JOURNAL OF MULTIDISCIPLINARY SCIENCES AND INNOVATIONS

VOLUME 04, ISSUE 11
MOPNTHLY JOURNALS

ISSN NUMBER: 2751-4390
IMPACT FACTOR: 9,08

ADVANCES IN THE MANAGEMENT OF STAGHORN STONES

Khadka Ravi Roshan

International students faculty, Asia International University

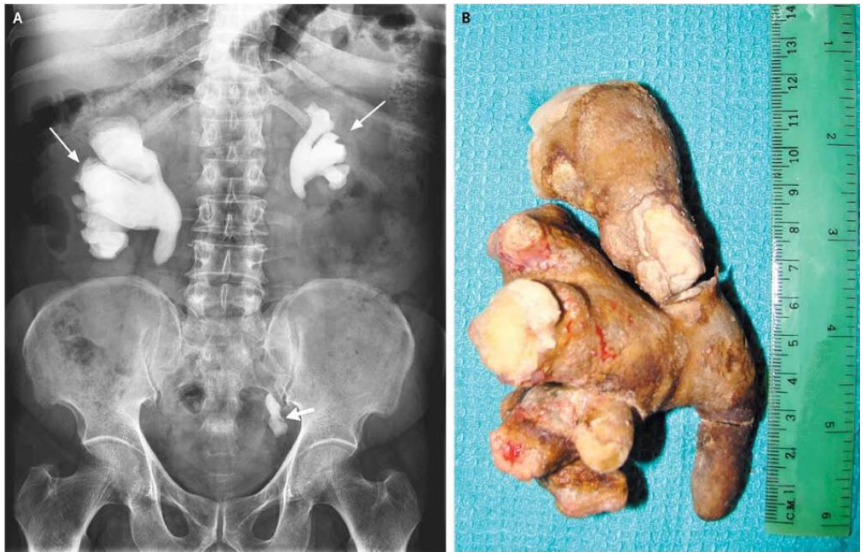
email: dr.ravi7209@gmail.com

Abstract: Background: Staghorn calculi are complex renal stones occupying the renal pelvis and multiple calyces, frequently associated with recurrent urinary tract infections and progressive renal impairment. Over the years, the treatment of these stones has become more efficient and minimally invasive, thanks to advances in imaging, percutaneous nephrolithotomy, flexible ureteroscopy, laser lithotripsy and infection control. This review will cover the current strategies, new technologies and preventive measures to be utilized for optimizing the care.

Key words: Advances, Management, Staghorn stones

Introduction

Staghorn stones, often composed of struvite or mixed minerals, present a unique clinical challenge due to their size, branching nature, and association with infection . Left untreated, they can lead to recurrent pyelonephritis, urosepsis, and progressive renal damage. Historically, open surgery was the mainstay of treatment, but the last two decades have witnessed a paradigm shift toward minimally invasive, endourological techniques guided by evidence-based protocols from the European Association of Urology (EAU) and the American Urological Association (AUA) (1,2).



Fig; 1 Stag horn calculus (7)

Advances in Diagnostics

High-resolution imaging is essential and Non-contrast CT (NCCT) is considered the gold standard for determining the size, location and branching anatomy of the stone (1), when planning the management of staghorn kidney stones. 3D reconstruction CT is an invaluable tool for multi-tract PCNL planning and dual energy CT, has the ability to identify the composition of the stone, enabling targeted therapy, Renal scintigraphy with DTPA/MAG3 also assesses kidney function and can forecast the recovery following surgery (2,3)

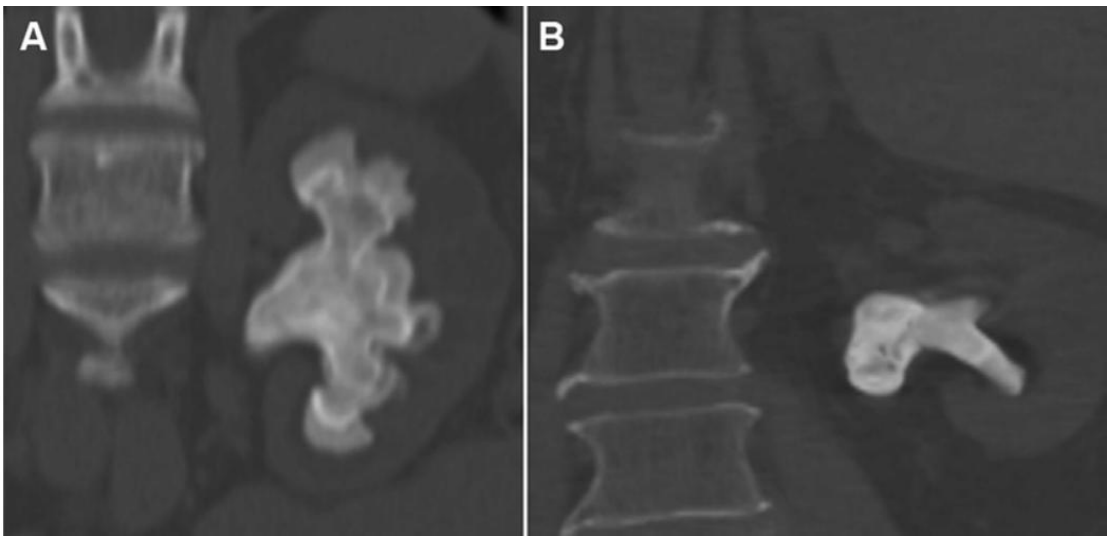


Fig 2; NCCT Staghorn calculi. (A) Complete staghorn calculi occupy the whole pyelocaliceal cavities; (B) Partial staghorn calculi have at least one calyceal branch attached to the renal pelvis.(8)

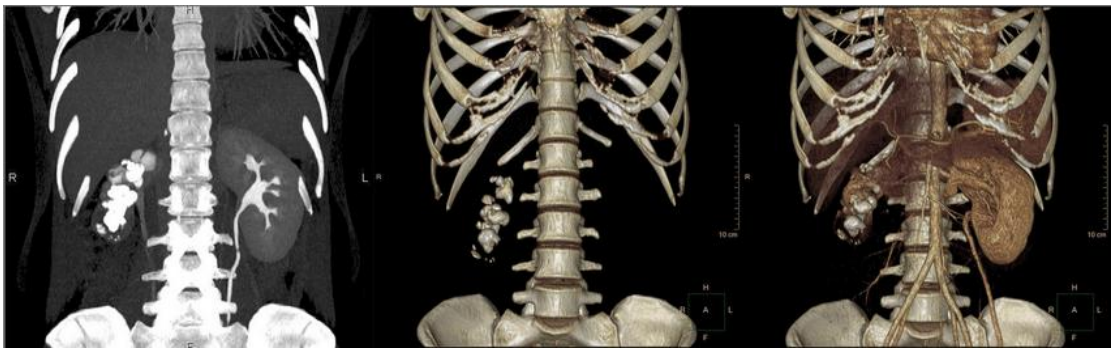


Fig 3; CT scan and 3D reconstruction for right staghorn calculus (9)

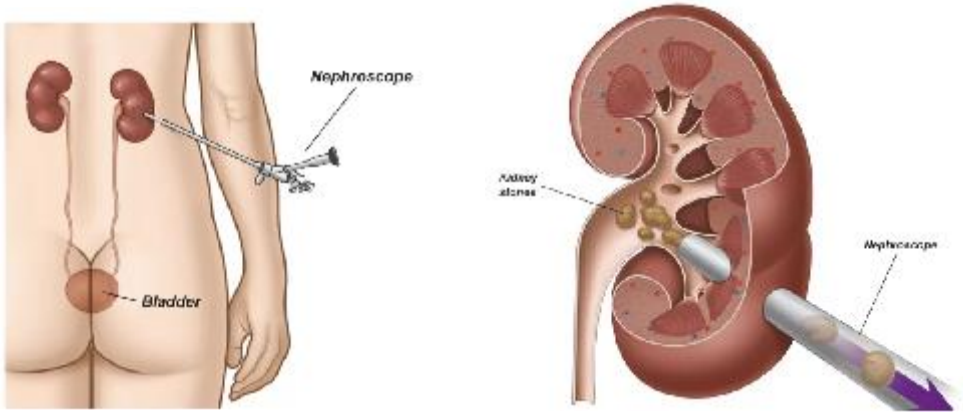
Surgical Management

1. Percutaneous Nephrolithotomy (PCNL)

JOURNAL OF MULTIDISCIPLINARY SCIENCES AND INNOVATIONS
VOLUME 04, ISSUE 11
MOPNTHLY JOURNALS
ISSN NUMBER: 2751-4390
IMPACT FACTOR: 9,08

PCNL is now considered as first-line treatment for complete or partial staghorn stones, as per the European Association of Urology 2023 and American Urological Association 2014 guidelines, when treating kidney stones.

Advances in the procedure have given rise to mini-PCNL and ultra-mini PCNL which, by reducing bleeding, pain and the need for hospitalisation, are still able to boast high stone clearance rates(3,4). Multiple tracts or a phased approach are now being employed in order to tackle more complex stones and, real-time imaging with ultrasound and fluoroscopy, and the use of robots in the procedure are all helping to increase precision and safety (2,3,5).



Fig; 5 Percutaneous Nephrolithotomy (PCNL) (1)

PCNL	Equipment	Outer sheath size (F)	Tract dilatation	Working channel (F)	Fragmentation device	Stone removal
Conventional	Reusable	≥24	MS, SS, balloon	– [a]	Ballistic, US, laser	Grasper, basket
Mini-PCNL	Reusable	11–20	MS, SS, balloon	– [a]	Ballistic, US, laser	Grasper, basket
Miniperc (Lahme)	Reusable	15–20	SS	6	Ballistic, US, laser	Grasper, basket, AWO
MIP L	Reusable	24–26	MS, SS, balloon	12.4	Ballistic, US, laser	Grasper, basket, AWO, VCE
MIP M	Reusable	16–22	SS	6.7	Ballistic, US, laser	Grasper, basket, VCE
MIP S	Reusable	12	SS	2	Laser	Basket, VCE, PE
MIP XS	Reusable	9.5	SS	2	Laser	Basket, AWO, VCE, PE
UMP	Reusable	11–13	MS or SS	–	Laser	AWO, VCE
SMP	Reusable	10–14	MS	3	Ballistic, laser	Grasper, basket, AWO, suction evacuation, PE, VCE
Micro-PCNL	Disposable	4.85	SS	–	Laser	PWO, PE
Mini-micro PCNL	Reusable [b]	8	SS	–	US, laser, suction	PWO, suction

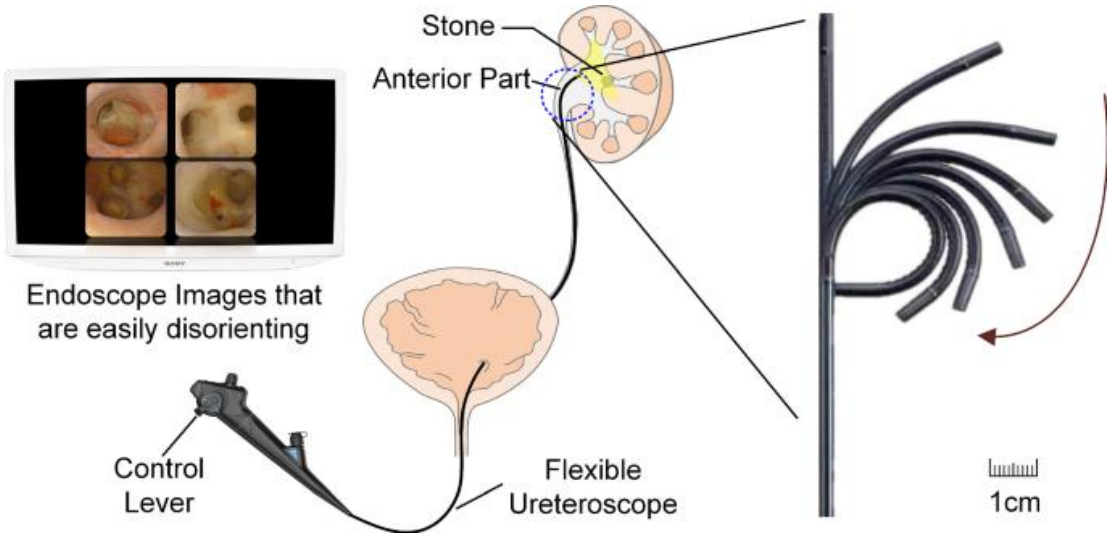
SS = single step; MS = multistep; US = ultrasonic; AWO = active washout; VCE = vacuum cleaner effect; PE = purging effect; PWO = passive washout.
[a] Depends on the manufacturer.
[b] The sheath is available as disposable and reusable models.

Table 1; Main characteristics of different percutaneous nephrolithotomy (PCNL) (10)

2. Flexible Ureteroscopy (fURS)

Flexible ureteroscopy (fURS) plays an important supportive role in the management of residual stones after percutaneous nephrolithotomy (PCNL). Recent advances in digital flexible ureteroscopes and laser fiber technology have made it possible to reach difficult calyces with minimal trauma to the urinary tract (3,6). In patients with complex staghorn anatomy, a combined PCNL and fURS approach has been shown to improve overall stone clearance.

The introduction of modern laser systems, particularly Holmium:YAG and thulium fiber lasers, has significantly enhanced stone fragmentation. Dusting and fragmentation techniques help optimize stone clearance while reducing operative time (3,6). Notably, the thulium fiber laser offers greater precision, lower stone retropulsion, and improved efficacy, especially in hard struvite stones.



Fig; 5 Flexible Ureteroscopy with laser lithotripsy (11)

3. Shock Wave Lithotripsy (SWL)

Shock wave lithotripsy has a limited role in the management of large staghorn calculi because of its lower stone-free rates. However, it may be useful for treating small residual fragments following percutaneous nephrolithotomy (PCNL) or as part of a combined treatment approach in selected patient (1,2)

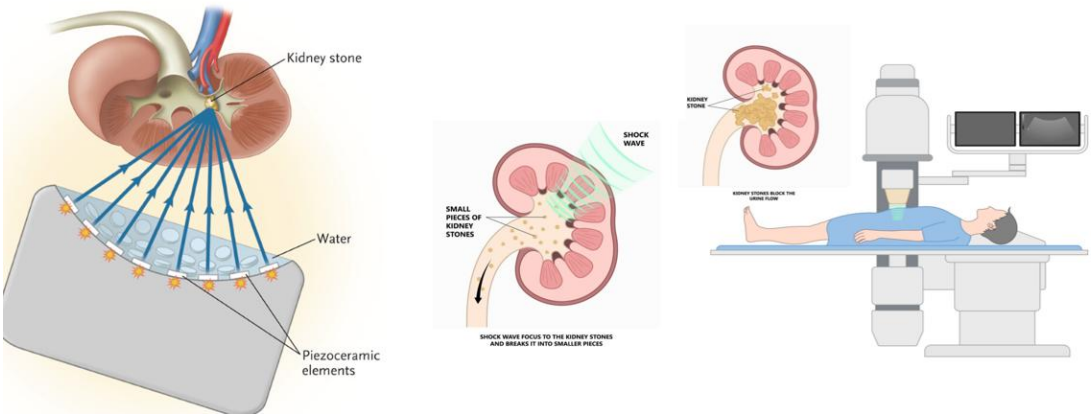


Fig 6; Shock Wave Lithotripsy (SWL) (12)

4.Open and Laparoscopic Surgery

Open or laparoscopic surgery is now rarely required and is generally reserved for patients with anatomical abnormalities, failed minimally invasive treatments, or exceptionally large stone burdens. Their use has declined markedly with the widespread adoption and continued advancement of percutaneous nephrolithotomy (PCNL) and flexible ureteroscopy (fURS) (1,2).

Infection Control and Antibiotic Strategies

Staghorn calculi are frequently infection-related stones formed in the presence of urease-producing bacteria. Therefore, preoperative urine culture and culture-directed antibiotic therapy are essential to minimize the risk of postoperative sepsis (2). In high-risk patients, staged urinary drainage and intraoperative irrigation with antibiotic solutions are recommended to further reduce infectious complications (1,2).

Postoperative Care and Prevention

It focus on reducing the risk of stone recurrence. Metabolic evaluation and stone composition analysis are important for identifying underlying risk factors and guiding long-term preventive strategies. Medical management, including potassium citrate, thiazide diuretics, and appropriate dietary modifications, plays a key role in lowering recurrence rates (1). Regular follow-up with imaging is essential to detect residual fragments or recurrent stones at an early stage.

Emerging approaches include:

Emerging approaches in the management of staghorn calculi are expanding the therapeutic landscape. Robotic-assisted PCNL is being explored to enhance surgeon ergonomics and procedural precision. Advances in three-dimensional printing and virtual reality are increasingly used for detailed preoperative planning, particularly in complex renal anatomy. Artificial intelligence–based imaging tools show promise in optimizing access tract placement and predicting stone clearance. In addition, novel pharmacological therapies aimed at inhibiting struvite crystallization and disrupting bacterial biofilms are under investigation (3,5).

Treatment summary (EAU)

According to the European Association of Urology (EAU) guidelines, the recommended treatment approach for staghorn calculi follows a stepwise hierarchy (1). Percutaneous nephrolithotomy (PCNL) is the first-line treatment, including multipuncture or multistage procedures when required. In selected patients with complex stone anatomy, a combined PCNL and retrograde intrarenal surgery (RIRS) approach may be employed to improve stone clearance. Adjunctive shock wave lithotripsy (SWL) or RIRS is reserved for the management of residual stone fragments. Open or laparoscopic surgery is now considered only in exceptional cases.

Conclusion

The management of staghorn calculi has evolved significantly toward minimally invasive, evidence-based, and patient-centered approaches. Technological advances in percutaneous nephrolithotomy (PCNL), flexible ureteroscopy (fURS), laser systems, and infection control have led to higher stone-free rates, reduced morbidity.

References

1. Türk C, Neisius A, Petrik A, et al. EAU Guidelines on Urolithiasis 2023. Arnhem: European Association of Urology; 2023.

2. Assimos D, Krambeck A, Miller NL, et al. American Urological Association guideline on management of kidney stones. J Urol. 2014;192(2):316–24.

3. Giusti G, Proietti S, Rodriguez-Monsalve M, et al. Modern technologies in percutaneous and endourological management of staghorn stones. World J Urol. 2020;38:1227–36.

4. Cebeci F, Muslumanoglu AY. Minimally invasive percutaneous nephrolithotomy: current perspectives. Res Rep Urol. 2019;11:177–84.

5. Ghani KR, Andonian S, Desai M, et al. Staged and combined approaches for complex staghorn stones. Curr Opin Urol. 2016;26:126–32.

6. Doizi S, Traxer O. Thulium fiber laser for complex renal stones: advantages and outcomes. World J Urol. 2021;39:2181–89.

7. Rajaian S, Kekre NS. Staghorn calculus. N Engl J Med. 2009;361(15):1486. doi:10.1056/NEJMicm0805190.

8. Keller EX, De Coninck V, Doizi S, Traxer O. The role of ureteroscopy for treatment of staghorn calculi: a systematic review. Asian J Urol. 2020;7(2):110–115. doi:10.1016/j.ajur

9. Petca RC, Salaheddin Y, Petca A, Popescu RI, Mehedintu C, Maru N, Jinga V. Could chemical composition of stone influence percutaneous nephrolithotomy in the management of staghorn calculi? Rev Chim. 2019;70(11):3872–3877. doi:10.37358/RC

10. Proietti S, Giusti G, Desai M, Ganpule AP. A critical review of miniaturised percutaneous nephrolithotomy: Is smaller better? Eur Urol Focus. 2017;3(1):56–61. doi:10.1016/j.euf

11. Zhang, C., Hu, C., He, Z. et al. Shape estimation of the anterior part of a flexible ureteroscope for intraoperative navigation. Int J CARS 17, 1787–1799 (2022).https://doi.org/10.1007/s11548-022-02670-8

12. Pearle MS. Shock-wave lithotripsy for renal calculi. N Engl J Med. 2012;367(1):50–57. doi:10.1056/NEJMct1103074