Analisis Dosimetri pada Teknik Radiasi Pelvis 3D Konformal dan Bone Marrow Sparing menggunakan Intensity-Modulated Radiation Therapy Step-And-Shoot, Volumetric Modulated Arc Therapy dan Tomoterapi pada Penderita Kanker Serviks = Dosimetric Analysis of 3D Conformal and Bone Marrow Sparing using Step-And-Shoot Intensity-Modulated Radiation Therapy, Volumetric Modulated Arc Therapy and Tomotherapy in Pelvic Irradiation for Cervical Cancer

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Abstrak

Latar Belakang: Belum tersedia penelitian yang membandingkan teknik radiasi konvensional dengan teknik bone marrow sparing (BMS) di Indonesia. Penelitian ini bertujuan mengetahui teknik yang paling superior secara dosimetri dan akan menjadi data dasar untuk studi-studi klinis berikutnya. Metode: Sepuluh data Digital Imaging and Communications in Medicine (DICOM) Computed Tomography (CT) simulasi pasien kanker serviks stadium IB2 - IVA di Rumah Sakit Umum Pusat Nasional Cipto Mangunkusumo pada studi eksperimental eksploratorik ini menjalani proses perencanaan radiasi teknik 3D konformal dengan 4 lapangan dan teknik BMS menggunakan intensity-modulated radiation therapy (IMRT) step-and-shoot (SS) dengan 7 lapangan, volumetric modulated arc therapy (VMAT) dengan full 2-arc dan tomoterapi spiral. Dosis 50 Gy dipreskripsikan terhadap planning target volume (PTV) dalam 25 fraksi. Parameter dosimetri pada target dan organ kritis, jumlah monitor units (MU) dan lama waktu radiasi dibandingkan melalui analisis statistik dan sistem skor keunggulan. Hasil: Seluruh teknik memberi cakupan PTV yang sangat baik. Perbedaan statistik terlihat pada rerata D98%; D95%; dan homogeneity index (HI), dengan IMRT SS dan tomoterapi merupakan teknik yang paling superior (D98% = 48 Gy; D95% = 48,98 Gy dan 48,97 Gy; HI = 0,06). VMAT memberi rerata terendah pada V40 (22,2%), Dmean (26,45 Gy) dan D2% (50,42 Gy) usus halus, namun IMRT SS paling mudah mencapai batasan dosis-volume V45 < 195 cc untuk volume usus halus yang luas. IMRT SS juga memberi rerata terendah pada V30 (86,93% dan 92,55%), V40 (65,92% dan 70,81%), Dmean (42,05 Gy dan 43,03 Gy) dan D2% (50,51 Gy dan 50,91 Gy) rektum dan buli, secara berurutan. Tomoterapi memberi rerata terendah pada V10 (83,31%), V20 (67,5%), V30 (46,04%), V40 (27,38%) dan Dmean (28,43 Gy) bone marrow, namun dengan rerata kedua tertinggi pada D2% (50,82 Gy) bone marrow. Teknik 3D konformal memberi rerata terendah pada V5 RVR (43,8%), jumlah MU (275,3) dan lama waktu radiasi (0,46 menit). Total skor keunggulan yang tertinggi diperoleh pada teknik IMRT SS (80), diikuti dengan VMAT (68), tomoterapi (65) dan terendah pada 3D konformal (43). Kesimpulan: Teknik IMRT SS, VMAT dan tomoterapi mampu menyelamatkan bone marrow pelvis dengan cakupan dosis PTV adekuat, homogenitas dan konformitas yang baik, serta memberi dosis radiasi yang aman terhadap organ-organ kritis. Secara keseluruhan, IMRT SS paling superior dibanding ketiga teknik lainnya, terutama terlihat pada dosis rektum, buli dan usus halus yang luas. VMAT paling superior menurunkan dosis usus halus secara umum.
Tomoterapi paling superior menurunkan dosis bone marrow kecuali untuk parameter D2%, sedangkan 3D konformal paling superior menurunkan dosis RVR, jumlah MU dan lama waktu

radiasi.

.....Background: Currently there is no research that compares conventional radiotherapy technique with bone marrow sparing (BMS) techniques in Indonesia. The aim of this research was to discover the most superior technique dosimetrically and will be the basic data for further clinical studies. Method: Ten Digital Imaging and Communications in Medicine (DICOM) images of simulation Computed Tomography from stage IB2 - IVA cervical cancer patients at Cipto Mangunkusumo National Center General Hospital were enrolled in this experimental exploratory study and planned for four-field three-dimensional (3D) conformal radiotherapy and BMS technique using seven-field step-andshoot intensity-modulated radiation therapy (SS IMRT), full 2-arc volumetric modulated arc therapy (VMAT), and helical tomotherapy. A dose of 50 Gy was prescribed to the planning target volume (PTV) in 25 fractions. Dosimetric parameters of the target and critical organs, total monitor units (MU), and beam-on time were compared by means of statistical analysis and superiority score system. Result: All techniques provided excellent PTV coverage. Statistical difference was seen in the average of D98%; D95%; and homogeneity index (HI), with SS IMRT and tomotherapy were the most superior techniques (D98% = 48 Gy; D95% = 48.98 Gy and 48.97 Gy; HI = 0.06). VMAT delivered the lowest average of small bowel V40 (22.2%), Dmean (26.45 Gy), and D2% (50.42 Gy), but SS IMRT was the easiest to achieve V45 < 195 cc dose-volume constraint for a large volume of the small bowel. SS IMRT also delivered the lowest average of rectum and bladder V30 (86.93% and 92.55%), V40 (65.92% and 70.81%),Dmean (42.05 Gy and 43.04 Gy), and D2% (50.51 Gy and 50.91 Gy), respectively. Tomotherapy delivered the lowest average of bone marrow V10 (83.31%), V20 (67.5%), V30 (46.04%), V40 (27.38%) and Dmean (28.43 Gy), although with second-highest average of D2% (50.82 Gy). Three-dimensional conformal radiotherapy delivered the lowest average of Remaining Volume at Risk (RVR) V5 (43.8%), total MU (275.3), and beam-on time (0.46 minutes). The highest total superiority score was obtained by SS IMRT (80), followed by VMAT (68), tomotherapy (65), and 3D conformal (43). Conclusion: SS IMRT, VMAT, and tomotherapy techniques were able to spare pelvic bone marrow with adequate PTV dose coverage, good homogeneity and conformity, and provided safe radiation dose to critical organs. Overall, SS IMRT was the most superior technique compared to the other three techniques, particularly seen in the dose of rectum, bladder and a large volume of the small bowel. VMAT was most superior to decrease the dose of the general small bowel. Tomotherapy was most superior to decrease the dose of bone marrow except for the D2% parameter, while 3D conformal was most superior to decrease the dose of RVR, total MU, and beam-on time.