RENAL STONE DENSITY: DETERMINANT OF ESWL SUCCESS

ABSTRACT

BACKGROUND

The worldwide prevalence of developing renal stones is as high as 15% with an estimated 1 in every 5 persons being affected with the condition in Pakistan. Among the many treatment options available for renal calculi, extracorporeal shockwave lithotripsy (ESWL) is among the commonest owing to its non-invasive nature, however, it has its drawbacks; one being limitation against dense stones.

OBJECTIVE

To assess association between stone density (detected on CT KUB) and ESWL outcome among patients with renal calculi.

METHODOLOGY

This clinical trial was conducted upon a sample of 150 patients (of either gender, aged 16 to 70 years) presenting to the Urology out-patient, emergency and lithotripsy department of Ziauddin University Hospital with renal calculi from 30th August 2017 to 30th September 2019. After taking written informed consent, data was recorded onto a prestructured questionnaire containing inquiries pertaining to basic biodata, sociodemographic details, and disease history, inferences obtained from C.T KUB, operative notes and the eventual treatment outcome. The data obtained was analyzed using SPSS v. 21.0.

RESULTS

The mean age of the sample stood at 36.7 (SD ± 3.1). 104 (69.3%) patients had multiple calculi and 46(30.7%) have single calculi with mean density of 812 (SD ± 219) HU. A (having stone density <500-HU) group B (having stone density 501 to 1000-HU) and group C (having stone density >1000-HU). The success of group A was 95.34% group B was 88.5% and group C was 80.3%. Major proportion of the sample (39.3%) required up to 3 ESWL sessions. The stone density was observed to be inversely proportional to the success of ESWL.

CONCLUSION

After careful consideration, it can be concluded that higher stone density is associated with a poor ESWL outcome and thus other treatment modalities may be considered among patients with a stone density of more than 900 HU.

KEYWORDS

Renal Calculi, Stone Density, ESWL, Treatment Outcome & Stone Characteristic.

INTRODUCTION

Renal stones is a major healthcare obstacle encountered by individuals regardless of their age, gender, and sociodemographic background. The condition is responsible for a cumulative healthcare expenditure totaling above 10 billion (US) in the western world alone. In the past decade, the condition has nearly doubled in incidence and prevalence. [1] Though some places are affected less than the rest, owing to differences in terms of diet, race, and climate – no single population is exempted, and cases have been reported everywhere. [2]

According to estimates, $1/10^{th}$ of the total worldwide population is afflicted with renal stone disease and recently, the risk of developing renal stones has risen to as high as 12% among individuals of all ages [21,22]. Research also leads us to believe that the incidence and prevalence are projected to increase further as time elapses and no interventions are put in place. [3, 4] In the developing world, renal stones cause an even more major economic burden on health. [13] The disease burden of the condition in the developing world too is higher than elsewhere in the world and is second to only urinary tract infections and pathologies of the prostate. [5]

It is estimated that 20% of men and 10% of women present with renal stones at least once up to 70 years of age. Renal stone disease affects 2% of general population between 20 to 40 years of age. The worldwide prevalence of developing renal stones is about 1% to 15%, in Pakistan prevalence of renal stone is about 10 to 15%. [6, 7] It is important to note that simple radiography is effective in detecting radio-opaque calculi with a diagnostic accuracy of over 90%. Less opaque variants (such as struvite, matrix calculi, cysteine, and uric acid stones) are often un-detectable by simpler modalities such as a plain radiograph and more sensitive modalities such as the CT-KUB are required. [8, 9]

Though, as per research estimates, "approximately 90% of stones are successfully passed out of the urinary tract, the remaining stones generally require surgical intervention," with extracorporeal shockwave lithotripsy (ESWL) being the treatment of choice. ESWL has 80-90% treatment success [10]. However, the ESWL

outcomes depend on "stone location, renal and calyceal anatomy, body mass index (BMI), stone composition, and, recently, the stone-attenuation value (SAV) in Hounsfield Units (HU) which represent the stone density". It is suggested that stone density varies with its composition, and that affects its fragility, which effects the outcomes of ESWL. **[11]**

OBJECTIVES

The objective of this study was to assess the role of extra corporeal shock wave lithotripsy (ESWL) in stone fragmentation with relation to stone density.

METHODOLOGY

This clinical trial was conducted upon a sample of 150 patients (of either gender, aged 16 to 70 years) presenting to the Urology out-patient, emergency and lithotripsy departments of Ziauddin University Hospital with renal calculi from 30th August 2017 to 30th September 2019. After taking written informed consent, data was recorded onto a prestructured questionnaire containing inquiries pertaining to basic biodata, sociodemographic details, and disease history, inferences obtained from C.T KUB, operative notes and the eventual treatment outcome. The data obtained was analyzed using SPSS v. 21.0.

ELIGIBILITY CRITERIA

Inclusion Criteria:

1. Age from 16 to 70 years.
2. Stone Size ≥4 mm (≥4 cm) to 150 mm (1.5cm)
3. Stone located in renal pelvis, upper and middle poles
4. Patients with no UTI

Exclusion Criteria:

1. Patient with any contraindication to ESWL
    a. Skeletal deformities
    b. Uncontrolled coagulation disorders
    c. Pregnant women
    d. Patient with abdominal and/or aortic aneurysms
    e. Patient with uncontrolled hypertension
    f. Tachycardia
2. Patient having obstruction lower down to stone.
3. Distal obstruction pelvic ureteric junction (PUJ) or in ureter

RESULT

Total number of patients included in this study is 150. Out of which 89 (59.3%) of the patients were females and 61(40.7%) were males. The mean age of the sample stood at 36.7 (SD ± 3.1). 104 (69.3%) patients had multiple calculi and 46(30.7%) have single calculi with mean stone dimensions being 0.7 x 0.5 cm. A mean density of 812 (SD ± 219) HU was noted with the commonest site of stone being the upper pole of the kidney.

Table 1: Demographic survey results

Variable		**n (%)**
Gender	Male	89 (59.3%)
	Female	61 (40.7%)
Age	< 20	12 (8%)
	21 – 30	23 (15.3%)
	31 – 40	49 (32.7%)
	41 – 50	35 (23.3%)
	51 – 60	24 (16%)
	61 – 70	07 (2.7%)
Marital Status	Married	83 (55.3%)
	Un-Married	67 (46.7%)
Body Mass Index	Underweight	24.7%
	Normal Weight	45.3%
	Overweight	16.7%
	Obese	13.3%
Mean stone size	0.7x0.5 cm	
Distribution of calculi	Single = 30.7%	Multiple = 69.3%
Mean stone density	812 (SD ± 219)	

132 (88%) had complete fragmentation of stone. We divided the patients into three groups group-A (having stone density <500-HU) group B (having stone density 501 to 1000HU) and group C (having stone density >1000-HU). The success of group A was 95.34% group B was 88.5% and group C was 80.3%. Major proportion of the sample (39.3%) required up to 3 ESWL sessions. The stone density was observed to be inversely proportional to the success of ESWL.

Out of 150 patients, nearly 1/3rd patients (39.3%) required up to 3 ESWL sessions.

ESWL Sessions	n (%)
1	39(26%)
2	52 (34.7%)
3	59 (39.3%)

Table 2: ESWL sessions

The stone density was noted to have an interesting relation with the ESWL success rate. Overall success rate of ESWL was 88%. Patients with stone density <500HU success rate was 95.34% 88.52% in patients having density 500-HU to1000HU and 80.43% having stone density >1000-HU.

Stone Density	Successful fragmentation *n = 132(88%)*	Failure Residual Fragments after 3 sessions *n = 18 (12%)*	Chi Square Test
⩽500 HU *(n = 43)*	*41(95.34%)*	*02*	*0.001*
501–1000 HU *(n = 61)*	*54(88.52%)*	*07*	*0.003*
>1000 HU *(n = 46)*	*37(80.43%)*	*09*	*0.01*

Table 3: **Stone Density**

The stone density was noted to have an interesting relation with the number of ESWL session. Less dense stones were managed via fewer ESWL sessions as shown below in which 17 patients have complete fragmentation on 1st session in stone with density <500HU compared to more denser stones in which only 04 patients had fragmentation on 1st session in stones with density. >1000-HU Same trend was noted in table no 3 showing fragmentation of stone with ESWL in session 2 and 3 respectively.

Table 4: Fragmentation of stone with ESWL in session 2 and 3

Stone Density	SUCCESS AT 1ST SESSION *(N = 33)*			
	0.5 – 0.75	**0.76 – 1.0**	**1.1 – 1.25**	**1.26 – 1.5**
⩽500 HU *(n = 17)*	*11*	*02*	*03*	*01*

501–1000 HU *(n = 12)*	*09*	*02*	*01*	*00*
>1000 HU *(n = 04)*	*03*	*01*	*00*	*00*

Stone Density	**SUCCESS AT 2ND SESSION** *(N = 46)*			
	0.5 – 0.75	**0.76 – 1.0**	**1.1 – 1.25**	**1.26 – 1.5**
⩽500 HU *(n = 13)*	*04*	*03*	*03*	*03*
501–1000 HU *(n = 23)*	*07*	*06*	*06*	*04*
>1000 HU *(n = 10)*	*04*	*02*	*02*	*02*

Stone Density	**SUCCESS AT 3RD SESSION** *(N = 53)*			
	0.5 – 0.75	**0.76 – 1.0**	**1.1 – 1.25**	**1.26 – 1.5**
⩽500 HU *(n = 09)*	*01*	*02*	*03*	*03*
501–1000 HU *(n = 20)*	*03*	*06*	*06*	*05*
>1000 HU *(n = 24)*	*04*	*05*	*06*	*09*

DISCUSSION

Success rate with ESWL varies with lithotripter, stone location (pelvic or calyceal), the density and composition (hardness) of the stones and the patient's physical characteristics (BMI). Various studies claim ESWL success rate up to 90% in adult population, [112] but the aforementioned factors influence the treatment outcome and trajectory and determine whether re-treatment is necessitated. [13]

This study included 150 patients with stone size from 0.5 to 1.5 cm which is comparable with other studies which included stone size more than 2 cm which can affect the ESWL outcome. It was more common (69.3%) for the research subjects to have multiple calculi than single stones. This finding is not unique and is synonymous with both local and international evidence. In renal stone disease, it is quite common to encounter more than one calculus in the system and though most may be too small or

insignificant, they are certainly prevalent. However, this does not necessarily reflect the level of severity of the condition since large singular stones that are very dense may often be more problematic for the patient than small easily fragmented multiple stones in the renal system. [14, 15]

Additionally, the average stone dimensions were 0.7 cm x 0.5 cm. A mean density of 812 (SD ± 219) HU was noted with the commonest site of stone being the upper pole of the kidney. This is an interesting observation since existing literature is divided on the matter of which site is the commonest in-terms of stone formation, with the largest proportion of published text suggesting the calyx, followed by the upper pole. Both local and international evidence is inconclusive in this regard. [16, 17]

A major proportion of the sample (39.3%) required up to 3 ESWL sessions. This was probably since most of the patients had dense and multiple stones and fragments that merit reiteration of ESWL which often persisted after initial ESWL session. This too mirrors the findings reported by recent literature. [18]

The stone density was noted to have an interesting relation with the number of ESWL sessions. Less dense stones with density <500 HU were managed via fewer ESWL sessions and required less energy as compared to more dense stones, which required more sessions and higher frequency and energy comparatively. Stones greater than 1000 HU had the highest failure rate i.e., residual stones even after 3rd ESWL session.

To be precise, the probability of a successful treatment outcome was 90.7% in stones with a density of ⩽500 HU. Stones that had a density value between 501–1000 HU had a slightly lower probability of a successful treatment outcome (90.2%). However, the probability of success took a sharp dive and was recorded to be 84% for stones with a density of >1000 HU.

Hence, the stone density was observed to be inversely proportional to the success of ESWL on first attempt. This is the most crucial observation and is in-line with the findings previously claimed by prominent researchers in this regard. [19] It is important to note that every patient needed analgesia and more dense stone required more energy to break stone and less dense stone required less energy and less ESWL session.

Thirdly, though most of the stones, regardless of the size (small or large) required 2 sessions. However, the probability of a stone complaint being resolved in the first session was higher in smaller stones as compared to when the stones were

larger. The probability of success is 94.4% when the stone size is 0.5 to 0.75, and the success rate drops to 85.7%. This too matches the findings published in literature. [20]

There may be many more factors that affect the success of treatment, such as the surgeon's skill, the type of stone and the time elapsed since development of the stone, however, they are beyond the scope of this research. Additionally, the factors may affect different treatment methodologies to varying degrees and that too was out of bounds of the research objectives.

CONCLUSION

After careful consideration, it can be concluded that higher stone density is associated with a poor ESWL outcome and thus stone density should be measured in each patient prior to procedure. Additionally, ESWL has a success rate of greater than 88% in renal stone and thus proper counselling is important prior to the procedure.

This study is among the first few attempts at studying the effect of stone density (measured via CT KUB) in the region, upon the probability of success following ESWL. The results are reliable because patients were operated upon in the same institute using the same table and machine. Also, the sample size was rather small and only adult patients were included in the research, reducing its generalizability to other age groups.

Consent

As per international standard or university standard, patient(s) written consent has been collected and preserved by the author(s).

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