View metadata, citation and similar papers at core.ac.uk
brought to you by CORE
provided by eCommons@AKU

THE AGA KHAN UNIVERSITY

eCommons@AKU

Section of Urology

Department of Surgery

January 1990

Extracorporeal shock wave lithotripsy

Jamsheer J Talati
Aga Khan University, jamsheer.talati@aku.edu

Follow this and additional works at: http://ecommons.aku.edu/pakistan_fhs_mc_surg_urol
Part of the Surgery Commons, and the Urology Commons

Recommended Citation
Talati, J. (1990). Extracorporeal shock wave lithotripsy. *Journal of Pakistan Library Association, 40*(1), 17-21.
Available at: http://ecommons.aku.edu/pakistan_fhs_mc_surg_urol/75

EXTRACORPOREAL SHOCK WAVE LITHOTRIPSY

Pages with reference to book, From 17 To 21

J. Talati (Departments of Urology , The Aga Khan University, Karachi.)

After circumcision the first operations done on man were for bladder stone. Done by charlatans the operation often resulted in loss of life and caused the early lithotomists to maintain a peripatetic existence, vanishing from the town the night after surgery was performed. About two centuries ago stones became a common disease amongst kings: surgeons took over from the charlatans and commenced blind skilful mechanical lithotripsy where a curved instrument was introduced per urethram, its jaws opened to engage the stone which was then crushed by a mechanical (screw driven) closure of the jaws. Now-a-days urinary bladder lithotripsy is done under vision and aided by ultrasound drilling, or electrohydraulic shock wave produced by a direct contact probe. Renal stones can be safely operated on or removed percutaneously.

Non-invasive lithotripsy

Aforementioned invasive methods are being gradually superseded by extracorporeal lithotripsy, available in Pakistan since August 1988, in which externally produced shock waves are focussed onto the stone. Repeated shocks act by alternately compressing the stone as the wave proceeds towards it and expanding it as the wave reflected from the far surface of the stone returns back as a tensile force. The shocks loosen up the texture of the stone, produce cracks in it and chip off minute particles from the surface..

To do this effectively a shock wave source, a stone locating device and motors to move the table on which the patient lies have been put together by various manufacturers to produce the extracorporeal lithotriptor.

Shock wave source

Shock waves may be produced from a point source electrohydraulically (as in the Dornier, Medstone and Technomed machines) or from an extended source electromagnetically (as in Siemens lithostar[1]), piezoelectrically (as in Edap and Wolff machines). The Japanese areat present developing their lithotriptor which uses micro-explosions to generate the shockwaves. Others are developing lasers[2]. Shock waves need to enter the body in such away that they are focussed onto a fine point. The smallest focus point according to manufacturers data is seen in the Wolff machine (focus point under 1 cm.) and the Dornier's MPL 9000 (focus point a spindle 2cm long 0.3 wide with 50% of shock wave energy for another 0.3cm). Focussing can be done by lens systems (Siemens) or by parabolic reflectors (Technomed, Dornier) or may be a function of the way in which an array of piezoelectric cells is arranged in a dish (Wolf and Edap). The finer the focus the more accurately can shockwaves be focussed onto the stone, avoiding renal substance and minimising damage. Distortion of the focus can occur as varying thicknesses of fat in obese patients refract the waves reducing their efficacy. Skin to focus distance is also important and it is at times virtually impossible to "reach" the stone in obese patients weighing 100 kilograms.

Piezoelectric lithotripsy is said to offer the advantage of being painless. However, Marberger[3] from Austria reports that even piezoelectric waves can be painful at repetition rates of 20/second or more. The pressure developed at the focus point varies from 310-1200 bar and children need to be treated at the lower pressures.

Valencien et al[4] using the Edap LTO1 piezoelectric lithotriptor, have performed analgesia free lithotripsy with 1.25 shocks/sec. However their success rate is 74% :26% failed therapy. Higher success rates need more shocks.

In the Japanese lithotriptor described by Kuwahara[5] explosive pellets peadiazide are cletonated electrically by a platinum igniting bridge connected to a 18V battery.

Stone locating device

Stones may be visualised by x-rays as in Siemens lithostar, Dornier HM3 and 4 or by ultrasound as in Dornier MPL 9000, Edap LTO1, Wolf Piezolith and Technorned Sonolith[2]. The ultrasound monitored machines can demonstrate opaque as well as non opaque stones in the kidney, gallbladder and urinary bladder. As 11% of our stones contain 30% of more uric acid, ultrasound imaging has definite advantages. However ureteric stones cannot belocalised with ease by this method except in the upper or lower 1/6. This disadvantage is offset by the fact that gall stones can be easily visualised. One has, however, to remember that in Pakistan less than 5% of stones in the gall bladder are treatable by ESWL keeping strict selection criteria.

A special advantage of ultrasound is that there is no harmfu! irradiation and lithotripsy staff can move about freely within the room. This allows close contact to be maintained with the patient and is comforting and reassuring to them. Continuous monitoring allows the operator to “shoot” shockwaves only when the stone is in the target zone thus during coughing, sighing, deep breathing or restlessness the patient’s kidney is spared the splattering of shocks that would occur if targeting were by intermittent radiological control. The value of continuous ultrasound monitoring is better understood when one realises that renal excursions of 50mm and over can occur during a deep sigh or cough and that mean movement of the kidney due to ventilation during anaesthesia is 34.3±4.3mm. High frequency jet ventilation reduces the movement to 4.1±1.9mm and would be useful when using radiological methods of stone localisation[6].

The disadvantage of not being able to visualise ureteric calculi can be overcome. Ureteric calculi can be pushed back into the kidney and blasted by ultrasound monitored machines by a push bang technique[7]. Marberger et al[3] mention that 60% of ureteric calculi proximal to the pelvic brim can be manipulated into the pelvis of the kidney. Graff[8] was also able to push back 57% of the stones causing ureteral obstruction. Our experience is otherwise as in Pakistan stones often have been impacted in the ureter for many months.

Vallencien[4] has reported on difficulty in visualising stones in 10% and inability in 3% of patients, using ultrasound monitoring. He also noted that the rib interfered with localisation in7% of patients. Third generation lithotriptor have more powerful ultrasounds and the ability to move the in line scanner obliquely and radially to overcome these problems. All stones larger than 3mm can be easily visualised. Radiological visualisation has an edge over ultrasound in that ureteric stones are easily visualised and treated. Graff et al[8] treat non obstructing ureteral stones in situ with a 13% second treatment rate and 5.9% ancillary procedure rate. In situ fragmentation of ureteral stones, however, gives a 60-90% successful fragmentation rate as against 98-99% successful fragmentation of renal calculi[9,10]. Stones impacted in the ureter are more resistant to shock wave fragmentation[11]. This is because of lack of fluid filled space surrounding the stone which therefore has little room to expand[11]. Urine does not permeate the stone and the thick muscle near the ureter absorbs sound. Non opaque stones can be identified by continuous irrigation of the pelvis with dye introduced through a ureteric catheter.

Radiation exposure with radiologically monitored machines

Radiation exposure has been variously quoted as less than that of an IVP to 5times that of an IVP. A patient is likely to receive a total of 26

Roentgen. A total time of 3-4 minutes of fluoroscopy would deliver 21 roentgens and 8 frames of video spot filming an additional 5. The scattered radiation has been found to be approximately 0.5m R per hour at 3 feet or 91cm from the center[12]. Surface radiation dose to the back of a patient from the X-ray unit on the side of the kidney averaged 10 rem (lOOm Sv) per treatment although the range was wide (1-30 rem). The opposing X-ray machine gave 5.5 rem (55m Sv) (range 01-21 rem). The estimated female gonad done averaged lOOm rem (1.2mSv). Radiationexposureto personnelwas2m rem (0.02m

Sv).
The most advantageous situation wouldbe to have an X-ray monitored lithotriptor available for ureteric stones and an ultrasound machine for renal, upper and lower 1/6th ureteric stones.

Mechanism to move the patients stone onto the focus point of the machine

Approximate surface marking of the stone allows placement of the patient so that the focus point is near the stone. Finer adjustments can then be done by mechanical movement of the table. Complex computerised motors which move the table in relation to the ultrasound scan are available in Dornier MPL 9000. These facilitate the not-so-expert in locating the stone.

Contraindications to Extracorporeal Shock-wave Lithotripsy

Patients with heartblock and pregnant patients should not be treated by ESWL. Patients with cardiac and respiratory problems need to be brought into the best possible situation and require intensive monitoring during the procedure. Coagulopathies should be corrected. We have treated a thrombocytopenic patient after platelet transfusion. Others have treated haemophiliacs[14]. Patients with solitary kidneys need to be treated with care.

Tissue damage in lithotripsy

A shock wave blast travelling through tissues would be expected to produce some cellular damage. This is minimised by (a) enlarging the area through which the shock wave enters the body so that the shockwave strength per unit skin area is. reduced and (b) by htving a very small focus. Mitochondral damage at cellular level is expected and animal experiments have shown oedema and capillary damage manifest as hematuria (14a). Pen-capsular and subcapsular hematomas were seen frequently with the older machines with greater power and larger focus. We have encountered only one perirenal hematoma in the series of our initial consecutive 350 treatments (0.28%).

Molley[15] has cautioned about possible soft tissue damage and has suggested a 25-75% pos sible incidence of perinephric, subcapsular and parenchymal hemorrhage. Sofras[16] has quoted a 0.2% hematoma rate.

An Indiana university study by Knapp[17] detected hematoma in 0.66% of 3620 patients. Coagulation studies were normal in these patients and the formation of the hematoma was not related to the number of shockwaves or voltage used. However, if the patient was hypertensive, then 2.5% formed a hematoma and if the hypertension was uncontrolled 3.8% did so. Whilst these were seen with the older machines with radiological control, powerful punch and large focus, it will be worthwhile carefully looking for a hematoma in patients who have had a drop of 2G hemoglobin, or persisting flank pain. Careful study of lithotripsy patients has shown elevation of enzyme levels in some cases. In a small study Gilbert[18] have shown that 12 of 26 patients had post ESWL protein excretion exceeding 1.5G. This is above what would be expected from simple hematuria and it is suggested that proteinuria is the result of shockwaves on the fixed negative charge of glomerular capillaries. This proteinuria was seen at mean operating voltage of 20KV and an average of 1600 shockwaves.

Ureteric obstruction

Fragments of stone passing down the ureter will cause temporary obstruction. This is often partial when the fragments are 2-3mm in size as they allow urine to trickle past the loosely arranged pieces. Finer dust is more likely to impact, but the fmer powder is more likely to pass spontaneously. Ureteric obstruction has been noted in upto 6.3% and aneuria in 1.3%[16]. One should be alert to the possibility of silent renal destruction[19]. Fedullo et al20 have noted a stein strasse (literally stone street), a collection of particles in the ureter in 20% of 1000 patients studied. 65% of these passed spontaneously but 35% needed ureteroscopy (in 3/4th of these patients)PCN or fluoroscopically inserted retrograde double J stent. If the leading stone is small, stein strasse will pass: but if the lead stone or the fragments are large then ancillary .procedures are needed. Keeping this in mind it is beneficial to (a) deliver shock waves that produce a finer powder by using a lower KV and (b) pulverise any large residual fragments by a second sitting before it has a chance of working its way into the ureter. It is. wise to preempt obstruction by plading a double J stent and we agree with Libby[21] and Shabsigh[22] that stenting provides extra safety in lithotripsy. The incidence of colic and urosepsis are reduced. Hospital stay is shortened and there are fewer episodes of readmission[22]. Using a stent, Libby[21], reduced the incidence of auxiliary procedures from 15 to 6% and Shabsigh[22] from 17 to 10%. Libby[21] used a stent for stone size above

25mm. We recommend it for stones over 2cm in size in agreement with Riehle[23] except when a calcium oxalate dehydrate stone is seen on x-ray and one can predict its easy fragmentation into fine dust. Libby's[21] stone population of 1645 kidneys (seen in one year of operations) had 646 kidneys with stones > 14mm and 283 > 25mm. Stent insertion at cystoscopy is a simple procedure, but adds to time and costs. A stent alone costs Rs.900-1800 plus consultant and O.R. time. Stents need to be removed after all fragments have been passed. Normally another cystoscopy is necessary but if stents with a pull through nylon thread are used then the stent can be removed by traction on this suture in the outpatient department. Because of safety factor, 30-70% of ESWL patients in America have pretreatment insertion of stents[23]. Complications and stent materials are well discussed in Saltzman's[24] reviews.

Recurrence and Stone clearance

Stones will recur at an expected rate of 5% per annum. Recurrence after lithotripsy will be expected to have the same frequency. However, if radiologically visible fragments are left in situ and do not clear out, recurrence would likely become more frequent. Molley[15] suggests that there will be a 15% recurrence rate in the first year and 50% overall recurrence rate. Chaussly and Schmiedt have reported (quoted in Miles[28]) a90% clearance of stones at 3 months. Fuchs, G. (also quoted in same article) mentions a 85% clearance rate. Miles et al[25] from Gainsville Florida found that 50% of their patients had residual stones 3-21 months after ESWL. This is a rather low figure for stone clearance and even the centers in US report 65-77% stone free status[26,26a] Diligent follow up and if necessary retreatment are a sine qua non of any lithotripsy programme if it is to be successful.

Good clearance of the stone is essential and is aided by a high water intake. Double J stents should not be removed until radiological and ultrasound evidence of complete stone clearance has been obtained.

Ancillary procedures

Combination percutaneous nephrolithotomy or operation and lithotrips,y is recommended for stones in excess of 40mm21. Much however depends upon stone fragility and availability of ancillary procedures. Uric acid stones may fragment with difficulty but they can be dissolved by allopurinal and alkalinasation of urine. Struvite stones fragment easily and citrates help their dissolution[27].

Acetylcysteine irrigation of the pelvis will assist cysteine stone fragmentation[28]. Calcium (Ca) oxalate dihydrate a loose textured stone often easily detectable as such on x-ray KUB, will shatter with ease. We have treated large Caoxalate dihydrate stones upto 5cms in size with ESWL monotherapy. Treatment needs to be spread out so that fragments have time to be washed out and the total fragment burden presented to the ureter is not excessive at any one time.

Occasionallyuric acid calculi fail to fragment easily. Calcium oxalate monohydrate stones appearing as dense white uniform opacities on KUB are notoriously difficult to fragment. In such cases and in patients with large stone burdens or burdens distributed over a large area as multiple stones, it is beneficial to debulk the stone by percutaneous nephrolithotomy(PCNL).

The lithotriptist has to be ready to detect downward migration of large fragments into the ureter. These need to be blown back into the pelvis and blasted again. This is possible with the stone in the upper ureter. In the lower ureter, Dormia basketing or ureterorenoscopy will, at times, be necessary.

Hazards to Personnel

In addition to radiation hazards, sound levels upto 110 dB were common with the first generation lithotriptors[29]. We have found that levels do not exceed 90 dB at 20 KV output on the MPL 9000 Donier lithotriptor.

Ureteric Stones: ESWL or Ureterorenoscopy?

Ureterorenoscopy (URS) has a 17% perforation rate[30], 17% major complication rate[31], 35% of failure rate[32]. Some ureteric stones are best tackled by ureterolithotomy[33] which even in 1989 gives avery satisfactory cost effective short hospital stay result. Distal stones are better treated by ESWL with an expected 94% stone free rate of 90% at six weeks and mean procedure time one third that of URS[34].. High power and large number of shocks are needed[35] for ureteric stones.

CONCLUSION

In a controlled environment with diligent follow up extracorporeal shockwave lithotripsy is safe and effective. For complex "hard" stones it is best used in combination with PCNL and open surgery. Major lithotripsy centers need to be established within Pakistan with both ultrasound and radiologically controlled machines. Intensive research is needed to eliminate unnecessary "frills" from these complex first to third generation machines and develop a simple lithotriptor accessible to the common man in Pakistan.

REFERENCES

1. Wilbert, D.M., Reichenberger, H., Noske, E, Riedmiler, H., Alken, P. and Hohenfellner, R. New generation shock waves lithotripsy.J. UroL, 1987; 138: 563.
2. Saltzman, B. Second-generation shock-wave lithotripters, variations, indications, and efficacy in the treatment of ureteral calculi. Urol. Clin, North Am., 1988; 15:385.
3. Marberger, M., Turk, C. and Steinkogler, I. Painless pie. zoelectric extracorporeal lithotripsy. J. Urol., 1988; 139: 695.
4. Vallencien, G., Aviles, J., Minoz, R., Veillon, B., Charton, M.and Brisset,J.M.Piezoelectricextracorporeallithotrip sy by ultrashort waves with the EDAP LT 01 Device. J. Urol., 1988; 139: 689.
5. Kuwahara, M., Kambe, K., Kurosu, S., Kageyama, S., loritani, N., Orikasa, M. and Takayama, K Clinical application of extracbrporeal shock wave lithotripsy using microexplosions. J. Urol., 1987; 137:837.
6. Warner, M.A., Warner, M.E., Buck, C. F. and Segura, J. W. Clinical efficacy of high frequency jet ventilation during extracorporeal shock wave lithotripsy of renal and ureteral calculi. A comparison with conventional mechanical yen tilation.J. Urol., 1988; 139:486.
7. Graff, J., Pastor, J., Funke, PJ., Mach, P. and Senge,T. H. Extracorporeal shock wave lithotripsy for ureteral stones. A retrospective analysis of 417 cases. J. Urol., 1988; 139: 513.
8. Mueller, S.C., Wilbert, D., Thueroff, J.W. and Alken, P. Extracorporcal shock wave lithotripsy of ureteral stones. Clinical experience and experimental findings. J. Urol., 1986; 135 : 831.
9. Cole, R.S., Shuttleworth, K.E. Is ESWL suitable for treatment of lower ureteric stones? Br. J. Urol., 1988; 62:525.
10. Jenkins, AD. Dornier extracorporeal shockwave lithotripsy for ureteral stones. Urol. Clin. North Am., 1988; 15: 377.
11. Bush, W.H., Jones, D. and Gibbons, R.P. Radiation dose to patient and personnel during extracorporeal shock waves lithotripsy. J. Urol., 1987; 138:716.
12. Partney, KL., Flollingsworth, R.L., Jordan, W.R., Beckham, D. and May, C.R. Hemophilia and extracorporeal shockwave lithotripsy a case report. J. Urol., 1987; 138: 393.
13. Lingeman, J.E., McAteer, J.A., Kempson, S.A. and Evan, A.P. Bioeffects of extracorporeal shock-wave lithotripsy. Strategy for research and treatment. Urol. Clin. North Am., 1988; 15:507.

14. MoIley, A. G.Jr., Carlson, K.J. and Dretler, S.P. Extracorporeal shock wave lithotripsy. Slam-Bang effects, and silent side effects? AJR., 1988; 150:316.
15. Sofras, F., Karayannis, A., Kosta, K.O., Poulos, A. Metho dology, results and complications in 2000 ESWL pro cedures. Br. J. Urol., 1988; 61:9.
16. Knapp, P.M., Kulb,T.B., Lingeman,J.E., Newman,D.M., Mertz,J.H.O., Mosbaugh, P.G. and Steele, R.E. Extracor poreal shock wave lithotripsy-induced perirenal hematoma. J. Urol., 1988; 139:700.
17. Gilbert, B.R., Riehie, R.A. and Vaughan, E.D. Jr. Extracorporeal shock wave lithotripsy and its effect on renal function. J. Urol., 1988; 139:482.
18. Hardy, M.R. and Mcleod, D. Silent renal obstruction with severe functional loss after extracorporeal shock wave lithotripsy a report of2cascs. J. UroL, 1987; 137:91.
19. Libby,J.M., Meacham, R.B. and Griffith, D.P.The role of silicone urethral stents in extracorporeal shock wave litho tripsy of large renal calculi. J. UroL, 1988; 139: 15.
20. Shabsigh, R., Gleeson, M.J. and Griffith, D.P.The benefits of stenting on a more-or-less routine basis prior to ex tracorporeal shock-waves lithotripsy. tJrol. Clin. North Am., 1988; 15:493.
21. Reihle, R.A. Jr. Selective use of ureteral stents beforeextracorporeal shock-waves lithotripsy. Urol. Clin. North Am., 1988; 15:499.
22. Saltzman, 13. tfreteral stents. Indications, variations, and complications. Urol. Clin. North Am., 1988; 15:481.
23. Miles, S.G., Kaude, J.V., Newman, R.C., Thomas, W.C. and Williams, CM. Extracorporeal shock-wave lithotripsy prevalence of renal stoncs 3-21 months after treatment. AJR., 1988; 150: 307.
24. Drach, G.W., Dretler, S., Fair, W., Finlayson, B., Gillenwater, J., Griffith, D., Lingeman, J. and Newman, D. Report of the limited United State cooperative study of extracorporealshock-wavelithotripsy.J. UroL, 1986; 135: 1127.
25. Lingeman, J.E., Newman, D., Mertz, JJHI.O., Mosbaugh, P.G.,Steele,R.E., Kahnoski,RJ., Couty,T.A. and Woods, J.R. Extracorporeal shock-wave lithotripsy. The Methodist Hospital of Indiana experience. J. Uro!., 1986; 135: 1134.
26. Akers, S.R., Cocks, F.H. and Weinerth, J.L. Extracorporeal shock wave lithotripsy, the usc of chemical treatments for imprnved stone comminution. J. Urol., 1987; 138:1295.
27. Schmeller, N.T., Kersting, H, Schuller,J., Chaussy, C. and Schmiedt, E. Combination of chemolysis and shockwave lithotripsy in the treatment of cystin renal calculi. J. UroL, 1984; 131:434.
28. Lusk, RP. and Tyler, RS. Hazardous sound levels prnduced by extracorporeal shock waves lithotripsy. J. Urol., 1987; 137:1113.
29. Carter, S.S., Cox, R. and Wickham, i.E. Complications associated with ureteroscopy. Br.J. Urol., 1986; 58:625.
30. Daniels, G.P. Jr., Garnett, i.E. and Carter, M.F. Ureteroscopic results and complications; experience with 130 Cases.J. Urol., 1988; 139:710.
31. O'Flynn, J.D. The treatment of ureteric stones; report of 1120 patients. Br.J. Urn!., 1980; 52:436.
35. el-Faqih, S.R., Husain, I., Ekman, P.E, Sharma, N.D., Chakrabarty, A. and Talic, R. Primary choice of intervention for distal ureteric stone; ureteroscopy or ESWL? Br. J. Urol., 1988; 62:13.
36. Becht, E., Mo!!, V., Neisius, D. and Ziegler, M. Treatment of prevesical urethral calculi byextracorporeal shock-wave lithotripsy.J. Urn!., 1988: 139:916.