Editorial Commentary

Radiation-free RIRS and setting a new standard: redefining safety and efficacy in stone surgery

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With the global prevalence of kidney stone disease (KSD) on the rise, the field of endourology has seen remarkable advancements, as cutting-edge techniques and innovative technologies coupled with enhanced training now deliver safer outcomes and more effective results. While KSD can be asymptomatic, many patients experience haematuria, urinary tract infections (UTI) or pain culminating in multiple hospital admission and interventions (1).

Historically open surgery was the preferred management option, but treatment paradigm however has now shifted to minimally invasive procedures, with factors such as stone size, location, volume, anatomical considerations, co-morbidities and patient preferences helping clinicians personalize treatment plans for better end results. Guidelines issued by organizations such as the American Urology Association (AUA) and the European Association of Urology (EAU) provide comprehensive, evidence-based recommendations designed to assist clinicians in developing tailored management strategies for KSD. Both the AUA and EAU find a consensus on treating stones of >20 mm with percutaneous nephrolithotomy (PCNL) and for those <20 mm the suggestion is either ureteroscopic stone removal (URS) or shock wave lithotripsy (SWL) (2). Despite availability of various treatment options, the end goal remains the same, achieving a high stone free rate (SFR) with minimal morbidity, the definition of which varies in literature influenced by the imaging technique to assess residual stones post operatively and the timing of this evaluation (3). Retrograde intrarenal surgery (RIRS) for renal calculi, as an alternative to SWL and PCNL, presents as less morbid and minimally invasive in comparison to PCNL and potentially yields a higher SFR than SWL (4).

Generally as a basic principle RIRS is performed under fluoroscopic guidance (5), which is primarily utilized for gaining initial access to the ureters, facilitating the navigation of stones, and ensuring the accurate placement of guidewires, ureteral access sheath (UAS) and stents (6). Exposure of patient and the operative room (OR) staff however, to ionizing radiations from the use of fluoroscopy is becoming increasingly concerning owing to the rise in the use of RIRS for KSD. The median effective dose (measurement that correlates absorbed dose with the harmful consequences of exposure, including the risk of malignancy development) for a URS procedure ranges from 0.67 to 2.23 mSV (7). The National Council on Radiation Protection and Measurements has established an annual occupational exposure limit of 50 mSv, but there are no specific exposure limits for patients in medical settings. Instead, the potential risks associated with radiation must be carefully weighed against the clinical necessity and benefits of therapeutic procedure (8). Radiation-induced malignancies are considered stochastic effects, as they can

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occur from any radiation dose due to the potential for DNA damage, regardless of exposure level. In contrast, deterministic effects, such as cataracts and skin burns, manifest only after a certain threshold dose is exceeded, with their severity increasing proportionally to the radiation dose. Although fluoroscopy is a notable source of radiation exposure (RE), the radiation levels associated with ureteroscopy are well below the thresholds required to induce deterministic effects (9).

Owing to the above mentioned risks, techniques are now being defined to attempt a reduction in the RE for endourological procedures while adhering to the protocols of ALARA (as low as reasonably achievable) (10) and at the same time ensuring there is no compromise in the end results or an increase in the complication rate (11).

Strict adherence to checklists before initiating endourological intervention, especially exhaustive reviewing of available radiological imaging has shown to reduce RE (12). Additionally checklists within the operating room ensuring adequate patient and C-arm positioning, appropriate C-arm setting and adaption of radiation protection measures by all operating room personnel are essential to reducing the RE (11). Use of a pre-fluoroscopy quality checklist has proven to reduce fluoroscopy screening time (FST) by a massive 67% (13).

Furthermore, several protocols have been described in the literature to perform URS with minimal possible radiation dose, with the aim of reduction in the FST. These include utilizing a laser-guided C-arm, involving a dedicated fluoroscopy radiographer, ensuring preoperative imaging is readily accessible and thoroughly reviewed, visually identifying the stone with the ureteroscope, and confirming stent position within the bladder. Adherence to these strategies can reduce FST by up to 82% without increasing operative duration, complication rates, or the incidence of residual stones (12). Additionally the use of pulse frequency settings rather than continuous beam on a fluoroscopy unit limits the number of exposure per second and time of exposure to the X-ray beam which can alone reduce FST by 70 seconds without compromise in the diagnostic information (14). Ultralow radiation RIRS is accomplishable by modifying certain techniques (15):

- ❖ Taking decision to omit performing a retrograde pyelogram if endoscope can be advanced successfully all the way to the renal pelvis;
- ❖ Insertion of 2 guidewires under direct vision;
- ❖ Considering the patient's height to select appropriate UAS length for insertion without fluoroscopy;
- ❖ Avoiding additional fluoroscopy if all calyces are visualized by the ureteroscope;
- ❖ Intermittent short X-ray controls rather than continuous guidance for stent insertion.

Fluoroless or completely radiation free RIRS represents an advancement over the low radiation techniques. Advances in optical systems, manoeuvrability and miniaturization of ureteroscopes, and the use of UAS have enhanced navigation of the ureter, renal pelvis, and calyces with excellent visualization. Modern flexible ureteroscopes enable access to the entire pyelocaliceal system, and laser stone fragmentation ensures high safety margins for fragmentation under direct vision thereby paving the path for this approach (16). Emiliani *et al.* describe a 7 step technique for achieving total fluoroless RIRS in presented patients (17):

(I) Procedure should be attempted under a general anaesthetic with a C-arm readily available to use in the operating room, if need be.

(II) Paying close attention to tactile feedback while partially withdrawing the stent and introduction of guidewire through the stent, gentle resistance is felt when the guidewire uncoils the stent and when it reaches the upper pole. Semi rigid ureteroscope should be used in this step for trouble shooting, and if continuing resistance is encountered this warrants the use of fluoroscope.

(III) Semi rigid ureteroscopy under low irrigation pressures to ascertain appropriate guidewire position and inspection of the ureter.

(IV) Selection of a right sized UAS by calculating the distance on the scope between the ureteropelvic junction and urethral meatus. Second guidewire should be introduced while withdrawing the ureteroscope and UAS advanced over it up to the measured desired length with least possible resistance.

(V) Careful visualization of all calyces while corelating with recent images defining the stone position and anatomy.

(VI) Inspection of all calyces following lithotripsy and examining the ureter while removing the UAS.

(VII) Stent if needed can be inserted by cystoscopy, distal coil should be seen in the bladder, ultrasound (US) can direct the renal coil position.

While the above mentioned technique is for presented patients, successful radiation free RIRS has also been demonstrated in non-stented cohort by Chung *et al.*

where for the initial step a first look ureteroscopy was performed with a semirigid scope, followed by introduction of a hydrophilic guidewire through the scope (18). This technique demonstrated a success rate of 78% when compared to the cohort using radiation for RIRS, which achieved a success rate of 80%. More importantly the rate of high-grade ureteral injury was also not remarkably higher than radiation using group, 4.8% *vs.* 3.1% respectively. Peng *et al.* also displayed significant results in the form of SFR of 95.7% and a complication rate of 3.6% (all Clavien <III) when adapting to a radiation free RIRS intervention (16), while applying similar technique of a diagnostic URS prior to RIRS to appreciate the ureteric anatomy, placement of guidewire under direct vision, ensuring the guidewire tip remains in the pelvis while withdrawing the scope and adapting to using a smaller diameter UAS (9.5/11 Fr), in comparison to presented patients where 12/14 Fr sheath was used. Additionally, in cases where a tight ureteric orifice prevents the passage of a ureteroscope in non-stented patients, a guidewire can be advanced through the cystoscope until resistance is encountered, subsequently, a dual-lumen catheter or an 8–10 Fr coaxial dilation set introduced over the guidewire to facilitate dilation of the orifice and intramural ureter (9).

Paediatric population is particularly vulnerable with more radio-sensitive tissue and considerable radiation dose related increase in occurrence rate of solid tumors (19). Fluoroless RIRS can be successfully put to use for this group, and Kirac *et al.* achieved a success rate of 89.2% while performing radiation free RIRS in 95% of their patients along with a remarkable safety profile (20). Fluoroless RIRS is also advantageous in pregnancy and in children to avoid radiation completely (21,22). Perhaps there could also be the use of artificial intelligence (AI) in minimising the use of radiation especially for complex procedures (23).

The emerging evidence suggests that radiation-free RIRS (RF RIRS) is a promising technique that offers comparable efficacy and safety to conventional radiation-usage RIRS (RU RIRS) for the treatment of kidney stones with noninferior success rates and similar complication profiles compared to RU RIRS. The primary advantage of this intervention lies in the elimination of RE, benefiting both patients and medical staff which could potentially lead to wider adoption of RIRS, particularly in settings where radiation protection measures are challenging to implement.

It is however important to note that while fluoroless methods maybe an ideal one, their limitations must be acknowledged, its implementation should be approached with careful consideration of patient factors, including ureteral strictures, renal anomalies (such as fusion or rotation), stone size, possibility of impacted stone or any abnormal anatomy which are all instances where fluoroscopy is recommended (17). Additionally, surgeon experience and available resources must be taken into account as the risk of RE should not overweigh suboptimal results and a decreased safety profile. Where the use of radiation is inevitable, clinicians should specifically adhere to the principles of as low as reasonably achievable. Prospective, multicentre studies with larger patient cohorts and longer follow-up periods and patient reported outcome measures (PROMs) will be crucial in establishing the role of radiation free RIRS in the broader landscape of kidney stone management (24).

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Footnote

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