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Percutaneous Nephrolithotomy, Pneumatic and Holmium Laser Lithotripsy for Urinary Calculi: Adopting the Paradigm Shift in Stone Management in Southern Nigeria

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Abstract **Background**: Medical advancement has led to endoscopic treatment becoming the first-line option in stone management. Holmium laser lithotripsy is the gold standard for stone fragmentation during retrograde intrarenal surgery (RIRS), as it can be applied with a flexible ureterorenoscope (fURS) to access the entire collecting system. Percutaneous nephrolithotomy (PCNL) is effective for large and multiple renal stones. Bladder stones can be crushed and evacuated using lithotrite, pneumatic and laser energy. While endourology is well established in the developed western countries, it remained budding in most of sub-Saharan Africa. This study aims to present our experience in percutaneous nephrolithotomy, RIRS and ureteroscopy with lithotripsy using holmium laser and pneumatic lithotripter for urinary calculi. **Methods and Methodology:** The study was a 4year retrospective study on patients presenting with urinary tract who had endoscopic management; including litholapaxy, pneumatic and holmium laser lithotripsy and PCNL. The case records of the patients were obtained. Their clinical records such as age, sex, CT urography, operative and post-operative notes and complications were extracted. This was coded into Excel format and then analyzed using SPSS Version 20. **Results:** There were 61 patients with an age range from 29 -80years and a mean age of 51.39± 14.40years with a male: female ratio of 3.5:1. The 40-49year age group had the highest prevalence {17(27.9%)}. Flank pain was the most frequent presenting complaint {49(80.3%)}. The mean size of the calculi was 19.28mm with a range from 3mm to a 120mm bladder stone. Renal stone was the most frequent, {40(65.6%)} followed by ureteric stones 12(19.7%). The mean Hounsfield of the stones was 738.60HU. There was an association between age and stone location, *(p=0.039)* but none between the sex of the patients, the development of stones, type of symptoms and the location of stones. RIRS with laser lithotripsy was the most frequently performed procedure. {31(50.8%)} followed by ureteroscopy with laser lithotripsy. Stone dusting was the most preferred setting used during RIRS. All but one was calcium oxalate stones. Majority were complication-free {28(70.5%)}, and fever {11(18.0%)} was the commonest. There was no mortality. **Conclusion:** RIRS and ureteroscopy with laser lithotripsy are the commonest procedures we now perform for upper urinary stones**.** The capacity to perform RIRS, ureteroscopy and laser lithotripsy and PCNL, and other forms of endoscopic stone management is a welcome development that will mitigate the morbidity associated with stone diseases in Nigeria and sub-Saharan Africa.

Keywords: *Laser lithotripsy, RIRS, Renal stones, Ureteric calculi, Ureteroscopy, PCNL*

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1. Introduction

Endoscopic management of urinary calculi is the most effective treatment for the majority of urolithiasis with the highest stone clearance rates. [1,2] Since 1964, when Marshall reported the first ureteroscopy [3], improvements in technology in modern times has led to the development of newer flexible ureterorenoscopes, endoscopic accessories and lithotripters that now establish endoscopic treatment as the first-line option in stone management. The holmium laser is the gold standard for stone fragmentation. It can be applied with a flexible ureterorenoscope (fURS) to access the entire collecting system. [4] Percutaneous nephrolithotomy (PCNL) is effective for large and multiple renal stones. [4,5] Bladder stones can be crushed and evacuated using lithotrite, pneumatic and laser energy.

While the field of endourology is well established in the developed western countries and commonplace in the Asian and far Eastern countries, it has remained budding in most sub-Saharan Africa because of the unavailability of equipment and human capacity limitations. Recent development has seen a welcomed increased application of this endourological approach to stone management in Nigeria. [6,7,8]

2. Aim

To present our intitial experience in retrograde intrarenal surgery, ureteroscopy, percutaneous nephrolithotomy and use of holmium laser lithotripsy for urinary calculi.

3. Methods and Methodology

This was a 4year retrospective study from October 2017 to September 2021 on patients presenting with urinary tract stone at Rosivylle Clinic and Urology Centre and Urology Division, University of Port Harcourt Teaching Hospital, Port Harcourt, Rivers, who had endoscopic management for urinary tract stones, including litholapaxy, pneumatic and holmium laser lithotripsy and PCNL. The case records of the patients were obtained. Their clinical records such as age, sex, CT urography, operative and post-operative notes and complications were extracted. Procedures outside this period and patients who had open procedures were excluded. The data was coded into Excel format and then analyzed using SPSS Version 20.

4. Results

There were 61 patients with an age range from 29-80years, mean age of 51.39± 14.40years and male: female ratio of 3.5:1. The 40-49year age group had the highest prevalence {17(27.9%)}. Flank pain was the most frequent presenting complaint {49(80.3%)}. The mean size of the calculi was 19.28mm with a range from 3mm to a 120mm bladder stone. Renal stone was the most frequent {40(65.6%)} followed by ureteric stones 12(19.7%). The mean Hounsfield of the stones was 738.60HU. There was an association between age and stone location *(p=0.039)* but none between the sex of the patients and the development of stones, type of symptoms and the location of stones. RIRS with laser lithotripsy was the most frequently performed procedure {31.0(50.8%); followed by ureteroscopy with laser lithotripsy. Stones dusting was the most preferred setting used during holmium laser lithotripsy. 6 (9.8%) patients had PCNL for either large or multiple renal stones. Sixty of the patients had calcium oxalate stones, while one had uric acid calculi. Most were complication-free {28(70.5%)}. Fever was the most frequent complication seen in 11 (18.0%) of the patients. There was no mortality.

Table 1. Age and stone characteristics of patients

		Age	Stone size mm	Hounsfield Unit
N	n	61	61	61
Mean		51.39	19.28	738.60
Minimum		29.00	3.00	120.10
Maximum		80.00	120.00	1300.00

Table 2. The distribution and relationship between Age, Symptoms and stone location among patients who had endoscopic treatment for urolithiasis

	Sex							
	Female		Male		Total		Chi-square	p-value
	N	(%)	N	(%)	N	(%)		
Age group								
<40	5	(35.7)	8	(17.0)	13	(21.3)		
40-49	1	(7.1)	16	(34.0)	17	(27.9)	5.28	0.323
50-59	3	(21.4)	10	(21.3)	13	(21.3)		
60-69	2	(14.3)	7	(14.9)	9	(14.8)		
70 above	3	(21.4)	6	(12.8)	9	(14.8)		
Symptom								
Anorexia	0	(.0)	1	(2.1)	1	(1.6)		
Flank pain	13	(92.9)	36	(76.6)	49	(80.3)	3.29	0.655
Haematuria	0	(.0)	5	(10.6)	5	(8.2)		
LUTS	1	(7.1)	5	(10.6)	6	(9.8)		
Stone location								
Bladder	1	(7.1)	8	(17.0)	9	(14.8)		
Renal	12	(85.7)	28	(59.6)	40	(65.6)	3.38	0.336
Ureter	1	(7.1)	9	(19.1)	10	(16.4)		
Vesicoureteric junction	0	(.0)	2	(4.3)	2	(3.3)		
Total	14	(100.0)	47	(100.0)	61	(100.0)		

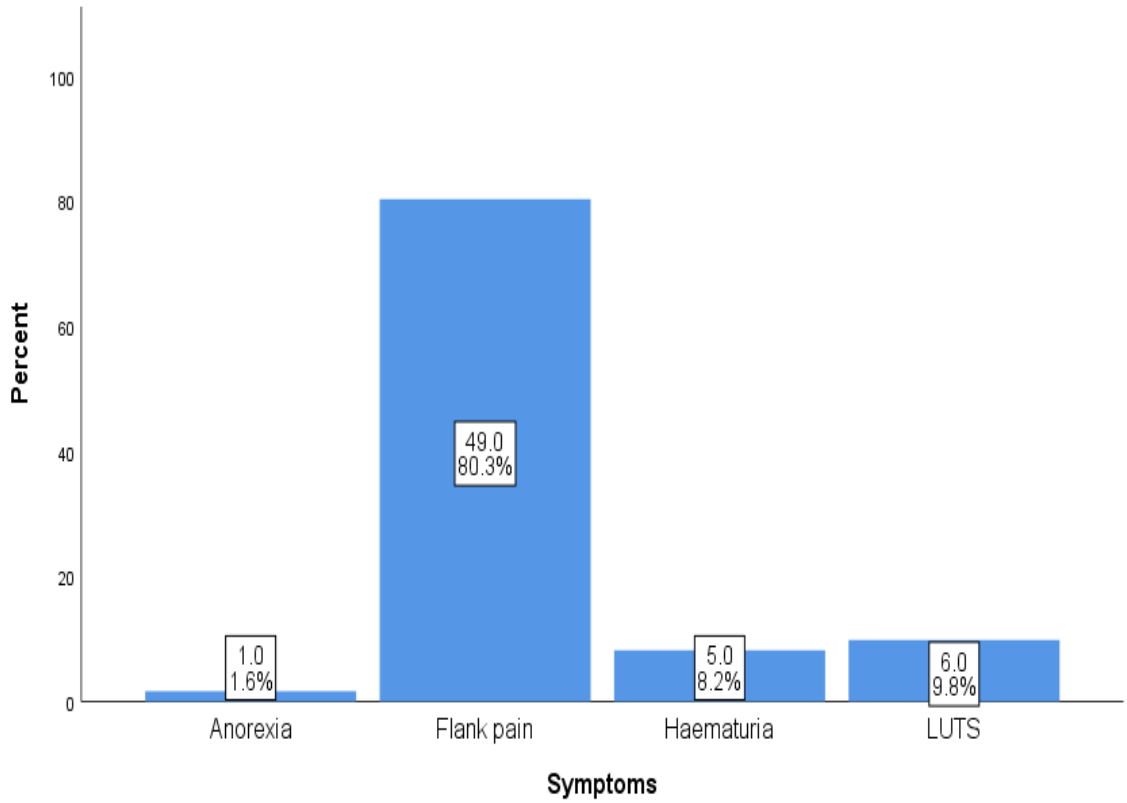

Figure 1. Clinical presentation of patients with urinary calculi

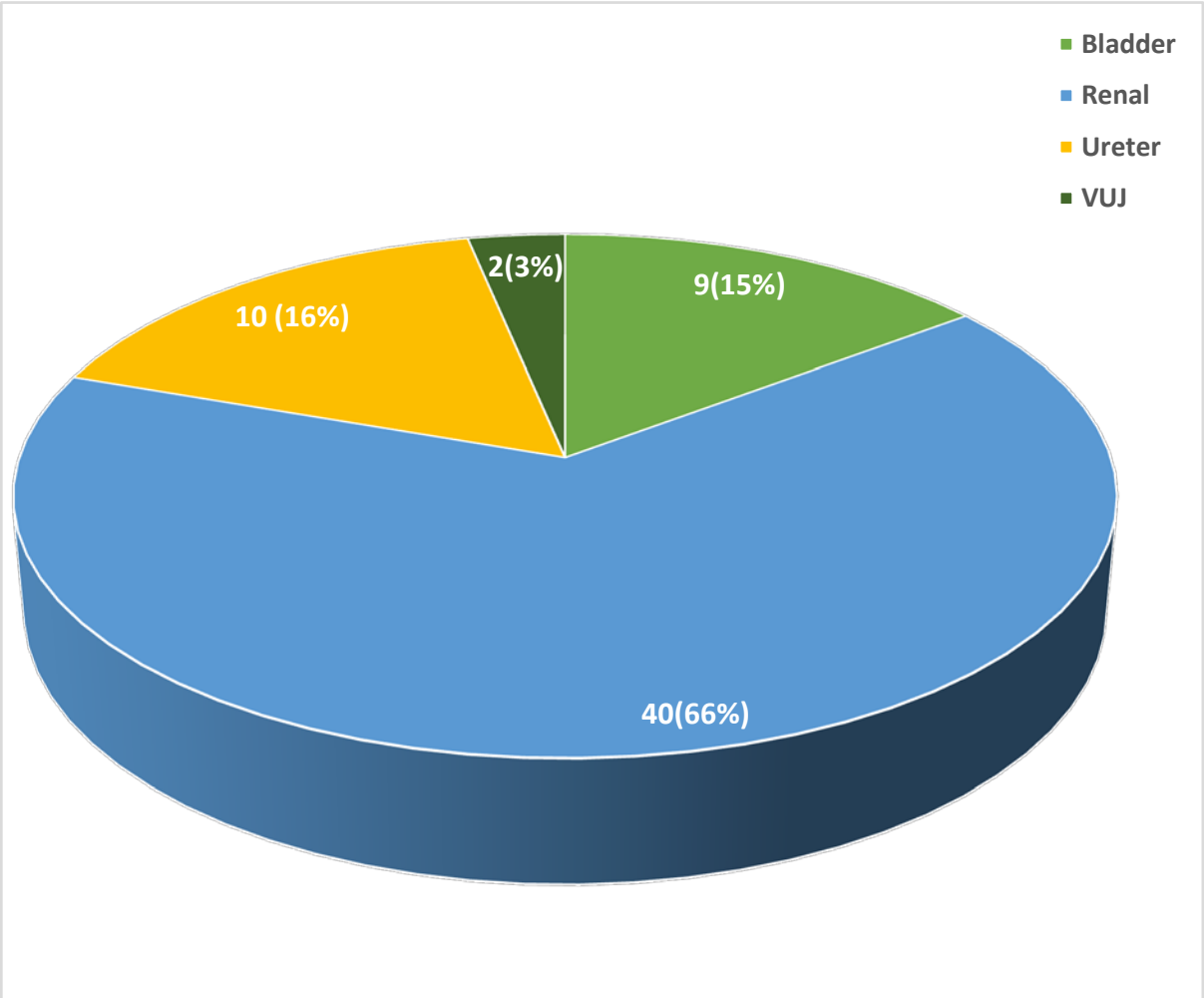

Figure 2. Distribution of stone location among patients

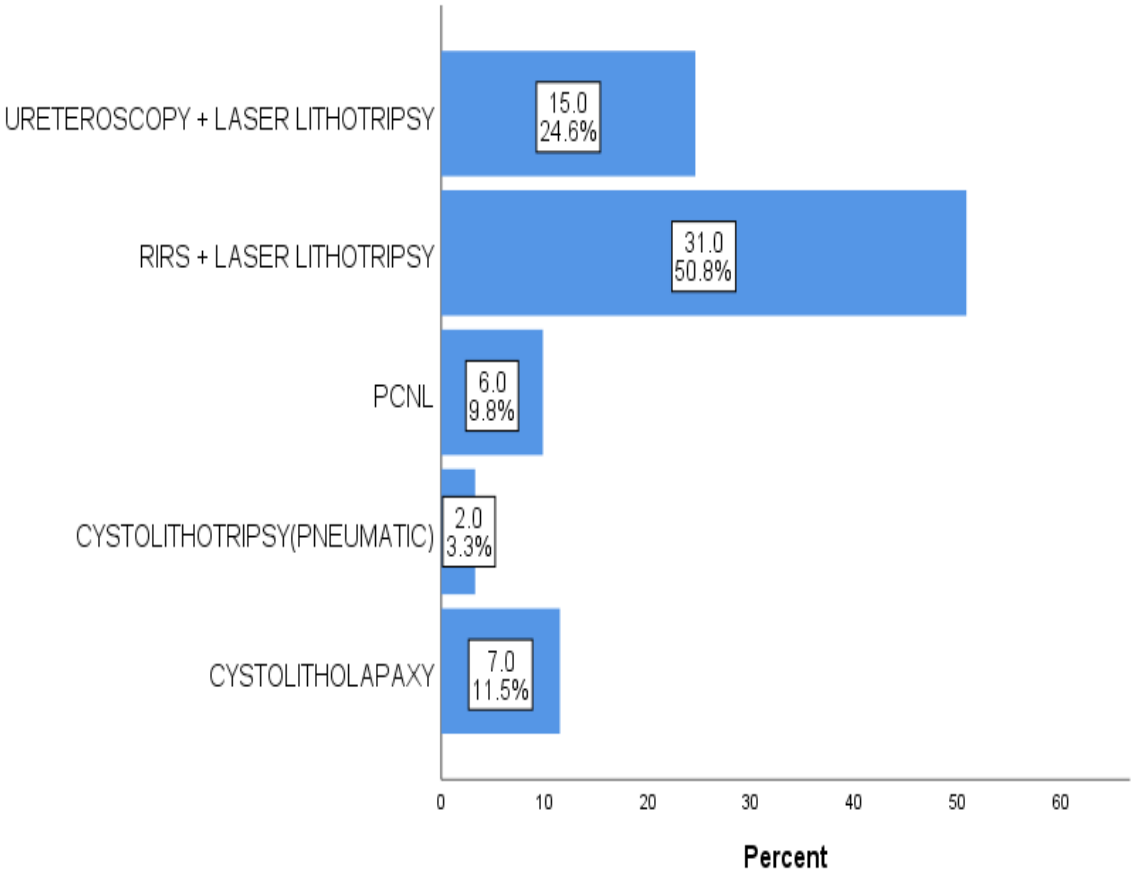

Figure 3. Endoscopic procedures were carried out on patients with urinary stones

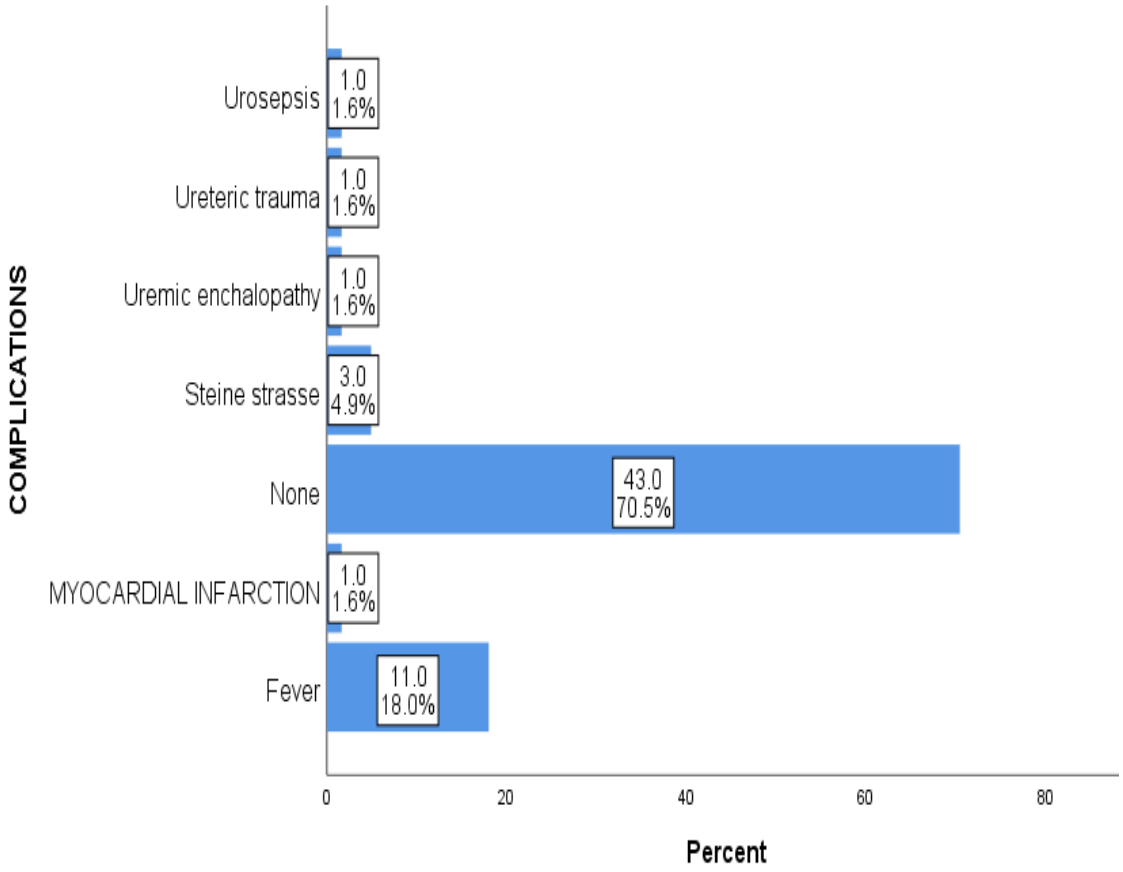

Figure 4. The postoperative complication in patients following endoscopic management of calculi

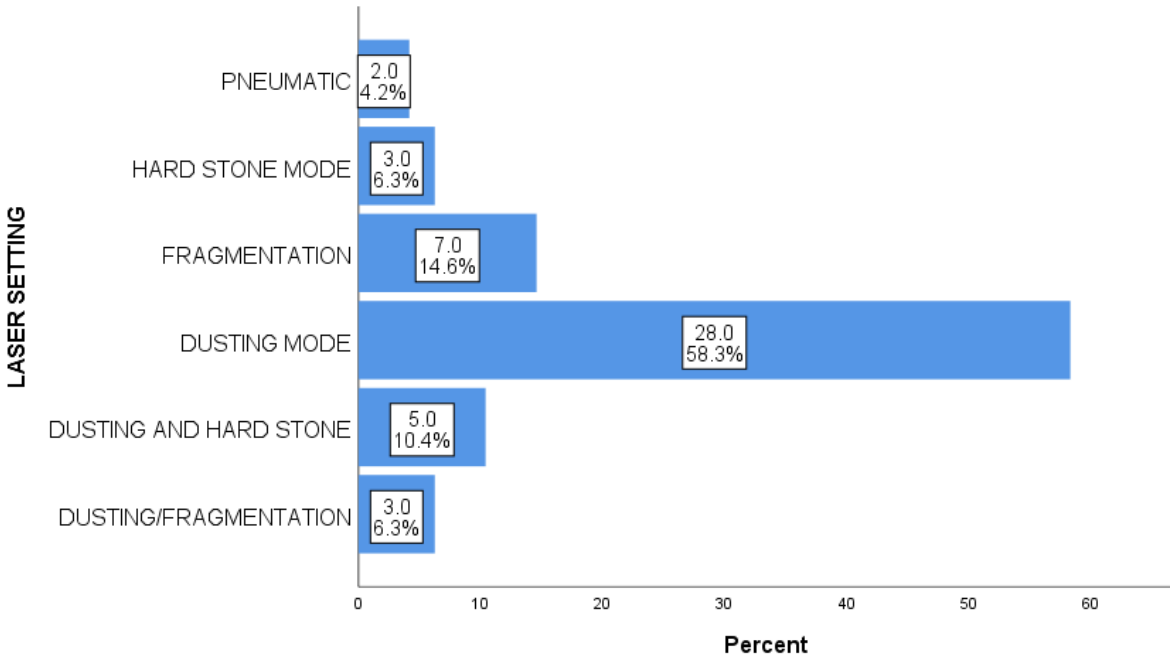

Figure 5. Methods of stone fragmentation utilized during endoscopic treatment

Table 3. Relationship between the age, stone size and Hounsfield with the locations of calculi

	Stone location					
	Bladder	Renal	Ureter	Vesicoureteric junction	ANOVA (F value)	p-value
	Mean±SD	Mean±SD	Mean±SD	Mean±SD		
Age	63.56±8.28	50.10±14.78	46.30±13.91	46.50±7.78	2.984	0.039
Stone size(mm)	28.5±13.19	20.37±46.06	8.34±1.44	7.50±4.95	0.316	0.813
Stone Hornesfield unit		803.33±315.87	768.50±125.16	547.70±604.72	0.367	0.708

5. Discussion

Urolithiasis is a common affliction in people, and the reported incidence and prevalence are increasing. [9,10] In the United States, the lifetime prevalence is 1 in 11, and 30 million people are at risk of developing the disease. [9] There is a lack of incidence studies in the literature from developing countries. In our research, sixty-one patients with urolithiasis who had endoscopic management during the four-year study period were considered. (Table 1) The modal age was the 40-49year age group. (Table 2) This is similar to other studies that observe a peak incidence between 40-60year age group. [9,10]

We observed a male: female ratio of approximately 3.5:1 in the sex distribution (Figure 1). This is a little higher than 2.5 to 3:1 male: female ratio observed in many other studies. [11-15]

The commonest presenting symptom in our study was flank pain in 49 (80.3%) of the patient. Most urinary stones originate within the kidney and migrate distally, creating varying degrees of urinary obstruction as they get trapped in narrow areas, including the ureteropelvic junction, pelvic brim, and ureterovesical junction. The location and nature of the pain are related to the site of the stone within the urinary tract. The severity of pain depends on the degree of obstruction, ureteral spasm, and associated infection. Stones trapped at the ureteropelvic junction may present with non-radiating flank pain from the distention of the renal capsule. It may sometimes radiate to the testis because of the shared dermatomal nerve supply. Ureteric stones could present with sudden onset, severe, colicky pain in the lower abdomen of the ipsilateral flank with radiation to the testicles or the vulvar area. Bladder stones could present with painful voiding that radiates to the tip of the penis, strangury and haematuria. In our study, macroscopic haematuria was the presentation in five (8.2%) of the patients. Nine (14.8%) patients within the study period had bladder stones and had either litholapaxy (seven; 11.5%) or pneumatic lithotripsy (two; 3.3%). (Table 2 and Figure 3)

Stones lodged at the ureterovesical junction, observed in two (3.3%) of our patients, could cause irritative LUTS such as nocturia, frequency, urgency and urge incontinence observed in six (9.8%) of our patients. (Table 2)

Ureteric stones that have entered the bladder pass relatively easily during urination because the urethral calibre is wider; hence urine retention from classic strangury is uncommon. None of our patients in the study population during the period had strangury.

The commonest procedure we performed was RIRS with laser lithotripsy {31(50.8%)}) for renal stones. (Figure 3) This is probably because majority of our patients had renal stones (Table 2) and the sizes of the stones were less than 2cm. RIRS is also the commonest endoscopic stone surgery reported by other researchers.[4,5] Stone dusting was the most frequently used method of stone pulverization in 58.3% of patients. The 'dusting mode' is associated with less stone retropulsion, less fibre

degradation, and more excellent stone dust. [16] The dust consists of tiny particles of <2 mm that can be spontaneously passed through the ureteral access sheath without basketing. [17] Some have defined "stone dust" as particles of <250 µm, small enough to spontaneous float under 40 cmH_2O irrigation pressure, mean sedimentation time of <2 seconds through 10 cm of saline solution, and total suitability for aspiration through a 3.6-Fr working channel. [18] Stone fragmentation, on the other hand, involves the creation of fragments that can be extracted through the UAS with a basket. Fragmentation with higher pulse energies and lower frequencies have advantages because they speed up the process of stone pulverization into smaller pieces. However, this can be a problem, as the multiple, large stone fragments that are produced require attention, prolong the surgery time, and increase the overall cost as more accessories may be utilized. This is why many urologists prefer to use a "dusting" technique. [19,20,21]

We utilize pneumatic lithotripsy in two patients with large bladder stones greater than 5cm to fragment the stones, followed by evacuation utilizing a nephroscope and graspers. The patients with smaller stones, less than 5cm had litholapaxy using a lithotrite. The sheath of the lithotrite was first introduced using a viewing obturator before insertion of the lithotrite. In the author's view, the lithotrite should be used with utmost caution to prevent bladder and bladder neck injuries.

Forty-three (70.8%) of the patients were complication-free. The commonest complication after surgery was fever in eleven (18.0%) of the patients. Fever is also the most frequent complication in laser lithotripsy reported by other researchers. [22] The cause could include renal backflow and reabsorption of infected urine. It is noteworthy that observation showed that RIRS has higher total fluid absorption than PCNL procedures. [23] Other risk factors for fever and septicaemia include the presence of a preoperative stent, obstructive pyelonephritis, a positive preoperative bladder urine culture result, female gender, increased stone size, or lengthy operating time. [24,25] Three patients with large calculi had post-ops ureteric obstruction from Steine Strasse after DJ stent removal. They presented with sudden onset ureteric colic. They all had successful ureteroscopy, removal of the fragments using semirigid ureteroscopes and gaspers with the resolution of symptoms.

Six (9.8%) patients had PCNL for either large renal stones >2.5cm or multiple stones. The number PCNL is low because the author prefers RIRS for most stones. In our experience, RIRS is often preferred by the patients after preoperative counselling. The morbidity associated with PCNL is also higher than RIRS. One of our patients, a 71-year-old lady, who is hypertensive and diabetic and had a mild CVD several years earlier, had PCNL for symptomatic multiple renal calyceal stones. She had a previously unsuccessful open surgery for the calculi. She developed post-ops acute myocardial infarction and post-operative cardiovascular accident with hemiparesis. She was managed by the cardiologist and neurologist, recovered, and discharged symptom-free. This emphasizes the need for an experienced anaesthesiologist working in sync with the urologist during endourological procedures. It underscores the importance of the patient's preexisting comorbidities, especially in the aged. In general, though, PCNL has the best stone-free rate among the endourological stone procedure with good patient selection. [4,25]

The majority of ureteric injuries are managed by ureteric stenting. Sudden movements by the assistant, surgeon and patients between anaesthetic agent administration can lead to ureteric injury, especially in a tight ureter.

One of our patients developed severe urosepsis with multiple organ dysfunction syndromes associated with O_2 desaturation, cardia dysrhythmia, azotemia and hypercreatinaemia from multidrug-resistant Escherichia coli. This was despite preoperative urine sterilization and antibiotic prophylaxis. He was managed with oxygen, vasopressors, antibiotic(meropenem) under intensive care to full recovery and discharge. All gram-negative bacteria can cause urosepsis. However, E. Coli is the most commonest associated with 50.0% of fatal endotoxemia. [26,27] Urosepsis is a deadly clinical syndrome associated with an exaggerated inflammatory response that can potentially result in multiple organ dysfunction syndrome and death. [28,29] Because of the prevalence of multidrug resistance, we routinely use ticarcillin, tazobactam or meropenem for antibiotic prophylaxis.

6. Conclusion

RIRS and ureteroscopy with laser lithotripsy are the commonest procedures we now perform for upper urinary stones. Our embracing endourological management of urinary tract stone, an established paradigm in the developed countries, was slow and associated with challenges. However, the steady development of the capacity in endoscopic stone management is a welcome development that will mitigate the morbidity associated with stone diseases in Nigeria and sub-Saharan Africa.

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