

Effective radiation exposure evaluation during a one year follow-up of urolithiasis patients after extracorporeal shock wave lithotripsy

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Introduction To determine and evaluate the effective radiation exposure during a one year follow-up of urolithiasis patients following the SWL (extracorporeal shock wave lithotripsy) treatment.

Material and methods Total Effective Radiation Exposure (ERE) doses for each of the 129 patients: 44 kidney stone patients, 41 ureter stone patients, and 44 multiple stone location patients were calculated by adding up the radiation doses of each ionizing radiation session including images (IVU, KUB, CT) throughout a one year follow-up period following the SWL.

Results Total mean ERE values for the kidney stone group was calculated as 15, 91 mSv (5.10-27.60), for the ureter group as 13.32 mSv (5.10-24.70), and in the multiple stone location group as 27.02 mSv (9.41-54.85). There was no statistically significant differences between the kidney and ureter groups in terms of the ERE dose values ($p = 0.221$) ($p > 0.05$). In the comparison of the kidney and ureter stone groups with the multiple stone location group; however, there was a statistically significant difference ($p = 0.000$) ($p < 0.05$).

Conclusions ERE doses should be a factor to be considered right at the initiation of any diagnostic and/or therapeutic procedure. Especially in the case of multiple stone locations, due to the high exposure to ionized radiation, different imaging modalities with low dose and/or totally without a dose should be employed in the diagnosis, treatment, and follow-up bearing the aim to optimize diagnosis while minimizing the radiation dose as much as possible.

Key Words: urolithiasis ↔ SWL ↔ radiation exposure ↔ follow-up

INTRODUCTION

There are various invasive and non-invasive treatment modalities in kidney and ureter stone treatments, each with inherent advantages, disadvantages, and differing stone free rates. Patients undergoing shock wave lithotripsy (SWL) due to urolithiasis make up a major part of the urological practice because

of the various diagnostic procedures used. Imaging plays a significant role in the diagnosis, treatment, and follow-up of urolithiasis. Although ultrasonography, plain abdominal radiography (KUB), and intravenous urography (IVU) are widely used in urolithiasis diagnosis, non-contrast computer tomography (NCCT) is accepted as the golden standard in the urinary system stone diagnosis due to the higher sensitivity and specificity when compared to IVU [1].

Urolithiasis with a high recurrence rate of 50%, affects 5–15% of the total world population. Simple renal calculi of <2 cm can be successfully treated up to 80–85% of the time with SWL in patients with normal renal anatomy [2]. There are numerous factors with an impact on both the urologists' and patients' diagnosis and treatment-related decision making mechanisms. Radiation exposure due to high recurrence rate and intense and close follow up is among one of the important disadvantages of SWL in urolithiasis. It is estimated that radiation exposure during NCCT to diagnose urolithiasis may lead to fatal malignancy in 1/1000 [3]. Throughout a single year, 50 millisieverts (mSv) or 20 mSv per year for a 5-year period are accepted as the threshold levels for "safe" exposure by the International Commission on Radiological Protection (ICRP) [4]. A recent study about the effective radiation exposure in evaluation and follow-up of patients with urolithiasis confirmed that 17.3% had surpassed that 50 mSv/a year threshold level determined by the ICRP within the first year [5]. Effective radiation exposure (ERE) evaluation during the one year follow-up of urolithiasis patients following the SWL treatment was calculated and compared according to stone locations in the present study.

MATERIAL AND METHODS

With a minimum follow-up of 12 months, 129 patients who had undergone SWL (ELMED Complit lithotripsy system, Turkey) due to renal stones ≤ 20 mm, ureteral stones ≥ 10 mm, and/or in conditions requiring active removal of the stones in size of <10 mm from September 2010 to January 2012 were reviewed retrospectively. Patient age, gender, and number of ionizing radiation sessions, including images obtained via KUB, IVU and CT were registered. Exclusion criteria: patients younger than 18 and older than 80 years of age, surgical intervention following SWL, presence of conditions decreasing SWL efficacy such as severe obesity, skeletal malformations, renal insufficiency,

and composition of the stone (hardness such as cystine), participation less than a year.

The amount of effective radiation exposure for each scan was calculated using the dose length product (DLP) of the CT scanner (Siemens Somatom Emotion 16 CT Scanner, Germany) during a standard CT scan protocol. The effective radiation exposure dose (reported in mSv) of each CT scan was calculated by multiplying the DLP (reported in mSv/cm) by the 0,015 conversion factor [6, 7]. ERE doses for the 2-view KUB was calculated as 1.7 mSv and for an IVU as 2.5 mSv [5, 8]. Total ERE doses for each patient was calculated by adding up the radiation doses of each ionizing radiation session, including images (IVU, KUB, CT) throughout a one year follow-up period following the SWL.

Data analysis was conducted using an SPSS version 20 package program. Statistical analysis of the variance was made with a One-Way ANOVA test. $P < 0.05$ was taken as the cut-off point to determine the statistical significance.

RESULTS

A total of 129 patients, 42 female and 87 male, were evaluated in the present study. In the kidney stone group there were 44 patients, 14 female and 30 male with a mean age of 43.4 (23-76). In the ureter stone group there were 41 patients, 13 female and 28 male with a mean age of 45.2 (26-73). In the multiple location (renal-renal, renal-ureter, ureter-ureter) group, there were a total of 44 patients, 15 female and 29 male, with a mean age of 46.9 (24-73). The mean number of KUB in the kidney stone group was 6.2 (1-14), in the ureter stone group 4.9 (0-11), and in the multiple location stone group 8.25 (2-18). The mean number of IVU in the kidney stone group was 0.56 (0-1), in the ureter stone group 0.29 (0-1), and in the multiple location group 0.63 (0-3). The mean number of CT scans in the kidney stone group was 0.59 (0-2), in the ureter stone group 0.51 (0-2), and in the multiple location group 1.38 (0-4) (Table 1), (Figure 1).

Table 1. Patients' characteristics and stone imaging/ ERE (effective radiation exposure) features

	Kidney stone Group	Ureter stone Group	Multiple location stone Group
Number of patients (n=female/male)	44=14/30	41=13/28	44=15/29
Mean age	43.4 (23-76)	45.02 (26-73)	46.9 (24-73)
Mean KUB number	6.2 (1-14)	4.9 (0-11)	8.25 (2-18)
Mean IVU number	0.56 (0-1)	0.29 (0-1)	0.63 (0-3)
Mean CT number	0.59 (0-2)	0.51 (0-2)	1.38 (0-4)
Mean ERE Dose (mSv)	15.91 (5.10-27.60)	13.32 (5.10-24.70)	27.02 (9.41-54.85)
Statistical ERE Evaluation (p*)	(p=0.221)	(p=0.221)	(p=0.000)

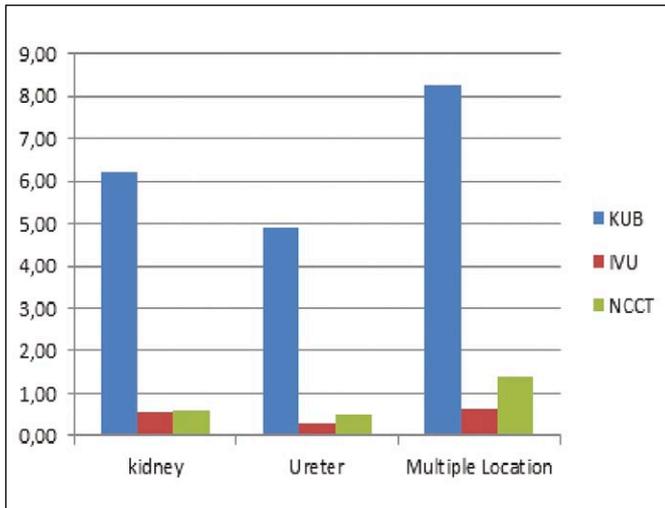


Figure 1. Stone location and ionizing radiation imaging numbers.

Total mean ERE values for the kidney stone group was calculated as 15.91 mSv (5.10-27.60), for the ureter group as 13.32 mSv (5.10-24.70), and in the multiple stone location group as 27.02 mSv (9.41-54.85). There were no statistically significant differences between the kidney and ureter groups in terms of ERE dose values ($p = 0.221$) ($p > 0.05$). In the comparison between the kidney and ureter stone groups with the multiple stone location group; however, there was a statistically significant difference ($p = 0.000$) ($p < 0.05$).

DISCUSSION

The effective dose in radiation protection is a measure of the cancer risk to a whole organism due to ionizing radiation delivered to the part(s) of the body. It takes into account both the type of radiation and the nature of each organ being irradiated. Due to the heterogeneity of organ exposure, a proportional estimate of overall harm is calculated and this estimate is the effective dose expressed in sieverts (Sv). Studies linked to cancer related mortality due to radiation exposure emerged after the Hiroshima and Nagasaki disasters during the 2nd World War and continued with the use of nuclear energy facilities. As reported by the US National Research, a high risk of cancer related mortality with exposure to a radiation doses as low as 100 mSv prevails in 1 per 100,000 patients highlighting the relation between solid organ and hematological malignancy and the exposure to radiation [9].

Urolithiasis patients are exposed to higher radiation due to the radiologic diagnostic tools employed such as KUB, IVU, CT and especially NCCT and thus are in jeopardy of cancer. In their study on national trends, diagnoses, and predictors of urinary tract stones, Westphalen et al. determined that the NCCT

use to assess patients with suspected stones increased disregarding the relatively high radiation dose drawback by approximately 10 times from 4% to 42.5% without an associated change in the proportion of kidney stone diagnoses between 1996 and 2007 [10]. In their study about computed tomography scans related with cancer risks, Berrington de Gonzales et al. estimated that 29,000 cancer cases determined in the US in 2007 were related with a high proportion to abdomen and pelvis CT scans. Three NCCT scans, each with an approximate exposure of 20mSv radiation, would be approximately equivalent to the radiation exposure of an atomic bomb survivor in Japan 3 km within the detonation site [11, 12]. 1.5–2% of all cancer types are estimated to be CT-related. There is a 5-fold increase of this risk in children due to probable DNA damage in rapidly replicating cells and the long developmental latency of these malignancies [13, 14]. Hence, patients as well as practitioners are recommended to follow the guidelines of the International Commission on Radiation Protection (ICRP) of yearly exposure with no more than 20 mSv per year during a 5-year period or 50 mSv in any single year. Whenever possible, alternative imaging methods such as ultrasonography or abdominal radiography to follow-up larger stones, renal calculi in children, and for normal-body habitus patients should be preferred in order to minimize ERE. Depending on BMI and stone size, ERE doses were determined to be higher in kidney stones in a comparative study of ERE doses in which fluoroscopy was used. The underlying reason of this might be attributed to the fact that urologists have an increased preference for extensive fluoroscopy use in order to determine the stone fragments [15]. Among the urolithiasis patients, 17.3% of the patients had surpassed the ERE dose of 50 mSv in the first year follow-up but remained within the limits during the second year in the study made by Fahmy et al. They also expressed that ERE doses were unrelated with patient age, gender, stone size and location [5]. However, in the present study approximately 1% surpassed the 50 mSv/yearly ERE dose. The reason behind this outcome might be the exclusion of the fluoroscopic ERE dose. In the present study, the 50 mSv/yearly ERE dose was surpassed only in the multiple stone location group by a single patient; yet, the numerous patients that were in this group were close to the yearly border limit. If the fluoroscopic ionized radiation exposure during the SWL would have been taken into consideration, ERE doses would have been higher and even surpassing the yearly limit. This stems from the fact that stones at multiple sites are to be treated with more SWL sessions and depending on their stone free rates require a closer follow-up with more images. Multi-

plicity and higher stone burden has a negative impact on the stone-free rates of urolithiasis patients. Moreover, if not treated, due to secondary factors such as chronic pain, infection, and growth of residual stones leading to obstructions increases the comorbidity factors of the patients. Hence, they become a member of a high risk group. Therefore, patients with multiple stone locations and a high stone burden need a more frequent periodic evaluation. In order to achieve effective radiation with low total ERE dose, low dose imaging methods such as low-dose CT scans with high sensitivity and specificity, up to 99%, could be preferred in patients treated with SWL for urolithiasis [16]. In the Jellison et al. study, using the ultra-low dose CT protocol (7.5 mA seconds) approximately close to one KUB ERE dose, radiation exposure was decreased by 95% without conceding the sensitivity and specificity similar to those of the conventional CT (140 mA seconds) [3]. High KUB use in the present study is due to the fact that it is fast and practical after a SWL session. The low number of KUB amount in the Ferrandino et. al. study on radiation exposure in the acute and short-term management of urolithiasis during a one year follow-up at two academic centers can be attributed to high URS and PNL and low SWL numbers, of 4% only, leading to higher stone free rates and thus less frequent follow-up visits [8]. They were no statistically significant differences in the patients exceeding the total ERE level of 50 mSv in terms of stone numbers, location, stone composition, patient age, gender, and surgical intervention modality. As an alternative to NCCT, KUB combined with ultrasonography is proposed to decrease the ERE doses

with minimal loss to the diagnostic accuracy and the determination of clinically unimportant extra-urinary pathology [17, 18]. The use of imaging methods such as NCCT, KUB, and IVU with ionized radiation in patients with urolithiasis and the use of fluoroscopy in SWL make them bare and vulnerable to the harmful effects of ionized radiation as if in a nuclear environment; a fact that is most of the time highly disregarded by the urologists asking for these images for a definitive diagnosis and treatment modality.

CONCLUSIONS

In conclusion, due to the high recurrence of stone diseases and the necessity of long-term follow-up and treatment-retreatment, ERE dose should be a factor to be considered right at the initiation of any diagnostic and/or therapeutic procedure. Hereby, the maximum ERE dose of 20 mSv should not be surpassed, especially in cases of multiple stones present. Due to the high exposure to ionized radiation in diagnostics, treatment and follow-up, aiming at optimizing diagnostics with minimizing radiation dose is important. Yet a definitive diagnosis should not be sacrificed for the sake of minimal radiation exposure. For young people, in particular, providing detailed information about the exposure of radiation, registration of the risk group, preference of non-ionized imaging methods, and the selection of intervention procedures providing the highest stone free status could be among the measures taken to prevent high radiation exposure.

CONFLICTS OF INTEREST

The authors declare no conflicts of interest.

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