Urol Res (2009) 37:51–53
DOI 10.1007/s00240-009-0171-y

SYMPOSIUM PAPER

# Pain in extracorporeal shock wave lithotripsy

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Received: 19 October 2008 / Accepted: 9 January 2009 / Published online: 29 January 2009


**Abstract** Pain tolerance has long been identified as a factor influencing successful treatment of renal calculi by shock wave lithotripsy (SWL). We aimed to clarify which factors directly influence pain tolerance to predict which patients are likely to undergo successful treatment. We analysed retrospectively 179 patients who received their first SWL for a solitary kidney stone. All patients were on a non-opioid analgesia protocol and were treated on an outpatient basis. The target was to deliver 4,000 shock waves at an energy level of 4. In total, 53% of patients could tolerate the targeted shock wave number and energy and were retrospectively allocated into group A. Those who required a reduction in either energy levels or shock wave number were allocated in group B. Multivariate and univariate analysis showed that female patients, who are young with thin body habitus, have lower pain tolerance to SWL.

**Keywords** Extracorporeal shockwave lithotripsy · Pain · Success rate · Non-opioid analgesia

11th international symposium on urolithiasis, Nice, France, 2–5 September 2008 Urological Research (2008) 36:157–232. doi:10.1007/s00240-008-0145-5. http://www.springerlink.com/content/x263655772684210/fulltext.pdf.

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## Introduction

Success rates for shock wave lithotripsy (SWL) currently average around 77% [1]. Although this percentage is respectable, a better understanding of factors affecting success of SWL may help to further improve it.

Successful treatment of renal calculi has long known to be influenced by multiple factors, in particular pain experienced during SWL and how it is tolerated [1]. There are currently a number of theories suggesting the origins of pain experienced during SWL and how these are coped with.

It is thought that pain can occur when shock waves from the lithotripter reach superficial structures such as skin and muscle and also deeper structures such as the ribs, subcostal nerves, the sciatic nerve and the kidney capsule. Three key factors that influence the propagation of pain at these sites are shock wave (SW) pressure, size of focal area and the SW distribution at the skin entry point [1]. A smaller skin aperture increases the shock wave density that increases the energy density and therefore increases the pain [2].

The size and location of the stone is known to affect the pain experienced during SWL. We know that small stones are more painful to treat with SWL than larger stones. We know that stone location is also important with stones in the renal pelvis far more painful to treat than stones found in the lower ureter [3].

An experienced operator is required to ensure that adequate coupling is achieved for pain control. It is also extremely important for the operator to increase the voltage in gradual increments to aid the development of pain tolerance.

Commonly, pain due to SWL is controlled by basic analgesics such as diclofenac or COX 2 inhibitors, which can also help aid stone passage [4].

Other methods of analgesia have been tested with varying degrees of success. A eutectic mixture of local

anaesthesia consisting of an emulsion of 2.5% lidocaine and 2.5% prilocaine was tested but shown to be ineffective without an occlusive dressing [5].

Sedo-analgesia such as fentanyl or propofol and patient controlled analgesia (PCA) [5] produce high patient satisfaction rates but require more hospital resources. Spinal blocks have also been tried but require expertise to monitor the patient.

Various nerve stimulation techniques have been tried. The logic behind these centres on the gate control theory of pain, whereby pain is transmitted to the dorsal horn of the spinal cord via C-fibres and A$\beta$ fibres. C-fibres release substance P that "opens" the gate and A$\beta$ fibres "close" the gate. Subcutaneous nerve stimulation activates A$\beta$ fibres, thereby stopping the transmission of pain stimuli. Prime examples of techniques that utilise nerve stimulation include acupuncture, chemo-acupuncture, and TENS [6].

## Materials and methods

The aim of the study was to identify which factors affect pain tolerance under SWL for renal calculi. Based on these factors, we will be able to predict which patients are most likely to undergo successful treatment. We present our experience with a non-opioid analgesia protocol for SWL of kidney stones on an outpatient basis.

We analysed retrospectively 179 patients who received their first SWL for a solitary kidney stone on an outpatient basis during 2006. Mean age was 48 years (22–80). There were 105 male and 74 female patients.

All patients were treated on a Siemens Lithostar Multiline® lithotripter. The target was to deliver 4,000 shock waves at an energy level of 4, which corresponds to manufacturer's recommendations for renal stones.

As per the protocol, all patients received pre-SWL 100 mg diclofenac per rectum only. Patients who could tolerate the targeted shock wave number and energy under this analgesia were allocated in group A and those who required a reduction in either energy levels or shock wave numbers were allocated in group B.

We recorded patient parameters [gender, age, body mass index (BMI)], stone parameters (side, size, location), and treatment parameters (applied energy, applied number of shock waves, operator). For univariate statistical analysis, we used the chi-square test and a *t* test, while for multivariate statistical analysis the logistic regression test was used.

## Results

Ninety-five patients (53%) could tolerate the full treatment and were in group A, defined as the group which could tolerate the maximum shock wave number and energy level under our outpatient analgesic protocol of diclofenac per rectum.

Eighty-four patients (47%) could not tolerate the full treatment, requiring a reduction in either shock wave number or energy level and were in group B.

Group A contained the majority of males (64%), whereas the majority of females were in group B (62%) ($P < 0.001$). Also, patients in group A were significantly older ($P < 0.05$).

The majority of patients with a higher BMI were in group A (68%). We also found that patients with a lower BMI tended to be less pain tolerant (group B) ($P < 0.05$).

For renal pelvic stones, the majority of patients could tolerate the full treatment (70% group A), whereas for calyceal stones the numbers were equal (51% group A).

Operator, stone size, and stone side were not found statistically different. Multivariate analysis confirmed that gender and BMI were the most important independent predictors for tolerating full treatment (Table 1).

**Table 1** Results analysis and their statistical significance

| Factor | Group A ($n = 95$) (%) | Group B ($n = 84$) (%) | *P* value |
|---|---|---|---|
| Male | 64 | 38 | <0.001 |
| Mean age > 60 years | 52 | 46 | <0.05 |
| BMI > 25 | 68 | 47 | <0.05 |
| Stone side | NS difference | | |
| Stone size | NS difference | | |
| Stone level | NS difference | | |
| kW | NS difference | | |
| # SW | NS difference | | |
| Operator | NS difference | | |

No significant (*NS*) difference $P > 0.05$

## Discussion

We know that successful disintegration of renal calculi is multifactorial. Many studies have performed univariate and multivariate analyses of how factors such as patient's sex, age, BMI, stones laterality, stone location, stone volume, mean attenuation value, and skin-to-stone distance on disintegration can affect the success of SWL treatment [2].

A study looking at the value of un-enhanced CT as a predictor of renal stone disintegration reported a failure rate of 12.5%. Patient BMI and a stone density >1,000 Hu were significant predictors of failure ($P = 0.04$ and 0.02, respectively) [2]. These studies are important in identifying which factors can influence successful SWL treatment. However, the next step is to find out why. In the context of our study,

this meant determining if any of these factors that have already been identified can induce pain during SWL.

Torrecilla et al. [1] noticed that 10% of SWL sessions were discontinued due to pain. They set out to determine whether the pain experienced during SWL was primarily due to factors that increase patient susceptibility to pain such as shock wave pressure, size of focal areas and pressure distribution at the skin entry point, or if the pain was related to a patient's anxiety trait. The results showed that 95% of patients experienced mild to moderate pain, proving that SWL is indeed a painful therapy, with patient pain status significantly correlated to pain ($P = 0.001$) as opposed to patient anxiety trait ($P = 0.02$).

Another study looking at which factors influence the analgesic and sedative requirements during SWL, found that a higher analgesic requirement was present in younger patients ($P = 0.003$), patients who received a higher number of shocks ($P < 0.001$) and patients requiring more sedation ($P < 0.001$). A higher sedative requirement was found in female patients ($P = 0.0026$), younger patients ($P < 0.001$), patients treated with higher voltages ($P = 0.032$) and patients with the highest analgesic requirements (<0.001) [7].

Our study is based on the fact that a patient's pain tolerance affects SWL treatment and its clinical outcomes. Energy levels are reduced for patients with lower pain threshold making total stone disintegration less likely. It shows that under simple non-opioid analgesia, there are a number of independent predictors for increased pain tolerance during SWL: being male, older, and bigger.

Multivariate analysis confirmed that gender and BMI were the most important independent predictors for tolerating full SWL treatment.

This fits with what we know about SW density at the skin aperture. A smaller aperture caused by a smaller muscle mass, as in women and patients with a low BMI, will have increased pain intensity [1]. We also know there is high subjective variation in pain perception and that older patients tend to have better pain tolerance in general [8].

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