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Comparison of Ultrasonic and Pneumatic Lithotripsy in Pcnl for Kidney Stones in Terms of Stone Clearance Rate and Residual Stone Fragments

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ABSTRACT:

Background: The aggregation of a solid crystalline material in the urinary tract i.e. kidney is called urolithiasis or kidney stone disease. Ultrasonic and pneumatic lithotripsy are the two methods done with PCNL to remove kidney stones. But there was no data available in local literature. So we conducted this study to assess the more beneficial method for local setting.
Objective: To compare the ultrasonic and pneumatic lithotripsy in PCNL for kidney stones in terms of stone clearance rate and residual stone fragments.
Material & Methods: Study design: Randomized control trial
Setting: Department of Urology Lahore general hospital
Duration of study: 12 months i.e. from (15-10-2016) to (15-10-2017).
Data collection: 50 patients enrolled in this study. All admitted patients would be diagnosed on the basis of history, clinical examination, baseline investigations and some specific investigations like urine culture &sensitivity, USG KUB, plain X-rays KUB, IVU and CT-scan KUB if needed. The patients were divided into two groups. One is treated with Ultrasonic lithotripsy and the other is with Pneumatic lithotripsy. All the collected data was entered and analyzed SPSS 21.
Results: In ultrasonic Lithotripsy group, the mean age of patients was 38.76±12.95years and in pneumatic Lithotripsy was 38.12±13.78years. There were 24(48%) male patients and 26(52%) female patients. In ultrasonic lithotripsy group, stone clearance was achieved in 19(76%) patients while with pneumatic lithotripsy, stone clearance was achieved in 11(44%) patients.
Conclusion: Thus ultrasonic lithotripsy is superior to pneumatic lithotripsy in PCNL in stone clearance and had better outcome.

Keywords: Kidney Stone, Stone Clearance, Residual, PCNL, ultrasonic and pneumatic lithotripsy.

1. Introduction

Renal stone disease is a known urological disorder since long time having a prevalence of about 2-3% in general population.(Gupta et al., 2011)The prevalence is increased to 4 to 20% in Pakistan due to stone forming belt of Afro-Asia.(López and Hoppe, 2010)The estimated

lifetime risk for development of a renal stone is approximately 12%.(Gupta et al., 2011)This disease predominates in male patients (2:1) and is characterized by a high rate of recurrences about 50%.(Simon et al., 2015)

Most common leading symptom of kidney stone is radiating colicky and excruciating nature of pain in the lumbar region. Patients are moving continuously and unable to find any position that is helpful to get relieve from pain. Associated features such as nausea, vomiting and fever may occur.(Hautmann and Gschwend, 2014)

The treatment of urinary lithiasis has been reformed with the arrival of extracorporeal shock wave lithotripsy (ESWL) and endo-urological procedures such as percutaneous nephrolithotomy (PCNL), ureterorenoscopy and retrograde intra-renal surgery.(D'souza et al., 2016)There is a great reduction in the indications for open stone surgery making it a 2nd or 3rdline treatment options.(Honeck et al., 2009)

The PCNL was introduced in 1980-81 and it revolutionized the management of large renal calculi. It has minimal post-operative pain, small negligible scar, early recovery, shorter hospital stay and low incidence of wound infections as well as stone clearance comparable to the open renal stone surgery. It is suitable for patients of any age.(Dogan et al., 2011)

The two most commonly used energy sources for stone fragmentation in PCNL i.e. the ultrasonic and pneumatic lithotripsy. In ultrasonic lithotripsy, a probe is used to transmit acoustic wave energy and to convert it to mechanical energy. The vibration is the basis of this energy that is helpful to fragment the stone efficiently and hollow metallic probe is used for suction of small particles while a ballistic probe is used in pneumatic lithotripsy for fragmentation of stones. An air supply (compression tank) is connected with probe for pressure creation to push air into a stone.(Pugh and Canales, 2010)

Different physical principles are used by these different intracorporeal lithotripters for fragmentation of stone.(Leongteh et al., 1998)The working of Pneumatic lithotripters is same as collision with a bullet in which energy as compressed air pulses enclosed in a steel probe work is transmitted for fragmentation of stone after impaction.(Atar et al., 2013)

This technique offers safe, cheap, and effective clearance of calculi, and it is particularly useful for large and hard stones. Also, all stones can be destroyed regardless of their composition, but it is required to extract the fragments of stone.(Hofmann et al., 2002a, Diri et al., 2012)

The most commonly used lithotripsy is still ultrasonic lithotripsy with the help of rigid nephroscopes during PCNL.(Leveillee and Lobik, 2003) Stones are fragmented into small pieces and the hollow bore of the transducer is used to aspirate these particles and also helpful for stone extraction manually.(Hofmann et al., 2002a, Diri et al., 2012)

This technique was the standard method of lithotripsy for many years, with a fragmentation rate of 97%.(Hofmann et al., 2002a) Although this lithotripsy technique has high success rates, but success rate can be decreased in patients having hard stones e.g. calcium oxalate monohydrate and cysteine. The potential for overheating is another disadvantage in which heat energy is produced from conversion of vibration energy.(Krambeck et al., 2011)

In accordance with the literature, more than 84% success rate has been obtained by the pneumatic lithotripsy. An overall success rate of pneumatic lithotripsy was 90.8%.(Hofmann et al., 2002a, Diri et al., 2012, Liatsikos et al., 2001, Unsal et al., 2012)

Fern strom and Johansson were the first who used a nephrostomy tract for removal a renal calculus in 1976, and PCNL is considered as gold standard procedure for patients having renal stones with size more than 2cm in diameter, stones having infection, stones in the lower calyx causing obstruction, stones with anatomical variations in the renal collecting system as well as for those patients having stones resistant to ESWL. If ESWL is performed on patients having higher stone burden, many stone fragments can cause obstruction while passing through the ureter.(Fernström and Johansson, 1976)

As there is a scarce data regarding PCNL in our setup so we intend to compare the outcomes of ultrasonic and pneumatic energy sources in PCNL in our local set up in terms of stones clearance rate and residual stone fragments to provide a justification for either technique.

2. Material and Methods

A Randomized control trial was conducted at department of urology Lahore General Hospital, Lahore among between 15-10-2016 to 15-10-2017. There were total 50 patients of kidney stone were divided into two groups of 25 each.
Total fifty patients were included in this study by using purposive sampling technique then they were randomly allocated to both groups by using balloting method. Adult patients of both genders with stone size ranges 2.5cm to 4cm, recurrent stones after open renal surgery and stones not disintegrated by ESWL were included. Patients with PUJ obstruction, polycystic kidneys, pregnancy, unfit for surgery and immuno-compromised were excluded. The patients fulfilling the inclusion criteria were admitted from outpatient department of Lahore General Hospital, Lahore and baseline investigations were advised to get fitness from anesthetist. Then patients were divided into two groups by balloting method. In Group A patients; PCNL with Ultrasonic lithotripsy and In Group B patients; PCNL with Pneumatic lithotripsy. Informed consent was obtained before operation. Results regarding stone clearance and residual stone fragments were entered in the Performa designed for it and later on analyzed by SPSS version 21.

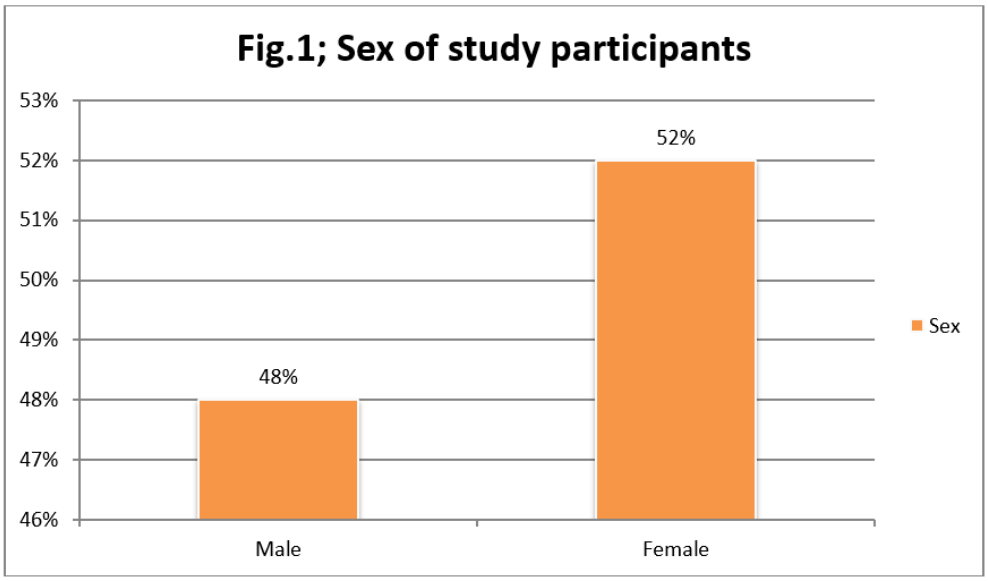
3. Results

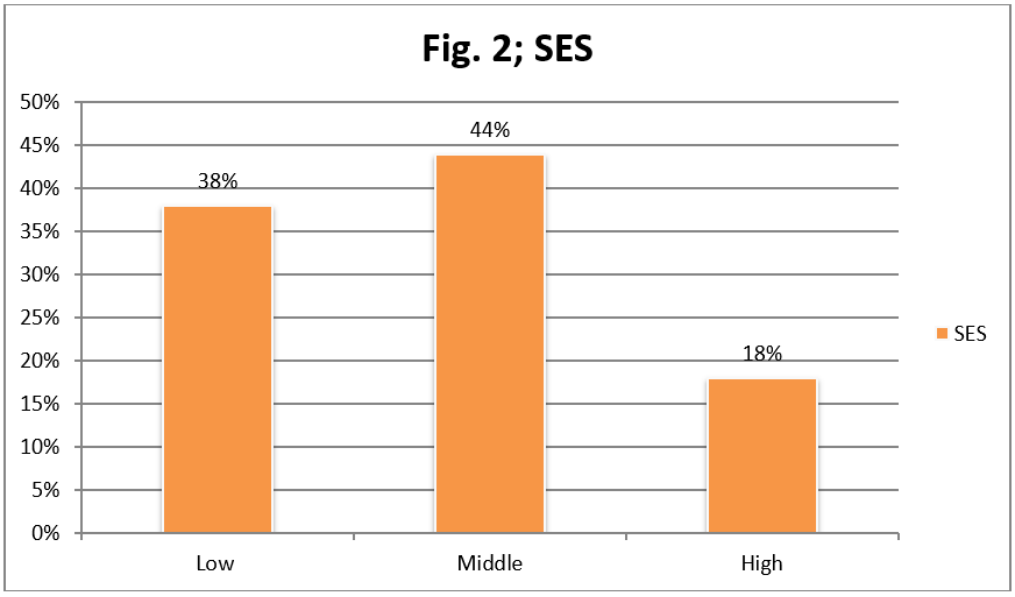
In ultrasonic Lithotripsy group, the mean age of the patients was 38.76±12.95 years and in pneumatic Lithotripsy were 38.12±13.78 years (Table 1). In this study there were 24(48%) male patients and 26(52%) female patients. The male to female ratio was 1:1.1 (Fig. 1). In ultrasonic lithotripsy group, there were 12 (48%) males while 13 (52%) females. In pneumatic lithotripsy, there were 12 (48%) males while 13 (52%) females (Table 1).
In this study, 19(38%) patients had low SES, 22(44%) patients had middle SES and 9(18%) had high SES (Fig. 2). In ultrasonic lithotripsy group, 8(32%) patients had low SES, 12(48%) patients had middle SES and 5(20%) had high SES. In pneumatic lithotripsy group, 11(44%) patients had low SES, 10(40%) patients had middle SES and 4(16%) had high SES (Table 1).
In ultrasonic Lithotripsy, the mean duration of disease was 3.32±1.68 months and in pneumatic lithotripsy was 3.72±1.79 months. Statistically insignificant difference was found for duration of disease in both groups i.e. p-value=0.419 (Table 1). In ultrasonic lithotripsy group, stone clearance was achieved in 19(76%) patients while with pneumatic lithotripsy, stone clearance was achieved in 11(44%) patients. Statistically significant difference found between both groups for stone clearance i.e. p-value=0.021 (Table 1). In ultrasonic lithotripsy group, residual stone were found in 5(20%) patients while with pneumatic lithotripsy, residual stone was found in 14(56%) patients. Statistically significant difference found between both groups for residual stone i.e. p-value=0.009 (Table 1).

Table 1: Comparison of age (years), sex, SES, Disease duration, stone clearance rate and residual stone with study groups

		Study Groups	
		Ultrasonic Lithotripsy	**Pneumatic Lithotripsy**
Age (years)	**n**	**25**	**25**
	Mean	38.76	38.12
	SD	12.95	13.78

Sex	**Male**	12 (48%)	12 (48%)
	Female	13 (52%)	13 (52%)
SES	**Low**	8(32%)	11(44%)
	Middle	12(48%)	10(40%)
	High	5(20%)	4(16%)
Disease Duration (months)	**N**	25	25
	Mean	3.32	3.72
	SD	1.68	1.79
	Ind. t test=-0.815, p-value=0.419 NS		
Stone clearance rate	**Yes**	19(76%)	11(44%)
	No	6(24%)	14(56%)
	Chi-square test = 5.333, p-value=0.021 Significant		
Residual stone	**Yes**	5(20%)	14(56%)
	No	20(80%)	11(44%)
	Chi-square test = 6.876, p-value=0.009 Significant		





4. Discussion

PCNL is a successful method and known as gold standard technique for the removal of kidneys stones larger in size and complex nature. About 90% stone free rate is reported showing the experience level, properties of stone and instruments used during procedure. Inability to approach stone fragments lie deep in the calyces, bleeding causing poor visualization, technical problems and composition of stone are the main factors leading to failure of complete clearance of stones.(Özdedeli and Çek, 2012)

According to a meta-analysis study by Hollingsworth, flexible ureteroscopy is best treatment modality for renal stones less than 2cm. In fURS, high power Holmium laser is used for the fragmentation of stone. But in our study, pneumatic and ultrasound are used as source of energy for stone removal and stone size is greater than 2cm. So, PCNL is superior to fURS for larger kidney stones. (J.M. Hollingsworth, 2015)

This randomized control trial was carried out to compare the ultrasonic and pneumatic lithotripsy in PCNL for kidney stones in terms of stone clearance rate and residual stone fragments. In our study stone clearance rate, residual stones and other complications are statistically significant between both the groups. Thus ultrasonic lithotripsy was superior to pneumatic lithotripsy.

Previously published studies compared a combination of the two lithotripsy techniques with one of them, or reported a retrospective comparison. Zengin et al, compared in a retrospective study about the outcomes for pneumatic, ultrasonic, and a combination of both pneumatic and ultrasonic lithotripsy in PCNL. Fluoroscopy time and stone disintegration time were significantly shorter in the ultrasonic and combination groups. There was also a significant difference present in success rate in favour of the ultrasonic and combination groups.(Zengin et al., 2014)

Another study by Radfar et al., presented that there were no significant differences between the groups in stone fragmentation and removal time ($p = 0.63$), stone free rate ($p = 0.44$), and hospital stay ($p = 0.66$). SFRT for hard stones was shorter using pneumatic lithotripsy ($p < 0.001$).(Radfar et al., 2017)

In another study by Tolga Karakan et al., demonstrated that intracorporeal lithotripsy can be done effectively and safely by both ultrasonic and pneumatic lithotripters. However, stone clearance rates are higher for the ultrasonic lithotripter with similar morbidity having comparison with pneumatic devices.(Karakan et al., 2013b)

Recently a single device is produced due to combining the both technologies of ultrasound and pneumatic lithotripsy. Significantly increased efficacy and efficiency (stone fragmentation and clearance) of lithotripsy are obtained by combined pneumatic and ultrasonic device as compared to an ultrasonic device.(Auge et al., 2002, Hofmann et al., 2002b)

On the other hand individually, ultrasonic lithotripters have been shown to be more efficient for stone clearance than pneumatic lithotripters.(Lowe and Knudsen, 2009)

However, combination ultrasonic-pneumatic devices are more efficient for stone clearance than either device individually.(Auge et al., 2002)Although the management of urolithiasis has been revolutionized by ESWL, but large or multiple kidney stones are still treated by PCNL.(Brannen et al., 1985)

Another retrospective study was performed by Karakan et al., in which comparison was made about the effectiveness of pneumatic and ultrasonic lithotripters. The authors found that the ultrasonic group has significantly better rates of stone clearance, but stone size was significantly small in this group..(Karakan et al., 2013b)

5. Conclusion

It has been proved in our study that theultrasonic lithotripsy is superior to pneumatic lithotripsy in PCNL and had statistically better outcome for kidney stones.

6. References

1. Atar, M.; Bodakci, M. N.; Sancaktutar, A. A.; Penbegul, N.; Soylemez, H.; Bozkurt, Y.; Hatipoglu, N. K. & Cakmakci, S. 2013. Comparison of pneumatic and laser lithotripsy in the treatment of pediatric ureteral stones. Journal of pediatric urology,**9,** 308-312.
2. Auge, B. K.; Lallas, C. D.; Pietrow, P. K.; Zhong, P. & Preminger, G. M. 2002. In vitro comparison of standard ultrasound and pneumatic lithotrites with a new combination intracorporeal lithotripsy device. Urology,**60,** 28-32.
3. Brannen, G. E.; Bush, W. H.; Correa, R. J.; Gibbons, R. P. & Elder, J. S. 1985. Kidney stone removal: percutaneous versus surgical lithotomy. The Journal of urology,**133,** 6-11.
4. D'souza, N.; Verma, A. & Rai, A. 2016. Laparoscopic-assisted mini percutaneous nephrolithotomy in the ectopic pelvic kidney: Outcomes with the laser dusting technique. Urology annals,**8,** 87.
5. Diri, A.; Resorlu, B.; Astarci, M.; Unsal, A. & Germiyonoglu, C. 2012. Tissue effects of intracorporeal lithotripsy techniques during percutaneous nephrolithotomy: comparison of pneumatic and ultrasonic lithotripters on rat bladder. Urological research,**40,** 409-413.
6. Dogan, H. S.; Kilicarslan, H.; Kordan, Y.; Celen, S. & Oktay, B. 2011. Percutaneous nephrolithotomy in children: does age matter? World journal of urology,**29,** 725-729.
7. Fernström, I. & Johansson, B. 1976. Percutaneous pyelolithotomy. A new extraction technique. Scandinavian journal of urology and nephrology,**10,** 257.
8. Gupta, R.; Gupta, A.; Singh, G.; Suri, A.; Mohan, S. K. & Gupta, C. 2011. PCNL-a comparative study in nonoperated and in previously operated (open nephrolithotomy/pyelolithotomy) patients-a single-surgeon experience. International braz j urol,**37,** 739-744.
9. Hautmann, R. & Gschwend, J. E. 2014. Urologie., Philadelphia, Pa, Springer.
10. Hofmann, R.; Olbert, P.; Weber, J.; Wille, S. & Varga, Z. 2002a. Clinical experience with a new ultrasonic and LithoClast combination for percutaneous litholapaxy. BJU international,**90,** 16-19.
11. Hofmann, R.; Weber, J.; Heidenreich, A.; Varga, Z. & Olbert, P. 2002b. Experimental studies and first clinical experience with a new Lithoclast and ultrasound combination for lithotripsy. European urology,**42,** 376-381.
12. Hollingworth.; W.W, Roberts.; et al. 2015. Contemporary Practice Patterns of Flexible Ureteroscopy for Treating Renal Stones: Results of a Worldwide Survey J Endourol, 29, 1221-1230.
13. Honeck, P.; Wendt-Nordahl, G.; Krombach, P.; Bach, T.; Häcker, A.; Alken, P.; Knoll, T. & Michel, M. S. 2009. Does open stone surgery still play a role in the treatment of urolithiasis? Data of a primary urolithiasis center. Journal of Endourology,**23,** 1209-1212.
14. Karakan, T.; Diri, A.; Hascicek, A. M.; Ozgur, B. C.; Ozcan, S. & Eroglu, M. 2013a. Comparison of Ultrasonic and Pneumatic Intracorporeal Lithotripsy Techniques during Percutaneous Nephrolithotomy. The Scientific World Journal,**2013,** 4.

15. Karakan, T.; Diri, A.; Hascicek, A. M.; Ozgur, B. C.; Ozcan, S. & Eroglu, M. 2013b. Comparison of ultrasonic and pneumatic intracorporeal lithotripsy techniques during percutaneous nephrolithotomy. The Scientific World Journal,**2013**.
16. Krambeck, A. E.; Miller, N. L.; Humphreys, M. R.; Nakada, S. Y.; Denstedt, J. D.; Razvi, H.; Preminger, G. M.; Nadler, R. B.; Matlaga, B. R. & Paterson, R. F. 2011. Randomized controlled, multicentre clinical trial comparing a dual-probe ultrasonic lithotrite with a single-probe lithotrite for percutaneous nephrolithotomy. BJU international,**107,** 824-828.
17. Leveillee, R. J. & Lobik, L. 2003. Intracorporeal lithotripsy: which modality is best? Current opinion in urology,**13,** 249-253.
18. Liatsikos, E. N.; Dinlenc, C. Z.; Fogarty, J. D.; Kapoor, R.; Bernardo, N. O. & Smith, A. D. 2001. Efficiency and efficacy of different intracorporeal ultrasonic lithotripsy units on a synthetic stone model. Journal of endourology,**15,** 925-928.
19. López, M. & Hoppe, B. 2010. History, epidemiology and regional diversities of urolithiasis. Pediatric Nephrology,**25,** 49-59.
20. Lowe, G. & Knudsen, B. E. 2009. Ultrasonic, pneumatic and combination intracorporeal lithotripsy for percutaneous nephrolithotomy. Journal of endourology,**23,** 1663-1668.
21. Özdedeli, K. & Çek, M. 2012. Residual fragments after percutaneous nephrolithotomy. Balkan medical journal,**29,** 230.
22. Pugh, J. W. & Canales, B. K. 2010. New instrumentation in percutaneous nephrolithotomy. Indian Journal of Urology,**26,** 389.
23. Radfar, M. H.; Basiri, A.; Nouralizadeh, A.; Shemshaki, H.; Sarhangnejad, R.; Kashi, A. H.; Narouie, B.; Soltani, A. M.; Nasiri, M. & Sotoudeh, M. 2017. Comparing the Efficacy and Safety of Ultrasonic Versus Pneumatic Lithotripsy in Percutaneous Nephrolithotomy: A Randomized Clinical Trial. European Urology Focus.
24. Simon, I.; Roumeguère, T.; Devuyst, F.; Cotton, F.; Tang, B.; Cappello, M.; Corbetta, S.; Idrissi, M.; Pozdzik, A. & Nortier, J. 2015. [Recurrent episodes of brushite nephrolithiasis revealing primary hyperparathyroidism]. Revue medicale de Bruxelles,**36,** 172-176.
25. Unsal, A.; Resorlu, B.; Atmaca, A. F.; Diri, A.; Goktug, H. N. G.; Can, C. E.; Gok, B.; Tuygun, C. & Germiyonoglu, C. 2012. Prediction of morbidity and mortality after percutaneous nephrolithotomy by using the Charlson Comorbidity Index. Urology,**79,** 55-60.
26. Zengin, K.; Sener, N. C.; Bas, O.; Nalbant, I. & Alisir, I. 2014. Comparison of pneumatic, ultrasonic and combination lithotripters in percutaneous nephrolithotripsy. International braz j urol,**40,** 650-655.