Investigation of Fetal Radiation Dose Estimation Methods

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Introduction

- Pregnant patients receive radiation from necessary computed tomography (CT) scans
- In utero doses greater than 100mGy may cause miscarriage or cancer induction
- Impossible to measure direct fetal radiation dose
- Accurate dose estimation is difficult
  - Several methods have been published
- Study purpose: compare four fetal radiation dose estimation methods
  - Secondary objective: identify sources of variability

Method

- Database of 40 CT scans of pregnant patients
  - Scans acquired between 2007 and 2017
  - Mean maternal weight: 78 ± 18kg
  - Mean gestational age: 159 ± 63 days
  - Seven 1st trimester, nineteen 2nd trimester, and fourteen 3rd trimester
  - Abdomen (n=10) or abdomen/pelvis (n=30) scans
- Manual measurements by two observers:
  - Fetal depth
  - Maternal circumference
  - Maternal diameter
- Volumetric CT dose index (CTDIvol) and Dose Length Product (DLP) obtained
- Four estimation methods were studied:
  - Classic calculation
  - Updated calculation
  - iPad app
  - Commercial dose tracking software (Radimetrics)
- Summary statistics, regression, and Bland-Altman analysis

Results

- Fetal radiation dose range: <1mGy to 32mGy
  - Differences between methods were significant (p<0.05), but generally small (<10mGy)
  - Bias between methods was less than 5mGy and 95% Confidence Intervals (CI) were < ±15mGy
  - Regression had typical slopes between 0.8 and 1.2
  - Coefficient of determination (R2) values between 0.3 and 0.8
  - Violating method assumptions such as tube voltages other than 120kV, differing trimester, and differing scanner models increased variability
  - If limited, both bias and CI were cut by 50% or more
- Measurement variability between observers generally resulted in fetal dose estimate changes of <10mGy
- Incomplete maternal circumference on CT for 75% of patients causes fetal dose overestimation
- Radimetrics system demonstrated large variability (~20mGy) depending on the patient model selected in the first trimester

Discussion

- Good agreement among the four methods
  - Variability and outliers noted
  - Recommend selecting a default method and limiting model variations
- No dose approached the 100mGy limit
- Variability could become important for dose tracking if estimates exceed the threshold considered acceptable
- Qualified medical physicists should review dose estimates
- Fetal dose estimation methods generally agree, but variability and outliers can cause substantial differences

References

4. ImPACT Group (www.impactscan.org/ctdosimetry).