UIJ UroToday International Journal®

www.urotodayinternationaljournal.com
Volume 5 - June 2012

Shock Wave Lithotripsy Re-treatment Rates Among 3 Different Lithotripters

Mohamed A Elkoushy, Konrad M Szymanski, Douglas D Morehouse, Maurice Anidjar, Sero Andonian

Submitted February 7, 2012 - Accepted for Publication March 20, 2012

ABSTRACT

Purpose: There is controversy as to whether electromagnetic (EM) lithotripters are associated with higher fragmentation and lower re-treatment rates when compared with electrohydraulic (EH) lithotripters. Therefore, the aim of the present study was to compare SWL re-treatment rates of two EH lithotripters (the Siemens LITHOSTAR and Philips Litho Diagnost M) together with an EM mobile lithotripter (the Storz MODULITH SLX-F2) at a single center.

Methods: A retrospective review of a SWL database was performed for patients with radio-opaque stones between July 2001 and February 2010. A total of 6 434 SWL treatments were included (2 824 with Siemens, 3 136 with Philips, and 474 with Storz). Patients presenting for SWL re-treatment of the same stone were considered SWL failures. Clinical follow-up information was available only for patients treated by the Storz lithotripter.

Results: The Storz lithotripter had a significantly lower re-treatment rate (14.7%) when compared with the Siemens (18.8%, OR = 1.34, p = 0.04) and the Philips (19.6%, OR = 1.41, p = 0.01). However, on multivariate analysis, the Storz significantly differed only from the Philips (OR = 1.36, p = 0.02). When compared with renal pelvic stones, stones in the upper calyx were associated with significantly lower re-treatment rates (OR = 0.65, p = 0.02), whereas distal ureteral stones were associated with significantly higher re-treatment rates (OR = 1.30, p = 0.01). The Storz lithotripter was associated with higher fluoroscopy time (2.4 ± 1.3 min) when compared with the Siemens (1.74 ± 0.8 min) and the Philips (2.13 ± 1.1 min, p = 0.001).

Conclusion: In the present retrospective study, the EM Storz SLX-F2 lithotripter was associated with significantly lower re-treatment rates compared with the Philips EH lithotripter, but not the Siemens.

INTRODUCTION

Since the early 1980s, shock wave lithotripsy (SWL) has been established as a minimally invasive procedure for the treatment of urinary stones. In 1982, Chaussy and colleagues installed the first electrohydraulic (EH) lithotripter, Human Model 2, in Munich while the first widely distributed clinical lithotripter, the Dornier HM3, was introduced to the United States 2 years later [1]. Since then, several generations of different types of lithotripters have been developed to improve patient comfort

KEYWORDS: Shock wave lithotripsy, lithotripters, retreatment rate

CORRESPONDENCE: Sero Andonian, MD, MSc, FRCS(C), Assistant Professor of Urology, Royal Victoria Hospital, McGill University Health Centre, 687 Avenue des Pins Ouest, Suite S6.92, Montreal, Quebec, Canada H3A 1A1 (sero.andonian@muhc.mcgill.ca).

CITATION: *UroToday Int J.* 2012 June;5(3):art 18. http://dx.doi.org/10.3834/uij.1944-5784.2012.06.05

ACRONYMS AND ABBREVIATIONS

EH: Electrohydraulic
EM: Electromagnetic
SWL: Shock Wave Lithotripsy
N/A: Not applicable
OR: Odds ratio

Table 1. Specifications of the 3 lithotripters.
http://dx.doi.org/10.3834/uij.1944-5784.2012.06.05t1

Variables	Siemens	Philips	Storz
Energy source	EH spark-gap electrode	EH	Dual focus EM
Coupling system	Water cushion	Water cushion	Water cushion
Aperture diameter	12 cm	20 cm	30 cm
Imaging system/localization	X-ray and separate ultrasound	X-ray and ultrasound	In-line fluoroscopy/in-line ultrasound
Focal zone (W x L)	5 x 80 mm	8 x 38 mm	Dual focus (6 x 28 to 9 x 45 mm)
Focal distance	11.3 cm	15 cm	16.5 cm
Date of installation	1984	September 2004	June 2009

and safety, optimize handling, reduce costs, and provide multifunctional use. This treatment comfort is a trade-off for less effective stone disintegration and a higher re-treatment rate when compared with the gold standard, the Dornier HM3 [2-5]. In addition to stone- and patient-related factors, the type of lithotripter used affects fragmentation and re-treatment rates [6]. Currently, it is controversial whether or not electromagnetic (EM) lithotripters are better than the original electrohydraulic (EH) lithotripters. Some authors found that EM lithotripters had higher re-treatment rates when compared with EH lithotripters (63% versus 55%) [7]. However, there was no difference in stone-free rates (83% versus 84%) [7]. Others reported significantly lower re-treatment rates for EM lithotripters when compared with EH lithotripters (34% versus 51.6%, $p < 0.001$), with significantly higher success rates (88.5% versus 82.4%, $p = 0.03$) [8]. Therefore, the aim of the present study was to compare re-treatment rates of 2 EH lithotripters; the Siemens LITHOSTAR and the Philips Litho Diagnost M with a Storz MODULITH SLX-F2 EM lithotripter at a single center.

METHODS

A retrospective review of a SWL database using 3 different lithotripters was performed. The Siemens LITHOSTAR (Siemens Medical Solutions, Erlangen, Germany) and the Philips Litho Diagnost M (Philips Healthcare, Eindhoven, The Netherlands) had EH generators, whereas the Storz MODULITH SLX-F2 (Storz Medical, Kreuzlingen, Switzerland) was a mobile EM lithotripter with dual focal zones. The specifications of these lithotripters are presented in Table 1. For each SWL treatment, stone size, and location, fluoroscopy time (in minutes) and fragmentation as assessed by fluoroscopy was recorded. A total of 1 195 treatments with incomplete data were excluded; 533, 616, and 46 treatments were recorded for Siemens, Philips, and Storz, respectively. In addition, 377 (5.5%) treatments for radiolucent stones were excluded (163, 198, and 16 for Siemens, Philips, and Storz lithotripters, respectively). Therefore, a total of 6 434 SWL treatments for radio-opaque stones were included (2 824 with Siemens [July 2001 to August 2004], 3 136 with Philips [September 2004 to May 2009], and 474 with Storz [June 2009 to February 2010]). In all lithotripters, shock waves were coupled to the patient by water-filled cushions directly abutting the patient with an ultrasound-compatible jelly interface. Intravenous sedation was used in most patients. Patients were treated at a rate of 2Hz, whereas SWL re-treatments were treated at a rate of 1Hz.

Treatment outcomes were assessed by intraoperative fluoroscopy at the end of the SWL session. SWL re-treatment was defined as repeat SWL sessions for the same stone; therefore, patients presenting for re-treatment of the same stone were considered SWL failures. Patients who failed treatment with a particular lithotripter, and were subsequently treated with another lithotripter for the same stone, were considered a re-treatment session for the original lithotripter. Patients with SWL failures were referred for a second SWL session rather than more invasive procedures such as ureteroscopy or percutaneous stone extractions. For the Siemens and Philips lithotripters, patients who failed 2 SWL sessions and underwent subsequent ureteroscopy were not captured in the current database. Clinical and radiologic follow-up, including auxiliary procedures, were only available for the Storz lithotripter.

Data analysis was done using the commercially available Statistical Package of Social Sciences for Windows (SPSS, Chicago, IL), version 17. Descriptive data were presented

Table 2. Stone location among the 3 lithotripters.
http://dx.doi.org/10.3834/uij.1944-5784.2012.06.05t2

Stone location	Siemens	Philips	Storz	p value	Total
Renal	1 466 (51.9%)	1 674 (53.4%)	270 (57%)	0.11	3 410
Upper calyx	148 (5.2%)	165 (5.3%)	21 (4.4%)	0.78	334
Middle calyx	155 (5.5%)	233 (7.43%)	52 (11%)	< 0.001	440
Lower calyx	566 (20%)	596 (19%)	117 (24.8%)	0.02	1 279
Renal pelvis	597 (21.1%)	680 (21.7%)	80 (16.9%)	0.054	1 357
Ureteral	1 358 (48.1%)	1 462 (46.6%)	204 (43%)	n/a	3 024
Proximal ureter	718 (25.4%)	722 (23.02%)	112 (23.6%)	0.10	1 552
Mid ureter	188 (6.7%)	224 (7.14%)	13 (2.7%)	< 0.001	425
Distal ureter	452 (16%)	516 (16.5%)	79 (16.7%)	0.86	1 047
Total	2 824	3 136	474	n/a	6 434

in terms of numbers, percentages, means, and standard deviations. Continuous variables were compared using an analysis of variance (ANOVA), while the Fisher's exact test was used to compare categorical variables where a 2-tailed p value of < 0.05 was considered statistically significant. Multivariate logistic regression was performed to compare re-treatment rates among the 3 lithotripters.

RESULTS

Left-sided stones represented 55.8, 56.4, and 52.7% of stones for the Siemens, Philips, and Storz lithotripters, respectively (p = 0.34). There was no significant difference in the percentage of renal stones treated among the 3 lithotripters: Siemens (51.9%), Philips (53.4%), and Storz (57%) (p = 0.11). In terms of stone location, the most common stone location was the proximal ureter in the 3 lithotripters (25.4, 23, and 23.6%), followed by the renal pelvis for Siemens and Philips lithotripters (21.1 and 21.7%, respectively), and the lower pole calyx for Storz (24.8%) (Table 2). When all 3 lithotripters were compared, Storz had a significantly higher percentage of stones in the middle and lower calices (p < 0.001 and p = 0.02, respectively) and a significantly lower percentage of midureteral stones (p < 0.001) (Table 2). In terms of mean stone size, there was a significantly larger mean stone size with Philips (10.3 mm ± 3.2) when compared with Siemens (9.6 mm ± 3.4) and Storz (9.7 mm ± 3.0) (p = 0.001). The Storz lithotripter was associated with a significantly higher fluoroscopy time (2.4 ±1.3 minutes) when compared with Siemens (1.74 ± 0.8 minutes) and Philips (2.13 ± 1.1 minutes) (p = 0.001). Furthermore, the mean ± SD energy levels used for each of the lithotripters are reported in Table 3. Since these energy levels were not comparable (different units), statistical analysis was not applicable.

Table 3. Re-treatment rates among the 3 lithotripters.
http://dx.doi.org/10.3834/uij.1944-5784.2012.06.05t3

Variables	Siemens	Philips	Storz	p value
Re-treatment rates	18.8%	19.6%	14.7%	0.04*
Mean stone size (mm)	9.6 ± 3.4	10.25 ± 3.18	9.73 ± 3	0.001*
Mean fluoroscopy time ± SD (min)	1.74 ± 0.78	2.13 ± 1.07	2.4 ± 1.3	0.001*
Energy ± SD	4.46 ± 0.99	21.9 ± 3.22	7.03 ± 2.63	n/a

The re-treatment rates for renal and ureteral stones were 18.3 and 19.4% for Siemens, 17.7 and 21.7% for Philips, and 15.2 and 14.2% for Storz (Table 4). The Storz lithotripter had significantly lower re-treatment rates (14.7%) when compared with Siemens (18.8%, OR = 1.34, p = 0.04) and Philips (19.6%, OR = 1.41, p = 0.01). On the multivariate analysis, the Storz lithotripter significantly

Table 4. Re-treatment rates by location among the 3 lithotripters.
http://dx.doi.org/10.3834/uij.1944-5784.2012.06.05t4

Variable	Siemens	Philips	Storz	Total
Renal	268 (18.3%)	297 (17.7%)	41 (15.2%)	606 (17.8%)
Upper calyx	16 (10.8%)	24 (14.5%)	2 (9.5%)	42 (12.6%)
Middle calyx	25 (16.1%)	37 (15.9%)	6 (11.5%)	68 (15.4%)
Lower calyx	113 (20%)	111 (18.6%)	26 (22.2%)	250 (19.6%)
Pelvis	114 (19.1%)	125 (18.4%)	7 (8.8%)	246 (18.1%)
Ureter	263 (19.4%)	317 (21.7%)	29 (14.2%)	609 (20.1%)
Proximal ureter	130 (18.1%)	136 (18.8%)	17 (15.2%)	283 (18.2%)
Mid ureter	43 (22.9%)	48 (21.4%)	3 (23%)	94 (22.1%)
Distal ureter	90 (19.9%)	133 (25.8%)	9 (11.4%)	232 (22.2%)
Total	531 (18.8%)	614 (19.6%)	70 (14.7%)	1 215 (18.9%)

differed only from Philips (OR = 1.36, p = 0.02). On the multivariate analysis, when compared with renal pelvic stones, stones in the upper calyx were associated with significantly lower re-treatment rates (OR = 0.65, p = 0.02) and stones located in the distal ureter were associated with significantly higher re-treatment rates (OR = 1.30, p = 0.01) (Table 5).

DISCUSSION

Since the introduction of the Dornier HM3 more than 2 decades ago, efforts have been made to design a lithotripter capable of maximizing stone fragmentation while minimizing pain and renal injury. More attention has been given to reduce the focal point size by increasing the aperture, thus increasing the peak-point pressure to reduce the patient's discomfort and renal injury. However, newer designs have demonstrated higher re-treatment rates owing to the difficulty of keeping the stone in the smaller focal zone [9]. This SWL failure may be lithotripter dependent, stone related (size, location, density), patient related (skin-stone distance, musculoskeletal deformities), or attributable to intrarenal anatomy and drainage [10]. Controversy exists about the superiority of modern EM energy sources over that of EH lithotripters. EM sources have the advantages of delivering several hundred thousand shock waves before servicing, thereby eliminating the need for frequent electrode replacement as with EH lithotripters. Direct comparisons of lithotripter efficacy are quite difficult because of the difference in study populations and treatment protocols. A prospective randomized study would require the simultaneous presence of more than 1 lithotripter at a single center, which is impractical [6]. In the present retrospective study, SWL re-treatment rates among the 3 different lithotripters at a single center were reviewed. The Storz MODULITH SLX-F2, an EM lithotripter, was found to be associated with significantly lower re-treatment rates (14.7%) when compared with 2 EH lithotripters, the Siemens LITHOSTAR (18.8%, OR = 1.34, p = 0.04) and the Philips Litho Diagnost M (19.6%, OR = 1.41, p = 0.01). Upon multivariate analysis, there was a significant difference between the Storz and Philips lithotripters (OR = 1.36, p = 0.02) (Table 5). It is important to note that for the present study, auxiliary procedures for the Siemens and Philips lithotripters were not available. Therefore, once these auxiliary procedures are added, the re-treatment rates for both lithotripters would increase the difference between the EM Storz and these 2 EH lithotripters.

In a previous study, both the EH and EM lithotripters were found to be equally efficacious with comparable stone-free rates (83% versus 84%) and re-treatment rates (55% versus 63%) [7]. In another study, a second generation EH lithotripter had similar results when compared with a fourth generation EM lithotripter in terms of stone-free rates (64.5% versus 61.1%, p = 0.07) and re-treatment rates (3.6% versus 4.5%, p = 0.21) [11]. In another study, comparing EH and EM sources at a single center revealed that the EH lithotripter was associated with significantly higher stone-free rates when compared with the EM lithotripter (77% versus 67%, p = 0.01) but also with a significantly higher rate of auxiliary procedures (56%

Table 5. Univariate and multivariate analysis of re-treatment rates.
http://dx.doi.org/10.3834/uij.1944-5784.2012.06.05t5

Variable	Re-treatment rate No (%)	Univariate analysis		Multivariate analysis	
		OR (95% CI)	p value	OR (95% CI)	p value
Stone location					
Upper calyx	42 (12.6)	0.65 (0.46 - 0.92)	0.02	0.65 (0.46 - 0.93)	0.02
Middle calyx	68 (15.4)	0.82 (0.61 - 1.10)	0.19	0.84 (0.63 - 1.13)	0.25
Lower calyx	250 (19.6)	1.11 (0.90 - 1.34)	0.35	1.13 (0.93 - 1.38)	0.22
Renal pelvis	246 (18.1)	1	Reference	1	Reference
Proximal ureter	283 (18.2)	1.01 (0.83 - 1.22)	0.94	1.02 (0.84 - 1.23)	0.86
Mid ureter	94 (22.1)	1.28 (0.98 - 1.68)	0.07	1.29 (0.99 - 1.69)	0.06
Distal ureter	232 (22.2)	1.29 (1.05 - 1.57)	0.01	1.3 (1.06 - 1.59)	0.01
Stone size	n/a	1 (0.98 - 1.02)	0.88	1 (0.99 - 1.02)	0.74
Fluoroscopy time	n/a	0.98 (0.92 - 1.05)	0.61	0.99 (0.93 - 1.06)	0.73
Siemens	18.8	1.34 (1.02 - 1.75)	0.04	1.3 (0.99 - 1.72)	0.06
Philips	19.6	1.41 (1.07 - 1.84)	0.01	1.36 (1.04 - 1.79)	0.02
Storz	14.7	1	Reference	1	Reference

versus 47%, p = 0.04) [12]. Although the EH lithotripter was associated with a higher SWL re-treatment (40% versus 10%), this was not significant (p = 0.21) [12]. Similarly, in a prospective randomized trial comparing the EH with the EM lithotripter, the EH lithotripter was associated with significantly higher re-treatment rates (51.6% versus 34%, p < 0.001) and significantly lower stone-free rates (82.4% versus 88.5%, p = 0.03) [8]. These findings are comparable to the results of the present series where the Storz EM lithotripter was associated with a significantly lower SWL re-treatment rate when compared in the multivariate analysis with the Philips EH lithotripter.

In another study, 2 EH lithotripters were compared with an EM lithotripter [4]. Although there was no significant difference in terms of stone-free rates at 3 months (87, 80, and 81%, p > 0.05), the EH lithotripters were associated with significantly lower re-treatment rates (4, 13, and 38%, (p < 0.05) [4]. However, in this study, authors followed patients on the postoperative day with plain X-rays and ultrasonography, and they may have had re-retreated stones that would have passed spontaneously after the EM lithotripsy.

In the present study, the Storz lithotripter was associated with significantly higher fluoroscopy time (2.4 ± 1.3 minutes) when compared with Siemens (1.74 ± 0.8 minutes) and Philips (2.13 ± 1.1 minutes) (p = 0.001) (Table 3). This may be due to the fact that the Storz lithotripter is a mobile lithotripter that had to be used with a mobile C-arm fluoroscopy unit. Furthermore, the higher fluoroscopy usage also reflects the initial training with this new lithotripter.

The Storz lithotripter was only used for 6 months to treat 20% of patients in the database while the Siemens and Philips lithotripters were used for over 50 months each. Therefore, 1 of the limitations of the present study is the small sample size for the Storz lithotripter. Perhaps with a larger sample size, there would have been a significant difference between the Storz and Siemens lithotripters on the multivariate analysis. Another limitation of the study is that only the SWL re-treatment was captured in the database. Follow-up information regarding stone-free rates, stone composition, or auxiliary procedures such as ureteroscopy were not captured because patients were referred to this tertiary care center for SWL, and were then cared for by the referring urologist. Furthermore, at the time of acquisition of the Storz lithotripter, a dedicated endourologist (SA) was hired. This may have contributed to the lower SWL re-treatment rates with the Storz lithotripter. The sequential acquisition of the 3 lithotripters may introduce bias in terms of changes in patterns of referral and practice over time.

CONCLUSION

Retrospective analysis of the SWL database at a single lithotripsy center showed that SWL re-treatment rates significantly varied depending on the type of lithotripter used and stone location. The EM Storz SLX-F2 lithotripter was associated with significantly lower re-treatment rates compared to the Philips EH lithotripter, but not the Siemens EH lithotripter.

ACKNOWLEDGEMENTS

This work was supported in part by the Northeastern AUA Young Investigator Award and Montreal General Hospital Foundation Award to Sero Andonian.

REFERENCES

1. Chaussy, C., E. Schmiedt, et al. (1982). "First clinical experience with extracorporeally induced destruction of kidney stones by shock waves." *J Urol* 127(3): 417-420. PubMed

2. Graber, S. F., H. Danuser, et al. (2003). "A prospective randomized trial comparing 2 lithotriptors for stone disintegration and induced renal trauma." *J Urol* 169(1): 54-57. PubMed ; CrossRef

3. Nomikos, M. S., S. J. Sowter, et al. (2007). "Outcomes using a fourth-generation lithotripter: a new benchmark for comparison?" *BJU Int* 100(6): 1356-1360. PubMed ; CrossRef

4. Gerber, R., U. E. Studer, et al. (2005). "Is newer always better? A comparative study of 3 lithotriptor generations." *J Urol* 173(6): 2013-2016. PubMed ; CrossRef

5. De Sio, M., R. Autorino, et al. (2007). "A new transportable shock-wave lithotripsy machine for managing urinary stones: a single-centre experience with a dual-focus lithotripter." *BJU Int* 100(5): 1137-1141. PubMed ; CrossRef

6. Argyropoulos, A. N. and D. A. Tolley (2009). "Failure after shockwave lithotripsy: is outcome machine dependent?" *Int J Clin Pract* 63(10): 1489-1493. PubMed ; CrossRef

7. Jamshaid, A., M. H. Ather, et al. (2008). "Single center, single operator comparative study of the effectiveness of electrohydraulic and electromagnetic lithotripters in the management of 10- to 20-mm single upper urinary tract calculi." *Urology* 72(5): 991-995. PubMed ; CrossRef

8. Sheir, K. Z., K. Madbouly, et al. (2003). "Prospective randomized comparative study of the effectiveness and safety of electrohydraulic and electromagnetic extracorporeal shock wave lithotriptors." *J Urol* 170(2 Pt 1): 389-392. PubMed ; CrossRef

9. Kim, F. J. and K. R. Rice (2006). "Prediction of shockwave failure in patients with urinary tract stones." *Curr Opin Urol* 16(2): 88-92. PubMed ; CrossRef

10. Madaan, S. and A. D. Joyce (2007). "Limitations of extracorporeal shock wave lithotripsy." *Curr Opin Urol* 17(2): 109-113. PubMed ; CrossRef

11. Alanee, S., R. Ugarte, et al. (2010). "The effectiveness of shock wave lithotripters: a case matched comparison." *J Urol* 184(6): 2364-2367. PubMed ; CrossRef

12. Matin, S. F., A. Yost, et al. (2001). "Extracorporeal shock-wave lithotripsy: a comparative study of electrohydraulic and electromagnetic units." *J Urol* 166(6): 2053-2056. PubMed ; CrossRef