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V CONGRESS OF POLISH BRACHYTHERAPY SOCIETY

2nd–4th June 2016

Poznań, Poland

Schedule and Abstracts

http://www.wco.pl/vkongresptb/en/

Schedule overview

Thursday, 2nd June 2016
Conference room – PAN, 17/19 Wieniawskiego Street

11.00–16.30	**Workshop I: Brachytherapy in clinical practice (Applied methodology and protocols) – Elekta**
11.00–11.10	**Welcome**
11.10–12.00	**Session 1:** Prostate cancer brachytherapy *Wojciech Burchardt (Poznań, Poland)*
12.00–13.00	**Session 2:** Skin cancer brachytherapy *Piotr Wojcieszek, Marta Szlag (Gliwice, Poland)*
13.00–13.30	**Lunch**
13.30–14.30	**Session 3:** Lung cancer 3D brachytherapy *Damian Kazalski, Marcin Sawicki (Brzozów, Poland)*
14.30–15.30	**Session 4:** I. Gynecological cancer brachytherapy *Dorota Kazberuk (Białystok, Poland)*
15.30–16.30	**Session 5:** II. Gynecological cancer brachytherapy *Andrzej Kukiełka (Kraków, Poland), Robert Kwiatkowski (Katowice, Poland)*
16.30–18.00	**Break**
18.00–18.10	**Welcome** *Janusz Skowronek, Julian Malicki (Poznań, Poland)*
18.10–19.00	**Opening lecture** Towards image guided adaptive treatment delivery: Where are we (going) in brachytherapy? *Dimos Baltas (Freiburg, German)*

Thursday, 2nd June 2016
Greater Poland Cancer Center

08.00–17.00	**Workshop II: Practical Workshop "Brachytherapy in partial breast irradiation" – Elekta Faculty:** *Prof. Janusz Skowronek, MD, PhD, Greater Poland Cancer Centre, Poznań, Poland,* *Prof. Vratislav Strnad, MD, PhD, University Hospital Erlangen, Germany,* *Tibor Major, PhD, National Cancer Institute Budapest, Hungary,* *Prof. Csaba Polgár, MD, PhD, National Cancer Institute Budapest, Hungary*
07.45–08.00	**Registration**
08.00–08.15	**Welcome** *Vratislav Strnad, Janusz Skowronek, Elekta*
08.15–08.45	Introduction of participants
08.45–09.30	Overview of partial breast irradiation in the management of breast cancer – facts & myths – *V. Strnad*
09.30–10.15	Patient selection – *C. Polgár*
10.15–10.35	**Break**
10.35–11.20	Physics: Dosimetric comparison of techniques – *T. Major*
11.20–12.00	Fractionation concepts, radiobiologic considerations – *J. Skowronek*
12.00–12.45	Target definition – *V. Strnad, C. Polgár*
12.45–13.30	**Lunch**
13.30–14.00	Image guided brachytherapy – Interstitial techniques – *J. Skowronek*
14.00–14.30	Video demonstration catheter insertion – *V. Strnad, J. Skowronek*
14.30–15.15	Hands-on session 1: Catheter insertion using phantoms – *V. Strnad, C. Polgár, J. Skowronek*
15.15–15.30	**Break**
15.30–16.30	Hands-on session 2: Target delineation (physicians) / treatment planning (physicists) – *V. Strnad, C. Polgár, J. Skowronek T. Major*
16.30–17.00	New directions – panel discussion (altered fractionation, neoadjuvant APBI, salvage-APBI) – *V. Strnad, C. Polgár, T. Major, J. Skowronek*

Friday, 3th June 2016
Conference room – PAN, 17/19 Wieniawskiego Street

08.30–10.30	**Session I** **Future of modern brachytherapy – where are we going?** **Chair: *Janusz Skowronek, Csaba Polgár***
08.30–09.00	APBI – a critical review of current techniques and results *Vratislav Strnad (Erlangen, Germany)*
09.00–09.30	Changing recommendations for APBI patient selection *Csaba Polgár (Budapest, Hungary)*
09.30–10.00	The future of H&N brachytherapy *Gyeorgy Kovacs (Lübeck, Germany)*
10.00–10.30	Electronic skin brachytherapy *José Pérez-Calatayud (Valencia, Spain)*
10.30–11.00	**Coffee break**
11.00–13.00	**Session II** **Modern brachytherapy – new techniques, indications** **Chair: *Silvia Rodriguez, Bradley Pieters***
11.00–11.25	Interstitial applications for cervical cancer: Utrech, MUPIT, and Template Benidorm, clinical experience and planning challenges *Silvia Rodriguez (Alicante, Spain)*
11.25–11.50	Techniques for bladder brachytherapy – just do it *Bradley Pieters (Amsterdam, The Netherlands)*
11.50–12.15	Brachytherapy under control of CT and MRI *Maciej Pech (Magdeburg, Germany)*
12.15–12.40	Commissioning and clinical experience of a new HDR system – SagiNova *Orla Hayman (Portsmouth, UK)*
12.40–13.00	Results, complications, quality of life, costs? What else matters? *Janusz Skowronek (Poznań, Poland)*
13.00–14.30	**Poster Session**
13.00–14.00	**Lunch**
14.00–15.00	**Polish Brachytherapy Society Meeting**
15.00–16.30	**Session III** **Prostate cancer – challenges for brachytherapy** **Chair: *Piotr Wojcieszek, Roman Makarewicz***
15.00–15.15	HDR brachytherapy or hypofractionation in prostate cancer treatment *Piotr Wojcieszek (Gliwice, Poland)*
15.15–15.30	Results of HDR brachytherapy combined with external beam radiation therapy – 10 years of experience *Roman Makarewicz (Bydgoszcz, Poland)*
15.30–15.45	LDR brachytherapy in prostate cancer treatment – our experience *Marek Kanikowski (Poznań, Poland)*
15.45–16.00	Is PSA bounce a significant control factor after initial treatment? *Wojciech Burchardt (Poznań, Poland)*
16.00–16.15	HDR brachytherapy as salvage treatment in prostate cancer recurrence after radiotherapy *Mateusz Dąbkowski (Warszawa, Poland)*
16.15–16.30	Accelerated prostate cancer treatment using HDR boost brachytherapy – Białystok experience *Dorota Kazberuk (Białystok, Poland)*
16.30–17.00	**Coffee break**
17.00–18.30	**Session IV** **Breast brachytherapy in the crossfire of competition** **Chair: *Krystyna Serkies, Adam Chicheł***
17.00–17.20	Evaluation of the incidence of fat necrosis in patients with breast cancer treated by APBI *Anetta Kasprowicz (Warszawa, Poland)*

17.20–17.40	Results of perioperative PDR brachytherapy "boost" *Krystyna Serkies (Gdańsk, Poland)*
17.40–18.00	Different techniques of boost after BCS – photons, electrons, IORT or brachytherapy? *Adam Chicheł (Poznań, Poland)*
18.00–18.20	The use of different markers in the planning of brachytherapy for breast cancer *Roman Makarewicz (Bydgoszcz, Poland)*
18.20–18.30	**Round table discussion**

Saturday, 4th June 2016
Conference room – PAN, 17/19 Wieniawskiego Street

09.00–11.00	**Session V** **Treatment planning in brachytherapy – on the way to excellence** **Chair: *Grzegorz Zwierzchowski, Marta Szlag***
09.00–09.25	Quality control of the planning and implementation of treatment – the methodology of verification of dose distributions for advanced computational algorithms used in brachytherapy *Grzegorz Zwierzchowski (Poznań, Poland)*
09.25–09.50	3D planning – new opportunities, limitations and pitfalls – Gliwice experience *Marta Szlag (Gliwice, Poland)*
09.50–10.15	Comparison of Ir-192 and Co-60 sources in the brachytherapy planning *Łukasz Kowalik (Brzozów, Poland)*
10.15–10.40	Optimization of treatment planning and implementation process in brachytherapy of gynecologic cancers based on advanced methods of 3D imaging *Magdalena Dymnicka (Poznań, Poland)*
10.40–11.00	Introduction of an advanced gynecological applicator *Eric Sewsingh (The Netherlands, Elekta)*
11.00–11.30	**Coffee break**
11.30–13.00	**Session VI** **3D brachytherapy – modern imaging** **Chair: *Agnieszka Żółciak-Siwińska, Damian Kazalski***
11.30–11.45	Intrauterine brachytherapy in patients with inoperable cancer of the uterus, from 2D to 3D *Sylwia Kellas-Ślęczka (Gliwice, Poland)*
11.45–12.00	Image-guided brachytherapy of liver oligometastasis *Dariusz Kieszko (Lublin, Poland)*
12.00–12.15	Image-guided brachytherapy of head and neck recurrences *Paweł Cisek (Lublin, Poland)*
12.15–12.30	Endoluminal brachytherapy in lung cancer – palliative treatment in 3D era *Damian Kazalski (Brzozów, Poland)*
12.30–12.45	CT planning in HDR brachytherapy of cervical cancer patients *Agnieszka* Żółciak-Siwińska (Warszawa, *Poland*)
12.45–13.00	Complementary lip cancer brachytherapy *Artur Chyrek (Poznan, Poland)*
13.00	**Closing remarks**

ORAL PRESENTATIONS

Session I

Future of modern brachytherapy – where are we going?

Chair: Janusz Skowronek, Csaba Polgár

Accelerated partial breast irradiation: current results

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Purpose: To analyze the current results of accelerated partial breast irradiation (APBI) using different techniques after breast conserving surgery, in terms of clinical experience, quality assurance, and clinical results.

Material and methods: Author analyses current results of phase 3 trials using different techniques for APBI as 1) external beam radiation therapy (EBRT) with 6 MeV (IMRT), 2) intraoperative radiation therapy with electrons (Linac), 3) intraoperative radiation therapy with 50 kV Röntgen-machine ("Intrabeam"), and 4) multicatheter – interstitial brachytherapy.

Results: The published data of APBI using EBRT are until now either disappointing or with low statistical control. Olivotto *et al.* in RAPID trial reported that APBI using three-dimensional conformal external beam radiation therapy (3D-CRT) significantly increased the rates of adverse cosmetic results and late radiation toxicity. In contrast, in a very small under-powered randomized trial with only 105 patients, Rodrigues *et al.* reported similar efficacy, toxicity, and cosmesis for patients either treated with 3D-CRT APBI or using WBI. In other trial, Livi *et al.* reported an encouraging recurrence rate of 1.5% with significantly better results considering late side effects and cosmetic outcomes (in the APBI arm). Unfortunately, the statistical power of this study is also low. In contrast, the data of IMPORT LOW trial – a randomized, multi-center phase III trial testing partial breast radiotherapy (RT) using intensity modulated RT in women with low risk early stage breast cancer (as presented by EBCC 10 in Amsterdam 2016), demonstrated by patients randomized 1 : 1 : 1 (40 Gy/15 F to whole breast (control) vs. 36 Gy/15 F to whole breast, and vs. 40 Gy/15 F to partial breast or 40 Gy/15 F to partial breast), very low LR rates without any differences after 5-years follow-up. Regarding IORT for APBI current, only negative results of two randomized clinical trials (ELIOT and TARGIT trials) are available. In ELIOT trial, significantly higher 5-year recurrence rate of 4.4% after IORT vs. 0.4% after WBI has been reported after 5-years follow-up. In the TARGIT trial, still at a very short follow-up (median 2.4 years) higher recurrence rate 3.3% after IORT vs. 1.3% after WBI have been published. Use of multicatheter interstitial brachytherapy for APBI has been tested until now in one small single-institution in Budapest and in one multicentric GEC-ESTRO phase 3 trial. In Budapest trial, after a median follow-up of 10.2 years, the 10-year rate of local recurrence was 5.9% (and 5.1%, $p = 0.767$) in the APBI and WBI arms, respectively. However, regarding the number of randomized patients ($n = 258$), this study is also underpowered. Recently, the long term results of GEC-ESTRO trial are also available. In this trial, after median follow-up of 6.6 years, very low rates of local recurrences in both arms, namely 0.92% in the WBI group vs. 1.44% in the APBI group ($p = 0.42$), and low incidence (around 3% in both groups) of all serious late side toxicities at 5 years have been observed. Consequently, the non-inferiority of APBI using multicatheter brachytherapy to conventional WBI on level 1 evidence has been confirmed.

Conclusions: Summarizing all current available facts it is obvious that APBI using multicatheter brachytherapy technique for 4-5 days and APBI using EBRT techniques for 3 weeks offers low recurrence rates at least comparable to WBI – both function excellently. Furthermore, multicatheter brachytherapy is today one of the best techniques for accelerated partial breast irradiation (APBI).

Changing recommendations for APBI patient selection

Csaba Polgár

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In the last two decades, accelerated partial breast irradiation (APBI) has been intensively evaluated in phase I and II studies as a possible alternative to conventional whole breast irradiation (WBI). The majority of these trials, using conservative patient selection criteria and proper treatment technique, were successful in yielding an annual local recurrence rate in the range of 0 to 1.3%. The 5-year results of the Hungarian single institutional phase III trial and the recently reported results of the multicentric GEC-ESTRO APBI trial also demonstrated

Table 1. Available guidelines for patient selection

Criterion	ASTRO	GEC-ESTRO	ABS	ASBS
Age (years)	≥ 60	> 50	≥ 50	> 50
Tumor size (cm)	≤ 2	≤ 3	≤ 3	≤ 2
Histology	Inv. duct. ca.	Inv. non-lobular ca.	Inv. ca. or DCIS	Inv. ca. or DCIS
Margin status	Free margin ≥ 2 mm	Free margin ≥ 2 mm	Negative	Free margin ≥ 2 mm
Nodal status	pN0	pN0	pN0	pN0

Table 2. Patient selection criteria for Phase III APBI clinical trials

Criterion	Budapest	GEC-ESTRO	NSABP-RTOG	ELIOT	IMPORT-LOW	RAPID	TARGIT
Age (years)	> 40	> 40	≥ 18	> 48	≥ 50	≥ 40	> 18
Tumor size (cm)	≤ 2	≤ 3	≤ 3	≤ 2.5	≤ 2	< 3	Any (excl. T4)
Unifocality	Yes	Yes	Same quadrant	Yes	Yes	Same quadrant	Yes
EIC	–	–	+	–	+	+	–
Lobular ca.	–	+	+	–	–	–	–
DCIS	–	+	+	–	–	+	–
LVI	+	–	+	+	–	+	+
Grade	1-2	Any	Any	Any	1-2	Any	Any
Margin status	≥ 2 mm	≥ 2 mm	Clear	Clear	≥ 2 mm	Clear	Clear
Nodal status	pN0-1mi	pN0-1mi	pN0-1a (no ECE)	pN0-1a	pN0	pN0	pN0-1

non-inferiority of APBI compared to WBI. Despite variability in selection criteria, the majority of women treated within these trials were > 40 years old, presented with node negative invasive ductal carcinomas up to 3 cm, without extensive intraductal component (EIC), and resected with clear margins. Based on available experience, the American Society for Therapeutic Radiology and Oncology (ASTRO), the Groupé Européan de Curietherapie European Society for Radiation Oncology (GEC-ESTRO), the American Brachytherapy Society (ABS), and the American Society of Breast Surgeons (ASBS) published their guidelines for patient selection (Table 1).

However, controversy exists regarding the possible extension of selection criteria including patients younger than 50 (or 45) years, women with lobular carcinomas, EIC positive tumors, or with one to three positive nodes without extracapsular extension. Ongoing clinical research actually focuses on better definition of candidates for APBI (Table 2).

As data from ongoing multicentric phase III trials mature, guidelines for patient selection should be revised and might be extended. However, until additional long-term outcome reports of phase III trials are available, conservative patient selection criteria (as defined by the GEC-ESTRO, ABS, and ASBS) should be considered for selecting candidates for APBI.

The future of head and neck brachytherapy

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Head and neck brachytherapy is one of the oldest type of clinical applications since radium was introduced into clinical practice. Existing literature data confirm the good outcome results with brachytherapy in small (T1-T2, N0) tumors; however, the need of local dose escalation in primary radiochemotherapy treatments is also documented. Since the normal tissue toxicity of aggressive radiation series is relatively high, local dose escalation techniques offering less normal tissue damage represent the most optimal treatment choice.

By introducing the stepping source technology, computer assisted treatment planning tools and modern imaging methods as well as interdisciplinary teams and treatment concepts, a new era called "interventional radiotherapy" has been started. Close networking systems and creation of professional data mining strategies with large databases enhance the potential of modern H&N cancer treatments.

Surgical debulking combined with adjuvant radiation could offer function preservation and less hypoxic tumor volume for an effective radiotherapy. The most econom-

ic choice seems to represent the combination of function preservative surgery combined with modern perioperative and intensity modulated interventional radiotherapy (brachytherapy). Since brachytherapy is limited in some anatomic situations, in this cases modern external beam techniques (SBRT, Protons, etc.) offer an equal chance for cure. A valuable accompaniment to interdisciplinary and multimodal treatment methods is their combination with targeted therapy- and/or chemotherapy.

Quality of life issues become more and more important aspect, and interventional brachytherapy results showed very advantageous outcomes if compared to other radiotherapy technologies like stereotactic/robot guided 3D external beam series. Also in the treatment of locally recurrent disease, interventional brachytherapy is more successful in selected cases than treatment strategies without involving interventional radiotherapy as a part of the treatment technology.

Health care economic evaluations forecasts the increased use of effective and less cost-generating treatment methods in the future. Interventional radiotherapy represents one of this methods.

Treatment planning and clinical practical aspects in skin brachytherapy: current techniques and recent developments

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Skin brachytherapy (BT) is a widely applied treatment technique. There are two modalities: interstitial and superficial, being the first one associated to deeper tumors. In superficial BT, there are also two modalities.

One consists on a simple plane implant using parallel catheters typically spaced 1 cm and embedded in a mould. Depending on the skin irregularities, flaps are used to keep constant distance between catheters. Typically, the prescription depth used is 5 mm.

Another technique, for small PTVs, uses specific radionuclide-based shielded applicators. These are cup-shaped and made of tungsten with the HDR source at its vertex. It tries to mimic a mini-beam with the benefit of protecting the surrounding healthy tissues due to its shielding. These are the Leipzig type applicators (Varian and Elekta) or the Valencia ones (Elekta). Typically, the prescription depth is 3 mm.

To improve the treatment time and to avoid dependence on HDR source, several electronically based applicators have been developed: Axxent (Xoft) and Intrabeam (Carl Zeiss) with 50 kVp. and Esteya (Elekta) with 69.5 kVp. Esteya has a dose gradient that is slightly smaller (8% per mm) than the Leipzig, Valencia, and Axxent (12% per mm) systems.

Several treatment planning and clinical practical aspects will be discussed on this presentation for all skin modalities: CTV vs. PTV, limitations of TPS calculations, to use or not bolus to compensate the scatter default, implant-skin distance, the use of lead shielding to decrease the integral dose, atlas or library plans for shielded applicators, the importance of using plastic caps, applicator-skin complete contact, internal shielding (i.e. eyelid), pros and cons of electronic applicators, the use of US for depth evaluation, practical aspects for marking and set-up.

Session II

Modern Brachytherapy – new techniques, indications

Chair: Silvia Rodriguez, Bradley Pieters

Interstitial applications for cervical cancer: Utrech, Mupit, and Benidorm template – clinical experience and planning challenges

Silvia Rodriguez Villalba

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The use of the modern magnetic resonance imaging (MRI) techniques has changed the prospects of the treatment of cervical carcinoma, and has become an essential tool in the brachytherapy (BT) component. The ABS and the GEC-ESTRO have recommended MRI as the preferred image modality for image guided brachytherapy (IGBT).

In locally advanced cervical carcinoma with moderate extension to the parametrium, combined endocavitary and interstitial applicators (Vienna or Utrecht type) are appropriate. However, these have coverage limitations in patients with more advanced disease or in those who respond poorly to external beam radiotherapy. This is the case of cervix tumors that extend to distal parametrium, bulky tumors, narrow vagina, medium or distal vaginal extension, and inability to allocate the cervical tandem.

In such cases, interstitial templates such as the MUPIT or the Syed Template have been recommended, nevertheless, these are non MRI compatible. Then, a new generation of MRI compatible applicators have emerged and are being developed to achieve endocavitary uterine component plus multi-interstitial one able to cover the medium-distal parametrium, vaginal, and rectum and bowel extension. One example of them is the Template Benidorm (TB) developed in our institution.

The TB allows for a uterine tandem plus straight and angled titanium needles. It can provide total coverage of the craniocaudal and lateral extension of the tumor with excellent conformation and OAR sparing. The MRI-based implemented procedure for treatment planning includes an efficient and practical solution with TPS applicator library and a pre-plan technique.

In this presentation, different clinical and practical aspects are discussed: application of the recommendations from societies, HR-CTV and IR-CTV determinations, response evaluation with MRI, prescription dose, local control, OAR dose constrains, motivation of interstitial component, BT as optimal therapeutic option, extended interstitial applicators motivation for advanced disease, personal clinical experience MUPIT vs. TB, treatment planning practical aspects and cautions.

Techniques for bladder brachytherapy – just do it

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Muscle-invasive bladder cancer is commonly treated with cystectomy and lymph node dissection. This treatment is up till now the golden standard but inevitably mutilating because of bladder removal. For solitary small sized tumors bladder, preserving techniques are emerging for which brachytherapy is very useful. Indication for brachytherapy is pT2-3, < 5 cm, and solitary.

Before brachytherapy, a course of external beam radiotherapy is given on the pelvis and bladder. The dose is 20 fractions of 2 Gy.

Nowadays, there are two techniques for bladder implantation. The oldest technique is the retropubic approach. With this technique, the bladder is opened to allow implantation of the flexible brachytherapy catheters at the tumor site. Recently, the endoscopic surgical approach has been developed. With this technique, the implantation is completed from the outside of the bladder under laparoscopic view. The correct placement is controlled by cystoscopy.

Several brachytherapy schedules have been used to reach a total EQD2 of 70 Gy. An example is 30 pulses of 1 Gy every 2 hours.

Results in this selected group of patients are very satisfactory and comparable to cystectomy. The reported 5-year local control rate is 62-100% for T1-T3 tumors with a 5-year overall survival rate of 38-73%. The bladder preservation rate is more than 90%.

For the group with small sized solitary tumors, a bladder preserving technique with brachytherapy has been proven to be safe with good functional outcome. The radiotherapy and urologic community need to seek collaboration to offer patients worldwide another organ sparing treatment with good oncologic outcome.

Commissioning and clinical experience of a new HDR brachytherapy system: SagiNova

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Purpose: Portsmouth Oncology Centre (POC) is the only radiotherapy department in the UK to utilize Co-60 for HDR brachytherapy, and is a reference center for Eckert and Zeigler Bebig GmbH. This work reports on the commissioning and the first year of clinical use of the new SagiNova HDR brachytherapy system.

Material and methods: The SagiNova HDR afterloader and SagiPlan treatment planning system were installed at the POC in January 2015, and a comprehensive commissioning plan was developed based on previous commissioning experience, current research and ESTRO Booklet 8. The first patient was treated on the 25th February 2015. Routine quality control based on current guidance was set up and managed using the QAssist™ tool within the SagiNova software (see Table 1). POC currently treat gynecological brachytherapy using SagiNova, and to date there have been 234 individual treatments: 50 full insertion ring cervix treatments with MR/CT fusion planning, 3 endometrium treatments, and 143 vaginal vault treatments.

Results: All commissioning results and subsequent QC tests were acceptable. All safety mechanisms and interlocks functioned satisfactorily. The mean source position error in clinical applicators was 0.6 mm between planned and measured position (± 1.0 mm uncertainty, k = 2). The source strength variation in well chamber measurements was < 1% (assumed uncertainty in the measurement). The result of 'end to end' system audit using the IPEM brachytherapy applicator dosimetry (BRAD) phantom produced a point A dose difference of < 0.4% and 97% gamma passing rate at 3% (local normalization), 2 mm. The SagiNova HDR afterloader has been in clinical use for 15 months and has had 1 version upgrade in November 2016; all post upgrade QC was satisfactory.

Conclusions: SagiNova has been commissioned and clinically implemented successfully, with the scope of its use being expanded to other treatment sites: esophagus, skin, and prostate treatments.

Table 1. HDR commissioning tests and results for SagiNova

HDR commissioning tests	Results for SagiNova system commissioning and Year 1 QC Results
Electrical and mechanical safety	All satisfactory
Radiation shielding (treatment unit and environment)	All satisfactory
Equipment safety interlocks (hardware and software)	All satisfactory
Manufacturer acceptance test schedule	All satisfactory
Source dwell positions in straight catheters (QC check system e.g. ruler, video camera, and autoradiographs)	Mean source position error measurement to TPS = 0.5 mm, maximum deviation using video check ruler 1.0 mm (± 0.5 mm (with k = 2) measurement uncertainty)
Source dwell positions in all clinical treatment applicators (autoradiograph dwell positions with respect to radiograph of applicators, compared to treatment planning system positions)	Mean source position error measurement to TPS = 0.6 mm (± 1.0 mm (with k = 2) measurement uncertainty)
Dwell times (accuracy, linearity)	All satisfactory, maximum deviation measured to set time 0.8% (± 0.2 s (with k = 2) measurement uncertainty)
Transit times and transit dose (accuracy of correction for transit dose at treatment unit and/or treatment planning system)	All satisfactory, appropriate correction for transit dose
Source strength (certificate, measurement, planning system, treatment unit)	All satisfactory, maximum variation between well chamber measurement and certificate 0.7%
Decay correction (planning system and treatment unit)	All satisfactory
Planning system applicator reconstruction (accuracy, consistency with physical applicator, validation of physical source path)	All satisfactory
Planning system dose calculation (source data, point doses, isodose, DVH, independent dose calculation system)	All satisfactory
'End to end' system check (image applicators in phantom, reconstruct in planning system, prescribe and plan, deliver, measure dose at treatment unit and compare to plan)	End to end check using IPEM 'BRAD' system < 0.4%-point dose, 97% gamma (3%, 2 mm)

Results, complications, quality of life, costs? What else matters?

Janusz Skowronek[1,2]

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After 100 years, since the first application of radium, brachytherapy is facing new challenges. During this period, this technique has undergone various stages of development – from the treatment of skin cancer and gynecological tumors treated with radium used in almost any location of the tumor, applying modern afterloading systems, and 3D treatment planning systems. Brachytherapy place in the treatment of cancer is constantly evolving and is often dependent from non-medical factors. The first of these factors is the availability of the method dependent on the level of reimbursement, the quality of the health care system. A slight change in the name of the refund procedure can reduce brachytherapy treatments. In last year's changes in reimbursement for brachytherapy are dramatically increasing. Expensive techniques are chosen without considering the patient benefits or to the whole group of patients. Competitive groups are interested. Main negative factors are: 1) the desire for income; 2) increasing use of active surveillance in prostate brachytherapy; 3) lack of training/sill; 4) competing technologies, e.g.: robotic prostatectomy; 5) lack of knowledge; 6) increasing sophistication of EBRT (IGRT, SBRT, Protons); 7) bad press; 8) excessive regulatory requirements.

Important factors are principles of cancer treatment accepted by the country (region) and attitude of medics to practice and its acceptance. Sometimes, a graduate of a medical school does not recognize the word 'brachytherapy'. Too often, other than medical factors decide about the development of brachytherapy. A noticeable trend is skipping and conducting meta-analysis, comparing different techniques of treatment. Doctors who use one technique does not pay attention to other methods or try to ignore them. Treatment results are not analyzed in terms of a 'golden' rule – to treat as many patients as possible in the available situation.

These questions are an attempt to study the possibility of the development of brachytherapy in a world where the choice of treatment method depends increasingly from other than medical factors.

Session III

Prostate cancer – challenges for brachytherapy

Chair: Piotr Wojcieszek, Roman Makarewicz

High dose rate brachytherapy or ultra-hypofractionation for prostate cancer

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There are a lot of modalities used to treat prostate cancer. Radical prostatectomy was widely utilized as an efficient but aggressive approach through the twentieth century. Since conformal techniques introduction radiotherapy plays an important and constantly growing role for prostate cancer patients, one of the most efficient tool for dose escalation is brachytherapy. There are data, which suggest superb outcomes among patients treated with brachytherapy. It can be used alone or with external-beam radiotherapy as a boost.

High dose rate brachytherapy experience (i.e. fraction dose > 7 Gy; non-homogenous dose coverage; short overall treatment time) is widely transferred to LINACs. The question should be raised if such approach is safe and efficient treatment option. There are data showing that integral doses are much higher for external beam techniques. Moreover, there is radiobiological phenomenon called intrafraction repair, unfavorable if fraction delivery takes too long. There are data showing efficacy of ultra-hypofractionation, particularly in the low risk patients. In the higher risk groups, probable brachytherapy advantage may appear. In our experience, ultra-hypofractionation is as safe as high dose rate brachytherapy; however, there might occur some differences, especially in high risk patients.

Future clinical trials should investigate if ultra-hypofractionation is suitable for patients with unfavorable risk but also brachytherapy should be compared with such schedules.

Long-term outcome of high dose rate brachytherapy with external beam radiotherapy of localized prostate cancer – retrospective results of Centre of Oncology in Bydgoszcz

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Purpose: To determine clinical outcomes of interstitial high dose brachytherapy (HDR-BT) combined with external beam irradiation (EBRT) in organ confined patients with prostate cancer.

Material and methods: 260 patients mainly with low and intermediate group risk (86.1%) were treated between 2004-2010. Median follow-up was 82 months, with range 63-132 months. The median pre-treatment PSA tests of the patients were 17.9 ng/ml (range 3.6-109 ng/ml). ADT was given in 87 patients as a neoadjuvant therapy for 3-6 months before radiation therapy for prostate volume reduction. Only in 20 patients, ADT was administered as an adjuvant treatment for 2-3 years after irradiation. Patterns of failure: biochemical failure free survival (bFFS), time to general clinical failure (GCF), overall survival (OS), and risk of toxicity were determined.

Results: The lowest level of PSA after the treatment (PSA nadir) ranged from 0 to 4.2 ng/ml (median value 0.32) within months varied from 1-24 (median 12 months). The 5-year Phoenix biochemical control for all patients was 84%; for low, intermediate, and high group of patients were 94%, 82%, and 72%, respectively. In total, 57 patients (21.9%) failed the treatment, biochemical failure with clinical progression occurred in 36 patients (13.8%), followed by no clinical progression in the rest. Probability of OS for all patients at 5 and 10 years following diagnosis was 93% and 86%, respectively. The risk for GCF rises with higher PSA nadir level, an increase of 1.0 ng/ml leads to 1.6 times higher risk of GCF. Also time to biochemical recurrence was statistically significant in range of PSA nadir < 0.5 ng/ml vs. > 0.5 ng/ml. Acute and late toxicity for all patients was low.

Conclusions: Although this study is retrospective, the results are noteworthy considering its long follow-up and

confirmation of HDR-BT combined with EBRT usefulness in the treatment organ confined prostate cancer patients.

LDR brachytherapy in prostate cancer patients in Poland

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Purpose: Brachytherapy of prostate cancer treatment seems to be nowadays as effective as external beam radiotherapy (EBRT) and surgery procedures. Ultra-low dose rate brachytherapy (LDR-BT) has to be applied as a single modality treatment in patients from low risk group with localized tumors. In comparison with external beam radiotherapy, it allows to depot higher dose inside the tumor and provides the chance to extremely shorten whole treatment time. With comparison to high dose rate (HDR-BT) prostate brachytherapy, LDR-BT enables to reduce urethral and rectum complication rates due to low dose radiation applied to healthy organs at risk in longer treatment time. The aim of this work was to present the results and complications of LDR-BT patients with prostate cancer, treated in the first oncology center in Poland.

Material and methods: The whole group consisted of 72 patients with prostate cancer were treated with interstitial LDR brachytherapy since December 2008 till June 2012 in Greater Poland Cancer Center. LDR-BT was performed with loose iodine seed sources (I-125), loaded by Mick Applicators in one, single procedure. Two patients received I-125 treatment as a boost after external beam radiotherapy (2.7%). Designed radiation dose after 204 days was 145 Gy per whole prostate gland with 5 mm margin area. The age of patients ranged from 49 to 83 years, average 63.53 years. Patients were divided into risk groups by TNM, initially PSA and Gleason score data's. The low, intermediate consisted of 53 (73.6%), 15 (20.83%) cases, respectively. So called high risk, was the salvage brachytherapy group and consisted of 5 patients (6.94%). Most of patients (44 – 61.11%) belonged to T1c group. The mean level of iPSA was settled on 9.97 ng/ml and ranged from 0.145 till 48.92 ng/ml. The majority of patients (36 pts – 50%) had Gleason histopathology result score as 6 (3 + 3) and as 7 (3 + 4) in 20 cases (27.77%). LH-RH androgen blockade had 14 of them (19.44%), given to intermediate and salvage group only. Number of seed source used in LDR-BT treatment was 49.59 in mean value (ranged 28-83) per procedure.

Results: Median observation was 53 months. Complete remission was observed in 51 patients (70.83%), partial remission in 6 (8.33%). The mean value of PSA nadir was settled on 0.677 ng/ml (range 0.003-2.64 ng/ml). Biochemical progression was noted in 7 patients (9.72%) and locoregional progression in 8 patients (11.1%). Three patients with developed progression died due to prostate cancer metastases, two of them survived on long-term hormonal therapy treatment. In one patient (1.39%) from EBRT/LDR-BT group, we observed biochemical progression. Urologic side effects were noted in most of patients (dysuria: 25.4%, incontinence: 4.4%, frequency: 70%). We did not observe gastrointestinal problems during treatment time due to specific low dose rate treatment and remote rectum distance from target area after LDR procedure.

Conclusions: 1. LDR brachytherapy of prostate cancer can be used as a single modality treatment or in some cases as a boost after external beam radiation therapy. 2. Small group shows encouraging results of LDR-BT treatment in low and intermediate risk group. 3. LDR-BT treatment of salvage patients' needs comparative investigation studies in larger groups with careful and proper qualification rules.

Is PSA bounce an important factor of biochemical control after primary treatment of prostate cancer?

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Purpose: Prostate specific antigen (PSA) is a serine protease from kallikrein group released from secretory cells of the prostate gland. The level of PSA in serum is the most common method of monitoring prostate cancer patients after definitive treatment. PSA after radiotherapy decreases gradually but usually remains detectable. After prostate cancer radiotherapy, PSA level fluctuations during follow-up may occur. There is still uncertainty regarding causes of this phenomenon. It is called "PSA bounce" and is well described in the literature after EBRT and LDR brachytherapy. There are only few papers about PSA kinetics in patients after HDR brachytherapy. The main goal of the study was to analyze the literature to determine the association between PSA kinetics and biochemical control of prostate cancer patients. The secondary goal was to describe factors predisposing to the emergence of PSA bounce after brachytherapy.

Results and conclusions: Differentiation of benign PSA bounce from real biochemical failure is a major issue in clinical practice. On the one hand, the analysis of literature revealed that after EBRT the PSA bounce seems to be a negative prognostic factor and predicts decreased rate of biochemical control for prostate cancer patients. On the other hand, the PSA bounce after brachytherapy is usually associated with improved biochemical control compared to patients who did not experience this phenomenon. The strongest predictor for PSA bounce is younger age. In attempt to distinguish PSA bounce from biochemical failure, several factors have been tested. Shorter time to PSA increase seems to be the most useful one to distinguish PSA bounce from biochemical failure.

Salvage HDR brachytherapy in radio-recurrent prostate cancer

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Purpose: The primary aim of this study was to evaluate results and toxicity of salvage HDR brachytherapy in localized prostate cancer failure after previous radiation therapy. The secondary aim was to assess the impact of clinical and dosimetric parameters on effectiveness and adverse events of this therapeutic scheme.

Material and methods: This is a retrospective analysis of 106 consecutive patients treated in Brachytherapy Department between August 2001 and November 2008 for radio-recurrent prostate cancer. The salvage prostate brachytherapy treatment consisted of 3 fractions of 10 Gy with time interval of 3 weeks. Re-irradiation was combined with hormonal treatment for 12 months. OS, PFS, and bPFS were assessed to evaluated treatment outcome. Selected clinical variables were analyzed in terms of their influence on PFS and bPFS: TNM status of recurrent disease (rTNM), Gleason score of recurrent disease, maximum PSA before salvage treatment (rmax PSA), PSA doubling time before salvage treatment (PSADT), PSA velocity before salvage treatment (PSAV), time from primary treatment to local recurrence. Acute rectal and urinary toxicity was scored according to RTOG scale, whereas late toxicity was evaluated with RTOG/EORTC scale. Late adverse events were also reported with NCI CTCAE v3.0. The influence of cumulative doses to PTV, urethra and rectum on acute and late toxicity profile was analyzed.

Results: Median follow-up for the entire group was 70 months (95% CI: 64;76). The actuarial 2- and 5-year OS rates were 95% and 85%. 2- and 5-year bPFS rates were 75% and 53% (Phoenix definition) and 59% and 44% (ASTRO definition), respectively. Median biochemical relapse free survival was 75 months for Phoenix definition and 42 months for ASTRO definition. In the entire analyzed group, no patient suffered from severe rectal toxicity. Severe acute urinary reactions were seen in 9% of patients, severe late urinary reactions in 6%. rTNM and PSAV appeared to have statistically significant influence on PFS and bPFS ($p < 0.05$). The median cumulative izoeffective doses to PTV, rectum, and urethra were 161.8 (89.8-247.5) Gy, 110.6 (70-202.7) Gy, and 153.6 (82.3-347.7) Gy, respectively. No correlation was found between frequency and severity of radiation adverse events, and the level of cumulative doses.

Conclusions: Salvage HDR brachytherapy is an effective and safe method in the treatment of local radio-recurrent prostate cancer. Biochemical progression free survival oscillates at 50% with long follow-up and severe radiation toxicity (grade 3 and 4) does not exceed 10%.

Hypofractionated external beam radiotherapy (EBRT) and single fraction high dose rate brachytherapy (HDR-BT) for patients with prostate cancer: single institution experience

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Purpose: To evaluate the short term efficacy, early toxicity, and dosimetric aspects of combined HDR-BT with EBRT in the radical treatment of prostate cancer patients (PCPs).

Material and methods: Between September 2013 and May 2015, forty PCPs underwent combined treatment including hypofractionated EBRT (37.5 Gy in 15 fractions over 3 weeks) and conformal HDR-BT. The mean age was 69 years with average PSA 6.7 ng/ml and median Gleason score 6.8. T stage was distributed from T1 to T2c. Half of the patients received androgen deprivation. Treatment was delivered using IMRT with 6- or 15-MV linear accelerator. HDR brachytherapy catheter insertion was performed under spinal anesthesia. The median number of catheters was 17 (14-18). HDR brachytherapy was delivered using an Iridum-192 source (Nucletron) and treatment planning systems (SWIFT 2.11.8 and Oncentra Prostate 3.0.9/4.0). Dose volume constraints included: prostate $V_{100} \geq 95\%$, V_{150}, and V_{200} below 40%; maximal urethral dose ≤ 120% and average rectal dose ≤ 85% of the prescription dose. Patients were monitored weekly during radiotherapy and in 3 months' intervals. after treatment. Follow-up visit included clinical examination and PSA value assessment. The acute toxicities were graded according to the EORTC/RTOG scales.

Results: The median V_{100} was 97.3 and median V_{90} was 99.1. All patients completed the scheduled therapy without interruption. The most common urinary symptoms were: urgency, frequency, dysuria, and nocturia. The rectal symptoms (urgency, frequency) were rare. No grade 3 and 4 acute toxicities were recorded. No patient developed clinical or biochemical progression. The constant decrease of PSA level was observed during follow-up.

Conclusions: Single fraction of 15 Gy HDR-BT with hypofractionated EBRT enables dose escalation with excellent dosimetric parameters for the radical treatment of PCPs. The treatment was well tolerated by all patients with satisfactory disease control in the short and medium term.

Session IV

Breast brachytherapy in the crossfire of competition

Chair: Krystyna Serkies, Adam Chicheł

Analysis of fat necrosis incidence in early-stage breast cancer patients treated with interstitial accelerated partial breast irradiation (APBI)

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Purpose: Fat necrosis (FN) is benign, sterile inflammatory process arising from post-lumpectomy irradiation of the breast or trauma as its most common cause. The aim of the study is to evaluate the factors, which could have potential impact on FN development in early-stage breast cancer patients treated with interstitial APBI as a part of BCT.

Material and methods: Between 2009 and 2014, 124 early-breast cancer patients were treated with interstitial APBI in Brachytherapy Department. The follow-up after treatment included clinical evaluation of cosmetic effects, treatment toxicity, recurrence, and mammography performed initially twice a year and then yearly. Incidence, time to occurrence, and clinical symptoms of FN as well as its radiologic features were noted. To estimate severity of FN, the 5-grade scoring system was adapted (from no FN to symptomatic FN requiring surgical intervention). Type of breast conserving surgery (tumorectomy, quadrantectomy, extended lumpectomy), breast size, the number of catheters, and treatment planning factors: V_{100}, V_{150}, V_{200}, DNR were analyzed at their impact on FN development.

Results: FN occurred in 14 (11.3%) of 124 patients with 12 (9.7%) asymptomatic radiologic findings. Two (1.6%) patients required short time non-steroid analgesics. Radiologic examinations suggested local recurrence in one case (0.8%) but there was FN in histopathological report after biopsy. Type of BCS and number of catheters had no impact on FN development. Median breast size in patients with FN was 1110 cm^3 and 805 cm^3 in the rest of treated group. Median V_{150} and V_{200} were 34.2 cm^3 vs. 21.8 cm^3, and 11.9 cm^3 vs. 7 cm^3 for patients with FN vs. without FN, respectively. As to DNR, median was 0.43 vs. 0.37 for patients with FN vs. without, respectively.

Conclusions: Breast size, V_{150}, V_{200}, and DNR are factors with statistically significant impact on fat necrosis development in presented series.

Interstitial boost with pulsed dose rate perioperative brachytherapy (PDRBT) in organ-sparing treatment of breast cancer

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Purpose: To evaluate peri-operative interstitial PDRBT with an intra-operative catheter placement to boost the tumor excision site in breast cancer patients undergoing organ-sparing treatment.

Material and methods: Ninety-six consecutive $T_{1-3}N_{0-2}M_0$ breast cancer patients who between May 2002 and October 2008 underwent breast-conserving therapy (BCT) including peri-operative PDRBT boost followed by whole breast external beam radiotherapy (EBRT) were analyzed. PDRBT (15 Gy, 1 Gy/pulse/h) was performed on the following day after surgery. All patients were diagnosed by true-cut or fine needle aspiration biopsy as carcinoma.

Results: Tube placement (median 9, range 5-13) prolonged time of surgery by no more than 20 minutes. No increased bleeding or wound healing problems related to the implants were observed. The only side effects included one case of temporary peri-operative breast infection after re-excision, and three cases of fat necrosis, both early and late. In 11 patients (11.4%), subsequent EBRT was omitted owing the final pathology findings. These include 8 cases with multiple adverse prognostic pathological factors resulting in subsequent mastectomy, one lobular carcinoma *in situ*, and two cases with no malignant tumor. After a median follow-up of 12 years (range: 7-14), among 85 patients who completed BCT, there was one ipsilateral breast tumor and one locoregional nodal recurrences (each 1.2%). Six patients developed distant metastases and one was diagnosed with angiosarcoma within irradiated breast. The actuarial 5- and 10-year disease free survival was, respectively, 90% and 87% for the whole cohort of invasive breast cancer patients, and 91% and 89% for patients who completed BCT. Self-assessed good cosmetic outcomes were achieved in 58 out of 64 (91%) assessable patients.

Conclusions: Peri-operative PDRBT boost with intra-operative tube placement followed by EBRT is feasible, devoid considerable toxicity, and provides excellent long-term local control. However, this strategy requires careful patient selection and histological confirmation of primary diagnosis.

Breast cancer brachytherapy under fire from competitors – boost techniques: photons, IORT, or rather brachytherapy?

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Purpose: The aim of this paper is to give a concise review of contemporary boost techniques to the tumor bed in breast conserving therapy (BCT) in breast cancer. As a standard, BCT consists of local surgery followed by chemotherapy (if indicated), mandatory radiation to the whole breast with additional boost to the tumor bed, and hormonal therapy in patients with positive hormonal receptors. While chemotherapy and hormonal therapy regimens are quite well described in guidelines, radiation therapy has set dose to be delivered to the target but techniques may substantially differ between oncology centers, especially in terms of boost techniques.

Material and methods: International and local consensus guidelines (ABS, NCCN, GEC-ESTRO, Polish Union of Oncology) and meta-analyses were reviewed focusing especially on prescriptions for techniques, radiation dose, timing, indications, and contraindications for breast cancer boost. Pros and cons of different boost techniques were analyzed and summarized. Exemplar comparison of external beam photon boost and HDR brachytherapy boost was carried out and prepared for display.

Results: Increase in dose of 15 Gy above standard 50 Gy results in decreasing of local recurrence risk by a half. Prospected annual local recurrence risk in patients ≥ 50 years should be as low as 0.4-0.7% along with good/excellent cosmetic outcome. Absolute indications for tumor bed boost with electrons, photons, or brachytherapy are: age ≤ 50; close, unknown or positive surgical margins; tumor grade 3 and presence of extensive intraductal component. The most common whole breast radiation therapy regimen is 46-50 Gy in 23-25 fractions followed by boost of 10-16 Gy in 4-8 fractions. There are many boost techniques available: electrons, photons, brachytherapy (LDR, HDR, PDR), intraoperative electron radiation therapy (IOeRT), intraoperative X-Rays (IntraBEAM), external HDR brachytherapy (AccuBoost), and protons. Long term results of all the techniques seem to be equivalent but brachytherapy boost has a trend to result in the lowest risk of local recurrence. In an ideal situation, a clinician is convinced that brachytherapy boost is better in outcome than electron boost, and the choice of treatment depends on the size, shape, and location of tumor bed in relation to the size and shape of the breast. Radiobiologic issue is also important. Taking into account that alpha/beta ratio for breast cancer cells is assessed to be approximately 4 Gy, it is stated, that hypofractionated regimens can achieve the same results as standard fractionation. Brachytherapy and IOeRT single boost dose of 10 Gy is translated in EQD2 to be about 23 Gy, which can explain excellent long term results in available series.

Conclusions: The aim of a boost technique is to minimize the risk of local recurrence and to achieve the best cosmetic outcome. In case of presence of negative predictive factors, the supreme aim is the cancer cure, even under the cost of poor cosmesis. The choice of the boost technique should be individualized, tailored to the patient characteristics, treatment acceptance, and important institutional practical issues and experience.

The use of different markers in the planning of brachytherapy for breast cancer

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Accurate tumor bed localization and target volume definition are key factors in breast brachytherapy planning. Retrospective researches showed a strong correlation between local recurrence and inaccurate target coverage. Precise target localization is therefore crucial to good treatment outcome. Tumor bed localization based on clinical examination, surgical note, and breast scar position is now considered to be insufficient. Implementation of computed tomography (CT) in brachytherapy planning improves the target definition by visualization of surgical clips and architectural tissue distortion inside the breast. But visibility of a tumor bed is strongly dependent on the type of surgery and even with CT imaging localizing a surgical cavity can be challenging. Nowadays, the gold standard in localizing the tumor bed in breast radiotherapy are surgical clips. According to GEC-ESTRO recommendations, it is necessary to place at least 6 markers on the borders of resection margins or at least 4 clips when fixing on the thoracic wall. It is also recommended to consider all pre- and postoperative information about the case and to use different imaging modalities before catheter insertion. Surgical clips and CT scans are not the only methods to visualize the tumor cavity. Other types of three-dimensional (3D) imaging like postoperative magnetic resonance imaging or preoperative positron emission tomography were examined in localization of surgical bed. Results, however, are not as good as expected. The other opportunity is to use new biodegradable markers like BioZorb Tissue Marker, a biodegradable spiral marker with six titanium markers, which provides 3D visualization of surgical site. Another biodegradable material – poliethylene glycol (PEG) is used in TraceIT Tissue Marker as a gel injected into tumor bed to distinguish their margins. The same hydrogel was also used as a point marker as an alternative to surgical clips. The first results of trials with these biodegradable tumor bed markers are promising.

Session V

Treatment planning in brachytherapy – on the way to excellence

Chair: Grzegorz Zwierzchowski, Marta Szlag

Developing dosimetric films based quality assurance procedures, for TG-43 and TG-186 recommendations – gamma analysis as a fast reliable tool for commissioning brachytherapy treatment planning systems

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Purpose: Well-known defect of TG-43 based algorithms used in brachytherapy is a lack of information about interaction cross-sections, which are determined not only by electron density but also by atomic number. TG-186 recommendations using of MBDCA (model based dose calculation algorithm), tissues segmentation, and the structure's elemental composition create difficulties in brachytherapy dosimetry. For the clinical use of new MBCDA algorithms, it is necessary to introduce reliable and repeatable methods of TPS commissioning. Film dosimetry with Gamma analysis is widely used in external beam quality assurance (QA); planar film dosimetry is also introduced for verification of the dose distribution in BT applications.

Aim: Commissioning of calculation algorithm (TG-43) for shielded vaginal and ring applicators. Developing commissioning procedures for current and further use, based on the film dosimetry method.

Material and methods: Calibration data was collected by separately irradiating 14 sheets of Gafchromic® EBT films with the doses from 0.25 Gy to 8.0 Gy using HDR Ir-192 source. Standard vaginal cylinders of three diameters and ring applicators with 26 and 30 mm diameters and a 60 mm intra-uterine tube (60º bent angle) were used in the water phantom. Dose grids, corresponding to each plane (dosimetric film location), were exported from the TPS as a raw data. Gafchromic® films were digitized after irradiation. Gamma analysis of the data were performed using the OMNI Pro I'mRT® system, as recommended by the AAPM TG-119 rapport criterion for gamma analysis of 3%, 3 mm and a level of 95%.

Results: Calibration curve was determined as third-degree polynomial type. Gamma analysis were performed and showed that over 90% analyzed points meets Gamma criteria.

Conclusions: Analysis showed excellent agreement between the dose distributions calculated using TPS and measured by Gafchromic films. Proposed commissioning procedure for further use with MBDCA algorithm was established for use at author's facility.

Comparison of Co-60 and Ir-192 in CT-based brachytherapy treatment planning

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Purpose: In HDR brachytherapy, it is possible to use two sources. Physical differences between Co-60 and Ir-192 are known but comparison of both sources in treatment planning system was highly recommended.

Material and methods: In three localizations: gynecology, breast, and oesophagus, group of 120 patients were selected. For each localization, 30 plans were chosen and for every patient two treatments plans were created. One using Ir-192 and one using Co-60 sources. In planning system (Oncentra Brachy, Elekta) target and organs at risk (OARs) appropriate for each localization were entered. Selected isodoses 100%, 120%, 150%, 200%, 90% in target and 100%, and doses in 2 ccm and 0.1 ccm for OARs were compared. The results were subjected to statistical significance p comparative factor.

Results: Statistical analysis of the results showed a significant statistical differences for target only in cervical stamp for the cover isodose 200%, $p = 0.04$ and $p = 0.05$ for cervical cancer. For each location, there was no statistically significant differences in doses in OARs and ICRU points.

Conclusions: The use of two radiation sources is equally and fully justified in cervical stamp, cervical carcinoma, breast, and oesophagus cancers. Statistically significant differences were found for targets in gynecological location for 200% isodose. Doses were smaller for Ir-192 source. These differences were, respectively, about 1.5% for cervical stamp and about 2% for cervical cancer. Statistical analysis of the results for the rest of the studied localization like breast and oesophagus showed no significant differences for meaningful values, which were taken into account during the planning.

Optimization of treatment planning and treatment delivery in gynecological brachytherapy based on advanced 3D imaging

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Optimization of the treatment planning and treatment realization in brachytherapy is always a multi-criteria process, because decisions must be taken on the basis of compromises between two or more conflicting goals. On the one hand, in order to prepare a treatment plan, we try to use all available imaging methods to gather as much accurate information about the patient's anatomy and application's geometry, as possible. With the geometric information, we are trying to reconstruct the applicator with highest possible precision and create a treatment plan meeting established dose distribution criteria using the latest software and computational algorithms available. On the other hand, throughout this process, we must think of a patient who is waiting for the treatment and always keep in mind the elapsed time.

It seems that the optimization of the treatment planning process and treatment realization in brachytherapy must go towards standardized procedures and clear dose distribution parameters of treatment plans. This approach will provide patients with safe and effective brachytherapy.

In brachytherapy of gynecologic malignancies, the whole process optimization (patient preparation, planning, and treatment realization) appears to be particularly important. Gynecological brachytherapy procedure is in fact very diverse. It offers brachytherapy professionals wide range of applicators and technical capabilities, and allows physicists to use modern methods of three-dimensional imaging and treatment planning with modern methods of optimization. It is a procedure that is properly described in the literature with recommendations of scientific organizations. The current recommendations of the European Society for Radiotherapy and Oncology (ESTRO) and the American Brachytherapy Society (ABS) on gynecologic brachytherapy will be discussed, focusing on imaging, planning, optimization of treatment plans, and reporting parameters of dose distributions.

Session VI

Brachytherapy 3D – modern imaging

Chair: Agnieszka Żółciak-Siwińska, Damian Kazalski

HDR brachytherapy for medically inoperable patients with endometrial cancer: from 2D to 3D

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Endometrial adenocarcinoma is the most common gynecologic cancer in Poland. For patients with localized disease, the standard treatment is surgery with total hysterectomy, bilateral salpingo-oophorectomy with or without pelvic and para-aortic lymph node dissection. It is estimated that approximately 10% of early stage endometrial cancer patients are medically inoperable. One of the main reasons for inoperability is obesity and related comorbid conditions: such as diabetes, hypertension, and cardiovascular diseases. For these patients, definitive radiation therapy with brachytherapy alone or combined with EBRT is an alternative treatment option. While the development of EBRT has advanced in the recent years, the use of brachytherapy has not progressed in the same way. For many years, brachytherapy treatment planning was based on orthogonal X-ray images. In medically inoperable endometrial cancer, 2D treatment planning did not allow to visualize uterus with tumor and the identification of organs at risk was insufficient.

The improvement in imaging techniques has allowed to move from 2D to 3D image-guided brachytherapy. Planning based on CT and MRI has given the possibility to visualize tumor and organs at risk, and individualize the treatment. In Gliwice Cancer Center, HDR-BT has been performed in medically inoperable endometrial cancer for 25 years. We started with traditional 2D X-ray-based treatment planning using our own dosimetry system, fractionation scheme, and applicators. In 2008 we moved from 2D to 3D treatment planning.

CT-guided high-dose-rate brachytherapy in the treatment of patients with liver metastases of gastrointestinal cancer

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Purpose: CT-guided high dose rate brachytherapy (CT-HDRBT) is an interventional radiologic technique. This method is a local ablation of primary and secondary malignomas using a radiation source, which is applied percutaneously through a catheter into the metastatic lesion. The aim of this study was to assess the minimal effective dose, safety, and efficiency of CT-HDRBT in the treatment of liver metastases of gastrointestinal cancer.

Material and methods: Eighteen consecutive patients with 22 unresectable liver metastases of gastrointestinal cancer were included in this retrospective trial and treated with CT-HDRBT, which was applied as a single fraction high-dose irradiation (15-20 Gy) using a 192Ir-source. Primary endpoint was to assess the minimal effective dose, and to determine the degree and frequency of complications. Secondary endpoint was to assess local control, progression-free survival, and overall survival.

Results: The mean tumor volume was 50.2 cm^3 (range 9.9-188.5). The mean irradiation time was 16.1 minutes (range 9.3-35.4). Seven patients were treated with one applicator, nine patients with two applicators, and two patients with 3 applicators. The average dose covering 100% of the target volume was 10.6 Gy (range 5.5-15.4), while the average dose covering 90% of the target volume D_{90} was 15.6 Gy (range 9-22). The mean follow-up time was 7.6 months (range 3-14 months). The average progression-free survival (PFS) was 5.7 months (range 2-14 months) and the median overall survival (OS) was 7.6 months (range 3-14 months). Local recurrence occurred in 5 patients (28%), the CR (complete regression) obtained in one patient (5%), partial regression (PR) obtained in 7 patients (39%), whereas the remaining 5 patients achieved stabilization of the lesion volume (28%). There were no significant complications associated with surgery (the liver puncture) or with irradiation in none of the patients.

Conclusions: CT-HDRBT occurred to be as safe and effective for the treatment of liver metastases of gastrointestinal cancer. Determining the optimal dose brachytherapy, which at low risk of complications will increase the effectiveness of local treatment, requires further study.

Image guided HDR brachytherapy in the head and neck area

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Purpose: The aim of the study was the evaluation of image guided transdermal application of interstitial brachytherapy in patients undergoing repeated irradiation for relapsed local tumor in the head and neck area.
Material and methods: The article describes transdermal application of interstitial HDR brachytherapy in 4 patients treated due to relapsed local tumor in soft palate, submandibular area, laryngopharynx, as well as pterygoid muscles and maxillary sinus. The application was conducted under continuous CT-image guidance (CT fluoroscopy). Patients qualified for this type of treatment had neoplastic lesions located deep under the skin surface. Because of their location, access to the lesions was limited and the risk of damaging the adjacent tissues such as vessels and nerves was high. The following parameters have been evaluated: clinical response using RECIST 1.1, incidence of perisurgical complications using CTCAE 4.0, and the frequency of occurrence of radiotherapy related early morbidity using RTOG.
Results: Various radiation schemes were used, from 3 to 5 fractions of 3.5-5 Gy. The median total dose (D_{90}) was 20.6 Gy. BED and EQ2 median doses were 30.4 Gy and 25.3 Gy, respectively. In the follow-up period of 3-7 months (the median value of 3.5 months), two patients had partial regression of the disease and in 2 others the neoplastic process was stabilized. None of the patients had serious complications of treatment (of 3rd degree or higher).
Conclusions: CT-image guided brachytherapy proved to be a safe method of treatment in patients with local relapse in sites, in which traditional visually controlled application was impossible due to risk of complications. Despite short observation period and small study group, it seems justified to conduct prospective studies for the evaluation of efficacy and safety of CT-image guided brachytherapy.

Endobronchial brachytherapy – palliative treatment in the era of 3D planning technique

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Purpose: The aim of this paper is to review indications and 3D planning rules in endobronchial brachytherapy.
Material and methods: The lecture presents the principles of endobronchial brachytherapy in the light of the guidelines of scientific societies (ESTRO, ASTRO), reports from scientific journals, and medical conferences. Takes into account the latest American Brachytherapy Society consensus guidelines for thoracic brachytherapy for lung cancer (2016), which recommends usage of 3D planning in endobronchial brachytherapy.
Results: The publications and own investigations indicate that 3D planning in endobronchial brachytherapy increases coverage of PTV with D_{90} isodose up to 85-100% in comparison with 15-35% in 2D planning. In addition, the data show that the use of 3D planning allows the dose reduction in the organs of risk. In 2D planning, they are not taken into account.
Conclusions: Due to the development of medical technologies and their availability, it is currently recommended to use 3D planning in endobronchial brachytherapy in all centers where the appropriate technical facilities are available. New oncological centers should be equipped in facilities for 3D planning technique.

CT-planned HDR brachytherapy for treating uterine cervical cancer

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Purpose: To evaluate the long-term results of CT-planned high dose rate (HDR) brachytherapy (BT) for treating locally advanced cervical cancer patients.
Material and methods: CT-planned HDR BT was performed according to the adapted GEC-ESTRO recommendations on 216 consecutive patients with cervical cancer FIGO stage IB-IVA who were treated with conformal EBRT and cisplatin based concomitant chemotherapy. We analyzed outcomes and late side effects evaluated according to the RTOG/EORTC and SOMA evaluation

scoring system, and compared them to the results from a historical group.

Results: The median age was 56 years (range 32-83). The median follow-up for living patients was 52 months (range: 37-63). The 5-year cumulative incidence function for the local recurrence rate for patients with FIGO II and III was 5.5% and 20%, respectively (p = 0.001). The 5-year overall survival and disease free survival rate was 66.4% and 58.5%, respectively. In two patients, recto-vaginal fistula occurred, and in one patient, vesico-vaginal fistula occurred without local progression. Comparison of late complications in patients treated according to GEC-ESTRO recommendations, and in the historical group revealed a reduction in fistula formation of 59% and also over a 50% reduction in rectal grade 3-4 late toxicity.

Conclusions: This is the largest report with mature data of CT-planned BT HDR for the treatment of cervical cancer with good local control and acceptable toxicity. Compared to the historical series, there is a substantial benefit in terms of severe late effects.

Adjuvant brachytherapy of the lip cancer after surgical resection

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Purpose: The aim of this work is to evaluate outcomes after adjuvant brachytherapy of the lip cancer after surgical resection with close (< 5 mm) or positive margins.

Material and methods: A total of 20 patients (3 women and 17 men in median age of 65.5) diagnosed between 2010 and 2014 with clinical T1-T2 N0 lip carcinoma were treated primarily with surgery. After histopathological result (40% positive, 60% close margins), they were qualified for adjuvant brachytherapy. At the discretion of the attending physician, 25% of patients were treated by high dose rate (HDR) and 75% by pulse dose rate (PDR) brachytherapy. The mean biologically effective dose (BED) given to the clinical target volume was 71.285 Gy (range 62.6-75 Gy). The mean follow-up was 24 months. For statistical calculations we used the Kaplan-Meier method and the *U* Mann-Whitney test.

Results: Only one patient in the group had nodal recurrence 6 months after treatment. The rest of the patients had no evidence of recurrence during the follow-up. Estimated 4-year disease-free survival rate was 95%. The acute skin toxicity according to RTOG scale was 65%, 30%, and 5% for grade I, II, and III, respectively; the late skin toxicity was 25%, 5%, and 5% for grade I, II, and IV, respectively. We also found a statistically significant correlation between the higher BED and appearance of acute toxicity greater than I grade (p = 0.014) and occurrence of any late toxicity (p = 0.047).

Conclusions: Adjuvant brachytherapy of the T1-T2N0 lip tumors achieves a long loco-regional control with relatively low toxicity and it may be taken into consideration for the adjuvant therapy of the lip cancer after surgical resection with close (< 5 mm) or positive margins. Such regimen allows to prevent reoperations along with large reconstructive surgery.

Poster Presentations

Radiation dose to the left anterior descending coronary artery during interstitial pulsed dose rate brachytherapy (PDRBT) used as a boost in breast cancer patients undergoing organ-sparing treatment

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Purpose: To assess dose received by the left anterior descending coronary artery (LAD) during interstitial PDRBT boost for left-sided breast cancer patients undergoing organ-sparing treatment.

Material and methods: Thirty consecutive pT1-T3N0-N2M0 breast cancer patients boosted between 2013 and 2016 with 10 Gy/10 pulses/hour PDRBT following a computed tomography (CT) simulation (slice thickness of 3 mm) were included. The most common localization of primary tumor were upper quadrants. Patients were implanted with rigid tubes following breast conserving surgery and whole breast external beam irradiation (40 Gy/15 or 50 Gy/25 fractions). CT scans were retrospectively reviewed and LADs were contoured with and without margin of 5 mm ($LAD_{5\ mm}$). LAD was contoured from its origin to each utmost visible and through the scrutiny of each planning CT image. Standard treatment plan encompassed tumor bed determined by the surgical clips, and clinical and pathological information with safety margin of 2 cm wherever possible. Paris system rules, with graphical and manual optimization to deliver adapted homogenous dose distribution to the PTV using Oncentra v. 3.3 planning system was applied.

Results: The mean D_{90} and V_{100} were 10.4 Gy (range, 6.6-13.3) and 42.0 ccm (range, 15.3-109.3), respectively. The median DNR was 0.50 (range, 0.27-0.82). The mean doses to LAD and LAD_{5mm} were 1.0 Gy and 0.96 Gy, and maximal doses 1.57 Gy and 1.99 Gy, respectively. The mean dose to the 0,1 cc of the LAD and LAD_{5mm} were 1.42 Gy and 1.85 Gy, respectively (range: 0-49.79% and 1.42-68.95% of the prescribed dose).

Conclusions: Interstitial PDRBT used as a boost for left-sided breast cancer is generally associated with low dose to the LAD. However, higher dose in individual cases may require alternative approaches.

Quality control tests of the ultrasound system used in prostate brachytherapy

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Purpose: The aim of this study was application of the Ultrasound Quality Assurance (QA) program based on the recommendations by the American Association of Physics in Medicine Task Group 128: Quality Assurance Tests for Prostate Brachytherapy Ultrasound Systems (AAPM TG 128) using the CIRS 045 brachytherapy QA phantom (CIRS 045). So far, the ultrasound quality control testing in brachytherapy is not mandatory in Poland.

Material and methods: The AAPM TG 128 recommendations were tested using Oncentra Prostate system (TPS), which consists of treatment planning system integrated with a compatible ultrasound imaging system, and of the CIRS 045 phantom and ultrasound gel for coupling. Using both tools, the size of prostate was measured. Measurements were taken for depths (6, 7, and 8 cm) and frequencies (8 and 10 MHz) of ultrasound used in clinical practice.

Results: The reference values of prostate volume in a phantom provided by vendor agree with calculations carried out with the treatment planning system to within ±5%. The difference between the measurements of prostate dimensions performed with the trans rectal ultrasound and TPS did not exceed ±2 mm for anterior-posterior and lateral directions, and ±3 mm in superior-inferior direction.

Conclusions: Our results agree with the AAPM TG 128 recommendation, therefore, in order to strengthen the quality control of our brachytherapy service, we have implemented CIRS 045 tests in our routine work.

The reirradiation for locally recurrent squamous cell carcinoma of the skin using HDR contact brachytherapy

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Squamous cell carcinoma (carcinoma planoepitheliale) is derived from the cells of the epidermis. The best method of treatment is the surgical removal, while the radiotherapy is an alternative method, used when the surgical resection is not possible, or as a complementary method after the surgery. We present a case of 79-year-old female patient with squamous cell carcinoma of the scalp. The lesion was measuring about 7 × 6 cm. Prior to disqualification from the surgery, the patient was qualified for EBRT. The dose of 55 Gy in 20 fractions was given to the tumor. After the treatment, a gradual regression of the tumor was observed. Thirteen months later, the biopsy of the tumor was performed, which revealed the continued neoplastic infiltration. The patient was qualified for the contact brachytherapy. In the first stage, 45 Gy in 25 fractions were given with the margin of 1.5 cm and normalization of the dose of 5-7 mm from the surface of the skin. In the second phase, the irradiated region was reduced to the residual tumor, and 17.6 Gy in 8 fractions were given. During the therapy, a gradual regression of the tumor was observed (reaction on the irradiated skin area was G3 CTCAE ver. 4.0). After five months, due to persisting ulceration in the area of previous tumor, another control biopsy was performed, which excluded the presence of cancer cells and necrosis, and revealed the chronic inflammation. During follow-up, a gradual decrease of ulceration was observed (eight months after the brachytherapy there was only a small ulceration measuring 0.5×1 cm). Reirradiation of the skin using HDR brachytherapy is associated with a high risk of severe radiation reaction and late complications, but on the other hand, it gives the chance of successful treatment.

Adjuvant brachytherapy after the resection of nodal recurrence of a patient with nasopharyngeal cancer treated with radical chemoradiotherapy – a case report

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Authors report a case of a 46-year old male patient with nasopharyngeal cancer staged as cT1N3M0 who was treated radically with neoadjuvant chemotherapy followed by radiochemotherapy. He received 70 Gy in 35 fractions for the upper pharynx and metastatic ride-sided lymph nodes (groups II and III), 56 Gy in 28 fractions bilaterally for the retropharyngeal lymph nodes (nodal groups II, III, IV, and V) in the IMRT 6 MV photons technique concurrently with cisplatine. Maximal dose in the area determined by 5 mm margin from skin reached 72.2 Gy. The patient stayed asymptomatic for 3 years when he developed ride-sided nodal recurrence in the area included in the 70 Gy target volume. During the operation, comfort brachytherapy applicators were placed in the recurrence bed. A pathology report indicated non-radical resection. 7 days after surgery, brachytherapy was introduced. In the treatment planning, the 100% isodose was excluded from the area determined by 5 mm margin from skin. It was calculated that every 1 cm^3 of this area (named as "skin") received 1.9 Gy during one fraction. The total administered dose reached 42 Gy fractioned for 3 Gy twice daily for the HR-CTV. The treatment was carried out in the planned dose and time. Three weeks afterwards, acute radiation reaction grade 1/2 was observed. However, the surgical wound healing was satisfactory and it was completely healed during the follow-up, three months after operation.

The aim of this case report is to evaluate the efficacy and safety of the total dose of 42 Gy in 14 fractions, administered twice daily to the skin area previously irradiated with classically fractionated teleradiotherapy.

Comparison of methods 3D and 2D with the use of three-dimensional images in HDR endobronchial brachytherapy

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Purpose: The purpose of this study is to demonstrate significant differences in dose distribution between 3D and 2D method in the area of the tumor and the tissue located in close proximity to the PTV.

Material and methods: The studies involved a group of 31 patients with advanced lung cancer treated in our Department from 2011 to 2013. In total, 31 patients and 76 treatment plans were analyzed. The treatment plans 2D and 3D were compared to the PTV dose coverage for V_{85}, V_{100}, V_{115}, and the dose of critical organs, $D_{0.1cm^3}$, D_{1cm^3}, $D_{2\ cm^3}$ for the heart, spinal cord, esophagus, and D20 for the heart and lung as "healthy" organs.

Results: The results clearly showed that the 3D method allows for individual dose distribution for every treatment plan, which permits for high control of the dose comprising the tumor while reducing treatment toxicity. In the case of the PTV_{V100}, statistical measures differences in both methods were for the average, median, minimum, and maximum values, 33%, 44%, 7.98%, and 1.27% respectively, and were superior for the 3D methods in relation to 2D methods.

Conclusions: Differences in median reference dose between 3D and 2D method in the HDR endobronchial brachytherapy for PTV were 44%, for the V_{100} dominance of the planning method for 3D images. In the analyzed group, significant improvements in duration of overall survival were reported.

Preliminary results of the treatment of cervical cancer patients utilizing IGBT in the 3D technology from 2013 to 2015

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Material and methods: From 1.06.2013 to 30.04.2015, 53 patients were radically treated with primary cervical cancer of the cervix. Two patients were in stage FIGO I, 25 patients in stage II, 26 in stage III, and 0 pts in stage IV. Plan of the treatment: radical teletherapy was done on pelvis from 46.0 Gy/23 fractions – 50.0 Gy/25 fractions with concomitant chemotherapy DDP = 40 mg/m^2/w/i.v. Next, 1-3 weeks later, IGBT-3D was applied (4 × 7.0 Gy/HR-CTV) using CT and MRI for planning in every fraction. Total time of planning for one patient was 3-3.5 hours. The follow-up was 1-3 years and 49 of patients were alive after 3 years.

Results: 40 patients (75.5%) had no symptoms of recurrences, and 9 (16.9%) had a spreading or/and recurrences (chemotherapy was applied). 3 patients died (5.6%). Reasons for death: 1 – cardiac arrest, 1 – broken leg, 1 – spreading of the cancer. 1 patient (1.9%) withdrew his consent from observation. 7 patients (13.2%) experienced complications: 1 – blood in faeces, intestine-vaginalis fistula, 1 – cystitis radiological, 2 – broken leg, 1 – thrombosis of leg.

Conclusions: No shrinkage of the treatment area HR-CTV correlated with number of fractions (meaning 3 and 4 fractions in comparison with 1-2 fractions) was observed. Reduced doses on points A, from 1.0 to 2.5 Gy in comparison with 2 D method in every fraction was noted. We have experience a major obstacle with covering recommended isodose i.m. 7.0 Gy/HR-CTV on patients in stage FIGO III.

Salvage HDR/PDR brachytherapy combined with interstitial hyperthermia in locally recurrent prostate adenocarcinoma after previous irradiation – actual status of multicenter phase II study

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Purpose: The aim of this work is to present the actual status of ongoing clinical trial. The primary endpoint of the study is to estimate the rate of late grade ≥ 3 gastrointestinal (GI) and genitourinary (GU) toxicities related to salvage treatment for locally recurrent prostate cancer after previous external beam radiation therapy.

Material and methods: Patients are recruited in Center of Oncology in Krakow and Center of Oncology in Warsaw (Poland), and in University Hospital in Erlangen (Germany).

Results: To date, there are 33 patients recruited out of 77 planned, of which 13 patients in Krakow, 9 in Warsaw, and 11 in Erlangen.

Conclusions: The clinical trial is still open for the centers interested in participating in the study. The centers should have the possibility to carry out interstitial hyperthermia combined with HDR or PDR brachytherapy.