Shock Wave Lithotripsy (ESWL) results aren't improving. What can Radiographers do to improve outcomes with better kidney stone fragmentation

Poster No.:	C-1094
Congress:	ECR 2015
Type:	Scientific Exhibit
Authors:	J. M. Hayes, R. Kirk, A. Richardson; Christchurch/NZ
Keywords:	Lithotripsy, Fluoroscopy, Kidney, Abdomen, Calcifications / Calculi
DOI:	10.1594/ecr2015/C-1094

Aims and objectives

There are pressures to reduce total shock numbers to reduce renal and other organ damage [1]. This in vitro study looks at the influence of air bubbles existing at the interface between the shock wave source and the patient skin. Can the diligent reduction of these bubbles before and during treatment improve the efficiency of stone fragmentation?

Clinically the problem of inefficient coupling is three-fold, inefficient coupling necessitates the delivery of more shocks than would otherwise be needed to fragment the urolith, therefore increasing the likelihood of adverse side effects. The high variability of coupling as shown by Pishchalnikov [2] leads to a high variability in clinical outcomes, and diminishes the effectiveness of the treatment. This problem is made more difficult as there is currently no clinical way to measure the coupling interface during treatment. Tests have shown that there are some practical techniques that can be used to improve the quality of the acoustic coupling [3].

Methods and materials

Set up

1. Water circuit of the Lithotripter machine inspected to check it complied with the Dornier® values before performing the Model Stone Test.
2. One litre of distilled water was boiled 'whirling' for five minutes.
3. Water cooled fast to 35 ^{o}C (by putting the container with the boiling water into another container with cold water)
4. One stone at a time soaked for 20 minutes in the water at 35 ^{o}C.

Performance of model stone test

1. Therapy head moved into the treatment position.
2. The therapy head must be positioned so that it is at 90^{o} to the vertical.
3. Dornier apparatus is then bolted to the treatment head.
4. Ultrasound gel was applied in an even fashion to the coupling bellows.

5. Gel was inspected visually for bubbles of gas and removed by smearing if necessary.
6. The test container was filled with the water at $35^{0}C$.
7. The basket mesh was screwed into the apparatus (mesh diameter 4mm).
8. One soaked model stone at a time was placed in the basket, ensuring the stone was below the water level.
9. CBellows coupled to pressure 6 to ensure complete contact with kidney apparatus.
10. 72 model stones fragmented in this manner to act as a control
11. 72 model test stones treated with air in the coupling medium
12. 20ml of air injected into the coupling gel. See figure 1.
13. The shockwave was started and left to run continuously until the fragments of the model stone had completely fallen through the basket. See figure 2.
14. The number of shock waves which were needed for the complete disintegration of the model stones was recorded.

Images for this section:

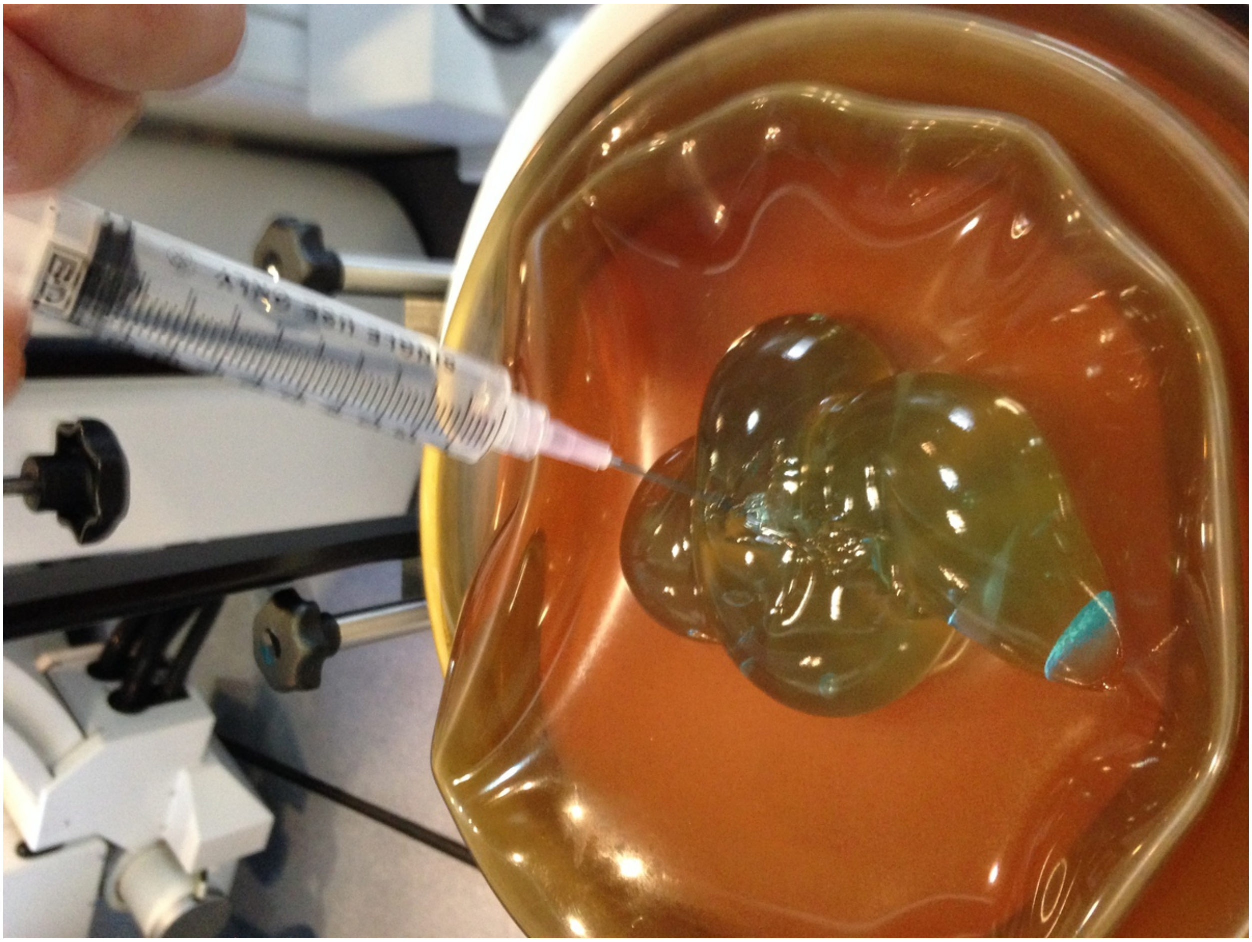

Fig. 1: Injecting 20ml of air into coupling medium

Fig. 2: Fragments of stone after ESWL

Results

Figure 3 and the table below shows that having a coupling medium free from gas results in a 22% reduction in the number of shocks needed to fragment the stone ($p<0.001$). In these experiments it was not possible to always have exactly the same amount of air in the coupling gel as some would occasionally bubble out of the gel; however the binary of gas or no gas provided a significant result. These results suggest that coupling in ESWL acts as a significant barrier to the transmission of shockwave energy to the stone. Stone breakage was sensitive to air pockets at the coupling interface. It seems reasonable that variability in the quality of coupling could contribute to variability in clinical outcomes.

	Mean shocks	Std. error of mean
No gas	442.211	6.2381
Gas	537	21.2311

Images for this section:

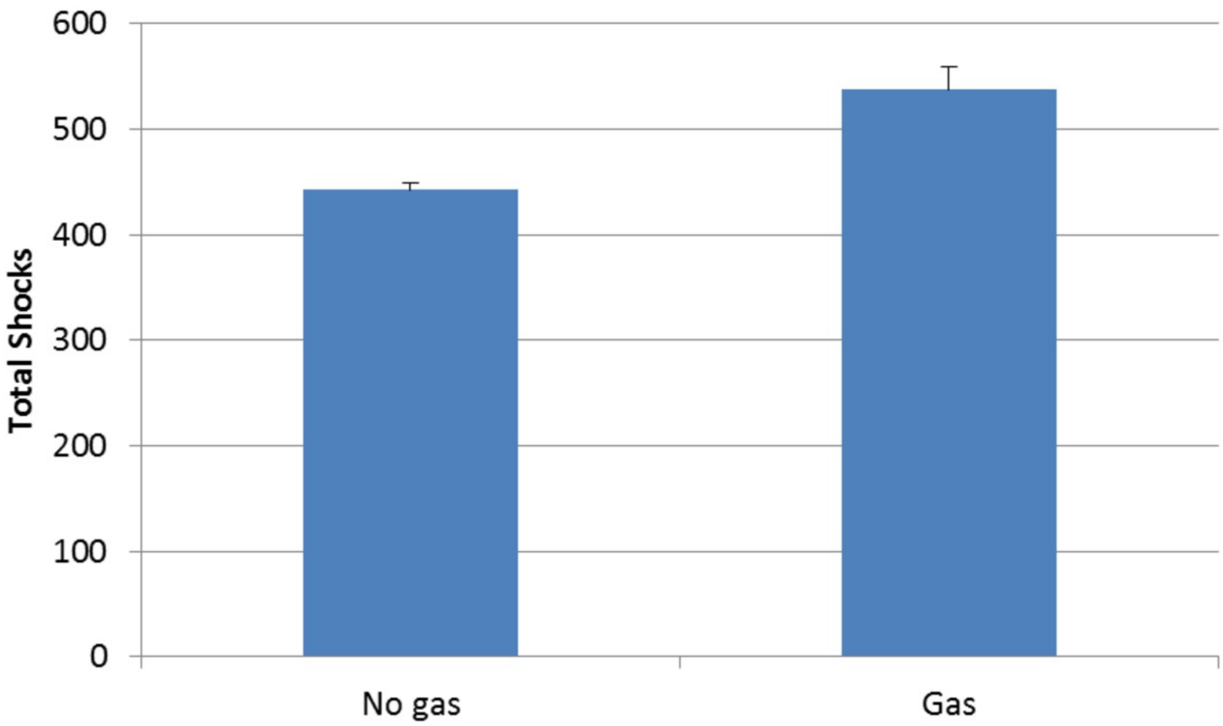

Fig. 3: Graph comparing shocks needed for stone fragmentation with and without gas in the coupling medium.

Conclusion

Air pockets within the coupling gel dramatically decrease stone fragmentation effectiveness by 22%. The experiments in this project used 20ml of air injected into the coupling gel. In some experiments, some of this gas would bubble out leaving me unsure of how much remained. For this reason the studies with gas have a higher std. error than those without gas. However of the two categories it was clear that any extra gas in the coupling gel resulted in a significantly greater number of shocks needed to fragment the stone.

This makes sense when the graph for the intensity transmission coefficient for an acoustic wave traveling from water to another medium with different impedance is viewed, see figure 4. As shown the transmission from water to tissue (as would occur when the shockwave leaves the therapy head) is very efficient, the water to stone transmission is also very efficient with between 75% and 95% of the energy transmitted into the kidney stones. However the water to air transmission has an extremely small coefficient and less than 0.1% of the energy of a shockwave in water will pass into air. This further establishes the need for great care when using a dry lithotripter to ensure that air pockets are removed in the coupling gel.

Images for this section:

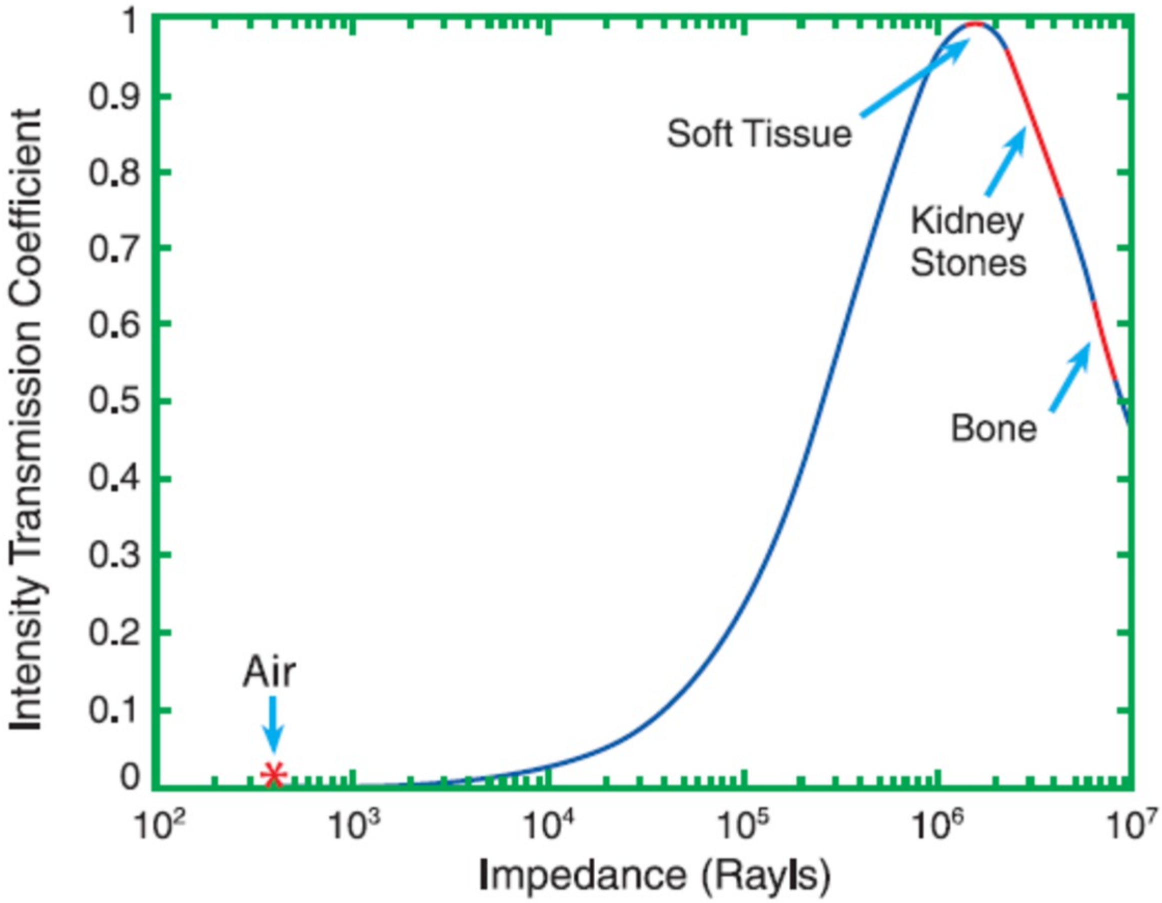

Fig. 4: The intensity transmission coefficient from water to a second medium, as a second of the impedance of the second medium.

Personal information

James M. Hayes, Senior Medical Imaging Lecturer, Dept. of Applied Science and Allied Health, CPIT, Christchurch, New Zealand.

Associate Professor Ray Kirk, School of Health Sciences. University of Canterbury, Christchurch, New Zealand.

Professor Ann K. Richardson, School of Health Sciences, University of Canterbury, Christchurch, New Zealand.

References

Semins, Michelle Jo, Trock, Bruce J., & Matlaga, Brian R. (2008). The Effect of Shock Wave Rate on the Outcome of Shock Wave Lithotripsy: A Meta-Analysis. *The Journal of urology, 179*(1), 194-197. doi: http://dx.doi.org/10.1016/j.juro.2007.08.173

Pishchalnikov, Yuri A, Neucks, Joshua S, VonDerHaar, R Jason, Pishchalnikova, Irina V, Williams Jr, James C, & McAteer, James A. (2006). Air pockets trapped during routine coupling in dry head lithotripsy can significantly decrease the delivery of shock wave energy. *The Journal of urology, 176*(6), 2706-2710.

Neucks, Joshua S, Pishchalnikov, Yuri A, Zancanaro, Anthony J, VonDerHaar, Jonathan N, Williams Jr, James C, & McAteer, James A. (2008). Improved acoustic coupling for shock wave lithotripsy. *Urological Research, 36*(1), 61-66.

Smith, Arthur D. (2007). *Smith's textbook of endourology*: PMPH-USA