Εξωσωματική Λιθοτριψία
Από το Α έως το Ω

Αθανάσιος Παπατσώρης

Χαράλαμπος Μαμουλάκης

Ανδρέας Σκολαρίκος

UROSchool 2013

Δήλωση συμφερόντων

ΚΑΜΙΑ

ΑΠΟ ΚΑΝΕΝΑ

6ο Ελληνικό Διαδραστικό Σχολείο Ουρολογίας
18-21/4/2013
Πορταριά Πήλιο

Σύντομη ιστορία της ESWL

Α. Σκολαρίκος

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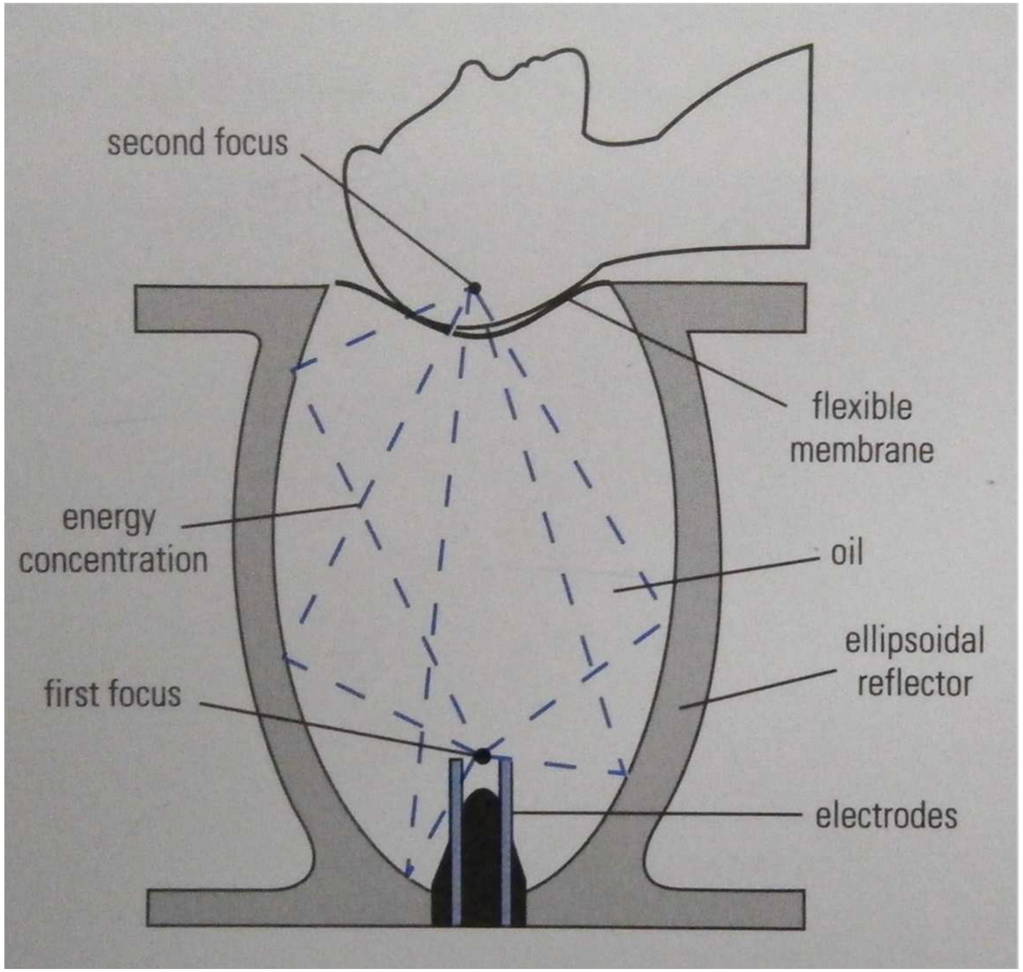
second focus
flexible membrane
energy concentration
oil
ellipsoidal reflector
first focus
electrodes

ΕΤΟΣ	ΟΝΟΜΑ	ΑΝΑΚΑΛΥΨΗ
1947	Rieber	Spark -gap technology for brain tumours
1950	Yutkin	Endoscopic electrohydraulic SW generator (YPAT-1)
1953	Mulvaney	Contact -free fragmentation with Continuous wave ultrasound
1966	Dornier	Pitting on supersonic aircrafts by shock waves generated after collision with micrometeorites or by rain
1969	Hausler(physicist)	Extracorporeal shock waves for medical proposes
	Behrendt , Hoff (Dornier)	
1969-1971	Dornier	Animal and in vitro underwater studies
1971	Hausler	Conference of German Physical Society in vitro studies
	Ziegler (Urologist)	
1974	German Government	Invest on a huge Research program Munich
1977	Eisenberger	Animal studies
	Chaussy	
1980	Chaussy , Staehler	Model to implant human stones into the renal pelvis of healthy dogs
	Forssmann (Dornier)	Technological advancement

ΕΤΟΣ	ΟΝΟΜΑ	ΑΝΑΚΑΛΥΨΗ
1976	Chaussy	Ultrasound localization system
1978	Chaussy	X-ray localization system
1978	Chaussy	Animal experiments on successful SWL
1979	Dornier	HM1 installed in Munich
1980	Chaussy-Jocham	First clinical application
1980-2	Chaussyet al	220 patients treated
1982	Dornier	HM2 installed in Munich
1983	Dornier	HM3 installed in Munich
1984	FDA	HM3 is approved
1986	Dornier	>200 HM3 installed worldwide and 250000 pts treated
-	Unmodified HM3	The original machine of 80nF capacitance
-	Modified HM3	Generator of 40nF capacitance, slightly larger reflector aperture to produce a tighter focal zone
1990	Dornier	HM4, a dry lithotripter with a water cashion

ΕΤΟΣ	ΟΝΟΜΑ	ΑΝΑΚΑΛΥΨΗ
1980	Kurtze, Riedlinger	Piezoelectric crystals, Karlsruhe
1985	Wolf Company	First ESWL with a piezoelectric machine
1980's	Erlagen	Electromagnetic lithotripters
1986	Coptcoat, Miller, Wickham	First ESWL with electromagnetic
1988	Delius, Heine Brendel	ESWL in gallbladder stones
1989	Sauerbruch	ESWL in pancreatic stones
1988	Bochum, Germany	ESWL of a non-union fracture
1993	Valchanou , Michailov	OssaTron, special orthopedic device
Late 80's	Direx medical systems	Compact Lithotripter and use of a C-arm

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Βασική φυσική (ενέργεια , ελαστικές ιδιότητες των υγρών, πυκνότητα και πίεση, ηλεκτρισμός και μαγνητισμός, μηχανικά κύματα)

Χ. Μαμουλάκης

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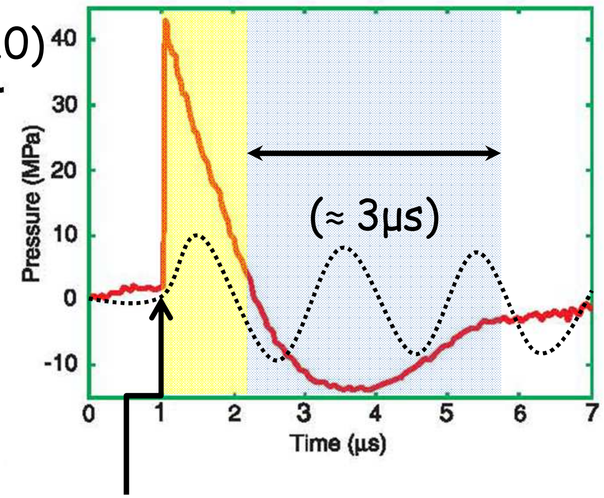
Χαρακτηριστικά ακουστικού (κρουστικού) κύματος

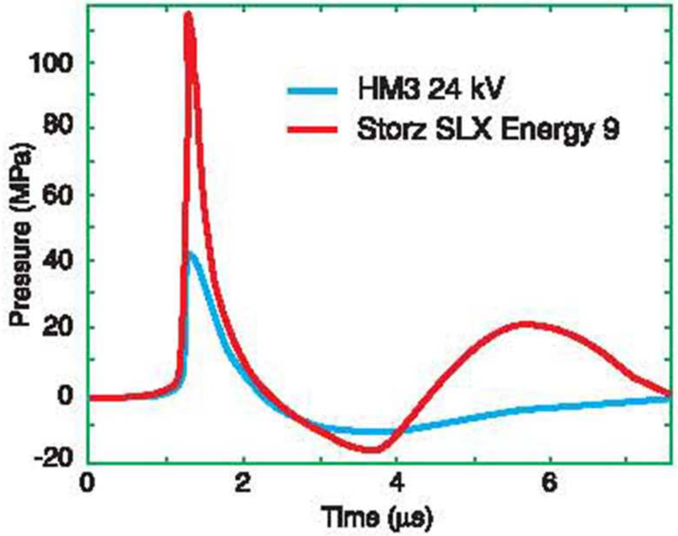
Κυματομορφή: Βραχεία παλμική (≈5μs; 100kHz – 1MHz) μη ημιτονοειδής (nonlinear)

(30-110)

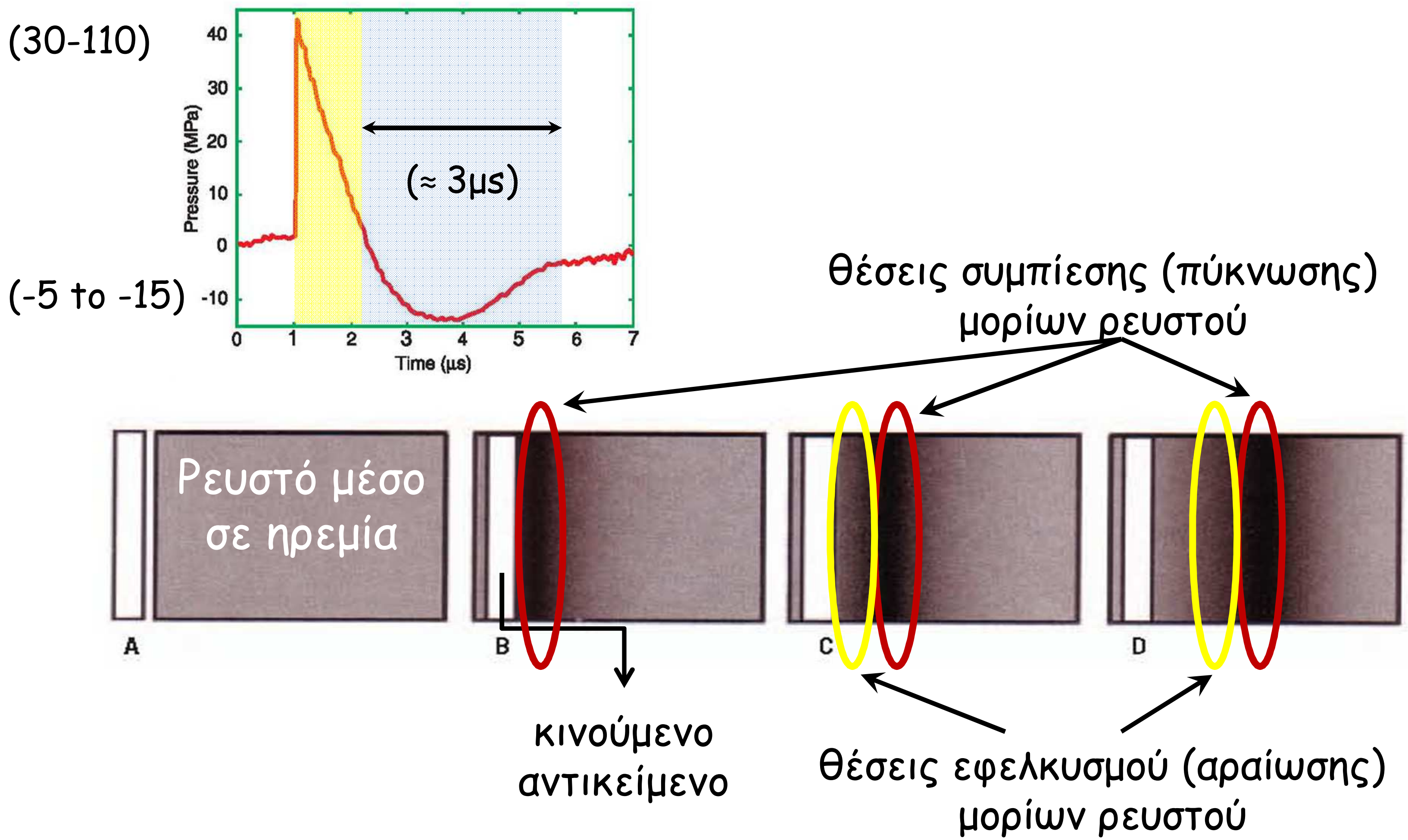
(-5 to -15)



"Shock" front (≈5ns)



Φάσεις ακουστικού κύματος (συμπίεση – εφελκυσμός)



Μετάδοση ακουστικού κύματος: επίδραση στο ρευστό

$\rho = \rho_0 + \rho_a$ (1)

$p = p_0 + p_a$ (2)

$p_a = \rho_a c_0^2$ (3)

Τυπικές τιμές για τους ιστούς:

$\rho_0 = 1000\ kg/m^3$

$c_0 = 1540\ m/s$

$Z_0 = \rho_0 c_0$ (impedance)

Πίεση λιθοτριψίας: $p_a = 100$ MPa (10^3 atm)

$\rho_a / \rho_0 = 0.04$

$u_a = 67 m/s$

Οι μεταβολές πυκνότητας λόγω επίδρασης των κρουστικών κυμάτων της λιθοτριψίας συνεπάγονται ελάχιστη (<5%) συμπίεση του ρευστού μέσου (ιστών)

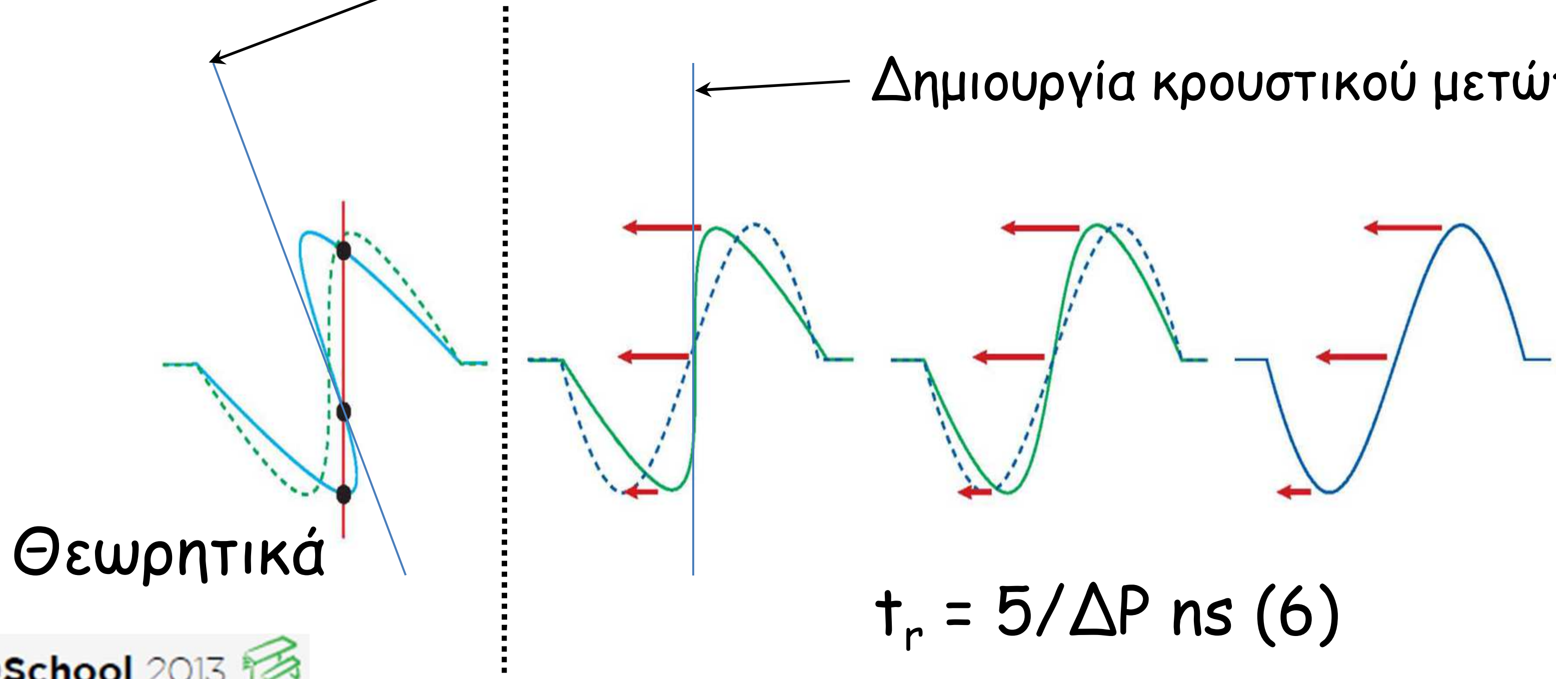
Μη γραμμική μετάδοση ακουστικών κυμάτων (nonlinear acoustics)

$c_a = p_a / Z_0$ (4) p_a ↑↑: $c_a = c_0 + \beta\, p_a / Z_0$ (5)

β=συντελεστής μη γραμμικότητας ρευστού (νερό:3,5 ιστοί:≈5)

κλίση καμπύλης τείνει στο ∞ εάν δεν υπήρχε απορρόφηση

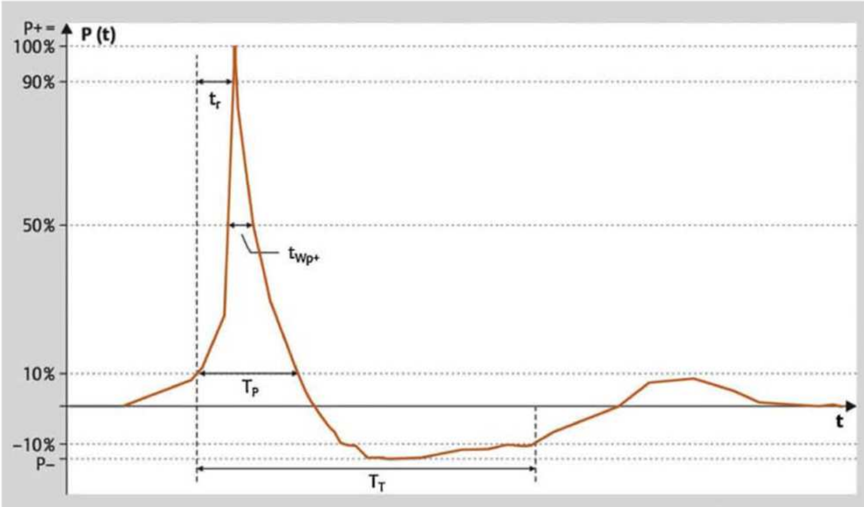
Μη γραμμική παραμόρφωση ↔ απορρόφηση:



$t_r = 5/\Delta P$ ns (6)

Ενέργεια και Ένταση του ακουστικού κύματος

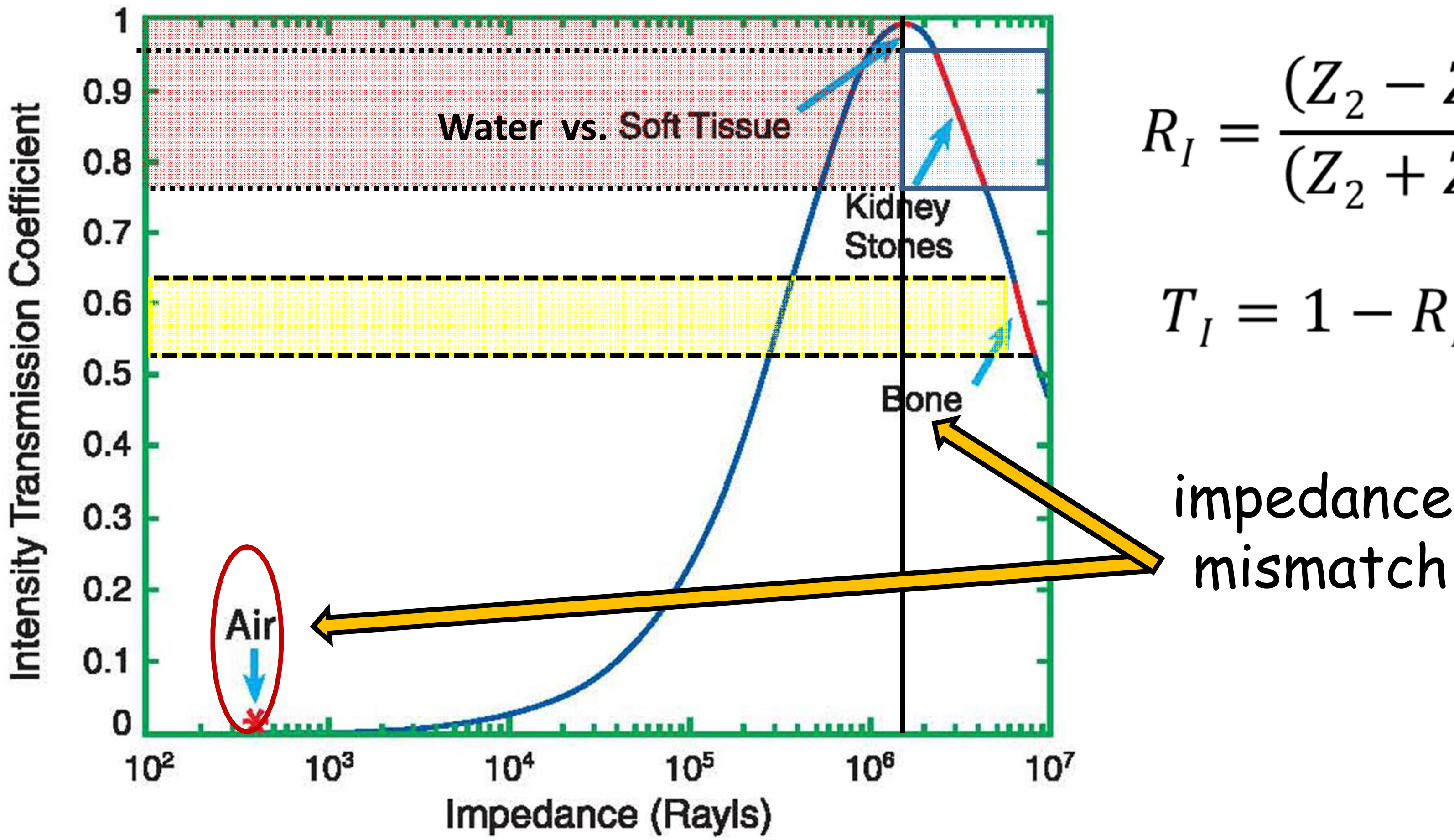
Ενέργεια παλμού: $PII = \int_{t=0}^{t=\mathrm{T}_p} p_a u_a dt = \int_{t=0}^{t=\mathrm{T}_p} \frac{{p_a}^2}{Z_0} dt$ (J/m²)



Εστιακή ενέργεια παλμού: $\mathrm{E} = \iint_{t=0}^{t=Tp} PII dA$ (J)

'Ενταση (Ισχύς) : $\mathrm{I} = \frac{PII}{T_p}$ (W/m²)

Μετάδοση και ανάκλαση του ακουστικού κύματος



$$R_I = \frac{(Z_2 - Z_1)^2}{(Z_2 + Z_1)^2}$$

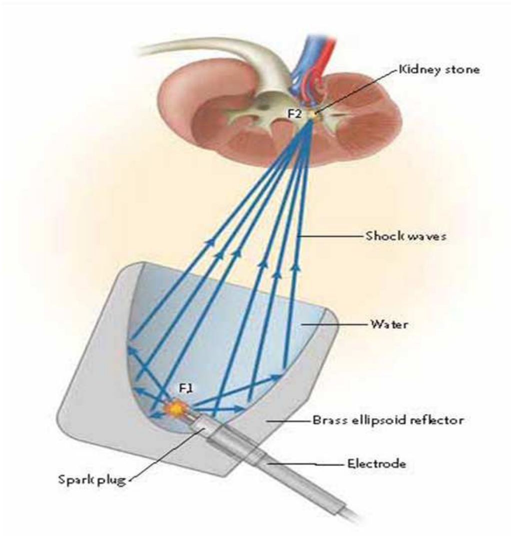
$$T_I = 1 - R_I$$

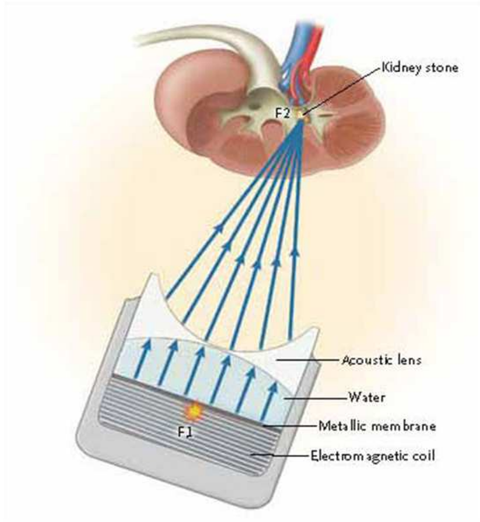
Intensity transmission coefficient (T_I) from water ($Z = 1.5 \times 10^6$ Rayls) to a second medium, as a function of the impedance of the second medium

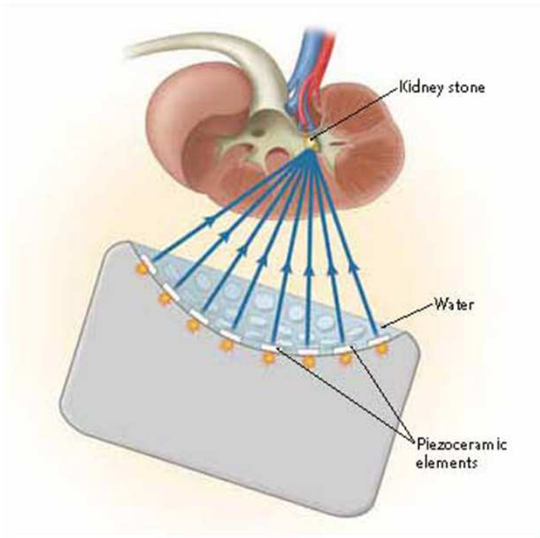
Εστίαση του ακουστικού κύματος

Στόχος:

Συγκέντρωση της ακουστικής ενέργειας σε ένα σημείο (πέτρα) μειώνοντας κατά το δυνατόν την επίδραση στους γειτονικούς ιστούς

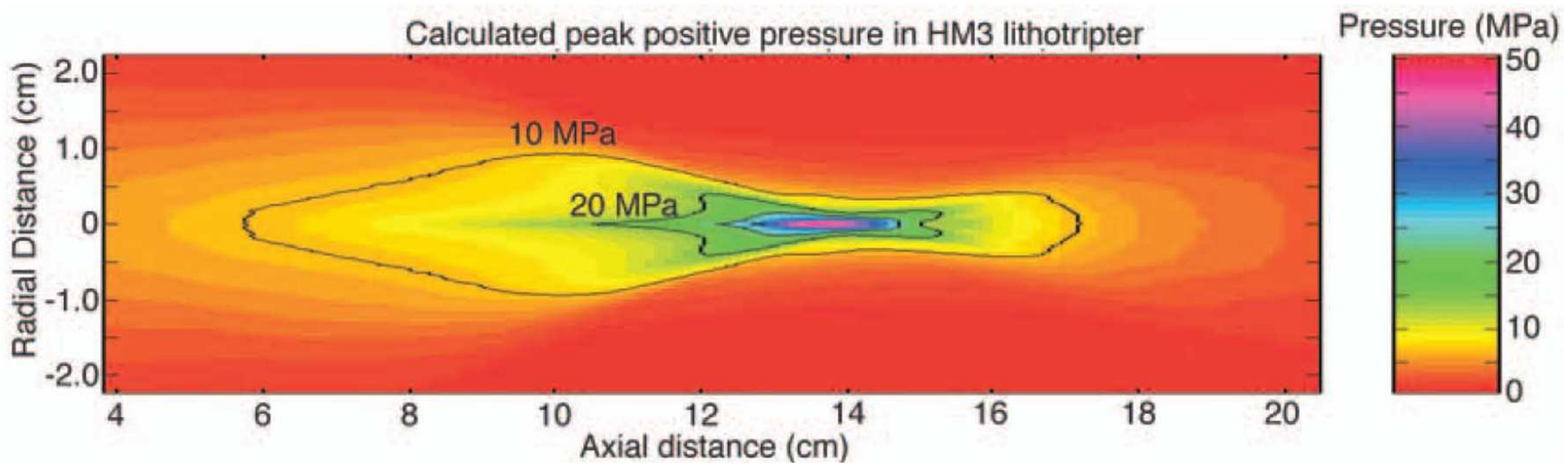




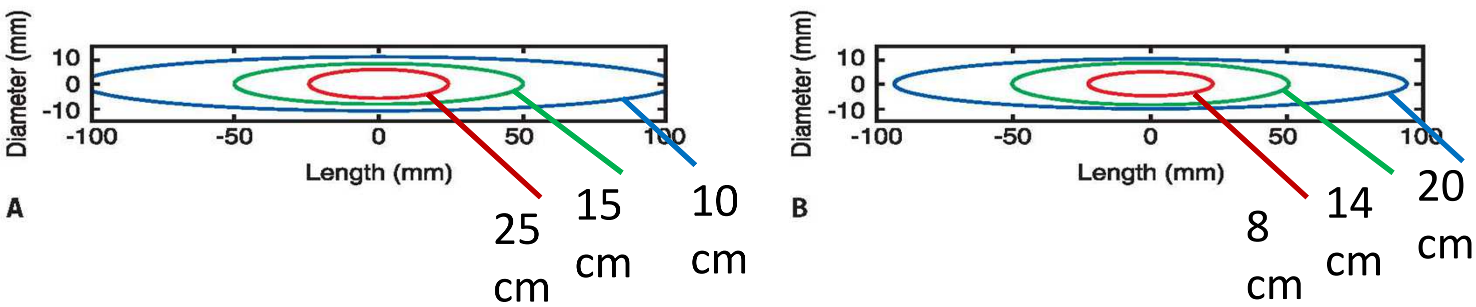


Αλλά λόγω Περίθλασης…

Ζώνη (υψηλής πίεσης-IEC: ≥50% $P+_{max}$) vs. Σημείο εστίασης



Focal zone (↓) = f (source diameter (↑), focal length (↓))



Fixed Focal length (14 cm) Fixed aperture diameter (15 cm);

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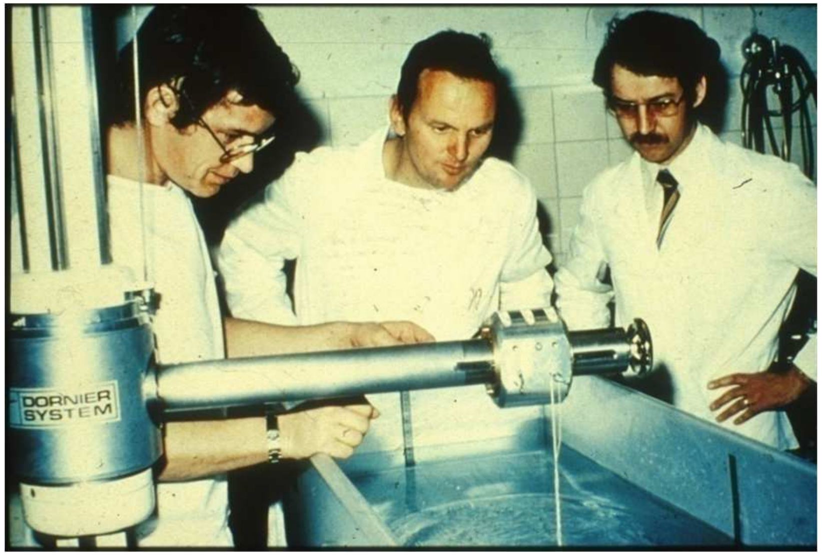
Παραγωγή & Εστίαση των Κρουστικών κυμάτων



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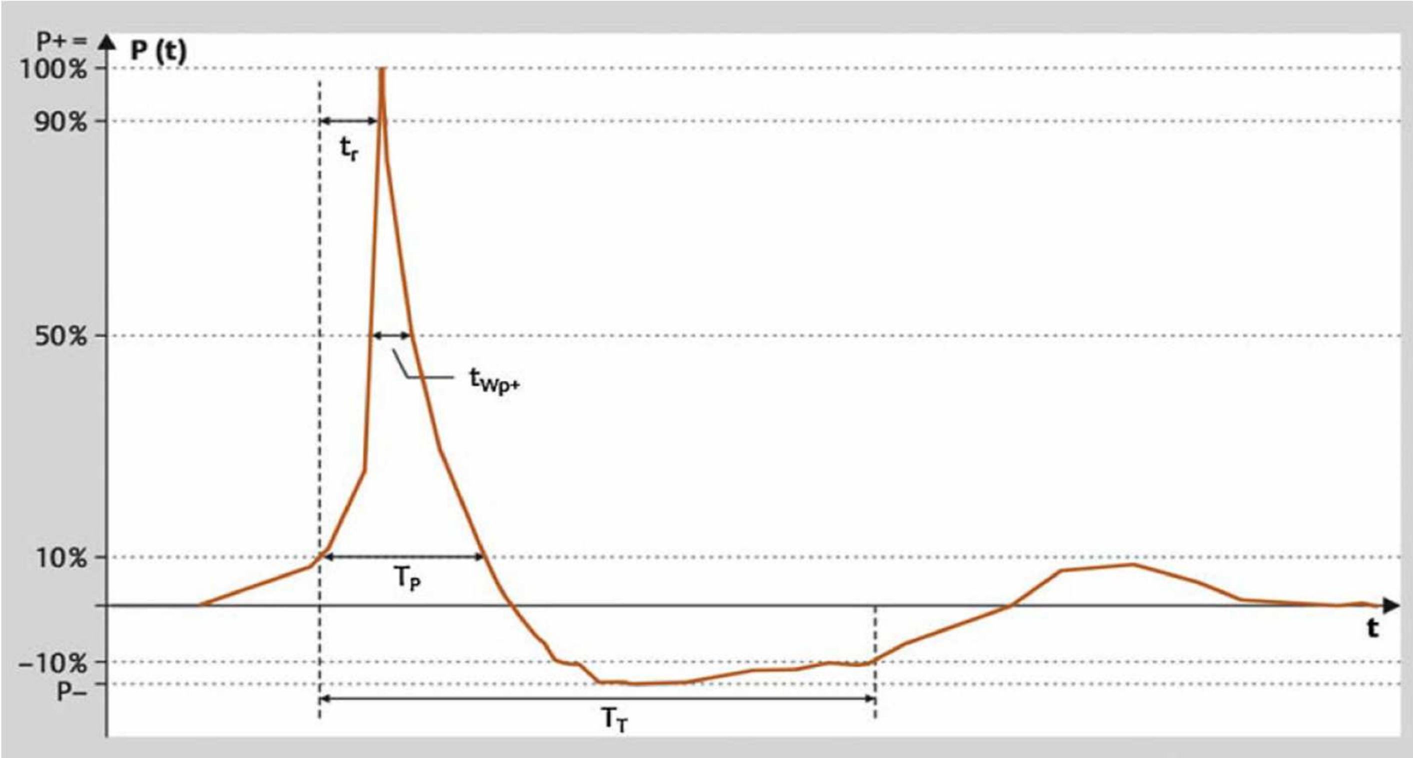
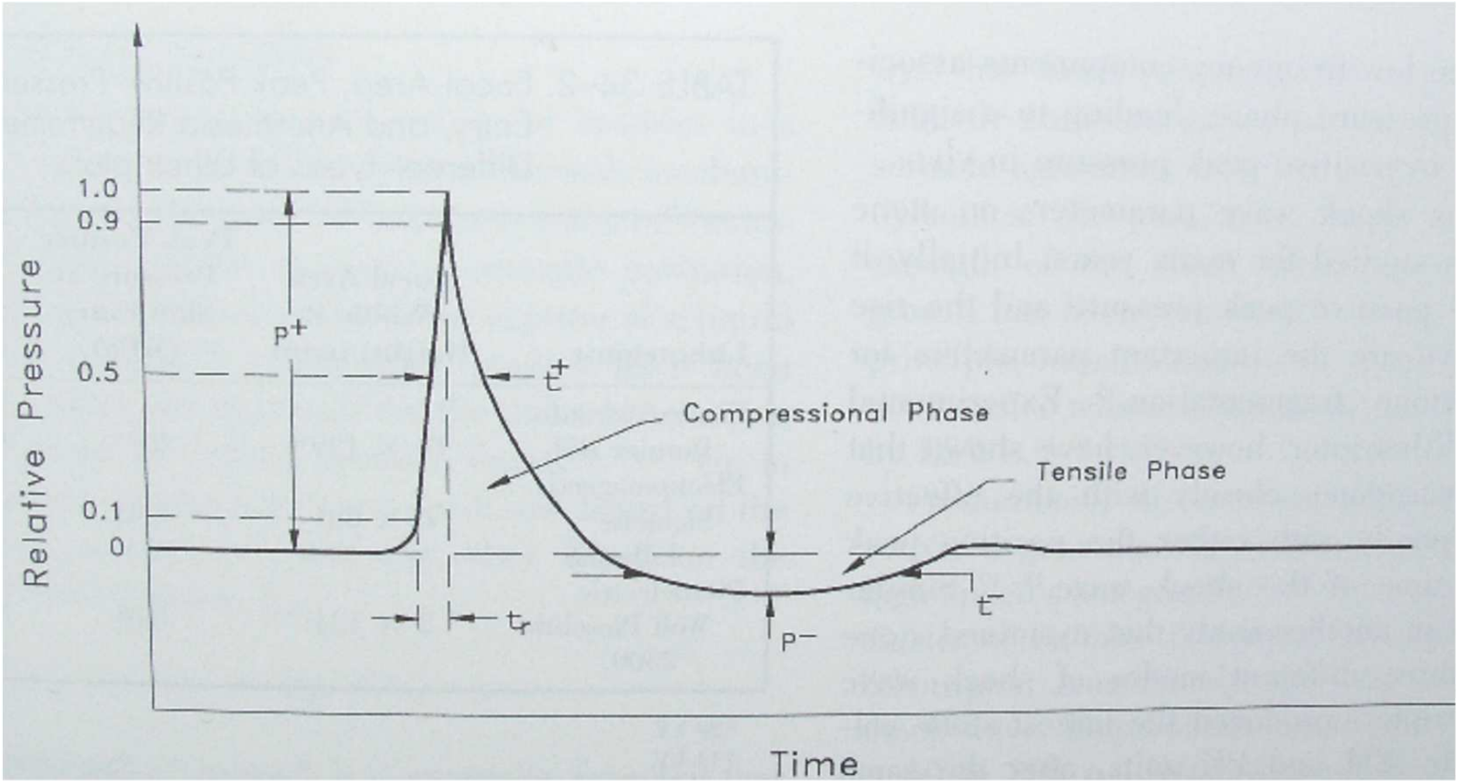
Α. Παπατσώρης



Typical shock wave pulse form in the focal zone. There is a rapid pressure increase at t_0 to a peak pressure value P_+, with the rise time *tr* followed by a decrease to zero crossing the zero line at t_1 and a negative phase P_- until t_2. The time interval t_0 to t_1 is denominated a positive pulse duration tp_+. P_+ varies according to the intensity settings of the shock wave generator. The pulse width t_w is defined as the time during which peak pressure is >50% of P_+. The pressure profile $P(x,y,z,t)$ describes shock waves in one specific location of the pressure field. The focal width is defined according to the −6-dB contour in the *x* and *y* direction.

Eur Urol. 2011 May ; 59(5): 784–796.

The Shock Wave



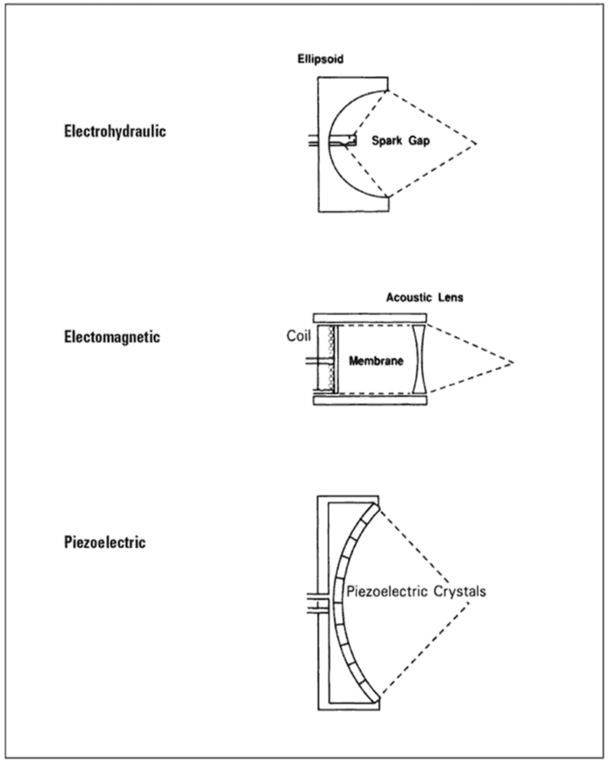
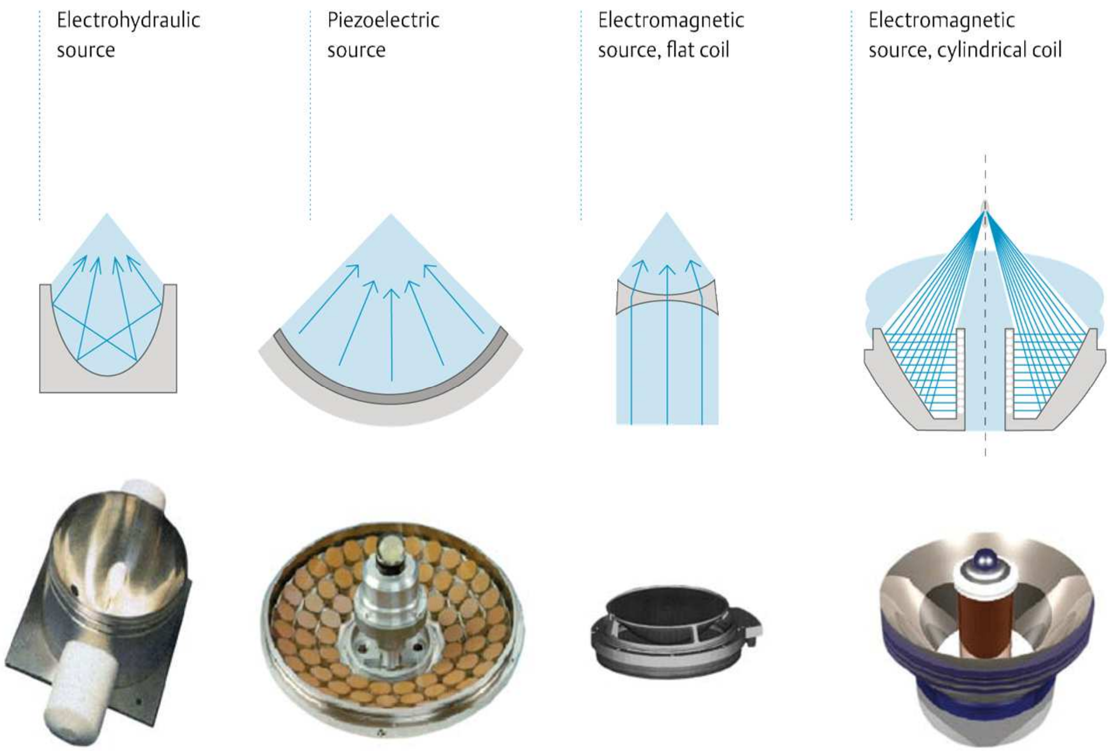
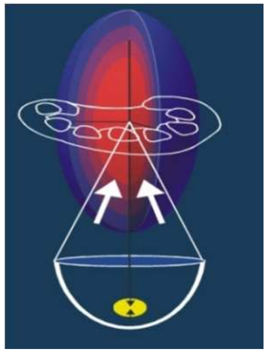
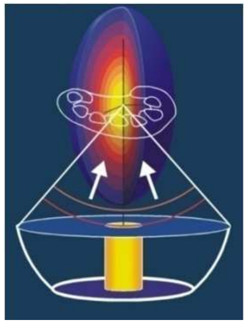
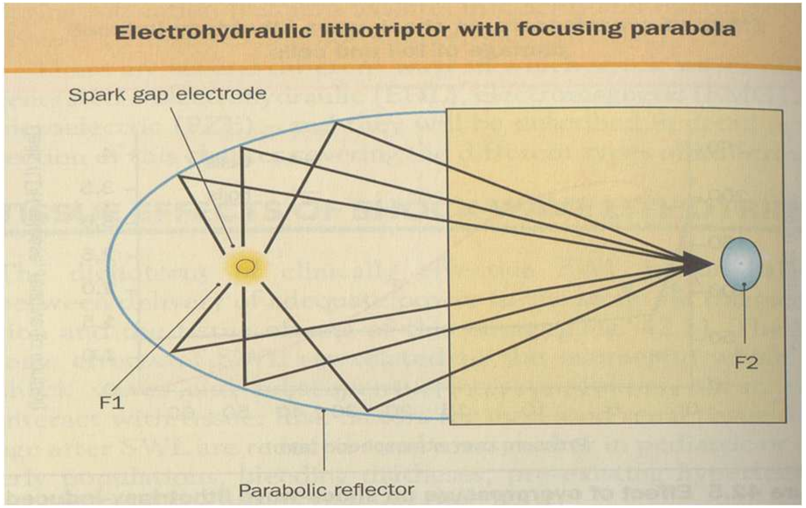


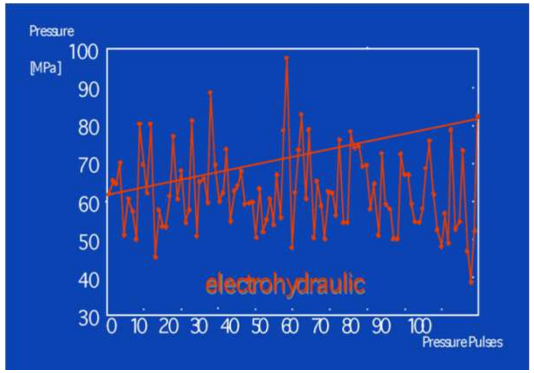
Figure 4. Shock wave generation methods.
Reprinted with permission from Ogden JA. Principles of shockwave therapy. Clin Orthop 2001;387:8-17.

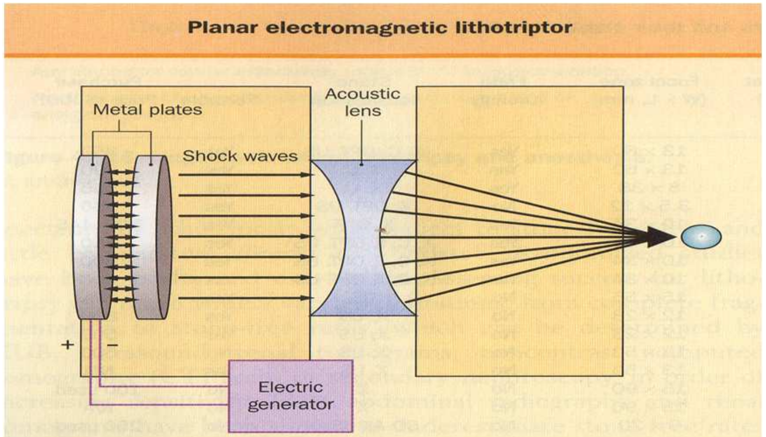


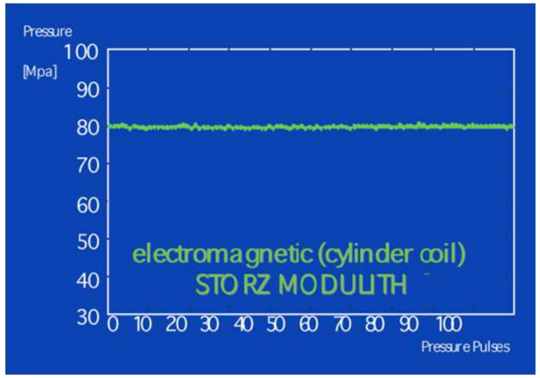


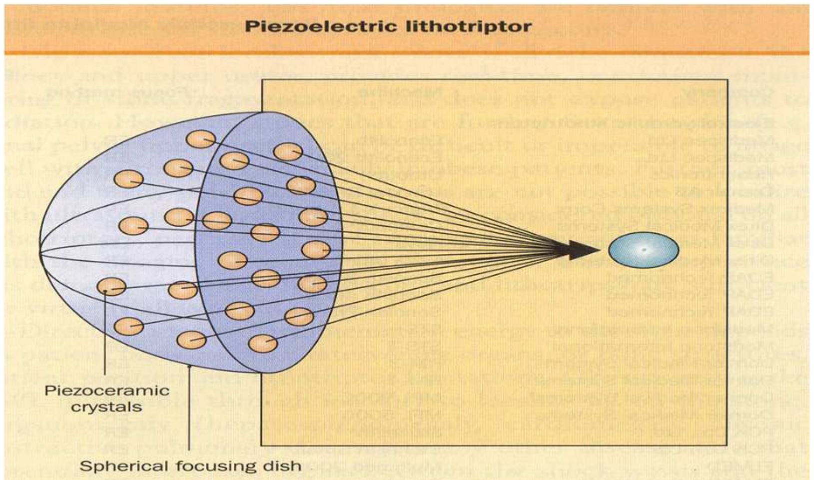


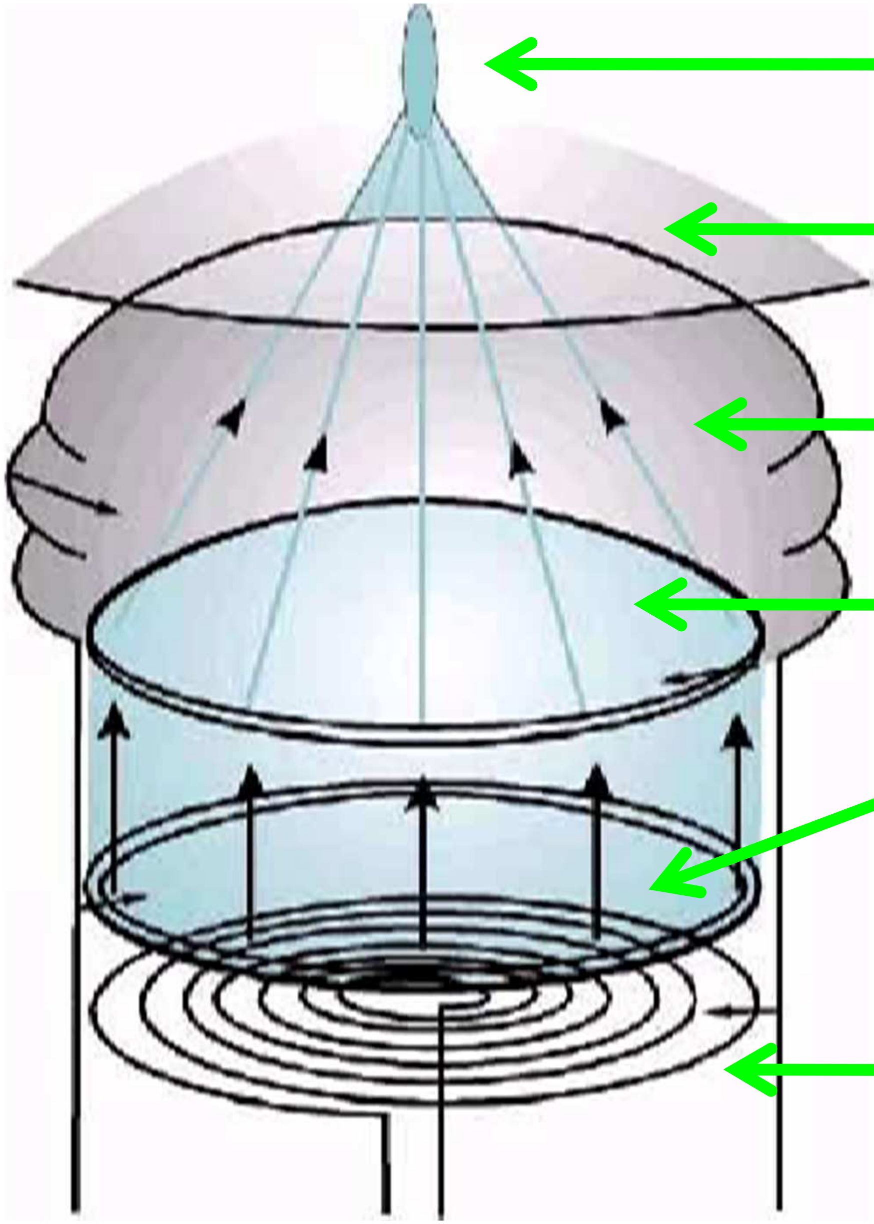

Electrohydraulic lithotriptor with focusing parabola
Spark gap electrode
F1
F2
Parabolic reflector


Pressure
[MPa]
100
90
80
70
60
50
40
30
0 10 20 30 40 50 60 70 80 90 100
Pressure Pulses
electrohydraulic

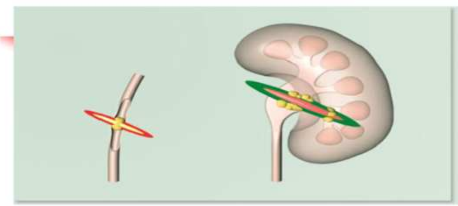

Planar electromagnetic lithotriptor
Metal plates
Acoustic lens
Shock waves
+
−
Electric generator


Pressure
[Mpa]
100
90
80
70
60
50
40
30
0 10 20 30 40 50 60 70 80 90 100
Pressure Pulses
electromagnetic (cylinder coil)
STORZ MODULITH


Piezoelectric lithotriptor
Piezoceramic crystals
Spherical focusing dish



εστία F2
ασθενής
μαξιλάρι σύζευξης
ακουστικός φακός
μεμβράνη αγωγιμότητας
σπείραμα



Factors influencing the success of extracorporeal shock wave lithotripsy

Factor for success	Options	Specific modifications	Advantages	Comments/problems
Shock wave generation and focussing	Electrohydraulic with ellipsoid reflector	Spark electrode	Large focus	Variability of pulses One electrode per session
		Twin heads	Lower energy density	Coupling from two sites is difficult
		Electroconductive	No variability of pulses 40 000 shock waves	-
	Electromagnetic	Coil membrane with acoustic lens	Extension of focal zone by prolonged pulse duration	Advantage of larger focal zone not clinically proven
		Cylinder with paraboloid reflector	Dual focus by different pulse duration (ie, for renal and ureter stones)	Advantage of dual focus not clinically proven
		Spherical element	Very large focal zone	Not available in Europe
	Piezoelectric	Spherical alignment with two layers	Three focal sizes	Advantage of triple focus not clinically proven

Eur Urol. 2011 May ; 59(5): 784–796.

Lithotriptors

EH

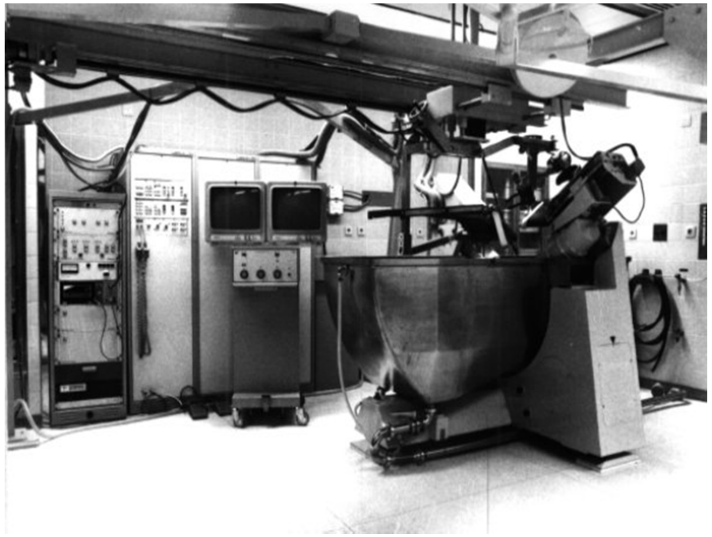
Dornier Human Model (HM) 3, Dornier HM4, Dornier MPL-9000, Dornier MFL-5000, Medstone STS, Technomed Sonolith 3000, Northgate SD-3

EM

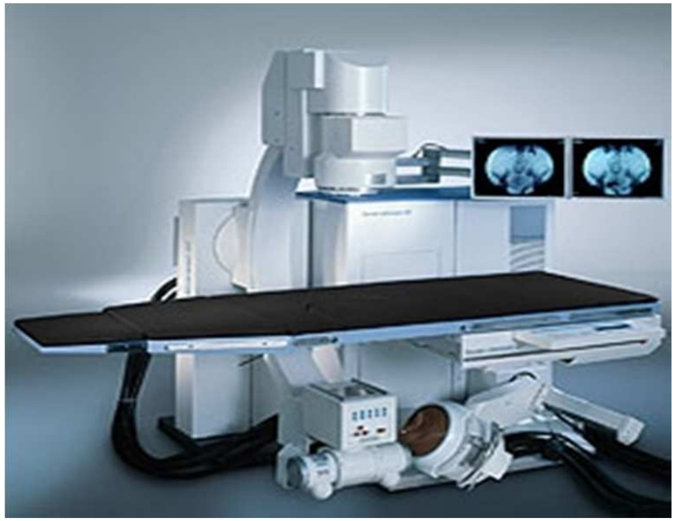
Lithostar Siemens , Storz Modulith SL, Dornier Compact

EP

EDAP LT, Wolf, Therasonics




DORNIER



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Μηχανισμοί κατακερματισμού των λίθων

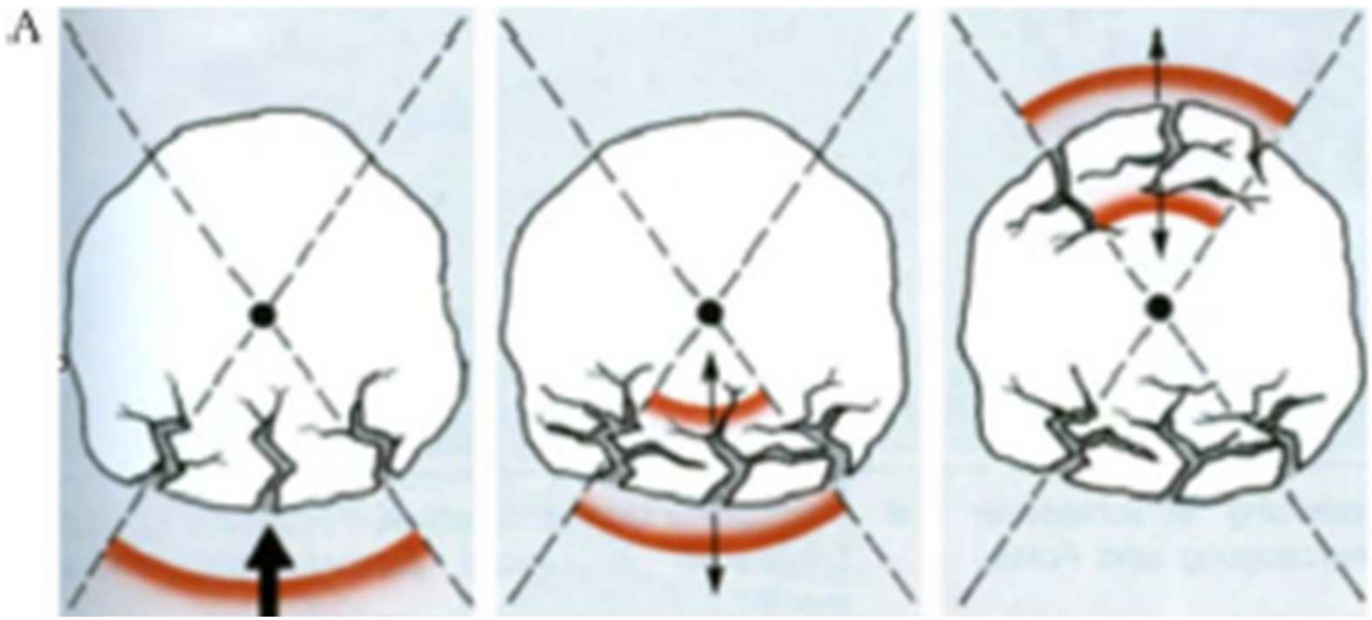
Α. Σκολαρίκος

UROSchool 2013

- Παρόμοια με το κάταγμα σε οποιοδήποτε εύθραυστο αντικείμενο
- Δημιουργούνται μικρές ρωγμές σε σημεία στα οποία το stress των κρουστικών κυμάτων ξεπερνά ένα κριτικό όριο.
- Η συσσώρευση αυτών των ρωγμών οδηγεί στον κατακερματισμό του λίθου

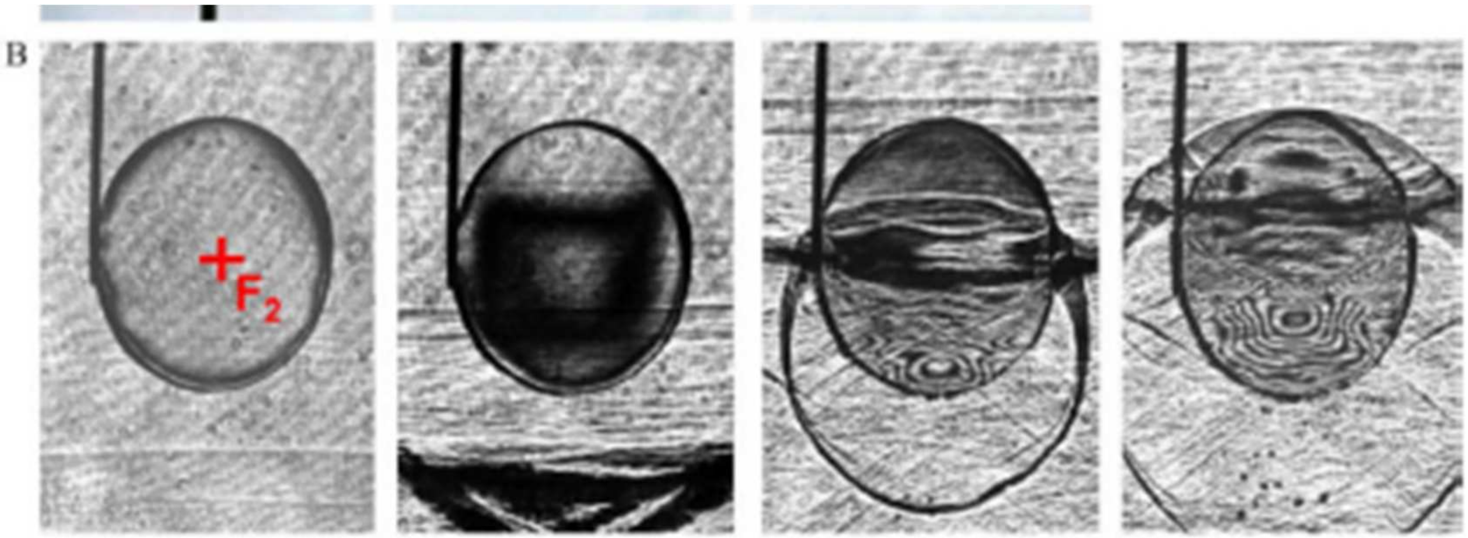
Rassweiler et al Eur Urol 2011

Tear and shear forces



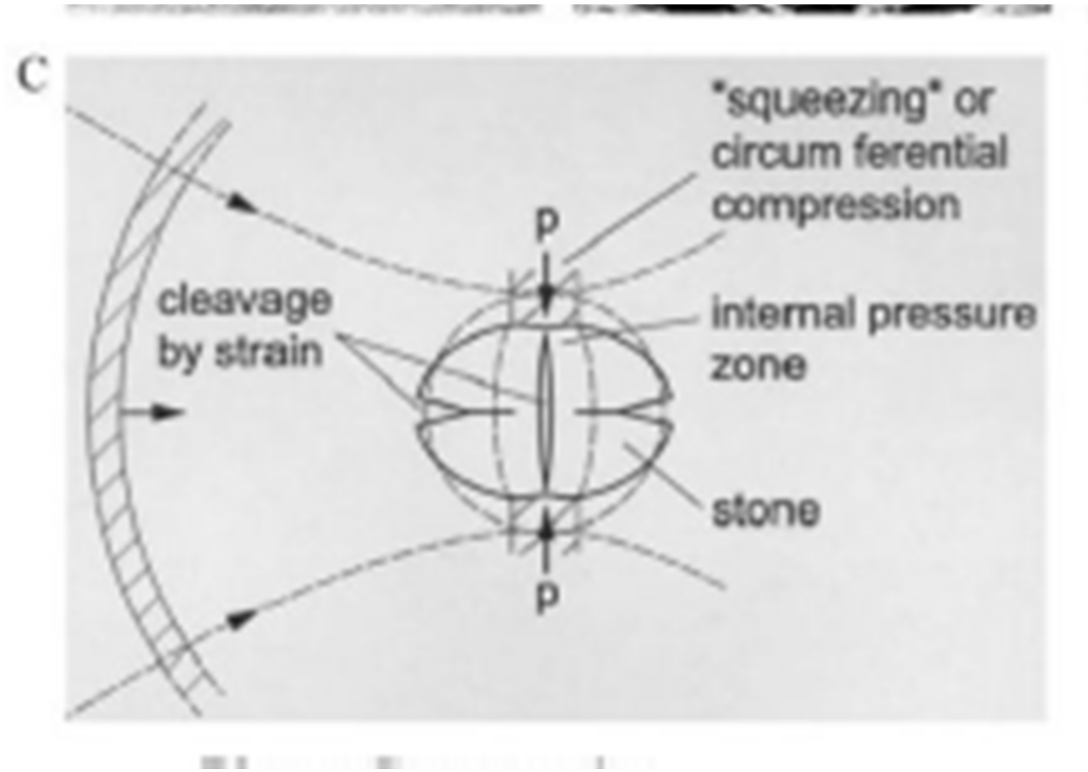
Different theories for initial stone fragmentation. (A) Tear and shear forces: Shock waves are transmitted and reflected at the low impedance stone-water interfaces, with pressure inversion splitting off stone material by tensile stress. (B) Spalling: The distal stone surface

Spallation



inversion splitting off stone material by tensile stress. (B) Spalling: The distal stone surface as an acoustically soft interface generates a reflected tensile wave of the initially compressive longitudinal shock wave pulse propagating through the calculus, with maximum tension within the distal third of the stone (high-speed shadowgraphy by Zhong).

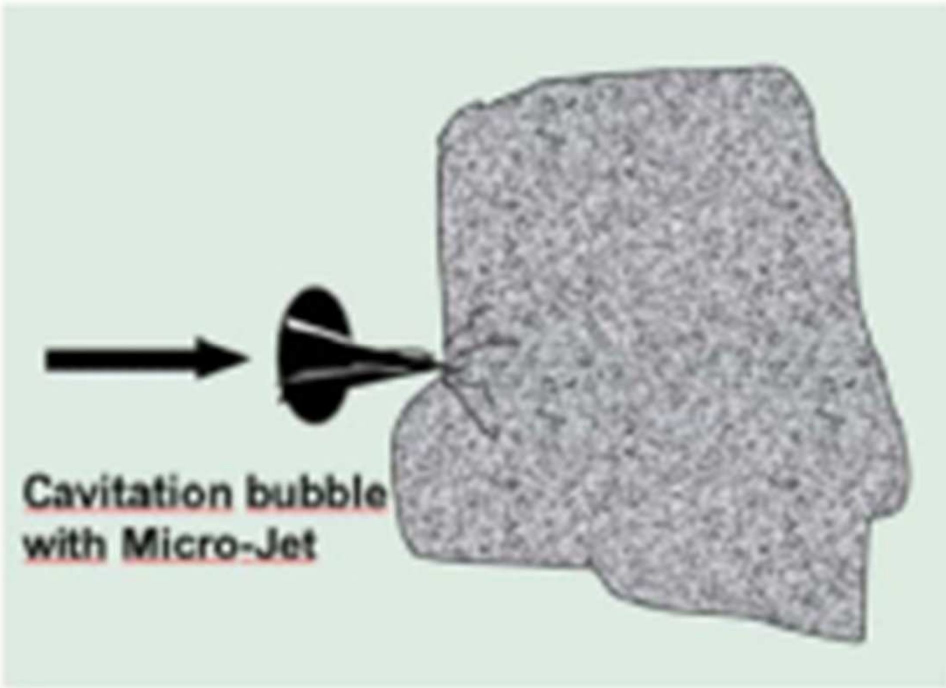
Quasi-static squeezing



(C) Quasi-static squeezing: Stone breakage by tensile stress of the circumferential shock wave resulting from a lower shock wave velocity in the surrounding fluid than within the stone (modified from Eisenmenger). (D) Cavitation: Negative pressure waves of high-speed

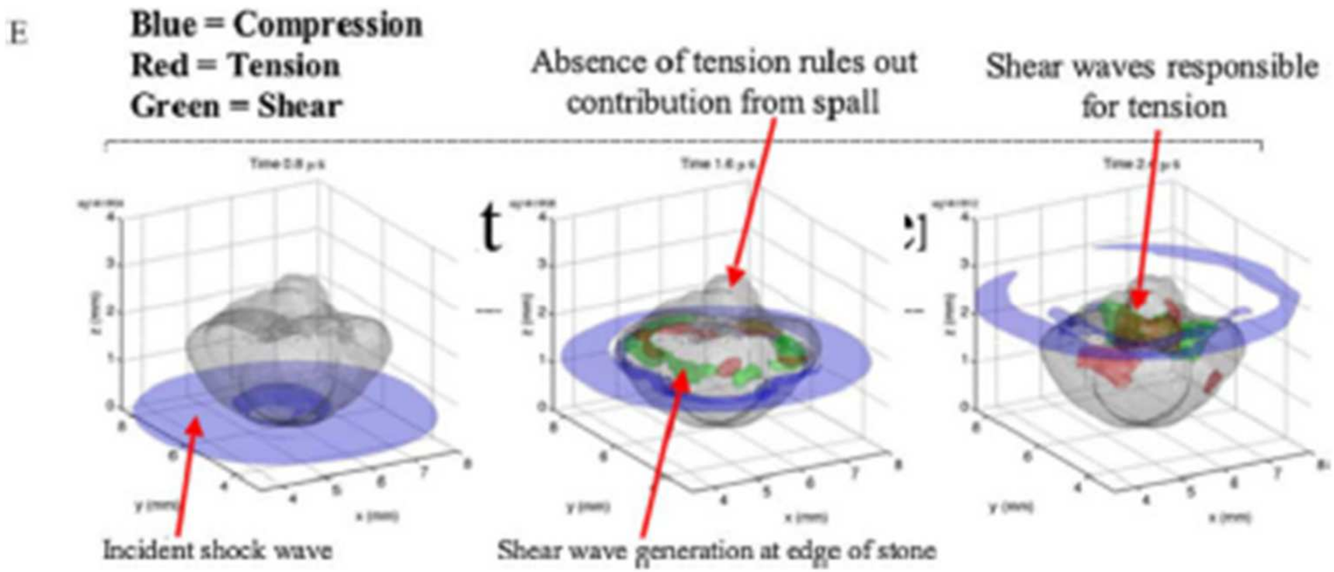
Quasi-static squeezing

D



stone (modified from Eisenmenger). (D) Cavitation: Negative pressure waves of high-speed shocks cause cavitation in liquids surrounding stones and within microcracks or cleavage interfaces by inducing microjets. (E) Dynamic squeezing: Shear waves initiated at the

Quasi-static squeezing



interfaces by inducing microjets. (E) Dynamic squeezing: Shear waves initiated at the corners of the stone and driven by squeezing waves along the calculus lead to the greatest stress and tension (three-dimensional computer simulation according to a numerical model by Cleveland). Note the different pressure distributions and travelling time of waves inside and along the stone surface. *Blue = compressive phase; green = maximum shear stress (55 MPa); red = maximum tensile stress (80 MPa).

Relevance of different theories

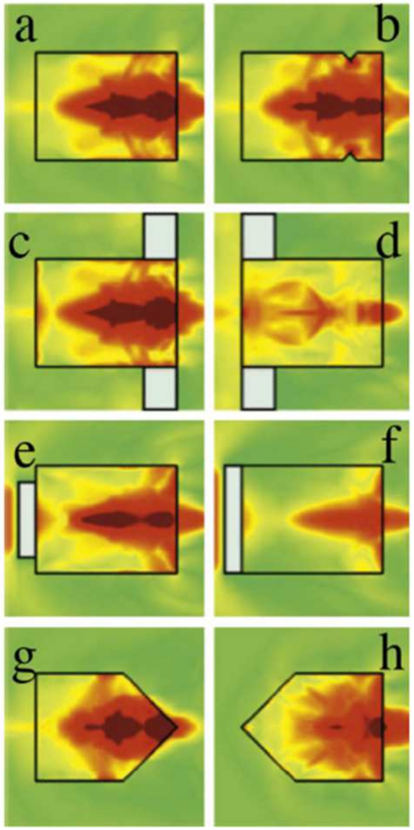


Fig. 3.
Stress fields in the different stone experiments using a research lithotripter patterned after the Dornier HM3 system (Sapozhnikov et al. [12]). The maximal stress field (a) is little changed by blocking the longitudinal wave entering the stone (e) or altering the distal end of the stone (b,c,g). However, blocking the circumferential squeezing wave alone (d) or preventing the creation of shear waves at the corners (f, h) significantly reduces the intensity of stress.

Table 2

Summary of existing theories for stone fragmentation

Hypothesis	Mechanism	Prerequisites	Type of action	Comments
Tear and shear forces [1]	Pressure gradients resulting from impedance changes at the stone front and distal surface with pressure inversion	Shock wave smaller in space extension than the stone	Hammer-like action resulting in a crater-like fragmentation at both ends of the stone	Only relevant for small focus zones
Spallation [9]	Reflected tensile wave at distal surface of the stone with maximum tension at the distal part of the stone	Shock wave smaller in space extension than the stone	Breaking the stone from the inside like freezing water in brittle material	Only relevant for small focus zones No explanation for stone breakage at the front side
Quasi-static squeezing [11]	Pressure gradient between circumferential and longitudinal waves results in squeezing of the stone	Shock wave is broader than the stone Shock wave velocity is lower in the water than in the stone	Nutcracker-like action requiring large focal diameters	Only relevant for large focal zones
Cavitation [10]	Negative pressure waves induce a collapsing cavitation bubble at the stone surface	Low viscosity of surrounding medium	Microexplosive erosion at the proximal and distal ends of the stone	More important during stone comminution Useful for improving the efficiency of shock waves (ie, EHL)
Dynamic squeezing [12]	Shear waves initiated at the corner of the stone are reinforced by squeezing waves along the calculus	Parallel travelling of longitudinal waves Shock wave velocity is lower in the water than in the stone	Nutcracker-like action in combination with spalling	Best theory to explain results of the numerical model

EHL = electrohydraulic lithotripter.

Table 3

Models and results of the experimental evaluation of stone fragmentation by shock waves (according to Sapozhnikov et al.[12]

Mechanism	Model	Hypothesis	Stone model/numerical calculation
Spallation	Stone length: 8–18 mm	Stone fractures at the same distance from the distal end	Stone fractures at a third of the way from the distal end dependent on length
	Block of proximal surface by corprene disk	Stone fracture is significantly inhibited	Little difference (50 vs 45 shock waves) Pressure field similar at the last third
Squeezing	Baffle ringing the proximal end	Stone fracture is significantly inhibited	Significant inhibition (300 vs 45 shock waves) but reduced stress field still at the last third
	Conical shape of the stone front	Stone fracture is not inhibited	Significant inhibition (200 vs 45 shock waves) Pressure field reduced because of diffraction
	Block of proximal end (complete)	Stone fracture is not inhibited	Significant inhibition (212 vs 45 shock waves) Pressure field reduced because of absorption

Αλληλεπίδραση των κρουστικών κυμάτων με τους ζωντανούς ιστούς και τα κύτταρα

6ο Ελληνικό Διαδραστικό Σχολείο Ουρολογίας
18-21/4/2013
Πορταριά Πήλιο

UROSchool 2013

Α. Παπατσώρης

Κυτταρική κάκωση

- Αρχικά η πίεση του κρουστικού κύματος προκαλεί κυτταρική λύση
- Στη συνέχεια η σπηλαιοποίηση προκαλεί ιστική κάκωση (συνήθως μετά τις 1000 κρούσεις)
- Δημιουργείται υποξία που οδηγεί σε απόπτωση

Eur Urol. 2011 May ; 59(5): 784–796.

Νεφρική κάκωση

- Φλεβίδια μυελού (grade I)
- Αρτηρίδια φλοιού (grade II)
- Μηχανισμοί κάκωσης: απόσπαση (αρχικά), διάσχιση, σπηλαιοποίηση, ασύμμετρη ανάπτυξη φυσαλίδων κατά μήκος των αγγείων
- Σημασία της ενεργειακής πυκνότητας

Eur Urol. 2011 May ; 59(5): 784–796.

2.3. Effects on Tissues

2.3.1. Kidney.

- **Συνηθέστερο σύμπτωμα: αιματουρία (λίγων ημερών)**
- **Αρχικά κάκωση στη μυελοφλοιϊκή συμβολή, σε αγγεία με λεπτό τοίχωμα και στο σπείραμα**
- **Μείωση νεφρικής κάκωσης με μικρό αριθμό κυμάτων, λόγω τοπικής αγγειοσυστολής**

The Scientific World Journal
Volume 2012, Article ID 619820, 6 pages

2.3. Effects on Tissues

2.3.2. Cardiovascular Apparatus.

- **Αρρυθμία (10-60%) λόγω πρόωρων κοιλιακών συστολών**
- **Έχουν αναφερθεί περιστατικά ρήξης ανευρύσματος αορτής / νεφρικής αρτηρίας**
- **Αρτηριακή υπέρταση (αύξηση διαστολικής πίεσης) έχει αναφερθεί στο 8% (μακροπρόθεσμα ίδια ποσοστά)**

The Scientific World Journal
Volume 2012, Article ID 619820, 6 pages

2.3. Effects on Tissues

2.3.3. Gastrointestinal Apparatus.

- **1.8% (διάτρηση στο κόλον, διάβρωση 12δακτύλου)**

2.3.4. Fertility and Pregnancy.

- **Απόλυτη αντένδειξη η κύηση**
- **Δεν έχουν διαπιστωθεί μόνιμες βλάβες στους όρχεις και τις ωοθήκες που να επηρεάζουν τη γονιμότητα**
- **Σε ESWL λίθων κάτω 1/3 ουρητήρα μπορεί να διαταραχθούν οι παράμετροι του σπέρματος**

The Scientific World Journal
Volume 2012, Article ID 619820, 6 pages

Table 12: SWL-related complications (1,4,46-48)

Complications			%	Refs.
Related to stone fragments		Steinstrasse	4 - 7	49-51
		Regrowth of residual fragments	21 - 59	52
		Renal colic	2 - 4	48
Infectious		Bacteriuria in non-infection stones	7.7 - 23	52,53
		Sepsis	1 - 2.7	52,53
Tissue effect	Renal	Haematoma, symptomatic	< 1	1,54
		Haematoma, asymptomatic	4 - 19	1,54
	Cardiovascular	Dysrhythmia	11 - 59	52,55
		Morbid cardiac events	Case reports	52,55
	Gastrointestinal	Bowel perforation	Case reports	56-58
		Liver, spleen haematoma	Case reports	58-60

The relationship between SWL and hypertension or diabetes is unclear. Published data are contradictory and no conclusion can be reached (9,61-63).

EAU Guidelines, Urolithiasis, Update March 2013

Twenty-year prevalence of diabetes mellitus and hypertension in patients receiving shock-wave lithotripsy for urolithiasis

BJUI BJU INTERNATIONAL

Ben H. Chew*, Bogard Zavaglia*, Christine Sutton*, Robin K. Masson*, Siu Him Chan*, Reza Hamidizadeh*, Justin K. Lee*, Olga Arsovska*, Victor A. Rowley†, Charles Zwirewich†, Kourosh Afshar* and Ryan F. Paterson*

*Department of Urologic Sciences, Gordon & Leslie Diamond Health Care Centre, Vancouver, and †UBC Faculty of Medicine, Department of Radiology, University of British Columbia, Vancouver BC, Canada

CONCLUSIONS

- No association between lithotripsy and the development of either DM or hypertension in a multivariate analysis
- Metabolic syndrome may have elevated the prevalence of DM and hypertension observed in our subjects on univariate analysis, which is in keeping with the fact that our study population had statistically higher body mass indices than the provincial rate.

Level of Evidence 2b

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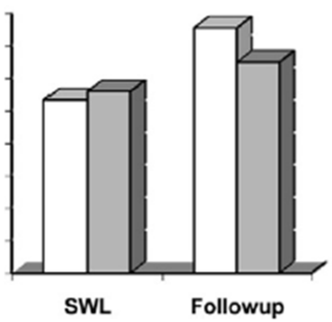
Επίδραση στην Αρτηριακή Πίεση

- Δεν υπήρξε στατιστικά σημαντική συσχέτιση μεταξύ ΑΥ και ESWL

Elves AW, BJU Int 2000;85:611

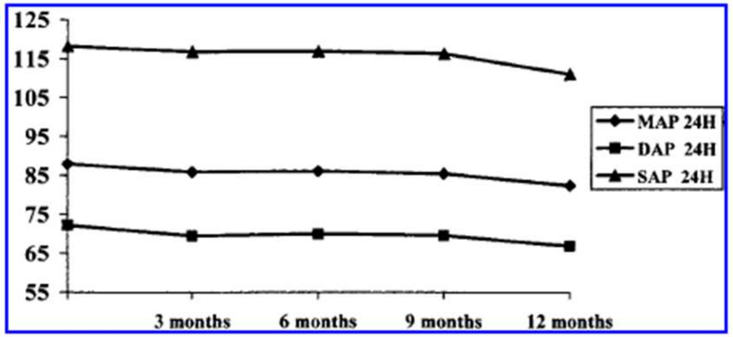
- ↑ της ΑΠ μετά από ESWL



Barbosa PV, Urology 2011;78:22

- ↓ της ΑΠ μετά από ESWL

Protogerou V, J Endourol 2004;18:17



ΕΝΔΕΙΞΕΙΣ ΚΑΙ ΑΝΤΕΝΔΕΙΞΕΙΣ ESWL

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Α. Σκολαρίκος

ΕΝΔΕΙΞΕΙΣ ESWL

Α) παράγοντες που εξασφαλίζουν επιτυχές αποτέλεσμα

Μέγεθος λίθου ≤ 2cm

Μονήρης λίθος

Εντόπιση λίθου (άνω-μέση καλυκική ομάδα, νεφρική πύελος, ανώτερο τμήμα ουρητήρα)

Σύνθεση λίθου: διυδρικό οξαλικό ασβέστιο, απατίτης, μικτοί λίθοι (CT-μονάδες Housefield)

Φυσιολογική ανατομία

Απουσία λοίμωξης

ΕΝΔΕΙΞΕΙΣ ESWL

Β) παράγοντες που προδικάζουν δυσμενές αποτέλεσμα

Μέγεθος λίθου > 2cm

Πολλαπλοί λίθοι

Εντόπιση λίθου: κάτω καλυκική ομάδα, κατώτερο τμήμα ουρητήρα

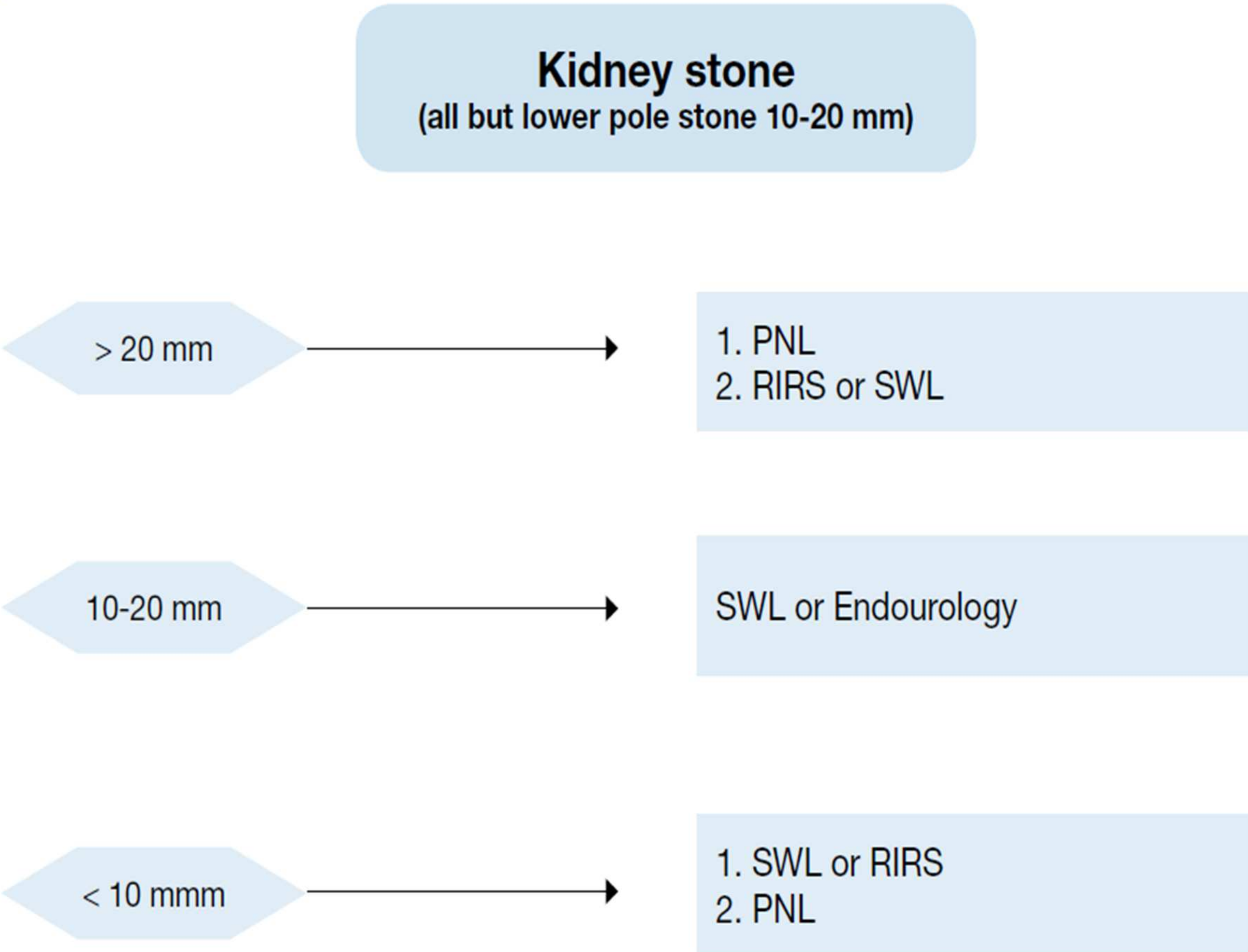
Σύνθεση λίθου: μονουδρικό οξαλικό ασβέστιο, βρουσίτης, κυστίνης, λίθοι matrix

Απόφραξη

ΑΝΤΕΝΔΕΙΞΕΙΣ ESWL

- Κύηση
- Σοβαρές ανωμαλίες του μυοσκελετικού
- Σοβαρού βαθμού Παχυσαρκία
- Ανευρύσματα αορτής ή νεφρικής αρτ.
- Μη-ελεγχόμενη διαταραχή πηκτικότητας
- Μη-ελεγχόμενη λοίμωξη ουροποιητικού
- Υπερήλικες
- Η παρουσία Βηματοδότη _ΔΕΝ_ αποτελεί αντένδειξη

Figure 1: Treatment algorithm for renal calculi



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Lower pole stone

> 20 mm and < 10 mm: like above

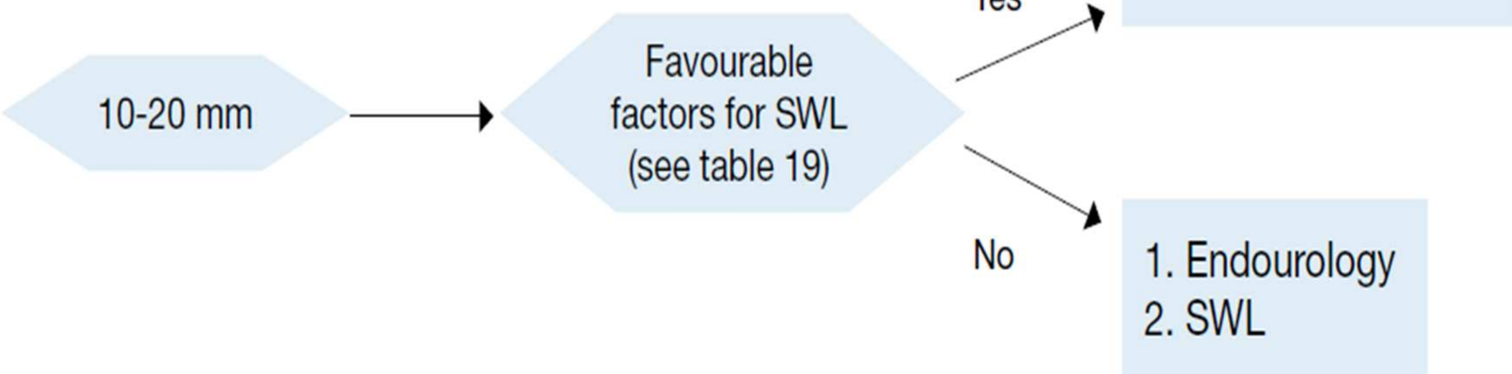

Table 19: SFRs after primary treatment with SWL and URS in the overall population (1-5)

Stone location and size	SWL		URS	
	No. of patients	SFR/95% CI	No. of patients	SFR/95% CI
Distal ureter	7217	74% (73-75)	10,372	93% (93-94)
< 10 mm	1684	86% (80-91)	2,013	97% (96-98)
> 10 mm	966	74% (57-87)	668	93% (91-95)
Mid ureter	1697	73% (71-75)	1,140	87% (85-89)
< 10 mm	44	84% (65-95)	116	93% (88-98)
> 10 mm	15	76% (36-97)	110	79% (71-87)
Proximal ureter	6682	82% (81-83)	2,448	82% (81-84)
< 10 mm	967	89% (87-91)	318	84% (80-88)
> 10 mm	481	70% (66-74)	338	81% (77-85)

Table 20: Recommended treatment options (if indicated for active stone removal) (GR A*)

Stone location and size	First choice	Second choice
Proximal ureter < 10 mm	SWL	URS
Proximal ureter > 10 mm	URS (retrograde or antegrade) or SWL	
Distal ureter < 10 mm	URS or SWL	
Distal ureter > 10 mm	URS	SWL

**Upgraded following panel consensus.*

Recommendation	GR
Treatment choices should be based on stone size and location, available equipment, and patient preference for stone removal.	A

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Επιλογή του Λιθοτρίπτη

Χ. Μαμουλάκης

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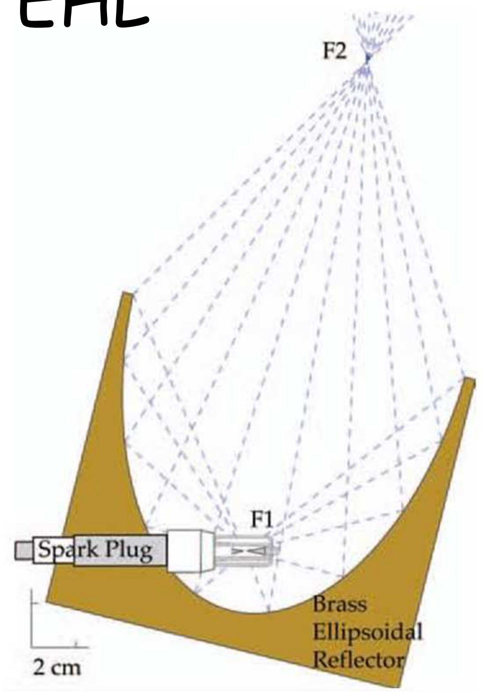
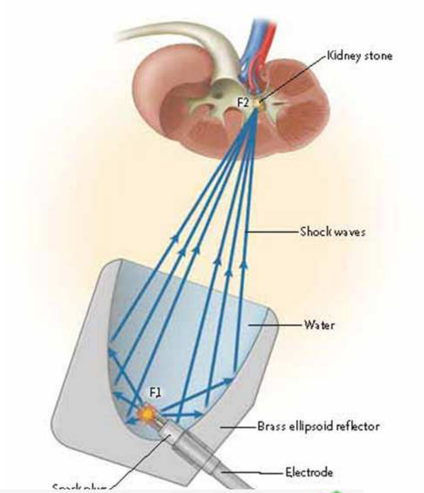
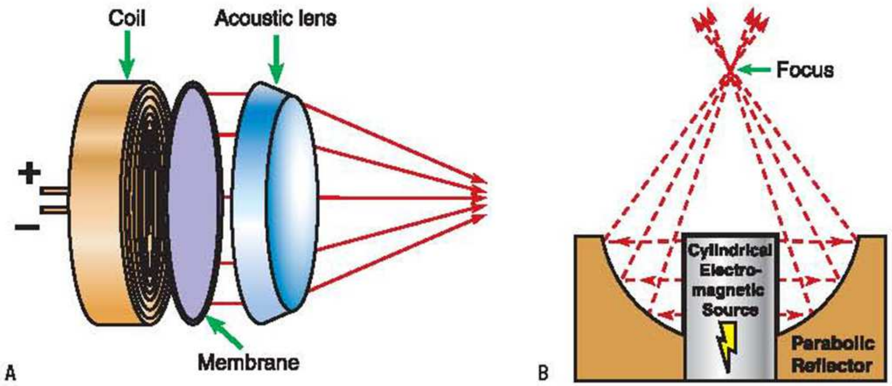
Αρχές λειτουργίας των λιθοτριπτών

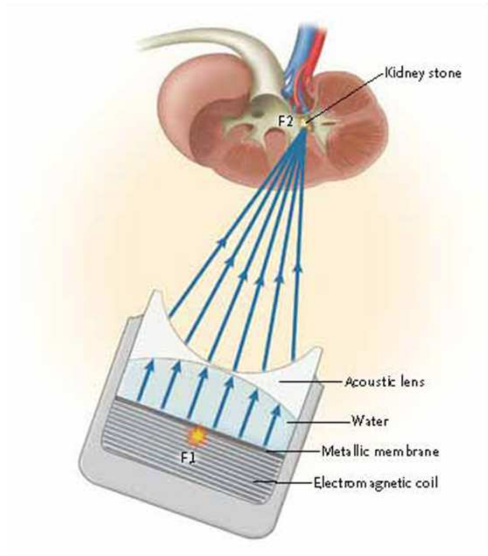
EHL



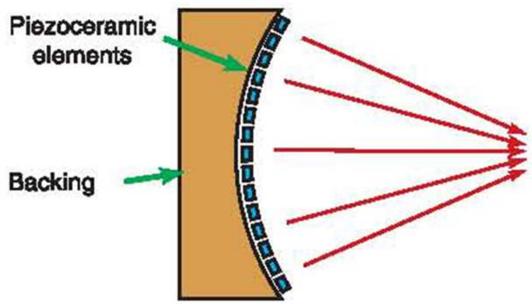


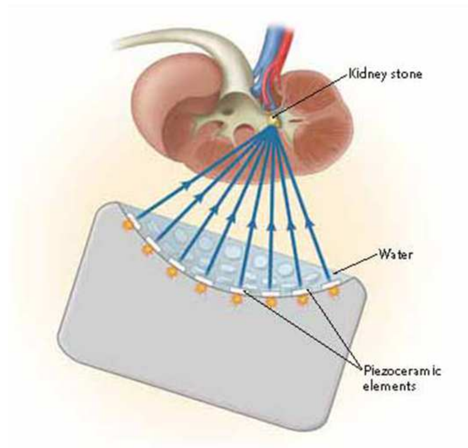
EML





PEL





- EML: οι πιο διαδεδομένοι (αναπαραγώγιμοι-ανθεκτικοί)
- EHL: σημαντική μεταβλητότητα (shot-to-shot >50%) των κυμάτων / μετατόπιση εστίασης & φθορά ηλεκτροδίων με το χρόνο – ανάγκη αντικατάστασης
- PEL: οι λιγότερο διαδεδομένοι (πιο φτωχά αποτελέσματα)
- Dornier HM-3: τα καλύτερα αποτελέσματα μέχρι σήμερα

- Προβληματικές οι συγκρίσεις – σχετικά λίγα δεδομένα
- Δεν υπάρχει σαφής τρόπος τυποποίησης των τριών κύριων παραμέτρων (ισχύς, αριθμός κυμάτων, ρυθμός) ώστε να συγκριθούν αξιόπιστα τα διάφορα συστήματα
- Πιο ισχυροί λιθοτρίπτες με στενότερη ζώνη εστίασης σχετίζονται με ↑ ποσοστά επανεπεμβάσεων και επιπλοκών συγκριτικά με λιθοτρίπτες ευρύτερης ζώνης εστίασης

Table 39-1 Mechanical Aspects — Electrohydraulic Lithotriptors

Company	Machine	Method of Focusing SW	Aperture (cm)	Focal Distance (cm)	Peak Pressure at Focal Point (PVDF)	Focal zone (W × L mm)	Electrode life span (SW)	SW Coupling
Dornier Medical Systems	HM-3*	Ellipsoid reflector	15.6, 17.2	13	220–360, 320–390	15 × 90, 10 × 40	2000	Water bath
Medispec Ltd.	Econolith	Ellipsoid reflector	17.6*	13.5	760	13 × 60	3000	Water cushion
Medispec Ltd.	E-2000	Ellipsoid reflector	17.6	13.5, 15.0	760	13 × 60	3000	Water cushion
Medispec Ltd.	E-3000	Ellipsoid reflector	17.6	13.5, 15.5	910	13 × 60	3000	Water cushion
Healthtronics	Litho Tron	Ellipsoid reflector	20	15	530	8 × 38	8000	Water cushion
Healthtronics	Litho Tron Ultra	Ellipsoid reflector	20	15	530	8 × 38	8000	Water cushion
HMT-USA	LithoDiamond	Ellipsoid reflector	20	15	580	11 × 96	20,000	Coupling water cushion
Direx Systems Corp.	Tripter X-1 Compact	Ellipsoid reflector	18.1	13.5	240-440	13 × 48	3000	Water cushion
Direx Systems Corp.	Duet	Dual ellipsoid reflectors	18.1	14.2	240–480	13 × 48	3–12,000	Dual water cushion
Medstone International	STS	Ellipsoid reflector	15	15	481	12 × 90	3600	Water cushion
Medstone International	STS-TC	Ellipsoid reflector	15	15	481	12 × 90	3600	Water cushion
EDAP Technomed	Sonolith Praktis	Ellipsoid reflector	21.9	13	106	25 × 3.6	27,000 at 100%	Water cushion
EDAP Technomed	Sonolith Vision	Ellipsoid reflector	21.9	13	106	25 × 3.6	27,000 at 20 KV	Water cushion
FMD, LLC	Twinheads TH101	Ellipsoid reflector	14.7	12.7	1100	15.4 × 15.6	3,000	Two water cushions
FMD, LLC	Twinheads TH103	Ellipsoid reflector	14.7	12.7	1100	15.4 × 15.6	3,000	Two water cushions

Table 39-2 Imaging/Financial Aspects—Electrohydraulic Lithotriptors

Company	Machine	ECG Gaiting	Endourology Capability	Stone Localization	Portability	Purchase Price	Service Contract	Upgrade Possibility	Upgrade Cost
Dornier Medical Systems	HM-3*	Yes	No	X-ray	Semi-trailer	$25 K used*	$45K	Digital X-ray	$60K
Medispec Ltd.	Econolith	Optional	Yes	X-ray, Portable C-arm, Optional US	Yes	$350K	$15-21K	ECG monitor, Endo., C-arm upgrades, comp. Console	N/A
Medispec Ltd.	E-2000	Optional	Yes	X-ray, Portable C-arm, Optional US	Yes	$380K	$15-26K	ECG monitor, Endo., C-arm upgrades	N/A
Medispec Ltd.	E-3000	Optional	Yes	X-ray, Portable C-arm, Optional US	Yes	$399K	$15-26K	ECG monitor, 4 or 5 axis Endourology Table, Console, C-arm upgrades	N/A
Healthtronics	Litho Tron	Optional	Yes	X-ray, Portable C-arm, Optional US	Yes	$350-400K	$48K	No	N/A
Healthtronics	Litho Tron Ultra	Optional	Yes	X-ray, Optional US	No	$700K	$65K	N/A	N/A
HMT-USA	LithoDiamond	Optional	Yes	X-ray, Optional US	Yes	$400K	N/A	N/A	N/A
Direx Systems Corp.	Tripter X-1 Compact	Yes	Yes	X-ray, Portable C-arm	Yes	$395K	$28-35K	Triple generator, non ECG gaiting	N/A
Direx Systems Corp.	Duet	Yes	Yes	X-ray, Portable C-arm, Optional US	Yes	$435K	$35K	Ultrasound	N/A
EDAP Technomed	Sonolith Praktis	Optional	Yes	X-ray and U/S	Yes	$400K	$35K	Yes	N/A
EDAP Technomed	Sonolith Vision	Optional	Yes	X-ray and U/S	Yes	$500K	$50K	Yes	N/A
FMD, LLC	Twinheads TH101	Yes	Yes	Flouroscopy, Integrated U-Arm	Semi-Portable	$540K	$50K	US, Laser Printer, DICOM 3	$9.8-56K
FMD, LLC	Twinheads TH103	Yes	Yes	Works with stand-alone C-arm	Semi-Portable	$495K	$40K	US, Laser Printer, DICOM 3	$9.8-56K

Table 39-3 Mechanical Aspects

Company	Machine	Method of Focusing SW	Aperture (cm)	Focal Distance (cm)	Peak Pressure at Focal Point (PVDF)	Focal Zone (W × L mm)	Generator Life Span (SW)	SW Coupling
Electromagnetic Lithotriptors								
Siemens Medical Systems	Lithostar Multiline	Acoustic lens	17	12	800	5 × 80	1 million	Water cushion
Karl Storz Lithotripsy	Modulith SL20*	Parabolic reflector	30	16.5	189–1056	4.6 × 34 to 2.8 × 37	6 million	Water cushion
Karl Storz Lithotripsy	Modulith SLX-MX	Parabolic reflector	30	16.5	189–1056	4.6 × 34 to 2.8 × 37	8 million	Water cushion
Karl Storz Lithotripsy	Modulith SLX-T	Parabolic reflector	30	16.5	189–1056	4.6 × 34 to 2.8 × 37	8 million	Water cushion
Karl Storz Lithotripsy	Modulith SLX-F2	Parabolic reflector	30	16.5	90–160	2.0 × 22 to 3.5 × 50	N/A	Water cushion
Dornier MedTech	Compact Delta	Acoustic lens	14	15	315–550	4.7 × 57	1 million	Water cushion
Dornier MedTech	Compact Sigma	Acoustic lens	14	15	315–550	4.7 × 57	1 million	Water cushion
Dornier MedTech	DoLi S 140	Acoustic lens	14	15	160–550	4.7 × 57	1 million	Water cushion
Dornier MedTech	DoLi S 220	Acoustic lens	22	15	288–991	2.5 × 41	1 million	Water cushion
Dornier MedTech	DoLi S 220-XP*	Acoustic lens	22	15	200–900	3.4 × 46	1 million	Water cushion
Dornier MedTech	DoLi S 220-XXP*	Acoustic lens	22	15	490–900	4.1 × 60.5	1 million	Water cushion
Dornier MedTech	DoLi S II 140	Acoustic lens	14	15	160–550	4.7 × 57	1 million	Water cushion
Dornier MedTech	DoLi S II 220	Acoustic lens	22	15	288–991	2.5 × 41	1 million	Water cushion
Dornier MedTech	DoLi S II 220-XP*	Acoustic lens	22	15	200–900	3.4 × 46	1 million	Water cushion
Dornier MedTech	DoLi S II 220-XXP*	Acoustic lens	22	15	490–900	4.1 × 60.5	1 million	Water cushion
Piezoelectric Lithotriptors								
Wolf	P3000†	Concave Dish	26	15	1320	3 × 16	>5 mil	Water cushion

Table 39-4 Imaging/Financial Aspects

Company	Machine	ECG Gaiting	Endourology Capability	Stone Localization	Portability	Purchase Price	Service Contract	Upgrade Possibility	Upgrade Cost
Electromagnetic Lithotriptors									
Siemens Medical Systems	Lithostar Multiline	Yes	Yes	X-ray, Inline US	No	$650K	N/A	N/A	N/A
Siemens Medical Systems	Lithostar Modularis (with Cplus)	Yes	Yes	X-ray, Co-axial US	Yes	$495K	N/A	N/A	N/A
Siemens Medical Systems	Lithostar Modularis Vario (with Cplus)	Yes	Yes	X-ray, Co-axial US	Yes	$455K	N/A	N/A	NA
Karl Storz Lithotripsy	Modulith SL20	No	Yes	Inline X-ray and US	No	$295K used‡	$69K	No	N/A
Karl Storz Lithotripsy	Modulith SLX-MX	No	Yes	Inline X-ray and US	No	$695K	$80K	No	N/A
Karl Storz Lithotripsy	Modulith SLX-T	No	Yes	Inline X-ray and US	Yes	$525K	$62.5K	No	N/A
Karl Storz Lithotripsy	Modulith- SLX-F2	No	Yes	Inline X-ray and US	N/A	N/A	N/A	N/A	N/A
Dornier MedTech	Compact Delta	Optional	Yes	X-ray, US optional, isocentric fluoro	Yes	$430k	$52k	US, laser printer, DICOM 3	$50K, $10K, $25K
Dornier MedTech	Compact Sigma	Optional	Yes	X-ray, US optional, mobile C-arm	Yes	$440k	$52k	US, laser printer, DICOM 3	$50K, $10K, $7K
Dornier MedTech	DoLi S 140	Optional	Yes	X-ray, US optional, isocentric fluoro	No	$695K	$73.5k	US, laser printer, DICOM 3	$50K, $10K, $25K
Dornier MedTech	DoLi S 220	Optional	Yes	X-ray, US optional, isocentric fluoro	No	$695K	$73.5k	US, laser printer, DICOM 3	$50K, $10K, $25K
Dornier MedTech	DoLi S, 220-XP	Optional	Yes	X-ray, US optional, isocentric fluoro	No	N/A	N/A	US, laser printer, DICOM 3	N/A
Dornier MedTech	DoLi S, 220-XXP	Optional	Yes	X-ray, US optional, isocentric fluoro	No	N/A	N/A	US, laser printer, DICOM 3	N/A
Dornier MedTech	DoLi S II, 140	Optional	Yes	X-ray, US optional, isocentric fluoro	No	$695K	$73.5k	US, DICOM 3 included	$50k
Dornier MedTech	DoLi S II, 220	Optional	Yes	X-ray, US optional, isocentric fluoro	No	$695K	$73.5k	US, DICOM 3 included	$50k
Dornier MedTech	DoLi S II, 220-XP	Optional	Yes	X-ray, US optional, isocentric fluoro	No	N/A	N/A	US, DICOM 3 included	N/A
Dornier MedTech	DoLi S II, 220-XXP	Optional	Yes	X-ray, US optional, isocentric fluoro	No	N/A	N/A	US, DICOM 3 included	N/A
Piezoelectric Lithotriptors									
Wolf	P3000‡	No	Yes	Coaxial x-ray & US	Yes	N/A	N/A	Yes	N/A

Table 2

Technical innovations in shock wave lithotripsy

Results	References
Increased focal width lithotripters	
Proof of concept	Eisenmenger *et al.* (2002)[87]
Enhanced potential to hit targeted stone	*In vitro* studies: Pishchalnikov *et al.* (2008)[83] Cleveland *et al.* (2004)[84]
Improved breakage of large stone fragments	*In vitro* studies and numerical modeling: Cleveland and Sapozhnikov (2005)[85] Sapozhnikov *et al.* (2007)[86]
Dual-head lithotripters	
Improved safety and efficacy	Prospective clinical trial: Sheir *et al.* (2008)[81]
Improved stone breakage	*In vitro* studies: Sokolov *et al.* (2001)[79]
Minimal renal injury	Animal study: Handa *et al.* (2009)[80]
Tandem-pulse shock sources	
Enhanced cavitation in stone comminution	Laboratory studies: Xi and Zhong (2000)[74] Zhou *et al.* (2004)[75]
Reduced time to breakage	Laboratory study: Fernandez *et al.* (2009)[77]
Acoustic detection for targeting and breakage assessment	
In development	Leighton *et al.* (2008)[95] Owen *et al.* (2007, 2004)[94,100]
Focused ultrasound to enhance clearance of residual fragments	
Proof of concept	Laboratory studies: Shah *et al.* (2009)[101] Sapozhnikov *et al.* (2009)[102]

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Επιλογή της δόσης

Χ. Μαμουλάκης

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τοτελεσματική Ενεργειακή Δόση (ορισμός):

Η ακουστική ενέργεια/κρουστικό κύμα που μεταφέρεται σε περιοχή στην εστία διαμέτρου 12 mm (μέσο μέγεθος λίθων) επί τον αριθμό των κρουστικών κυμάτων, δηλαδή:

$$E(dose) = E(stone) = Eeff(12mm) \times n$$

$$Eeff(12mm) = \int_0^r ED(r) = 2\pi/Z \int_0^r \int_{t0}^{t2} P^2 \, dr dt$$

ED=Energy flux density: Η μεταφερόμενη ενέργεια από το κρουστικό κύμα σε συγκεκριμένο εστιακό βάθος (r)

- Συνιστώμενες δόσεις (με βάση κλινικά αποτελέσματα):

  (1) Λίθοι νεφρού: Edose(12 mm) = 100–130 J

  (2) Λίθοι ουρητήρα: Edose(12 mm) = 150–200 J

- Εξαρτάται από τον λιθοτρίπτη (προϋποθέτει μετρήσεις)
- Μέτρο σύγκρισης στρατηγικών θεραπείας και αποτελεσματικότητας των διαφόρων λιθοτριπτών
- Η επιτυχία της ESWL σε διάφορα επίπεδα έντασης (πυκνότητες ενεργειακής ροής) είναι ίδια αν ο αριθμός κρούσεων μεταφέρει συνολικά ισοδύναμη ενεργειακή δόση

Therapeutic recommendations for extracorporeal shock wave lithotripsy (for the Siemens LITHOSKOP)

Stone size, mm	Location	No. of shock waves	Energy level 8–117 mJ/impulse	Frequency, shock waves/min
5–10	Kidney	3000–3500	Ramping: 100 shock waves with Level 0.1–1	60
			Afterwards, maximal level:	
			Lower calyx: 3.0	
			Upper and middle calyx: 3.5	
			Pelvis: 4.0	
	Ureter	3500–4500	No dose escalation (ramping)	Upper and middle ureter: 90
			Maximal Level:	
			Upper ureter: 4.0	Distal ureter: 120
			Middle ureter: 6.0	
			Distal ureter: 8.0	
10–20	Kidney	Single stone: 3500	Ramping: 100 shock waves with level 0.1–1	60
		Multiple stones: 4000 (ie, 2 × 2000)	Afterwards, maximal level:	
			Lower calyx: 3.0	
			Upper and middle calyx: 3.5	
			Pelvis: 4.0	
	Ureter	4500	No dose escalation (ramping)	Upper and middle ureter: 90
			Maximal level:	
			Upper ureter: 4.0	Distal ureter: 120
			Middle ureter: 6.0	
			Distal ureter: 7.0	

5.5.3.2 Shock wave rate

Lowering shock wave frequency from 120 to 60-90 shock waves/min improves SFR (12-16). Tissue damage increases with shock wave frequency (17-19).

Recommendation	LE	GR
The optimal shock wave frequency is 1.0-1.5 Hz (16).	1a	A

EAU Guidelines, Urolithiasis, Update March 2013

Επιλογή της συχνότητας

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The Effect of Shock Wave Rate on the Outcome of Shock Wave Lithotripsy: A Meta-Analysis

Michelle Jo Semins, Bruce J. Trock and Brian R. Matlaga*
From the James Buchanan Brady Urological Institute, The Johns Hopkins University School of Medicine, Baltimore, Maryland

Randomized, controlled trials of the effect of shock wave rate on outcome of shock wave lithotripsy

References + Cohorts	No. Pts	Mean Pt Age	Stone Size	% Success	% Stone-Free
Pace et al:[8]					
Slow	111	49.2	84.4 mm^2	74.5*	56.4
Fast	109	50.7	80.4 mm^2	60.6*	44.4
Madbouly et al:[9]					
Slow	76	42	13.2 mm	98.7†	Not recorded
Fast	80	42.2	13.2 mm	90.0†	Not recorded
Yilmaz et al:[10]					
Slow	57	44	13.12 mm	89.5‡	Not recorded
Fast	56	40.5	14.02 mm	73.2‡	Not recorded
Davenport et al:[11]					
Slow	49	53	67 mm^2	59§	49
Fast	51	50	56 mm^2	61§	49

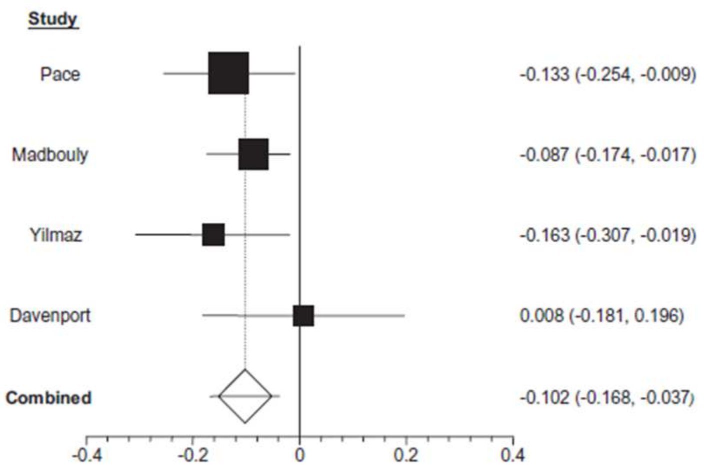

FIG. 1. Risk difference in proportion of successful lithotripsy procedures using fast vs slow rate (fixed effects model).

THE JOURNAL OF UROLOGY®
Vol. 179, 194-197, January 2008

Evaluation of the Optimal Frequency of and Pretreatment with Shock Waves in Patients with Renal Stones

Jong Yeon Lee, Young Tae Moon

Department of Urology, Chung-Ang University College of Medicine, Seoul, Korea

TABLE 1. ESWL treatment, outcomes, and costs according to shock wave frequency

	60 shocks/min (group I)	120 shocks/min (group II)	p-value
No. of patients	25	23	
Age (yr, SD)	52.4 (±14.2)	50.9 (±15.2)	0.728
Male:Female	17:8	15:8	0.838
Stone side (Lt:Rt)	12:13	9:13	0.536
Stone location			
Renal stone:Pelvis stone	9:16	9:14	0.823
Stone size (mm, SD)	6.6 (±0.5)	7.6 (±5.2)	0.149
No. of ESWL sessions to success (SD)	1.36 (±0.11)	2.00 (±0.21)	0.008
Total no. of shock waves (SD)	3,358 (±271)	4,924 (±517)	0.008
Treatment success after 1st ESWL (%)	64.0	34.8	0.044
Analgesia requirement	40.0	34.8	0.709
Pain scale (VAS) (0-10)	0.63	0.6	0.523

Group I had received 2,000-3,000 shocks at a rate of 60 shocks/min, and group II had received 2,000-3,000 shocks at a rate of 120 shocks/min, EWSL, extracorporeal shock wave lithotripsy, Lt: left, Rt: right, VAS: visual analogue scale

Korean J Urol 2011;52:776-781

Evaluation of the Optimal Frequency of and Pretreatment with Shock Waves in Patients with Renal Stones

Jong Yeon Lee, Young Tae Moon

Department of Urology, Chung-Ang University College of Medicine, Seoul, Korea

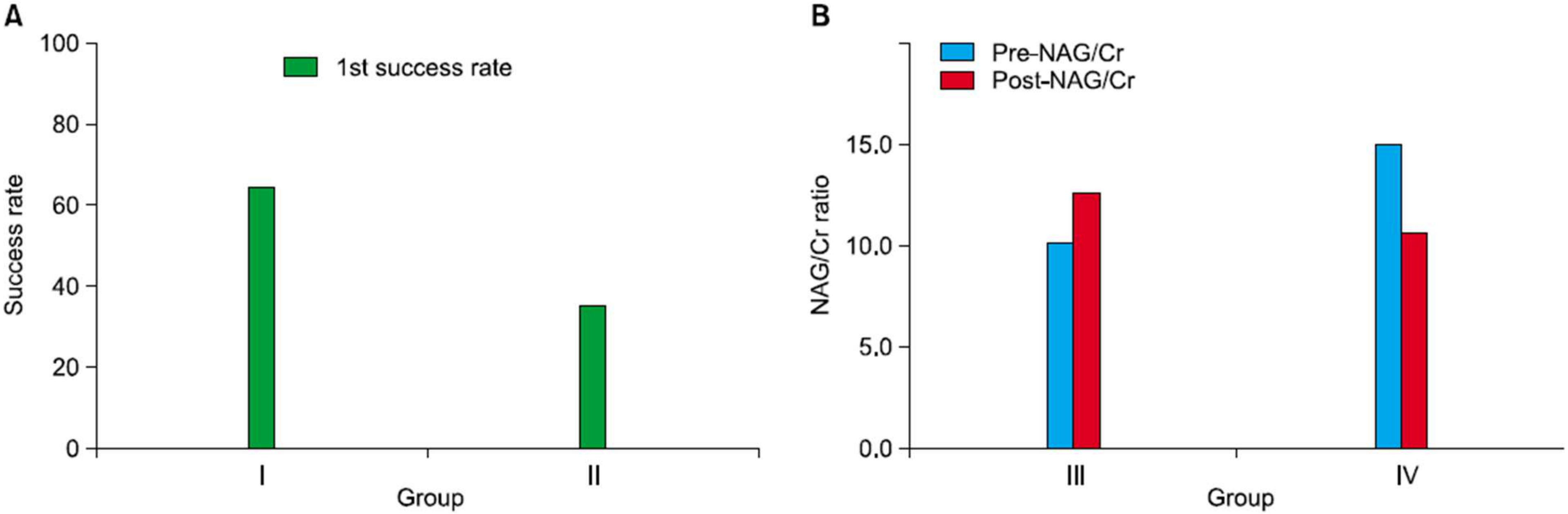

FIG. 1. (A) Treatment outcomes according to frequency (p=0.044). (B) N-Acetyl-β-d-glucosaminidase (NAG)/creatinine (Cr) levels according to pretreatment (p=0.406). I: 60 shocks/min (group I), II: 120 shocks/min (group II), III: pretreatment (group III), IV: non-pretreatment (group IV).

Korean J Urol 2011;52:776-781

Randomised controlled trials (evidence level Ib/A) comparing different pulse rates for extracorporeal sho

Study	No. (slow/fast)	Lithotriptor	Pulse rates, No./min	No. of impulses, slow vs fast	Overall SFR at 3 mo, %
Pace et al. [48]	220 (111/109)	LithoTron (Healthtronics, Atlanta, GA, USA)	60 vs 120	2423 vs 2906	60 vs 45
Yilmaz et al. [47]	170 (56/57/57)	StoneLitho3pter (PCK, Ankara, Turkey)	60 vs 90 vs 120	3037 vs 2989 vs 3019	N/A
Madbouly et al. [46]	156 (76/80)	Lithostar Multiline (Siemens)	60 vs 120	5755 vs 7414	85 overall
Chacko et al. [49]	349 (171/178)	DoLi-50 (Dornier)	70–80 vs 120	2428 vs 2785	N/A
Davenport et al. [46]	104 (50/54)	DoLi S (Dornier)	60 vs 120	3000 vs 3000	49 vs 47 (n.s.)
Kato et al. [50]	134 (66/68)	MODULITH SLX (Storz-Medical)	60 vs 120	6348 vs 6348	77 vs 76 (n.s.)
Koo et al. [51]	102 (51/51)	DoLi S (Dornier)	70 vs 100	3045 vs 4414	67 vs 26
Total	1235	-	-	-	-

SFR = stone-free rate; RCT = randomised controlled trial; n.s. = not significant; SSA = stone surface area (length × width); N/A = not applic

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Τοποθέτηση του ασθενούς και σύζευξη για την δράση των κρουστικών κυμάτων

Χ. Μαμουλάκης

UROSchool 2013

Τοποθέτηση ασθενούς – Σύζευξη

Στόχοι:

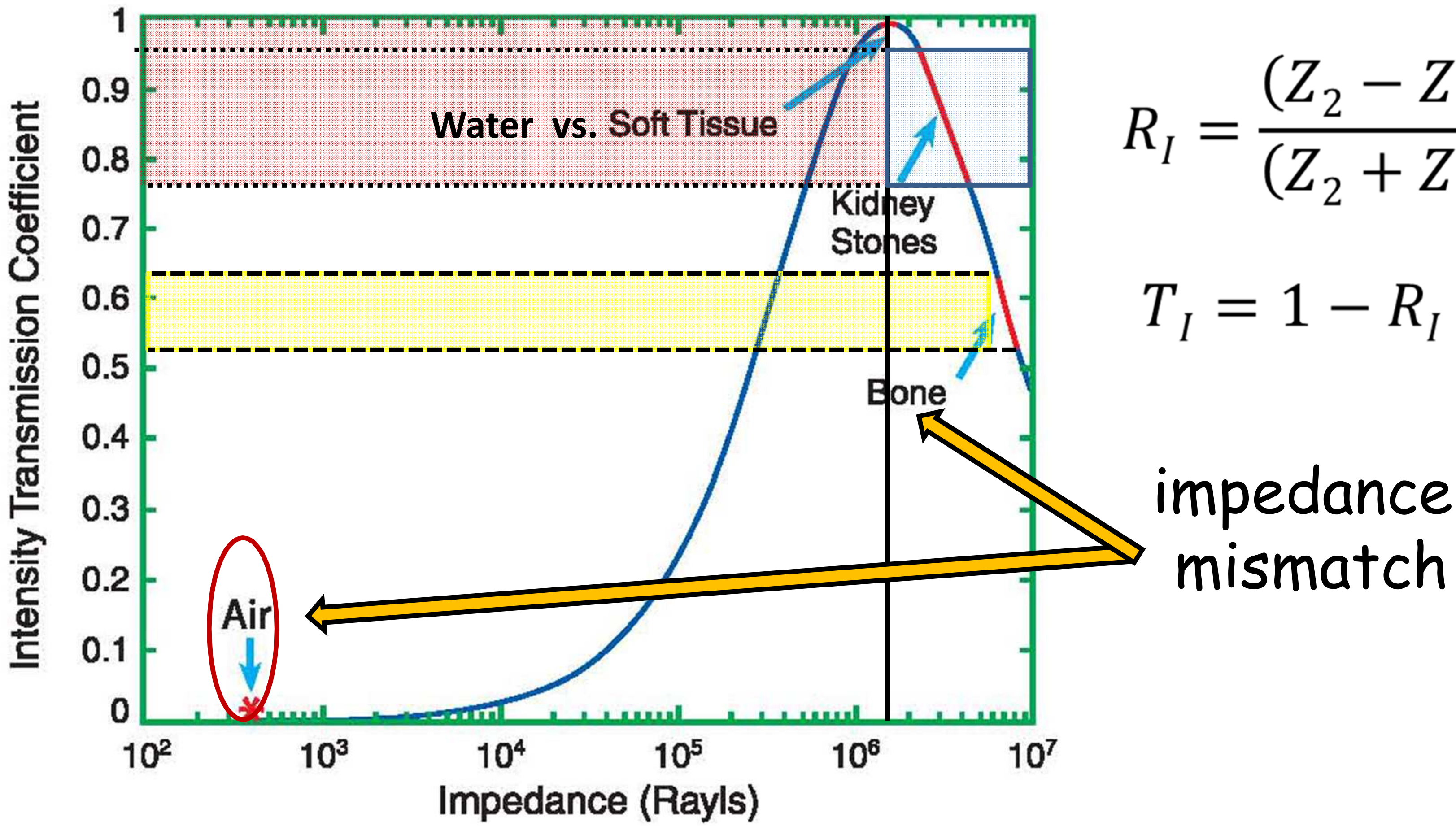
Καλύτερη δυνατή επαφή σώματος-υδροφόρου μαξιλαριού (σφιχτή – ομαλή – χωρίς παρεμβολή αέρα)

Καλύτερο δυνατό ακουστικό παράθυρο (αποφυγή οστών)

Άνετη θέση (αποφυγή μετακινήσεων)

Istanbulluoglu et al. Urol Res. 2011;39:177-80

Μετάδοση και ανάκλαση του ακουστικού κύματος



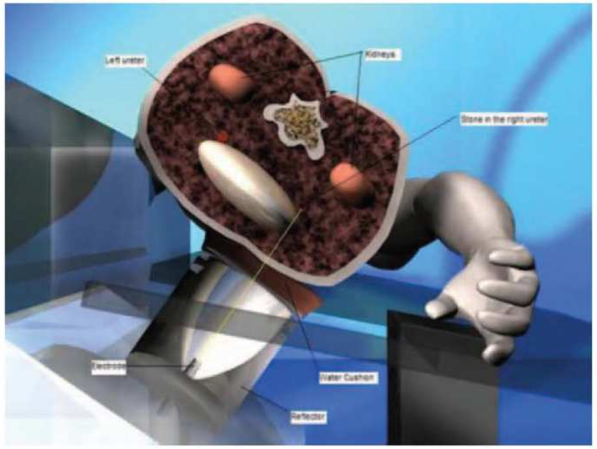
$$R_I = \frac{(Z_2 - Z_1)^2}{(Z_2 + Z_1)^2}$$

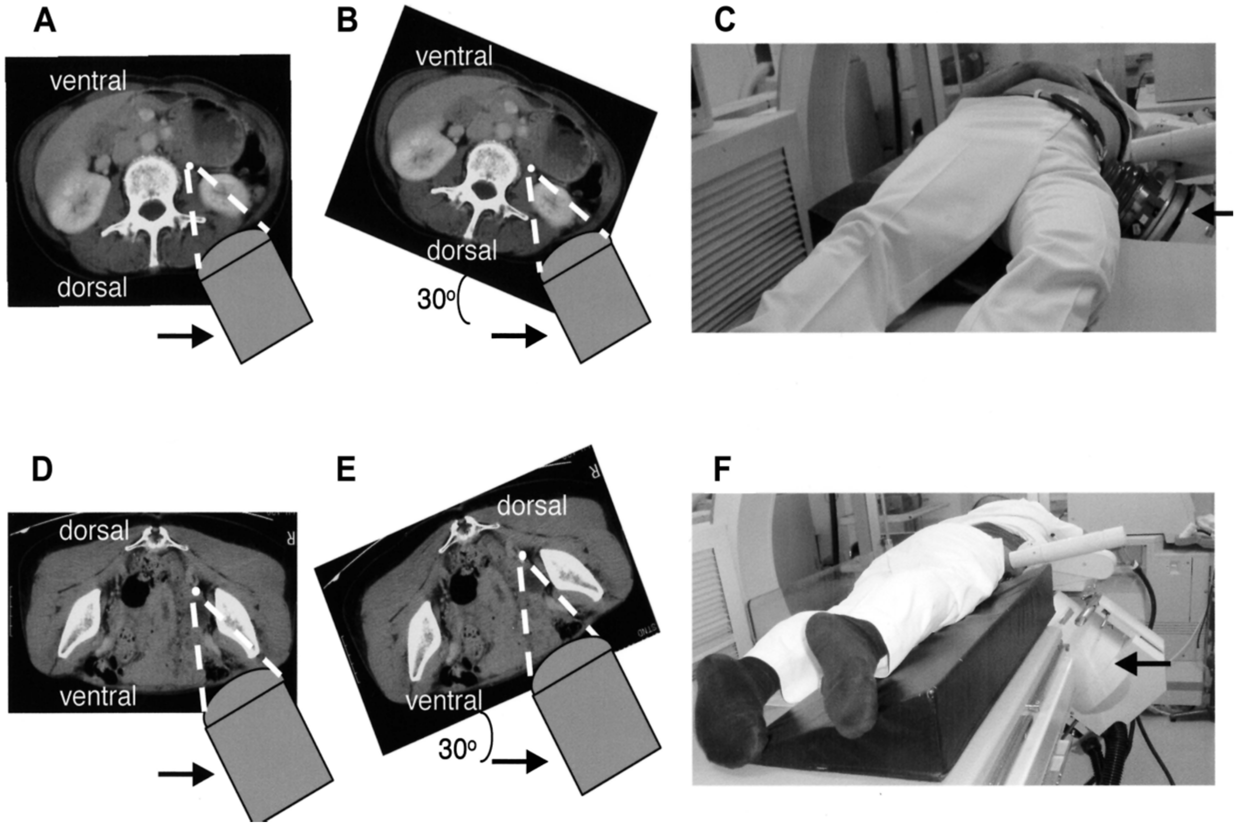
$$T_I = 1 - R_I$$

Intensity transmission coefficient (T_I) from water ($Z = 1.5 \times 10^6$ Rayls) to a second medium, as a function of the impedance of the second medium

- ✓ Τυπική θέση η ύπτια (δεν υπάρχει απόλυτη συμφωνία)
- ✓ Ελάχιστες μελέτες:
- ✓ Υπέρ ύπτιας:
  - Cost effective
  - Less morbidity
  - Prone caries risk of small intestine perforation
- ✓ Υπέρ πρηνούς λίγες μελέτες (κάτω 3-μόριο ουρητήρα)

✓ Τροποποιημένη πρηνής/ύπτια (μέσο-κάτω 3-μοριο ουρητήρα)





Köse, Demirbas M. BJU Int. 2004;93:369-73
Hara et al. J Endourol. 2006;20:170-4
Demirbas Urol J. 2012;9:557-61

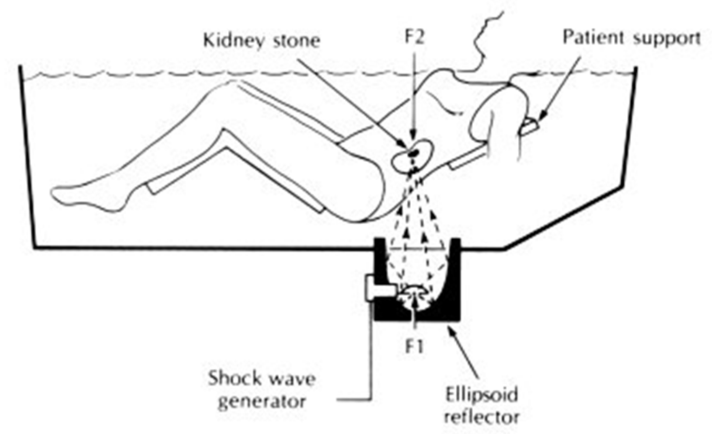


Diagram of patient positioning for ESWL

Water-bath lithotriptors:

Dornier HM3

"The ideal coupling"

Dry lithotriptors today:

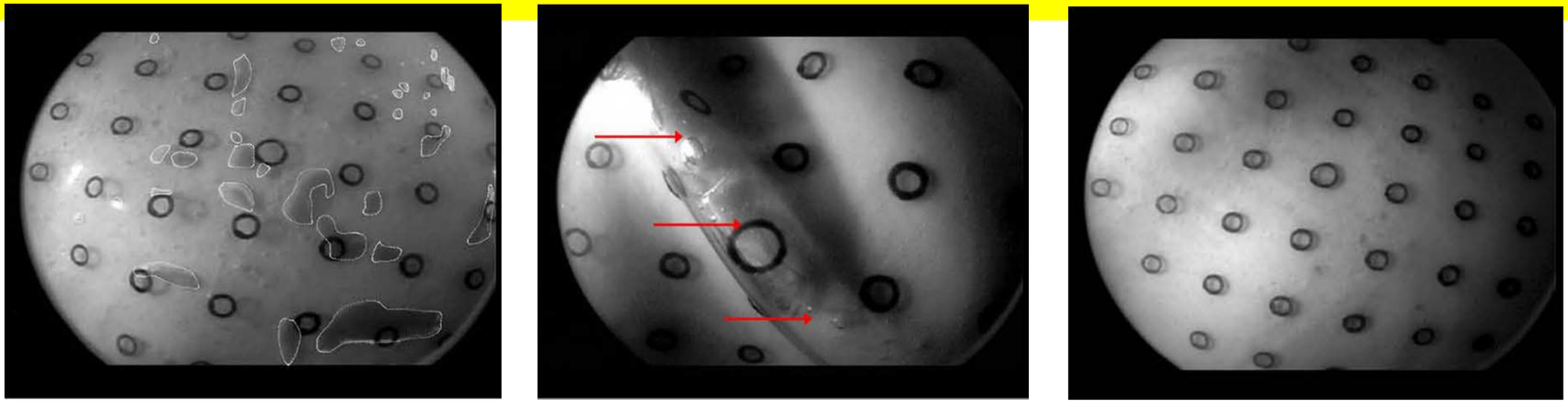
SW source mounted in a "therapy head," capped by a thin rubber membrane filled with water (water cushion)

- Συνεχής κυκλοφορία – απαέρωση του νερού
- Πιο βολικός σχεδιασμός στην κλινική πράξη
- Λιγότερο αποτελεσματική ζεύξη εγγενώς (μεμβράνη)

✓ Παρουσία μεμβράνης → επιπλέον επιφάνειες ανάκλασης

✓ Η παρουσία μικρών φυσαλίδων αέρα μεταξύ μεμβράνης – δέρματος είναι σχεδόν αδύνατο να αποφευχθεί

✓ Έλλειμμα κάλυψης 2% → 20–40% ↓ κατακερματισμού in vitro



Ωστόσο, ο βολικός σχεδιασμός φαίνεται να βαρύνει πιο πολύ από τα θέματα της επίδοσης

Βελτιστοποίηση της σύζευξης (πρακτικές οδηγίες)

1. Ξύρισμα δέρματος
2. Χρήση γέλης υπερήχων ελεύθερης φυσαλίδων
3. Διανομή από μπουκάλι/δοχείο με άνοιγμα μεγάλης διαμέτρου – όχι μέσο μικρού ακροφυσίου
4. Εφαρμογή λογικής ποσότητας στο κέντρο της κεφαλής με μορφή σωρού – αποφυγή ομοιόμορφης εφαρμογής
5. Φούσκωμα μαξιλαριού – καλή εφαρμογή με δέρμα
6. Παρακολούθηση διατήρησης της ζεύξης κατά τη διαδικασία και διόρθωση εφόσον χρειάζεται
7. Συντήρηση της μεμβράνης με σκούπισμα στο τέλος κάθε συνεδρίας ή αλλαγής θέσης

Bohris et al. J Urol. 2012;187:157-63

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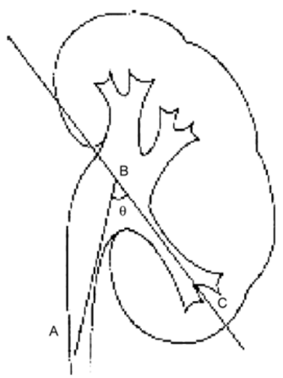
Προϋποθέσεις για καλό κατακερματισμό των λίθων

Χ. Μαμουλάκης

UROSchool 2013

A) (Δυσμενείς) Παράγοντες σχετιζόμενοι με το λίθο

- Μέγεθος > 2cm
- Εντόπιση (κάτω καλυκική ομάδα*, κάτω 3-μόριο ουρητήρα)



*Ανατομία κάτω κάλυκα:

- ✓ Οξεία αυχενο-πυελική γωνία (<70°)
- ✓ Μακρύς κάλυκας (> 10 mm)
- ✓ Στενός αυχένας κάλυκα (< 5 mm)

- Σύσταση: βρουσίτης, μονουδρικό οξαλικό ασβέστιο, κυστίνη

  (CT-HU > 900-1000)

B) (Δυσμενείς) Παράγοντες σχετιζόμενοι με τον ασθενή

- Σοβαρές σκελετικές ανωμαλίες
- Παχυσαρκία (BMI>30)
- Απόσταση δέρματος–λίθου (>9-10 cm)

Παράγοντες σχετιζόμενοι με την εκτέλεση της ESWL (best clinical practice)

- Σωστή θέση – Επίτευξη βέλτιστης ακουστικής σύζευξης
- Αριθμός κρουστικών κυμάτων = f (λιθοτρίπτη – ενέργειας): Δεν υπάρχει ομοφωνία για το μέγιστο αριθμό κρούσεων
- Τρόπος χορήγησης κρουστικών κυμάτων (power ramping)
- Συχνότητα κρουστικών κυμάτων (60-90/min: 1.0-1.5 Hz)

Current standard: low-to-moderate acoustic pressures with as few shock waves as possible, at a slow shock wave rate"

- Προσεκτική παρακολούθησης εστίασης (ακτινοσκοπικά/US)
- Προσεκτικός έλεγχος του πόνου (περιορισμός κινήσεων)

Δ) Παράγοντες σχετιζόμενοι με τον λιθοτρίπτη

Table 1

Treatment strategies to improve outcomes and reduce adverse effects

Strategy	Effect	References
Slow shock wave rate (<120 shock waves per min)	Improved success rates	Pace *et al.* (2005)[46] Yilmaz *et al.* (2005)[47] Madbouly *et al.* (2005)[48] Chacko *et al.* (2006)[49] Kato *et al.* (2006)[50] Weiland *et al.* (2007)[51] Meta-analysis: Semins *et al.* (2008)[52]
Slow shock wave rate	Reduced renal injury	Animal studies: Evan *et al.* (2007)[56] Evan *et al.* (2007)[57]
Step-wise power ramping	Low complication rate	Mobley *et al.* (1993)[69]
Two-step power ramping	Reduced kidney injury	Animal study: Willis *et al.* (2006)[16]
Brief pause between ramping steps	Reduced renal injury	Animal study: Connors *et al.* (2009)[18] Vasoconstriction as potential mechanism: Handa *et al.* (2009)[17]
Minimal handling of gel; proper method of applying gel	Reduced coupling defects	*In vitro* study: Neucks *et al.* (2008)[55]

Table 4

ctors influencing the success of extracorporeal shock wave lithotripsy

actor for success	Options	Specific modifications	Advantages	Comments/problems
Shock wave generation and focussing	Electrohydraulic with ellipsoid reflector	Spark electrode	Large focus	Variability of pulses
				One electrode per session
		Twin heads	Lower energy density	Coupling from two sites is difficult
		Electroconductive	No variability of pulses 40 000 shock waves	-
	Electromagnetic	Coil membrane with acoustic lens	Extension of focal zone by prolonged pulse duration	Advantage of larger focal zone not clinically proven
		Cylinder with paraboloid reflector	Dual focus by different pulse duration (ie, for renal and ureter stones)	Advantage of dual focus not clinically proven
		Spherical element	Very large focal zone	Not available in Europe
	Piezoelectric	Spherical alignment with two layers	Three focal sizes	Advantage of triple focus not clinically proven
Coupling of shock waves	Water bath	Complete (Dornier HM3)	Ideal coupling	No multifunctional use
		Partial (EDAP TMS Sonolith 2000, Richard Wolf PiezoLith 2200)		No longer manufactured
	Water cushion	Gel pad (abandoned)	Multifunctional use	20% attenuation of shock wave energy
		Coupling gel		Warm ultrasound gel from container
				High amounts on cushion
				Shave skin of patient
				Check quality of coupling by inline ultrasound
Stone localisation	Fluoroscopic C-arm	Automated positioning	Reduction of x-ray exposure	Fluoroscopy first choice worldwide
	Inline fluoroscopy	Optical tracking	Reduction of x-ray exposure	Camera checks position of shock wave source
		Acoustic tracking	Adaptation to external C-arm	Five piezoelectric elements track the position of the shock wave source
	Inline ultrasound	-	Real-time shock wave application	Difficult in obese patients and midureteral stones
			Control of coupling quality	
	Lateral ultrasound	Tri-mode localisation system (isocentric)	-	5 mm tolerance (range: 3–9 mm) to inline ultrasound

Πόσες λιθοτριψίες και μετά από ποιό χρονικό διάστημα;

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Α. Παπατσώρης

There are no conclusive data on the intervals required between repeated SWL sessions. However, clinical experience indicates that repeat sessions are feasible (within 1 day for ureteral stones).

Statement	LE
Clinical experience has shown that repeat sessions are feasible (within 1 day for ureteral stones).	4

EAU Guidelines, Urolithiasis, Update March 2013

- **Σε κυτταρικό επίπεδο επούλωση νεφρικής κάκωσης διαπιστώνεται σε 1-2 εβδομάδες (δείκτης απόπτωσης)**

The Scientific World Journal
Volume 2012, Article ID 619820, 6 pages

Urine cytology to evaluate urinary urothelial damage of shock-wave lithotripsy

Mahmoud Mustafa · Kuddusi Pancaroglu

transitional cells at cytologic examination after SWL was significantly influenced only by number of shock waves applied ($p = 0.003$). No muscle cell was detected in all cytologic examinations. The cytologic examinations which were done after 10 days of SWL therapy showed recovery from all cytologic abnormalities. The acute increment in number of transitional cells after the SWL is not clinically important and it is a temporary change. Urothelial lesion is limited to mucosal layer and there is no evidence of damage to basal membrane or deeper muscle layer. SWL safety on

Urol Res (2011) 39:223–227

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Ποια είναι η αξία της ESWL για μικρούς ασυμπτωματικούς καλυκικούς λίθους

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Α. Σκολαρίκος

BJU International (2001), **87**, 1–8

Preliminary results of a randomized controlled trial of prophylactic shock wave lithotripsy for small asymptomatic renal calyceal stones

F.X. KEELEY Jr, K. TILLING*, A. ELVES, P. MENEZES, M. WILLS, N. RAO† and R. FENELEY

*Bristol Urological Institute, Southmead Hospital, Bristol, *Department of Public Health Sciences, Kings College, London, and †Withington Hospital, Manchester, UK*

Table 3 Details of the kidney stones and outcome at the most recent follow-up

Variable	*Observation* n = 99, n *(%)*	*ESWL* n = *101*, n *(%)*	*OR* (95% CI)*	P	*Adjusted OR (95% CI)*	*Adjusted* P
Stone-free	16 (17)	28 (28)	1.95 (0.97–3.89)	0.06	1.58 (0.68–3.67)	0.29
LRF	56 (58)	29 (30)	0.30 (0.17–0.55)	0.0001	0.26 (0.12–0.57)	0.001
Improved KUB	27 (28)	43 (44)	2.03 (1.12–3.69)	0.019	2.16 (1.09–4.24)	0.026
Visited GP	24 (24)	21 (21)	0.84 (0.43–1.64)	0.61	0.98 (0.45–2.11)	0.95
Requirement for additional treatment	21 (21)	15 (15)	0.66 (0.32–1.37)	0.27	0.61 (0.27–1.40)	0.25
Prescribed analgesics	17 (17)	8 (8)	0.41 (0.17–1.01)	0.05	0.57 (0.21–1.53)	0.27

*OR of <1 indicates that the outcome is less likely in the ESWL than in the control group; †Adjusted for confounding variables listed in the text; LRF, large residual fragments (combined diameter >5 mm).

Table 4 Symptoms and blood test results at the final follow-up

Variable	*Observation*	*ESWL*	*OR (95% CI)*	P*
No. of patients	99	101		
Symptoms during preceding 6 months, *n* (%):				
Kidney pain	20 (22)	22 (24)	1.11 (0.56–2.22)	0.76
Pain passing urine	4 (4)	6 (7)	1.5 (0.41–5.50)	0.54
Backache	42 (44)	31 (32)	0.61 (0.34–1.10)	0.10
Used painkillers	17 (17)	18 (18)	1.21 (0.54–2.68)	0.65
Urinary infection	2 (2)	7 (7)	3.5 (0.71–17.31)	0.10
Blood in urine	6 (6)	6 (6)	0.97 (0.30–3.11)	0.96
Frequent urine	13 (14)	18 (19)	1.38 (0.64–3.02)	0.41
No pain from kidneys today	80 (82)	87 (90)	1.85 (0.80–4.27)	0.15
Blood tests:				
No. of patients	74	76		
Median (range) serum level of:				
Urea, mmol/L	5.2 (2.9–11)	5.5 (2.4–10.3)		0.89
Creatinine, µmol/L	104 (72–832)	101 (64–862)		0.13
Calcium, mmol/L	2.38 (0.31–2.62)	2.36 (0.37–2.60)		0.28
Phosphate, mmol/L	1.02 (0.57–1.43)	1.03 (0–1.63)		0.48
Urate, mmol/L	0.55 (0.16–0.35)	0.52 (0–0.32)		0.16

*P from testing the hypothesis that the control and ESWL population proportions or medians are equal at the final follow-up.

Τοποθέτηση pigtail ή όχι πριν την εξωσωματική;

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Α. Παπατσώρης

5.5.2 ***Stenting before carrying out extracorporeal shock wave lithotripsy***

5.5.2.1 Stenting in kidney stones

Routine use of internal stents before SWL does not improve SFR (LE: 1b) (7). A JJ stent reduces the risk of renal colic and obstruction, but does not reduce formation of steinstrasse or infective complications (8).

However, stone particles may pass along stents while urine flows in and around the stent. This usually prevents obstruction and loss of ureteral contractions. Occasionally, stents do not efficiently drain purulent or mucoid material, increasing the risk of obstructive pyelonephritis. If fever occurs and lasts for a few days despite proven correct stent position, the stent must be removed and replaced by a new JJ stent or a percutaneous nephrostomy tube, even when US does not reveal any dilatation. (panel consensus)

5.5.2.2 Stenting in ureteral stones

The 2007 AUA/EAU Guidelines on the management of ureteral calculi state that routine stenting is not recommended as part of SWL (9). When the stent is inserted, patients often suffer from frequency, dysuria, urgency, and suprapubic pain (10).

Recommendation	LE	GR
Routine stenting is not recommended as part of SWL treatment of ureteral stones.	1b	A

EAU Guidelines, Urolithiasis, Update March 2013

Use of Ureteral Stent in Extracorporeal Shock Wave Lithotripsy for Upper Urinary Calculi: A Systematic Review and Meta-Analysis

Shen Pengfei, Jiang Min, Yang Jie, Li Xiong, Li Yutao, Wei Wuran, Dai Yi, Zeng Hao* and Wang Jia*

- **8 randomized controlled studies (453 vs 423 pts)**
- **Stenting did not benefit stone-free rate and auxiliary treatment after ESWL**
- **Stenting induced lower urinary tract symptoms**

J Urol 2011;186:1328

BJUI

Ureteric stents compromise stone clearance after shockwave lithotripsy for ureteric stones: results of a matched-pair analysis

Athanasios N. Argyropoulos and David A. Tolley

BJUI 2008;103:76

Extracorporeal Shock Wave Lithotripsy for Ureteral Stones: Do Decompression Tubes Matter?

Seshikanth Middela, Georgios Papadopoulos, Shalom Srirangam, and Poduri Rao

Urology 2010;76:821

The effects of JJ stent placement on upper urinary tract motility and calculus transit

- Canine models
- Acute effects: raised intrarenal pressure, reduced pelvic and ureteric motility, delayed calculus transit time
- Prolonged effects: return of normal intrarenal pressure, persistent motility changes and delayed calculus transit

Ryan et al. Br J Urol 1994;74:434

ESWL of middle ureteral stones: are ureteral stents necessary?

- 33 pts
- Pre-treatment stenting did not provide any advantage

Nakada et al. Urology 1995;46:649

Επηρεάζει ή όχι η ύπαρξη υδρονέφρωσης το αποτέλεσμα της εξωσωματικής;

6ο Ελληνικό Διαδραστικό Σχολείο Ουρολογίας
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Α. Παπατσώρης

Impact of the degree of hydronephrosis on the efficacy of insitu extracorporeal shock-wave lithotripsy for proximal ureteral calculi

- 284 pts, prospective randomized study
- Stone-free rate: 80% vs 89% (p=0.012)
- Hydronephrosis was highly associated with re-treatment (2.4 vs 1.7; p< 0.001) and prolonged clearance time (16.2 vs 11.6 days; p< 0.001)

El-Assmy et al. Urology 2007;69:431

Does Degree of Hydronephrosis Affect Success of Extracorporeal Shock Wave Lithotripsy for Distal Ureteral Stones?

Ahmed El-Assmy, Ahmed R. El-Nahas, Ramy F. Youssef, Ahmed S. El-Hefnawy, and Khaled Z. Sheir

Urology 2007;69:431

Extracorporeal Shock Wave Lithotripsy in the Treatment of Proximal Ureteral Stones: Does the Presence and Degree of Hydronephrosis Affect Success?

Christian Seitz, Harun Fajkovic, Matthias Waldert, Enis Tanovic, Mesut Remzi, Gero Kramer, Michael Marberger*

Eur Urol 2006;49:378

Impact of hydronephrosis on treatment outcome of solitary proximal ureteral stone after ESWL

- 182 pts
- In multivariate analysis, hydronephrosis and stone size were stone-free predictors
- < 1cm stone: stone-free rate 80% vs 56% (mild vs moderate-severe hydronephrosis)
- > 1cm stone: stone-free rate 65% vs 33% (mild vs moderate-severe hydronephrosis)

Hsiao et al. Kaohsiung 2008;24:507

Is pre-shock wave lithotripsy stenting necessary for ureteral stones with moderate or severe hydronephrosis?

- 186 pts, prospective randomized study
- JJ did not affect the stone-free rate (85% vs 92%)
- No statistical difference in the re-treatment rate, flank pain, temperature
- JJ group with statistically more stent-related symptoms

El-Assmy et al. J Urol 2006;176:2056

Χρειάζεται ή όχι ΜΕΤ μετά την εξωσωματική

Χ. Μαμουλάκης

Recommendations for MET	LE	GR
For MET, α-blockers are recommended.	1a	A
Patients should be counseled about the attendant risks of MET, including associated drug side effects, and should be informed that it is administered off-label[†]**.		A*
Patients, who elect for an attempt at spontaneous passage or MET, should have well-controlled pain, no clinical evidence of sepsis, and adequate renal functional reserve.		A
Patients should be followed once between 1 and 14 days to monitor stone position and be assessed for hydronephrosis.	4	A*

5.3.2.6 Duration of medical expulsive therapy treatment

Most studies have had a duration of 1 month or 30 days. No data are currently available to support other time-intervals.

5.3.2.3 Medical expulsive therapy after extracorporeal shock wave lithotripsy (SWL)

Clinical studies and several meta-analyses have shown that MET after SWL for ureteral or renal stones can expedite expulsion and increase SFRs and reduce analgesic requirements (7,12,41-49) (LE: 1a).

EAU guidelines, 2013

α-Blockers to assist stone clearance after extracorporeal shock wave lithotripsy: a meta-analysis

BJUI
BJU INTERNATIONAL

Yefang Zhu*, Diederick Duijvesz†, Maroeska M. Rovers‡ and Tycho M. Lock*§

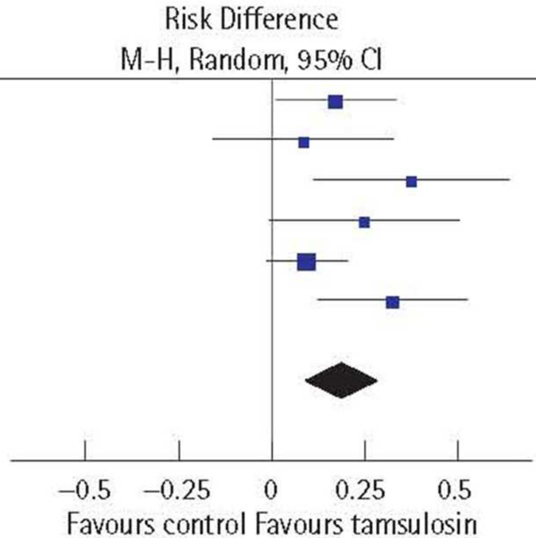
Zhu *et al.* BJU Int. 2010;106:256-61

FIG. 3. Forest plots with: stone clearance as the outcome for tamsulosin 0.4 mg; and expulsion time as the outcome.

Study or Subgroup	Tamsulosin Events	Tamsulosin Total	Control Events	Control Total	Weight	Risk Difference M-H, Random, 95% CI
[24]	28	29	23	29	20.6%	0.17 [0.01, 0.33]
[25]	20	30	18	31	12.1%	0.09 [–0.16, 0.33]
[27]	17	24	8	24	10.7%	0.38 [0.11, 0.64]
[28]	23	28	12	21	11.2%	0.25 [–0.00, 0.50]
[29]	48	51	55	65	29.7%	0.10 [–0.01, 0.20]
[30]	31	40	18	40	15.7%	0.33 [0.12, 0.53]
Total (95% CI)		202		210	100.0%	0.19 [0.10, 0.29]
Total events	167		134			

Heterogeneity: $Tau^2 = 0.01$; $Chi^2 = 7.90$, df = 5 (P = 0.16); $I^2 = 37\%$

Test for overall effect: Z = 3.88 (P < 0.001)

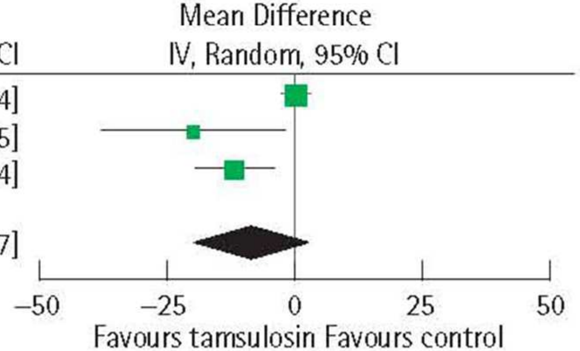


NNT = 5

Study or Subgroup	Tamsulosin Mean	Tamsulosin SD	Tamsulosin Total	Control Mean	Control SD	Control Total	Weight	Mean Difference IV, Random, 95% CI
[25]	13.22	4.73	30	12.95	6.92	31	42.9%	0.27 [–2.70, 3.24]
[26]	15.66	6.14	38	35.47	53.7	34	20.7%	–19.81 [–37.97, –1.65]
[29]	35.53	19.47	51	47.22	23.64	65	36.4%	–11.69 [–19.54, –3.84]
Total (95% CI)			119			130	100.0%	–8.24 [–19.54, 3.07]

Heterogeneity: $Tau^2 = 75.25$; $Chi^2 = 11.74$, df = 2 (P = 0.003); $I^2 = 83\%$

Test for overall effect: Z = 1.43 (P = 0.15)



Pain and usage of analgesics was reported in 4 RCTs: lower for tamsulosin

sulosin as adjunctive treatment after shockwave lithotripsy in patients with upper urinary tract stones: A systematic review and meta-analysis

SHUO ZHENG, LIANG REN LIU, HAI CHAO YUAN & QIANG WEI

Zheng et al. S, Scand J Urol Nephrol. 2010;44:425-32

Study or Subgroub	Tamsulosin Events	Tamsulosin Total	Control Events	Control Total	Weight	Risk ratio M-H, Random, 95% CI	Year
1.1.1 Tamsulosion 0.4 mg							
KÜPELI B 2004 [24]	17	24	8	24	2.3%	2.13 [1.14, 3.96]	2004
Gravina GL 2005 [11]	51	65	39	65	8.5%	1.31 [1.03, 1.66]	2005
Gravas S 2007 [12]	20	30	18	31	4.7%	1.15 [0.78, 1.70]	2007
Bhagat SK 2007 [2]	28	29	23	29	9.8%	1.22 [1.00, 1.48]	2007
Micali S 2007 [8]	23	28	12	21	4.4%	1.44 [0.96, 2.16]	2007
Wang HJ 2008 [16]	31	40	18	40	4.9%	1.72 [1.18, 2.52]	2008
Naja V 2008 [15]	27	51	20	65	3.9%	1.72 [1.10, 2.69]	2008
Wang CJ 2009 [20]	29	34	31	38	9.5%	1.05 [0.85, 1.28]	2009
Agarwal MM 2009 [18]	11	20	5	20	1.3%	2.20 [0.93, 5.18]	2009
Tajari H 2009 [6]	68	80	64	80	11.8%	1.06 [0.92, 1.23]	2009
Hussein MM 2010 [21]	49	67	38	69	7.8%	1.33 [1.03, 1.72]	2010
Subtotal (95% CI)		**468**		**482**	**68.9%**	**1.29 [1.14, 1.47]**	
Total events	354		276				

Heterogeneity: $Tau^2 = 0.02$; $Chi^2 = 20.99$, df = 10 (P = 0.02); $I^2 = 52\%$
Test for overall effect: Z = 3.89 (P < 0.0001)

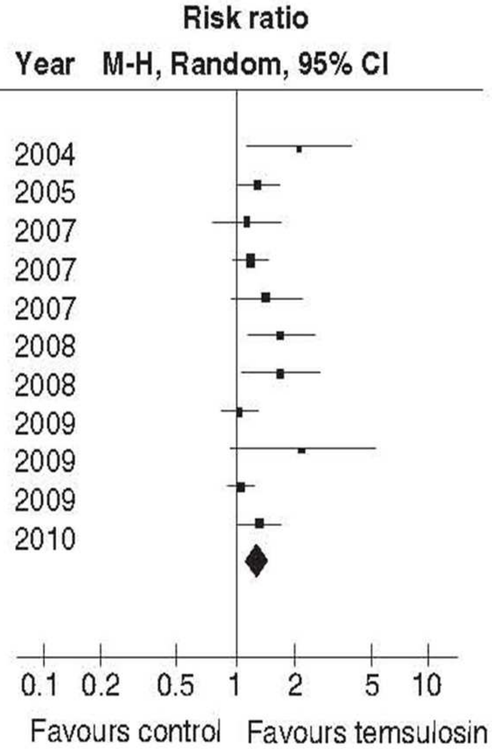
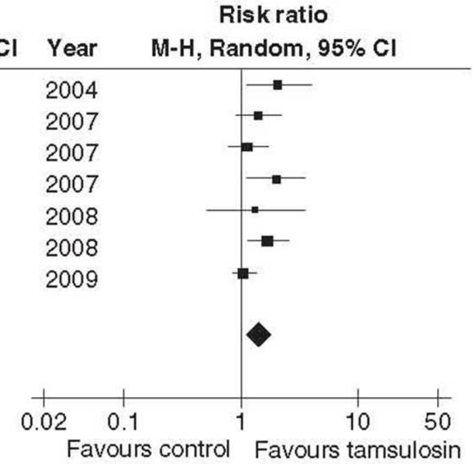


Figure 1. Pooled stone clearance of tamsulosin

A.

Study or Subgroup	Tamsulosin Events	Tamsulosin Total	Control Events	Control Total	Weight	Risk ratio M-H, Random, 95% CI	Year
KÜPELI B 2004 [24]	17	24	8	24	9.8%	2.13 [1.14, 3.96]	2004
Micali S 2007 [8]	23	28	12	21	15.9%	1.44 [0.96, 2.16]	2007
Gravas S 2007 [12]	20	30	18	31	16.5%	1.15 [0.78, 1.70]	2007
QUAN WH 2007 [13]	19	24	9	23	11.5%	2.02 [1.17, 3.50]	2007
Kim TH 2008 [14]	10	24	4	13	5.2%	1.35 [0.53, 3.48]	2008
Wang HJ 2008 [16]	31	40	18	40	16.9%	1.72 [1.18, 2.52]	2008
Wang CJ 2009 [20]	29	34	28	35	24.1%	1.07 [0.86, 1.32]	2009
Total (95% CI)		**204**		**187**	**100.0%**	**1.43 [1.13, 1.81]**	
Total events	149		97				

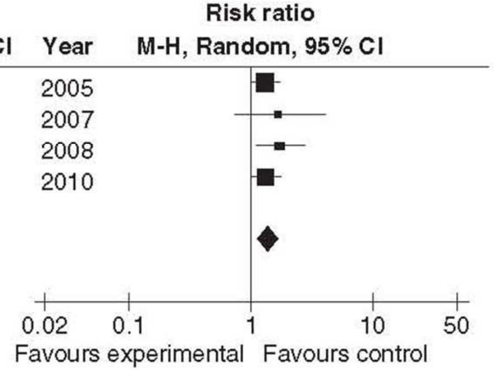
Heterogeneity: $Tau^2 = 0.05$; $Chi^2 = 12.51$, df = 6 (P = 0.05); $I^2 = 52\%$
Test for overall effect: Z = 2.97 (P < 0.003)



B.

Study or Subgroup	Tamsulosin Events	Tamsulosin Total	Control Events	Control Total	Weight	Risk ratio M-H, Random, 95% CI	Year
Gravina GL 2005 [11]	51	65	39	65	45.6%	1.31 [1.03, 1.66]	2005
QUAN WH 2007 [13]	8	14	5	15	3.5%	1.71 [0.73, 4.00]	2007
Naja V 2008 [15]	27	51	20	65	12.7%	1.72 [1.10, 2.69]	2008
Hussein MM 2010 [21]	49	67	38	69	38.2%	1.33 [1.03, 1.72]	2010
Total (95% CI)		**197**		**214**	**100.0%**	**1.38 [1.17, 1.61]**	
Total events	135		102				

Heterogeneity: $Tau^2 = 0.00$; $Chi^2 = 1.56$, df = 3 (P = 0.67); $I^2 = 0\%$
Test for overall effect: Z = 3.92 (P < 0.0001)



C.

Study or Subgroup	Tamsulosin Events	Tamsulosin Total	Control Events	Control Total	Weight	Risk ratio M-H, Random, 95% CI	Year
QUAN WH 2007 [13]	16	22	8	22	47.8%	2.00 [1.09, 3.68]	2007
Kim TH 2008 [14]	8	18	7	21	28.0%	1.33 [0.60, 2.95]	2008
Agarwal MM 2009 [18]	11	20	5	20	24.2%	2.20 [0.93, 5.18]	2009
Total (95% CI)		**60**		**63**	**100.0%**	**1.83 [1.20, 2.78]**	
Total events	35		20				

Heterogeneity: $Tau^2 = 0.00$; $Chi^2 = 0.87$, df = 2 (P = 0.65); $I^2 = 0\%$
Test for overall effect: Z = 2.80 (P = 0.005)

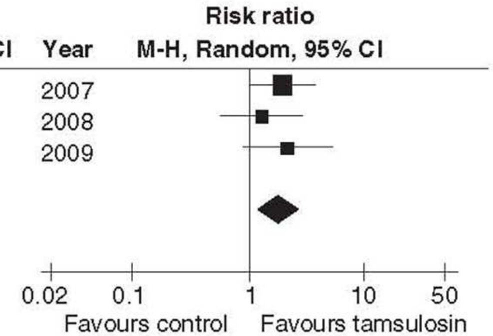
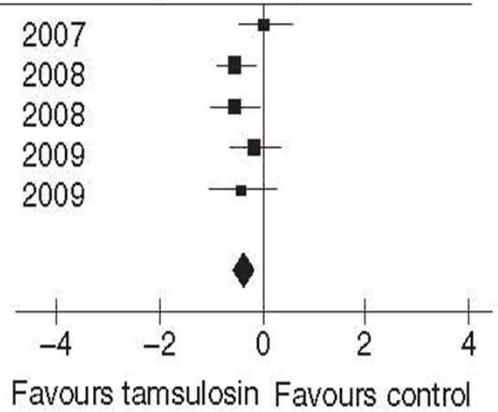


Figure 3. Pooled stone clearance rate of the upper urinary tract stones: (a) lower ureteral stone; (b) renal stone; (c) upper ureteral stone.

A.

Study or Subgroup	Tamsulosin Mean	Tamsulosin SD	Tamsulosin Total	Control Mean	Control SD	Control Total	Weight	Std. Mean difference IV, Random, 95% CI	Year
Gravas S 2007 [12]	13.22	4.73	30	12.95	6.92	31	17.8%	0.04 [−0.46, 0.55]	2007
Naja V 2008 [15]	35.53	19.47	51	47.22	23.64	65	29.8%	−0.53 [−0.90, −0.16]	2008
Kobayashi M 2008 [17]	15.66	6.14	38	35.47	53.7	34	20.0%	−0.53 [−1.00, −0.06]	2008
Wang CJ 2009 [20]	6.1	2.3	34	6.5	2.7	38	20.6%	−0.16 [−0.62, 0.31]	2009
Agarwal MM 2009 [18]	30.7	19.6	20	39	19.9	20	11.9%	−0.41 [−1.04, 0.22]	2009
Total (95% CI)			**173**			**188**	**100.0%**	**−0.34 [−0.56, −0.11]**	

Heterogeneity: $Tau^2 = 0.01$; $Chi^2 = 4.51$, df = 4 (P = 0.34); $I^2 = 11\%$
Test for overall effect: Z = 2.95 (P = 0.003)



B.

Study or Subgroup	Tamsulosin Mean	Tamsulosin SD	Tamsulosin Total	Control Mean	Control SD	Control Total	Weight	Std. Mean difference IV, Random, 95% CI	Year
Naja V 2008 [15]	28.67	20.35	51	47.3	24.98	65	42.4%	−0.80 [−1.18, −0.42]	2008
Liu Y 2009 [19]	1.98	2.08	53	3.11	2.6	65	42.1%	−0.48 [−0.86, −0.16]	2009
Agarwal MM 2009 [18]	25.3	17.9	20	38.3	28	20	15.4%	−0.54 [−1.17, 0.09]	2009
Total (95% CI)			**124**			**140**	**100.0%**	**−0.62 [−0.87, −0.38]**	

Heterogeneity: $Tau^2 = 0.00$; $Chi^2 = 1.48$, df = 2 (P = 0.48); $I^2 = 0\%$
Test for overall effect: Z = 4.93 (P < 0.00001)

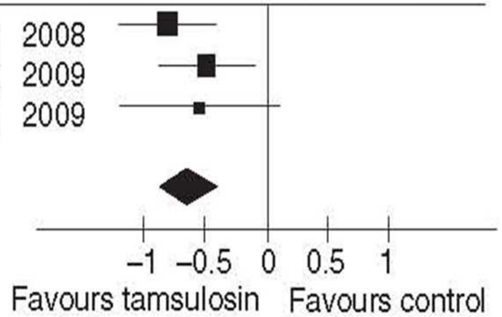


Figure 4. Pooled standardized mean difference of (a) expulsion time and (b) pain intensity. VAS = visual analogue scale.

6ο Ελληνικό Διαδραστικό Σχολείο Ουρολογίας
18-21/4/2013
Πορταριά Πήλιο

Ποια η τύχη και η σημασία των υπολειμματικών θραυσμάτων μετά την ESWL;

UROSchool 2013

Α. Σκολαρίκος

Table 1: Fate of residual stone fragments following SWL					
Series	**No of patients**	**Mean follow-up in months (range)**	**Stable (%)**	**Regrowth (%)**	**Stone free (Spontaneous passage) (%)**
Beck	53	26.6	11	78	11
Moon	248	6	-	-	92.7
Streem	160	23 (1.6-88.8)	43.5	10	46.5
Buchholz	55	54	12.7	2	85.3
Zanetti	129	12 (3-12)	43.5	10	46.5
Candau	83	40.6 (7-96)	29	37	34
Khaitan	81	15 (6-60)	17.3	58.7	24
Afshar*	26	46	31	69	-
Osman	76	57 (52-63)	27.3	21.4	51.3
El-Nahas	154	31 (7.3-80.2)	52.6	33.8	13.6

Table 2: Medical therapy effect on residual stone fragment activity.

Reference	Stone free		Stone size unchanged or decreased		Stone size increased**	
	Medical therapy	Control	Medical therapy	Control	Medical therapy	Control
Cicerello*	80.5%	36%	75%	52.6%	5%	47%
Soygur*	44.4%	12.5%	56.6%	25%	-	62.5%
Sarica*†	-	-	81.8%	27.2%	18.2%	72.8%
Fine	58.3%	38.4%	13.9%	0%	27.8%	61.6%
Wang* **	85%/80%	82%	-	-	-	-

6ο Ελληνικό Διαδραστικό Σχολείο Ουρολογίας
18-21/4/2013
Πορταριά Πήλιο

Συχνότητα Πρόληψη και αντιμετώπιση των επιπλοκών της ESWL;

UROSchool 2013

Α. Σκολαρίκος

Table 1 – Complications after ESWL for urinary stones

Immediate	Delayed
Related to stone fragments	Renal Function?
Infectious	Hypertension?
Tissue effects	Fertility?
• Renal (haematoma, haemorrhage)	
• Cardiovascular	
• Gastrointestinal	
• Genital system	
• Foetus	

Table 2 – Complications of ESWL related to stone fragments

Possible predisposing factors	Possible prevention measures
Hard stones	Alternative therapy for hard and large stones (PCNL, sandwich therapy)
Large stones	Stenting when treating large stones
Lower pole stones	Improve ESWL efficacy
Increased number of stones	
Impaired renal anatomy	
Increased shock wave rate	
Decreased shock wave energy	

Table 3 – Infectious complications following ESWL

Possible predisposing factors	Possible prevention measures
Pre-existing UTI	Treatment of pre-existing UTI
Infected calculi	Early diagnosis of UTI
Multiple stones	Prophylactic antibiotics when predisposing factors are present
Staghorn stones	Prophylactic antibiotics for all?
History of recurrent UTIs	
Urinary obstruction	
Instrumentation at the time of ESWL	

Table 4 – Possible renal effects of ESWL

Effect	Possible predisposing factor	Possible prevention measures
Acute		
Damage to vascular endothelium	Pre-existed hypertension	Use of different types of lithotriptor
Damage to nephron, renal tubules, and interstitium	Pre-existed renal disease	Decrease shock wave number, rate, and energy
Loss of corticomedullary demarcation	Increased shock wave number, rate, and energy	Use of two shock wave tubes
Increased excretion in urine of metabolites indicating renal damage	Increased patient age	Delivery of two shock-waves at carefully timed close intervals
Haematuria		
Haematoma		
Decrease in GFR		
Decrease in effective RPF		
Chronic		
New onset of hypertension?	Increased shock-wave number, rate, and energy	Decrease shock-wave number, rate, and energy
Perirenal Fibrosis	Increased patient age	
Loss of renal function		