Retrograde Intrarenal Surgery (RIRS) in Urolithiasis: A Narrative Review

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Retrograde intrarenal surgery (RIRS) has revolutionized as a minimally invasive mode in the management of urolithiasis. RIRS has largely replaced percutaneous nephrolithotomy (PCNL) and traditional extracorporeal shock wave Lithotripsy (ESWL) in the current practice of urolithiasis management. Despite RIRS being minimally invasive with fewer complications, reliable in stones with complex anatomical renal system, and relatively safer in patients with anticoagulants, however, it is not immune to adverse consequences. Continuous modifications to this procedure have been made over the period of years in order to enhance its efficacy and outcome. Stone-free rates (SFR), accessory usage, intraoperative and postoperative complications observed, associated comorbidities status, and proper pre-operative evaluation of the patients are the factors to determine its efficacy and outcome. SFR may be a major indicator of the success of RIRS; however, not be at the cost of the patient's safety and well-being. Multiple factors are there in determining SFR after RIRS, including Stone burden, composition of stone, stone location, anatomy of renal systems, types of energy available, experience of surgeon, and accessories available. Apart from factors predicting SFR, other multiple factors have to be taken into serious account to optimize the overall outcome of the RIRS. This paper aims to critically review publications on the RIRS and summarize with factors that need to be taken into account in order to achieve an optimum outcome with the procedure as a whole.

Keywords: flexible ureteroscopy, Retrograde Intrarenal Surgery (RIRS), Stone-free Rate (SFR), Urolithiasis.

Retrograde intrarenal surgery (RIRS) is the widely accepted procedure for stone diseases worldwide. This is the procedure with a series of updates, time to time, with some form of accessories added or modifications. Apart from updates in the Laser system, continuous modifications have been made to its different accessories, and currently, with a flexible and navigable suction ureteral access sheath (FANS-UAS). Newer laser-like Thulium fiber laser or upgraded high-power holmium laser, and single-use ureteroscopes are extensively practiced with much safer outcomes. However, the cost factor with the update of the accessories and equipment, along with related complications, is bothersome too in the current scenarios.[1,2]

Despite its safety profile with a series of modifications, post-operative sepsis and limitations in a large volume of stone requiring multiple sessions of RIRS, potential morbidity associated and financial burden on the institute and to the patients are equally bothersome. The main objective of the study is to meticulously review the literature and come up with some key factors in making the procedure with optimum outcome with respect to the selection of the patients, taking precautions with comorbidities, and proper preparation of the patients prior to the procedure, along with intra-operative and post-operative vigilance.[3,4]

There are plenty of studies that have been published related to the topic and its success rates. Takazawa et al. had reported 100 % stone clearance for stones 2 to 4 cm in size.[5] Similarly study done by Riley et al. came up with a 90.9% stone clearance rate of a 3 cm-sized stone.[6]

The complication rate varies widely in different studies. One of the studies by Ural Uguz et al.[7] observed an 81% stone-free rate after one session. Intraoperative complications were recorded in 30.4% of the patients.

Bartosz et al.[8] reported infectious complications after RIRS of 2.8-7.5% of patients (mean 7.1 and operating time, positive urine culture status or urinary tract infections, and caliber of access sheath, character of stone, irrigation rate, and comorbidities are said to be the risk factors for the infectious outcome.

A study by Francesco et al.[2] included 403 patients who received antibiotic prophylaxis. Infection complications were recorded in 31 patients (7.7 %), consisting of fever in 18 (4.4 %), SIRS in 7 (1.7), and sepsis in 3 (0.7 %).

Hua Zhang et al.[9] had infectious complications after RIRS of 7.14%. They concluded that the operating time was the main factor in the complications. Stone size >2 cm was observed in 153 (27.37%) patients in the SIRS group and 29 patients (67.44%) in the non-SIRS group.

Yong Xu et al.[4] reported a complication rate of 26.1% using the modified Clavien classification system (MCCS) (MCCS: I= 67.7%, II=22.7%, IIIb= 7.2%, IVb = 2.4%). Recently vacuum vacuum-assisted ureteral access sheath has been practiced widely, which helps in simultaneously suctioning tiny fragments and enhancing clarity due to continuous irrigations and unobstructed suction drainage. The use of this vacuum-assisted device is claimed to enhance its efficacy in end-urological management of stones, ureteroscopy.

With the introduction of flexible and navigable suction ureteral access sheath (FANS-UAS), the outcome of RIRS has been further along with more powerful lasers, dust, and fragment removal devices like the direct in-scope suction technique. Adequate irrigation along with controlled suction and aspiration using an appropriate sheath, leading to a clear view, leading to operative success with a proper stone-free rate, and minimizing infectious complications with the adaptation of FANS-UAS.[1]

There are various factors taken into serious account, starting from a proper workup of the patient before being subjected to the procedure. We need to be aware of other available modalities of management for the particular scenarios. During the procedure, we need to make sure that all the necessary armamentarium is available. Undue prolongations of the procedure in compromising with the armamentarium and available skills might adversely affect the outcome. Operating surgeons and the anesthesia team all should be vigilant throughout the procedure, particularly in recognizing any alarming features, and if any doubt, be ready to abandon the procedure for an appropriate time later. Features of sepsis are the main factors leading to prolonged hospital stay and unforeseen high dependency requirements. Early recognition of the impending sepsis is the key during post-operative assessment. Prompt recognition and prompt management are the keys. Clear instructions should be given right before discharge, particularly in cases of stents in situ or requiring future sessions.

Factors Prior to The Procedure

Foreign bodies in the form of stents or tubes kept for the purpose are not uncommon. Infection complications are found to be quite common in those circumstances who

already had stents or tubes in situ prior to the definitive procedure.[3]

Stents and tubes in situ provide microorganisms to colonize and form a biofilm, which acts as a nidus, making an environment favorable for the infections.[10]

Catheter-associated urinary tract infection (CAUTI) is very common as a nosocomial infection, particularly in those who have with indwelling catheter and tubes in situ.[11]

Biofilm is the substance released by the organism on the surface of foreign materials like stents or tubes, allowing the surface to adhere and propagate colonization.[12]

Likewise, a study by Chug et al.[13] stated that an indwelling bladder is found to be associated with high chances of infection after RIRS.

Manipulations of the urinary tract with preexisting stents or tubes with biofilm and colonization of pathogens could propagate organisms through the urinary tract.[10]

A meta-analysis by Sun et al found significant increases in infectious complications after RIRS with an odds ratio of 1.53.[14] Biofilm formation is likely shortly after placement of stents and tubes.[12]

With ample evidence, routine preoperative urine culture in all patients before the procedure is strongly advised and aids in minimizing infections related to post-operative complications.[15]

Similarly, the European Association of Urology (EAU) strongly recommends that a preoperative urine culture should be obtained and treated accordingly prior to the stone surgery.[16]

Apart from in situ stents and tubes as risk factors, several other comorbidities have been found to contribute equally to the infectious complications and others. Being diabetic, with renal abnormalities, ischemic heart disease, advanced age, history of recurrent urinary tract infections, previous stone surgery, with urinary diversions, paraplegics, immune suppressants, recent chemotherapy or steroid treatment, female patients, poor nutritional status, and prolonged hospital stay, and the Charleston Comorbidity Index too are prerequisite factors for the infectious complications after RIRS.[17]

Sun et al. reported that diabetes mellitus was among the most clinically relevant pre-operative risk factors for infectious complications after undergoing ureteroscopy. Glycosuria acts to facilitate bacterial survival and proliferation in the genitourinary system, along with impaired immune functions secondary to incomplete phagocytosis and diminished function of granulocytes, and possible diabetic cystospathy makes them more vulnerable to the possible infectious complications following the procedure.[14] Patients with diabetes mellitus as also at a higher

likelihood of developing a UTI compared to the general population outside the context of post-surgical complications.[18] Overall, a higher degree of suspicion should be maintained for infectious complications postoperatively for diabetic patients.

Apart from all the above possible factors that can influence the procedure's outcome, Yinglong Xiao[19] came up with the novel scoring system in RIRS. The score consists of renal stone density, inferior pole stone, stone burden, and renal infundibular length. The scoring system was found to prognosticate the stone-free rate and correlated with the operative time. This will help surgeons be aware of appropriate indications, possible requirement of additional sessions, and ultimately help in preventing surgical complications as well.

To summarize, the appropriate selection of the patient and adequately optimizing the possible influencing factors are the keys to achieving an optimum outcome. One should be alert while dealing with pre-stented or catheterized, or intermittently cauterized patients. These are patients likely to develop sepsis complications if not appropriately dealt with. Patients with a history of previous stone surgery, particularly with the residual stones left behind, are equally at risk of intraoperative or postoperative sepsis-related complications. Routine pre-operative urine culture workup and adequate treatment are advisable before the procedure is undertaken. It may be advisable to decompress the renal system in case of obstructed uropathy with the features of sepsis or impending sepsis first, then deal with the proper option once adequately stabilized.

Apart from the above, various comorbidities, including diabetes, advanced age, cardiac morbidities, preexisting mobility-related disorders, immunosuppressive disorder, on steroid treatments, poor nutritional status, history of prolonged hospital stay, and so on, are to be taken into account and adequately managed with a multidisciplinary approach prior to the proper procedure. Charlson's Co-morbidity Index may be a useful tool in such scenarios.

Factors During the Procedure

After being aware of several factors that need to be taken into account before the procedure, there are many other factors that need to be considered right before and during the procedure itself. Prior study of the stone pattern in terms of locations, anatomy, and density fairly gives an idea of choosing appropriate procedure options available. Proper counselling to the patients regarding the possibilities of postponing the procedure in case of difficult negotiation of your scope or requirement of future sessions, depending upon the burden and

density of the stone. Being aware of current trends of UAS-FANS usage and making it available along the routine armamentarium might be beneficial. The crucial factors in achieving optimum benefit would be adopting measures to reduce operating time in achieving the set goal. It could be choosing the correct patient, using the proper armamentarium with appropriate laser settings, achieving clear vision throughout the procedure, and maintaining low intra-pelvic pressure throughout the procedure.[20,21]

The current Urology guidelines recommend antibiotic prophylaxis for gram-negative rods and Enterococci species for patients undergoing upper urinary tract endoscopic procedures. Parenteral antibiotic prophylaxis should be administered within one hour of the procedure, or two hours if vancomycin is used. It would be better to choose an antibiotic as per the local sensitivity pattern if known. For the fungal prophylaxis, the AUA suggests that single-dose antifungal prophylaxis is recommended for patients with asymptomatic funguria undergoing urinary tract surgery.[22]

Increased operating time likely requires the use of a larger amount of irrigation volume. A higher stone burden would also necessitate more operative time and provide more chances of infections. A large volume of irrigating fluid, along with repeated exposure of the internal matrix of the stone, would enhance the dissipation of infection. Moreover over if performed at high pressure, pyelo-venous reflux of the irrigant with the infective contamination further increases the chances of systemic infections.[23]

Normal intra-pelvic pressure is approximately 5 mmHg, and the threshold for pyelo-venous reflux is approximately 35 mmHg. Intraoperative pressures can reach up to 328 mmHg during forced irrigation, almost 10 times the reflux threshold.[20] Maintaining low pressure during RIRS is the key in order to preventing retrograde pyelo-venous back flow, where there is communication of urine and the renal venous blood.[21]

Ureteral access sheath (UAS) has been shown to decrease intra-pelvic pressure by up to 75% and a larger sheath helps in keeping the threshold low.[20] Intra-pelvic pressure is found to be inversely proportional to the UAS and directly with the size of the flexible ureter scope. Hence larger the UAS and the smaller the ureteroscope seems to be theoretically better however, difficulty in negotiating large-bore UAS always, and the cost factor of the smaller-bore ureteroscope also have to be considered.

Kim et al. have found that operating time to an independent risk factor for the development of febrile UTI after RIRS.[24]

De Coninck V et al. stated that UAS, however, reduces time for the repeated entry into the collecting system; it is not without its own risks of independent minor damage to ureters, causing superficial lesions to circumferential perforation of the ureter.[20]

Wollin DA et al. suggested forceful diuresis during the procedure may reduce the risk of infections by preventing pyelo-venous reflux; however, the evidence is weak. They also suggested intraoperative stone culture for vital information for post-operative infections. Bacteria situated within the matrix of the stone can be procured during the process of stone fragmentation, which otherwise may not be procured by doing a pre-operative urine culture. Positive stone culture is one of the important predictors of infectious complications.[15] They routinely send an intraoperative stone for culture when there is suspicion of an infectious stone.

It is essential to keep constant communication with the bedside anesthesia team during the procedure. They are the ones who observe the physiological changes of impending complications in terms of changes in the vital parameters in the monitor and physical examinations. The changes, including cold and clammy skin, altered blood pressure, pulses, saturations, altered temperature, and so on, can be communicated promptly with the surgeon, and necessary action can be taken, like holding an ongoing procedure temporarily or abandoning the procedure itself. If there is intraoperative suspicion that an infectious complication may be developing or that the patients are at high risk, placement of a Foley's catheter and ureteral stent should be strongly considered for maximum urinary tract decompression.

To summarize, appropriate antibiotic prophylaxis of the parenteral route, maintaining or reducing intra-pelvic pressure with optimum irrigation volume, are the essential factors to be taken into account. Long operating time adversely affects the outcome, which is possible while dealing with a large burden of stone. Adoption of UAS is strongly recommended, and the association of FANS further enhances the RIRS outcome. Higher stone burden and density of stone are the known factors in prolonging the procedure duration. It may be safer to deal with such stones in multiple sessions rather than in a single session. Some of the studies advocate sending a stone for the culture and forced diuresis during the procedure for the optimum outcome. It is advisable to decompress the renal system with the stent and an indwelling Foley’s catheter at the end of the procedure; however, in case of absolute clearance of the stone with UAS-FANS, it may not be necessary. Continuous communication with the anesthetist team is

utmost important in updating the status of the patient. It is advisable to make all the essential armamentarium available while dealing with urolithiasis for maximum benefits.

Factors After the Procedure

All the factors discussed before the procedure and the intraoperative pictures determine the after-procedure status, either immediately or later. At times, even with the adoption of preoperative and intraoperative precautions, infectious complications are inevitable; in such instances, early recognition and early institution of treatment will be the only way.[15]

Adequate monitoring of the patient after RIRS in the recovery room is a must, which may be prolonged in cases of patients with multiple co-morbidities, took a long operating time, or any unsmooth events during the procedure were noticed by the anesthetists.

Instant cultures of the urine and blood should be sent in case of any suspicion of an uneventful recovery period. Antibiotics should be administered instantly after sending the culture study. Antibiotics of broad spectrum have to be chosen for the impending urosepsis as per the cultures and sensitivity pattern in the institute guideline. Morbidity and mortality are found to be increased in delaying an empiric antibiotic therapy.[25] Switching antibiotic therapy from empiric to therapy-based sensitivities should be done as soon as the information becomes available. Moreover, the urinary tract should be decompressed with the indwelling catheter if not put in beforehand or already removed. Ideally impending uroseptic patient should be monitored in high dependency care with multidisciplinary observations.

To summarize, after the procedure, the place for possibilities of adopting preventive precautions will no longer be there; now is to deal promptly with the events and try to optimize the consequences. Adequate care of the patients in the recovery immediately after the procedure is the key. Early recognition of features of impending sepsis and addressing it timely with proper antibiotics, drainage of the urinary system, with multidisciplinary care is very crucial.

Conclusions

Urolithiasis is the most common procedure performed by the Urologist worldwide, and will remain so, and RIRS has become the procedure of choice in dealing with renal stones nowadays. Serious adverse events, though rare, infectious complications can produce serious consequences. It is very much essential for clinicians to be aware of confounding factors associated before, during, and after the procedure in achieving

the substantial goal in managing urolithiasis. Acquiring adequate skills associated with and being aware of ongoing updates is essential for time management during the procedure. Adoption of optimum strategies, early recognition of unwanted events, and timely addressing of the issues are the key factors in achieving the optimum goal with RIRS in managing stone diseases. Maintaining adequate well-being of the patient with minimal disturbances of renal anatomy and physiology, followed by the clearance of the stone, should be the sequence in managing urolithiasis.

Conflict of Interest: None.

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