Editorial Commentary

Feasibility and future directions of radiation-free retrograde intrarenal surgery

Shuzo Hamamoto^, Takahiro Yasui

Department of Nephro-urology, Nagoya City University Graduate School of Medical Sciences, Nagoya, Japan

Correspondence to: Shuzo Hamamoto, MD, PhD. Department of Nephro-urology, Nagoya City University Graduate School of Medical Sciences, 1 Kawasumi, Mizuho-cho, Mizuho-ku, Nagoya, Aichi, Japan. Email: hamamo10@med.nagoya-cu.ac.jp.

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Advancements in endourological technology have significantly increased the adoption of retrograde intrarenal surgery (RIRS). However, radiation exposure during RIRS remains a critical concern for both patients and medical staff. Numerous studies have highlighted the cumulative risks associated with ionizing radiation, including an increased incidence of cancer among patients and urologists (1-3).

Hein *et al.* demonstrated that preoperative training and heightened awareness among surgeons can significantly reduce fluoroscopy time (FT) and dose-area product without compromising the stone-free rates (SFR) or increasing the complication rates (2). These findings underscore the urgent need to minimize radiation use in urological procedures while maintaining safety and efficacy.

Radiation exposure during RIRS varies widely depending on case complexity and the surgeon's technique. Mean FT during RIRS has been reported to range from 0.9 to 5.13 minutes per procedure, with the highest mean radiation exposure recorded at 0.0427 mSv to the eyes, 0.10 mSv to the forehead, and 0.81 mSv to the hands (4). Park *et al.* emphasized the cumulative risks of radiation exposure for urologists, noting that without appropriate protective measures, the annual number of RIRS procedures a urologist can safely perform could drop from 517 to just 85 cases (5). These findings highlight the importance of personal protective equipment and strategies to reduce radiation exposure. The "As Low As Reasonably Achievable" (ALARA) principle has become a cornerstone of radiation safety in endourology, advocating practical measures such as reducing FT, utilizing low-dose settings, and adopting alternative imaging techniques.

Recent technological advancements have facilitated efforts to reduce radiation exposure. Low-dose pulse fluoroscopy and single-shot imaging techniques have significantly lowered radiation levels during ureteroscopy (6-8). Hein *et al.* reported that standardized protocols and surgeon education reduced FT from 130.8 to 77.4 seconds across multiple centers, showcasing the effectiveness of awareness-driven interventions (2).

The European Association of Urology (EAU) now emphasizes minimizing radiation exposure wherever feasible and encourages adopting fluoroscopy-free techniques, particularly in centers with experienced practitioners (9).

Chung *et al.* (10) conducted a randomized controlled trial (RCT) and concluded that radiation-free (RF) RIRS is non-inferior to radiation-usage (RU) RIRS in terms of success rates (78% *vs.* 80%) and complication rates, including high-grade ureteral injuries (4.8% *vs.* 3.1%). This milestone study highlights the potential of RF RIRS to eliminate radiation exposure without compromising surgical outcomes. RF RIRS offers significant advantages, including eliminating radiation-related risks and removing the need for surgeons

^ ORCID: 0000-0002-9968-7468.

and assistants to wear protective gear. However, RF RIRS requires meticulous surgical techniques, such as using a semi-rigid ureteroscope for initial visualization and careful placement of guidewires and ureteral access sheaths (UAS) under direct vision. Previously, we reported that 13.0% of patients who underwent ureteroscopic lithotripsy had distal ureteric tightness (DUT) with severe resistance to the insertion of a semi-rigid ureteroscope (rURS) and 2.7% had severe DUT that precluded the insertion of a rURS (11). In this study, six patients (0.7%) had ureteral stricture that prevented the insertion of rURS. Nevertheless, rURS may contribute to safe insertion of the guidewire under direct vision and the choice of appropriately sized UAS, preventing ureteral injury during UAS insertion. However, challenges persist, particularly during UAS placement for upper tract urinary calculi, especially impacted ureteral stones. Accurate UAS positioning heavily relies on the surgeon's expertise and tactile feedback. RF RIRS is better suited for renal stones, as highlighted in this study, but it requires attention during ureteral stent placement to avoid complications like pain, hematuria, or urinary tract infections.

Direct visualization through a rURS during ureteral stent insertion ensures smooth advancement and proper distal tip positioning, thereby avoiding malpositioning. In this study, although there were no significant differences in surgical time or perioperative complications between RF RIRS and RU RIRS, urologists accustomed to fluoroscopy might require additional experience to master RF RIRS techniques.

A critical consideration is the discrepancy between endoscopic and radiologic evaluations of residual stones. Postoperative imaging often reveals residual stones despite endoscopic stone-free findings (12). Surgeons must interpret the three-dimensional morphology of the renal pelvicalyceal system (13) from preoperative imaging to achieve comprehensive stone clearance. Large renal calculi with a divided pelvis are difficult to treat by percutaneous nephrolithotomy (14). To identify all the renal calyces endoscopically, it is necessary to consider the three-dimensional morphology of the renal pelvicalyceal system using preoperative images. We found that the complete stone clearance rate was not significantly different between RF RIRS and RU RIRS. However, this trial was limited to cases involving a single uncomplicated stone, making RF RIRS manageable for experienced urologists. Further refinement of this technique will be needed for unexperienced urologists.

Awareness of radiation risks significantly impacts FT during RIRS (2). For urologist reluctant to abandon fluoroscopy it is advisable to increase the rotation of surgeons performing RIRS as to divide the burden of exposure. The worst scenario is when only one endourologist in the department performs RIRS and gets all the exposure. Transitioning to RF RIRS necessitates comprehensive training programs to ensure novice surgeons achieve comparable outcomes to their experienced counterparts. Simulation-based curricula and proctorship programs could facilitate this transition while maintaining patient safety.

In conclusion, Chung *et al.*'s (10) findings represent a pivotal step toward reducing radiation exposure in endourology. RF RIRS is a safe and effective alternative to RU RIRS, particularly in uncomplicated cases managed by experienced surgeons. However, challenges such as UAS and ureteral stent placement highlight the need for ongoing research and refinement. Future studies should validate these findings in larger, more diverse populations and explore the technique's applicability to complex cases.

Integrating innovative imaging protocols and addressing economic considerations will be critical for the widespread adoption of RF RIRS. By prioritizing safety for both patients and surgeons, the urological community can advance minimally invasive stone management while significantly reducing radiation exposure.

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Footnote

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