An overview of Extracorporeal shock wave lithotripsy (ESWL) and the role of Radiographers in ESWL

Tse Ka Wai, Sam (Rad II, TMH)
What is ESWL?
Renal Stone Incidence rate in HK population

- From a questionnaire survey done in 2008, ~2.5% population have renal stone
- Commonest age group: 50-59 years (worldwide)
- Usually Male more than Female in ratio 3:1 (worldwide)
Renal Stone (Nephrolithiasis)

- Crystallization of minerals inside urine, which act as the nidus for more sedimentation and finally the formation of a stone within the kidney.
Types of Kidney Stones (mentioned in the IVU tutorial)

- Calcium-containing stone (Radiopaque)
  - Calcium Oxalate
  - Calcium Phosphate
- Uric acid stone (Radiolucent)
- Cysteine stones (Light Radiopaque)
Signs and Symptoms of renal stone

- NO symptom
- Pain: sudden or severe pain, nausea, vomiting
- Renal colic
- Frequent and painful urination, hematuria
- Urinary tract infection: Block the urinary tract
Diagnosis

- Abdominal X-ray
- Intravenous Urogram (IVU)
- Ultrasound
- CT
Treatment (Small Stones)

For Stone < 5mm:
- Drink more water
  -> help to flush the stone out
- Medicine (e.g. calcium channel/Alpha-blockers)
- No progress -> other treatments
Treatments

- ESWL
- Percutaneous nephrolithotomy (PCNL)
- Ureteroscopy (URS) / URSL
- Open surgery

**Depend on size, number, location, kind of stone and patient type.**
ESWL

Indication

- Stones of less than 2 cm in the kidney or
- Stones of less than 1 cm in the ureter (usually proximal ureteric stone)

Why?
Contra-indication

- Relevant coagulation problems
- Lung tissue in shock wave path
- Tumors in shock wave area
- Aneurysms
- Polyarthritis (difficult to positioning)
- Active pyelonephritis
- Pregnancy

Relative contraindication:
- Untreated hypertension
What is ESWL?

- Use focusing Shock Waves to breakdown a stone into small pieces.
- Shock waves are acoustic pulses.
- Pass through better in water and solid but not in air.
- Introduce in 1980 by Dornier which is a supersonic aircraft company.
Early ESWL

Dornier HM-3

Placed in water tank

http://www.mwstone.com/STONES/equipment.htm
Nowadays ESWL
Basic Components of lithotripsy machine

1) A shockwave generator
2) A focusing system
3) A coupling system
4) An imaging/localization units
Shockwave generator and focusing system (TMS)

F1: shockwave generator
F2: Target (Stone)

The shockwave is generated by electromagnetic generator.

http://www.tms-uro.com/eng/physicians/swl/la_vision_device.htm
Coupling system

- Provide a air-free contact
- In the propagation and transmission of a wave, energy is lost at interfaces with differing densities.
- A coupling system is needed to minimize the dissipation of energy of a shockwave as it traverses the skin surface
Coupling system

TMS

Dornier
Imaging units

- Fluoroscopy
- Ultrasound
The fracture mechanism of stone in ESWL

- Several models of mechanism were discussed in different articles
- Fragmentation need stress and strain
- ESWL pulse create pressure gradient to the stone
- Thus, resulting in stress and strain within the stone
- Effective when focus diameter is small than the stone.

**The mechanisms of stone fragmentation is ESWL**

Fig. 1. Schematic crater-like fragmentation erosion in ESWL with a sharp focus of 2 to 6 mm −6-dB focal width and larger stone diameter.

**The mechanisms of stone fragmentation is ESWL**
Focal dimension

- Focal dimension is depends on the energy level.
- The higher energy level the larger the focal dimension.
- The focal dimension of around 3mm to 6mm
Video

- **In vitro experiment of ESWL**
  [http://www.youtube.com/watch?v=huYR7ktyM7Q](http://www.youtube.com/watch?v=huYR7ktyM7Q)

- **Ureteral Stone under ESWL**
  [http://www.youtube.com/watch?v=L6UeNFVo-oM](http://www.youtube.com/watch?v=L6UeNFVo-oM)
ESWL procedures
Preparation

1) Check preliminary KUB to find out the location of stone
2) Fasting
3) Take the blood pressure
4) Check the cardiac physical exam result to ensure patient’s physical condition suit for exam (done by nurse)
5) Pre-medication (pain relief) by nurse
6) Check LMP for female patients
7) Brief the details of the treatment to the patient **
Patient co-operation is important!

- The feeling during the treatment
  (What is the feeling?)
- Shallow breathing (Why?)
- Any uncomfortable after positioning?
- Keep the posture for ~1 hour
- Raise out concern
Procedures

1) Lie the patient on the table (Supine oblique or prone?)

Avoid the shockwave path pass through spine and pelvis!!! (Why?)
1) Compare with the previous KUB image
2) Using LCM, iliac crest and the spine as landmark
3) Move the patient in the mid level of the removable broad
Procedures (localization using flororo)

4) Remove the broad
5) Screening in PA view (optional)
6) **Apply gel to the coupling cushion**
7) Move the coupling cushion to treatment position
8) Increase the coupling pressure and **touch** the patient skin
9) **Apply soft pad or sand bag on the opposite side of the patient** (immobilize the patient)
Procedures (localization using flororo)

10) Screening in PA view
11) Move the table to locate the stone in the center
12) Screening in CC view
Procedures (localization using floro)

13) Adjust the height of the table to locate the stone in center
14) Instruct to the patient
15) Call doctor to confirm the position and start the treatment
Procedures (localization using US)

**Renal stone only, Why?**

1) Apply gel to coupling and attach to the patient skin
2) Position the ultrasound transducer on the patient in the longitudinal section
Procedures (localization using US)

3) Move the table in green arrow plane
Procedures (localization using US)

4) Move the table in green arrow plane
5) Center the stone in target
Procedures (localization using US)

6) Turn the transducer 90 degree and scan in transverse plane
Procedures (localization using US)

7) Instruct to the patient
8) Call doctor to confirm the position and start the treatment
During the treatment

- Select the suitable parameters
  1) Power of shockwave (start from low energy level to high energy level)
  2) The frequency of shockwave (ECG gated for patients with cardiac pacemakers or those with arrhythmias who regularly take anti-arrhythmic drugs)
  3) Total energy of shockwave (Renal stone < Ureteric stone)

High energy level + high frequency = shorter treatment time

Low energy level + low frequency = longer treatment time
During the treatment

- Monitor the patient condition (e.g. Blood pressure, heart rate, pain)
  Any abnormality => Stop shock wave!

- Monitor the position and the progress of stone (floro or US)
  Move far away from the center => Stop shock wave and make adjustment!
Post Treatment

- Patient is being observed for at least an hour in Day ward.
- Follow up 2 weeks later with X-ray (KUB)
- Remaining Stone => ESWL again
- Other treatment
Complications

- Hematomas
- Risk of hemorrhage
- Hyperventilation tetany
- Blockage of urinary tract

The higher the total energy, the higher the risk.
Advantages

- Non-invasive
- Safe
- No General anaesthesia
- Short treatment time
- Convenience
Disadvantages

- May require repeat procedures
- Not suitable for all types of stones
- Cause complications
- Painful
Reference

1) Presentation powerpoint by Beatrice Pang and Connie Li, 2011
3) JS Rodman et al. No more kidney stones. 2007
4) SWH Chan et al. A report on randomly sampled questionnaire survey about renal stone disease in Hong Kong. HK Med J. 2008
8) http://www.medison.ru/uzi/img/p287.jpg
9) http://www.mwstone.com/STONES/equipment.htm
10) http://www.tms-uro.com/eng/physicians/swl/1a_vision_device.htm
12) http://emedicine.medscape.com/article/444554-overview
Questions
Question 1

What size of renal stone can be treated by ESWL?

a. <5mm
b. 5mm to 2cm
c. >2cm

Answer: B
**Question 2**

What is the sequence of priority to treat following stones?

1. Renal Stone (upper pole)
2. Renal Stone (lower pole)
3. Ureteric Stone (above iliac crest)
4. Ureteric Stone (below iliac crest)

a) $1 > 2 > 3 > 4$

b) $4 > 3 > 2 > 1$

c) $3 > 4 > 1 > 2$

d) $2 > 1 > 4 > 3$

Answer: B
Question 3

Which stone require prone position during ESWL?

a) Renal Stone (upper pole)
b) Renal Stone (lower pole)
c) Ureteric Stone (above iliac crest)
d) Ureteric Stone (below iliac crest)

Answer: D
Question 4

Which following components are important in ESWL?

1) A shockwave generator
2) A focusing system
3) A coupling system
4) An imaging/localization units

a) 1, 2, 3
b) 1, 3, 4
c) 2, 3, 4
d) All of above

Answer: D
Question 5

Which of following stones are not suitable for US localization?

1) Renal Stone (upper pole)
2) Renal Stone (lower pole)
3) Ureteric Stone (above iliac crest)
4) Ureteric Stone (below iliac crest)

a) 1, 2
b) 1, 3
c) 2, 3
d) 3, 4

Answer : D
Question 6

Which are the advantages of US localization?
1) No ionizing radiation
2) Continuous monitoring of stone positioning
3) Operator dependent
4) Suitable for all renal stones
a) 1, 2
b) 1, 2, 3
c) 1, 2, 4
d) All of above

Answer: C
Question 7

During the treatment, patient is complaint of severe pain. What will you do?

a) Use X ray to check to stone
b) Call nurse to communicate to the patient
c) Call doctor to communicate to the patient
d) Stop shock wave

Answer : D
Question 8

During the treatment (only use floro, No US), the stone is no longer seen under screening after 80% of total energy was delivered. What will you do?

a) Stop shock wave
b) Keep treatment until the total target energy
c) Consult doctor

Answer: B
Question 9

During the treatment, the patient is moved. You stop the shock wave and try to localize the stone again, but you can’t find it. What will you do?

a) Continue the treatment
b) Using the previous screening images to help in re-localize the position
c) Consult doctor to end the treatment

Answer: C
Acknowledgement

Ms Connie Li (PPT 2011)
Ms Beatrice Pang (PPT 2011)
Ms Gwendo Yiu
Lithotripsy center in Ward C1, TMH