Ultrasound basic principles

Professor Christian CACHARD

Creatis, Université Claude Bernard Lyon 1, France

Abstract:

Ultrasound has become common practice in medicine in the 70's and has the last ten years been the fastest growing imaging modality for non-invasive medical diagnosis. Its current importance can be judged by the fact, of all the various kinds of diagnostic produced in the world, one of four is an ultrasound scan. Reasons for this are the ability to image soft tissue and blood flow, the real time imaging capabilities, the harmlessness for the patient and the physician and the low cost of the equipment. In addition there are no special building requirements as for X-ray, Nuclear, and Magnetic Resonance imaging. Limitations are that ultrasound imaging cannot be done through bone or air, setting limitations on chest and abdominal imaging.

Ultrasound energy is exactly like sound energy, it is a variation in the pressure within a medium. Medical diagnostic ultrasound usually operates in the range 2-10 MHz for transcutaneous measurements, but frequencies up to 40 MHz are used intraoperatively and with intra-arterial imaging with ultrasound catheters.

The pulse-echo method relies on the partial reflection of a short burst of ultrasound (the pulse) by tissues. The same probe is used to transmit the pulse and to receive the echoes. The amplitude of the back-scattered echoes was first used to identify organ structures along a fixed beam direction using the A-mode display. A 2D image of tissue structures is obtained by a controlled swept of the beam in a plane. The B-mode displays the amplitude of the echoes coded with a grey scale. With the moving structures of the heart, the M-mode is used to display the time variation of the structure position along a fixed beam direction.

When the scatterer is moving, the back-scattered signal will also have a change in frequency in accordance with the Doppler effect. This can be used for the measurement of the velocity of moving targets, for example the blood.

This presentation describes the generation, the transmission and interactions of ultrasound which explain its use in medical applications.

Ultrasound imaging

Professor Christian CACHARD

Creatis, Université Claude Bernard Lyon 1, France

Abstract:

Pulse echo imaging techniques are based on the representation of the amplitude on the basis of the delay of an ultrasound signal reflected by a medium to represent its structure.
In order to deal with the requirements of the different domains of application, there are variants in the use of this signal to create a set of modes of ultrasound imaging which are made available to the doctor. The modes of imaging commonly used for echography are: B-mode, M-mode, harmonic mode and pulse inversion mode.
B-mode imaging and second harmonic imaging use the transmission of a single pulse. To deal with the compromise between harmonic detection and resolution in conventional harmonic imaging, or discrimination between the zones perfused with contrast agent from un-perfused tissues, various multi-pulse techniques have been developed. The transmission sequences comprise multiple transmission pulses with different parameters: frequency, amplitude, phase, duration, number and repetition frequency. The received signals are processed with a view to reinforcing these characteristics, by weighted summing or filtering.
All these imaging modes will be introduced and their performance will be compared.

Ionizing radiations in Radiotherapy

Uarda Gjoka

University Hospital Centre "Mother Teresa", Tirana, Albania

Abstract

Ionizing radiations play an important role in tumor treatment. In this talk we will discuss different ionization radiations and their biological effects. Some radiations are more efficient than others in medical applications, depending on clinical needs. We explain the current use of radiotherapy at our hospital clinic, including X-ray, use of radioactive materials, as well as the linear accelerator, which has just been put in use recently. Special attention is being paid to optimization of treatment, depending on the characteristics of the tumor which is being treated. It is difficult, but also very important to find a midway between treating the disease and minimizing the undesired effects. For this techniques such as hypo- and hyperfractioning are being used. Depending on the characteristics of the tumor, one or the other might be optimal, and we are on the way of optimizing dosages, to obtain the best results for our patients.

Keywords: ionization radiation, radiotherapy, linac, dosage fractioning.

Training and simulations methods in radiotherapy

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Abstract

A very important step in radiotherapy during the treatment process is the procedure of image processing (Matlab) and the radiation doses calculations. Many commercial software and techniques are developed for these procedures. The methodology of using numerical methods in medical imaging and radiotherapy for training and simulations is very important for students and researches in laboratories before clinical practice. Using Matlab, we can analyze data, develop algorithms, and create models and applications. The language, tools, are built-in math functions enable us to explore multiple approaches and reach a solution faster than with spreadsheets or traditional programming languages, such as C/C++ or Java. Matlab is a high-level language and interactive environment for numerical computation, visualization, and programming. From 2010 our team is working to adapt a module in Matlab environment for Medical Physics and Medical Imaging Technicians based on CERR and DEES modules in Matlab. First we describe the computational environment for radiotherapy research, developed to facilitate reproducible research in radiation oncology treatment planning in Matlab environment, as a basic framework to make inter-institutional treatment planning research more feasible. At the end we describe the first Albanian module for training and simulation in radiotherapy called PPIR[1]. One of the most important applications of this module is medical images processing, visualization and structure contouring for radiotherapy treatment. The simulation procedure of linear accelerator and the configuration of beams for tumor treatments is another application of this module. The dose calculation on this module is based on Eudmodel for dose volume histograms (DVH), which in radiotherapy treatment plan evaluation relies on an implicit estimation of the tumor normal tissue complication probability (NTCP) and control probability (TCP).

Keywords*:* medical images, radiotherapy, simulation, treatment plan

http://pos.sissa.it/

ACCURACY OF GRAYSCALE IN ULTRASOUND

Drilona Kishta,

Tirana University, Tirana, Albania

Abstract:

Ultrasounds are electromagnetic waves with frequency from 20,000 Hz to hundred MHz. Physical properties of ultrasounds are similar to those of the acoustic sound waves. Development of Medical Physics brings a very unique use of these waves as obtaining medical imaging, detection, measurement and cleaning services.

In medical imaging, production and acquisition of ultrasounds is based on Piezoelectric effect. The device which produces ultrasound waves is called probe and it is an integral part of the imaging equipment which we used for our experimental measurements. Images taken are black and white or with colors. Echo – pulse method depends on the time that has passed between the spreading of ultrasound pulse and detection of this echo by a reflection. The use of ultrasound is based on different methods of ultrasound examination such as : A – mode, B – mode, M – mode, Doppler mode, Color mode, 3D or 4D mode, etc.

Ultrasound transducers

Hervé Liebgott

Creatis, Lyon, France

Abstract:

The ultrasound probe is the key element of the ultrasound system. It makes the physical link between the tissue to image and the system itself. It transforms the electrical signal into an acoustic pulse during the transmission phase and the collected echoes into signals that can be processed to form an ultrasound image during the receiving phase. Depending on the targeted organ different probes will be used.

This lecture will first present the basic physical principle that permits to transmit and receive ultrasound pulses. The way this phenomenon can be modelled will be presented. The lecture will also present the different kind of probes and the reasons for these differences. The way an array of transducers is controlled to give a particular shape to the ultrasound beam, the so-called beam forming, will be presented. Finally technological aspects will be discussed.

ULTRAFAST IMAGING

Hervé Liebgott

Creatis, Lyon, France

Abstract:

Medical ultrasound imaging has undergone a real revolution during the last 10-15 years with the emergence of high framerate imaging techniques. Even if most of these new imaging modes are still at the stage of development in the academic and companies' laboratories, there is no doubt that the next generation ultrasound scanners will include such imaging modes.

High framerate ultrasound imaging (sometimes called ultrafast ultrasound imaging) permits to go from framerates usually below one hundred of frames per second to several thousands of frames per second. During this lecture we will first explain how such an improvement is possible thanks to a completely different insonification approach based on broad beams instead of focused beams. We will explain how, with the motivation of developing quantitative tissue elasticity imaging, ultrafast shear wave elastography based on plane waves has been developed. We will also speak about synthetic aperture imaging and circular/spherical wave imaging. Different applications including arterial and intra-cardiac vector flow imaging as well as functional imaging of the brain with ultrasound will be illustrated. To conclude other original approaches based for example on multi-line transmit as well as the first steps towards high framerate 3D ultrasound imaging will also be addressed.

The place of simulation in medical ultrasound

Hervé Liebgott

Creatis, Lyon, France

Abstract:

Numerical simulation is a fast and cheap approach to develop and evaluate new imaging techniques. When designing a simulation several aspects are important. First of all the specificities of the real imaging system should be taken into account, geometry of the probe (size and number of elements), its impulse response (center frequency and bandwidth), imaging sequence (excitation signal, focalisation, apodization) etc... Second the imaged medium, also called numerical phantom must be designed. It can be a simple static geometrical model for contrast/resolution evaluation or more realistic organ resembling anatomic models as for example heart, liver, kidney and even dynamic three dimensional organs reproducing with high fidelity the dynamic behaviour of the organ including some pathologies. Finally a propagation model for the ultrasound wave should be included. For this last point linear or non-linear propagation models coexist.

During this lecture the main simulation software used in the community (Field II, DTU Denmark, Prof. J.A. Jensen) will be presented as well as our own developed solution for non linear simulation (CREANUIS) and its accessibility through the Virtual Imaging Palform (VIP) developed at CREATIS. Examples of applications of simulation will be given for image segmentation, motion and flow imaging as well as for the design of complex systems like 2D matrix arrays for 3D imaging.

MEDICAL IMAGING Definitions & Applications

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In the perspective of the workshop where emphasis will be given to “relatively cheap” Medical techniques this talk will review of various medical imaging techniques and devices. Recent progresses are due to introduction of hybrid devices. Some parts are recalls and some parts are suggestions for progress. The 2 hours talk will be dived in two parts. In the first part we will review ”classical “ devices in use at the clinics. Second part will be devoted to hybrid devices, What they actually bring as decisive progress, what are the main trends.

Part 1 : 5 small chapters about techniques different from the US ones which will be extensively studied by C. Cachard, H. Liebgott, M. Mischi, P. Tortoli and others:

-1) CT-scanner (with X-Rays): A classic system based on attenuation of X-rays thru the patient body. Good spatial resolution. Intensively used in Hospitals, well understood, but concerns exist about dose delivered and accumulated for patients if we are not careful…..

-2) Magnetic Resonance Imaging; A world in itself. It uses magnetic properties of Protons inside atoms and molecules of the body immersed in an intense magnetic field. Advantages are: Excellent / flexible contrast (large range), Non-invasive technique (except sound!), No Ionizing Radiation, Excellent space resolution:

-3) SPECT ; which is not only “a cheap PET”. Based on beta minus radio-isotopes which have to be injected to patients (often Technicium-99m). Less sensitive than PET (Higher radioactivity injected than PET). Since several years Hybrid SPECT-CT are used inside the clinic. Progresses in image quality for tumour detection are spectacular…

-4) PET: Despite it is an invasive method (often based on radioactive Glucose) it as a modest spatial resolution but an incomparable sensitivity (until Pico-mole level). Now in hospitals it is often paired with another high spatial sensitivity device (hybrid PET-CT systems, PET-MR) giving a very powerful imaging tool.

-5) Need of some Quantification; (PET, SPECT)
Observation of images not sufficient: Numerical values are required in a REALLY scientific approach. Quantification is a measurement. Numerical values are extracted from image to get for instance concentration of radiotracer from signal strength in the region of interest. Here we have only time to define SUV (Standardized Uptake Value). Used intensively in Oncology SUV equals measured concentration from radioactive counts by pixel which is multiplied by patient weight then divided by injected dose and divided by tissue density (often 1). Usually SUV varies from 1 to about 10. In BioMedical research, sophisticated quantification is compulsory.

Part 2:
-6) Evolution and Recent news in Medical Imaging in general:
* Short Comparison of strong and weak points of some techniques;
* obvious complementarities ((CT and PET; MR and PET…)
* From image fusion to hybrid systems…

-7) Hybrid PET Devices (CT or MR)
SOME RECENT IMPROVEMENTS
Digital SiPM ! Combined whole-body PET/CT to PET/MR.. Move patient or not move . Main Challenges for PET/MR is to obtain PET attenuation correction factors from MR images
PET/MR in the same device is used routinely for Small Animal PET (“Medical Imaging Ideas”) biomedical research….

-8) EXAMPLES OF USES @ HOSPITAL
Example of PET CT protocol: -i) Scout scan < 20 s ; -ii) Selection of scan region 2 min; -iii) Helical CT < 2 mn; -iv) PET sequence 6 to 40 min. Note : 4000 PET/CT scanners are operational worldwide.
PET-CT is more powerful than PET alone (ex Vaginal cancer) CT only - PET only - PET+CT Adjacent focal anorectal uptake (SUV: 5.5). CT is negative with no abnormality seen. Only combination of CT and PET can show that!

-9). Hybrid devices with Ultrasound.: ClearPEM and Sonic ClearPEM; Use of Elastrography. Laboratory developments.

-10). CONCLUSION
During last decade it was impressive progress in Medical Imaging due to enormous work on the technical front: -i) New detectors; -ii) new Software; -iii) more Training; -iv) Better Radiation Protection; -v) PET/MR scanners are beginning now in hospitals (2014). Hybrid Specialized PET-US are in test.
All that for benefit of patients….

Modern Brachytherapy Techniques

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Abstract:

Brachytherapy, which is derived from the Greek word *brachio*, meaning "short", is the treatment of cancer by radioactive sources placed at a short distance from the tumor or inside the tumor (interstitial). Beginning of the 20th century the first patient was treated with radium by Danlos. Around 50 years ago remote afterloading has replaced the use of radium and manual afterloading. To minimize the radiation exposure of personnel an electro-mechanical loading device for radioactive sources was developed. The Remote Afterloader automatically places the radioactive source at predetermined positions within the applicator and stores the source in between treatments. While the patient is being treated, the personnel can stay outside the room to avoid radiation exposure. Today Brachytherapy is used as boost in combination with external beam or as monotherapy. In the earlier days initially sources were positioned based on direct visualization and "Treatment Planning" was based on didactic systems. Over the last decade Brachytherapy has moved to Image Guided Brachytherapy (IGBT). An example is prostate, where the applicators are placed under ultrasound guidance, which allows a better control on applicator positioning. During the whole procedure – from applicator insertion, dose planning to treatment - the patients need not to be moved. The benefits are reduction of normal tissue dose, higher tumor dose and dose optimization for the target and critical structures. Also advanced dose calculation modules have been implemented in the treatment planning systems. ACUROS is a Grid-Based Boltzmann Solver (GBBS) code and calculates inhomogeneity corrections taking into account the effect of applicator material, air and patient (tissues, boundaries). It provides Monte Carlo-like accuracy dose calculations with speed and ease, and it is TG186 compliant.

External beam radiotherapy:

Conventional and Stereotactic radiotherapy with LINAC

Irena Muçollari

University Hospital "Mother Teresa" Tirana

Abstract :

Radiation therapy is a clinical modality dealing with the use of ionizing radiations in the treatment of patients with malignant and occasionally benign diseases. The aim of radiation therapy is to deliver a precisely measured dose of irradiation to a defined tumor volume with as minimal damage as possible to surrounding healthy tissue. It has started since 1896 after a short time of the discovery of the X-ray, but rapid technology advances began in the early 1950s, with the invention of the linear accelerator. Radiation therapy can be delivered either externally or internally. External beam radiation therapy typically delivers radiation using a linear accelerator.

In this lecture basic concepts in radiation physics, radiation therapy treatment machines, and the dosimetry parameters used for photon external beam treatment will be discussed, emphasizing on two techniques Conformal 3D radiotherapy and Stereotactic radiosurgery irradiation.

Key words: radiotherapy, medical linear accelerators, dose, 3D-CRT, SRS.

Beamforming lecture

Dr. Ir. Massimo Mischi

Eindhoven University of Technology, Eindhoven, the Netherlands

Abstract:

The main topic of this lecture is beamforming by multi-element array transducers. After a short introduction on the various types of array transducers, the pressure beam profile is derived for both continuous wave and pulsed wave regimes. The main lobe as well as the side lobes and grating lobes are derived and their effects on image characteristics are discussed. Furthermore, the influence of apodization of the contribution of array elements on the overall beamforming is considered. Some specific aspects of beam processing that are also discussed include directional beam steering and compounding of ultrasound images. Compounding can be performed by superimposing images from slightly different insonation directions, or from sub-bands of the frequency spectrum of the received echoes. Smart compounding of images generated from single-element transmissions (synthetic aperture) will also be discussed, and the effects of focusing on both transmission and reception investigated.

Ultrasound Contrast Agents lecture

Dr. Ir. Massimo Mischi

Eindhoven University of Technology, Eindhoven, the Netherlands

Abstract:

Ultrasound contrast agents (UCAs) are gas microbubbles encapsulated in a biocompatible shell that permits increasing their life time after injection in the circulatory system. Because of their high echogenecity, UCAs are used to enhance the echographic signal from the blood pool, enabling a number of qualitative and quantitative clinical investigations by ultrasound imaging. This lecture will first present the nonlinear models describing the dynamic behavior of UCAs driven by an ultrasound field, with focus on single microbubbles. Based on this description, the imaging modalities aimed at specific enhancement of the signal produced by UCAs will be presented and discussed. The most common UCA-imaging modalities are Pulse Inversion, Amplitude Modulation, sub-, ultra-, super-, and second- harmonics. Combinations of these modalities are also used. The lecture will then continue by presenting a number of applications of contrast enhanced ultrasound (CEUS) imaging, ranging from the mere enhancement of the blood-pool signal for supporting with the echocardiographic delineation of the left-ventricle endocardial contour, to the advanced semi-quantitative and quantitative assessment of tissue perfusion for investigating myocardial viability as well as for detecting cancer angiogenesis. UCA destruction/replenishment imaging for perfusion quantification will be presented together with the latest developments for quantitative angiogenesis imaging by contrast ultrasound dispersion imaging. Microbubbles also show potential for extraordinary novel applications in the area of molecular imaging by specific targeting. Moreover, targeted microbubbles can also be used as vectors for targeted delivery of drugs and genes, whose uptake is locally enhanced by ultrasound-driven bubble cavitation. Bubble cavitation can also be exploited for improved clot lysis e.g. in the coronary arteries. All these applications and related perspectives will be briefly mentioned.

The education of Medical Physicists in Albania

Prof. Partizan Malkaj

Polytechnic University of Tirana

Abstract

Medical physics in Albania was recognized by a status: "STATUS of medical physicist in ALBANIA Nr.459 / 1 protocol dated 31.01.2012 of atomic authority in Albania. Medical physicists, known in Albania under this status are 7. These physicists are currently working in public hospitals and private centers in radiotherapy and diagnostic in the RPO.

Historically, physicist working in medicine in Albania dating back to the years 70 was a physicist working in nuclear medicine and in radiotherapy. They were trained to do the job by basic physical training and IAEA. Currently to be approved as medical physicist in Albania one has to satisfy the Albanian evaluations and criteria based on "Guidelines on Assessment Procedure Application for recognition as a physicist MEDICAL BY KMR" Nr.4629 / 1 dated 11/1/2012 and approved by atomic authority. In 2013 these conditions and needs of this profession, most notably in Albania, have led to open a professional master in "Engineering Faculty of Mathematics and Physics" for the management of medical physics where the student had completed the engineering and physical bachelor.

This master syllabus was reformatted according to the requirements of article 53 and modeling IAEA in practice according to these requirements.

The total number of medical physicists recognized by authority in Albania is 7 where two are not in Albania. There are 11 physicists who are currently working in different hospitals.

University and atomic authority are cooperating to issue a medical physicist statistic that I must use to open an Albanian master based on the European standards based on the recommendations of the IAEA in order to have student EOMP from other Balkan countries.

Ultrasound use in cardiology

Marsjon Qordja

Mother Teresa Hospital, Tirana, Albania

Abstract

Echocardiography has become an important component of the cardiac evaluation. Currently, it provides essential clinical information and is the second most frequently performed diagnostic procedure. There are a lot of applications of ultrasound in cardiac assessment.

M-mode echocardiography is valuable to measure the left ventricle cavity dimension and wall thickness

***Two-Dimensional* echocardiography** is performed in three orthogonal planes:

1. Long-axis 2. Short-axis 3. Four-chamber

These three planes can be visualized using four basic transducer positions: parasternal, apical, subcostal, and suprasternal. The examination usually begins with the transducer in the left parasternal position in the long-axis view. This provides excellent images of the left ventricle, aorta, left atrium, and the mitral and aortic valves. By angling the beam slightly rightward and inferiorly the right atrium, right ventricle, and tricuspid valve are visualized. In the apical position we have the four-chamber view which visualizes the septal, apical, and lateral walls of the left ventricle. The apical two-chamber view demonstrates the left atrium and the inferior, apical, and anterior wall segments of the left ventricle. Three-chamber view provides images of the posterior, apical, and anteroseptal left ventricle wall segments.

Three-dimensional echocardiography can be valuable in quantifying cardiac volumes and ejection fraction (EF), assessing congenital heart disease (CHD), and evaluating structures of complex geometry such as the right ventricle

Doppler echocardiography consists in: **continuous wave Doppler** (can accurately measure the direction and velocity of overall flow), **pulse wave Doppler** (may also be of value in quantifying flow dynamics in the setting of laminar flow) and **color wave Doppler** (gives spatial information regarding the size, shape, and 2D direction of flow)

Tissue Doppler echocardiography enables accurate analysis of regional left ventricle wall motion velocity and is usually performed in the apical view assessing longitudinal myocardial velocity.

Transesophageal echocardiography gives detailed information especially in the evaluation of posterior cardiac structures (left atrium, left atrial appendage, interatrial septum, aorta distal to the root), in the assessment of prosthetic cardiac valves, and in the delineation of cardiac structures <3 mm in size (small vegetations or thrombi).

Contrast echocardiography uses intravenous injection of ultrasonic contrast agents and is used to identify intracardiac shunts particularly patent foramen ovale.

Stress echocardiography has assumed an important role in the diagnosis of coronary artery disease (CAD). A stress induced imbalance in the myocardial blood supply will produce regional ischemia and resultant abnormalities of regional contraction. The location of wall motion abnormalities may be used to predict the stenosed coronary vessel.

Keywords: echocardiography, Doppler, left ventricle wall, valves.

PHOTON SOURCES IN BRACHYTHERAPY.

Alex Rijnders,

Europe Hospitals,Brussels Belgium

Abstract:

From the beginning of the 20th century encapsulated radioactive sources put in close contact or inserted into the tissues have been used to apply radiation therapy. We will start this lecture with a short overview of the history of brachytherapy, with a focus on the evolution in the photon sources that have been used over the years.

A major step in this evolution was the introduction of the automatic afterloading devices, which could be compared to the introduction of linear accelerators in external beam radiotherapy. The modern afterloaders allow for optimization of the dose delivery and the use of different dose rates (low dose rate, high dose rate and pulsed dose rate) in function of tumor biology and patient comfort.

Brachytherapy is known to offer for certain treatment sites several advantages, and tends to give by nature a very conformal radiation dose distribution with good protection of critical structures. The inherent dose inhomogeneity within the high dose region of a brachytherapy implant can lead to a better cure rate in certain cases.

Still today new sources are under investigation, and these developments together with the improvements in treatment planning and treatment techniques allow brachytherapy to be delivered with high precision and better adapted to the target volume, making it for specific treatment sites still the treatment of choice over state-of-the-art external beam therapy, and this at a much lower investment cost in equipment and resources.

PATIENT SAFETY AND QA.

Alex Rijnders,

Europe Hospitals,Brussels Belgium

Abstract:

Brachytherapy might seem as a rather simple treatment technique, requiring limited investments in equipment. But in order to perform adequate treatments, the brachytherapy treatment needs to be performed by a skilled team that is working closely together: radiation oncologist, medical physicist, technologist, nurse, radiation biologist and often other health care professionals. The overall treatment quality depends on each link of the chain, the weakest link having the largest impact.

Modern brachytherapy puts high requirements on tumour control and on low probability of normal tissue complications. Tolerances on dose calculation and -determination as well as on the geometrical accuracy are low, demands on precision are stringent, and proper QA and QC on all steps, processes and equipment is mandatory.

A QA programme for brachytherapy should cover both “device QA” – correct function and physical characteristics of treatment planning and delivery devices (including sources, afterloaders, dose calculation tools, measurement instruments) –, and “procedure specific QA”,– correct execution of each brachytherapy procedure, more focussed on the patient. Similarly, the QA programme endpoints must encompass device function as well as human function. It includes safety of the patient, the public and dose delivery accuracy, both physical and clinical aspects.

The device QA is usually the sole responsibility of the medical physicist. The development of procedure specific QA is usually the responsibility of the physicist, requiring close cooperation with the radiation oncologist and other members of the brachytherapy team.

A short review of some of the recommendations on QA and QC (IAEA, AAPM, ESTRO) will be given.

Radiobiology in Brachytherapy.

Alex Rijnders,

Europe Hospitals, Brussels, BelgiumAbstract:

Abstract:

The radiobiological processes involved in continuous low dose rate (LDR), hypofractionated high dose rate (HDR) and hyperfractionated pulsed dose rate (PDR) brachytherapy are similar to those involved in fractionated external beam radiotherapy. A proper understanding of these processes is crucial for a safe application of brachytherapy, esp. in the case of HDR applications.

Repair of sublethal damage, tumor repopulation, and the degree of tumor oxygenation (or reoxygenation) are the main factors determining the outcome of the treatment. The impact of variations in dose rate is equivalent to the effects of variations in dose per fraction in external beam radiotherapy. The role of dose rate is relevant only to the radiobiological mechanisms, and is quite independent of implantation parameters, such as the technique of inserting the sources, or methods of determining or specifying the delivered dose.

Both radiobiological and clinical studies have provided data that are useful for interpreting these radiobiological mechanisms. The two most important factors are repair capacity and repair kinetics, which differ from one tissue to another. Simple mathematical formulas have been developed which can adequately describe the role of dose rate, and which can be safely applied in current clinical problems.

Treatment Planning For Brachytherapy Photon Sources

Alex Rijnders,

Europe Hospitals,Brussels Belgium

Abstract

At present the most commonly used calculation algorithm for brachytherapy (BT) dose calculation is the AAPM TG-43 formalism. This formalism is implemented in all commercially available treatment planning systems.

The major advantage of this dosimetry system is that it provides a comprehensive concept: not only a dose calculation algorithm is proposed, but also guidelines are given for researchers on how to determine for each source the parameters that are used by this algorithm, and consensus datasets of these parameters are proposed for a number of commonly used sources. These consensus datasets are available on the RPC-website (for certain low-energy-photon sources) and on the ESTRO-BRAPHYQS website.

The formalism was initially designed for low energy photon sources (seeds), but can also be used for high-energy sources. Some limitations remain when using this model: it supposes that the treatment is performed in an infinite, full-scatter and water-equivalent medium, while the actual patient situation can be quite different. It also ignores effects of absorption in the applicators and by other sources, and has problems to adequately handle the effects of shielding that could be used for certain applications.

More powerful dose calculation algorithms are currently been studied and start to become available in commercial TPS. These model based dose calculation algorithms are capable of coping with the limitations of TG-43 and provide more accurate 3D calculations based on CT and other imaging information. However any change in the clinical dosimetry must be evaluated with the radiation oncologist as his experience has been based on a specific calculation methodology. Introduction of a new dose calculation algorithm should therefore been done based on international guidelines, as of AAPM TG-186.

In the past, the usual procedure to locate sources and points has been the radiographic based method. The use of CT images and/or other image modalities for target delineation and catheter reconstruction in BT has suffered historically a set of obstacles, which are resolved nowadays. The modern TPS have incorporated this option and BT dosimetry can be considerably improved in accuracy by using these imaging techniques.

Brachytherapy room

PhD. Ervis Telhaj

Medical Physics Department, Hygeia Hospital Tirana

Abstract:

The incidence of cancer throughout the world is increasing with the prolonged life expectancy that has resulted from improvements in standards of living. The shielding design of a radiotherapy treatment center should be by a qualified expert. Radiation treatment facilities are comprised of primary and secondary barriers. For HDR remote after – loading brachytherapy all the walls, the floor and the ceiling will be primary barriers and must be of adequate thickness to protect not only the staff but and visitors. The shielding requirements will need to be determined based on the type of source and his position to the treatment room. HDR source are usually Ir^{192} and Co^{60}.

Key: Brachytherapy, HDR, Ir^{192}, Co^{60}

Dosimetry Systems

PhD. Ervis Telhaj

Medical Physics Department, Hygeia Hospital Tirana

Abstract:

Radiation detected by measurements of the effect of its interactions with target materials. The radiation induced on a detector produces a signal that can be interpreted to give the radiation quantity on interest. Dosimetry systems started by primary laboratory until to end users which are related to each other by a traceability system. As part of this system is also and different audits for absorbed delivery dose. Today we use different dosimetry systems in the field of applied of radiation in medicine which included films, TLDs, ionizing chambers, scintillation detectors etc. The choice of dosimetry system for a particular application is usually based on a number of factors such as the nature and intensity of the radiation to be measured, the time available for counting, the efficiency and the cost. But above all their use aims diagnosis and treatment of patients in maximum security conditions.

Key: dosimetry systems, TLDs, ionizing chamber, traceability,

Ultrasound Doppler Systems

Piero Tortoli

University of Florence, Italy

Abstract:

Any ultrasound equipment currently includes Doppler facilities capable of providing information about moving structures inside the human body. In most cases, the primary interest is in the investigation of blood flow dynamics, since this may be helpful for early diagnosis of cardiovascular diseases. However, there is also an interest in tracking the movements of human tissues, since such movements can give an indirect evaluation of their elastic properties, which are valuable indicators of the possible presence of pathologies.

These lectures aim at presenting an overview of the different ways in which the Doppler technique was developed and used in medical ultrasound, from early continuous wave (CW) systems to advanced pulsed wave (PW) color-Doppler equipment. In particular, we will review the most important characteristics of CW, single-gate PW, multi-gate PW and flow-imaging systems. The main signal processing approaches used for detection of Doppler frequencies will be described, including time-domain and frequency-domain (spectral) methods. Factors contributing to the so-called "Doppler artifacts" will also be discussed.