Influence of shock rate and power on effective and efficient kidney stone fragmentation with extracorporeal shockwave lithotripsy

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Introduction

There are pressures to reduce total shock numbers to reduce renal and other organ damage. There is also a need to improve the efficiency of ESWL in light of improvements in ureteroscopy treatment. This in vitro study looks at the influence of shock rate and power on stone fragmentation. Can both of these outcomes be achieved through the adequate understanding of how and why shock waves produce effects on stone and tissue?

Throughout this poster "power" is mentioned. Altering the ESWL intensity alters the input voltage to the electromagnetic shockwave emitter (EMSE) coil which alters the intensity of the EMSE electromagnetic field. This in turn alters the intensity of the shockwave. In a clinical environment this is called increasing/decreasing the power.

Objectives

The use of certain technical factors may be able to optimise the stone fragmentation results of ESWL. The aim of this study is to discover which modifiable technical factor settings allow the most efficient urolith fragmentation. This is important as faster, more efficient, stone elimination would reduce symptom duration and limit the adverse effects of an acute episode of renal colic.

Materials & Methods

A simulation model was chosen, this was a mock silicone kidney suspended in water with a wire mesh basket used to catch the stone fragments. The drainage was provided by gravity and when the fragments were broken from the stone – they fell from the basket and were out of the way of the following shocks. Although this model typically promotes faster clearance of fragments than a kidney draining to the ureter it is more similar than a non-draining model (Cui, Thomee, Noble, Reynard, & Turney, 2013; Mustafa, 2012).

We studied the stones until complete fragmentation had occurred, as observational evidence indicates that stone fragmentation does not follow a linear path.

The initial sample consisted of two hundred and eighty identical calcium sulphate dehydrate (plaster) balls of 300mg each sourced from Dornier, Germany which were used to mimic kidney stones.

Results

A general linear model was used to simultaneously test the effects of Rate and Power on the number of shocks.

The first set of results pertain to effectiveness (the least number of shocks to complete fragmentation). The second to efficiency (least time to fragmentation).

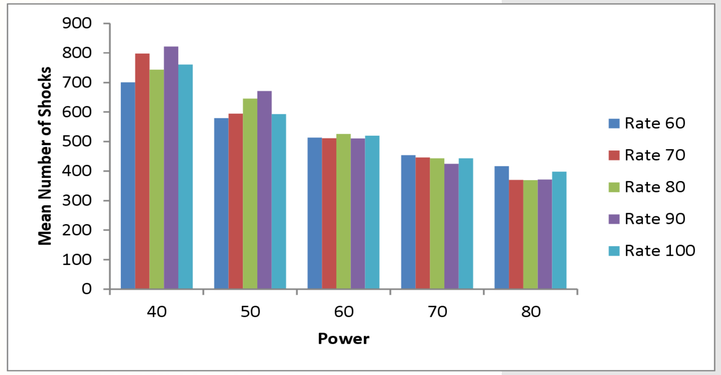
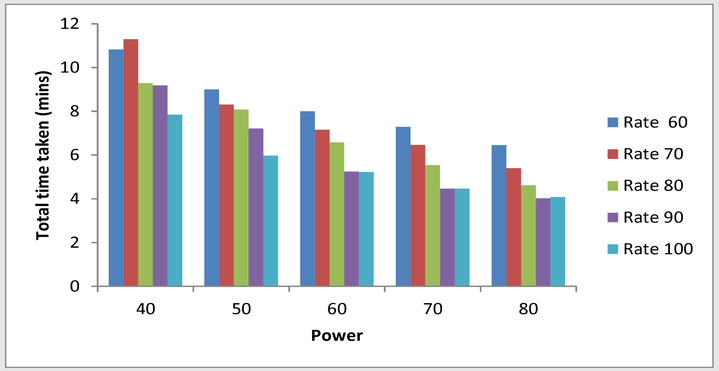


Figure 1. The relationship between power and rate and the number of shock needed to fragment the mock stones.

In this analysis it can be seen that at rates of 70,80, and 90 SW/min, the power at which fragmentation occurs with the least number of shocks is 80% power which is not surprising in this model. This is the most effective power and rate combination. However these results suggest that the rate should be kept at 60 SW/min at the start of the treatment while using the lower powers (40, 50, and 60%) but once the power is increased beyond 60%, the rate can be increased and this will reduce the number of shocks required for complete fragmentation. However in Figure 2 it can be seen that the most efficient rates are 90 and 100 SW/min and 80% power. As shown in both figures, the mean number of shocks needed to fragment the stone decreases with increasing shockwave power. However the relationship is not linear; with the decrease in mean number of shocks from 70% to 80% being about a third of that seen for a decrease from 40% to 50%.



Conclusions

There are many ways to improve the stone fragmentation results with ESWL. The modifiable technical factors discussed here can facilitate a greater success rate when attention is paid to the methods that have been shown to work well. There is some evidence that slowing the shock rate improves the effectiveness of the stone fragmentation, however it decreases the efficiency. There is strong evidence that increasing the power of the shockwave increases fragmentation rates. However this needs to be traded with clinical evidence which shows that kidney and other tissue damage may occur at higher powers.

References

Cui, Helen, Thomee, Eeke, Noble, Jeremy G, Reynard, John M, & Turney, Benjamin W. (2013). Efficacy of the lithotripsy in treating lower pole renal stones. Urolithiasis, 41(3), 231-234.

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