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QUALITY ASSURANCE OF MONITOR UNIT CALCULATIONS

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Monitor unit, MU, calculations are performed by a computerized treatment planning system, TPS, or by a MU calculation program run on a separate computer applying tables stored in that system, or a hand calculation applying tables with beam data. Three sources of possible errors will be discussed: 1. discrepancies between the beam data applied in the various calculation systems and actual beam data; 2. systematic errors in the dose calculation method and 3. human mistakes. Quality control, QC, programmes of MU calculations may include various procedures such as a check of the patient data, a check of the machine related input data, an independent recalculation using the same MU calculation program or a completely independent second calculation, without reference to the original one. The data relevant for the calculations should be available for future quality audits. It is therefore recommended that worksheets are designed suitable for both TPS manufacturers and individual institutions. Finally the role of in vivo dosimetry for checking the number of MUs will be elucidated.

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DOSE CALIBRATION IN REFERENCE CONDITIONS OF THERAPEUTIC ELECTRON BEAMS USING DIFFERENT INSTRUMENTATION AND METHODS.

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In the radiotherapy department of our hospital, therapeutic accelerators are installed, providing electron beams on a wide range of nominal energies, from 4.5 to 24 MeV. Moreover we have at our disposal some different dosimetric systems.
Usually the procedure to determine the absorbed dose in water in standard conditions in electron beams, by ionization measurements, consists of some steps: range parameters such as R_{100} (which in most cases coincides with the reference depth), R_{50} and R_p are obtained from depth-dose or depth-ionization curves in water. From these data and by means of energy-range relationships, energy parameters are determined. When the proper energy parameter (usually $\overline{E_0}$) and reference depth are known, the conversion factors to calculate dose in water are derived. Finally, the actual ionization measurement can be performed with different devices, for example with a thimble or plane-parallel ionization chamber.
Our aim was to investigate the influence of using different instruments and methods, both on intermediate parameters and on final results. In particular, R_{50}, R_p, $\overline{E_0}$, $E_{p,0}$ determined from measurements in water with the plane-parallel chamber of NACP, the thimble chamber of Italian Protocol ESC/87, and a silicon semiconductor were compared, for electron beams of a Saturne 43 G.E linac. Attention was also put on the influence of:
the type of curve used (depth-dose or depth-ionization, experimental curve at 1 m SSD or corrected for "infinite SSD", field dimension used);
the way in which parameters are obtained from a curve (that is manually, automatically by dedicated commercial software or by a home-made one).
The conversion factors, as tabulated in Italian Protocol were also determined and compared.
Finally, dose measurements were performed by an NACP and an ESC/87 chamber, using a Farmer type chamber connected to an independent electrometer as external monitor to account for variation in accelerator output per monitor unit and the results compared.
Differences in range and energy parameters can be noticed, but the uncertainties they introduce are in general lower than those affecting the knowledge of conversion factors. This does not exempt from investigating in order to use the most suitable instruments and methodologies.
A more detailed discussion has to be made for the lowest energy beam (4.5 MeV) for which the use of a plane-parallel chamber should be more essential.

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ANALYTICAL EXPRESSION FOR THE PHANTOM GENERATED BREMSSTRAHLUNG BACKGROUND IN HIGH ENERGY ELECTRON BEAMS

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Qualification of the bremsstrahlung photon background generated by an electron beam in a phantom is important for accurate high energy electron beam dosimetry in radiation therapy. An analytical expression has been derived for the background of phantom generated bremsstrahlung photons in plane parallel electron beams normally incident on phantoms of any atomic number between 4 and 92 (Be, C, H_2O, Al, Cu, Ag, Pb and U). The expression can be used with fairly good accuracy in the energy range between 1 and 50 MeV. The expression is globally based on known scattering power and radiation and collision stopping power data for the phantom material at the mean energy of the incident electrons. The depth dose distribution due to the bremsstrahlung generated in the phantom is derived by folding the bremsstrahlung energy fluence with a simple analytical one-dimensional photon energy deposition kernel. The energy loss of the primary electrons and the generation, attenuation and absorption of bremsstrahlung photons are taken into account in the analytical formula. The photon energy deposition kernel is used to account for the bremsstrahlung produced at one depth that will contribute to the down stream dose. A simple analytical expression for photon energy deposition kernel is consistent with the classical analytical relation describing the photon depth dose distribution. From the surface to the practical range the photon dose increases almost linearly due to accumulation and buildup of the photon produced at different phantom layers. At depths beyond the practical range a simple exponential function can be use to describe the bremsstrahlung attenuation in the phantom. For comparison Monte Carlo calculated distributions using ITS3 Monte Carlo Code were used. Good agreement is found between the analytical expression and Monte Carlo calculation. Deviations of 5% from Monte Carlo calculated bremsstrahlung background are observed for high atomic number materials. The method can be used for estimating the depth dependence of phantom generated bremsstrahlung in different materials in therapeutic electron beams.

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PARAMETRISATION OF THE COLLIMATOR SCATTER CORRECTION FACTORS OF SQUARE AND RECTANGULAR PHOTON BEAMS.

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Collimator scatter correction factors S_c have been measured with a cylindrical mini-phantom for five types of dual photon energy accelerators with energies between 6 and 25 MV. Using these S_c-data three methods to parametrise S_c of square fields have been compared including a third-order polynomial of the natural logarithm of the fieldsize normalised by the fieldsize of 10 cm^2. Also six methods to calculate S_c of rectangular fields have been compared including a new one which determines the equivalent fieldsize by extending Sterling's method.
The deviation between measured and calculated S_c for every accelerator, energy and all methods are determined resulting in the maximum and average deviation per method. Applied to square fields the maximum and average deviation were for the method of Chen 0.64% and 0.15%, of Szymzcyk 0.98% and 0.21%, and of this work 0.41% and 0.10%. For the rectangular fields the deviations were for the method of Sterling 1.89% and 0.50%, of Vadash 1.60% and 0.28%, of Szymczyk et al. 1.21% and 0.25%, of Chen 1.84% and 0.31% and of this work 0.79% and 0.20%. Finally, a recommendation is given how to limit the number of fields at which S_c should be measured.