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Original Article

Worldwide variations in the knowledge and use of fluoroscopy during percutaneous nephrolithotomy—should we do better? A survey by the European Association of Urology Section for Uro-Technology and the International Alliance of Urolithiasis

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Abstract *Objective:* This study aimed to investigate the level of knowledge among urologists of usage of fluoroscopy during percutaneous nephrolithotomy.
Methods: We conducted an anonymous internet-based survey addressed to the EAU Section of Uro-Technology and the International Alliance of Urolithiasis members with particular interest in the stone treatment at all levels of expertise. The final version of the questionnaire included 31 questions, evaluated the level of knowledge on X-ray utilization and exposure, and identified correlations between geographic areas, levels of seniority, surgical volumes, and awareness on radiation protection.
Results: In total, 586 respondents were included. Knowledge of fluoroscopy settings appeared low, particularly among trainees (up to 87.5% were uninformed, $p=0.008$). Precautions to reduce exposure appeared poorly followed as up to 25.4% of respondents used regularly continuous fluoroscopy, and up to 20.5% used regularly high-frequency setting and this trend was more obvious among senior specialists (6.2% of trainees used high-frequency settings *vs.* 21.3% of consultants, $p<0.05$). Additionally, only 24.9% of respondents would provide X-ray protection to patients too.
Conclusion: Although high and routinary utilization of X-rays, the level of awareness and adhesion to "as low as reasonably achievable" principles among endourologists seems suboptimal in 65.0% of all respondents. Highest volume surgeons, inevitably at higher risk, do not seem to adopt more precautions. More efforts should be addressed to improve these results, reducing the risk related to excessive radiation exposure for both surgical staff and patients in order to minimize health related issues.

1. Introduction

Urolithiasis is a common health problem with an increasing prevalence rate of 14% and a 10% estimated lifetime risk [1,2]. It remains one of the commonest causes of emergency visits and hospital admissions, and one out of seven of these affected individuals will require active treatment [3]. A study from England with an investigation period of 8 consecutive years, revealed an increment of all stone-related procedures, with only exception of extracorporeal shock wave lithotripsy [4]. Therefore, a proportionate increase of X-ray utilization is expected, with possible additional harms for both patients and surgical staff. X-rays have fundamental implications in modern medicine, including diagnostic and interventional purposes. Unfortunately, they have well-known deleterious effects. Patients are repeatedly exposed to radiations during diagnosis, treatment, and follow-ups. Repeated X-ray exposure is associated with radiation-induced hazards and risks of secondary malignancies. The real burden of this risk is not well defined, but approximately 1%–2% of all cancers in the United States are believed caused by CT studies, as shown by Brenner and Hall [5]. Meanwhile, data from Berrington de González et al. [6], predicted that 29 000 additional cancers and 14 500 deaths were caused by CT examinations. Additionally, there are some evidences that low-doses (either during single or repeated exposure) of radiations during childhood and adolescence may increase the risk of solid and hematologic cancers [7,8].

Endourology is inherently associated with the use of peri-procedural radiations, resulting in increased radiation exposure (RE) to patients, nursing, and medical personnel. Low-dose non-contrast-enhanced CT (NCCT) has been proposed as a standard tool because of its high sensitivity and specificity for the evaluation of stone events and stone imaging, as recommended by the European Association of Urology (EAU) and the American Urological Association guidelines on urolithiasis. This imaging modality can correspond to up to 1.6 milli-Sievert (mSv) of RE to patients [4,9]. Although considered a low-dose imaging modality, the use of NCCT in stone patients has raised from 4% to 42.5% during periodic follow-ups, while in the emergency setting it rose from 19.6% to 45.5% [10]. Furthermore, EAU guidelines indicate the use of NCCT every time a new intervention for stones is planned [11]. Fluoroscopy is also necessary during any type of urinary stone intervention, summing up to an increased lifetime RE to patients and operating theater staff. Currently, the modest knowledge exists on RE during endourological procedure for patients. Demirci et al. [12] estimated a median RE of 43.3 mGy for percutaneous nephrolithotomy (PCNL) and 27.6 mGy for retrograde intra-renal surgery. Estimating the absorbed dose among surgical staff is currently rather difficult. In literature, it emerged that PCNL and retrograde intra-renal

surgery can be responsible of 64% and 29%, respectively, of the total absorbed dose from surgeons [13]. Certainly, these data are rather variable and largely influenced by the type of routinary activities of each specialist. Additionally, Cohen et al. [13] showed how a single endourologist could have used fluoroscopy for 252 min, corresponding to 282 mSv, over a 9-month period. Although in some centers "fluoroless" procedures are utilized in particular settings [14], surgeons still routinely rely on ionizing radiations in vast majority of cases.

As a result of rising concern on RE, the International Commission on Radiological Protection has proposed on relatively safe occupational exposure to X-rays, with a cut-off of 50 mSv per year or 20 mSv per year in a 5-year consecutive period [15]. Exposure exceeding this limit is associated with a lifetime risk of one thousandth of fatal cancer [16]. According to Ferrandino et al. [17], 17%—20% of patients with urinary tract stones exceed a 1-year RE limit of 50 mSv during diagnosis, treatment, and follow-ups, particularly if low-dose NCCT protocols are not used. A significant amount of them is delivered during endourological procedures when fluoroscopy is used.

In literature, data investigating surgeons' RE are limited. Demirci et al. [12] calculated an average of 5.61 min and 0.1—0.2 mSv absorbed per case of PCNL, although this can significantly vary according to the intensifier orientation and stone characteristics. Considering the thresholds recommended by the International Commission on Radiological Protection, high-volume surgeons (carrying out >1—2 cases of PCNL per week) will easily reach this limit, making reducing RE crucial.

Medical societies and organizations for medical protection provide indications for annual occupational limits on RE [18] and recommendations such as "as low as reasonably achievable" (ALARA) to reduce RE of both staff and patients [19]. Technical measures to reduce RE during the endourological procedures include reducing the fluoroscopy time, limiting time adjacent to the patient, using low-dose radiation, irradiating only to observe motion, intraoperative use of pulsed fluoroscopy, reducing fluoroscopy pulse rates, using collimated fields, avoidance of digital image acquisition, relying on last image hold, and instant reply technology [20].

Although good evidence exists among radiologists on radiation utilization and their high level of concern and compliance, data on endourological practice are currently quite limited [21,22]. Herein, we present an internet-based survey evaluating the habits of surgeons at different levels of seniority regarding RE in the operating room. We aimed to make an insight into the current PCNL settings and used techniques, with a focus on the level of knowledge on fluoroscopy use, control, and RE protection among health care providers.

2. Methods

2.1. Study design and participants

We conducted an internet-based survey to assess knowledge and habits in the utilization of fluoroscopy in the operating room during PCNL. A non-validated questionnaire has been addressed to urologists worldwide with an interest in stone surgery. The participation has been voluntary, and the questionnaire was filled out anonymously and diffused via e-mail using Google Docs to members of the EAU Section of Uro-Technology and the International Alliance of Urolithiasis.

We aimed to involve urologists with specific interest in stone surgery at all levels of seniority, including academic and non-academic centers (trainees, academic urologists, and non-academic urologists). Aiming to obtain a larger sample size, no further exclusion criteria were introduced.

2.2. Content of the questionnaire

A panel of four senior urologists (Durutovic O, Zeng G, Mazzon G, and Choong S) was involved in the creation of the questionnaire (Supplementary file 1). All members had high level of expertise in the field of percutaneous stone treatments as well as in the creation of surveys or consensuses. The main aims were to evaluate the level of knowledge on X-ray utilization and exposure among respondents. We also aimed to identify eventual differences between geographic areas, levels of seniority, and surgical volumes in terms of habits of the utilization of X-ray in the operating rooms.

The initial version of the questionnaire was created and included 26 questions taking into consideration all aspects of the PCNL setup, X-ray utilization, and the strategies to reduce RE during PCNL. During a second meeting, the questionnaire was implemented to 31 questions, including information on affiliations, geographic origins, and levels of seniority. They have been then corrected for eventual grammar and spelling mistakes. The final version was agreed upon by all investigators before being administered. A face validity was conducted with support of five urology specialists and subsequently a pilot test was carried out, using a group of 37 colleagues excluded from questionnaire creation and final data collection. The survey items were multiple-choice and close-ended, using nominal, scale range, and yes/no questions. In its final version, the questionnaire contained a total of 31 questions covering: affiliations and origin of participants (questions 1—4); modalities of utilization of radiations in the operating room (questions 5—10); awareness of strategies to reduce exposure (questions 11—14); modalities of PCNL execution (questions 15—23); internal hospital regulations and ultrasound utilization (questions 24—31). In this study, we analyzed questions inherent to levels of awareness and modalities of X-ray usage.

2.3. Statistical analysis

Analyses have been carried out by a statistician who was not involved with creation of the questionnaire and data collection. Frequencies and proportions were used for categorical variables. Categorical variables were tested with the Chi-square test. Answers to different questions have been categorized based on geographic origin, level of seniority (resident, urology consultant, assistant professor,

associate professor, or full professor), and surgical volumes expressed as the number of PCNL per week (1–2, 3–4, 5, or more). Correlations have been made between these three categories and questions 4–7, 10, 12, 24, and 28. All tests were two-sided, and significance was fixed at $p<0.05$. Statistical analyses were performed using SPSS v.24 (IBM SPSS Statistics for Mac, IBM Corp., Armonk, NY, USA). We could estimate a sample size of at least 380 respondents, considering a population size of 8000 specialists, with a 95% confidence level and a 5% margin of error.

3. Results

A total of 586 respondents adhered to the survey, with all questionnaires completely filled. Among them, 458 (78.2%) were urologists; 39 (6.7%) were assistant professors; 28 (4.8%) were associate professors; 29 (4.9%) were full professors; and 32 (5.5%) were urologists in training. Most answers were collected in Asia, including 250 (42.7%) from India and 202 (34.5%) from China. Sixty-six (11.3%) were collected from Europe and 68 (11.6%) from other parts of the world. On average, 327 (55.8%) surgeons performed 1–2 cases of PCNL per week, 152 (25.9%) 3–4 cases of PCNL per week, whereas 107 (18.3%) more than 5 procedures per week.

In Table 1, answers according to surgeons' seniority are reported. Knowledge on RE appears to be rather poor among surgeons in training as only 68.8% of them were aware of the possibility of adjusting the fluoroscopy setting, and 43.8% could not state which type of fluoroscopy setting was regularly used. In fact, 43.8% did not know whether they were using continuous or pulsed fluoroscopy and majority of respondents were not aware of how many frames per second (fps) the intensifier could deliver, and this percentage is particularly higher among surgeons in training (87.5%, $p=0.008$). Additionally, they also

Table 1 The correlation between seniority levels and answers ($n=586$).

Characteristic of participants and questions asked	Survey participant, *n* (%)[a]			*p*-Value
	Urologist in training, 32 (5.5%)	Urologist, 458 (78.2%)	Urological academic, 96 (16.4%)	
Hospital type				<0.001
General	11 (34.4)	236 (51.5)	20 (20.8)	
University	18 (56.2)	44 (9.6)	52 (54.2)	
Private	3 (9.4)	173 (37.8)	23 (24.0)	
Other institution	0 (0)	5 (1.1)	1 (1.0)	
Country				<0.001
European countries	12 (37.5)	41 (9.0)	13 (13.5)	
India	13 (40.6)	172 (37.6)	65 (67.7)	
China	0 (0)	202 (44.1)	0 (0)	
Rest of the world	7 (21.9)	43 (9.4)	18 (18.8)	
Possibility of adjusting FS setting on X-ray C-arm	22 (68.8)	411 (89.7)	85 (88.5)	0.002
FS shot control				0.006
Modality of FS shot control	6 (18.8)	223 (48.7)	48 (50.0)	
By command given to the radiology technician	16 (50.0)	108 (23.6)	22 (22.9)	
Both	10 (31.2)	127 (27.7)	26 (27.1)	
FS setting				<0.001
Not sure, must check it	14 (43.8)	104 (22.7)	7 (7.3)	
Continuous FS	6 (18.8)	118 (25.8)	25 (26.0)	
Pulsed FS	12 (37.5)	236 (51.5)	64 (66.7)	
C-arm fps				0.008
>25 to ≤30	1 (3.1)	35 (7.6)	3 (3.1)	
>15 to ≤25	1 (3.1)	73 (15.9)	7 (7.3)	
>8 to ≤15	2 (6.2)	27 (5.9)	13 (13.5)	
>4 to ≤8	0 (0)	27 (5.9)	5 (5.2)	
>2 to ≤4	0 (0)	7 (1.5)	4 (4.2)	
Not sure	28 (87.5)	289 (63.1)	64 (66.7)	
FS time and radiation dose record during PCNL	9 (28.1)	172 (37.6)	43 (44.8)	0.200
Knowledge of allowed threshold for RE	6 (18.8)	163 (35.6)	51 (53.1)	<0.001
Protective equipment				<0.001
Just for OR staff	30 (93.8)	296 (64.6)	83 (86.5)	
For both OR staff and patients	2 (6.2)	132 (28.8)	12 (12.5)	
No specific protective strategy yet	0 (0)	30 (6.6)	1 (1.0)	
Person in charge of RE	16 (50.0)	231 (50.4)	52 (54.2)	0.796

FS, fluoroscopy; fps, frames per second; OR, operative room; PCNL, percutaneous nephrolithotomy; RE, radiation exposure.
[a] Percentages may not add up to 100% due to rounding.

considered the possibility of providing X-ray protection to patients in fewer cases (surgeons in training, specialized urologists, and academic urologists would provide protections to patients in only 6.2%, 28.8%, and 12.5%, respectively, $p<0.001$). Moreover, a significant number of participants adopt strategies requiring a higher RE, as 18.8%, 25.8%, 26.0% of urologists in training, urologists, academic urologists, respectively, used continuous fluoroscopy ($p<0.001$), and up to 20.5% used high fps (15–25 fps or 25–30 fps); this trend was more obvious among senior specialists (6.2% of trainees used high-frequency settings *vs.* 21.3% of consultants, $p<0.05$).

Table 2 reports correlations between results and the geographic origins of surgeons. It emerged that habits significantly varied in different regions of the world. Pulsed fluoroscopy (the Question 6 in the questionnaire shown in Supplementary file) resulted being preferred by 74.2% of European respondents (with 16.7% of surgeons unaware of settings), whereas the lowest rate of pulsed fluoroscopy use was among Asian surgeons, particularly in China (38.6% declared to use pulsed settings and 36.6% were unable to respond, $p<0.001$). A significant degree of unawareness was confirmed among all respondents (overall, 65.0% of all respondents could not state the used fps, $p<0.001$), and higher frequencies were used particularly by Chinese surgeons (35.6% using at least 15 fps).

In Table 3, correlations between surgical volumes and characteristics of participants or questions asked are presented. Lack of knowledge still emerged, as 17.1%–24.5% of participants were unaware of their utilized fluoroscopy settings, with a higher percentage represented by lower volume surgeons (1–2 cases of PCNL per week, $p=0.024$). Additionally, up to 32.9% of participants from surgical volume of 3–4 cases of PCNL per week would use continuous fluoroscopy. When interrogated on fps, up to 70.1% of participants from surgical volume of ≥5 cases of PCNL per week did not answer. A minority of surgeons would routinely record the intraoperative X-ray dose; these data appeared particularly low among lower volume surgeons (34.6% doing 1–2 cases of PCNL per week *vs.* 43.9% doing ≥5 cases of PCNL per week, $p=0.04$).

Table 2 The correlation between geographic origins and answers ($n=586$).

Characteristic of participants and questions asked	Survey participant, *n* (%)[a]					*p*-Value
	Total, 586 (100)	European countries, 66 (11.3)	India, 250 (42.7)	China, 202 (34.5)	Rest of the world, 68 (11.6)	
Participant						<0.001
Urologist in training	32 (5.5)	12 (18.2)	13 (5.2)	0 (0)	7 (10.3)	
Urologist	458 (78.2)	41 (62.1)	172 (68.8)	202 (100)	43 (63.2)	
Urological academic	96 (16.4)	13 (19.7)	65 (26.0)	0 (0)	18 (26.5)	
Hospital type						<0.001
General	267 (45.6)	15 (22.7)	29 (11.6)	201 (99.5)	22 (32.4)	
University	114 (19.5)	48 (72.7)	38 (15.2)	1 (0.5)	27 (39.7)	
Private	199 (34.0)	2 (3.0)	179 (71.6)	0 (0)	18 (26.5)	
Others	6 (1.0)	1 (1.5)	4 (1.6)	0 (0)	1 (1.5)	
Possibility of adjusting FS setting on X-ray C-arm	518 (88.4)	54 (81.8)	217 (86.8)	187 (92.6)	60 (88.2)	0.077
FS shot control						<0.001
Yourself with foot pedal	277 (47.3)	22 (33.3)	106 (42.4)	98 (48.5)	51 (75.0)	
By command to the radiology technician	146 (24.9)	36 (54.5)	76 (30.4)	29 (14.4)	5 (7.4)	
Both	163 (27.8)	8 (12.1)	68 (27.2)	75 (37.1)	12 (17.6)	
FS setting						<0.001
Not sure, must check it	125 (21.3)	11 (16.7)	32 (12.8)	74 (36.6)	8 (11.8)	
Continuous FS	149 (25.4)	6 (9.1)	73 (29.2)	50 (24.8)	20 (29.4)	
Pulsed FS	312 (53.2)	49 (74.2)	145 (58.0)	78 (38.6)	40 (58.8)	
C-arm fps						<0.001
>25 to ≤30	39 (6.7)	2 (3.0)	9 (3.6)	23 (11.4)	5 (7.4)	
>15 to ≤25	81 (13.8)	7 (10.6)	17 (6.8)	49 (24.3)	8 (11.8)	
>8 to ≤15	42 (7.2)	10 (15.2)	15 (6.0)	8 (4.0)	9 (13.2)	

(*continued on next page*)

Table 2 (*continued*)

Characteristic of participants and questions asked	Survey participant, *n* (%)[a]					*p*-Value
	Total, 586 (100)	European countries, 66 (11.3)	India, 250 (42.7)	China, 202 (34.5)	Rest of the world, 68 (11.6)	
>4 to ≤8	32 (5.5)	2 (3.0)	15 (6.0)	5 (2.5)	10 (14.7)	
>2 to ≤4	11 (1.9)	1 (1.5)	4 (1.6)	3 (1.5)	3 (4.4)	
Not sure	381 (65.0)	44 (66.7)	190 (76.0)	114 (56.4)	33 (48.5)	
FS time and radiation dose record during PCNL	224 (38.2)	36 (54.5)	78 (31.2)	74 (36.6)	36 (52.9)	<0.001
Knowledge of allowed threshold for RE	220 (37.5)	25 (37.9)	101 (40.4)	72 (35.6)	22 (32.4)	0.580
Protective equipment						
Just for OR staff	409 (69.8)	56 (84.8)	219 (87.6)	77 (38.1)	57 (83.8)	<0.001
For both OR staff and patient	146 (24.9)	9 (13.6)	28 (11.2)	100 (49.5)	9 (13.2)	
No specific protective strategy yet	31 (5.3)	1 (1.5)	3 (1.2)	25 (12.4)	2 (2.9)	
Person in charge of RE	299 (51.0)	50 (75.8)	95 (38.0)	123 (60.9)	31 (45.6)	<0.001

FS, fluoroscopy; fps, frames per second; OR, operative room; PCNL, percutaneous nephrolithotomy; RE, radiation exposure.
[a] Percentages may not add up to 100% due to rounding.

4. Discussion

This study included the largest cohort of endourologists, interrogated on X-ray utilization during PCNL, and aimed to understand the degree of awareness in different countries and with different degrees of experience, ranging from trainees to senior professors. Our study shows that although routinary utilization of radiations was performed, urologists did not seem adhering to ALARA principles. For example, 25.4% of participants used continuous fluoroscopy, and 20.5% used at least 15 fps or higher as fluoroscopic guidance. Surprisingly, 51.0% of respondents declared to work in an institution with a person in charge of RE monitoring (Table 2). Although differences are noted among higher volume surgeons (≥5 cases of PCNL per week), they did not seem to adopt better precautions, compared to smaller volume ones (Table 3). Also, only 24.9% of participants would regularly provide protective gear to patients. We believe that more actions should be taken in the endourological field to reduce unnecessary RE.

Level of knowledge and awareness among specialists have been previously investigated, although data remain sparce with alternate outcomes. Altintas et al. [23] presented a cohort of 226 Turkish urologists with no sub-specialization in stone surgery, and more than 50% of respondents reported they had no literature information on possible hazards of X-ray usage. Also, above 75% of them were not regularly using dosimeters. Harris et al. [24] involved 136 urologists in training from the United States. When interrogated on general radiation safety topics, approximately 46% of them were unable to respond correctly. However, no questions were made to evaluate ALARA principles or X-ray settings. Our paper provides some exciting additions to available studies. First of all, surgeons from different continents have been involved, including areas previously non-investigated. Additionally, we focused on ALARA strategies that can reduce RE during PCNL.

In this study, 65.0% of participants were uncertain about the frame rate generated by their C-arm fps (as high as 87.5% among trainees), and approximately 21.3% of participants were unable to determine whether they were using pulsed or continuous fluorescence mirrors, especially among trainees (43.8%).

Our results showed that 61.8% of participants did not record fluoroscopy time and radiation doses of PCNL, and 62.5% of participants did not know what the allowed RE threshold was.

Our study has some limitations. Firstly, the survey questionnaire was not validated as we did not plan to generate a standardized tool, but mainly to collect information regarding the habits and strategies of surgeons. Moreover, due to the voluntary participation of respondents, different subgroups were not equally represented, with a limited number based in European countries (66 [11.3%] of all the participants) and younger surgeons represented 32 (5.5%) of all the trainees.

Table 3 The correlation between surgical volumes and answers ($n=586$).

Characteristic of participants and question asked	Case of PCNL per week, *n* (%)[a]			*p*-Value
	1–2, 327 (55.8)	3–4, 152 (25.9)	≥5, 107 (18.3)	
Participant				0.118
Urologist in training	22 (6.7)	4 (2.6)	6 (5.6)	
Urologist	259 (79.2)	122 (80.3)	77 (72.0)	
Urological academic	46 (14.1)	26 (17.1)	24 (22.4)	
Country				<0.001
European countries	53 (16.2)	7 (4.6)	6 (5.6)	
India	122 (37.3)	66 (43.4)	62 (57.9)	
China	109 (33.3)	62 (40.8)	31 (29.0)	
Rest of the world	43 (13.1)	17 (11.2)	8 (7.5)	
Hospital type				0.116
General	150 (45.9)	77 (50.7)	40 (37.4)	
University	71 (21.7)	20 (13.2)	23 (21.5)	
Private	101 (30.9)	54 (35.5)	44 (41.1)	
Others	5 (1.5)	1 (0.7)	0 (0)	
Possibility of adjusting FS setting on X-ray C-arm	279 (85.3)	141 (92.8)	98 (91.6)	0.032
FS shot control				0.329
Yourself with foot pedal	142 (43.4)	78 (51.3)	57 (53.3)	
By command given to the radiology technician	89 (27.2)	34 (22.4)	23 (21.5)	
Both	96 (29.4)	40 (26.3)	27 (25.2)	
FS setting				0.024
Not sure, must check it	80 (24.5)	26 (17.1)	19 (17.8)	
Continuous FS	67 (20.5)	50 (32.9)	32 (29.9)	
Pulsed FS	180 (55.0)	76 (50.0)	56 (52.3)	
C-arm fps				0.031
>25 to ≤30	25 (7.6)	11 (7.2)	3 (2.8)	
>15 to ≤25	35 (10.7)	30 (19.7)	16 (15.0)	
>8 to ≤15	29 (8.9)	6 (3.9)	7 (6.5)	
>4 to ≤8	14 (4.3)	14 (9.2)	4 (3.7)	
>2 to ≤4	6 (1.8)	3 (2.0)	2 (1.9)	
Not sure	218 (66.7)	88 (57.9)	75 (70.1)	
FS time and radiation dose record during PCNLs	113 (34.6)	64 (42.1)	47 (43.9)	0.116
Knowledge of allowed threshold for RE	107 (32.7)	65 (42.8)	48 (44.9)	0.024
Protective equipment				0.328
Just for OR staff	234 (71.6)	96 (63.2)	79 (73.8)	
For both OR staff and patients	76 (23.2)	47 (30.9)	23 (21.5)	
No specific protective strategy in our OR yet	17 (5.2)	9 (5.9)	5 (4.7)	
Person in charge of RE	170 (52.0)	82 (53.9)	47 (43.9)	0.247

FS, fluoroscopy; fps, frames per second; OR, operative room; PCNL, percutaneous nephrolithotomy; RE, radiation exposure.
[a] Percentages may not add up to 100% due to rounding.

Lastly, we cannot provide the response rate as the survey was distributed to the International Alliance of Urolithiasis and Section of Uro-Technology members and we were unaware of the total number of surgeons contacted via mail. Nevertheless, this represents the largest cohort of surgeons interrogated on the utilization of X-ray in the operative room during PCNL, including a large sample of high-volume endourological surgeons (259 respondents out of 586 [44.2%] carried out at least three cases of PCNL per week).

Several important elements emerged from this document, highlighting the need for further studies on RE among endourologists to better address which surgical steps are associated with higher RE and how the ALARA principles can effectively be applied. Certainly, further studies are needed, to define the real RE for surgeons during stone procedures including a better evaluation of the real burden of X-ray exposure. Meanwhile, we emphasize the need to adhere to ALARA principles and a better awareness of X-ray exposure for patients and surgical staff.

5. Conclusion

We present a survey involving a large cohort of endourologists, interrogated on RE during PCNL. Our data suggest that a large proportion of specialists are not aware of settings and/or do not adopt strategies in adherence to ALARA principles. Highest volume surgeons, inevitably at higher risk, do not seem to adopt more precautions. The lack of clear instructions from urological societies underlines the need for training on X-ray utilization and adoption of ALARA principles to better support trained surgeons and trainees.

Author contributions

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Conflicts of interest

The authors declare no conflict of interest.

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Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.ajur.2024.02.004.

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