AAPM REPORTS

AAPM is a scientific and professional organization, founded in 1958, composed of more than 8000 scientists whose clinical practice is dedicated to ensuring accuracy, safety and quality in the use of radiation in medical procedures such as medical imaging and radiation therapy. We are generally known as medical physicists and are uniquely positioned across medical specialties due to our responsibility to connect the physician to the patient through the use of radiation producing technology in both diagnosing and treating people. The responsibility of the medical physicist is to assure that the radiation prescribed in imaging and radiation therapy is delivered accurately and safely.

One of the primary goals of AAPM is the identification and implementation of improvements in patient safety for the medical use of radiation in imaging and radiation therapy.

"This article contains the titles and summaries of various AAPM reports "

Report No. 253

Surface brachytherapy: Joint report of the AAPM and the GEC-ESTRO Task Group No. 253 (2020)

Executive Summary

The surface brachytherapy Task Group report number 253 discusses the common treatment modalities and applicators typically used to treat lesions on the body surface. Details of commissioning and calibration of the applicators and systems are discussed and examples are given for a risk-based analysis approach to the quality assurance measures that are necessary to consider when establishing a surface brachytherapy program.

Report No. 292

Dose-rate considerations for the INTRABEAM electronic brachytherapy system: Report from the American association of physicists in medicine task group no. 292 (2020)

Executive Summary

The purpose of this report is to provide detailed guidance on the dosimetry of the INTRABEAM® (Carl Zeiss Medical AG, Jena, Germany) electronic brachytherapy (eBT) system as it stands at the present time. This report has been developed by the members of American Association of Physicists in Medicine (AAPM) Task Group 292 and endorsed by the AAPM. Members of AAPM Task Group 292 on Electronic-Brachytherapy Dosimetry have reviewed pertinent publications and user manuals regarding the INTRABEAM system dosimetry and manufacturer-supplied dose calculation protocols.

Report No. 291

Principles and Applications of Multi-energy CT Report of AAPM Task Group 291 (2020)

Executive Summary

In x-ray computed tomography (CT), materials with different elemental compositions can have identical CT number values, depending on the mass density of each material and the energy of the detected x-ray beam. Differentiating and classifying different tissue types and contrast agents can thus be extremely challenging. In multi-energy CT, one or more additional attenuation measurements are obtained at a second, third or more energy. This allows the differentiation of at least two materials. Commercial dual-energy CT systems (only two energy measurements) are now available either using sequential acquisitions of low- and high-tube potential scans, fast tube-potential switching, beam filtration combined with spiral scanning, dual-source, or dual-layer detector approaches. In this report, the underlying physical principles of multi-energy CT are reviewed and each of the current technical approaches described. In addition, current and evolving clinical applications are introduced. Finally, the impact of multi-energy CT technology on patient radiation dose is summarized.

Report No. 202

Physical Uncertainties in the Planning and Delivery of Light Ion Beam Treatments (2020)

Executive Summary

Light ion beam treatments are becoming more widely used. Safe and optimal treatments may only be achieved when uncertainties are considered at every step of the planning and delivery process. These uncertainties include, but are not limited to, penetration uncertainties due to beam delivery, uncertainties in dose compliance, uncertainties of x-ray computed tomography numbers, absolute and relative linear stopping powers, absolute and relative linear scattering powers, conversion of x-ray computed tomography numbers to relative linear stopping power, lateral alignment uncertainties, and uncertainties due to inter-fractional and intra-fractional anatomical variations. Knowing the source and magnitude of these uncertainties, the planner must optimize the plans to mitigate the effect of these uncertainties as much as possible without making the plan undeliverable. Visualization of dose distributions considering the effects of these uncertainties is an important step in evaluating the safety and effectiveness of the plans. This report by Task Group 202 of the AAPM has endeavored to address each of these topics as a guide to the user of light ion beam treatments.

Report No. 200

The Design and Use of the ICRU/AAPM CT Radiation Dosimetry Phantom: An Implementation of AAPM Report 111 (2020)

Executive Summary

Task Group 200 and the ICRU's Committee on Radiation Dose and Image-Quality Assessment in Computed Tomography have jointly developed a phantom design and robust measurement schemes that follow the methodology of AAPM Report 111 and are suitable for a wide range of CT scanner designs and scanning conditions. Several prototype phantoms were built by a research group at the University of California–Davis (UC Davis), and these phantoms have been tested at several centers around the United States as well as in England.

The purpose of this current report is to (a) describe the design of the phantom and (b) suggest a broadly applicable measurement methodology that overcomes the limitations of CTDI100 and the met- rics derived from it, such as CTDIvol. The resulting measurement procedures have been developed for conventional MDCT scanners, including models with wide (16 cm, for example) beams. However, the application of this methodology to flat panel and specialized cone-beam CT systems presents special challenges that are briefly discussed in Appendix 1. The solutions to these particular problems are beyond the scope of this report.

Report No. 329

AAPM Task Group 329: Reference dose specification for dose calculations: dose-to-water or dose-to-muscle? (2019)

Executive Summary

In this report we provide guidance on the steps necessary to go from the linac absorbed dose-to-water calibration to dose-to-muscle in patient, for various commercial treatment planning system algorithms. If the treatment planning system does not account for the difference between dose-to-water and dose-to-muscle, then TPS reference dose scaling is warranted. We have tabulated the major vendors' TPS in terms of whether they approximate dose-to-muscle or calculate dose-to-water and recommend the correction factor required to report dose-to-muscle directly from the treatment planning system algorithm. Physicists should use this report to determine the applicable correction required for specifying the reference dose in their TPS to achieve this goal and should remain attentive to possible changes to their dose calculation algorithm in the future.

Report No. 182

Electronic Intracavitary Brachytherapy Quality Management based on Risk Analysis: The Report of AAPM TG 182 (2019)

Executive Summary

The task group used the risk-assessment approach of Task Group 100 of the American Association of Physicists in Medicine. Because the quality management program for a device is intimately tied to the procedure in which it is used, the task group first designed quality interventions for intracavitary brachytherapy for both commercial electronic brachytherapy units in the setting of accelerated partial-breast irradiation. To demonstrate the methodology to extend an existing risk-analysis for a different application, the task group modified the analysis for the case of post-hysterectomy, vaginal cuff irradiation for one of the devices. The analysis illustrated how the TG-100 methodology can lead to interventions to reduce risks and improve quality for each unit and procedure addressed. This report provides a model to guide facilities establishing a quality management program for electronic brachytherapy.

Report No. 157

Beam modeling and beam model commissioning for Monte Carlo dose calculation-based radiation therapy treatment planning: Report of AAPM Task Group 157 (2019)

Executive Summary

Dose calculation plays an important role in the accuracy of radiotherapy treatment planning and beam delivery. The Monte Carlo (MC) method is capable of achieving the highest accuracy in radiotherapy dose calculation and has been implemented in many commercial systems for radiotherapy treatment planning. The objective of this task group was to assist clinical physicists with the potentially complex task of acceptance testing and commissioning MC-based treatment planning systems (TPS) for photon and electron beam dose calculations. This report provides an overview on the general approach of clinical implementation and testing of MC-based TPS with a specific focus on models of clinical photon and electron beams. Different types of beam models are described including those that utilize MC simulation of the treatment head and those that rely on analytical methods and measurements. The tradeoff between accuracy and efficiency in the various source-modeling approaches is discussed together with guidelines for acceptance testing of MC-based TPS from the clinical standpoint. Specific recommendations are given on methods and practical procedures to commission clinical beam models for MC-based TPS.

Executive Summary

A rigorous and ongoing quality assurance (QA) program for dual-modality positron emission tomography/computed tomography (PET/CT) systems is recommended to include an initial evaluation of scanner performance to establish a baseline of measurements and then periodic assessment of system performance of the scanners on an annual, semi-annual, quarterly, weekly, and daily basis. Over the years, numerous agencies have published their recommendations for such an assessment, including the Society of Nuclear Medicine and Molecular Imaging (SNMMI), International Electrotechnical Commission (IEC), International Atomic Energy Agency (IAEA), American College of Radiology (ACR), and National Electrical Manufacturers Association (NEMA) [1–9]. Since the early 1990s, the most widely implemented and cited reference for testing these systems has been the NEMA Standards Publication NU 2–Standard Performance Measurements of Positron Emission Tomographs (PET) set forth by the Medical Imaging and Technology Alliance (MITA) division of NEMA. However, the NEMA NU 2 and other standards can be challenging to follow given their requirements for specialized software, equipment, and phantoms.

Report No. 191

AAPM TG 191 Clinical Use of Luminescent Dosimeters: TLDs and OSLDs (2019)

Executive Summary

Thermoluminescent dosimeters (TLD) and optically stimulated luminescent dosimeters (OSLD) are practical, accurate, and precise tools for point dosimetry in medical physics applications. The charges of Task Group 191 were to detail the methodologies for practical and optimal luminescence dosimetry in a clinical setting. This includes: (1) to review the variety of TLD/OSLD materials available, including features and limitations of each; (2) to outline the optimal steps to achieve accurate and precise dosimetry with luminescent detectors and to evaluate the uncertainty induced when less rigorous procedures are used; (3) to develop consensus guidelines on the optimal use of luminescent dosimeters for clinical practice; and (4) to develop guidelines for special medically relevant uses of TLDs/OSLDs such as mixed photon/neutron field dosimetry, particle beam dosimetry, and skin dosimetry. While this report provides general guidelines for TLD and OSLD processes, the report provides specific details for TLD-100 and nanoDotTM dosimeters because of their prevalence in clinical practice.

Report No. 246

Estimating Patient Organ Dose with Computed Tomography: A Review of Present Methodology and Required DICOM Information

Executive Summary

The purpose of this report is (1) to summarize the current state of the art in estimating organ doses from CT examinations and (2) to outline a road map for standardized reporting of essential parameters necessary for estimation of organ doses from CT imaging in the DICOM standard. To address these purposes, the report includes a comprehensive discussion of (1) the various metrics, concepts, and methods that may be used to achieve estimates of patient organ dose and (2) the DICOM standard for CT.

Report No. 174

Task Group 174 Report: Utilization of [18F] Fluorodeoxyglucose Positron Emission Tomography ([18F] FDG-PET) in Radiation Therapy (2019)

Executive Summary

The use of positron emission tomography (PET) in Radiation Therapy (RT) is rapidly increasing in the areas of staging, segmentation, treatment planning and response assessment. The most common radiotracer is 18F-fluorodeoxyglucose ([18F] FDG), a glucose analogue with demonstrated efficacy in cancer diagnosis and staging. However, diagnosis and RT planning are different endeavors with unique requirements, and very little literature is available for guiding physicists and clinicians in the utilization of [18F]FDG-PET in RT. The two goals of this report are to educate and provide recommendations. The report provides background and education on current PET imaging systems, PET tracers, intensity quantification, and current utilization in RT (staging, segmentation, image registration, treatment planning and therapy response assessment). Recommendations are provided on acceptance testing, annual and monthly quality assurance, scanning protocols to ensure consistency between inter-patient scans and intra-patient longitudinal scans, reporting of patient and scan parameters in literature, requirements for incorporation of [18F]FDG-PET in treatment planning systems, and image registration. The recommendations provided here are minimum requirements and are not meant to cover all aspects of the use of [18F] FDG-PET for RT.

Report No. 224

AAPM task group 224: comprehensive proton therapy machine quality assurance (2019)

Executive Summary

Task Group (TG) 224 was established by the American Association of Physicists in Medicine's Science Council under the Radiation Therapy Committee and Work Group on Particle Beams. The group was charged with developing comprehensive quality assurance (QA) guidelines and recommendations for the three commonly employed proton therapy techniques for beam delivery: scattering, uniform scanning, and pencil beam scanning. This report supplements established QA guidelines for therapy machine performance for other widely used modalities, such as photons and electrons (TG 142, TG 40, TG 24, TG 22, TG 179, and Medical Physics Practice Guideline 2a) and shares their aims of ensuring the safe, accurate, and consistent delivery of radiation therapy dose distributions to patients. To provide a basis from which machine-specific QA procedures can be developed, the report first describes the different delivery techniques and highlights the salient components of the related machine hardware. Depending on the particular machine hardware, certain procedures may be more or less important, and each institution should investigate its own situation.

Report No. 233

Performance Evaluation of Computed Tomography Systems - The Report of AAPM Task Group 233 (2019)

Executive Summary

This document aims to supplement and complement existing and prior equipment performance testing guidelines (e.g., AAPM Report 741) by addressing the more advanced aspects of current CT systems, such as IR and TCM. The goal of this report is to briefly summarize current performance evaluation metrics and quality control (QC) tests, and introduce advanced performance assessment methods within a single document.* Pass-fail criteria or performance guidelines are not provided for the results of these advanced assessment methods; there are no manufacturer specifications or regulatory or accreditation performance requirements available for these quantities. Rather, in line with the current professional trajectory of the field toward operational engagement, it is hoped that the assessment methods described in this report will be adopted by the clinical medical physicist for the purposes of protocol optimization, and for indicating clinical imaging performance in a way that can be compared between systems and imaging protocols. These important assessment methods also pave the way to approach performance testing of new CT systems, not only in terms of acceptance testing (i.e., verifying a device meets predefined specifications), but also for system commissioning (i.e., determining how the system can be used most effectively in clinical practice).

Report No. 177

Acceptance Testing and Annual Physics Survey Recommendations for Gamma Camera, SPECT, and SPECT/CT Systems (2019)

Executive Summary

This report makes recommendations for performing acceptance tests and annual physics surveys of gamma camera and SPECT systems. Recommendations are compiled from several documents and publications that define and describe methods for gamma camera testing and from the experience of many medical physicists working in the field of nuclear medicine. Recommendations for SPECT/CT are a new feature of this document. They are of limited scope to address issues of SPECT and CT spatial alignment and tests to assure a certain degree of attenuation correction accuracy and image quality.

Report No. 270

Display Quality Assurance (2019)

Executive Summary

The purpose of this task group report is to provide recommendations for the assessment of display quality for flat-panel displays used in medicine. This includes both LCDs and OLED displays used in the acquisition and review of medical images. The information provided in this report is intended to help design a QA program for flat-panel displays, as well as aid in purchasing decisions.

Report No. 248

Interoperability Assessment for the Commissioning of Medical Imaging Acquisition Systems (2019)

Executive Summary

The relatively straight-forward imaging chain of a film-based environment has given way to a more complex digital environment that stretches beyond the acquisition unit for processing, storage, and display. Each interface between devices and information systems provides an opportunity for communication errors which could affect the quality of the image or the accuracy of the associated patientencounter information. While the development of data and communication standards has allowed for greatly enhanced interoperability, there still remains complexity and variability that can create risk for patient image and information fidelity.

Report No. 180

Image Guidance Doses Delivered During Radiotherapy: Quantification, Management, and Reduction (2018)

Executive Summary

With radiotherapy having entered the era of image guidance, or image-guided radiation therapy (IGRT), imaging procedures are routinely performed for patient positioning and target localization. The imaging dose delivered may result in excessive dose to sensitive organs and potentially increase the chance of secondary cancers and, therefore, needs to be managed. This task group was charged with: a) providing an overview on imaging dose, including megavoltage electronic portal imaging (MV EPI), kilovoltage digital radiography (kV DR), Tomotherapy MV-CT, megavoltage cone-beam CT (MV-CBCT) and kilovoltage cone-beam CT (kV-CBCT), and b) providing general guidelines for commissioning dose calculation methods and managing imaging dose to patients. We briefly review the dose to radiotherapy (RT) patients resulting from different image guidance procedures and list typical organ doses resulting from MV and kV image acquisition procedures. We provide recommendations for managing the imaging dose, including different methods for its calculation, and techniques for reducing it. The recommended threshold beyond which imaging dose should be considered in the treatment planning process is 5% of the therapeutic target dose.

Report No. 113

Guidance for the Physics Aspects of Clinical Trials (2018)

Executive Summary

The charge of AAPM Task Group 113 is to provide guidance for the physics aspects of clinical trials to minimize variability in planning and dose delivery for external beam trials involving photons and electrons. Several studies have demonstrated the importance of protocol compliance on patient outcome. Minimizing variability for treatments at different centers improves the quality and efficiency of clinical trials. Attention is focused on areas where variability can be minimized through standardization of protocols and processes through all aspects of clinical trials. Recommendations are presented for clinical trial designers, physicists supporting clinical trials at their individual clinics, quality assurance centers, and manufacturers.

Report No. 268

RECORDS: improved reporting of montE CarlO RaDiation transport Studies: Report of the AAPM Research Committee Task Group 268 (2017)

Executive Summary

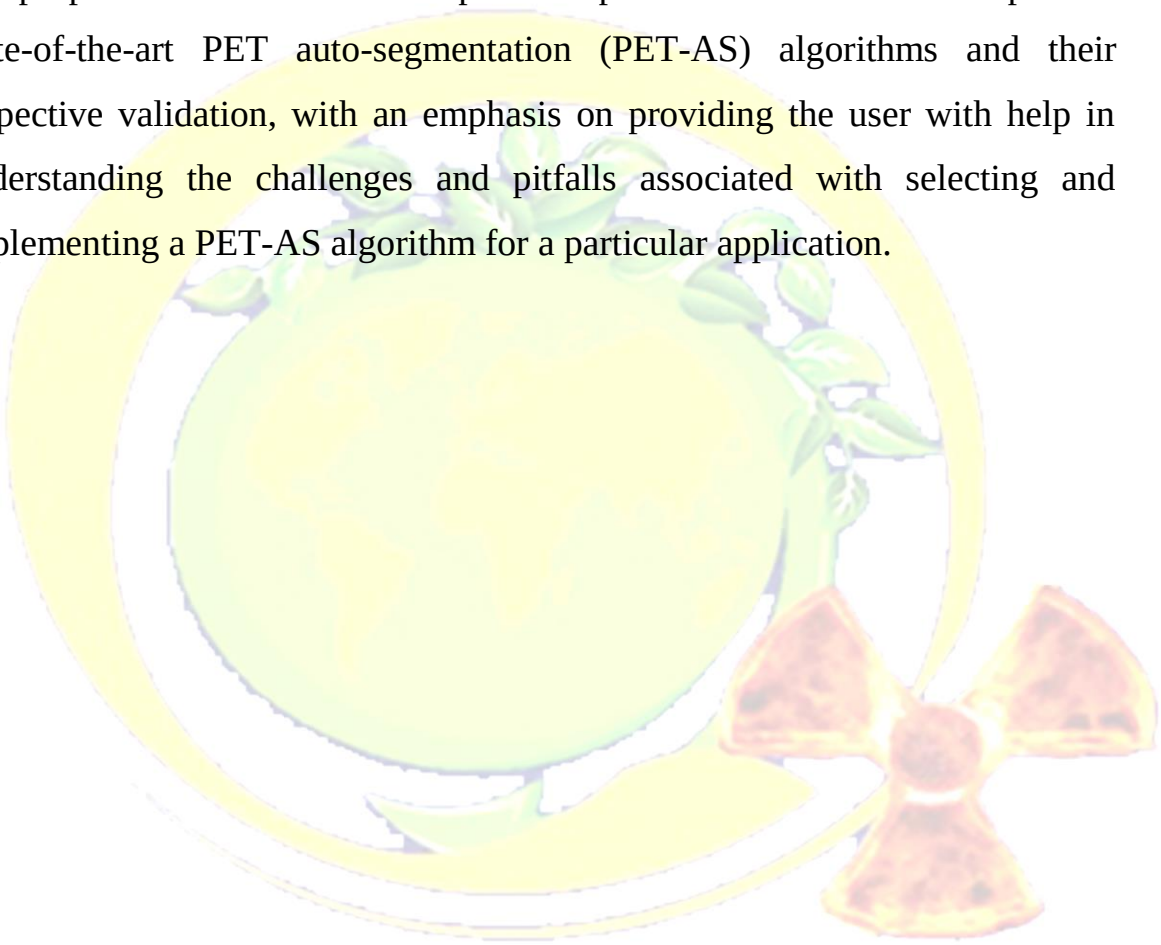
Studies involving Monte Carlo simulations are common in both diagnostic and therapy medical physics research, as well as other fields of basic and applied science. As with all experimental studies, the conditions and parameters used for Monte Carlo simulations impact their scope, validity, limitations, and generalizability. Unfortunately, many published peer-reviewed articles involving Monte Carlo simulations do not provide the level of detail needed for the reader to be able to properly assess the quality of the simulations. The American Association of Physicists in Medicine Task Group #268 developed guidelines to improve reporting of Monte Carlo studies in medical physics research. By following these guidelines, manuscripts submitted for peer-review will include a level of relevant detail that will increase the transparency, the ability to reproduce results, and the overall scientific value of these studies. The guidelines include a checklist of the items that should be included in the Methods, Results, and Discussion sections of manuscripts submitted for peer-review. These guidelines do not attempt to replace the journal reviewer, but rather to be a tool during the writing and review process. Given the varied nature of Monte Carlo studies, it is up to the authors and the reviewers to use this checklist appropriately, being conscious of how the different items apply to each particular scenario.

Report No. 211

Classification and evaluation strategies of auto-segmentation approaches for PET: Report of AAPM task group No. 211 (2017)

Executive Summary

The purpose of this educational report is to provide an overview of the present state-of-the-art PET auto-segmentation (PET-AS) algorithms and their respective validation, with an emphasis on providing the user with help in understanding the challenges and pitfalls associated with selecting and implementing a PET-AS algorithm for a particular application.



Report No. 158

AAPM TG 158: Measurement and calculation of doses outside the treated volume from external-beam radiation therapy (2017)

Executive Summary

Task Group 158 was therefore formed to provide guidance for physicists in terms of assessing and managing non-target doses. In particular the report: (1) highlights major concerns with non-target radiation, (2) provides a rough estimate of doses associated with different treatment approaches in clinical practice, (3) discusses the uses of dosimeters for measuring photon, electron, and neutron doses, (4) discusses the use of calculation techniques for dosimetric evaluations, (5) highlights techniques that may be considered for reducing non-target doses, (6) discusses dose reporting, and (7) makes recommendations for both clinical and research practice.

Report No. 132

Use of image registration and fusion algorithms and techniques in radiotherapy: Report of the AAPM Radiation Therapy Committee Task Group No. 132 (2017)

Executive Summary

Image registration and fusion algorithms exist in almost every software system that creates or uses images in radiotherapy. Most treatment planning systems support some form of image registration and fusion to allow the use of multimodality and time-series image data and even anatomical atlases to assist in target volume and normal tissue delineation. Treatment delivery systems perform registration and fusion between the planning images and the in-room images acquired during the treatment to assist patient positioning. Advanced applications are beginning to support daily dose assessment and enable adaptive radiotherapy using image registration and fusion to propagate contours and accumulate dose between image data taken over the course of therapy to provide up-to-date estimates of anatomical changes and delivered dose. This information aids in the detection of anatomical and functional changes that might elicit changes in the treatment plan or prescription. As the output of the image registration process is always used as the input of another process for planning or delivery, it is important to understand and communicate the uncertainty associated with the software in general and the result of a specific registration. Unfortunately, there is no standard mathematical formalism to perform this for real-world situations where noise, distortion, and complex anatomical variations can occur. Validation of the software systems performance is also complicated by the lack of documentation available from commercial systems leading to use of these systems in undesirable 'black-box' fashion. In view of this situation and the central role that image registration and fusion play in treatment planning and delivery, the Therapy Physics Committee of the American Association of Physicists in Medicine commissioned Task Group 132 to review current approaches and solutions for image registration (both rigid and deformable) in radiotherapy and to provide recommendations for quality assurance and quality control of these clinical processes.

Report No. 175

Acceptance Testing and Quality Control of Dental Imaging Equipment (2016)

Executive Summary

It is important to properly perform tests for image quality and safety purposes right after the installation and during routine operation of a dental x-ray unit. Having a quality control (QC) program for dental x-ray facilities is instrumental in ensuring that patients are not receiving excessive radiation during their examination. A QC program also ensures that the dental x-ray imaging equipment is working properly, as exemplified by scientific and technical testing to confirm that the machine is performing as per manufacturer's specification and regulatory requirements. Recommendations for specific parameter evaluations and practical procedures for quality control evaluations of dental imaging equipment are described in this document. Section 2 of this report provides image receptor recommendations for intraoral dental units. Sections 3, 4, and 5 provide information for the evaluation of intraoral, panoramic, and cephalometric dental units, respectively. In addition, all methods mentioned in this report are intended to provide guidance on how to perform these medical physics tests, but they are not intended to be the sole methods for performing any particular evaluation. While cone-beam CT (CBCT) has become common in the offices of many dental specialists, this modality falls outside the scope of this task group report. Another AAPM task group (TG-261) will be addressing CBCT for dental and maxillofacial imaging, and their report should be forthcoming.

Report No. 283

The report of Task Group 100 of the AAPM: Application of risk analysis methods to radiation therapy quality management (2016)

Executive Summary

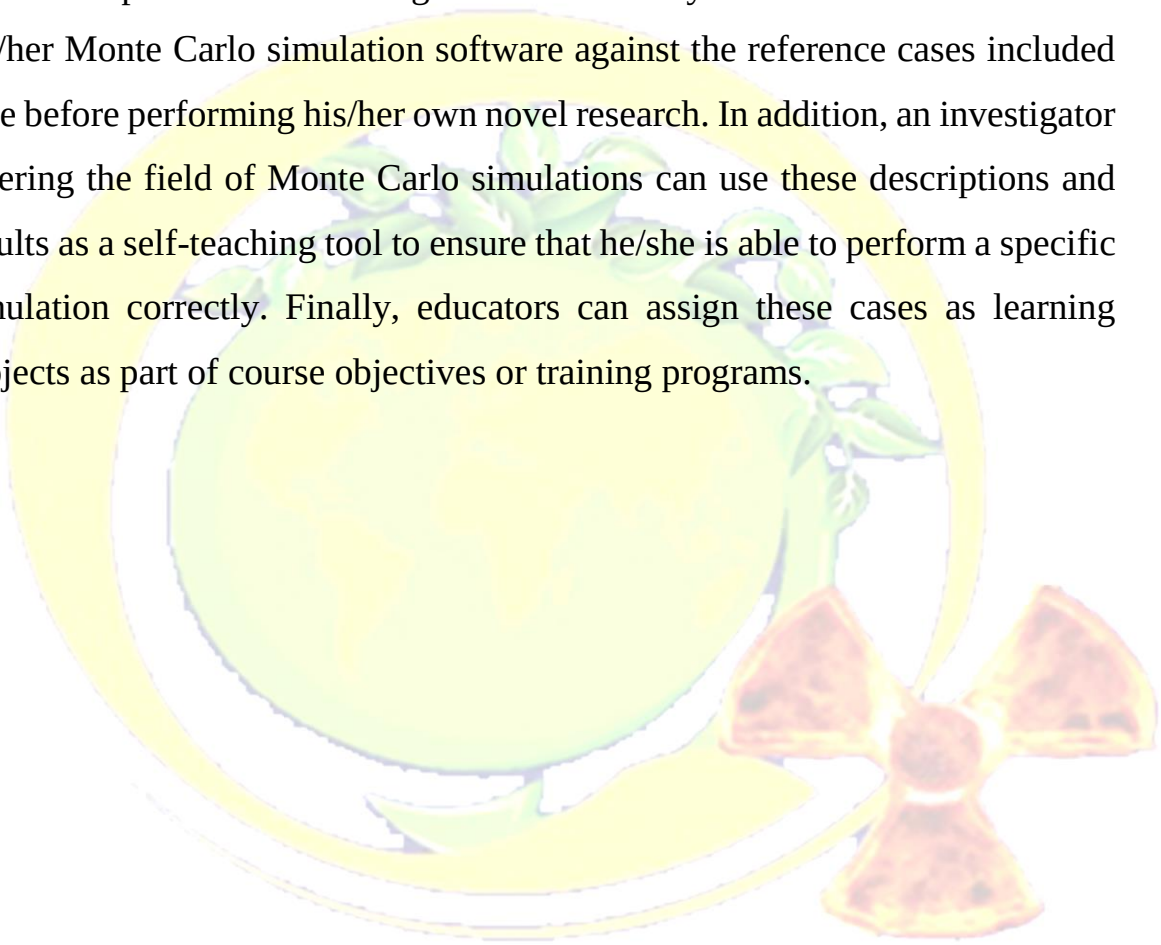
The goal of this work is to apply modern risk-based analysis techniques to this complex RT process in order to demonstrate to the RT community that such techniques may help identify more effective and efficient ways to enhance the safety and quality of our treatment processes. The task group generated by consensus an example quality management program strategy for the IMRT process performed at the institution of one of the authors. This report describes the methodology and nomenclature developed, presents the process maps, FMEAs, fault trees, and QM programs developed, and makes suggestions on how this information could be used in the clinic. The development and implementation of risk-assessment techniques will make radiation therapy safer and more efficient.

Report No. 195

Monte Carlo Reference Data Sets for Imaging Research: The Report of AAPM Task Group 195 (2015)

Executive Summary

This work provides an investigator the necessary information to benchmark his/her Monte Carlo simulation software against the reference cases included here before performing his/her own novel research. In addition, an investigator entering the field of Monte Carlo simulations can use these descriptions and results as a self-teaching tool to ensure that he/she is able to perform a specific simulation correctly. Finally, educators can assign these cases as learning projects as part of course objectives or training programs.



Report No. 190

Accuracy and calibration of integrated radiation output indicators in diagnostic radiology: A report of the AAPM Imaging Physics Committee Task Group 190 Medical Physics, Vol 42,

Executive Summary

Due to the proliferation of disciplines employing fluoroscopy as their primary imaging tool and the prolonged extensive use of fluoroscopy in interventional and cardiovascular angiography procedures, “dose-area-product” (DAP) meters were installed to monitor and record the radiation dose delivered to patients. In some cases, the radiation dose or the output value is calculated, rather than measured, using the pertinent radiological parameters and geometrical information. The AAPM Task Group 190 (TG-190) was established to evaluate the accuracy of the DAP meter in 2008. Since then, the term “DAP-meter” has been revised to air kerma-area product (KAP) meter. The charge of TG 190 (Accuracy and Calibration of Integrated Radiation Output Indicators in Diagnostic Radiology) has also been realigned to investigate the “Accuracy and Calibration of Integrated Radiation Output Indicators” which is reflected in the title of the task group, to include situations where the KAP may be acquired with or without the presence of a physical “meter.” To accomplish this goal, validation test protocols were developed to compare the displayed radiation output value to an external measurement. These test protocols were applied to a number of clinical systems to collect information on the accuracy of dose display values in the field

Report No. 118

Parallel Imaging in MRI: Technology, Applications, and Quality Control (2015)

Executive Summary

The field of magnetic resonance imaging has been undergoing a transformation during the past decade, with a growing emphasis on characterizing disease using imaging metrics of more direct physiological relevance, i.e., quantitative imaging biomarkers. As a result, the complexity of clinical magnetic resonance imaging techniques and the availability of new image sequences have increased dramatically in search of these biomarkers. Two critical challenges have emerged during this transformation: 1) how does the clinic acquire increased amounts of imaging data within a clinically reasonable amount of time? and 2) how does the physician assess this increased volume of data in a time-efficient manner? To address the first challenge, parallel imaging (pMRI) was developed as a class of image acquisition and reconstruction schemes that serves to increase the amount of imaging data acquired within a given time. While the use of pMRI is becoming widespread clinically, the complexity of the technique can lead to corrupted, nondiagnostic images if not utilized properly. This document is the report from Task Group 118, formed in order to help educate the medical physicist about the technique of pMRI, and about how this technique can affect image characteristics. Important topics that are addressed within this document are clinical uses of pMRI, artifacts, and properties of phased-array coils (which are strictly required in pMRI). This report also enumerates and describes specific quality assurance concerns that arise with the use of pMRI, although a comprehensive treatment of pMRI-based QA procedures is beyond the scope of this report.

Report No. 151

Ongoing Quality Control in Digital Radiography: The Report of AAPM Imaging Physics Committee Task Group 151 (2015)

Executive Summary

Quality control (QC) in medical imaging is an ongoing process and not just a series of infrequent evaluations of medical imaging equipment. The QC process involves designing and implementing a QC program, collecting and analyzing data, investigating results that are outside the acceptance levels for the QC program, and taking corrective action to bring these results back to an acceptable level. The QC process involves key personnel in the imaging department, including the radiologist, radiologic technologist, and the qualified medical physicist (QMP). The QMP performs detailed equipment evaluations and helps with oversight of the QC program, the radiologic technologist is responsible for the day-to-day operation of the QC program. The continued need for ongoing QC in digital radiography has been highlighted in the scientific literature. The charge of this task group was to recommend consistency tests designed to be performed by a medical physicist or a radiologic technologist under the direction of a medical physicist to identify problems with an imaging system that need further evaluation by a medical physicist, including a fault tree to define actions that need to be taken when certain fault conditions are identified. The focus of this final report is the ongoing QC process, including rejected image analysis, exposure analysis, and artifact identification. These QC tasks are vital for the optimal operation of a department performing digital radiography.

Report No. 258

Monitor unit calculations for external photon and electron beams: Report of the AAPM Therapy Physics Committee Task Group No. 71 (2014)

Executive Summary

A protocol is presented for the calculation of monitor units (MU) for photon and electron beams, delivered with and without beam modifiers, for constant source-surface distance (SSD) and source-axis distance (SAD) setups. This protocol was written by Task Group 71 of the Therapy Physics Committee of the American Association of Physicists in Medicine (AAPM) and has been formally approved by the AAPM for clinical use. The protocol defines the nomenclature for the dosimetric quantities used in these calculations, along with instructions for their determination and measurement. Calculations are made using the dose per MU under normalization conditions, D'0D0' , that is determined for each user's photon and electron beams. Forelectron beams, the depth of normalization is taken to be the depth of maximum dose along the central axis for the same field incident on a water phantom at the same SSD, where D'0D0' = 1 cGy/MU. For photonbeams, this task group recommends that a normalization depth of 10 cm be selected, where an energy-dependent D'0D0' = 1 cGy/MU is required. This recommendation differs from the more common approach of a normalization depth of d m , with D'0D0' = 1 cGy/MU, although both systems are acceptable within the current protocol. For photon beams, the formalism includes the use of blocked fields, physical or dynamic wedges, and (static) multileaf collimation. No formalism is provided for intensity modulated radiation therapycalculations, although some general considerations and a review of current calculation techniques are included. For electron beams, the formalism provides for calculations at the standard and extended SSDs using either an effective SSD or an air-gap correction factor. Example tables and problems are included to illustrate the basic concepts within the presented formalism.

Report No. 220

Use of Water Equivalent Diameter for Calculating Patient Size and Size-Specific Dose Estimates (SSDE) in CT (2014)

Executive Summary

This report is organized as follows. First, the concept of water equivalent diameter (Dw) is presented, and the methodology of calculating it from either a CT image or a CT localizer radiograph image is described. Second, data are provided comparing the accuracy of Monte Carlo dose estimates made using geometrical-based versus attenuation-based metrics for a series of virtual abdomen and thorax phantoms and their respective virtual CT images, and for patient images. Third, data are pro- vided comparing Dw calculations from CT image and CT localizer radiograph phantom measurements. Fourth, practical considerations involved in implementing either approach are discussed, and recommendations for users and for manufacturers are provided. Finally, a road map for commercial adoption is suggested such that both patient size and SSDE can be calculated in a robust and consistent fashion across CT scanner manufacturers, and the resultant values stored in either the DICOM image header or the DICOM-structured dose report.

Report No. 176

Dosimetric effects caused by couch tops and immobilization devices: Report of AAPM Task Group 176 (2014)

Executive Summary

This report of Task Group 176 serves to present a survey of published data that illustrates the magnitude of the dosimetric effects of a wide range of devices external to the patient. The report also provides methods for modeling couch tops in treatment planning systems so the physicist can accurately compute the dosimetric effects for indexed patient treatments. Both photon and proton beams are considered. A discussion on avoid- ance of high density structures during beam planning is also provided. An important aspect of this report are the recommendations the authors make to clinical physicists, treatment planning system vendors, and device vendors on how to make measurements of surface dose and attenuation and how to report these values. For the vendors, an appeal is made to work together to provide accu- rate couch top models in planning systems.

Report No. 255

An introduction to molecular imaging in radiation oncology: A report by the AAPM Working Group on Molecular Imaging in Radiation Oncology (WGMIR) (2013)

Executive Summary

Molecular imaging is the direct or indirect noninvasive monitoring and recording of the spatial and temporal distribution of in vivo molecular, genetic, and/or cellular processes for biochemical, biological, diagnostic, or therapeutic applications. Molecular images that indicate the presence of malignancy can be acquired using optical, ultrasonic, radiologic, radionuclide, and magnetic resonance techniques. For the radiation oncologyphysicist in particular, these methods and their roles in molecular imaging of oncologic processes are reviewed with respect to their physical bases and imaging characteristics, including signal intensity, spatial scale, and spatial resolution. Relevant molecular terminology is defined as an educational assist. Current and future clinical applications in oncologic diagnosis and treatment are discussed. National initiatives for the development of basic science and clinical molecular imaging techniques and expertise are reviewed, illustrating research opportunities in as well as the importance of this growing field.

Report No. 217

Radiation Dose from Airport Scanners (2013)

Executive Summary

This work represents an independent study by the American Association of Physicists in Medicine (AAPM) of the x-ray backscatter systems used by the Transportation Security Administration (TSA) for screening airport passengers, the Rapiscan Secure 1000 SP. Exposure output measurements were made across multiple scanners in both the factory and in real-time use in an airport setting. From these exposure measurements, effective and organ dose calcula- tions were performed for several passenger sizes. The average corrected air kerma measurement across the systems evaluated was 0.046 μGy (for each master or slave unit which together com- prise a scanner). For a standard man of 178.6 cm (5'10") tall and 73.2 kg (161.4 pounds), the effective dose from a single-pose, two-sided scan was determined to be 11.1 nSv (nSv = 10–9Sv) and the skin dose to be 40.4 nGy (nGy = 10–9 Gy). This effective dose is equivalent to 1.8 min- utes of background dose received by the average individual in the U.S. in 2006 and is approxi- mately equivalent to 12 seconds of naturally occurring dose during an average flight.

Report No. 229

Dose Calculation for Photon-Emitting Brachytherapy Sources with Average Energy Higher than 50 keV: Full Report of the AAPM and ESTRO (2012)

Executive Summary

Recommendations of the American Association of Physicists in Medicine (AAPM) and the European Society for Radiotherapy and Oncology (ESTRO) on dose calculations for high-energy (average energy higher than 50 keV) photon-emitting brachytherapy sources are presented, including the physical characteristics of specific 192Ir, 137Cs, and 60Co source models.

Report No. 186

Report of the Task Group 186 on model-based dose calculation methods in brachytherapy beyond the TG-43 formalism: Current status and recommendations for clinical implementation (2012)

Executive Summary

The charge of Task Group 186 (TG-186) is to provide guidance for early adopters of model-based dose calculation algorithms (MBDCAs) for brachytherapy (BT) dose calculations to ensure practice uniformity. Contrary to external beam radiotherapy, heterogeneity correction algorithms have only recently been made available to the BT community. Yet, BT dose calculation accuracy is highly dependent on scatter conditions and photoelectric effect cross-sections relative to water. In specific situations, differences between the current water-based BT dose calculation formalism (TG-43) and MBDCAs can lead to differences in calculated doses exceeding a factor of 10.

Report No. 181

The Selection, Use, Calibration, and Quality Assurance of Radionuclide Calibrators Used in Nuclear Medicine (2012)

Executive Summary

To develop guidance on the selection, use, calibration, and quality control of radionuclide calibrators for use in nuclear medicine. The calibrators addressed are pressurized, well-type, ionization chamber radionuclide calibrators for measuring the activity of x- and gamma-ray emitting radionuclides, positron emitters, and medium to high-energy beta emitters.

Report No. 179

Quality assurance for image-guided radiation therapy utilizing CT-based technologies: A report of the AAPM TG-179 (2012)

Executive Summary

Commercial CT-based image-guided radiotherapy (IGRT) systems allow widespread management of geometric variations in patient setup and internal organ motion. This document provides consensus recommendations for quality assurance protocols that ensure patient safety and patient treatment fidelity for such systems.

Report No. 166

The Use and QA of Biologically Related Models for Treatment Planning (2012)

Executive Summary

Treatment planning tools that use biologically related models for plan optimization and/or eval- uation are being introduced for clinical use. A variety of dose response models and quantities along with a series of organ-specific model parameters are included in these tools. However, due to various limitations, such as the limitations of models and available model parameters, the incomplete understanding of dose responses, and the inadequate clinical data, the use of a bio- logically based treatment planning system (BBTPS) represents a paradigm shift and can be potentially dangerous. There will be a steep learning curve for most planners. The purpose of this task group (TG) is to address some of these relevant issues before the use of BBTPS becomes widely spread. In this report, we (1) review the biologically related models including both used and potentially to be used in treatment planning process; (2) discuss strategies, limi- tations, conditions, and cautions for using biologically based models and parameters in clinical treatment planning; (3) demonstrate the practical use of the three commercially available BBTPSs and potential dosimetric differences between biologically model–based and dose-volume (DV)–based treatment plan optimization and evaluation; (4) identify the desirable features and future directions in developing BBTPS; and (5) provide general guidelines and methodology for the acceptance testing, commissioning, and routine quality assurance (QA) of BBTPS.

Report No. 147

Quality assurance for nonradiographic radiotherapy localization and positioning systems: Report of Task Group 147 (2012)

Executive Summary

New technologies continue to be developed to improve the practice of radiation therapy. As several of these technologies have been implemented clinically, the Therapy Committee and the Quality Assurance and Outcomes Improvement Subcommittee of the American Association of Physicists in Medicine commissioned Task Group 147 to review the current nonradiographic technologies used for localization and tracking in radiotherapy. The specific charge of this task group was to make recommendations about the use of nonradiographic methods of localization, specifically; radiofre- quency, infrared, laser, and video based patient localization and monitoring systems. The charge of this task group was to review the current use of these technologies and to write quality assurance guidelines for the use of these technologies in the clinical setting. Recommendations include testing of equipment for initial installation as well as ongoing quality assurance. As the equipment included in this task group continues to evolve, both in the type and sophistication of technology and in level of integration with treatment devices, some of the details of how one would conduct such testing will also continue to evolve.

Report No. 204

Size-Specific Dose Estimates (SSDE) in Pediatric and Adult Body CT Examinations (2011)

Executive Summary

This task group was charged with developing conversion factors that can be applied to the displayed CTDIvol dose index to allow practitioners to be able to estimate patient dose. These factors take into account patient size, and hence are especially important for pediatric CT or when small adults are scanned. The work presented here was specifically motivated by the needs of the Alliance (Strauss 2009), but also reflects ongoing, independent research performed by a number of research groups around the United States. The scope of this task group is limited to estimating patient dose using scanner output (CTDIvol) and factors associated with patient size. Other differences between the current CT scanner radiation output indices and patient dose estimates due to the use of "short" phantoms (15 cm along the z-axis) for CTDIvol measurements (Dixon 2003, 2006; Boone 2007) are not addressed by this task group.

Report No. 138

A dosimetric uncertainty analysis for photon-emitting brachytherapy sources: Report of AAPM Task Group No. 138 and GEC-ESTRO (2011)

Executive Summary

This report addresses uncertainties pertaining to brachytherapy single-source dosimetry preceding clinical use. The International Organization for Standardization (ISO) Guide to the Expression of Uncertainty in Measurement (GUM) and the National Institute of Standards and Technology (NIST) Technical Note 1297 are taken as reference standards for uncertainty formalism. Uncertainties in using detectors to measure or utilizing Monte Carlo methods to estimate brachytherapy dose distributions are provided with discussion of the components intrinsic to the overall dosimetric assessment. Uncertainties provided are based on published observations and cited when available. The uncertainty propagation from the primary calibration standard through transfer to the clinic for air-kerma strength is covered first. Uncertainties in each of the brachytherapy dosimetry parameters of the TG-43 formalism are then explored, ending with transfer to the clinic and recommended approaches. Dosimetric uncertainties during treatment delivery are considered briefly but are not included in the detailed analysis.

Report No. 135

Report of AAPM TG 135: Quality assurance for robotic radiosurgery (2011)

Executive Summary

The task group (TG) for quality assurance for robotic radiosurgery was formed by the American Association of Physicists in Medicine's Science Council under the direction of the Radiation Ther- apy Committee and the Quality Assurance (QA) Subcommittee. The task group (TG-135) had three main charges: (1) To make recommendations on a code of practice for Robotic Radiosurgery QA; (2) To make recommendations on quality assurance and dosimetric verification techniques, especially in regard to real-time respiratory motion tracking software; (3) To make recommendations on issues which require further research and development. This report provides a general functional overview of the only clinically implemented robotic radiosurgery device, the CyberKnifeVR . This report includes sections on device components and their individual component QA recommendations, followed by a section on the QA requirements for integrated systems. Examples of checklists for daily, monthly, annual, and upgrade QA are given as guidance for medical physicists. Areas in which QA procedures are still under development are discussed.

Report No. 120

Dosimetry tools and techniques for IMRT (2011)

Executive Summary

This report is not intended to provide a comprehensive review of commissioning and QA procedures for IMRT. Instead, this report focuses on the aspects of metrology, particularly the practical aspects of measurements that are unique to IMRT. The metrology of IMRT concerns the application of measurement instruments and their suitability, calibration, and quality control of measurements. Each of the dosimetry measurement tools has limitations that need to be considered when incorporating them into a commissioning process or a comprehensive QA program. For example, routine quality assurance procedures require the use of robust field dosimetry systems. These often exhibit limitations with respect to spatial resolution or energy response and need to themselves be commissioned against more established dosimeters. A chain of dosimeters, from secondary standards to field instruments, is established to assure the quantitative nature of the tests. This report is intended to describe the characteristics of the components of these systems; dosimeters, phantoms, and dose evaluation algorithms. This work is the report of AAPM Task Group 120.

Report No. 114

Verification of monitor unit calculations for non-IMRT clinical radiotherapy: Report of AAPM Task Group 114 (2011)

Executive Summary

This report addresses the following charges of the task group: (1) To re-evaluate the purpose and methods of the "independent second check" for monitor unit calculations for non-IMRT radiation treatment in light of the complexities of modern- day treatment planning. (2) To present recommendations on how to perform verification of monitor unit calculations in a modern clinic. (3) To provide recommendations on establishing action levels for agreement between primary calculations and verification, and to provide guidance in addressing discrepancies outside the action levels. These recommendations are to be used as guidelines only and shall not be interpreted as requirements.

Report No. 160

Radiation Safety Officer Qualifications for Medical Facilities: Report of Task Group 160 (2010)

Executive Summary

The purpose of the Task Group is to develop a document that addresses the role of a Radiation Safety Officer (RSO) in the Radiation Protection Program (RPP) of a medical facility. The document includes a discussion of the authority, responsibility, and duties of the RSO and the radiation safety responsibilities of other members of the facility's "radiation safety team" from facility management to the supervised individuals who work directly with the ionizing radiations.

The regulatory training and experience requirements for an individual to function as the RSO are summarized and guidance is provided to assist facilities man- agement when adding an individual as an RSO on a license. The document discusses RSO qualifications based on facility size and the scope and complexity of ionizing radiation use and the role of medical physicists and other medical professionals as an RSO.

Report No. 148

QA for helical tomotherapy: Report of the AAPM Task Group 148 (2010)

Executive Summary

Helical tomotherapy is a relatively new modality with integrated treatment planning and delivery hardware for radiation therapy treatments. In view of the uniqueness of the hardware design of the helical tomotherapy unit and its implications in routine quality assurance, the Therapy Physics Committee of the American Association of Physicists in Medicine commissioned Task Group 148 to review this modality and make recommendations for quality assurance related methodologies. The specific objectives of this Task Group are: (a) To discuss quality assurance techniques, frequencies, and tolerances and (b) discuss dosimetric verification techniques applicable to this unit. This report summarizes the findings of the Task Group and aims to provide the practicing clinical medical physicist with the insight into the technology that is necessary to establish an independent and comprehensive quality assurance program for a helical tomotherapy unit. The emphasis of the report is to describe the rationale for the proposed QA program and to provide example tests that can be performed, drawing from the collective experience of the task group members and the published literature. It is expected that as technology continues to evolve, so will the test procedures that may be used in the future to perform comprehensive quality assurance for helical tomotherapy units.

Report No. 121

Off-label use of medical products in radiation therapy (2010)

Executive Summary

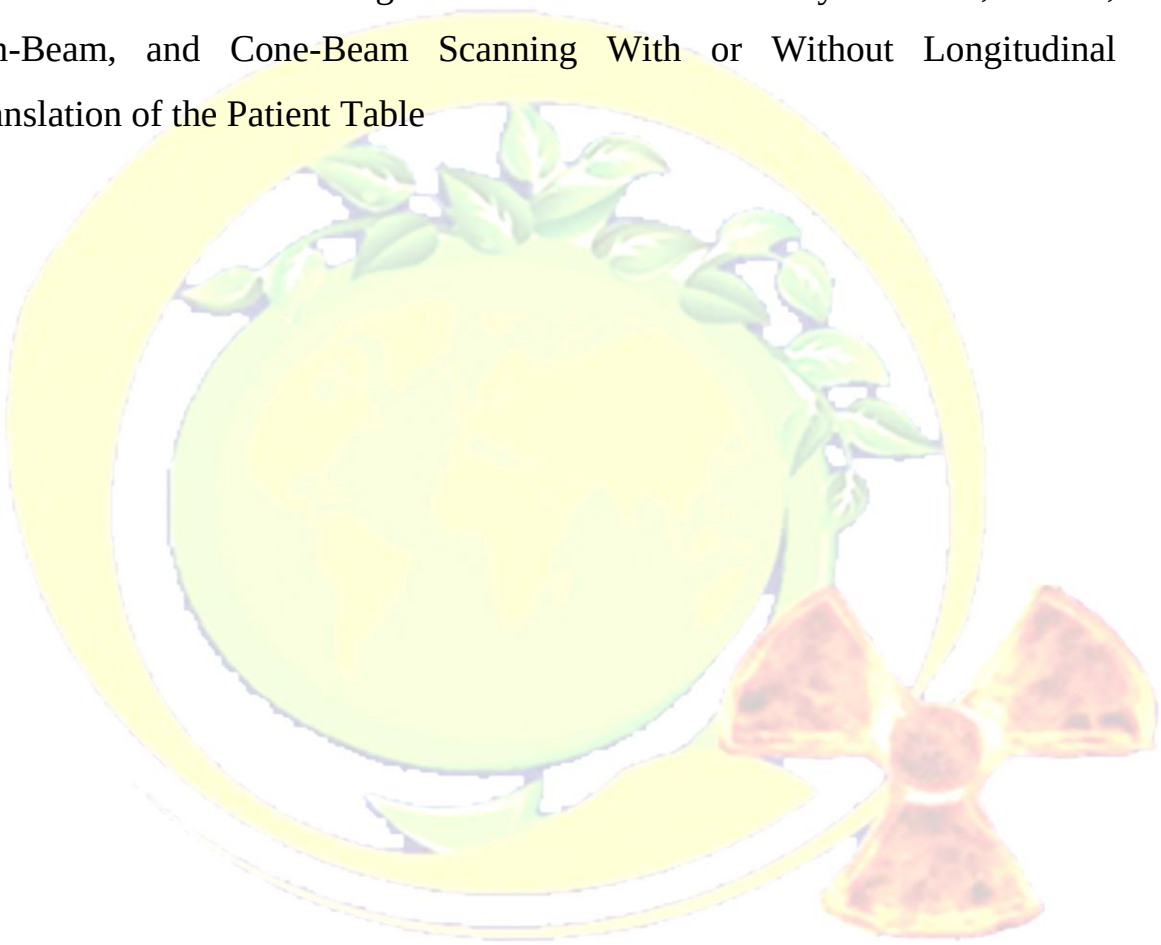
This report summarizes the various ways medical products, primarily medical devices, can legally be brought to market in the United States and includes a discussion of the approval process, along with manufacturers' responsibilities, labeling, marketing and promotion, and off- label use. This is an educational and descriptive report, and does not contain prescriptive recommendations. This report also addresses the role of the medical physicist in clinical situations involving off-label use. Case studies in radiation therapy are presented. Any mention of com- mercial products is for identification only; it does not imply recommendations or endorsements by any of the authors or the AAPM.

Report No. 111

Comprehensive Methodology for the Evaluation of Radiation Dose in X-Ray Computed Tomography (2010)

Executive Summary

A New Measurement Paradigm Based on a Unified Theory for Axial, Helical, Fan-Beam, and Cone-Beam Scanning With or Without Longitudinal Translation of the Patient Table



Report No. 101

Stereotactic body radiation therapy: The report of AAPM Task Group 101 (2010)

Executive Summary

Task Group 101 of the AAPM has prepared this report for medical physicists, clinicians, and therapists in order to outline the best practice guidelines for the external-beam radiation therapy technique referred to as stereotactic body radiation therapy (SBRT). The task group report includes a review of the literature to identify reported clinical findings and expected outcomes for this treatment modality. Information is provided for establishing a SBRT program, including protocols, equipment, resources, and QA procedures. Additionally, suggestions for developing consistent documentation for prescribing, reporting, and recording SBRT treatment delivery is provided.

Report No. 100

Acceptance Testing and Quality Assurance Procedures for Magnetic Resonance Imaging Facilities (2010)

Executive Summary

This document was prepared to assist the medical physicist in defining an acceptance test strategy and quality assurance procedures for magnetic resonance imaging (MRI) facilities. Due to the wide variety of MRI systems available, with an equally wide range of options on each type of system, this document does not seek to provide a definitive guideline for development of such procedures. Instead, the goal of this document is to provide suggestions for relevant, practical tests that qualified medical physicists can perform independently or with the assistance of the magnetic resonance (MR) system vendor's service personnel. The docu- ment outlines a recommended general testing strategy, overviews phantom availability/ preparation issues, and then lists individual tests, each with a rationale for performing the test, a suggested procedure, and, where appropriate, suggested acceptance criteria. In some cases, alternative procedures are also provided.