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Stone clearance rate in patients treated with open surgery versus percutaneous nephrolithotomy for the management of staghorn renal calculi.

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Abstract

Background: Urinary calculi, particularly staghorn renal calculi, pose a significant health challenge. Percutaneous nephrolithotomy (PCNL) and open surgery are two distinct surgical interventions employed for treating staghorn renal calculi. This study compared the stone clearance rates of patients undergoing open surgery versus percutaneous nephrolithotomy at the Department of Urology, Sindh Institute of Urology and Transplantation (SIUT) in Karachi, Pakistan.

Methodology: A prospective cohort study was conducted from February 8th to August 7th, 2019. Patients aged 18 to 60 years diagnosed with staghorn renal calculi were included. Patients with other renal stones and untreated urinary tract infections were excluded. The study enrolled 230 patients, divided into two groups: Group I underwent percutaneous nephrolithotomies, and Group II underwent open surgery. Stone clearance was assessed through post-surgery X-ray KUB.

Results: The mean age of participants was 44.99 years, with a balanced gender distribution. Both PCNL and open surgery achieved stone clearance rates of 68.7%, with significantly higher rates observed in the PCNL group (74.8% vs. 62.6%, p = 0.04). Stratification by age, gender, illness duration, and stone location did not yield substantial variations in stone clearance rates.

Conclusion: PCNL demonstrated a superior stone clearance rate compared to open surgery in the treatment of staghorn renal calculi. This finding highlights the potential of PCNL as a more effective intervention for addressing this challenging urological condition.

Keywords

Staghorn Stones, Percutaneous Nephrolithotomy, Open Surgery

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Introduction

Urolithiasis, affecting 2-9% of the global population, presents a significant health concern[1]. A complete staghorn calculus refers to the concretion that occupies the entire renal pelvis and its calyces, leading to obstruction[2]. Within this category, staghorn calculi can be further classified as complete or incomplete based on the extent of obstruction[3]. In Pakistan, staghorn calculi constitute approximately 15% of renal calculi cases, deviating slightly from the international average of 12.5%[4]. Minimally invasive procedures have become the cornerstone of treatment for staghorn calculi, with Percutaneous Nephrolithotomy (PCNL) standing out as the primary choice[5]. The prevalence of open surgical interventions has declined significantly due to advancements in minimally invasive techniques and proficient surgeons[6]. This study aims to delve into the divergence in stone clearance rates between PCNL and open surgical approaches in the context of Pakistan's clinical landscape.

Staghorn calculi, encompassing the renal pelvis and calyces, impose a notable burden on urological health worldwide. With their prevalence at 15% among renal calculi cases in Pakistan, these obstructions demand effective management strategies[7,8]. The paradigm shift towards minimally invasive interventions, exemplified by PCNL, has revolutionized staghorn calculus treatment. This is in contrast to the historical reliance on open surgical procedures, which has gradually diminished owing to advancements in technology and surgeon expertise[9]. Prior studies present a varied spectrum of outcomes, with stone clearance rates diverging between PCNL and open surgery[10]. The intricate debate over the supremacy of one technique over the other calls for a nuanced exploration within the local Pakistani context[11].

In the Pakistani medical landscape, the persistence of open surgical interventions alongside PCNL for staghorn calculus treatment necessitates an in-depth analysis of their respective stone clearance rates. This study aims to comprehensively assess the discrepancy in stone clearance outcomes between patients subjected to open surgery and those undergoing PCNL for the management of staghorn renal calculi. By shedding light on the comparative efficacy of these interventions, the study endeavors to inform clinical decision-making and contribute to refining treatment strategies in this specific patient population.

Methodology

Study Design

This study employed a prospective cohort design to investigate the outcomes of patients undergoing different surgical procedures for the treatment of staghorn renal calculi. The research was conducted at the Department of Urology, Sindh Institute of Urology and Transplantation (SIUT) in Karachi. The study was conducted from February 8, 2019, to August 7, 2019, encompassing a period of six months.

Sample Size Calculation

The sample size was determined using the formula for comparing proportions. Considering a significance level of 5% and a test power of 80%, the calculated sample size was 115 patients in each group. Thus, a total of 230 patients were enrolled in the study. A non-probability consecutive sampling technique was employed to select patients for the study.

Sample Selection

The study included both male and female patients aged between 18 and 60 years who were diagnosed with staghorn renal calculi of any duration. Patients with renal stones other than staghorn calculi detected through ultrasound and those with untreated urinary tract infections (UTI) identified during clinical examination or urine analysis, which could potentially impact post-procedure stone clearance rates, were excluded from the study.

Ethical Consideration

Prior to the commencement of the study, ethical approval was acquired from the hospital's committee to ensure compliance with ethical standards and patient welfare. Additionally, informed consent was diligently obtained from each participating patient, underscoring their full

understanding and voluntary agreement to be a part of the study.

Data Collection

A lottery-based system was employed to allocate patients into two groups. Patients picked folded sheets indicating the type of surgery they would undergo, resulting in an equal distribution between Group I (undergoing percutaneous nephrolithotomy) and Group II (undergoing open surgery).

Staghorn calculi were identified based on patients' CT scan results and operational definitions. Skilled surgeons with a minimum of three years of post-fellowship experience performed both procedures. Post-surgery, an X-ray KUB was conducted on the second day to assess stone clearance. A standardized Proforma was employed to document stone removal details and patient information.

Data Analysis

Statistical Package for the Social Sciences (SPSS) version 20.0 was used for data analysis. Quantitative variables like age, duration of kidney stone disease, height, weight, and BMI were presented as means with standard deviations. Categorical variables, including gender, hypertension, staghorn calculi characteristics, location, and stone clearance rate, were presented as frequencies and percentages.

Comparisons between groups regarding stone clearance rates were conducted using the Chi-square test. To control for potential confounding factors such as age, gender, BMI, hypertension, duration of renal stone disease, type of staghorn calculi, and calculi location, a stratified analysis was performed. Subsequently, the Chi-square test was used within strata, and a significance level of 0.05 was considered indicative of a statistically significant difference.

Results

The study's participants exhibited a mean age of 44.99 years (SD = 10.67), ranging from 18 to 60 years. Notably, participants displayed an average body mass index (BMI) of 26.01 kg/m² (SD = 4.22), spanning from 15.78 kg/m² to 37.95 kg/m². The average duration of kidney stone disease was 5.65 months (SD = 4.23), with cases extending from one to 24 months. The gender distribution demonstrated a prevalence of 145 males (63.0%) and 63 females (27.0%) among the participants.

Both open surgery and percutaneous nephrolithotomy achieved successful stone clearance rates in 158 patients (68.7%), while 72 patients (31.3%) experienced failed stone clearance. A noteworthy disparity emerged when comparing stone clearance rates between percutaneous nephrolithotomy (PCNL) and open surgery groups. Specifically, the PCNL group exhibited a significantly higher stone clearance rate of 74.8% (86 patients), in contrast to the open surgery group's rate of 62.6% (72 patients) ($p = 0.04$).

Stratification by age into three groups revealed consistently high stone clearance rates within the PCNL group across all age categories. However, no substantial variations were observed between age groups. Similarly, gender stratification did not yield any notable differences in stone clearance rates within male or female subgroups, with p-values of 0.24 and 0.09, respectively (Table 3).

Analysis of the illness duration in three categories unveiled no significant impact on stone clearance rates. When stratified based on stone location, no noteworthy differences were noted in stone clearance rates among patients with unilateral or bilateral stones ($p = 0.13$ and $p = 0.14$, respectively).

Table 1: Baseline Characteristics.

Variable	Mean±SD
Age (years)	44.99±10.67
Height (cm)	165.11±9.03
Weight (kg)	71.03±13.33
BMI (kg/m^2)	26.01±4.22
Duration of Disease (months)	5.65±4.23

Table 2: Comparison of stone clearance rate between the groups.

Stone Clearance	Groups		P-value
	PCNL N(%)	Open Surgery N(%)	
Yes	86(74.8)	72(62.6)	0.04*
No	29(25.2)	43(37.4)	

*P<0.05 is considered statistically significant.

Table 3: Stone clearance rate between the groups with respect to various patient characteristics.

				PCNL	Open Surgery	P-value
Age group	18-40 years	Stone Clearance	Yes	32(13.91)	22(9.56)	0.15
			No	9(3.91)	13(5.65)	
	41-50 years	Stone Clearance	Yes	18(7.82)	24(10.45)	0.62
			No	8(3.47)	14(6.08)	
	51-60 years	Stone Clearance	Yes	36(15.65)	26(11.30)	0.18
			No	12(5.21)	16(6.95)	
Gender	Male	Stone Clearance	Yes	55(23.91)	45(19.56)	0.24
			No	20(8.6)	25(10.8)	
	Female	Stone Clearance	Yes	31(13.47)	27(11.73)	0.09
			No	9(3.91)	18(7.82)	
Hypertension	Yes	Stone Clearance	Yes	25(10.80)	30(13.04)	0.18
			No	6(2.64)	15(6.52)	
	No	Stone Clearance	Yes	61(26.52)	42(18.26)	0.10
			No	23(10)	28(12.17)	
BMI	Normal (<25 kg/m^2)	Stone Clearance	Yes	33(14.34)	37(16.08)	0.48
			No	11(4.78)	17(7.39)	
	Overweight (25 to <30 kg/m^2)	Stone Clearance	Yes	38(16.52)	27(11.73)	0.21
			No	13(5.65)	19(8.26)	
	Obese (25 to ≥30 kg/m^2)	Stone Clearance	Yes	15(6.52)	8(3.47)	0.31
			No	5(2.17)	7(3.04)	
Duration of Disease	1-6 months	Stone Clearance	Yes	57(24.78)	42(18.26)	0.09
			No	21(9.13)	28(12.17)	
	6-12 months	Stone Clearance	Yes	20(8.69)	20(8.69)	0.24
			No	6(2.60)	12(5.21)	
	12-24 months	Stone Clearance	Yes	9(3.91)	10(4.34)	0.77

			No	2(0.86)	3(1.30)	
Location of Stones	Unilateral	Stone Clearance	Yes	69(30.00)	61(26.52)	0.13
			No	23(10.00)	33(14.34)	
	Bilateral	Stone Clearance	Yes	17(7.39)	11(4.78)	0.14
			No	6(2.60)	10(4.34)	
Staghorn Stones	Partial	Stone Clearance	Yes	62(26.95)	50(21.73)	0.10
			No	24(10.43)	33(14.34)	
	Complete	Stone Clearance	Yes	24(10.43)	22(9.56)	0.20
			No	5(2.17)	10(4.34)	

*P<0.05 is considered statistically significant.

Discussion

Globally, the prevalence of open surgical interventions for urinary stones has diminished considerably due to advancements in equipment, surgical expertise, and less invasive approaches[12-15]. The decreasing trend of open surgical stone treatment is evident across different healthcare settings. This decline is attributed to the rise of minimally invasive techniques like PCNL and the gradual shift away from open surgical procedures[16]. In the UK, the recorded rate of open renal stone surgery (ORSS) cases was 1% in 2006[17]. The ORSS rate is significantly higher in poorer nations[18-20]. A 2009 Chinese study reported an incidence of 7.4% for ORSS, while Zargooshi found a 14% incidence after analyzing several cases of open stone surgery. The primary treatment options for large complex staghorn stones are generally accepted to be percutaneous nephrolithotomy (PNL) with or without shock wave lithotripsy (SWL) or open surgery. In our series, the failure of PNL in managing renal stones accounted for 10.3% of the indications for ORSS. Similar figures were reported as 16%, 17%, 29%, and 48.6% in studies by Sy et al., Kane et al., Paik et al., and Assimos et al., respectively[21-24]. The adoption of open surgical approaches varies across nations, with resource constraints sometimes necessitating open surgery, as seen in regions where open stone surgery rates remain notably higher. However, advancements in surgical methodologies like PCNL have revolutionized stone management, reducing the need for open interventions.

For complex stone cases, individualized considerations play a pivotal role in determining the choice between open surgery and PCNL. Factors such as the inability to perform PCNL, anatomical variations, and the presence of unique complications may lead to the selection of open surgery. This individualized approach is especially pronounced in cases involving pediatric patients and conditions like UPJ obstruction[25]. The coexistence of varying factors underscores the ongoing relevance of open surgical interventions, particularly in specific clinical scenarios where alternative techniques may not be feasible or appropriate. Since the mid-1980s, urologists have achieved success in treating patients with large renal calculi, including complete staghorn stones, using less invasive therapies[26,27]. Brannen et al. and Brown et al. suggested that percutaneous procedures result in significantly reduced recovery times and costs compared to open surgery. Preminger et al. found that the percutaneous approach was slightly more expensive than open surgery but carried a lower risk of postoperative complications[28-30].

In trials of combined or sandwich therapies, Streem and Lammert observed recurrent stones in 22% of patients after an average follow-up of 25.3 months[31]. When a combination treatment was employed, Lam et al. noted stone-free rates ranging from 83.3% to 86.7% at the time of hospital discharge[32]. For both total and partial staghorn calculi, Winfield et al. reported an 86% stone-free rate with percutaneous nephrolithotomy monotherapy, while SWL monotherapy resulted in 39% of patients still having some stone burden at 8 months after treatment completion[33]. The evolution of stone treatment strategies highlights the gradual shift towards less invasive methods[34,35].

While an atrophic nephrolithotomy and combination therapies have historically been utilized for complex stones, the advent of percutaneous procedures has drastically changed the landscape. Percutaneous approaches offer advantages in terms of reduced recovery time, costs, and postoperative complications compared to open surgery. Notably, the study's comparison of stone clearance rates between PCNL and open surgery underscores the efficacy of PCNL, yielding a higher clearance rate of staghorn stones.

Limitations

This study has limitations that should be acknowledged. The short-term nature of the study limits the assessment of long-term outcomes. Additionally, the relatively small sample size may impact the generalizability of the findings. A more extensive study with a larger and more diverse participant pool, coupled with a longer follow-up duration, would enhance the robustness of the results.

Conclusion

In the context of managing staghorn stones, the present study demonstrates the superiority of Percutaneous Nephrolithotomy (PCNL) over open surgery in terms of stone clearance rates. This research provides valuable insights into short-term outcomes; however, there is a need for larger-scale trials with extended follow-up periods to further validate these findings. As medical practices continue to evolve, the shift towards minimally invasive interventions reaffirms the importance of personalized treatment strategies in optimizing patient outcomes.

Conflicts of Interest

The authors declared no conflict of interest.

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