ELSEVIER
Brachytherapy xxx (xxxx) xxx
BRACHYTHERAPY

Implementation of online workshops on image-guided adaptive brachytherapy (interventional radiotherapy) in locally advanced cervical cancer: Experience of BrachyAcademy

Elena Dizendorf[1], Alina Sturdza[2,*], Luca Tagliaferri[3], Luca Russo[3], Nicole Nesvacil[2], Christian Kirisits[2]

[1] *Nucletron Operations B.V. (Elekta), Veenendaal, The Netherlands*
[2] *Department of Radiation Oncology, Comprehensive Cancer Center, Medical University of Vienna, Vienna, Austria*
[3] *UOC Radioterapia Oncologica, Dipartimento di Diagnostica per Immagini, Radioterapia Oncologica ed Ematologia, Fondazione Policlinico Universitario Agostino Gemelli IRCCS, Rome, Italy*

ABSTRACT

PURPOSE: To provide educational support to brachytherapy users during the COVID-19 pandemic, online workshops were developed and implemented by BrachyAcademy, non-profit peer-to-peer educational initiative in Elekta.

METHODS AND MATERIALS: In 2021–2022 two online workshops were organized. Participating teams had to send a clinical case of locally advanced cervical cancer (LACC) including brachytherapy Digital Imaging and Communications in Medicine (DICOM) files and questions to the faculty. During the workshop, feedback was given to each clinical case by five faculty members (two Radiation Oncologists, one Radiologist, two Medical Physicists). Participants competed a post-workshop questionnaire which included combination of qualitative and quantitative questions via yes/no responses, Likert scale, and 1 to 10 scale.

RESULTS: Twenty-one teams from eight countries (Europe, Asia, Latin America) participated in two online workshops. The total number of participants was 49. The clinical cases represented LACC with The International Federation of Gynecology and Obstetrics (FIGO) stages from IB3 to IVA. During both, Workshop1 (W1) and Workshop 2 (W2) the following areas of improvement were identified: familiarity with the GEC ESTRO and The International Commission on Radiation Units & Measurements, Report 89 (ICRU 89) recommendations for contouring and planning based on clinical drawings and MRI sequencing choice; appropriate applicator selection; experience with interstitial needles; appropriate applicator reconstruction; dose optimization. The participants rated both workshops with overall scores 8,3 for W1, and 8,5 for W2. In 82% participants the training course fully met expectations for W1, and in 76% in W2.

CONCLUSIONS: We successfully implemented the online workshops on image-guided adaptive brachytherapy (IGABT) in LACC. Main performance issues and areas for improvement were identified based on multidisciplinary discussion of participant's clinical cases through all steps of the brachytherapy procedure. We encourage teams to consider online workshops in addition to hands-on training. © 2023 The Authors. Published by Elsevier Inc. on behalf of American Brachytherapy Society. This is an open access article under the CC BY-NC-ND license (http://creativecommons.org/licenses/by-nc-nd/4.0/)

Keywords: Education; Training, Online; Image-guided brachytherapy; Cervix; Cervical cancer

Received 20 October 2022; received in revised form 17 January 2023; accepted 21 January 2023; Available online xxx

Disclosures: The authors declare the following financial interests/personal relationships which may be considered as potential competing interests: AS, LR, LT, CK report educational grants from Elekta for teaching at the online workshops. Medical University of Vienna receives financial support for the EMBRACE study office from Elekta and Varian Medical Systems. ED works for Elekta; BrachyAcademy is a non-profit initiative in Elekta.

* Corresponding author. Comprehensive Cancer Center, Department of Radiation Oncology, Medical University of Vienna, Währingergürtel 18-20, 1090, Vienna, Austria.

E-mail address: alina.sturdza@akhwien.at (A. Sturdza).

Introduction

Brachytherapy (BT), also known as interventional radiotherapy, plays a fundamental role in the management of locally advanced cervical cancer (LACC). Magnetic resonance imaging (MRI)-based image-guided adaptive brachytherapy (IGABT) is the established gold standard for brachytherapy in LACC. The clinical outcome of the prospective EMBRACE-I study was published in Lancet Oncology (1). Chemoradiotherapy and MRI-based IGABT resulted in 5-year local control 92% across all stages of LACC, with a limited grade 3–5 morbidity.

Implementation of IGABT in cervical cancer is critically dependent on effective multidisciplinary education of all healthcare professionals involved in the brachytherapy treatment process (2). The current options for postgraduate education in brachytherapy are varied: teaching courses (e.g., ESTRO, ABS) (2–4), simulation trainings based on mannequins or cadavers (2,5–7), contouring workshops (2), dedicated on-site schools (8–9), on-site teaching when observing and performing brachytherapy procedures (3,10), didactic lectures (3,10), fellowships with mentorship and coaching (2–4,11), annual meetings (e.g., GEC-ESTRO, ABS, ESTRO, ASTRO) (2,3), clinical trial participation (e.g., EMBRACE) (2). BT education can be established as a national training curriculum: “300 in 10 initiative” in the USA (4), “Area of Focused Competence in Brachytherapy” in Canada (10), second-level university Master’s degree or PhD programs in brachytherapy in Italy (12).

Industry also plays an important role in brachytherapy education. With a rapid growth of IGABT in LACC around the globe, companies started to receive numerous requests from customers for education. Typical product trainings on brachytherapy equipment couldn’t cover educational needs for IGABT. Elekta organized 28 in-person peer-to-peer workshops at the Medical University of Vienna since 2008, and Varian organized nine workshops in Aarhus/Ljubljana since 2011 (2). During the 2-day workshops, practical and hands-on learning activities were offered to radiation oncologists and medical physicists: observation of a live patient case in operation theater, practice with applicators and mannequins, contouring and treatment planning exercises, and discussion of workflow issues. To support peer-to-peer education in brachytherapy, Elekta established the BrachyAcademy in 2013 and expanded brachytherapy educational activities to low- and middle-income countries (4).

The idea of online training in radiation oncology is not new. Contouring workshops, lectures and teaching courses, discussion of clinical cases with experts were organized in the past by different entities (13–16). Furthermore, the COVID-19 pandemic transformed educational programs in brachytherapy, forced to change curriculums, adopt new technologies and overcome obstacles to meet students’ needs (17).

BrachyAcademy wanted to provide educational support to brachytherapy users during the pandemic by keeping an interactive component as much as possible. Since the online format didn’t allow to apply key elements of in-person workshops like live clinical case observation, hands-on training, or live contouring and treatment planning practice on demo workstations, the workshop faculty proposed an in-depth discussion of participants’ clinical cases instead. Key lectures from in-person BrachyAcademy workshops were kept in the online format.

This paper describes preparation, execution, and evaluation of two online BrachyAcademy workshops in 2021–2022. The purpose of the paper was to share our educational experience with the brachytherapy community, discuss lessons learned and find opportunities for possible implementation of online workshops in the future.

Methods and materials

Minimum two team members were required to participate in the online workshop from each hospital: a radiation oncologist/clinical oncologist (RO/CO) and a medical physicist (MP). Participants were required to have clinical experience with combined intracavitary/interstitial (IC/IS) IGABT in LACC. Each participating team was asked to send a case including applicator choice, contours and the actual plan. Each case was assessed individually by each faculty member and discussed online in order to identify main issues and recommendations for improvement. To satisfy the needs of participating teams, we encouraged them to send questions together with the clinical case. We limited the number of participating hospitals to 11. Each hospital could send one clinical case. Registrations were accepted on a first come, first served basis. There was a long waiting list after the first workshop in November 2021, therefore BrachyAcademy organized the second workshop with the same agenda in March 2022. Participants attended the online workshops free of charge as it was a pilot program.

The participants were asked to send a presentation of the clinical case in Microsoft PowerPoint format, together with questions to the faculty. A template was sent to homogenize the case presentation, the requested information for the case presentation is summarized in Table 1. In addition, participants were requested to send DICOM brachytherapy treatment files of the same patient including MRI or/and CT images, structures, and RT doses. All patient data should be anonymized. A deadline for sending the complete clinical case was 1 month before the Workshop 1 (W1), and 2 months before the Workshop 2 (W2). The files of clinical cases were collected and forwarded to the faculty in a bundle using the online transfer service (MediaFire, Shenandoah, TX). A demo workstation of the treatment planning system Oncentra Brachy (Elekta, Sweden) was used to review the treatment plans.

The workshop agenda was reviewed by the faculty including 2 RO, 1 radiologist, 2 MP.

Table 1
Template for clinical case presentation.

Patient & tumor	Age
	Local stage
	Stage L (Lymph nodes metastases) and M (Distant metastases)
	Histological type
Initial clinical findings	Cervix: exophytic/endophytic tumor
	Vagina: not involved/involved (detailed description)
	Parametria: Right: proximal/distal/pelvic wall involvement. Left: proximal/distal/pelvic wall involvement
Initial clinical drawings	Sagittal, coronal, axial, speculum views (according to the GYN GEC-ESTRO recommendations)
Initial MRI findings	Para-sagittal, para-coronal, axial views
Initial MRI findings with measurements	Ellipsoid formula applied: $V = \text{width} \times \text{thickness} \times \text{height} \times 0.5$
EBRT	EBRT technique, total dose, dose per fraction
Chemotherapy	Drug name, dose, # of cycles
Clinical findings at brachytherapy	Cervix: exophytic/endophytic tumor
	Vagina: not involved/involved (detailed description)
	Parametria: Right: proximal/distal/pelvic wall involvement. Left: proximal/distal/pelvic wall involvement
Clinical drawings before brachytherapy	Sagittal, coronal, axial, speculum views (according to the GYN GEC-ESTRO recommendations)
MRI findings after EBRT	Para-sagittal, para-coronal, axial views: compare with initial MRI findings
Applicator choice	Name of the applicator, characteristics, reason for choosing
Questions for the faculty	

GYN GEC-ESTRO = Gynaecology working group of the GEC-ESTRO; EBRT = External Beam Radiation Therapy.

The workshop was conducted over 6 h (3 + 3 h) in two consecutive days, from 3 PM till 6 PM Central European Time zone. Each topic was led by one or two faculty members. The workshop program of the first day included: “Patient preparation, applicator choice and insertion”; “Imaging, image fusion, applicator reconstruction.” The second day was dedicated to: “Contouring and patient care”; “Treatment planning and optimization.” Duration of each of the four topics was 1.5 h. The teacher started a topic with a lecture, then analyzed each clinical case from the topic’s perspective. Therefore, feedback was given to each clinical case by five faculty members. The workshop also included Q&A and discussion after each topic.

Kaltura Virtual Classroom (New York) was used as the online workshop platform. Participants received instructions for Kaltura prior to the workshop and asked to test their connection. Attendees could connect to the workshop platform individually or as a team. Kaltura features used: uploading files (Microsoft PowerPoint presentations, videos) prior to workshop and play them when needed during the workshop; desktop share function for demonstration of Oncentra Brachy and Picture Archiving and Communication System (PACS); quick polls; Q&A by chat or verbally through raising hand function; session recording (for quality assurance only; wasn’t shared with participants).

Clinical cases were discussed in the presence of all workshop participants; therefore, the hospital names were anonymized. Each hospital received a number from one to 11, and only the hospital and the faculty knew the number.

Participants were asked to fill in post-course questionnaire and send it after the workshop. The questionnaire included combination of qualitative and quantitative questions which could be answered by yes/no, or ranked on a Likert scale, or 1 to 10 scale. Likert scale (very good – good – neutral – poor – very poor) was used to evaluate general impression about the workshop, course logistics, and course content. Scale 1 to 10 (where 10 is the highest score) was used to score the workshop. A copy of the post-course questionnaire is available online as a supplementary material.

Completion of the post-course questionnaire was mandatory prior to issue of course attendance certificate and workshop presentations in pdf format.

Results

In total, 21 hospitals participated in two workshops: W1–10 hospitals, W2–11 hospitals. Summed geographic distribution and corresponding number of hospitals for both workshops were: UK–9, Germany–3, Spain–3, Netherlands–2, Austria–1, Brazil 1, Guatemala–1, China–1. Total number of participants was 49: 23 RO/CO (47%), 22 MP (45%), and 4 radiation therapy technologists (8%).

Two teams from each workshop sent incomplete DICOM files (without imaging data, or structures, or RT doses), or there were technical issues (problems with anonymization of the plan file, incorrect data export or invalid links between DICOM objects). Those cases were impossible to be reviewed during the workshop, and those individuals were given feedback after the workshop.

The main characteristics of clinical cases discussed at both workshops are summarized in Table 2. The patients had LACC with FIGO stages from IB3 to IVA. All patients were treated by IGABT (MRI- or CT-based). Eight of 10 (80%) and six of 11 (55%) of clinical cases included IC/IS brachytherapy during W1 and W2, respectively; the rest intracavitary BT. Various BT applicators were used: Venezia, Geneva, Utrecht, Fletcher, Interstitial Ring CT/MR, Ring CT/MR, and three dimensional (3D) printed.

Table 2
Clinical FIGO stage and characteristics of the type of brachytherapy performed on the submitted clinical cases at W1 and W2.

Clinical cases W1	FIGO stage	BT technique	Applicator	# of needles
1	IIB	IC	unknown	0
2	IB3	IC/IS	Geneva	6
3	IIIA/IIIB	IC/IS	Venezia	8
4	IIIA	IC/IS	Interstitial Ring CT/MR	3
5	IIB	IC/IS	Utrecht	6
6	IIIC1	IC/IS	Venezia	4
7	IIIC2/IVA	IC/IS	Utrecht	3
8	IIB	IC	Ring CT/MR	0
9	IIIB	IC/IS	Utrecht	4
10	IIB	IC/IS	Venezia	n/a
Clinical cases W2	FIGO stage	BT technique	Applicator	# of needles
1	IIB	IC/IS	Venezia	4
2	IIIC	IC	Venezia	0
3	IIB	IC	Venezia	0
4	IIIA	IC/IS	3D printed	n/a
5	IB3	IC	Geneva	0
6	IB3	IC/IS	Fletcher	4–6
7	IVA	IC/IS	Venezia, Interstitial Ring CT/MR	4–6
8	IIB	IC	Utrecht	0
9	IIB	IC	Ring CT/MR	0
10	IIIC1	IC/IS	Venezia	6–8
11	IIIC1	IC/IS	Venezia	5

IC = intracavitary; IC/IS = combined intracavitary/interstitial; CT/MR = Computed Tomography/ Magnetic Resonance compatible; 3D = three dimensional.

We summarized the participant queries according to the workshop topics (Table 3). Most of the questions were dedicated to applicator choice and insertion, applicator reconstruction, dose optimization, and patient care. All questions were discussed during the workshops.

The sections “Preparation, applicator choice and insertion” and “Contouring” featured a relatively broad spectrum of experience among the participants. In 30% of the successfully loaded cases in each workshop, the clinical drawings and the MRI sequencing choice at the time of diagnosis and prior to BT were inadequate. In terms of applicator type choice, most participants chose the correct assembly. In a couple of patients with vaginal involvement, a 3D printed applicator or an adapted Venezia was used. However, there were some recommendations for changes regarding the applicator insertion. The participants had difficulty in choosing the right length and angle of the intrauterine component and the right diameter of the intravaginal component of the applicator. In two cases in W2 an air gap between ring/ovoids and cervix was evident after insertion; this could be overcome by the right length of the tandem and diameter of the ring as such that the intravaginal component is adjacent to the cervix. The most obvious shortage in experience was related to the use of interstitial needles. 20% of the participants in W1 asked about external beam boost of the parametria as surrogate for dose escalation. In both workshops, almost half of the cases could benefit from interstitial needles, both straight and oblique in order to better cover the rest tumor extend (majority) or to spare the OARs Moreover, in two cases with parametrial involvement treated by intracavitary therapy only, interstitial needles would have been advantageous for dose coverage. The discussions during the workshop also highlighted the possibility to increase the therapeutic window between target and organ doses for cases with small CTV (<30 cm^3), but unfavorable topography.

The section “Imaging, image fusion, applicator reconstruction” focused on the analysis of participants’ cases in three major aspects: reconstruction of the intracavitary applicator, reconstruction of interstitial needles, and overall image quality and applicator visibility. For the IC applicators, most centers who had already implemented the use of MRI for treatment planning used 3D applicator library models for reconstruction. Some centers with CT-only BT applied a manual reconstruction technique. Two major issues for discussion of basic concepts and caveats were encountered for both techniques in some submissions: (1) Applicator digitization on axial CT slices may lead to unrealistic shapes of the source path if not verified in 3D view after slice-by-slice reconstruction; and (2) vaginal packing may lead to wrong identification of applicator surface and consequential misplacement of the 3D applicator model. The use of CT or MR markers was also discussed. Concerning reconstruction of interstitial needles, some submissions revealed that there was a necessity to discuss about the starting point for needle digitization. The main question was to locate the external needle tip in relation to the internal first dwell position correctly on either MRI or CT. In this context, the use of individual MR sequences obtained in different orientations or 3D isotropic MR se-

Table 3
Most common questions of W1+W2 inquired by the participants.

Workshop topic	Questions
Patient preparation, applicator choice and insertion	• BT schedule and fractionation schemes • Applicator choice in case of extensive uterine involvement, vaginal growth, mesorectal invasion, elderly women with cervical and uterine atrophy • Choice of the correct size of ovoids and intrauterine length • Loading of needles versus tandem/ovoids, definition of number and location of needles best suited to the tumor, use of oblique needles • Use of EBRT boost to parametria as surrogate for dose escalation • Bladder filling during applicator insertion
Imaging, image fusion, applicator reconstruction	• Location of the external needle tip in relation to the internal first dwell position correctly on either MRI or CT • Uncertainty for applicator commissioning • Use of MRI- and CT-markers
Contouring and patient care	• Delineation of GTV and differentiation from the adjacent organs • Use of auto contouring to project the target delineation of one fraction to another • Management of complications (uterine perforation and bleeding) during applicator insertion • Modifications in management for elderly/frail patients
Treatment planning and optimization	• Dose optimization for best target coverage and sparing OARs • Set right priorities when dose constraints cannot be achieved • Rules to optimize dwell positions in the needles • Application of inverse optimization for BT • Combination of EBRT and BT doses; dose constraints for EBRT

GTV = Gross Tumor Volume; OAR = Organ at Risk; BT = Brachytherapy.

quences was also discussed with participants. Finally, the recommendation to use as few digitization points as possible for straight needles, was demonstrated.

The section “Contouring and patient care” featured the scarcity of contouring in both workshops (W1 and W2), in which 60% of participants used CT imaging for planning. Both high-risk clinical target volume (HRCTV) and intermediate-risk clinical target volume (IRCTV) were contoured from seven of 10 participants in W1. Three of 4 participants using CT imaging for brachytherapy planning contoured a single volume, corresponding to HRCTV. In 6 of 11 cases (55%) a single tumor volume (HRCTV) was contoured also in W2 group. Many centers excluded the IRCTV; some using interstitial needles contoured the target according to the position of the needles and not based on the imaging and clinical examination at the time of BT.

The section “Treatment planning and optimization” highlighted two main recommendations for changes. First, issues in the definition of dose points, which resulted in deviations for the reported dose (e.g., point A dose reported as 7 Gy instead of 5 Gy). However, most issues were in the second step, which are optimization methods and their resulting loading patterns. In lack of a well-established published standard (“Treatment planning recommendations of GEC-ESTRO/IBS/ABS” are currently in preparation) it is difficult to report quantitative results. One important parameter was the distribution of total reference air-kerma (TRAK) between vaginal applicators (ring or ovoids), intrauterine applicators (tandem) and needles. Ratios of those values could be compared to larger cohorts (unpublished data from the EMBRACE studies) to identify outliers. For example, the use of >50% of the overall dwell time (TRAK) in needles for HRCTVs of <30 cm^3 was discussed regarding the resulting spatial dose distribution. Spatial loading close to the vaginal mucosa or only few dwell positions with relative high dwell time in ovoids or needles resulting in hot spots were matter of discussion. A major issue was also the compromise between target dose and dose to organs at risk (OAR) based on presented dose and volume parameters.

The discussion of the individual cases didn’t result in a binary good or bad result but triggered the need to discuss the issues of each case by the faculty.

The post-course questionnaire response rate was 88%: 22 of 25 for participants of W1, and 21 of 24 for W2. Table 4 shows responses of the workshops participants to quantitative questions using Likert scale.

Relatively low rating of “Contouring and patient care” topic of W1 (55% of “very good” and “good” answers; other 45% responded “neutral,” no “poor” or “very poor” answers) can be explained by the workflow of this part of the training. With the intent to offer an interactive session, the teachers implemented an “on-line PACS view,” discussing each case with “live” contouring approach. Moreover, the teachers switched between PACS and Microsoft PowerPoint presentation when discussing each clinical case and provided remarks. The switching was distracting; therefore, we didn’t use PACS and “live contour-

Table 4
Responses of W1 and W2 participants to quantitative questions in post-course questionnaire.

Question group	Quantitative question	% of participants responded "very good" and "good"	
		W1	W2
General impression	Scope of the topics covered	90	100
	Presentation content is clear	91	85
	Length of the training	91	86
	Realization of learning objectives	82	100
Logistics	Required information received on time	100	95
	Organization of the course	95	95
Course content	Patient preparation, applicator selection & insertion	86	86
	Imaging, image fusion, applicator reconstruction	91	90
	Contouring, patient care	55	81
	Treatment planning and optimization	100	86

ing" during the W2, where the rating of the same topic was much higher–81% versus 55%, and in line with evaluation of other sessions.

Overall, only one question for both workshops ("Patient preparation, applicator selection & insertion" at W2) received one answer "poor" (5%). This participant commented: "Too many cases presented leaving no time for meaningful discussion, maybe for virtual meeting it would work better selecting fewer cases." There were no answers "very poor" to any quantitative questions for both workshops.

Participants provided with free-form responses to qualitative questions. Participants' comments regarding both workshops are summarized in Table 5.

The participants rated both workshops very high. Scores for W1 and W2 were 8,3 and 8,5 on a scale from 1 to 10. We received "yes" to the question "Did the training course meet your expectations?" from 82% and 76% of participants, "partly" from 18% and 24% participants, and "no" from 0 participants for W1 and W2, respectively.

Discussion

In BT hands-on training is essential (3,5–7,18–20). Theoretical teaching could only partially replace on-site education (3,21); therefore, organization of online courses can be challenging. At the same time, virtual training has a big advantage: no travel costs. A recent survey from Poland concluded that lack of financial support was the most important factor preventing radiation oncologists from attending educational or clinical activities outside of home institution (22). Other advantages of the online training are comfort to attend from home or workplace, interaction with teachers in real time (16,23). However, unawareness of availability of virtual training, resistance to new teaching methods prevented online courses from growing fast (23). COVID pandemic facilitated this transition, and now online teaching is becoming an integral part in radiation oncology education, including brachytherapy. For instance, ESTRO teaching courses "Image-guided radiotherapy and chemotherapy in gynecological cancer" in 2020–2021 were conducted online (24). Given the current travel restrictions, brachytherapy experts from the USA are developing virtual curricula for brachytherapy in cervical cancer which may prove to be a cost-effective alternative to in-person simulation-based training (25).

Post-course questionnaires after our workshops demonstrated high satisfaction of participants with the online course despite the lack of physical contact with the faculty. Another positive result was a large geographic spread of participating hospitals regardless of the different time zones (Latin America, Europe, Asia). These findings are in line with previously reported outcomes of online brachytherapy courses (24). Although some of participants stressed on necessity of organizing in-person workshops and hands-on training (which was precluded by the pandemic), in 82% participants the training course fully met expectations for W1, and in 76% for W2.

Participants of both workshops liked to see and discuss clinical cases of other hospitals because they could get new ideas and compare their performance with others. Reports from the ESTRO GYN teaching courses confirmed a necessity of discussing challenges in the group, interaction with centers having similar issues in their clinical practice, benchmarking, and individualized systematic feedback (2,24).

Incorporating all steps of the brachytherapy procedure into the training program is important (18). There is an emphasis on contouring and treatment planning among current educational initiatives in IGABT, while other skills like applicator insertion, patient care and logistics get less attention. There is a misbelief that these skills will be achieved only with experience (2). Taking this information into account, challenges during all steps of the brachytherapy procedure were discussed at our online workshops. Although Kaltura software allows break-out rooms, we wanted to keep RO and MP together to emphasize the necessity of the teamwork in brachytherapy. This approach was appreciated by most of the participants.

Several authors reported lack of training for interstitial or hybrid gynecological brachytherapy and a need in addressing the brachytherapy training to more complicated,

Table 5
Summary of responses of workshops participants to qualitative questions in post-course questionnaire.

Qualitative question	Comments and corresponding # of responders
Learning objectives have been met	• Treatment planning and optimization (13) • See clinical cases from other centers and compare performance with others (7) • The whole treatment (7) • Contouring (5) • Feedback provided on the clinical case (4) • Pitfalls in reconstruction (3) • Insertion of applicators and needles (3) • All objectives met (3)
Learning objectives haven't been met	• Optimal use of perineal template and vaginal caps (1)
Suggestions for improving the course content	• Present an "ideal" clinical case by the faculty and discuss how to make a "good" plan (3) • Organize separate streams for doctors and physicists (2) • More focus on the applicator choice (2) • Differentiate between basic and advanced courses (1) • Focus on one topic (contouring or treatment planning) with more practice (1) • Combine EBRT and BT plans (1)
Suggestions for improving the course organization	• The organization was great, no suggestions (13) • Improve Internet connection and sound (4) • Add more time for discussion, longer course (3) • Do an extra training for the teachers on Kaltura software (2) • Organize breaks between presentations (1) • Add automatic subtitles for non-native speakers (1) • Record workshop sessions and distribute recorded clinical case to each hospital for discussion with the team (1)
Subjects could be addressed in future training courses	• Present a challenging clinical case by the faculty (4) • Organize in-person workshop (2) • Add hands-on (2) • Discuss fractionation regimen (2) • Present clinical cases with complications and discuss how to handle them (1) • Add applicator commissioning (1) • Send one clinical case to all participants before the workshop and compare contouring and treatment planning results (1) • Cover other brachytherapy indications: HDR prostate BT (1), skin BT (1), and vaginal BT (1)

advanced cases (2,5). A particular attention during our online workshops was given to hybrid brachytherapy in cervical cancer: 67% of all cases included IC/IS brachytherapy. Although the clinical IC/IS brachytherapy experience was a requirement to participate in the workshop, one third of teams sent IC cases for the review. We believe that participants would benefit from the online case discussion more if the level of the brachytherapy experience in the group is the same. We learned that we should make a stratification of the workshop participants into groups through a precourse questionnaire. This selection could allow to separate advanced brachytherapy users from the ones who just started gynecological brachytherapy and discuss topics and cases according to their experience. These types of webinars could benefit from a combination of pre and post course questionnaires. These could compare participants' skills, behavior, and understanding before and after the workshop, so the impact of the online learning could be quantified. We will consider implementing precourse questionnaire in future workshops.

Disadvantages of online learning are: lack of physical interaction, inability to control the audience's environment, lack of kinesthetic learning, technical issues such as network interruptions, software incompatibility, and hardware malfunction (16,23). During our online workshops we met some technical drawbacks and couldn't control the attention of the audience. With transfer of DICOM files we experienced the same problems as other groups (26): institutional firewall for file transfers, possible inability to export the data in the proper format, different versions of software, discrepancies when performing anonymization. We learned from our workshops that we should provide to the participants detailed technical instructions regarding collection, anonymization, export of DICOM files.

The faculty identified main areas for improvement in clinical cases presented at both workshops: issues with clinical drawings and the MRI sequencing choice, appropriate applicator selection; experience with interstitial needles; appropriate applicator reconstruction; dose optimization. Issues with clinical drawings and the MRI sequencing choice may be solved by learning of the GEC ESTRO and ICRU 89 recommendations (27–29), and by building an effective cooperation with radiologists (30).

Many participants asked for EBRT boost to parametria as a surrogate for IC/IS BT dose escalation. This has proven issues, including organ movement; increase in the volume of normal tissue irradiated to 60 Gy (31), therefore prone to more side effects. With the advent of IGABT, the use of interstitial needles allows a good distribution, which results in increased therapeutic ratio (1,32). There is an obvious need in teaching the practice of choosing the position and the length of the interstitial needles appropriately. This training can be done successfully in person, using simulation-based modules (6,33).

The online workshops revealed that the participants mostly used CT for BT treatment planning, and many of them didn't contour IRCTV or/and contoured the target incorrectly. Contouring uncertainties were identified as the most important protocol deviations in the EMBRACE study dummy run (34). Our experience confirmed that the contouring discrepancies remain an important issue for IGABT. We hope that due to the recently published CT-based contouring recommendations (35) these deficiencies would be overpassed. In addition to the contouring, appropriate applicator reconstruction was identified as an issue in presented clinical cases which correlates with earlier publications (34,36).

There is a misconception about education that brachytherapy workshops would result in long-term changes in competency and behavior (2). Brachytherapy requires the continuous development of the program (37). We consider an opportunity for both online and in-person educational activities in brachytherapy for LACC because they can address different needs and provide flexibility. Online discussion of clinical cases by multidisciplinary teams can be useful for brachytherapy users through the learning curve and should be carried out periodically. It is highly likely that the online training only is not sufficient for physicians and physicists at the beginning of IGABT implementation. However, we believe that it could be useful after gaining a solid clinical experience in IC brachytherapy (>10 cases), soon after starting IC/IS brachytherapy (3–5 cases), and after performing >10 IC/IS cases. Since learning efforts, performance issues and questions depend on the learning curve phase, it is important to organize workshops in homogenous groups. Online training cannot replace hands-on learning but could be suggested in 6–12 months as follow-up of a hands-on workshop in order to maintain and strengthen skills gained.

Conclusion

We successfully implemented the online workshops on IGABT in LACC. Main performance issues and areas for improvement were identified based on in-depth multidisciplinary discussion of participant's clinical cases through all steps of the brachytherapy procedure. We encourage teams to consider online workshops in addition to hands-on training.

Supplementary materials

Supplementary material associated with this article can be found, in the online version, at doi:10.1016/j.brachy.2023.01.006.

References

[1] Pötter R, Tanderup K, Schmid M, et al. MRI-guided adaptive brachytherapy in locally advanced cervical cancer (EMBRACE-I): a multicentre prospective cohort study. *Lancet Oncol* 2021;22:538–547.
[2] Tan LT, Tanderup K, Kirisits C, et al. Education and training for image-guided adaptive brachytherapy for cervix cancer – The (GEC)-ESTRO/EMBRACE perspective. *Brachytherapy* 2020;19:827–836.
[3] Tagliaferri L, Kovács G, Aristei C, et al. Current state of interventional radiotherapy (brachytherapy) education in Italy: results of the INTERACTS survey. *J Contemp Brachytherapy* 2019;11:48–53.
[4] Petereit DG. Increasing global access to brachytherapy: the ABS 300 in 10 initiative and ongoing international efforts. *Brachytherapy* 2022;21:1–3.
[5] Singer L, Braunstein S, Klopp A, et al. Development and implementation of a simulation-based educational workshop on gynecological brachytherapy: pilot study at a national meeting. *Pract Radiat Oncol* 2019;9:e465–e472.
[6] Donnelly ED, Sachdev S, Zhang H, et al. Development of a gynecologic brachytherapy curriculum and simulation modules to improve radiation oncology trainees' skills and confidence. *Brachytherapy* 2020;19:732–737.
[7] Williams VN, Mansoori B, Young L, et al. Simulation-based learning for enhanced gynecologic brachytherapy training among radiation oncology residents. *Brachytherapy* 2021;20:128–135.
[8] Tagliaferri L, Pagliara MM, Bodrini L, et al. INTERACTS (INTErventional Radiotherapy ACtive Teaching School) guidelines for quality assurance in choroidal melanoma interventional radiotherapy (brachytherapy) procedures. *J Contemp Brachytherapy* 2017;9:287–295.
[9] Tagliaferri L, Vavassori A, Lancellotta V, et al. INTERACTS (INTErventional Radiotherapy ACtive Teaching School) consensus conference on sarcoma interventional radiotherapy (brachytherapy) endorsed by AIRO (Italian Association of Radiotherapy and Clinical Oncology). *J Contemp Brachytherapy* 2020;12:397–404.
[10] Morton G, Taggar A, Keyes M, et al. Brachytherapy education and certification – a Canadian approach. *Brachytherapy* 2020;19:857–860.
[11] Croke J, Taggar A, Fyles A, et al. More than learning technical skills: the importance of mentorship and coaching during a brachytherapy fellowship. *Brachytherapy* 2020;19:758–761.
[12] Tagliaferri L, Vavassori A, Lancellotta V, et al. Can brachytherapy be properly considered in the clinical practice? Trilogy project: the vision of the AIRO (Italian Association of Radiotherapy and Clinical Oncology) interventional radiotherapy study group. *J Contemp Brachytherapy* 2020;12:84–89.
[13] Hardenbergh PH, Gehl B, Kavanagh BD, et al. International health care transformation through web-based education. *Int J Radiat Oncol Biol Phys* 2016;96(2):E396 suppl.
[14] Robin TP, Grover S, Palkonda VAR, et al. Utilization of a web-based conferencing platform to improve global radiation oncology education and quality-proof of principle through implementation in India. *Int J Radiat Oncol Biol Phys* 2019;103:276–280.

[15] Hatcher JB, Oladeru O, Chang B, et al. Impact of high-dose-rate brachytherapy training via telehealth in low- and middle-income countries. *JCO Glob Oncol* 2020;6:1803–1812.
[16] Eansor P, Norris ME, D'Souza LA, et al. Is remote learning as effective as in-person learning for contouring education? a prospective comparison of face-to-face versus online delivery of the anatomy and radiology contouring bootcamp. *Int J Radiat Oncol Biol Phys* 2022;112:590–599.
[17] Donnelly ED. Adapting to ensure brachytherapy remains a vital component of our future. *Brachytherapy* 2020;19:717.
[18] Zhao S, Francis L, Todor D, et al. Proficiency-based cervical cancer brachytherapy training. *Brachytherapy* 2018;17:653–659.
[19] Marcrom SR, Kahn JM, Colbert LE, et al. Brachytherapy training survey of radiation oncology residents. *Int J Radiat Oncol Biol Phys* 2019;103:557–560.
[20] Singer L, McLaughlin P-Y, Alban G, et al. Simulation-based graduate medical education in MR-guided brachytherapy for cervical cancer. *Brachytherapy* 2020;19:725–731.
[21] Kovacs G, Tagliaferri L, Valentini V. Is an interventional oncology center an advantage in the service of cancer patients or in the education? The Gemelli Hospital and INTERACTS experience. *J Contemp Brachytherapy* 2017;9:497–498.
[22] Napieralska A, Tomasik B, Spałek M, et al. Radiation Oncology Training in Poland: multi-institutional Survey. *J Cancer Educ* 2021;36:769–778.
[23] Hussain STA, Rapole PS, Sethi P, et al. Target volume delineation training in radiation oncology in india: a survey evaluating its status, the need for educational programs and the utility of virtual teaching. *Asian Pac J Cancer Prev* 2021;22:3875–3882.
[24] Tan LT, Tanderup K, Nappa A, et al. Impact of transitioning to an online course - A report from the ESTRO gyn teaching course. *Clin Transl Radiat Oncol* 2021;29:85–92.
[25] Damast S, Felder S, Fields E, et al. Feasibility of deploying a U.S. simulation-based gynecological brachytherapy educational workshop to an international setting. *Brachytherapy* 2020;19:777–782.
[26] Weber DC, Poortmans PMP, Hurkmans CW, et al. Quality assurance for prospective EORTC radiation oncology trials: the challenges of advanced technology in a multicenter international setting. *Radiother Oncol* 2011;100:150–156.
[27] Dimopoulos JCA, Petrow P, Tanderup K, et al. Recommendations from Gynaecological (GYN) GEC-ESTRO Working Group (IV): basic principles and parameters for MR imaging within the frame of image based adaptive cervix cancer brachytherapy. *Radiother Oncol* 2012;103:113–122.
[28] Haie-Meder C, Pötter R, Van Limbergen E, et al. Recommendations from Gynaecological (GYN) GEC-ESTRO Working Group (I): concepts and terms in 3D image based 3D treatment planning in cervix cancer brachytherapy with emphasis on MRI assessment of GTV and CTV. *Radiother Oncol* 2005;74:235–245.
[29] International commission on radiation units and measurements. prescribing, recording, and reporting brachytherapy for cancer of the cervix (ICRU Report 89). *J ICRU* 2013;13:1–2.
[30] Russo L, Lancellotta V, Miccò M, et al. Magnetic resonance imaging in cervical cancer interventional radiotherapy (brachytherapy): a pictorial essay focused on radiologist management. *J Contemp Brachytherapy* 2022;14:287–298.
[31] Fenkell L, Assenholt M, Nielsen SK, et al. Parametrial boost using midline shielding results in an unpredictable dose to tumor and organs at risk in combined external beam radiotherapy and brachytherapy for locally advanced cervical cancer. *Int J Radiat Oncol Biol Phys* 2011;79:1572–1579.
[32] Fokdal L, Sturdza A, Mazeron R, et al. Image guided adaptive brachytherapy with combined intracavitary and interstitial technique improves the therapeutic ratio in locally advanced cervical cancer: analysis from the retroEMBRACE study. *Radiother Oncol* 2016;120:434–440.
[33] Shiao JC, Santoso A, Stuhr K, et al. Gynecologic interstitial brachytherapy curriculum using a low-cost phantom with ultrasound workshop and a treatment planning workshop is effective. *Brachytherapy* 2022;21:110–119.
[34] Kirisits C, Federico M, Nkiwane K, et al. Quality assurance in MR image guided adaptive brachytherapy for cervical cancer: final results of the EMBRACE study dummy run. *Radiother Oncol* 2015;117:548–554.
[35] Mahantshetty U, Pötter R, Beriwal S, et al. IBS-GEC ESTRO-ABS recommendations for CT based contouring in image guided adaptive brachytherapy for cervical cancer. *Radiother Oncol* 2021;160:273–284.
[36] Palmer AL, Diez P, Gandon L, et al. A multicentre 'end to end' dosimetry audit for cervix HDR brachytherapy treatment. *Radiother Oncol* 2015;114:264–271.
[37] Jääskeläinen E, Kärkkäinen H, Palmgren J-E, et al. MRI-guided brachytherapy for locally advanced cervical cancer: program initiation, learning curve and dose delivery results in Kuopio University Hospital. *Brachytherapy* 2021;20:738–747.