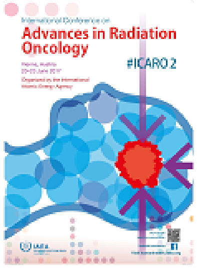

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Nodal doses during image-guided adaptive brachytherapy for cervical cancer and implication to simultaneous integrated boost

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Purpose/Objective
The use of image-guided adaptive brachytherapy (IGABT) in cervical cancer has allowed safer and more conformal delivery of higher tumor doses leading to better local control. The use of simultaneous integrated boost (SIB) to pelvic adenopathies is increasingly being used to improve regional control. Significant nodal doses during brachytherapy have been previously demonstrated and must be integrated in the SIB plan. This study aims to report the BT-delivered doses to adenopathies in different pelvic nodal regions and to propose SIB dose-fractionation regimens.

Material and methods
Patients with locally advanced cervical cancer comprising pelvic nodal involvement and treated with chemoradiation followed by image-guided adaptive pulsed-dose rate BT were included. During brachytherapy, GEC-ESTRO recommendations for target volume delineation and optimization constraints were followed. Nodal coverage was not included in the planning objectives. The adenopathies were delineated on 3-mm thick simulation scans to determine physical doses delivered. Physical D100, D98, D90 and D50 were reported and converted to 2-Gy equivalents (EQD2), using the linear quadratic model with an α/β of 10 Gy.

Results
Ninety-one patients were identified, allowing the evaluation of dose delivered in 226 adenopathies. The majority of the studied nodes were located in the external iliac (48%), common iliac (25%), and internal iliac (16%) regions. Overall, the EQD2 contribution was 3.6 ±2.2, 4.1 ±1.6, 4.4 ±3.3, and 5.2 ±3.9 Gy for the D100, D98, D90, and D50, respectively. The EQD2 D98 values were 4.4±1.9 Gy, 5.4±3.1 Gy, 4.3±2.1 Gy for obturator, internal iliac and external iliac nodes respectively, and 2.8±2.5 Gy for the common iliac. Whereas no significant difference was observed between the brachytherapy contributions of external and internal iliac nodes, the doses delivered in common iliac adenopathies were significantly lower ($p<0.001$). Furthermore, dose variations were noted among individual nodes within regions, due to differences in relative distances between the node and the implant.

Legend to attached figure: Descriptive statistics of D98 of pathologic nodes according to regions.
Ext: external iliac, Int: internal iliac, Ing: inguinal, Com: common iliac, Obt: obturator, Sac: presacral, Cent: central (pararactal or parametrial). Red cross: mean value, blue diamond: minimal and maximal values, lower limit of the box: first quartile, upper limit of the box: third quartile, central horizontal bar: median, whiskers: from minimal value to 1.5 x box length.

Finally, to deliver a cumulative EQD2 ≥60 Gy to pathologic nodes accounting a pelvic external beam radiation dose of 45 Gy in 25 fractions (44.3 in EQD2) and these nodal dose estimations, we propose nodal SIB of 2.2 Gy x 25 (55 Gy, 55.9 in EQD2) in the obturator, external and internal iliac nodes, 2.3 Gy x 25 (57.5 Gy, 58.9 in EQD2) in the common iliac nodes, and 2.4 Gy x 25 (60 Gy, 62 Gy in EQD210) in the para-aortic nodes (where the BT contribution can be considered as negligible).

Conclusion
The contribution of brachytherapy to the treatment of pelvic nodes is significant - around 5 Gy in the obturator, internal iliac, and external iliac areas and 2.5 Gy in the common iliac, and should be considered in planning the

simultaneous integrated boost. However, important individual variations have been observed and evaluation of the actual brachytherapy contribution is recommended.

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