Ten-Year Sepsis Rates Comparing Extracorporeal Shock Wave Lithotripsy and Ureterorenoscopic Laser Lithotripsy in an Australian Population

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Abstract

Objectives To compare the rate and predictors of septic complications after shock wave lithotripsy (SWL) and flexible ureteroscopy and laser lithotripsy (FURS) in an Australian population.

Methods Hospital admission data were extracted from the Victorian Admitted Episodes Dataset (VAED) regarding all elective admissions for SWL and FURS for treatment of intrarenal stones from 2009 to 2018, inclusive. Sepsis was defined by the ICD-10 diagnostic code, A41.

Results There were 13 154 inpatient episodes analysed, comprising SWL (6033) and ureterorenoscopic laser lithotripsy (7121). Males made up 67.43% of SWL patients and 63.34% of FURS patients. Median age was 57 years in both groups. Median American Society of Anesthesiologists physical status classification grade (ASA grade) was 2 for both groups, but proportionally more FURS patients were ASA grade 3 to 4 ($P < 0.001$). Postoperative sepsis was more common in the FURS group (1.43% vs. 0.03%), as was intensive care unit admission (1.00% vs. 0.10%). Average length of stay was longer for FURS (1.43 days vs. 1.06 days). There were 4 inpatient deaths, all from the FURS group. FURS procedure, female sex, and a higher ASA grade were each independent predictors of sepsis.

Conclusions FURS may have a significantly higher relative risk of postoperative sepsis than SWL in high-risk patients as determined in this study. While overall risk is low, higher comorbidity (ASA grade 3 or 4) and female sex were independent predictors of sepsis. For these patients in particular, and when clinically appropriate, SWL may be considered as a potentially safer alternative to FURS.

Introduction

Urolithiasis is a common condition, with increasing incidence and prevalence in the developed world[1–3]. The management of renal stone disease is therefore a major health care issue in Australia and worldwide. Technological advancements have led to an increase in the number of both elective and emergency procedures for renal stone disease worldwide. Surgical treatment options for intrarenal calculi include percutaneous nephrolithotomy (PCNL), flexible ureteroscopy and laser lithotripsy (FURS), and extracorporeal shock wave lithotripsy (SWL). The choice of treatment modality is dependent on size, location, and composition of the stone, as well as patient factors and availability of resources and expertise. Both SWL and FURS are considered effective and safe options for small to medium sized stones[4,5]. PCNL is the most invasive treatment option, and while indications for PCNL have broadened with the advent of smaller calibre systems, in most situations PCNL is reserved for larger and more complex stone burdens, especially involving the lower calyx[6].

Key Words

SWL, URS, pyeloscopy, sepsis, lithotripsy, urolithiasis

Competing Interests

None declared.

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Abbreviations

ASA grade American Society of Anesthesiologists physical status classification grade
FURS flexible ureteroscopy and laser lithotripsy
PCNL percutaneous nephrolithotomy
SWL shock wave lithotripsy

For small and medium stone burdens, as endoscopic and holmium laser technology has improved and become more widely available, FURS has become increasingly popular, while the rate of SWL has been stable or declining[2,3,7,8]. In many places, FURS has become the dominant modality for treating renal stones[8]. FURS allows more accurate stone visualisation and therefore potentially more assured stone clearance.

Sepsis is a well-recognised risk of renal stone treatment. Stone disease can both promote and be caused by urinary tract infections. In up to 75% of renal stones, bacteria will be present within the stone matrix[9,10]. Lithotripsy can therefore release bacteria and precipitate patient sepsis. The risk of sepsis is known to be higher for FURS than for SWL[11,12]. FURS requires retrograde pressurisation of the collecting system with irrigation fluid, and increases in pressure have been found to increase sepsis risk. Pyelovenous and pyelolymphatic backflow can then carry urinary bacteria and endotoxin into the circulation, potentially leading to a rapid systemic inflammatory response (urosepsis)[13,14]. Identification of higher risk patients is therefore critical as such events may require ICU support and can be fatal.

As the number of renal stone treatments increases, and FURS increasingly becomes the most popular treatment approach, we can expect cases of postoperative sepsis to become more common. This study seeks to quantify the relative risk of sepsis for FURS and SWL in a state-wide Australian population of over 6 million people with access to FURS and SWL through multiple health networks. We also seek to identify patient risk factors for postoperative sepsis.

Methods

Data Extraction

After obtaining our institution's ethics board approval, we extracted from the Victorian Admitted Episodes Dataset (VAED) all elective admissions from the period of January 2009 to December 2018, relating to Medicare Benefit Schedule procedure codes for ureterorenoscopic laser lithotripsy with stone treatment (36 656) or SWL (36 546) combined with the ICD-10 diagnosis code N200 (stones within the renal collecting system). We excluded admissions of patients aged less than 15 years. While all patients were admitted for their procedure, not all had an overnight stay (many were discharged the same day).

The government dataset (VAED) used in this study is compiled from the compulsory reporting from all hospitals in Victoria of each hospital admission. Hospitals are regularly independently audited to ensure data compliance, consistency, and validity[15,16]. We are therefore confident that we have a largely accurate and complete picture of all elective renal stone SWL and FURS cases in this population over the 10-year study period. All data within the VAED are de-identified, and this prevented follow-up post discharge (including re-presentation to the emergency department)

We evaluated patient demographics (age, sex, ASA grade), and treatment variables (SWL or FURS, type of anaesthesia, stent insertions or removals). Postoperative complications were assessed by incidence of sepsis, LOS, hours in ICU, and deaths. Sepsis was defined by an ICD-10 diagnosis code beginning with A41.

Statistical Analysis

Calculations were performed using Stata/MP version 13.0 for Mac (StataCorp LP). Variables were checked for skewness and kurtosis to determine normality. Clinical and demographic features are presented as medians (interquartile range) and means (± standard deviation) for non-parametric and parametric data, respectively. Differences between continuous parametric variables were examined with the t-test; the Wilcoxon rank-sum test or the Wilcoxon-Mann-Whitney test were used for non-normally distributed continuous and ordinal variables, while differences between dichotomous variables were evaluated with the chi-square test or the Fisher exact test (**Tables 1 and 2**). *P*-values throughout the results were 2-sided. Logistic regression was performed on clinically and statistically significant variables as part of a multivariate analysis.

Results

We analysed a total of 13 154 patients over 10 years who underwent either SWL (n = 6033) or FURS (n = 7121). Table 1 summarises both groups. Age and rate of general anaesthesia (GA) was similar between the two groups. Males made up 67.43% of SWL patients and 63.34% of FURS patients ($P < 0.001$). The median ASA grade was 2 for both cohorts, however the proportion of ASA grade 3 to 4 was greater for FURS patients ($P < 0.001$). Stents were inserted in 84.89% of FURS versus only 4.72% of SWL patients. Length of stay was significantly longer for FURS patients (1.06 days vs. 1.43 days, $P < 0.001$). FURS patients more frequently required an overnight admission (10.48% vs. 1.59%, $P < 0.001$).

We completed a univariate analysis to compare inpatient complications for the two groups (**Table 2**). The sepsis

TABLE 1.

Descriptive statistics

	SWL	Pyeloscopy	*P*-value
Number in cohort	6033	7121	
Median age	57 [45–67]	57 [47–67]	0.0182
Male sex	67.43%	63.34%	< 0.001
Average LOS (days)	1.06	1.43	< 0.001
General anaesthesia	99.13%	99.12%	0.971
Regional anaesthesia	0.97%	0.99%	0.928
ASA grade, median [IQR]	2 [1–2]	2 [2–3]	< 0.001
Stent inserted	3.45%	39.72%	< 0.001

TABLE 2.

Inpatient complications

Inpatient Complications	SWL N = 6033	Pyeloscopy N = 7121	*P*-value
Sepsis	0.03%	1.41%	< 0.001
ICU admission	0.10%	1.00%	< 0.001
Prolonged length of stay > 24 hrs	1.59%	10.48%	< 0.001
Death	0%	0.056%	0.130

rate for FURS was significantly higher than that for SWL (1.43% vs. 0.03%, $P < 0.001$). Similarly, more FURS patients required ICU admission during their hospital stay, (1.00% vs. 0.10%, $P < 0.001$). Mortality was very low with no significant difference between the two groups (0% for ESWL versus 0.056% for FURS, $P = 0.130$).

On completion of multivariate logistics regression analysis (**Table 3**), for our primary outcome, sepsis rates, we found that FURS, female gender, and a higher ASA grade were each independent predictors of sepsis during the admission. Compared to SWL, patients undergoing FURS had higher odds of developing sepsis (OR = 23.12, 95% CI 5.66 to 94.39). ASA grade was also independently associated with sepsis. Patients with an ASA grade ≥ 3 were significantly more likely to become septic (OR = 3.37, 95% CI 2.08 to 5.48). Females also had higher odds of sepsis than males (OR = 3.76, 95% CI 2.36 to 5.97). In this model, patient age had a lesser impact (OR = 1.02, 95% CI 1.01 to 1.04). Its effect may be better accounted for by ASA grade.

Discussion

To our knowledge, this is the first study that has collated and analysed the morbidity and mortality associated with SWL and FURS for the elective treatment of intrarenal calculi on a population level in Australia.

We found patients treated with FURS have a significantly increased risk of postoperative sepsis compared with those treated with SWL. This corresponds with an increased risk of ICU admission and prolonged LOS. These findings are consistent with those in the published literature[17–20], although there is a lack of similar studies that directly compare all renal SWL and FURS treatments in the same population. Most studies are confined to a single institution, a single treatment modality, or a single subset of stone patients based on size or location[1–3,7,21].

Aside from FURS surgery, we found female sex and high comorbidity (ASA grade 3 or 4) to be independent risk factors for postoperative sepsis. Female sex is

TABLE 3.
Multivariate analysis

Risk factor for sepsis	Regression coefficient	Standard error	*P*-value	OR	95 % CI of OR	
					Lower	Upper
Procedure type	3.14	0.72	<0.001	23.12	5.66	94.39
ASA ≥ 3	1.21	0.25	<0.001	3.37	2.08	5.48
Age	0.02	0.01	0.01	1.02	1.01	1.04
Sex	1.32	0.24	<0.001	3.76	2.36	5.97
Constant	-9.88	0.87	<0.001	<0.01	$9.4x10^{-6}$	0.0002

an expected risk factor, given the increased prevalence of infection stones and lower urinary tract infection or colonisation in this population[23]. There have been similar findings from other studies[15,20,24].

All 4 deaths were sepsis-related and in the FURS group, although the number of deaths was not statistically significant. This is similar to statistically significant mortality reported in other studies[22].

The differences in postoperative morbidity were not related to use of GA, which was similar between SWL (99.12%) and FURS (99.13%). Some authors have suggested that GA is unnecessary for SWL and cannot be justified because of the risk of possible anaesthetic complications[27]. This study suggests that the choice of procedure is likely to be the more important determinant of morbidity, and SWL has very low morbidity even with GA.

Our findings are important, because in Australia and in many other parts of the world, we are seeing rapid expansion in the use of FURS for the treatment of intrarenal calculi. This growth in many places far exceeds the relative decline in SWL[2,3,7,8], suggesting that indications for intervention in renal stone disease are expanding. At the same time, rates of antimicrobial resistance are increasing around the world, making postoperative sepsis more difficult to treat[23]. It is therefore increasingly important that we have the data to counsel our patients about the risks of sepsis and are prepared to mitigate these risks, particularly in higher risk patients.

Limitations

This study is retrospective and non-randomised. Stone characteristics, including size and location, were not included in our dataset; however, future studies looking at a subset of these patients may address this limitation. There are no local guidelines to direct the choice between SWL and FURS based on stone size or position. If we look at the European Association of Urology guidelines, we see a large overlap in the type of renal stones recommended for treatment with either FURS or SWL[24]. In Victoria, the choice of approach is often determined by the availability of equipment (lithotripter or laser) rather than purely stone factors. Nevertheless, while the demographics of the 2 cohorts are well matched, it is possible that stone characteristics were significantly different, and this may independently affect the risk of sepsis. Other studies have shown operative length during FURS to be an independent risk factor for sepsis[25].

We also have no data regarding the use of antibiotic prophylaxis and preoperative urine screening in the 2 groups. Local guidelines recommend that patients have a clear urine culture preoperatively, no antibiotic prophylaxis for uncomplicated renal SWL, and antibiotic prophylaxis for FURS[26], with the specific choice of antimicrobial agent depending on local hospital recommendations.

We used de-identified hospital admission data, and therefore it was not possible to track complications post discharge. A common feature of sepsis post-stone surgery is rapid onset[27]. Nevertheless, it is likely that some patients had septic complications post discharge, resulting in presentation to the emergency department and hospital admission. These are not included in our study. Potentially, this omission is more significant for the SWL cohort, in which discharge on the same day was more common (98.4% vs. 89.5%), and the rate of stent insertion, which might protect against delayed obstructed urosepsis, was significantly lower (3.45% vs. 39.72%).

Conclusions

These results suggest that FURS may confer a significantly higher relative risk of postoperative sepsis than SWL, especially in higher risk populations. As we see increased use of FURS and expanding antimicrobial

resistance patterns, postoperative sepsis is likely to become an increasing problem. Higher comorbidity (ASA grade 3 or 4) and female sex were independent predictors of sepsis, and for these patients, SWL should be considered as a potentially safer alternative to FURS. However, confounding variables associated with this study, including preoperative factors as well as stone/patient characteristics, must be considered in future prospective research further defining treatment algorithms in this space.

References

1. Rukin NJ, Siddiqui ZA, Chedgy ECP, Somani BK. Trends in upper tract stone disease in England: Evidence from the Hospital Episodes Statistics Database. *Urol Int.*2017;98(4):391–396. doi: 10.1159/000449510
2. Heers H, Turney BW. Trends in urological stone disease: a 5-year update of hospital episode statistics. *BJU Int.*2016;118(5):785–789. doi: 10.1111/bju.13520
3. Ghani KR, Sammon JD, Karakiewicz PI, Sun M, Bhojani N, Sukumar S, et al. Trends in surgery for upper urinary tract calculi in the USA using the Nationwide Inpatient Sample: 1999–2009. *BJU Int.*2013;112(2):224–230. doi: 10.1111/bju.12059
4. Rosette Jdl, Denstedt J, Geavlete P, Keeley F, Matsuda T, Pearle M, et al. The Clinical Research Office of the Endourological Society Ureteroscopy Global Study: Indications, Complications, and Outcomes in 11,885 Patients. *J Endourol.*2014;28(2):131–139. doi: 10.1089/end.2013.0436
5. Türk (Chair) CN, A, Petrik AS, C, Skolarikos (Vice-chair) A, Thomas K. Urolithiasis 3.4.10.4.1: European Association of Urology; 2020. 3.4.10.4.1 p.
6. Türk (Chair) CN, A, Petrik AS, C, Skolarikos (Vice-chair) A, Thomas K. Urolithiasis 3.4.10.4.2: European Association of Urology; 2020. 3.4.10.4.2 p.
7. Seklehner S, Laudano A M, Del Pizzo J, Chughtai B, Lee K R. Renal calculi: trends in the utilization of shockwave lithotripsy and ureteroscopy. *Can J Urol Int.*2015;22(1):7627–7634.
8. Perera M, Papa N, Kinnear N, Wetherell D, Lawrentschuk N, Webb D, et al. Urolithiasis treatment in Australia: the age of ureteroscopic intervention. *J Endourol.*2016;30(11):1194–1199. doi: 10.1089/end.2016.0513
9. Schwaderer AL, Wolfe AJ. The association between bacteria and urinary stones. *Ann Transl Med.*2017;5(2):32. doi: 10.21037/atm.2016.11.73
10. Tavichakorntrakool R, Prasongwattana V, Sungkeeree S, Saisud P, Sribenjalux P, Pimratana C, et al. Extensive characterizations of bacteria isolated from catheterized urine and stone matrices in patients with nephrolithiasis. *Nephrol Dial Transplant.*2012;27(11):4125–4130. doi: 10.1093/ndt/gfs057
11. Skolarikos A, Alivizatos G, de la Rosette J. Extracorporeal Shock Wave Lithotripsy 25 Years Later: Complications and Their Prevention. *Eur Urol.*2006;50(5):981–990. doi: 10.1016/j.eururo.2006.01.045
12. Geavlete P, Georgescu D, NiţĂ G, Mirciulescu V, Cauni V. Complications of 2735 retrograde semirigid ureteroscopy procedures: a single-center experience. *J Endourol.*2006;20(3):179–185. doi: 10.1089/end.2006.20.179
13. Wilson WT, Preminger GM. Intrarenal pressures generated during flexible deflectable ureterorenoscopy. *J Endourol.*1990;4(2):135–141. doi: 10.1089/end.1990.4.135
14. Jung H, Osther PJS. Intraluminal pressure profiles during flexible ureterorenoscopy. *Springerplus.*2015;4:373. doi: 10.1186/s40064-015-1114-4
15. Associates AH. Victorian Admitted Episodes Dataset (VAED) Audit Program 2020. Available at https://www.ahaconsulting.com.au/projects/victorian-admitted-patient-dataset/. Accessed
16. VAED Manual 2019-20 [Document]: State of Victoria, Department of Health and Human Services 2019–2020 11/5/20].
17. De Coninck V, Keller EX, Somani B, Giusti G, Proietti S, Rodriguez-Socarras M, et al. Complications of ureteroscopy: a complete overview. *World J Urol.*2020;38(9):2147–2166. doi: 10.1007/s00345-019-03012-1
18. Cindolo L, Castellan P, Primiceri G, Hoznek A, Cracco CM, Scoffone CM, et al. Life-threatening complications after ureteroscopy for urinary stones: survey and systematic literature review. *Minerva Urol Nephrol.*2017;69(5):421–431. doi: 10.23736/S0393-2249.17.02787-4
19. Srisubat A, Potisat S, Lojanapiwat B, Setthawong V, Laopaiboon M. Extracorporeal shock wave lithotripsy (ESWL) versus percutaneous nephrolithotomy (PCNL) or retrograde intrarenal surgery (RIRS) for kidney stones. *Cochrane Database Syst Rev.*2014(11). doi: 10.1002/14651858.CD007044.pub3.
20. Drake T, Grivas N, Dabestani S, Knoll T, Lam T, Maclennan S, et al. What are the benefits and harms of ureteroscopy compared with shock-wave lithotripsy in the treatment of upper ureteral stones? a systematic review. *Eur Urol.*2017;72(5):772–786. doi: 10.1016/j.eururo.2017.04.016.
21. Geraghty RM, Jones P, Somani BK. Worldwide trends of urinary stone disease treatment over the last two decades: a systematic review. *J Endourol.*2017;31(6):547–556. doi: 10.1089/end.2016.0895
22. Whitehurst L, Jones P, Somani BK. Mortality from kidney stone disease (KSD) as reported in the literature over the last two decades: a systematic review. *World J Urol.*2019;37(5):759–776. doi: 10.1007/s00345-018-2424-2

23. Zowawi HM, Harris PNA, Roberts MJ, Tambyah PA, Schembri MA, Pezzani MD, et al. The emerging threat of multidrug-resistant Gram-negative bacteria in urology. *Nat Rev Urol.*2015;12(10):570–584. doi: 10.1038/nrurol.2015.199

24. Türk (Chair) CN, A, Petrik AS, C, Skolarikos (Vice-chair) A, Thomas K. Urolithiasis 3.4.9.4.: European Association of Urology; 2020. 3.4.9.4. p.

25. Blackmur J, Maitra N, Marri R, Housami F, Malki M, McIlhenny C. Analysis of Factors' Association with Risk of Postoperative Urosepsis in Patients Undergoing Ureteroscopy for Treatment of Stone Disease. *J Endourol.*2016;30(9):963–969. doi: 10.1089/end.2016.0300

26. Surgical Prophylaxis for Urological Surgery [Internet]. Therapeutic Guidelines Limited. 2019. Available at: https://www.tg.org.au. Accessed August 14, 2023.

27. Peng Y, Zhang W, Xu Y, Li L, Yu W, Zeng J, et al. Performance of SOFA, qSOFA and SIRS to predict septic shock after percutaneous nephrolithotomy. *World J Urol.*2020;39(2):501–510. doi: 10.1007/s00345-020-03183-2