Clinical and radiation risk across one million patients in Computed Tomography: influence of age, size, and race

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Purpose

We recently developed a mathematical model to balance radiation risk and clinical risk, namely the risk of misdiagnosis due to insufficient image quality. In this work, we applied this model to a population of one million CT imaging cases to evaluate the risk stratification with different ages, sexes, and races.

Materials and Methods

The demographics were informed by literature and census information simulating a clinical liver cancer population. The Total Risk (TR) was calculated as the linear combination of radiation risk and clinical risk. The model included factors for the radiation burden for different age and sex; the prevalence of the disease; the false positive rate; the expected life-expectancy loss for an incorrect diagnosis for different ages, sex, and race; and a typical false positive rate of 5%. It was assumed that each case received an average radiologist interpretative performance of 0.75 AUC for a hypothetical lesion without any changes in radiation dose beyond routine practice. We further, for each patient, simulated 2,000 imaging conditions with $CTDI_{vol}$ varying from 0.1 and 200 mGy with 0.1 mGy increments. Per each $CTDI_{vol}$ value, the anticipated AUC was calculated by applying the established asymptotic relationships between $CTDI_{vol}$ and image quality. The AUC distribution was then used to calculate the theoretical minimum total risk (TR_{min}) per each patient.

Results

For the routine practice, the median theoretical total risk was estimated to be 0.058 deaths per 100 patients (range: 0.002 – 0.154) comprising of the median radiation risk of 0.009 (range: 0.001 – 0.069), and of the median clinical risk of 0.049 (range: 7.0×10^{-5} – 0.094). Considering the varying scanner output conditions, the median TR_{min} was 0.054 deaths per 100 patients for White male patients, 0.054 for Blacks, 0.057 for Hispanics, and 0.065 for Asians. For female patients, the median TR_{min} values were 0.049, 0.056, 0.054, and 0.061 deaths per 100 patients, respectively.

Conclusion

For each demography condition, the clinical risk was found to largely outweigh the radiation risk by at least 500%. Total risk showed different stratifications with patient age and race.

Clinical Relevance Statement

To optimize CT conditions for specific patients and/or population, both radiation risk and clinical risks should be all accounted for together with demographic information. We demonstrated a methodology that allows a complete depiction of total risk in CT, considering radiation and clinical risks at comparable units, and patient demographic.

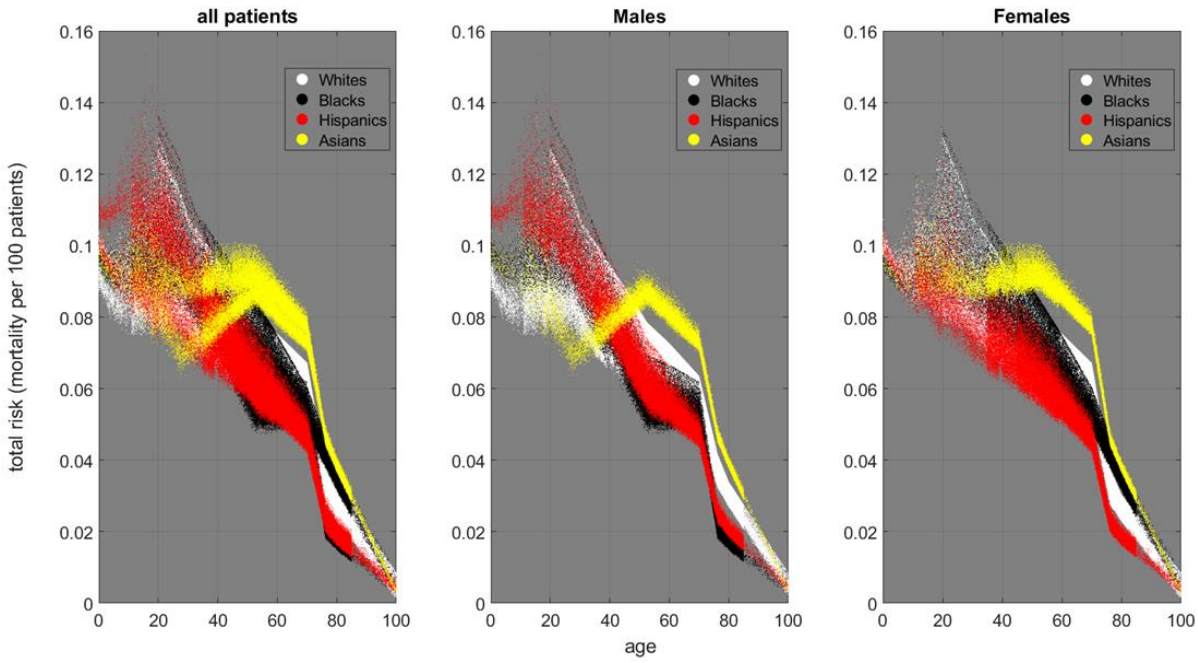

Figure 1. Minimum Total Risk versus age for the whole population (left), male patients (center), and female patients (right). Different colors are different races.