Patient effective doses and cancer risks in hybrid PET/CT and SPECT/CT of common nuclear medicine scintigraphy

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Objectives

To simulate effective doses for adult patients undergoing common nuclear medicine scintigraphy using hybrid PET/CT and SPECT/CT, and to estimate their corresponding induced cancer risks.

Materials and Methods

Whole-body scan of ^{18}FDG and of ^{11}C-acetate PET/CT, and of ^{99m}Tc-MDP (bone scan) SPECT/CT were studied. Organ absorbed doses from ^{18}FDG, ^{11}C-acetate and ^{99m}Tc-bone scintigraphy were simulated using MIRDcalc internal dose calculation software. Organ absorbed doses from CT were simulated using MIRDct software with 120-kVprotocol normalized by 100 mAs. Effective doses were calculated according to ICRP-103 recommendations. The total effective doses was calculated as the sum of the effective doses from the radiotracers used in PET or SPECT and the corresponding CT scan. The induced cancer risks were estimated using lifetime attributable risk (LAR) of cancer incidence according to the National Academy of Sciences BEIR VII report.

Results

- The effective doses of the two PET/CT examinations were evaluated using 64-slice CT scanners from two different manufacturers (scanner A and B), as shown in Table 1. For a typical whole-body ^{18}FDG PET/CT scan using scanner A(B), the total effective doses for male and female patients were 18.43(20.31) mSv and 21.22(21.48) mSv, respectively. For a typical whole-body ^{18}FDG and ^{11}C-acetate PET/CT scan using scanner A(B), the total effective doses for male and female patients were 18.96(20.84) mSv and 21.75(22.14) mSv, respectively.
- The effective doses of the SPECT/CT examination were evaluated using 16-slice CT scanners from two different manufacturers (scanner C and D), as shown in Table 2. For a typical whole-body bone SPECT/CT scan using scanner C(D), the total effective doses for male and female patients were 23.44(30.04) mSv and 26.72(31.52) mSv, respectively.
- Among the three NM examinations and scanners evaluated, patients received the highest total effective doses in whole-body bone SPECT/CT scan. Correspondingly, for 60-year-old U.S. population, LARs of cancer incidence for male and female patients were 0.15 % and 0.18 %, respectively.

Conclusion

Effective doses of whole-body scan in hybrid PET/CT and SPECT/CT could be substantial. Radiation reduction techniques in hardware and reconstruction algorithm should be investigated to reduce the corresponding cancer risks induced by hybrid imaging systems of PET/CT and SPECT/CT.

Table 1: Normalized effective doses of the two PET/CT examinations

	PET/CT scanner A (CT: 64 slices)				PET/CT scanner B (CT: 64 slices)			
	Adult male		Adult female		Adult male		Adult female	
	^{18}FDG only	^{18}FDG & ^{11}C-acetate	^{18}FDG only	^{18}FDG & ^{11}C-acetate	^{18}FDG only	^{18}FDG & ^{11}C-acetate	^{18}FDG only	^{18}FDG & ^{11}C-acetate
Effective dose of F18-FDG (mSv/mCi)	0.59	0.59	0.72	0.72	0.59	0.59	0.72	0.72
Effective dose of C11-acetate (mSv/100mAs)		0.11		0.11		0.11		0.13
Effective dose of WB CT (mSv/100mAs)	6.26	6.26	7.02	7.02	7.20	7.20	7.15	7.15
Total effective dose [mSv/(100mAs mCi)]	6.85	6.96	7.74	7.84	7.79	7.90	7.87	8.00

Table 2: Normalized effective doses of the SPECT/CT examination

	SPECT/CT scanner C (CT: 16 slices)		SPECT/CT scanner D (CT: 16 slices)	
	Adult male	Adult female	Adult male	Adult female
Effective dose of ^{99m}Tc-MDP (mSv/mCi)	0.16	0.20	0.16	0.20
Effective dose of WB CT (mSv/100mAs)	10.10	11.40	13.40	13.80
Total effective dose [mSv/(100mAs mCi)]	10.26	11.60	13.56	14.00