GEC-ESTRO recommendations for Quality Assurance of Ultrasound in Brachytherapy

Frank-André Siebert
Clinic of Radiotherapy, University Hospital of Schleswig-Holstein, Campus Kiel, Germany
Christian Kirisits
Department of Radiation Oncology, Comprehensive Cancer Center, Medical University of Vienna, Austria
Taran Paulsen Hellebust
Department of Medical Physics, Oslo University Hospital, Oslo, Norway, Department of Physics, University of Oslo, Norway
Dimos Baltas
Division of Medical Physics, Department of Radiation Oncology, Medical Center, Faculty of Medicine, University of Freiburg, Germany
Frank Verhaegen
Department of Radiation Oncology (MAASTRO), GROW – School for Oncology and Developmental Biology, Maastricht, the Netherlands

Saskia Camps
Faculty of Electrical Engineering, University of Technology Eindhoven, Eindhoven, the Netherlands
Bradley Pieters
Academic Medical Center Amsterdam, the Netherlands
György Kovács
Interdisciplinary Brachytherapy Unit, University of Lübeck, Germany
Bruce Thomadsen
University of Wisconsin, School of Medicine and Public Health, Department of Medical Physics, Madison, U.S.A.

INTRODUCTION

Ultrasound (US) is an important imaging modality in brachytherapy (BT). In particular for low-dose-rate (LDR) and high-dose-rate (HDR) prostate implants, transrectal ultrasound (TRUS) is widespread; but European guidelines for quality assurance (QA) for US in BT are lacking. The purpose of this study was to develop such guidelines.

TG 128 [1] focuses on US systems and prostate BT, the current recommendations also cover tests for stepping devices and include other interstitial or intracavitary treatment sites in BT, such as anal implants and gynecological BT.

METHOD

The BRAPHYQS and UroGEC working groups of GEC-ESTRO developed guidelines describing QA methods for US in BT. Existing literature was studied in detail for a comprehensive review of the state of the art, experiences of the working group members were summarized, QA procedures were systematically reviewed and tested.

RESULTS

The main aim of the guidelines is consideration of the US system and stepping device as the basic imaging tool for guidance and navigation during implantation and for image-based treatment planning.

Section 2. General aspects of ultrasound use in BT
When using US phantoms the temperature of the medium is of importance. Most US systems assume a fixed speed of sound (SOS) of 1540 m/s for soft tissue. It was shown [2] that tap water can be a suitable medium when heated to 47.4°C. Alternatively, a 9% by volume mixture of ethylene glycol and degassed water can be used to achieve a SOS of 1540 m/s at room temperature [3].

Section 3. Ultrasound phantoms
The US-unit QA testing requires a phantom. But only a few phantoms on the market fulfil the requirements, as e.g., tissue equivalency, high and low contrast objects in known geometry, design compatible for TRUS probes, and stability over time.

Section 4. Image quality of brachytherapy ultrasound units
In this section methods are presented to check element dropout of the US probe, maximal penetration depth, high-contrast resolution, and length and distance measurements (Figure 1).

Section 5. Quality assurance of the brachytherapy treatment planning system
In particular, scaling and volume checks are explained in this section. Furthermore, offset calibration for biplane probes is detailed presented (Figure 2).

Section 6. Ultrasound for Prostate Brachytherapy
Requirements of template calibration, in particular the temperature dependence, is highlighted in this section. Also, the stepper calibration and hints for US-based needle reconstruction are given (Figure 3).

Section 7. Ultrasound for gynaecological brachytherapy
The main aspect is to verify the position of applicators in phantoms compared to the position achieved by the US probe and applicator tracking systems (Figure 4).

Section 8. Ultrasound for anal cancer treatment
Anal cancer BT is similar to prostate BT. Typically 360° probes are used. If these are motorized, the step size should be checked using a phantom having inserts with known distances.

Section 9. Daily check
In addition to the checks above, a short daily check is recommended that tests basic functioning of the US system and movements of the stepping device, and its link to the treatment planing system.

In the recommendations we provide a **Summary QA sheet,** including tests, frequencies, tolerances, and needed phantoms, to be adapted to individial clinical needs (Table 1).

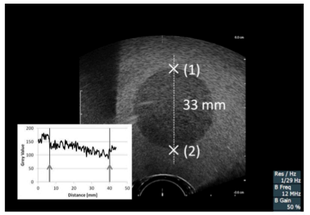

Figure 1 A low-contrast test object in a phantom with diameter measured between points (1) and (2) results in 33 mm. In addition, a profile plot of grey values along the dotted line is depicted.

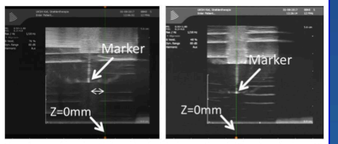

Figure 2 Longitudinal image planes. The US marker is placed in transversal coordinate at 0 mm. Left is an offset between longitudinal and transversal viewing planes. Right the offset is zero as it was properly adapted in the treatment planning system.

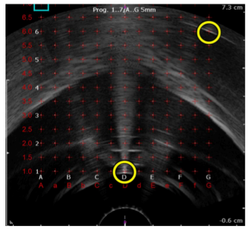

Figure 3 Adjustment and verification of the template and the US system with a water tank of 45° C.

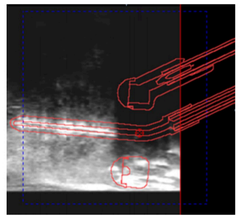

Figure 4 3D datasets for combined intracavitary/interstitial gynecological applications based on TRUS. The 3D model of the applicator is registered to the TRUS. While the ring shows artefacts, the tandem is clearly visible.

Test procedure	Test type	Frequency	Tolerance	Phantom material
4. Image Quality				
4.1 Element dropout	Electronical	Yearly	Number of elements missing	QA phantom, water tank
4.2 Penetration depth	Electronical	Yearly	Changes in depth of penetration > 10mm	QA phantom
4.3 High-contrast resolution	Electronical	Yearly	2mm / 2%	QA phantom
4.4 Length and distance measurement	Electronical	Yearly	1mm on a distance of e.g. 10 and 40mm	QA phantom, water tank
5. QA of TPS				
5.1 Scaling checks	Electronical	Yearly	1mm on a distance of e.g. 10 and 40mm	QA phantom, water tank
5.1 Volume checks	Electronical	Yearly	5%	QA phantom, water tank
5.2 Offset calibration for biplane probe	Electronical	Yearly	1mm	Water tank
6. Ultrasound for prostate treatment				
6.1 Template calibration	Mechanical	Biannually	2mm	Water tank
6.2 Stepping device calibration	Mechanical	Biannually	Longitudinal 1mm Rotational 0.5°	QA phantom, water tank, ruler, water spirit level
6.3 Needle reconstruction of needle tip	Electronical	Yearly	2mm	Water tank, implant needle, US marker
9. Daily checks				
Stepping device check (in/out, rotation)	Mechanical	Each working day preceding use	Longitudinal 1mm Rotational 0.5°	Without phantom
Scaling in TPS using scaling marker (ruler) in US image	Electronical	Each working day preceding use	1mm	Without phantom

***Table 1** Table of QA tests with frequencies and tolerances (example sheet for prostate BT).*

CONCLUSIONS

The recommendations explain practical test procedures of US devices in BT. They will help to implement a QA program with standardized procedures to ensure performance at a high level of quality in daily clinical routine of US in BT.

The recommendations are available at
Radiotherapy and Oncology 148 (2020) 51-56
https://doi.org/10.1016/j.radonc.2020.02.024.

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CONTACT INFORMATION

siebert@onco.uni-kiel.de