Stone movement secondary to respiration during shockwave lithotripsy treatment

Shirley Yick, Magdalen College

MOTIVATION AND OBJECTIVES

- Shockwave lithotripsy (SWL) is a commonly used non-invasive procedure to break up kidney and ureteric stones using targeted shockwaves.
- Effective SWL depends on accurate targeting of the stone within the focal zone of the lithotripter. Stone movement secondary to respiration is a challenge to this.
- In vitro studies mimicking respiratory motion show that stone movement >10mm significantly reduces fragmentation efficiency, consistent with calculations of time spent outside the focal zone[1].
- However, little clinical data exists to quantify stone movement during respiration in SWL.
- Here, we aimed to measure the amount of stone movement secondary to respiration in patients at different points during SWL.

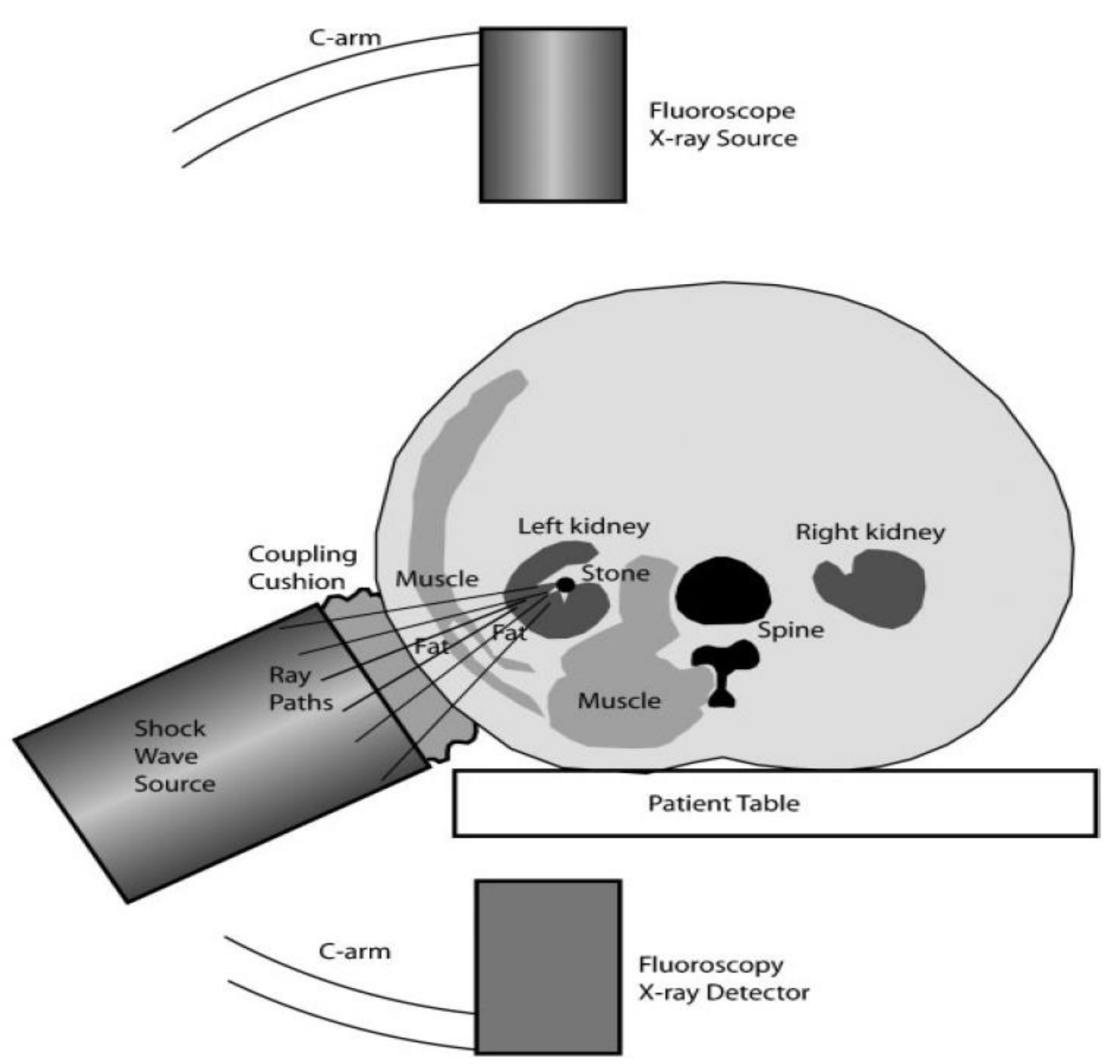


Figure 1: Schematic from [2] showing the basic components of a lithotripter with a patient lying supine on the table. The shockwave source is in contact with the patient via a fluid-filled cushion to ensure good coupling. The stones are visualised and targeted using X-ray fluoroscopy or ultrasound.

METHODS

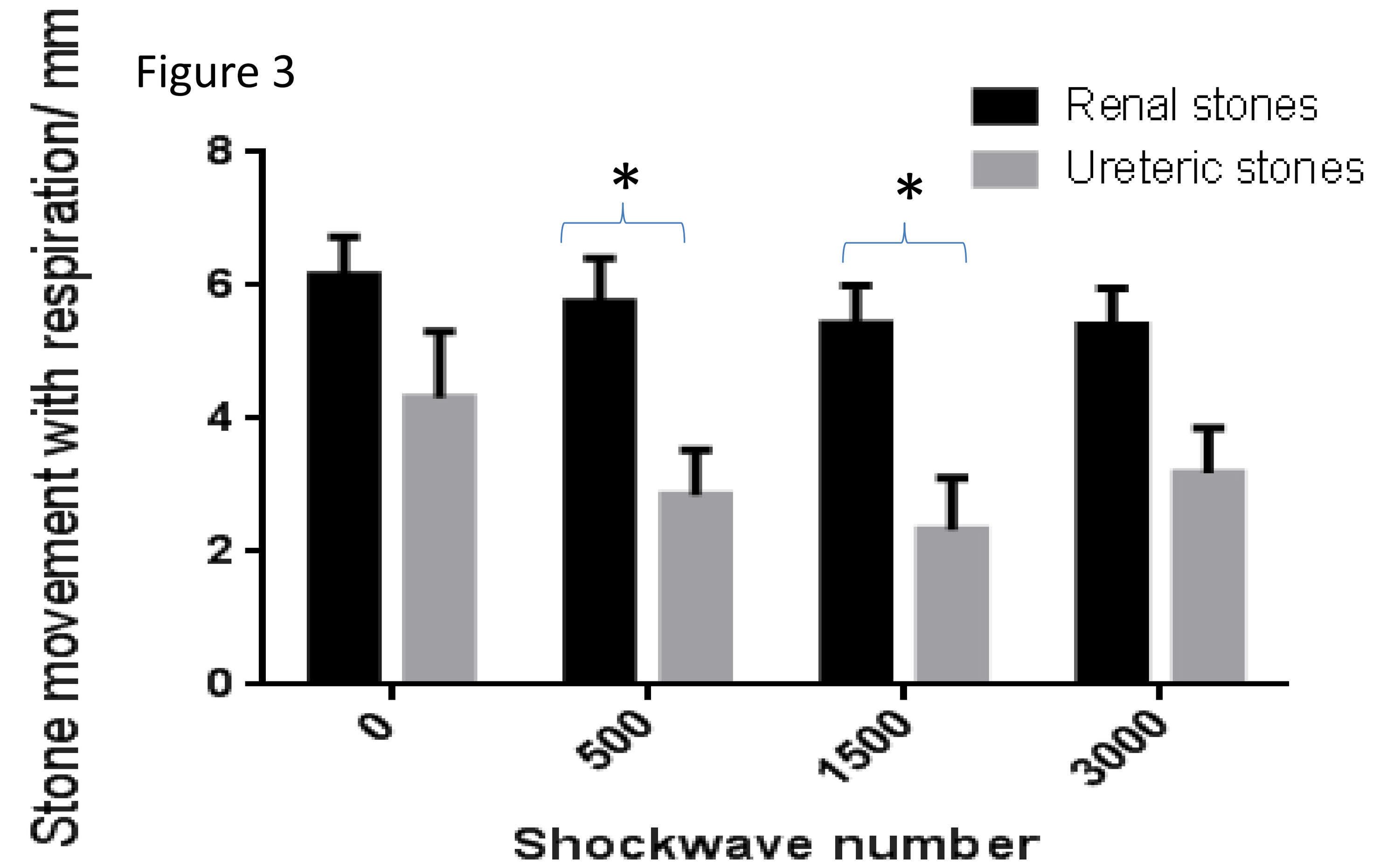
- Twenty-three patients (15 kidney stones and 8 ureteric stones) were treated by one of three radiographers on the Storz Modulith SLX-F2 lithotripter (Figure 2). 4000 shockwaves were delivered to each patient.

Figure 2: Storz Modulith SLX-F2 lithotripter at the Churchill Hospital, Oxford. This lithotripter has a focal zone of 4mm diameter. (Image courtesy of R. Cleveland)

- Images of kidney stones were taken by X-ray fluoroscopy at baseline, 500, 1500 and 3000 shockwaves. A verbal pain score and an observation of respiratory rate over 15 seconds were also taken at these points.
- One image was taken at the furthest point travelled in inspiration and another at the furthest point travelled in expiration.
- Images were analysed on ImageJ. Paired images were overlaid and the distance between the centroids of the two stones was calculated to give distance moved in respiration.
- Statistical analysis for stone movement was undertaken using two-way ANOVA and post-hoc analysis using Sidak's multiple comparison test. In all cases, P<0.05 was taken to be statistically significant.

RESULTS

- Figure 3 shows movement of kidney and ureteric stones during SWL. Bars show mean ± SEM.
- There were no significant difference in stone motion during treatment for either kidney or ureteric stones.



- Ureteric stones moved significantly less (P<0.05) than kidney stones at 500 and 1500 shockwaves. No statistically significant changes were observed at other shockwave numbers between the two groups.
- Pain scores significantly increased from baseline and from 500 to 1500 and 3000 shockwaves. However, pain did not correlate with stone movement or respiratory rate.

CONCLUSIONS

- Stone movements in the kidney or ureter due to respiration do not significantly change over the course of one SWL treatment. Ureteric stone movement is significantly less than kidney stone movement at certain points during treatment.
- These clinical results suggest that stone movement is less than the 15mm previously reported[3], and thus may have a smaller impact on fragmentation efficiency than had been anticipated.
- Further work should examine whether there is any correlation between amount of stone movement and treatment outcome.

REFERENCES

[1] CLEVELAND, R.O., ANGLADE, R. and BABAYAN, R.K., 2004. Effect of stone motion on in vitro comminution efficiency of storz modulith SLX. *Journal of Endourology,* **18**(7), pp. 629-633.
[2] LEIGHTON, T.G. and CLEVELAND, R.O., 2010. Lithotripsy. *Proceedings of the Institution of Mechanical Engineers, Part H: Journal of Engineering in Medicine,* **224**(2), pp. 317-342.
[3] SORENSEN, M.D., BAILEY, M.R., SHAH, A.R., HSI, R.S., PAUN, M. and HARPER, J.D., 2012. Quantitative assessment of shockwave lithotripsy accuracy and the effect of respiratory motion. *Journal of Endourology,* **26**(8), pp. 1070-1074.

With thanks to Robin Cleveland and Ben Turney for their supervision and the lithotripsy team at the Churchill for their help and support.