The Role of ESWL today

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History

• 1972 - Investigation on therapeutic potential of shock wave
• 1980 - First clinical ESWL treatment for renal stone by Prof Christian Chaussy
• 1983 - Distribution of Dornier HM3 lithotriptor
• 1984 – ESWL approved by U.S FDA
Energy Source

• Spark gap: Electrohydraulic, Electroconductive (Dornier, Technomed etc…)
  • Powerful generator

• Electromagnetic (Dornier, Storz, Siemens)
  • No disposable costs

• Piezoelectric
  • No disposables, not so powerful
Stone breakage mechanism

- Compression fracture
- Spallation
- Acoustic cavitation
- Dynamic fatigue
Indications for ESWL

• Renal Stone
  – 80-85% of single renal stone can be treated satisfactorily with ESWL (Wickham, 1993)
  – FDA recommendation: calculi<2cm should be treated by ESWL

• Ureteric stone
Bioeffects

- Vascular Injury
- Hypertension
- Perirenal haematoma, subcapsular hematoma, petechies.
Vascular injury

• ESWL induced vascular injury (subcapsular hematoma)
• Bio-effect in animal model: treated kidney ↓GFR , ↓RPF
• Factors influencing Vascular injury
  • Renal size
  • Kilovoltage
  • Number of shocks, Size of focal point
  • Pyelonephritic kidney
Perirenal Hematoma

• Occurrence
  – Radiographic 20-25% to correct
  – Clinically significant 0.6-4%

• Risk factors
  – HPT
  – Untreated coagulopathy
  – Type of lithotriptor
  – NSAID
Fate of Patient with Perirenal hematoma

• 19 patients with 21 hematomas
• Mean follow-up 19.6 months
  – 18 (85.7%) resolved
  – 2 (9.5%) smaller
  – 1 (4.8%) unchanged
• No change in creatinine
• No new onset of HPT
  » Krishnamurthi et al, Journal of Urology, 1995;154: 1673
ESWL & Hypertension

• RCT of 228 adult patients revealed no evidence that ESWL caused changes in BP.
  • Elves AWS et al, BJU Int 2000; 85: 611-5
ESWL effect on children

- 19 infants (5/12 to 24/24), average f/u 36/12; no HPT recorded, no scar or significant variations in differential function attributable to ESWL.
  - Lottmann et al, BJU Int 2000; 85: 311-5

- 75 children 13/12 to 18 years, mean f/u 4.8 years showed no differences in pre- and post-ESWL age adjusted BP, no evidence of scar formation or progression.
  - Samadi AA et al, Endourol 2002; 16(suppl 1): P32-18(abstract)
ESWL for Renal calculi

- Large renal stone > 2cm
- Frequent complications: fever, occasional urosepsies due infected stones, passage of big fragments.
ESWL for Renal calculi…cont

• Total Stone Burden
  – No clear cut-off for critical stone size
  – < 30 x 40 mm area – ESWL monotherapy (+ stent); success rate 86% at 3/12
  – > 30 x 40 mm area; success rate 43% at 3/12 but in sandwich therapy; success rate 71-96%
    » (EAU guideline 2004)
ESWL for Renal calculi…cont

• Factors associated with poor result
  – Large renal calculi (mean 22.2mm)
  – Stone in dependent & obstructed portion of collecting system
  – Stone composition (Ca oxalate monohydrate & brushite)
  – Obesity
ESWL for Renal calculi…cont

• Results
  – Mean overall stone free rate (SFR) in solitary stone, 79.9% for < 10mm; 64.1% for 11 to 20 mm and 53.7% for > 20mm

• SFR for calyceal diverticulum stone
  – ESWL, 21%; PCNL, 93% and URS, 80%
  – Successfull limited mainly to upper & middle calyceal diverticula with small stone burden (<1cm, a short, accessible diverticular neck)
ESWL for Renal calculi…cont

• Steinstrasse formation
• Risk is significantly increased for stone with surface area on plain X-ray > 300 mm$^2$, corresponding to circular stone with diameter about 20mm.
Management of a steinstrasse

• In patients without sepsis
  – ESWL
  – Instillation of lubricant jelly
  – Stent insertion
  – Percutaneous nephrostomy

• In patients with sepsis
  – Percutaneous nephrostomy
  – Antibiotics
Other indications for stenting prior ESWL session

- Infective stones
- Obstruction + bacteriuria
- Pronounced obstruction
- Reduced renal function
- Single kidney
Ureteric stenting

- A RCT evaluated outcome of ureteric stenting in treating kidney stone (10-20mm) or proximal ureteric stone <20mm.
- Stenting associated with more irritative symptoms but fewer hospital readmission & emergency visits (7%) than not stenting (22%)

Lower Pole Stone (LPS)

- ESWL less effective in lower pole than other sites
- PCNL effectiveness not affected by stone location
- URS/RIRS effectiveness improving
Lower Pole Stone…cont

• Lingeman, 1994 reported the results of metaanalysis showed that SFR for ESWL for LPS was 60% (Upper & middle calyx, 70 to 90%)
• SFR 74% for < 10 mm stone; 56% for 11 to 12 mm stone and 33% for >20mm
• Efficacy of PCNL independent of stone size (SFR 90%)
Lower Pole Stone…cont

• Keeley *et al*, 1999

• 116 patients with ESWL for lower pole stone (11-20mm)

• 52% stone-free, 35% fragment < 4mm

• Favorable factors: Infundibulo-pelvic angle >90°, absence of distorted calyces, infundular width > 5mm
  – 71% stone-free if all 3, 9% if none
Lower Pole Stone…cont

- Madbouly et al, 2001
- 108 lower pole stones
- 73% stone-free rate
- Infundibular length and width not associated with success
- No infundibular angles >90° were found, and no association between angle and success
- Other smaller series shed doubt too
Lower Pole Stone…cont

• Result of Lower Pole Study Group suggest PCNL should be considered primary approach for LPS > 10mm

• Alternative treatment: RIRS (SFR – 86%) but reduced if stone > 20mm
ESWL in proximal ureteric stone

- OSS: SFR 97% - longer hospitalization, greater morbidity, not recommended for first line treatment.
- ESWL – primary approach for stone < 1cm. For bigger stone, ESWL, PCNL, URS are acceptable choice.
ESWL in proximal ureteric stone

• Stenting – no improvement of fragmentation but appropriate for management of pain, relief of obstruction, difficult to visualize stone.
• Mandatory in solitary obstructed stone

• Impacted stone – more resistant to ESWL
ESWL in distal ureteric stone

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<tr>
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<th>ESWL</th>
<th>URS</th>
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<tr>
<td>Mean SFR</td>
<td>81%</td>
<td>94%</td>
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<tr>
<td>Retreatment rate</td>
<td>27%</td>
<td>8%</td>
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(Turk and Jenkin, 1999)

- For stone < 1 cm, ESWL equivalent to URS but significantly insufficient in larger stone
Role of CTU

• Spiral CT performed to assess the chemical composition of renal calculi could not distinguish between the most common types of human calculi except for,
  - Pure cystine (915 ± 126 HU)
  - Uric acid (617 ± 416 HU)
  - Calcium oxalate monohydrate / brushite (1741 ± 346 HU)

  » Conort P et al, J Endourol 2002; 16(suppl 1): P4-7
• Calculus attenuation value (CAV) – strong predictor of success of ESWL
  – Below 400 HU, 92% of stones were successfully treated
  – Above 800 HU, all failed

» Stern et al, J Endourol 2002; 16(suppl 1): P5-11(abstract)
Role of CTU…cont

- A prospective study, classify according to CAV,
  - CAV less than 500, stone clearance rate 100%
  - CAV 500-1000, stone clearance rate 85.7%
  - CAV greater than 1000, 54.5%
  - Mean attenuation value correlated significantly with the number of shock waves required for calculus fragmentation.

Improving ESWL

• SWL Targeting
  – Patient movement causes mistargeting

• Impact of anaesthesia
  – Higher stone free rate with GA compared to sedation

• Effect of SW rate on fragmentation

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<tr>
<th></th>
<th>60 Hz</th>
<th>120 Hz</th>
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<tr>
<td>% Stone free (&lt;100mm²)</td>
<td>67</td>
<td>56</td>
</tr>
<tr>
<td>% Stone free (&gt;100mm²)</td>
<td>58</td>
<td>27</td>
</tr>
<tr>
<td>Median number of shocks</td>
<td>2500</td>
<td>3000</td>
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World Congress of Endourology, 2002
Improvement of stone disintegration

• Reasons for insufficient disintegration (ureteral stone)
  – Impacted & surrounded by edema
    • Creating a fluid space
  – Shock wave power been attenuated during its path
    • Prone position but intestinal gas has to be eliminated
Prevention of reduced renal function

- Great care in renal impairment
- Significant risk of worsening the renal insufficiency
- The rule: small number of shock, energy as low as possible
- Renal protection using allopurinol or verapamil, nifedipine
Recurrence post ESWL

- Stone recurrence 6 to 15% after stone free and 17 to 80% if residual fragment present
- Stream et al, 1996 follow-up <4mm
  - 24% pass spontaneous
  - 18% increased
  - 16% decreased
  - 42% stable
• Plain X-ray insufficient to determine SFR accurately (nephrostomogram detected additional 14 to 47% residual stone (Golwasser et al, 1989)

• Ultrasound- inferior than X-ray (sensitivity 19% for ureteral stone)

• Good to detect hydronephrosis and if combined with X-ray, as good or better than IVU in identifying residual stone

• NCCT – sensitivity >94%
• Coughlin et al, 1989 suggested routine radiologic evaluation of symptomatic patient after ESWL would be limited to abdominal radiograph & ultrasound.
Adjuctive Medical Treatment

- Fine and ass., 1997 - ↓ stone recurrence rate after stone removal
- Sodium potassium citrate can improved stone clearance by ↓ stone regrowth & ↓ stone reaggregation at ESWL (Ca oxalate & struvite)
- Should not replace an effort to choose the treatment approach that allow the best chance to achieve stone free
Adjuctive Medical Treatment

- Prospective study on adults ureteric calculi.
- ESWL using Sonolith 4000+
- %SFR – Nifedipine (75%) & No Rx (50%)
  » Purplglies et al, Urology 2002; 59: 835
Pediatric ESWL

<table>
<thead>
<tr>
<th>% Stone free</th>
<th>Pediatric</th>
<th>Adult</th>
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<tr>
<td>10-15 mm</td>
<td>95</td>
<td>95</td>
</tr>
<tr>
<td>16-20 mm</td>
<td>100</td>
<td>65</td>
</tr>
<tr>
<td>&gt; 20 mm</td>
<td>89</td>
<td>56</td>
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- Retropective study
- Renal calculi
- Unmodified Dornier HM3

Role in acute renal colic

- Prospective study of 57 patients presented with acute renal colic & treated with ESWL
- Overall complete success rate after 1X ESWL was 49%
- Site: UPJ stone 46% success, lumbar ureter: 14%, iliac ureter: 33%, pelvic ureter: 66%
- Size: < 5mm: 57%, 6 to 10mm: 70%, 11 to 15mm: 27%, > 15mm: 0%
- Conclusion: Can be considered in UPJ stone <10mm

Simultaneous Bilateral Renal SWL

• Is it safe?
  – 10% initial ↓ effective renal plasma flow
    » Thomas et al, *Journal of Endourology*

• Clinical studies

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<thead>
<tr>
<th>patients</th>
<th>Creatinine (mg/dl)</th>
<th>Follow-up, mo</th>
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<tr>
<td></td>
<td>Pre-ESWL</td>
<td>Post ESWL</td>
</tr>
<tr>
<td>77</td>
<td>1.10</td>
<td>1.07</td>
</tr>
<tr>
<td>79</td>
<td>1.03</td>
<td>1.04</td>
</tr>
<tr>
<td>120</td>
<td>1.46</td>
<td>1.41</td>
</tr>
<tr>
<td>17</td>
<td>2.18</td>
<td>2.36</td>
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Simultaneous Bilateral Renal SWL...cont

- Avoid in renal insufficiency
- Avoid in HPT
- Stenting if there is a risk of steinstrasse
- Avoid large stone volume
- Limit number of shock waves delivered
Current Stone Treatment Trends

• Current lithotriptors not as effective as HM-3
• Endourologic training more widespread, instruments improved, indications and techniques more refined
  • Improved results of endourology
  • Decreasing morbidity of endourology

• Still, SWL useful for many stones
Important Factors for Successful ESWL Treatment

- Careful positioning of the patient
- Precise focusing
- Attention to the shock wave transmission
- Selection of appropriate shock wave power & frequency
- Sufficient and adequate pain relief
- Ensure high urine flow during treatment
- Informed search for factors in explanation of insufficient stone disintegration
- Care to eliminate the risk of complications
Thank You For Your Attention

12/04/2005