Fetal doses and induced childhood cancer risks of abdominal and pelvic CT examinations using commonly available CT scanners in Hong Kong

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Objectives

To simulate fetal doses for pregnant patients undergoing abdominal and pelvic (Abd/Pel) CT examinations at three stages of pregnancy using commonly available CT scanners in Hong Kong, and to estimate the corresponding induced childhood cancer risks.

Materials and Methods

Normalized fetal doses in mGy/100mAs for pregnant patients undergoing Abd/Pel CT imaging in the first, second and third trimester of pregnancy were simulated using VirtualDoseCT software with 120-kV protocol and body bowtie filter. The CT scanners under evaluation were of 64-, 128-, 256- and 384-slice CT models from three different CT manufacturers. Wilcoxon signed ranks test was used to compare the fetal doses between different CT scanners for the three stages of pregnancy. The corresponding average normalized fetal doses and total fetal doses were calculated. The corresponding excess fatal childhood cancer risks after in utero irradiation were estimated according to ICRP Publication 84.

Results

- Normalized fetal doses ranged from 6.75 to 8.91 mGy/100mAs, 6 to 7.93 mGy/100mAs and 5.68 to 7.51 mGy/100mAs, respectively, and the average normalized fetal doses were 7.38 mGy/100mAs, 6.56 mGy/100mAs and 6.22 mGy/100mAs, respectively for the three stages of pregnancy (Table 1).
- There was no statistically significant difference between the inter-comparison among the normalized fetal doses of the scanners evaluated for the three stages of pregnancy ($p > 0.05$).
- For a typical Abd/Pel CT scan, the total fetal doses were 14.76 mGy, 19.68 mGy and 24.86 mGy, and the corresponding excess fatal childhood cancer risks were 0.09%, 0.12% and 0.15%, respectively for the three stages of pregnancy.
- If a dual phase CT scan was required, the total fetal doses would be doubled compared with that of a plain scan.

Table 1: Average normalized fetal doses simulated for the three stages of pregnancy using the CT scanners under evaluation

Average normalized fetal dose (mGy/100mAs)	64-slice CT	128-slice CT	256-slice CT	384-slice CT
1st trimester	7.58	7.17	7.31	7.25
2nd trimester	6.74	6.38	6.5	6.45
3rd trimester	6.39	6.04	6.16	6.11

Conclusion

In general, the fetal doses would not reach the threshold dose of 100 mGy for deterministic effects unless multiple examinations or multiphase scans are required. However, the induced childhood cancer risks by current-technology CT scanners are not low and still warrant further dose optimization strategies to be validated by measurements, such as the use of dynamic z-axis collimation and artificial intelligence reconstruction algorithms.