

Brachytherapy Vs Stereotactic Body Radiotherapy: A Comparative Dosimetric Study in the Carcinoma of the Cervix

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Intrduction :In this study ,we investigate the feasibility of using Stereotactic radiotherapy (SBRT)Based on Linear accelerator as an alternative to Brachytherapy) BT (for cervical cancer when BT cannot be performed.

Twenty patients diagnosed with locally advanced cervical cancer were included in the study .Each patient underwent a treatment regimen consisting of external beam radiotherapy (EBRT (combined with chemotherapy ,followed by an intracavitary high-dose-rate) HDR(brachytherapy) BT (boost .For dosimetric Purposes ,two treatment plans were developed using different treatment techniques ,with the first plan utilizing BT on the Oncentra Treatment Planning System) TPS (and the second plan employing SBRT on the Monaco TPS .The dose constraints utilized for brachytherapy were derived from the EMBRACE II trial ,while those for stereotactic body radiation therapy) SBRT (in four fractions were employed for comparison purposes .A comparative analysis of the dose distribution ,maximum dose points on target volumes ,bladder and rectum ,and dose-volume histograms was conducted between the two techniques.The proximity of organs at risk was assessed to evaluate potential treatment-related adverse effects.

In regard to the target D100% and D98% the variation in the two planning techniques was significantly better (p value <0.0005) in favor of the SBRT technique. In regard to critical organ doses, SBRT has shown better sparing for many metrics. For example, D2cc was 22.86 ± 3.65 vs 25.61 ± 3.83 Gray (Gy) for the bladder and for D1cc was 24.34 ± 4.02 vs 28.39 ± 4.49 Gy, while no significant difference resulted regarding D5cc.

In addition, there was a significant difference between D2cc and D1cc for the sigmoid, also there was a significant difference for the maximum dose for the left and right head of femurs (p< 0.005) all in favor of SBRT. In regard of D2cc and D1cc for the rectum there was a significant difference (P <0.005) both in favor of SBRT. However, for D5cc there is no significant difference between the two techniques.

The study found that SBRT is effective and safe for treating cervical cancer when brachytherapy is not possible. However, the movement of organs and potential low doses to other structures should be considered. Further research is necessary to optimize SBRT for cervical cancer treatment.

Keywords: Stereotactic Body Radiotherapy (SBRT, Brachytherapy (BT), Cervical Cancer, High Dose Rate)HDR (and Organs at Risk) OAR(

Introduction

Cervical cancer is the fourth most common female cancer and the fourth most common cause of death from cancer in women worldwide .[1]In ,2017 the European Society for Medical Oncology) ESMO (published the guidelines for

the non-surgical management of cervix cancer [2]which recommend the use of External Beam Radiotherapy) EBRT (for the pelvis followed by Brachytherapy) BT (boost .The introduction of BT in cervix cancer treatment has persistently shown reduced local recurrence and improved

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overall survival compared to pelvic EBRT alone [3]. ESMO's guidelines recommended EBRT for the pelvis followed by BT boost in order to achieve a final dose of 85 to 90 Gy to the Clinical Target Volume (CTV). (BT boost to cervical cancer is considered the only safe way to achieve such high doses, which correlates with improved local control and local survival.[4] On the other hand, BT has superiority when compared with EBRT techniques, the superiority of BT can be explained by its unparalleled dose distribution, which is characterized by sharp dose gradient and low integral dose.[5] The sharp dose gradient permits maximum sparing of Organs at Risk (OARs) (while delivering high doses to the tumor). In addition, the radioactive sources loaded within the applicators are inserted in the target volume, therefore, no need for additional margins to account for setup errors or to adapt changes in bladder and rectal filling.[5] Although these mentioned benefits of BT, some limitations of BT were reported; Mahmoud et al [5] summarized the limitations of BT in the following points:

- (1) BT is an operator-dependent technique that necessitates a set of skills that, if lacking, it may have a major impact on the outcomes; For example, inadequate ovoid placement and/or displacement reduced both local control and disease-free survival rates, while inadequate packing reduced disease-free survival^[8]
- (2) Significant inter and intra-fraction differences might occur after proper applicator positioning^[9]
- (3) Independent of clinician's skills, there are extra features to the BT procedural requirements, such as:
 - (A) Cervical dilation can be difficult sometimes, which necessitates full anesthesia with its associated operating and recovery rooms, which increases BT's overall cost.
 - (B) BT may be linked to serious side effects such as uterine perforation, vaginal laceration,^[10] and anesthesia-associated risks.
 - (C) Physical limitations resulting from differences in vaginal accommodation, such as normal variations with age, prior pelvic procedures, or uterine abnormalities, as well as insufficient tumor volume reduction that prevents certain patients from receiving appropriate applicator insertion.^[11]
 - (D) due to applicator discomfort, some patients refuse BT applicator insertion.^[11]
 - (e) According to recent survey findings,

high-quality volumetric image-guided brachytherapy, a powerful form of radiation therapy associated with superior treatment outcomes, is utilized by only 25% of clinicians in their everyday practice. However, the technique requires specific procedural and logistical considerations which are not yet standardized globally, resulting in limited awareness and implementation of this approach. This issue is pervasive worldwide and may contribute to the underutilization of this highly effective treatment modality by healthcare practitioners.^[12]

In some cases, BT cannot be performed, e.g. due to patient refusal, anatomic issues, pelvic/para-aortic lymphadenopathy or small volume recurrence. In these situations, SBRT boost has been used as an alternative to BT.

In recent years, SBRT, one of EBRT techniques, has been used and compared as an alternative to BT. This technique has evolved from Stereotactic Radiosurgery (SRS), (which consists of delivering a high dose per fraction usually to a small target in a single fraction). SRS was initially developed to treat brain tumors and functional disorders with delivery requiring a neuro-navigational stereotactic system. Eventually this led to evolution of SBRT treatment, in which few fractions, typically 3 to 5 fractions utilized, and neuro-navigational stereotactic systems are replaced with images, surfaces, or fiducial based navigation.^[6]

SBRT is a precise and targeted form of radiation therapy that delivers high doses of radiation to a specific area of the body using advanced imaging techniques. It is based on the principles of SRS [33]. SBRT is a highly precise and advanced technique that utilizes real-time image-guidance to deliver radiation therapy to a specific target volume. This method produces steep gradients around the tumor, enabling the delivery of a high dose to the tumor while protecting critical structures surrounding the target. SBRT shares similarities with high-dose-rate (HDR) BT, including the use of hypofractionated large fraction doses and dose distributions with a rapid fall-off around the target. However, SBRT offers the advantage of more efficient dose distribution sculpting compared to BT. Additionally, the real-time tracking capability associated with advanced SBRT techniques provides the added benefit of minimizing the risk of missing the target area.^[19]

Several studies have compared different boost modalities for the treatment of cervical cancer. Dahbi et al. found that high-dose-rate BT had superior target volume coverage and organ-at-risk sparing compared to SBRT. [27] In "Boost modalities in cervical cancer: dosimetric comparison between intracavitary BT vs. intracavitary + interstitial BT vs. SBRT", the authors compare three different boost modalities in the treatment of cervical cancer - intracavitary (IC) (with tandem/ovoids brachytherapy) BT, (IC + interstitial) IS (BT, and SBRT. The aim is to determine the dosimetric impact in terms of target coverage and OAR doses. The study concludes that IC + IS BT provides significantly better target coverage and a lower dose to the OARs, making it the preferred boost modality in CC. The paper highlights the limitations of using SBRT as an alternative to BT and emphasizes the importance of comparing different boost modalities in the same patient to have comparable volumes in terms of target coverage and organ at risk. [28]

Gao et al. investigated the use of CyberKnife-based SBRT as an alternative to BT in patients with locally advanced cervical cancer (LACC). The study compares the dose distributions and radiobiological effects of a CyberKnife (CK)-based SBRT boost and a BT boost and finds that the CK-based SBRT plan could result in significantly better target coverage, OAR sparing, and radiobiological effects compared to the BT plan for tumors that are not excessively large. The article suggests that CK-based SBRT could be an alternative option for patients who are not candidates for BT [29]

Lee, T. H. et al. analyzed the treatment efficacy and safety of stereotactic ablative body radiotherapy (SABR) (boost for cervical cancer patients who are not eligible for brachytherapy). A retrospective review of the medical records of 25 patients was conducted, and the results showed that SABR boost was effective and well-tolerated. The study concluded that SABR boost can be a treatment option when brachytherapy is not feasible. O'Donnell B, Shiao JC, Pezzi TA, et al. compared the overall survival of cervical cancer patients treated with SBRT, intensity-modulated IMRT, and brachytherapy boost techniques. The analysis of 15,905 patients showed no significant difference in overall survival for those who received SBRT boost compared to brachytherapy boost, but a significant detriment in overall survival for those who received IMRT boost. The authors suggest

that SBRT may be a suitable alternative to brachytherapy, but further studies are needed. [31]

Georg D, et al. compared high-tech EBRT with high-tech BT for locally advanced cervix cancer. Nine patients were treated with either intracavitary, combined interstitial/intracavitary, or complex interstitial BT, and PTVs (were constructed for EBRT. Inversely planned EBRT with photons) IMRT (and protons) IMPT (was challenged to deliver the highest doses to PTVs while respecting dose limits from BT. The study found that for cervix cancer boost treatments, both IMRT and IMPT were inferior to advanced BT. Therefore, high-tech BT techniques should be used for benchmarking high-tech EBRT. [32]

In this work, we investigate the feasibility of using SBRT Based on Linear accelerator as an alternative to BT for cervical cancer when BT cannot be performed.

Materials and Methods

For this dosimetric study, twenty patients with locally advanced cervical cancer were selected. All patients received external beam radiotherapy (EBRT) (concomitant with chemotherapy, followed by intracavitary high-dose-rate) HDR (brachytherapy) BT (boost. During the EBRT phase, an IMRT technique was used to deliver a prescribed dose of 45 Gy in 25 fractions to all patients. In the BT phase, all patients were prescribed to point A or to the clinical target volume at high risk) CTV-HR, (and the dose distribution was optimized to achieve the best possible treatment plan. In both cases, the dose was 7 Gy per fraction delivered once per week in four fractions. The HDR BT was delivered using a Cobalt 60-isotope via a Flexitron HDR remote afterloading unit) Nucletron Inc., Veenendaal, The Netherlands.)

Patient Simulation

For imaging purposes, all patients underwent two modalities and two image sets were acquired. The first image set was obtained using 2 mm magnetic resonance imaging (MRI), (while the second image set was obtained using a computed tomography) CT (scanner. These two imaging modalities were used to provide complementary information for treatment planning and to ensure accurate delineation of the target volume and surrounding organs at risk.

MRI Simulation: The first images set

Magnetic resonance imaging (MRI) has become increasingly important in radiation treatment planning because of its superior soft tissue contrast compared to CT [13]. This can be achieved by acquiring an MRI in the treatment position or through fusion with the diagnostic MRI. By providing detailed soft tissue information, MRI can help to ensure accurate target delineation and minimize the risk of damage to surrounding healthy tissue during radiation therapy. For this study, all patients underwent imaging using a closed MR scanner (ESSENZA, Siemens 1.5 T). T2-weighted MR images were acquired and selected for delineation and treatment planning. The use of T2-weighted images helps to provide high contrast between the tumor and surrounding healthy tissue, allowing for more accurate and precise treatment planning.

CT Simulation: The second images set

Computed tomography (CT) scanners are a crucial component in modern radiation therapy centers. Three-dimensional conformal radiotherapy techniques are commonly used to manage different malignancies, which provide better target (PTV) accuracy and avoid nearby organs at risk (OARs). In gynecologic cancers, CT-based treatment planning is the most commonly used technique for both EBRT and brachytherapy applications [14]. In this study, a set of CT scan images with 2 mm slices was obtained for each patient using a Biograph mCT scanner (Siemens), which has a high enough resolution for target delineation. All patients were simulated in a supine position without applicator insertion, with a full bladder and empty rectum. Delineation was performed with the guidance of MR images to contour the tumor and OARs, ensuring accurate treatment planning for each patient.

Delineation

All patients in both image sets were delineated according to The GYN GEC-ESTRO protocol which defines the GTV and CTV in the following manner.

GTV:

Gross tumor volume at time of brachytherapy includes microscopic tumor extension at time of BT as detected by clinical examination and as visualized on MRI in patients treated with upfront BT or with BT alone. GTV at brachytherapy time is identical to GTV at diagnosis time [15].

HR-CTV:

High risk CTV for BT encompasses

macroscopic tumor burden and includes GTV at brachy time, always the whole cervix and the presumed extra-cervical tumor extension at time of BT.

IR-CTV:

Intermediate-risk CTV for BT (IR-CTVB1, IR-CTVB2, etc.), which carries significant microscopic tumor load, encompasses high-risk CTV with margins of 0.5-1.5 cm.

Dose Constraints Protocol

In this study, we used dose-volume constraints for target volumes and organs at risk according to the EMBRACE II protocol [26].

Treatment planning and delivery

For each patient two separate plans, SBRT and BT, were designed. All BT plans were designed using the ONCENTRA Brachy treatment planning system, version 4.5.3, and were delivered using a Flixetron machine with a Co60-source. In BT each case was planned four times, at the beginning of every session on the MRI data set, as recommended by ESTRO. The dose distribution was calculated with the principles of TG-43. In addition, all plans were normalized to point A, while the final dose distribution was evaluated on 3D view and DVH. On the other hand, all SBRT plans were generated through the use of the TPS and Monte Carlo (MC6) (MV algorithm), but were not administered and were only employed for comparative analysis. In SBRT, all plans were VMAT-based, with 3 Arcs of 360° rotating clockwise as the following:

The prescribed dose in our study for stereotactic body radiation therapy was 28 Gy delivered in 4 fractions. The normalization method used for all plans was to ensure that 95% of the target volume received the prescription dose. The isodose line used for normalization ranged from 50% to 80% of the prescription dose. This approach was employed to achieve a balance between dose coverage of the target volume and sparing of surrounding normal tissues, and the choice of isodose line was based on a trade-off between target volume coverage and normal tissue sparing. One arc Coplanar beam with couch angle 0°. The two other arcs with couch angle ± 10°. The statistical uncertainty of MC was kept at 1% per calculation and grid spacing of 2 mm. 150% of hot spots were allowed in the target, in other words the hot spots were not constrained in addition to being centralized inside the GTV.

The dose constraints employed in this study were obtained from the Embrace II [26] and are currently utilized for BT. Typically, in clinical practice, the total dose is calculated in terms of cumulative dose. However, in this investigation, we analyzed the dose without calculating the equivalent cumulative dose for the external beam and BT.

PLAN EVALUATION.

The different plans were compared in terms of target coverage and DVH parameters concerning OARS) D2, D5, D1 and maximum dose (metrics, where D2cc, D5cc and D1cc refer to the dose received by 5, 2 and 1 cubic centimeters) cc (of the volume of an OAR that receives the highest dose. This value is typically used to evaluate the maximum dose received by a small volume of the OAR. We concerned with the rectum, Bladder, Sigmoid and Head of Femurs as OARS.

Results

Statistical analysis of the data

Data was fed to the computer and analyzed using IBM SPSS software package version.20.0 (Armonk, NY: IBM Corp. (The Shapiro-Wilk test was used to verify the normality of distribution. Quantitative data were described using range, minimum and maximum, (mean, standard deviation and median. The Significance the obtained results was judged at the 5% level.

The analysis was performed using:

Paired t-test, to compare between SBRT and Brachytherapy considering normal distribution.

Results

The dose and dose differences for HR-CTV) and PTV in case of SBRT (attributed to SBRT and BT techniques are presented in Table 1. For D100% and D98% the variation in the two planning techniques was significantly better) p value ($0.0005 >$ in favor of the SBRT technique. Although no significant difference was observed in the D90% metric, the BT technique exhibited the lowest value for this parameter. A more comprehensive outline of the target coverage outcomes is provided in Table 1. In regard of critical organs doses, SBRT has shown better sparing for many metrics. For example, D2cc was 3.65 ± 22.86 vs 3.83 ± 25.61 Gray Gy (for the bladder and for D1cc was 4.02 ± 24.34) vs ± 28.39 (4.49Gy, while no significant difference resulted regarding D5cc. further details in Table (3).

The following table presents a comparative analysis of Target volume, Conformity index) C_i , (Gradient index) GI, (and Heterogeneity index for each position. It is important to note that the target volume in SBRT includes the CTV plus a 3 mm margin.

The next figures show the dose distribution and DVHs of SBRT and BT plans from the current study. In regard to D2cc and D1cc for the rectum there was a significant difference) P ($0.005 >$ both in favor of SBRT. However, for D5cc there is no significant difference between the two techniques. In addition, there was a significant difference between D2cc and D1cc for the sigmoid, also there was a significant difference for the maximum dose for the left and right head of femurs) p($0.005 >$ all in favor of SBRT. Further details in Table(3).

TABLE 1. Comparison between SBRT and Brachytherapy according to PTV in each position.

PTV	SBRT (n = 20)	Brachytherapy (n = 20)	p	t
D90				
Min. – Max.	30.70 – 36.0	22.80 – 41.20		
Mean \pm SD.	33.73 ± 1.47	33.28 ± 6.0	0.761	0.309
D98				
Min. – Max.	26.70 – 31.90	19.70 – 33.30		
Mean \pm SD.	30.0 ± 1.44	26.70 ± 4.29	0.006*	3.072*
D100				
Min. – Max.	18.10 – 28.20	16.70 – 27.60		
Mean \pm SD.	24.12 ± 2.45	21.15 ± 3.13	0.003*	3.464*

SD: Standard deviation

t: Paired t-test

p: p value for comparing between SBRT and Brachytherapy

*: Statistically significant at $p \leq 0.05$

TABLE 2. Comparison between SBRT and Brachytherapy according to the target volume indices in each position.

PTV	Brachytherapy (CTV) (n = 20)	SBRT (PTV) (n = 20)	p	t
Target Volume (cc) Min-Max Mean±SD	5.2 – 62 <hr/> (26.31 ± 24.33) cc	13.6 – 97.2 <hr/> (44.51 ± 34.13) cc		
CI Min-Max Mean±SD	0.1 - 0.46 0.2029 ± 0.121	0.62 - 0.8 0.73 ± 0.062	0.000*	10.806*
GI Min-Max Mean±SD	2.5 – 2.9 2.678 ± 0.128	2.5 – 3.3 2.9 ± 0.294	0.183	1.505
HI Min-Max Mean±SD	4.5 – 9.5 6.543 ± 1.596	1.5 - 1.72 1.577 ± 0.0865	0.000*	-8.118*

SD: Standard deviation
*: Statistically

T: Paired Samples t-test
significant at

p: value for comparing between BT and SBR
p ≤ 0.05

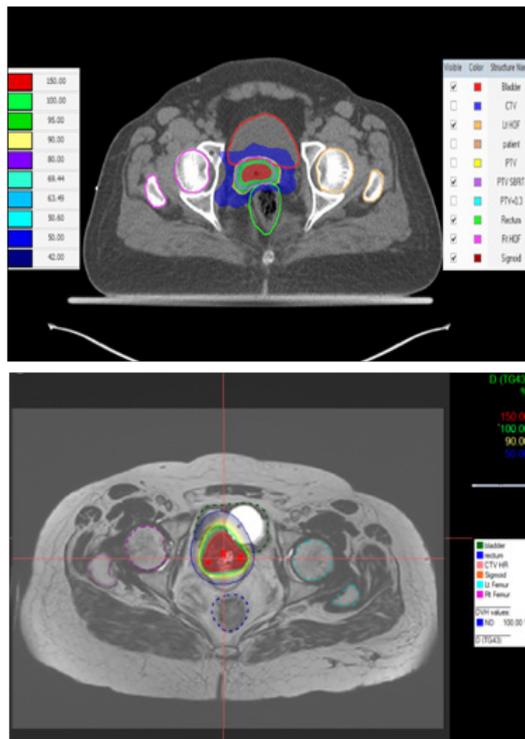


Fig 1. Represent the dose distribution of SBRT and BT respectively on the axial plane.

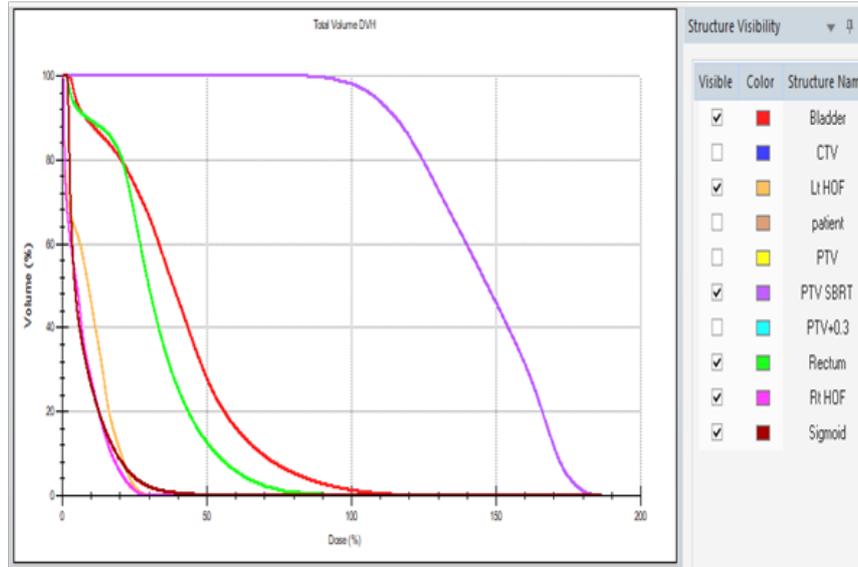


Fig 2. Present the DVH of SBRT plan.

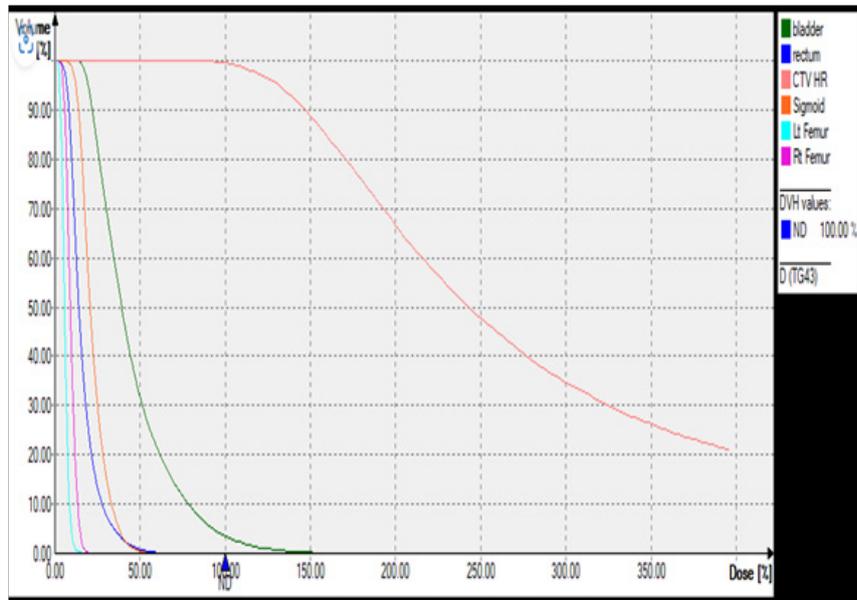


Fig 3. Present the DVH of BT plan.

Discussion

This is a feasibility study of SBRT based linear accelerator compared with BT in patients with locally advanced cervix cancer. The doses sparing from the critical structures and target coverage were superior with SBRT) except D90% and D5cc to the Bladder and Rectum. (Furthermore, SBRT shows superiority in terms of the conformity index) table ;(2 it can be attributed to SBRT's ability to utilize multiple beam angles, create numerous segments, and employ intensity modulation. On the other hand, there is

no substantial difference between SBRT and BT regarding the gradient index. This is because we place particular emphasis on the dose fall-off to minimize low doses to normal tissues.

On the contrary, BT demonstrated a significantly higher heterogeneity index compared to SBRT. This difference may be attributed to fundamental differences in the radiation delivery methods. BT involves implantation of radioactive sources directly within or adjacent to the tumor target, allowing very focused dose escalation to the surrounding volume.

TABLE 3. Comparison between SBRT and Brachytherapy according to bladder, rectum, head femur, RT head femur and sigmoid in each position.

		SBRT (n = 20)	Brachytherapy (n = 20)	p	t
Bladder	D2cc Min. – Max. Mean ± SD.	17.50 – 27.50 22.86 ± 3.65	17.20 – 30.70 25.61 ± 3.83	0.004*	3.293*
	D1cc Min. – Max. Mean ± SD.	19.30 – 29.90 24.34 ± 4.02	19.10 – 35.70 28.39 ± 4.49	0.001*	3.901*
	D5cc Min. – Max. Mean ± SD.	16.0 – 24.50 20.01 ± 2.77	12.10 – 28.0 21.08 ± 3.73	0.303	1.058
Rectum	D2cc Min. – Max. Mean ± SD.	16.10 – 24.30 18.94 ± 1.83	9.20 – 24.50 15.86 ± 4.04	0.004*	3.233*
	D1cc Min. – Max. Mean ± SD.	17.30 – 26.90 20.85 ± 2.21	10.0 – 28.0 17.79 ± 4.62	0.006*	3.092*
	D5cc Min. – Max. Mean ± SD.	11.10 – 19.60 15.42 ± 2.51	8.0 – 22.0 13.03 ± 3.54	0.021*	2.527*
Head Femur	Dmax Min. – Max. Mean ± SD.	3.0 – 9.70 7.88 ± 1.31	4.80 – 8.40 6.46 ± 0.84	<0.001*	4.330*
RT head femur	Dmax Min. – Max. Mean ± SD.	6.70 – 9.70 8.02 ± 0.72	4.0 – 8.40 6.58 ± 1.13	<0.001*	4.223*
Sigmoid	D2cc Min. – Max. Mean ± SD.	3.0 – 20.20 9.07 ± 5.03	3.90 – 29.10 13.22 ± 7.10	0.006*	3.128*
	D1cc Min. – Max. Mean ± SD.	4.10 – 19.50 10.85 ± 5.03	4.0 – 34.30 15.60 ± 8.48	0.010*	2.849*

Several authors have demonstrated target coverage with IMRT or SBRT when compared with BT [23,29,30,22,21,20,19]. They showed that SBRT achieves better dose distribution in PTV and lower maximum doses to critical organs at risk at the expense of greater dose to normal tissue and bone marrow.

Additionally, many studies comparing EBRT with BT have been criticized for having inadequate PTV margin in EBRT setting (to account for the large organ motion related to the bladder and rectal fullness [20]). All these comments have been

taken into account in this study, the CTV to PTV margin was added to overcome this motion (the margin was added in SBRT arm only, (also special concern has been given to the low doses to the normal tissues) unspecified tissues (and this can be noticed from the low maximum doses to the both head of femurs). In addition, as shown in the previous results there were significant differences between the PTV coverage in both D100% and D98% also, in the regard of D1cc and D2cc for the bladder and rectum, all in favor of SBRT despite of adding margin to the CTV.

This potency of SBRT may be attributed to its ability to use multiple beam angles and to create many segments to spare organs at risk, while this potency is missed in BT. The efficiency of emulating BT dose distribution using SBRT is currently under investigation in another pelvic organ) the prostate (with promising results,[21] and SBRT has shown its effectiveness in this arm. [23, 22] indeed, there is an advantage for cervical cancers when compared with prostate tumors, that cervical tumors undergo substantial shrinkage during the treatment sessions [24] and that will permit the using of adaptive strategies between fractions, which finally will lead to minimizing the dose to the organs at risk while maintaining the coverage to the target.[25]

On the contrary, some studies found that brachytherapy demonstrated dosimetric superiority in terms of target volume coverage and organ-at-risk sparing. [3,27,28,31] These contradictory results highlight the complexity of cervical cancer treatment and the need for further research to fully understand the potential benefits and drawbacks of different treatment options. Therefore, it is important to carefully consider the available evidence and weigh the benefits and limitations of each treatment modality before making clinical decisions.

Conclusion

In conclusion, this study has shown that SBRT is a highly effective non-invasive treatment modality for cervical cancer, offering superior coverage and lower risk to organs at risk compared to other treatment options. The results of this study suggest that SBRT should be considered as a viable alternative when brachytherapy is not feasible. However, it is important to take into consideration the motion of organs and potential low doses to unspecified structures, which may impact treatment outcomes. Further studies are needed to better understand the effectiveness of SBRT and to optimize its use in cervical cancer treatment.

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العلاج الإشعاعي الداخلي مقابل العلاج الإشعاعي محدد التجسيم: دراسة مقارنة توزيع الجرعات الإشعاعية لسرطان عنق الرحم

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سرطان عنق الرحم هو رابع أكثر أنواع السرطان شيوعاً بين النساء في جميع أنحاء العالم. الخط العلاجي الحالي هو العلاج الخارجي بالأشعة السينية يليه العلاج الإشعاعي الداخلي (البراعي). العلاج بالبراعي يوفر ميزة إنحدار حاد لجرعة الإشعاع بالإضافة إلى انخفاض جرعة الأنسجة السليمة، مما يسمح بجرعات عالية للورم. وهذا ما يرتبط بنتائج جيدة للعلاج. ومع ذلك، فإن العلاج بالبراعي لديه بعض القيود مثل اعتماده على المشغل operator، وإزعاج المرضى بالأجهزة التي يتحرك بها المصدر المشع، والحاجة إلى التخدير وغيرها، مما يجعله غير ملائم لبعض المرضى. وقد ظهر في العصر الحديث العلاج بجرعة عالية موضعياً باستخدام المعجل الخطي كبديل محتمل للعلاج بالبراعي في الحالات التي لا يمكن فيها إجراء العلاج بالبراعي لعدم ملائمتها.

هذه الدراسة تسعى لبحث إمكانية استخدام العلاج بالمعجل الخطي كبديل للعلاج بالبراعي وذلك مع المرضى الذين لا يمكن علاجهم بالطريقة الأخيرة. وإجمالاً: فإن العلاج بالبراعي هو النهج المعياري والأسلوب المستخدم حالياً بسبب نتائجه الجيدة. ومع ذلك، فإن العلاج بجرعة عالية باستخدام المعجل الخطي قد يكون خياراً للمرضى الذين لا يمكنهم الخضوع للعلاج بالبراعي لأسباب مختلفة.