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RADIATION EXPOSURE DURING STANDING, VOIDING CYSTOURETHROGRAPHY (VCUG) IN WOMEN

Hypothesis / aims of study

VCUG can serve as a diagnostic tool and an outcome measure in the evaluation and management of urinary incontinence and prolapse. Due to concerns over radiation risks [i], the total radiation exposure and effective organ doses were studied with a standard protocol [ii].

Study design, materials and methods

Following IRB approval, a prospective series of consecutive, non-neurogenic women underwent VCUG by a single, experienced technologist practicing ALARA (as low as reasonably achievable) techniques and using the same radiographic/fluoroscopic (R/F) equipment (Siemens Sireskop Fluorospot; Siemens, Erlangen, Germany) in reduced-dose mode. Protocol images included: posterior-anterior upper (PA_{us}) and lower (PA_{ls}) abdominal scout films, PA at capacity (PA_c), lateral (LAT) rest-straining view at 125 cc (with catheter) and at capacity (no catheter), lateral voiding images, and post-void upper/lower abdominal films. Studies which deviated from the protocol when clinically indicated were excluded. Based on entrance skin exposure and recorded technique factors from the fluoroscope, effective organ dose to the pelvic organs was calculated (Figure 1) using a commercially-available dose-modeling program (PCXMC version 1.4) [iii]. Data on patient age, ethnicity, body mass index (BMI), uterine and ovarian status, R/F techniques, fluoroscopy time, and image count in each study were prospectively collected and analyzed. Statistical analysis was performed using SPSS Version 12.0 (SPSS, Chicago, IL).

Results

Between April and December 2004, 137 VCUGs were performed, of which 119 studies in 118 women satisfied inclusion criteria. The mean age was 60 $\pm$ 13 years (range 30-93), BMI was 26.7 $\pm$ 4.5 kg/m^2 (18-40), and 96% were Caucasian. Of 43 patients (36%) with any extant reproductive organs (uterus and/or ovary(ies)), only 15 (13%) were pre-menopausal. The indications for the studies included urinary incontinence (43%), pelvic organ prolapse (22%), both (12%), bladder outlet obstruction (8%), recurrent urinary tract infections (5%), frequency/urgency (5%), and other (4%). The mean number of radiographic images for each exam was 12.8 $\pm$ 7.4, with most images taken in lateral position (7.5 $\pm$ 1.3). The mean fluoroscopic time for each study was 35.8 $\pm$ 11.2 seconds, with an effective organ dose from fluoroscopy of 1.1 $\pm$ 0.6 milliSieverts (mSv). The mean effective dose for a single VCUG study was calculated to be 4.3 $\pm$ 1.3 mSv. Of the total effective organ dose, the majority was generated by lateral view radiographic images, as these comprised the largest proportion of the total image count (Figure 2a, 2b). Estimated gonadal doses accounted for half of the effective organ dose. A correlation analysis between exposure and BMI yielded an appreciable r-value for PA views (r=0.73), while the r-values for the overall and lateral images were smaller (r=0.37 and 0.32, respectively). Using existing data on the malignant and genetic risks of radiation studies, estimated to be 7.3%/Sievert, total risk for fatal cancer and hereditary changes was about 3/10,000 patients, or a 99.997% chance of no detrimental effect incurred from the study.

Interpretation of results

Using a standard protocol, a VCUG study is associated with an acceptable radiation risk comparable to other studies (Table 1). Fluoroscopy accounted for 25% of the total radiation exposure. The genetic risk is further reduced in this cohort of patients, with low or no reproductive potential in 87%. Furthermore, the risk of malignancy is lowered by the latency period between radiation exposure and neoplastic development, which in this cohort is more likely to exceed the lifespan of the average patient (mean age 60 years).

Concluding message

The VCUG is a safe imaging study, with a low risk for radiation-induced malignant and genetic changes. Protocols tailored to specific indications may further reduce the radiation exposure without compromising the clinical yield of the study.

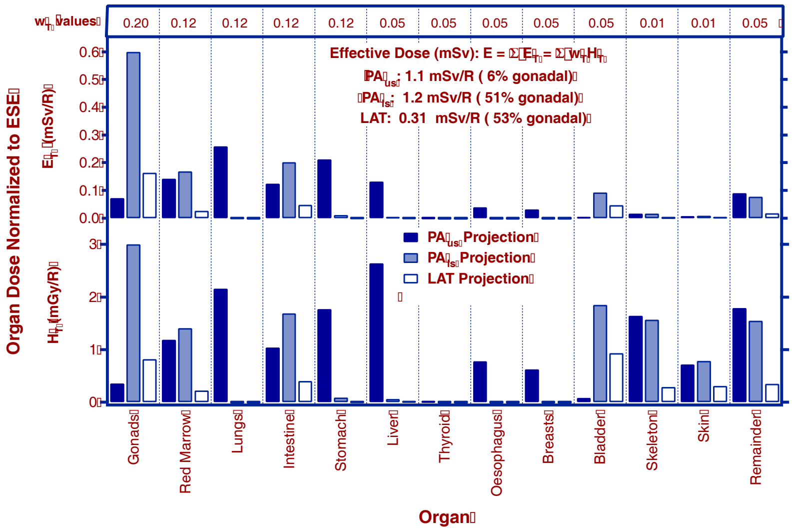
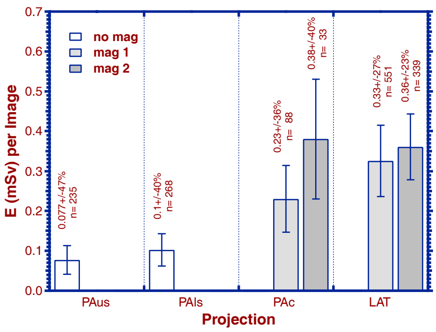


Figure 1: Typical organ doses derived from phantom model. Note lateral radiographs have lower dose to gonads and bladder, thought to be due to shielding from surrounding pelvic bones and presence of contrast. Gonadal doses accounted for 50% of the total effective organ dose.



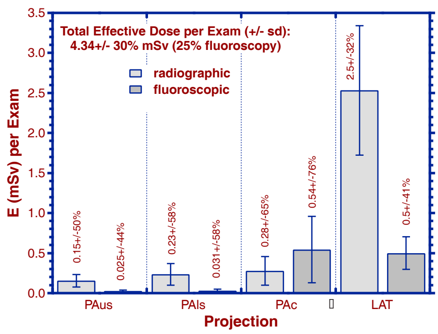


Figure 2a: Effective dose per image. LAT images produced higher doses due to increased technique factors to penetrate hips and presence of contrast.

Figure 2b: Total effective dose based on image projection/position, which shows dose is primarily due to the LAT radiograph projections

Radiologic Study	Effective Organ Dose per Study (mSv)
Computerized Tomography	8.8
Barium Enema	6.4
VCUG (this study)	4.3
Intravenous Urography	3.7
Mammography	0.5

Table 1: Comparative typical effective organ dose associated with common radiographic studies.

REFERENCES

[i] 2nd International Consultation on Incontinence, 1999. p 431.
[ii] Urology, 2001. **58**: 33-37.
[iii] STUK, Radiation and Nuclear Safety, Finland.