-1 Levels < 7.7 ng/ml; (**G & H**) OS and PFS in Patients with CYFRA21-1 Levels ≥ 7.7 ng/ml

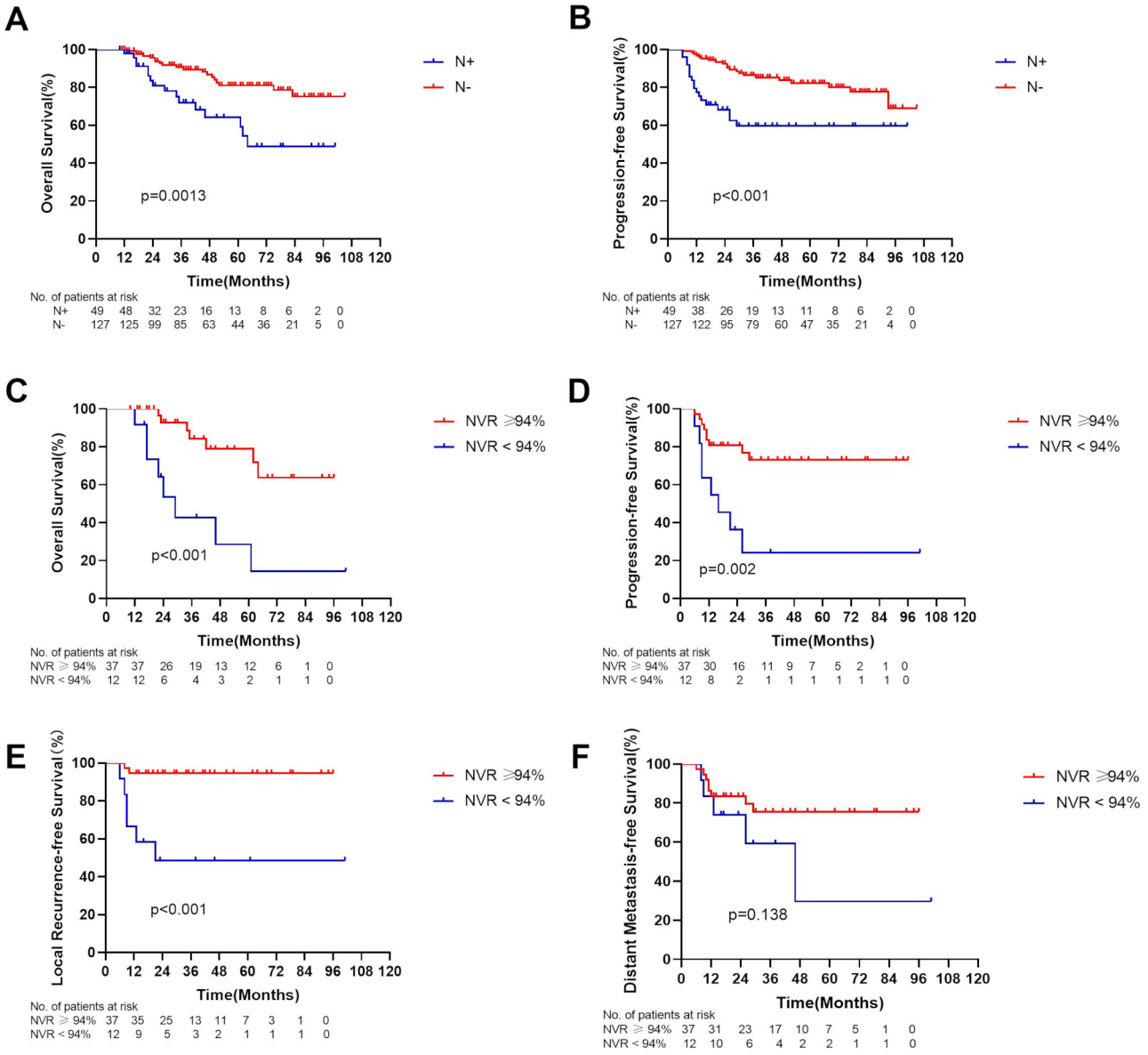

Fig. 4 Kaplan-Meier survival charts **A** and **B** showed the effects of lymph node metastasis on overall survival (OS) and progression-free survival (PFS), respectively. **B**, **C**, **D** and **E** showed the effects of NVR (lymph node volume regression) on OS, PFS, local recurrence-free survival (LRFS) and distal metastases-free survival (DMFS), respectively

due to the higher proportion of patients achieving TVR ≥ 94% in the CCRT group. Mayr et al. [10] analyzed 114 CC patients and identified residual TV after EBRT exceeding 20% as a negative prognostic factor. However, only a small fraction of Mayr et al.'s cohort received concurrent platinum-based chemotherapy, which may account for differences in key TVR thresholds between studies.

Our subgroup analysis, stratified by synchronous chemotherapy administration, reaffirmed TVR as a significant prognostic marker for OS and PFS in patients receiving CCRT, consistent with prior studies [9, 10, 20]. Conversely, the association between TVR and prognosis was not observed in patients treated with RT alone. These findings indicate that the prognostic value of TVR may be influenced by the treatment modality.

These findings suggest that treatment modalities may influence the prognostic value of TVR. Additionally, CYFRA 21 – 1 is an independent prognostic factor that may modify TVR's prognostic significance [25]. Further validation is necessary to clarify TVR's role in LACC patients with varying CYFRA 21 – 1 levels [17]. Our subgroup analysis showed no significant survival differences between TVR levels in patients with elevated CYFRA 21 – 1, likely due to a significant

interaction between CYFRA 21 – 1 and TVR [17, 25]. These results highlight the importance of incorporating CYFRA 21 – 1 levels into future assessments of TVR's prognostic impact. Notably, even in patients with elevated CYFRA 21 – 1, a high TVR does not ensure a favorable prognosis. This underscores the need for more intensive treatment strategies and vigilant follow-up in this subgroup.

The study has several limitations. Its stem from its retrospective design and execution at a single center setting, which may restrict limit the generalizability generality of our findings. Additionally, there is heterogeneity in the treatment regimens, necessitating validation through regimen, which needs to be further verified by external data. The intracavitary brachytherapy in this study was performed using conducted on a Point A-based approach rather than RT guided by 3D imaging, which could impact the results. Finally, the analysis study was conducted exclusively on T2-weighted imaging sequences. In future studies, other MRI sequences, such as diffusion-weighted imaging (DWI), should be incorporated to further validate these findings.

Conclusion

In conclusion, our study identifies TVR as an independent prognostic marker for therapeutic outcomes in LACC. Through risk stratification, TVR was shown to be a significant prognostic factor, particularly in patients with CYFRA21-1 levels below 7.7 ng/ml undergoing CCRT. Furthermore, among patients with lymph node metastasis, those achieving a NVR of ≥ 94% demonstrated favorable prognoses.

Abbreviations

CC	Cervical cancer
LACC	Locally advanced cervical cancer
CCRT	Concurrent radiotherapy and chemotherapy
EBRT	External beam radiotherapy
ICBT	Intracavitary brachytherapy
MRI	Magnetic resonance imaging
TV	Tumor volume
NV	Lymph node volume
TVR	Tumor volume regression
NVR	Nodal volume regression
ROI	Regions of interest
CTV	Clinical target volume
SIB	Simultaneous Integrated Boost
ROC	Receiver operating characteristic
OS	Overall survival
PFS	Progression-free survival
LRFS	Local relapse-free survival
DMFS	Distant metastasis-free survival

Supplementary Information

The online version contains supplementary material available at https://doi.org/10.1186/s13014-025-02623-w.

Supplementary Figures 1: **A** and **B** sketch the tumor volume before and during radiotherapy, respectively. The red curve is the primary tumor volume of cervical cancer, and the pink curve is the metastatic lymph node volume

Supplementary Figures 2: Study design flow chart

Supplementary Figures 3: Receiver Operating Characteristic (ROC) Curve Analysis Outcomes depicting: (**A**) Tumor Size; (**B**) Tumor Volume; (**C**) Tumor Volume Reduction (TVR); (**D**) CA125 Levels; (**E**) CYFRA 21-1 Levels; (**F**) Pre-treatment Albumin Levels

Author contributions

CYL, NX, QC, DXL, FLY, PFL, YSJ, DZ, BLG and XLN gathered the data. NX, CYL analyzed the data. NX, CYL wrote the manuscript. All authors reviewed the manuscript.

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Data availability

No datasets were generated or analysed during the current study.

Declarations

Competing interests

The authors declare no competing interests.

Ethics approval and consent to participate

This study was approved by the Ethics Committee of Longyan First Hospital Affiliated to Fujian Medical University of our Hospital (Approval number: 2020 Ethics Approval No. 08), which conforms to the ethical standards stipulated in the Declaration of Helsinki. The study received verbal consent and confirmation from all patients.

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