

# Pediatric Urolithiasis: News trends in pediatric urosurgery



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# Pediatric stones

- Urinary stone disease is **increasingly** affecting the pediatric population

**Table 1** Age and gender distribution among pediatric stone formers

Age quartile (years)	1997		2000		2003	
	Male n (%)	Female n (%)	Male n (%)	Female n (%)	Male n (%)	Female n (%)
0–5	98 (60)	66 (40)	111 (54)	95 (46)	168 (55)	111 (45)
6–10	136 (57)	101 (43)	208 (53)	186 (47)	269 (57)	256 (43)
11–15	213 (44)	275 (56)	327 (45)	401 (55)	452 (49)	589 (51)
16–20	299 (26)	852 (74)	954 (27)	2645 (73)	1153 (23)	3766 (77)
Total	746 (37)	1294 (63)	1600 (32)	3327 (68)	2042 (30)	4722 (70)
p value	<0.0001		<0.0001		<0.0001	

The numbers in parentheses represent the percentages of male and female stone patients in each age group. The p value represents the difference in age distribution between males and females for the given year

- High recurrence rate as 55% at 5 years

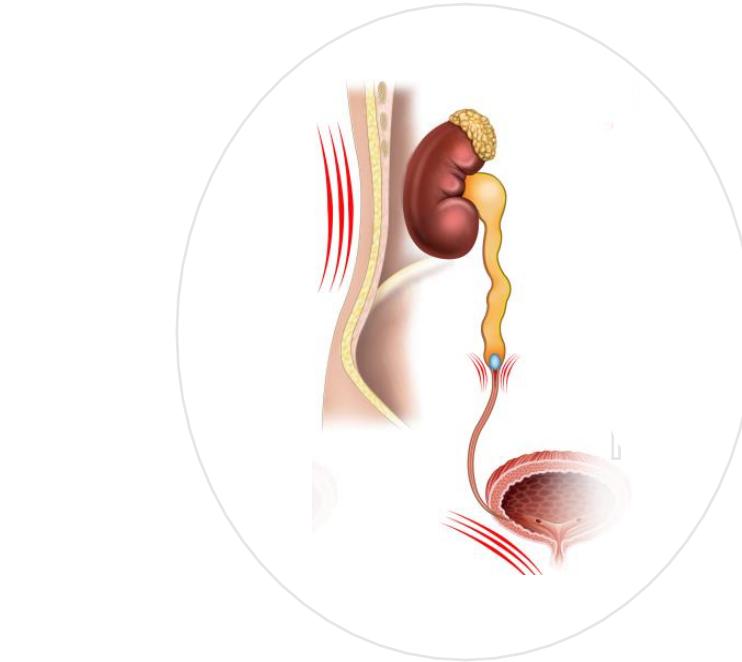
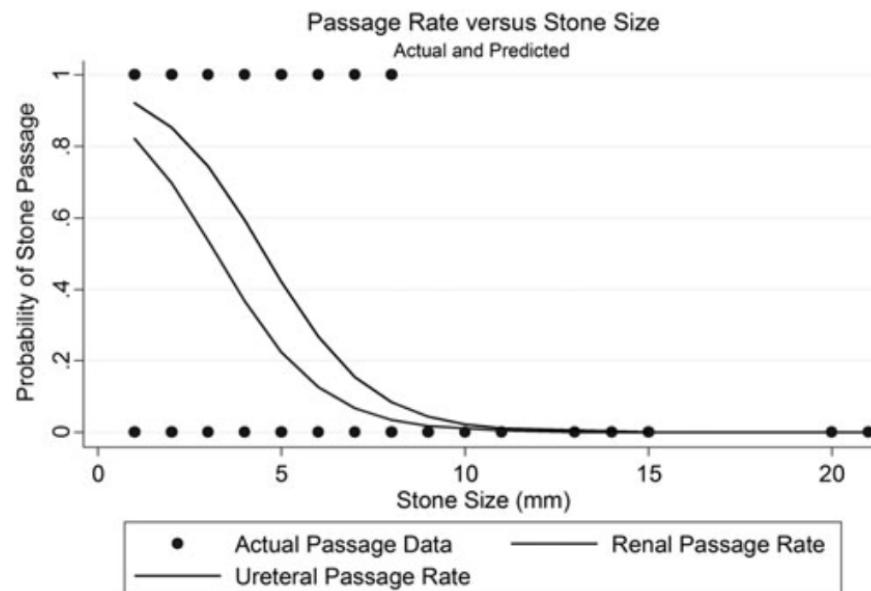
# Management of urolithiasis

- Indications to treat **do not differ** among adults and children
  - Extracorporeal shock wave lithotripsy (SWL)
  - Ureterorenoscopy (URS)
  - Percutaneous nephrolithotomy (PNL)
  - Laparoscopic surgery
- Management depends on stone size, location and composition, the anatomy of the tract and co-existing metabolic disorders

# Management of urolithiasis

## URETERAL STONES

- A size threefold of **3.5 mm** : higher likelihood for spontaneous ureteral stone passage



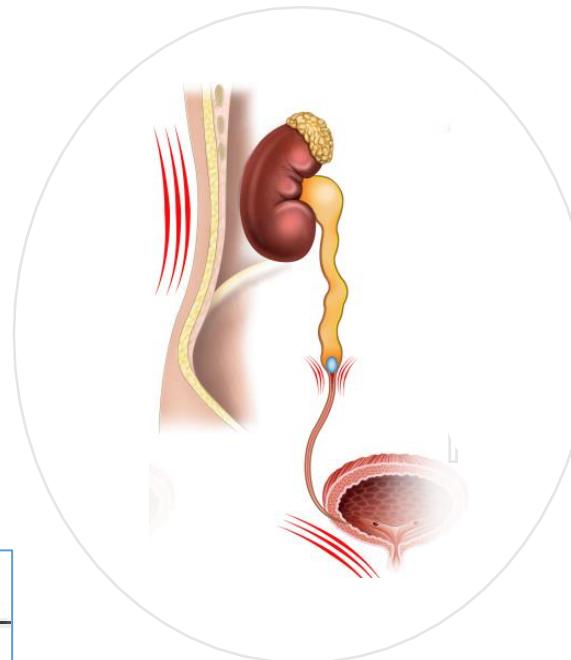
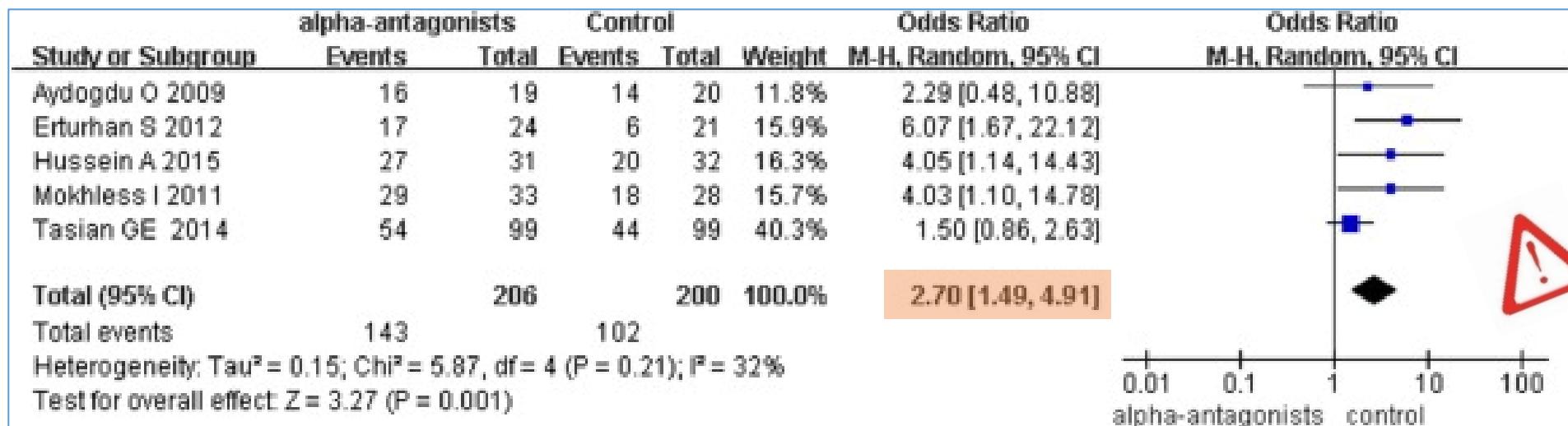
→ Watchful waiting

Dangle P et al. J Endourol (2016)

# Management of urolithiasis

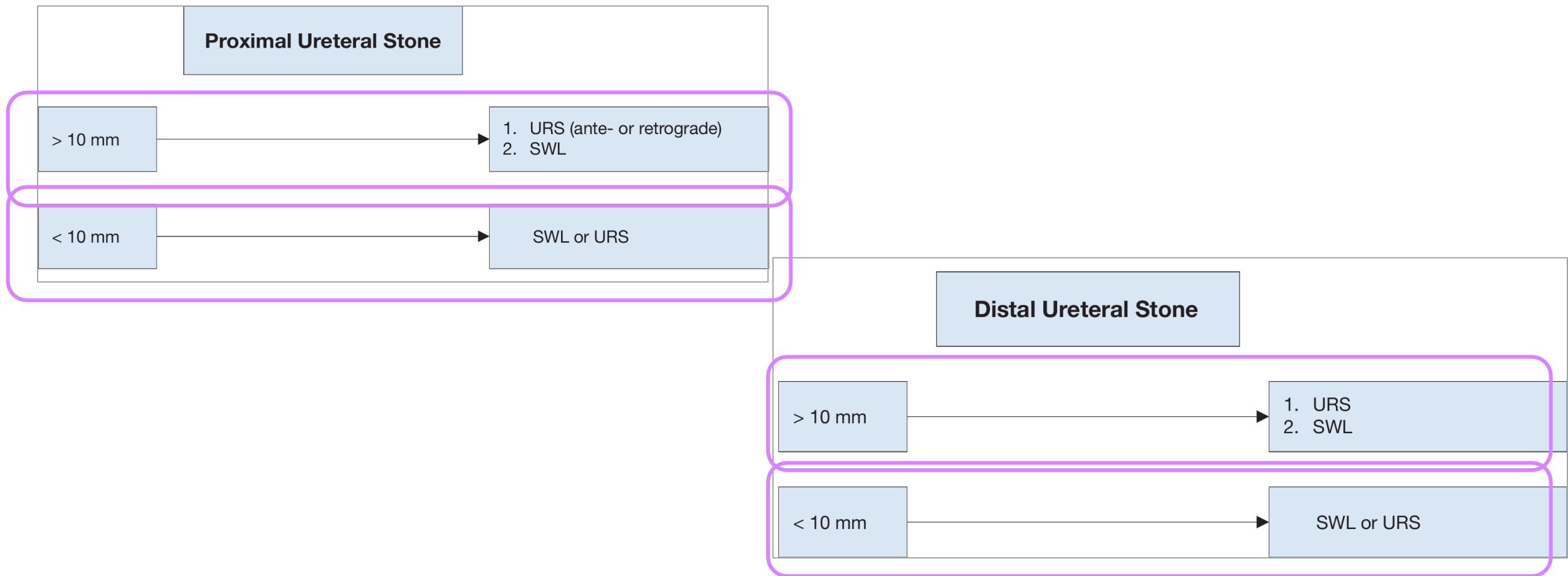
## URETERAL STONES

- Positive effect of **Medical Expulsive Therapy (MET)** for the distal ureteral stones



# Management of urolithiasis

## URETERAL STONES



# Management of urolithiasis

## URETERAL STONES

- SWL is still the first-line treatment for most ureteral stones in children
- Semi-Rigid ureteroscopy with holmium or pneumatic lithotripsy is increasingly used

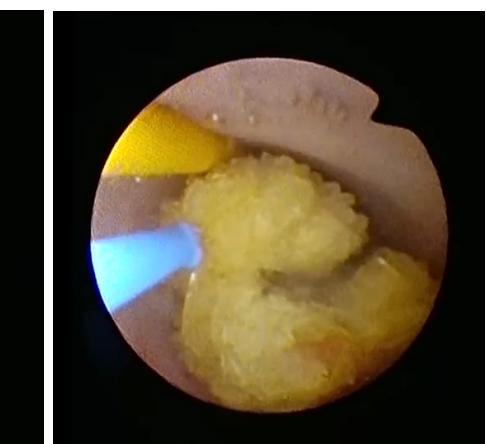
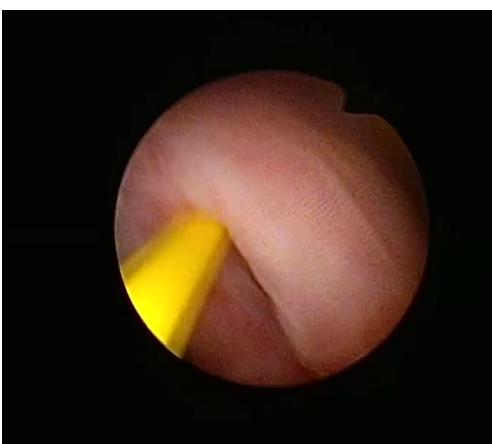


CO : 3.3 / 3.6 / 4.2 Ch  
Instruments Ch 3 max

# Management of urolithiasis

## URETERAL STONES

Semi-Rigid ureteroscopy



# Management of urolithiasis

## URETERAL STONES

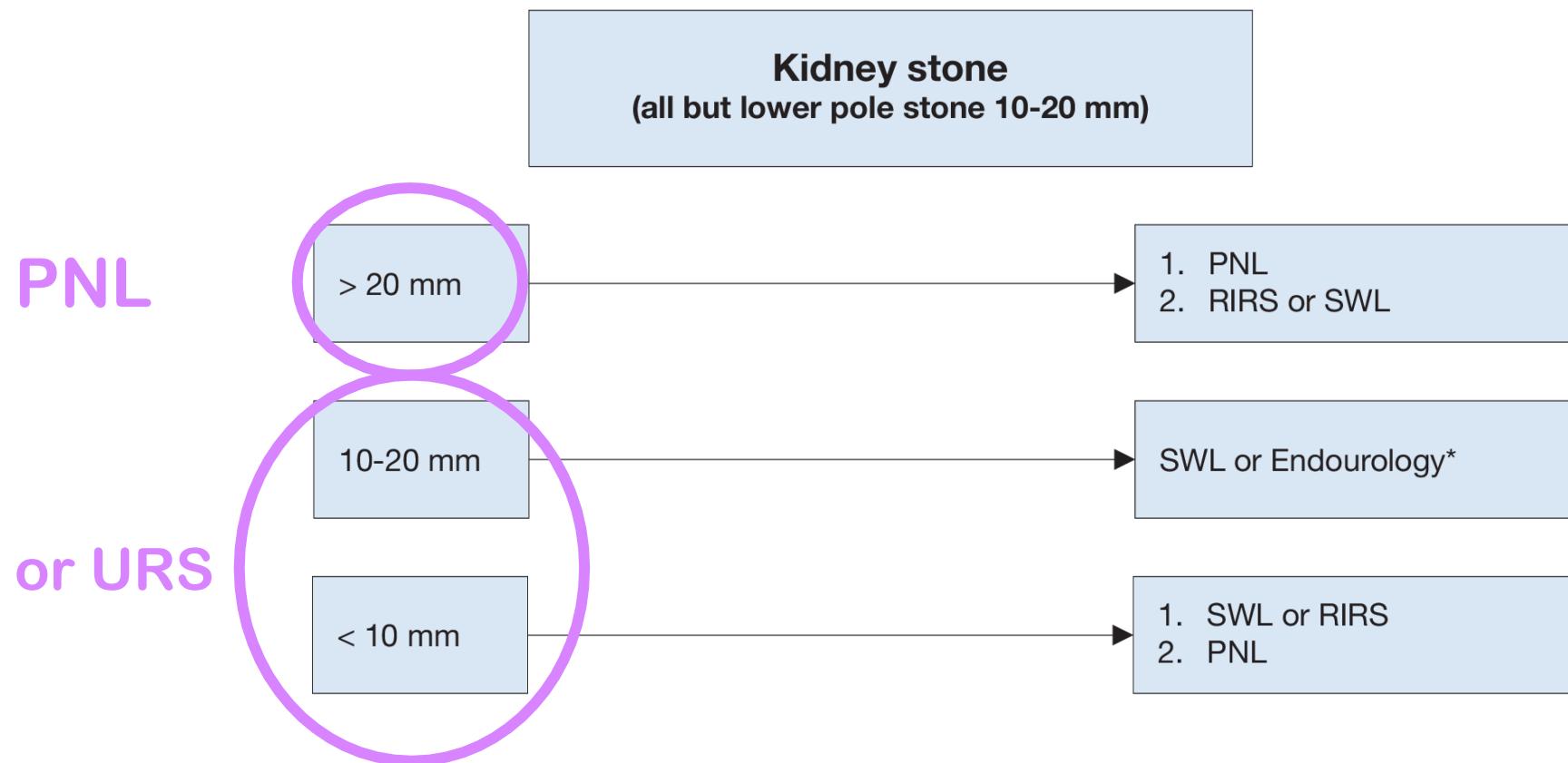
- SWL is still the first-line treatment for most ureteral stones in children
- Semi-Rigid ureteroscopy with holmium or pneumatic lithotripsy is increasingly used
  - SFR: 81-98%, retreatment rates: 6.3-10%, complication rates : 1.9-23%

Grivas N et al. J Pediat Urol (2020)

→ SWL vs URS : no conclusions can be drawn, low quality evidence

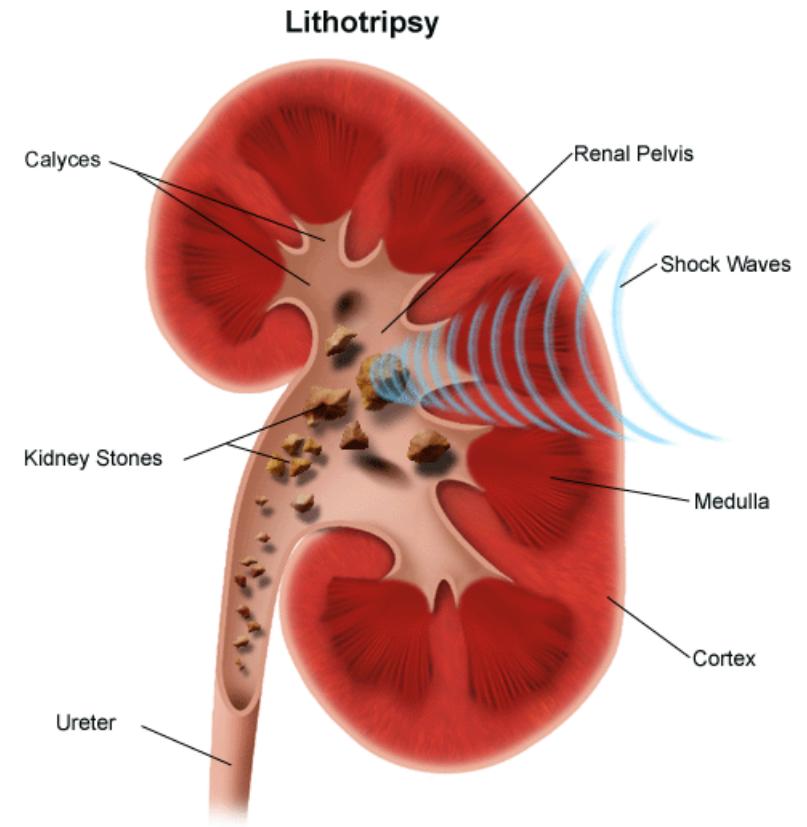
# Management of urolithiasis

## RENAL STONES



# Extracorporeal shock wave lithotripsy (SWL)

Treatment to be discussed in renal stones (excluding lower polar stones)  
between 10 and 20 mm



# Pediatric SWL

- Since 1986, ESWL remains the first-line treatment for minimally invasive management of pediatric stone in children

Muslumanoglu AY et al. J Urol (2003)

- Stone free rate (SFR) > 70% after 3 months

D'addessi A et al. J Endourol (2008)

- Single session SFR : 45%

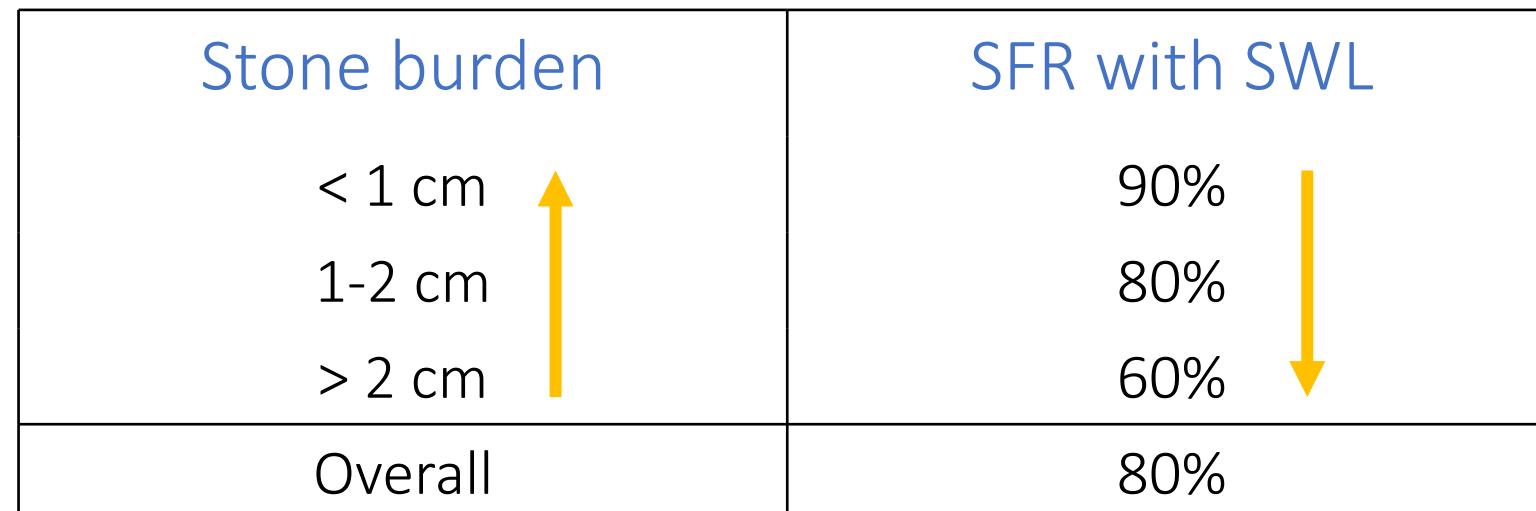
Half of children with renal stones <2 cm will require at least 2 procedures to achieve complete clearance

- Retreatment rates are high

Silay MS et al. Eur Urol (2017)

# Efficacy of SWL

- Significantly affected by various factors
- Stone size and location: the 2 most important predictors of success for SWL



Lu P et al. Urolithiasis (2015)  
Habib EI et al. J Pediatr Urol (2012)

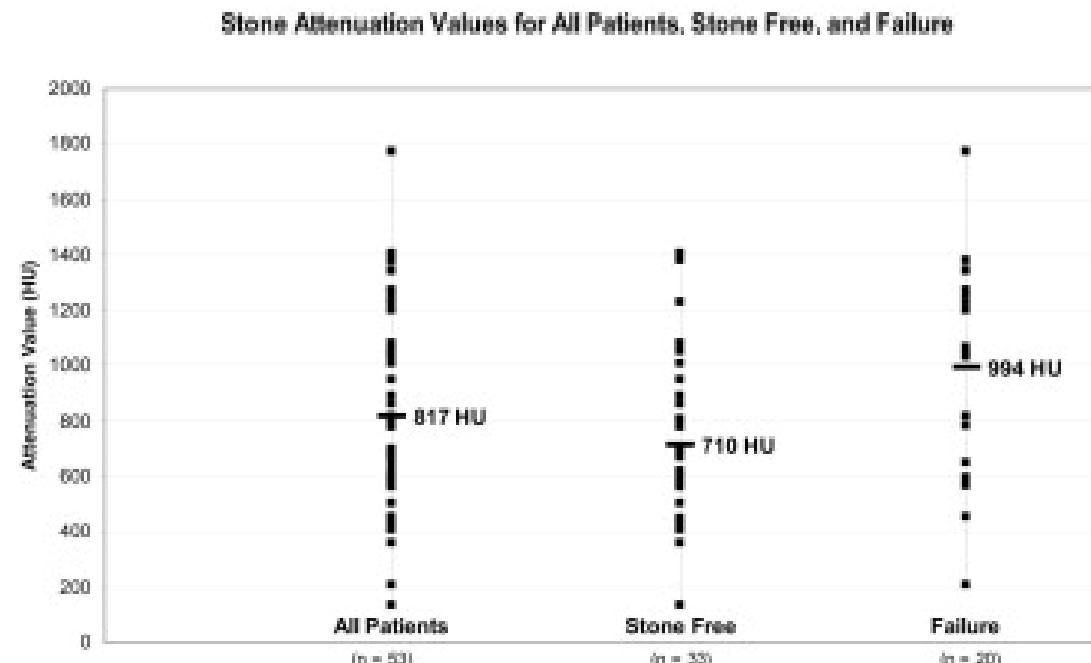
# Efficacy of SWL

- Significantly affected by various factors
- Stone size and location:
  - Lower calyceal stones have poorer clearance rate

Stone location	Stone clearance after a single session of SWL	Mean numbers of sessions required
Renal pelvis	84%	1.2
Upper calyx	87%	1.1
Lower calyx	67%	1.5

# SWL and stone composition

- SWL: more successful in stones with HU **less than 600 and 1000**



McAdams S et al. J Urol (2010)  
El-Assmy et al. J Urol (2013)



Cystinuria or primary hyperoxaluria respond poorly

# Type of SWL machine

- Second-generation lithotripter with small focal area



- Effectiveness of ultrasound-guided SWL

Grabsky AS et al. J Pediatr Urol (2021)

- Application of low frequency (60 shockwaves/sec)

	Group 60 (n=25)	Group 90 (n=25)	Group 120 (n=25)	p
Success; n (%)	16 (64.0)	16 (64.0)	8 (32.0)	<sup>a</sup> 0.032*
SFR after first session	10	7	5	
SFR after second session	6	5	2	
SFR after third session	0	4	1	
Complications (Clavien); n (%)	11 (44.0)	7 (28.0)	9 (36.0)	<sup>a</sup> 0.499
Grade 1	11	6	8	
Grade 2	0	1	1	
Additional interventions; n (%)	1 (4.0)	3 (12.0)	5 (20.0)	<sup>b</sup> 0.276
URS	1	3	1	
PNL	0	0	4	
Efficiency quotient (EQ); (%)	%41	%36	%17	<sup>a</sup> 0.143

Tuncer M et al. Urolithiasis (2021)

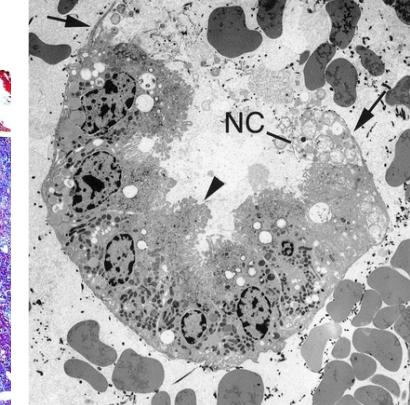
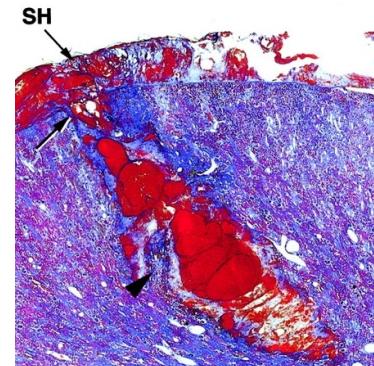
# Complications

- Well tolerated in children
- Complications rates < 15% in modern series
  - Ureteral obstruction secondary to streinstrasse formation

Dobrowiecka K et al. Dev Period Med (2018)

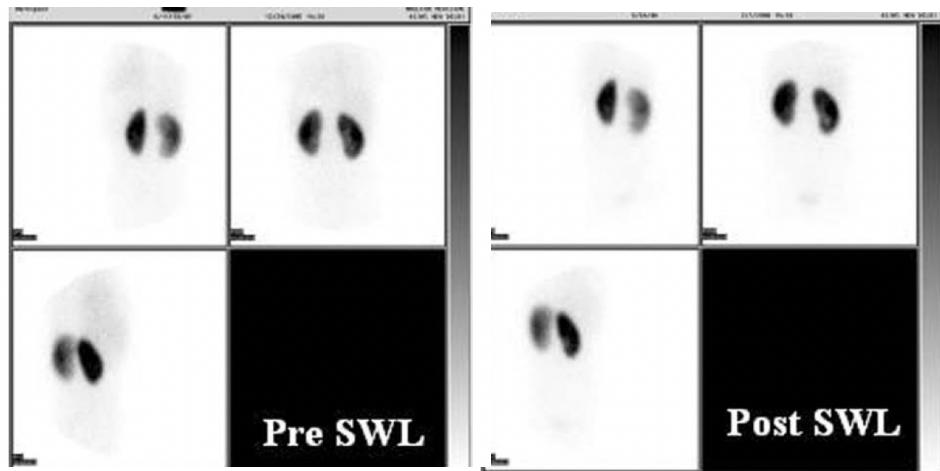
# Long-term outcomes ?

## Renal parenchymal damage

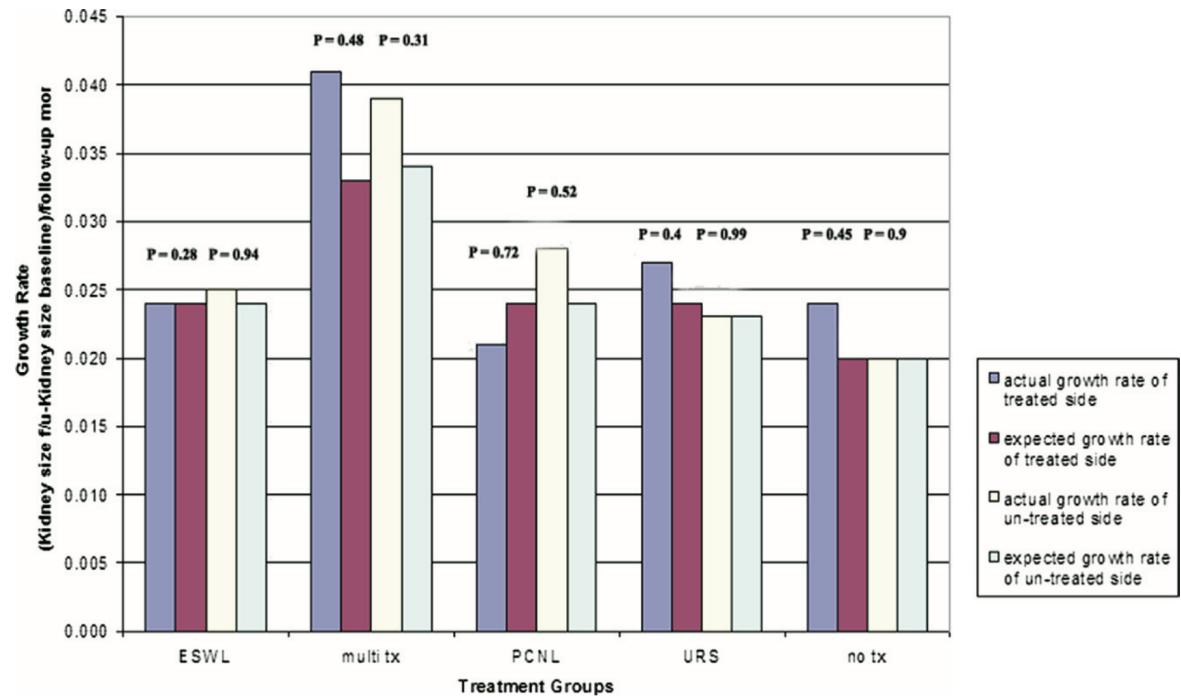


Shao et al. Anat Rec A Discov mol Cell Evol Biol (2003)

- No impact on long-term kidney function



Wadhwa P et al. J Endourol (2007)



# Efficacy of SWL

## Clinically insignificant residual fragments (CIRF)

- Residual fragments < 4mm
- 69% resulted in the adverse outcomes
  - 40% clinical symptoms
  - 21% growth

→ Close monitoring +++

**Table 2** Outcomes of residual fragments.

	p value
Spontaneous passage (%)	22/85 (25.8%)
According to stone location	<0.05 *
Renal pelvis	4/7 (57.1%)
Mid/upper pole	9/26 (34.6%)
Lower pole	5/31 (16.1%)
Multi-caliceal	4/21 (19.1%)
IPA	<0.05 *
$\geq 45^{\circ}$	7/15 (46.7%)
$<45^{\circ}$	0/11 (0%)
According to no. fragments	<0.05 *
Single (%)	15/50 (30%)
Multiple (% [median, range])	7/35 (20% [3, 2 – 4])
Growth in size (%)	18 (21.2%)
Stone related events (%)	34 (40%)
Renal colic	21 (24.7%)
Hematuria	14 (16.4%)
Urinary tract infection	5 (5.8%)
Secondary interventions (%)	25 (29.4%)

# Postural therapy for renal stones in children: A Rolling Stones procedure



CrossMark

A. Faure <sup>a,b</sup>, E. Dicrocco <sup>c</sup>, G. Hery <sup>b</sup>, R. Boissier <sup>c</sup>, L. Bienvenu <sup>d</sup>,  
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P. Alessandrini <sup>a</sup>, J.-M. Guys <sup>b</sup>, E. Lechevallier <sup>c</sup>



"The centrifugal force should help to  
dislodge your kidney stone."

# Postural therapy for renal stones in children: A Rolling Stones procedure

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## Forced-diuresis

30 min before the session  
<40kg 500mL  
>40Kg 1L

## Postural drainage

Inversion in prone  
Trendelenbourg position  
(45°-angle couch)

## Mechanical percussion

By a physiotherapist  
<40Kg 30Hz  
>40kg 50Hz

# Postural therapy for renal stones in children: A Rolling Stones procedure

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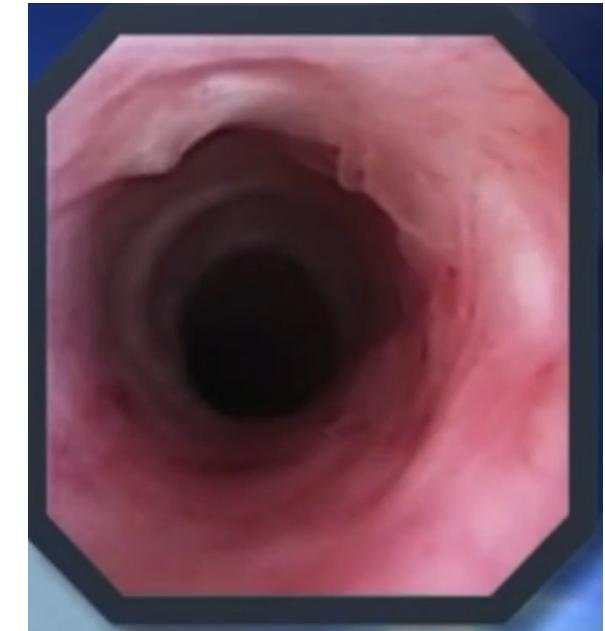
	Residual fragments after SWL ( <i>n</i> = 5) or URS ( <i>n</i> = 1)	Native symptomatic LCS ( <i>n</i> = 11)
Sex		
Male	5	8
Female	1	3
Number of PDI sessions (median by child)	26 4 (4–6)	56 4 (4–8)
Median age at PDI (range)	13 years (9–18)	10 years (18 months–14 years)
Median stone size (range)	5 mm (4–6)	5 mm (3–9)
Stone side		
Left	2	5
Right	2	7
Bilateral	0	0
Stone localisation		
Lower calyx	6	7
Middle calyx	0	4
Upper calyx	0	0
Pelvis	0	0
Stone composition		
Calcium oxalate	2	5
Cystine	2	1
Struvite	0	0
Undetermined	2	5
Complications	0	1 (renal colic)
Overall stone-free rate	63%	67%
Median reduction of the stone-area (range)	55% (41–67%)	57% (34–71%)
Observance	100%	100%
Median follow-up (range)	11 months (3–18)	10 months (1–16)

## Flexible URS (f-URS)

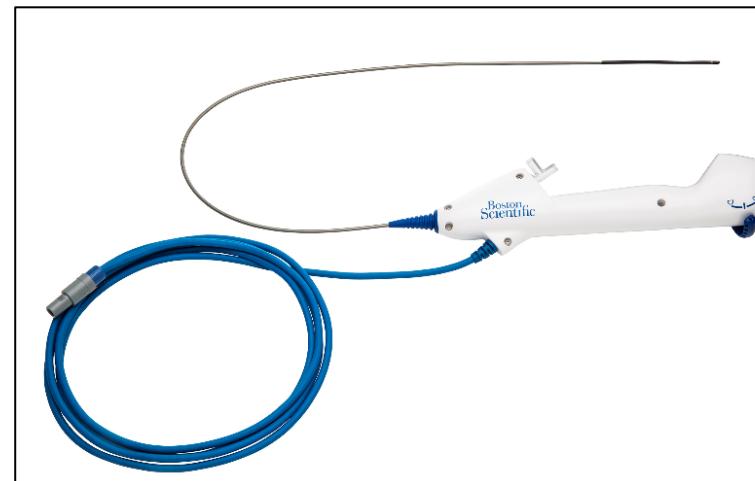
## Retrograde intra renal surgery (RIRS)

An option for stones between 10 and 20 mm, especially lower pole stones, in cases of difficult lower polar anatomy, stones located in a diverticulum

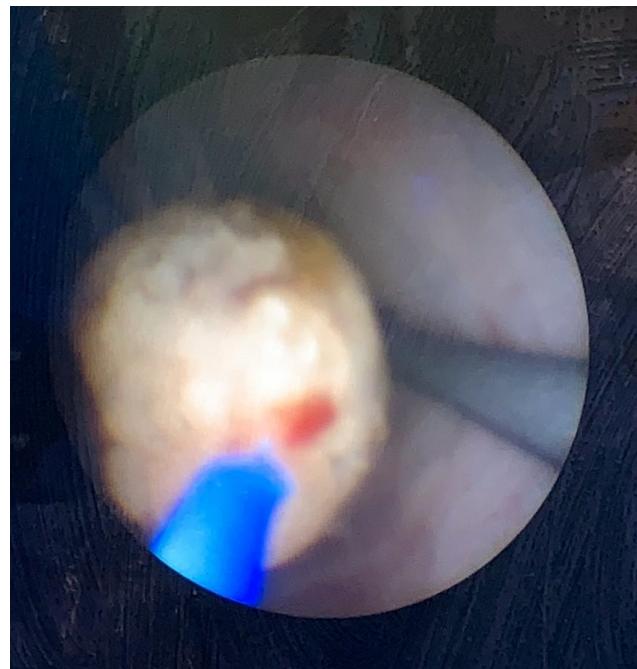
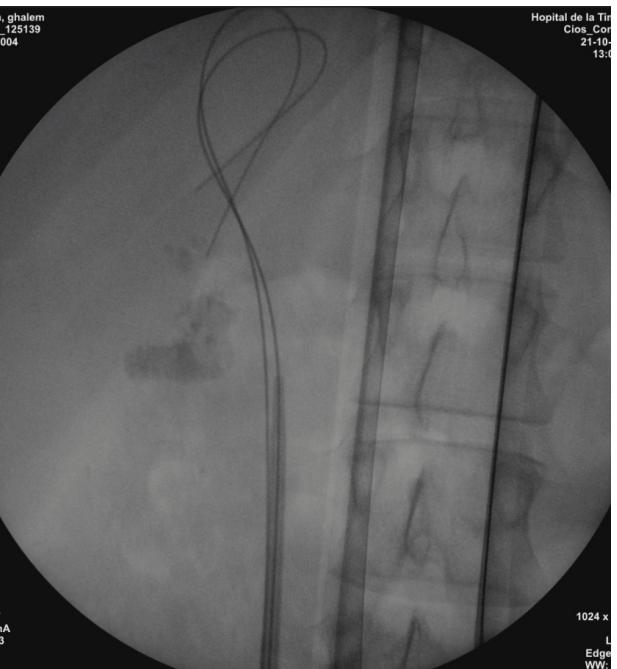
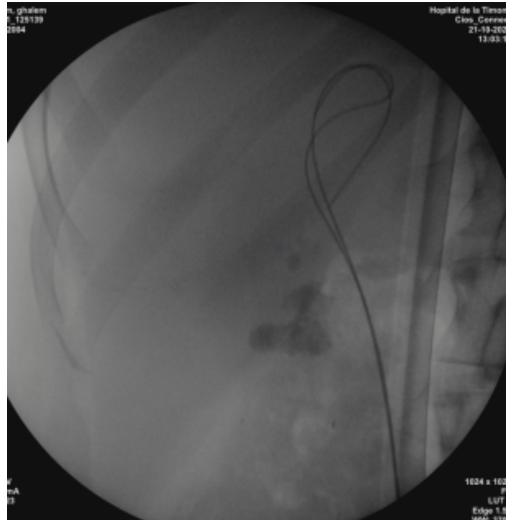
# Flexible URS



# Flexible URS : single use

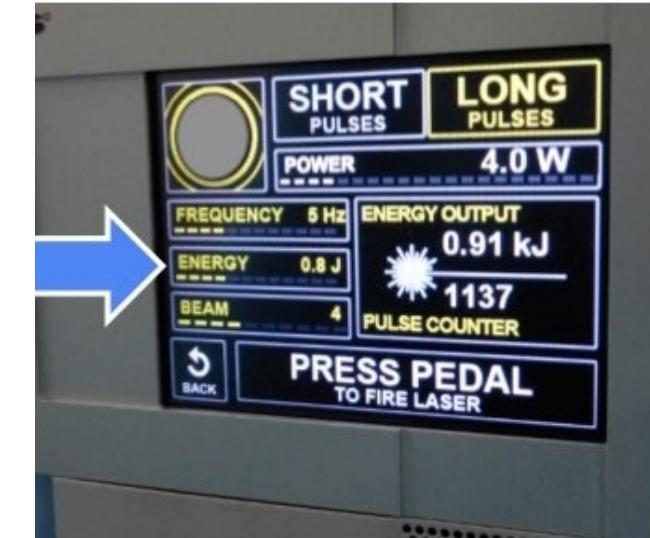
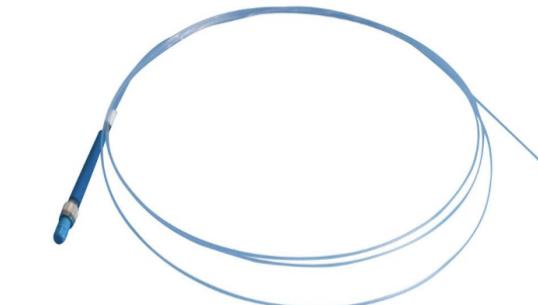


# fURS: surgical procedure

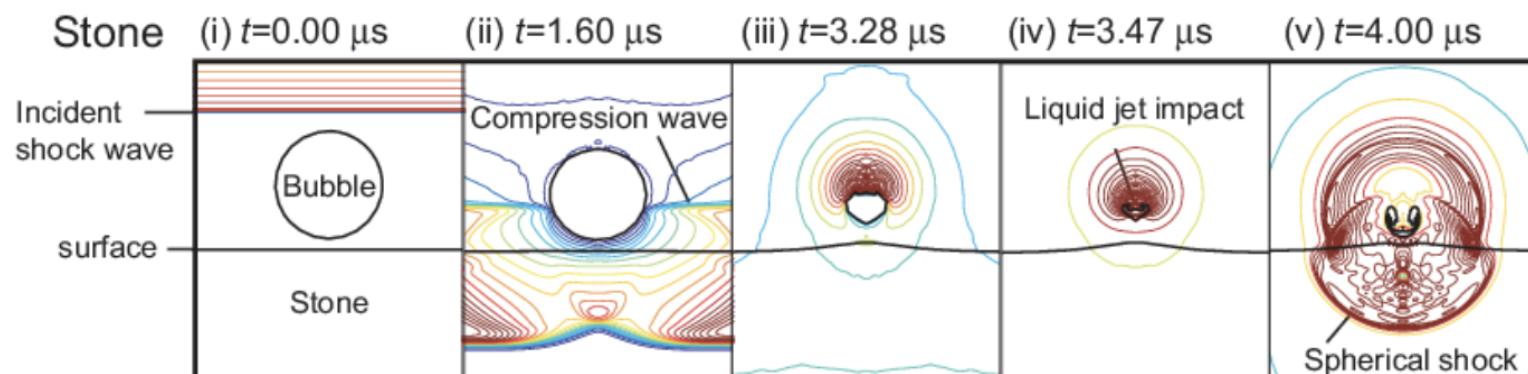


# Holmium: YAG laser

Characteristic	Ho:YAG
Wavelength (nm)	2120
Optical pumping	Flash lamp
PE (J)	0.2–6
Pulse frequency (Hz)	5–80
PW ( $\mu$ s)	350–1300
Temporal pulse profile	Peak initially and taper toward the end “shark fin”
Core laser fiber size ( $\mu$ m)	>200
Maximum power output (W)	120
Availability	In clinical use for >20 y



Total power (W) = Pulse energy (J) x Frequency (Hz)



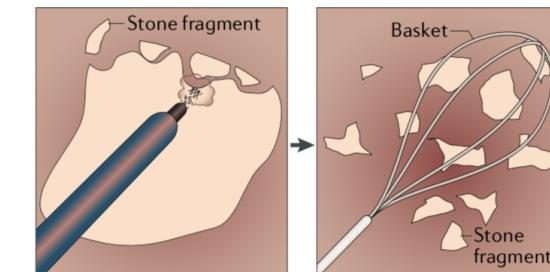
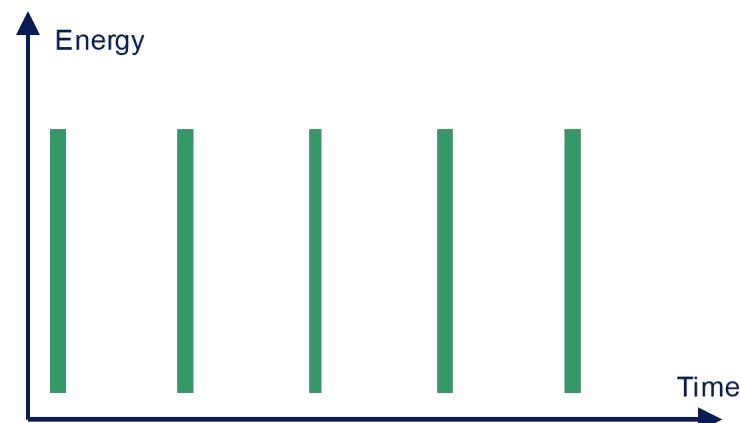
# Laser techniques

## FRAGMENTATION

Low-frequency: 6-10 Hz

High-PE: 0.8-1.2 J

Power : 4-10 W

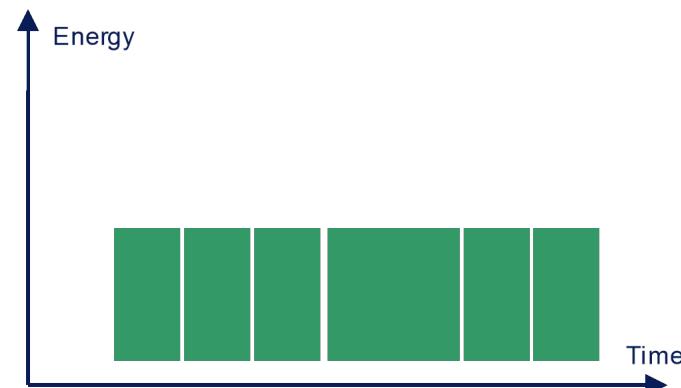


Faure A et al. J Pediatr Urol (2020)

# Laser techniques

## DUSTING

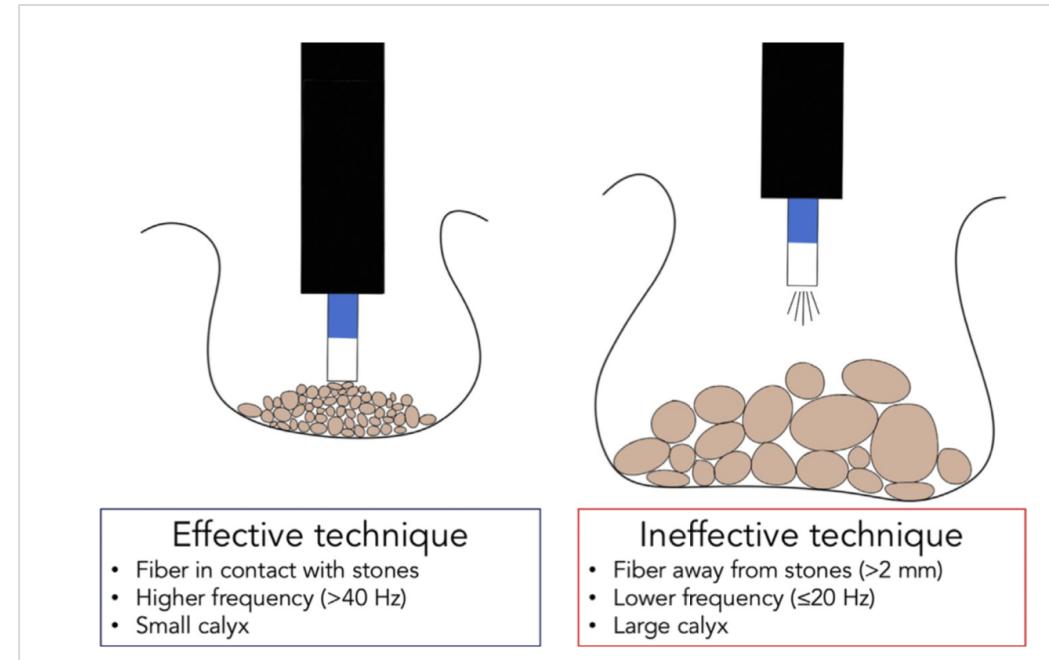
High-frequency: 10 Hz  
Low-PE: 0.2-0.5 J



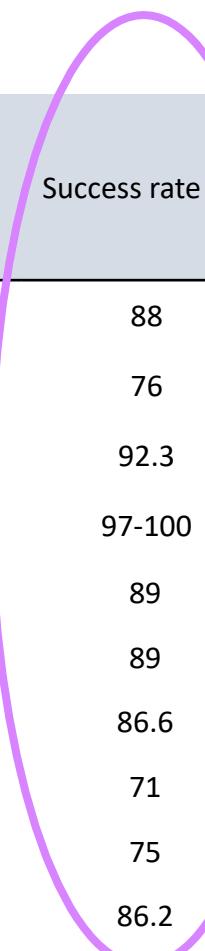
Faure A et al. J Pediatr Urol (2020)

# Laser techniques

- Laser fiber size
- Fiber tip to stone working distance



# fURS - Results



Study	n	Mean age (years)	Success rate (%)	Retreatment rate (%)	Pre- stenting (%)	Complications rate (%)		Follow- up (months)
						Clavien 1+2	Clavien 3+4	
<i>Unsal (2011)</i>	16	4.2	88	NR	NR	0	6.25	10.3
<i>Cannon (2007)</i>	21	15	76	38	38	0	0	11
<i>Erkurt (2014)</i>	65	4.3	92.3	16.9	26.2	24.6	3	3
<i>Kim (2008)</i>	167	5.2	97-100	3	56.9	0	0	19.7
<i>Suliman (2018)</i>	36	10.6	89	19.64	59	3.6	0	17.1
<i>Xiao (2019)</i>	100	3.51	89	12	100	69	0	NR
<i>Mokhless (2014)</i>	30	2.4	86.6	NR	3.3	NR	0	3
<i>Saad (2015)</i>	21	6.44	71	9.5	NR	9.5	0	1
<i>Pelit (2017)</i>	32	3.65	75	15.6	NR	9.3	3.1	3
<i>Bas 2016</i>	36	8.39	86.2	NR	16.7	13.9	2.7	1

SFR : 76 - 100%

# fURS - Results

- Complications rates : 0-28%
- SFR, retreatment rate and complications is **similar** to the outcomes seen in adults
  - One difference : need of second anesthesia for stent removal
- Younger age, cystine composition, larger stone diameter : predispose to fURS failure

# Percutaneous nephrolithotomy (PNL)

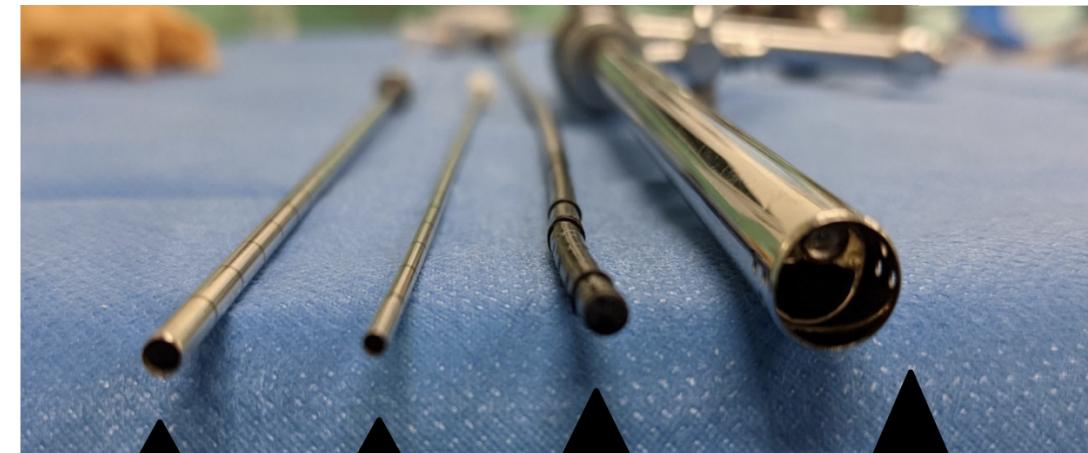
The accepted indication is stones larger than 20 mm

# Micro - Mini – Macro PNL

Terminology proposed by different investigating groups

Procedure	Sheath outer diameter
Standard PCNL [11]	>22 Fr
Mini-PCNL [4]	≤22 Fr
The minimally invasive PCNL (MIP) [14]	18 Fr
Ultra-mini PCNL [15]	11–13 Fr
Mini-micro PCNL [16]	8 Fr
Micro-PCNL [8]	<5 Fr
Super mini-PCNL [30]	7 Fr

Kamal et al. Urolithiasis (2016)



# Pediatric PNL



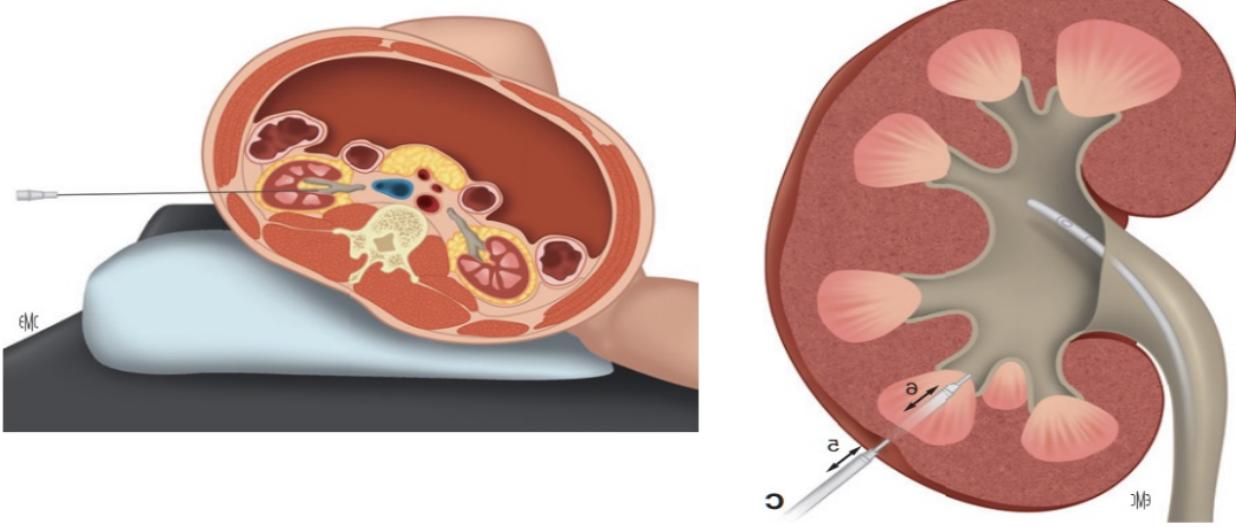
Supine



Prone

# Percutaneous renal access

- Under fluoroscopic and US guidance
- Lower pole posterior calyx access preferred
- Duncture tract dilatation and placement of th



# Micro-PNL

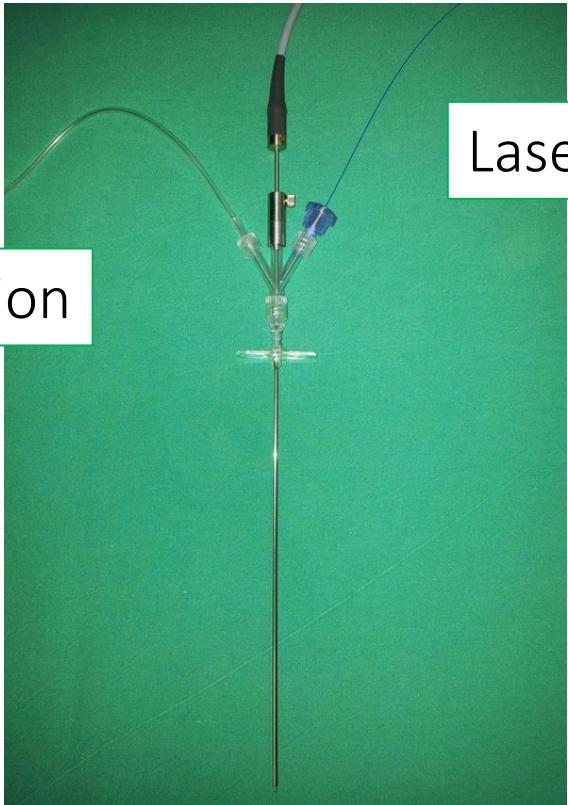


3-way connector

Fiber-optic  
3.5F nephroscope  
Diameter 0.9 mm

4.85F Needle  
(1.6 mm)

# Micro-PNL



Laser fiber (262 micron)



# PNL results

**71.4- 95%**

**20%**

Study	n	Tract (scope) size (Ch)	Mean age (years )	Stone burden (mm)	Success rate (%)	Hospital Stay (days)	Complications rate (%)		Follow -up (months)
							Clavien 1+2	Clavien 3+4	
Guven 2013	107	22.9 (NR)	7.1	272	70.1	NR	Transfusion= 9.3% Fever=14%	NR	NR
Saad 2015	22	22 (17)	6.93	NR	95.5	2.59	Bleeding=13. 6% Fever=18.2%	9.09	1
Pelit 2017	45	20- 22 (17)	3.71	NR	91.1	3.46	15.5	0	NR
Bas 2016	45	NR	5.62	NR	80	2.29	11.1	2.2	NR
Cicekbilek 2015	40	12- 24 (11- 22)	9.5	34.1	97.5	3	25	0	7
Daggulli 2016	40	4.5 (14)	6.3	16.5	80 (85)	3.8	25	5	1.5
Aghamir 2016 Single- access	70	30 (NR)	NR 46.33 yrs for both gps	NR	85.7	3.1	7.1	0	1week
Aghamir 2016 Double- access	37	30 (NR)	NR 46.33 yrs for both gps	NR	97.3	3.2	10.8	0	1week
Celik 2017 Ultra-mini PCNL	50	12 (9.5)	6.67	126.1	78 (96)	5.2	6	0	NR
Celik 2017 Mini PCNL	91	20 (18)	9.52	166.7	75.8 (90.1)	5.2	5.5	0	NR
Celik 2017 Adut-sze PCNL	84	26 (24)	10.8	208.9	71.4 (91.7)	5.7	10.7	0	NR
Dombrov skiy 2018	320 6	NR	NR	NR	NR	3	Total complication rate: 20.7%	NR	NR
Senocak 2018	105	18-24 (15.9-22)	5	218.4	80.95	4	5.71% required transfusion	NR	NR
Iqbal 2018 Tubed PCNL	17	23 (20)	9	NR	NR	2.8	5.5% transfusion 5.5% fever	0	3 weeks
Iqbal 2018 Tubeless PCNL	18	23 (20)	7.5	NR	NR	3.1	11.7% tansfusion	0	3 weeks

# PNL - Results

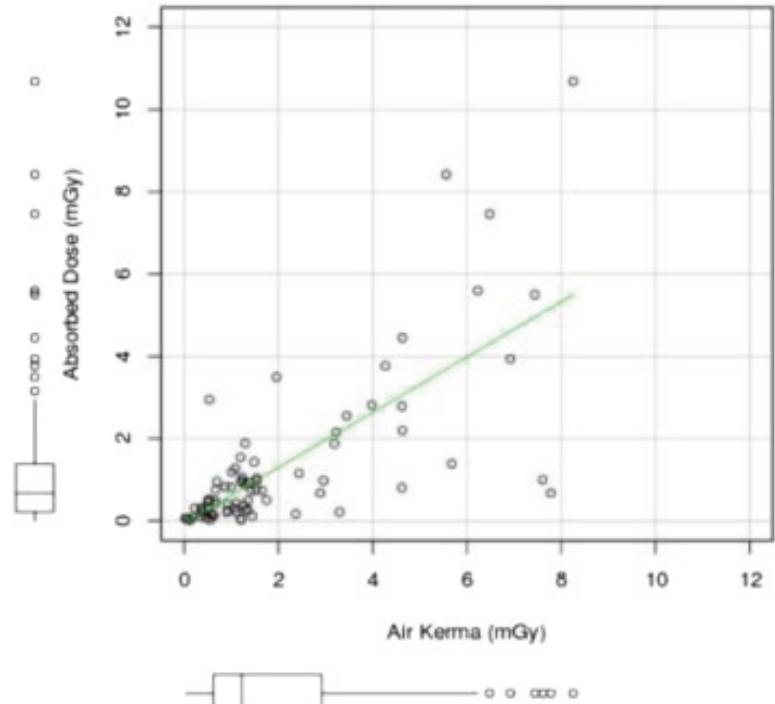
- Similarly to adults, PNL in children is indicated for stones > 2cm
- Older age and higher stone burden predispose to the use of larger instruments
- Adverses effects on the renal parenchyma of the developing child ?
  - Focal damage in 5% of cases
  - PNL tracts between 12-24Ch did not cause significant renal harm

# Radiation exposure

	Median dose
Retrograde pyelography	0,6 mGy
Ureteral stent insertion	1 mGy
URS	0.82 mGy

Not negligible !

Air Kerma (mGy) v Absorbed Dose (mGy),  
n= 79, r= 0.72 (95% CI p= 0.53-0.87)



Optimize fluoroscopy settings  
during URS ++++

# **Open and laparoscopic/robot-assisted stone surgery**

- Very few cases
- Extremely large staghorn calculi, unfavorable collecting system anatomy, morbid obesity and skeletal abnormalities
- Lap/Robotic pyelolithotomy and nephrolithotomy

Swearingen R et al. Eur Urol (2017)

# Pediatric Urolithiasis: News trends in pediatric urosurgery



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