

CAIRIBU 2020 VIRTUAL MEETING

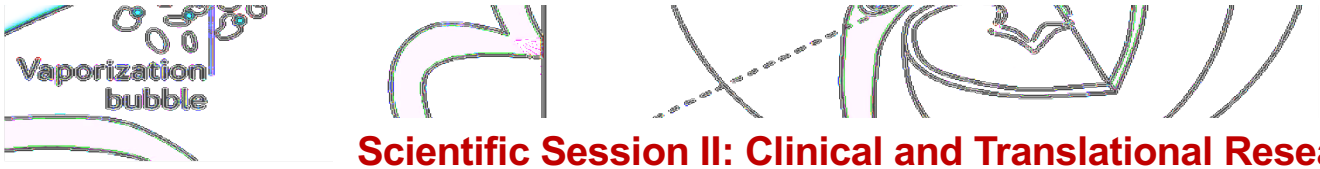
Surgical Management of Urolithiasis: Mechanism of Stone Damage in a New Era of Laser Lithotripsy



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Duke University



Scientific Session II: Clinical and Translational Research (DEC 4, 2020)

CURE (Center for Urological Research and Engineering)

ADVISORY BOARD

P20: Improving Mechanistic Understanding and Treatment Efficiency of Laser Lithotripsy

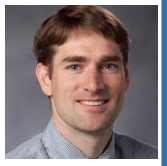
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(K12-Scholar)

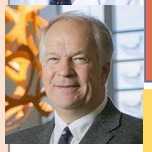
RESEARCH TEAM DIRECTORS



Glenn Preminger
Urologic Disease, Lithotripsy

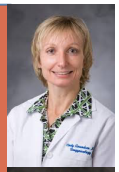


Michael Lipkin
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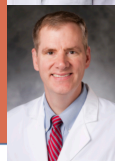


Joseph Izatt
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ACADEMIC PARTNERSHIPS



Duke KURe Program



NIDDK U01 USDRN

INDUSTRY PARTNERSHIP

Dornier MedTech

NIDDK: P20-DK123970

Urinary Stone Disease (USD)

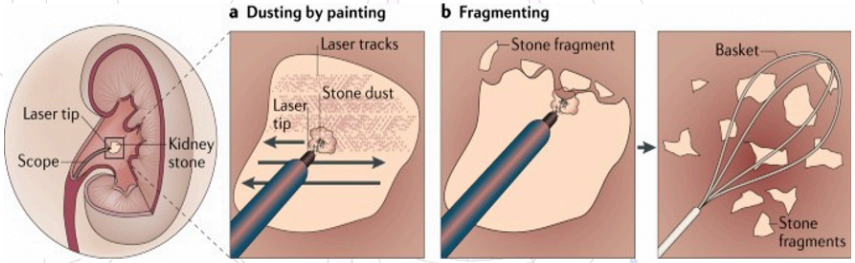
1. USD: 2nd most costly benign urologic condition in the US (>$2B/yr)

2. Laser lithotripsy (LL): treatment of choice for USD

3. Despite rapid advances in LL technologies, fundamental knowledge of LL has not changed in the past decades

Lumenis MOSES (2017)





Dornier Medilas (2019)







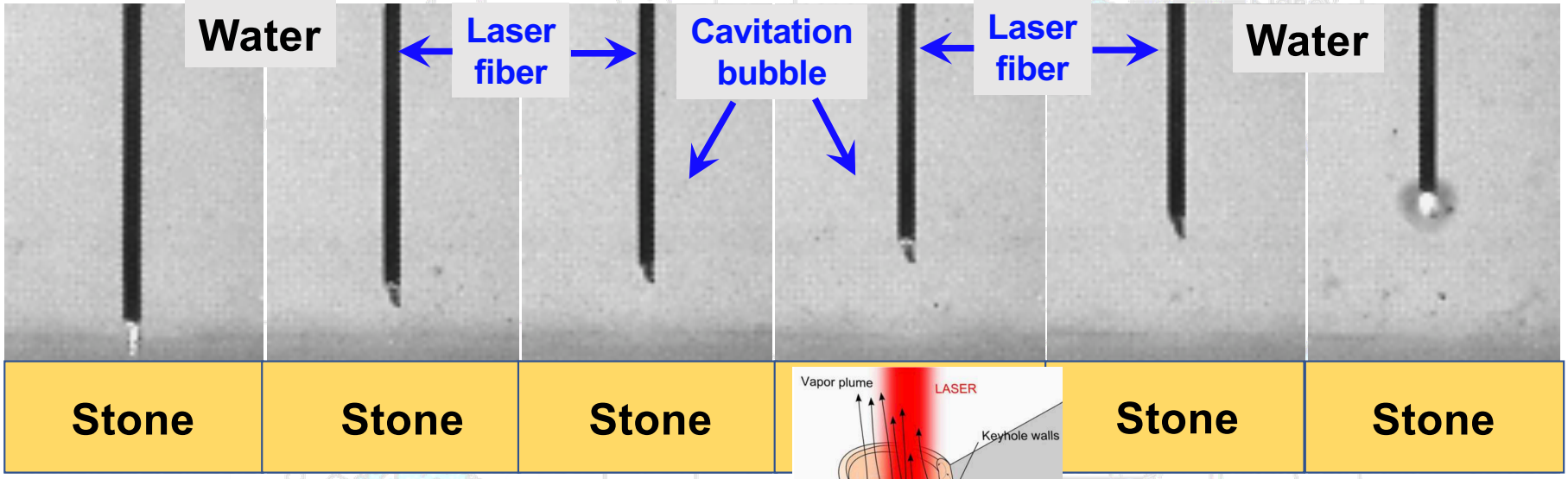


Quanta Vapor Tunnel (2018)

Olympus Soltive (2020)

Stone Damage in LL

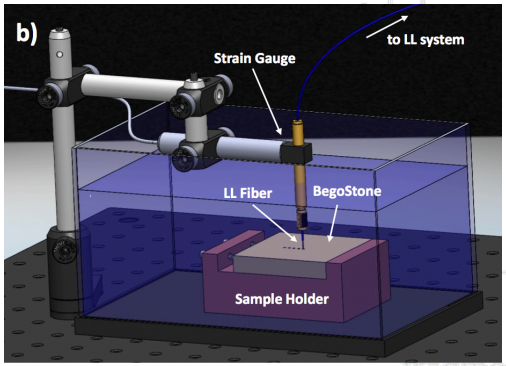
(the MOSES Effect)



Conventional Theory: Photothermal ablation dominates; cavitation damage is negligible

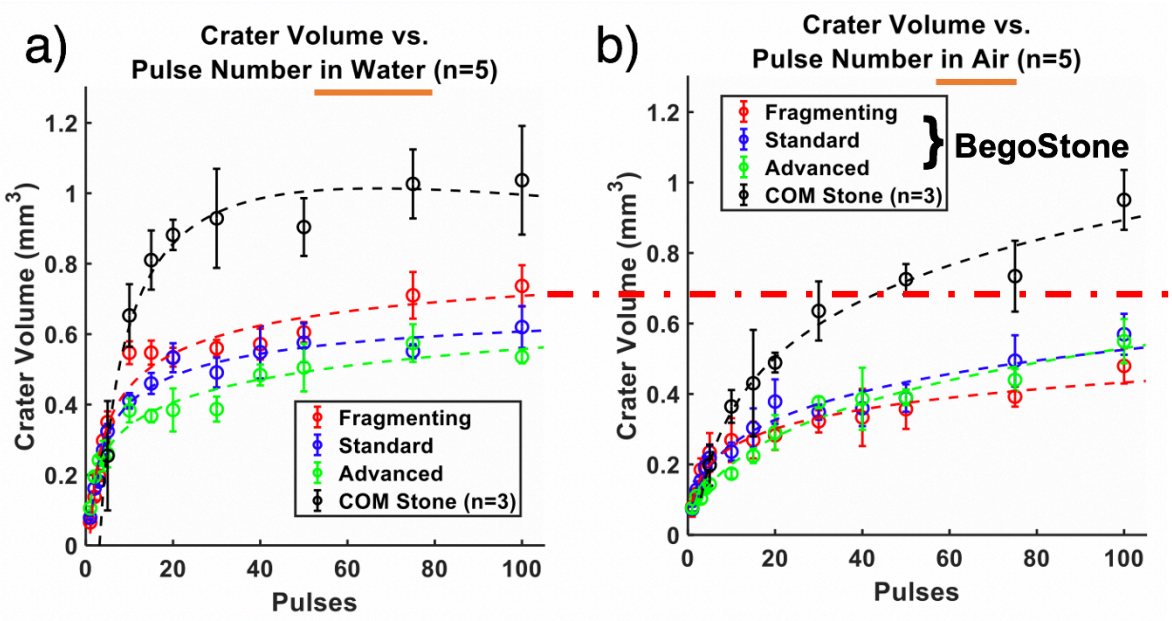
New Evidence - Part I

NIDDK: P20-DK123970

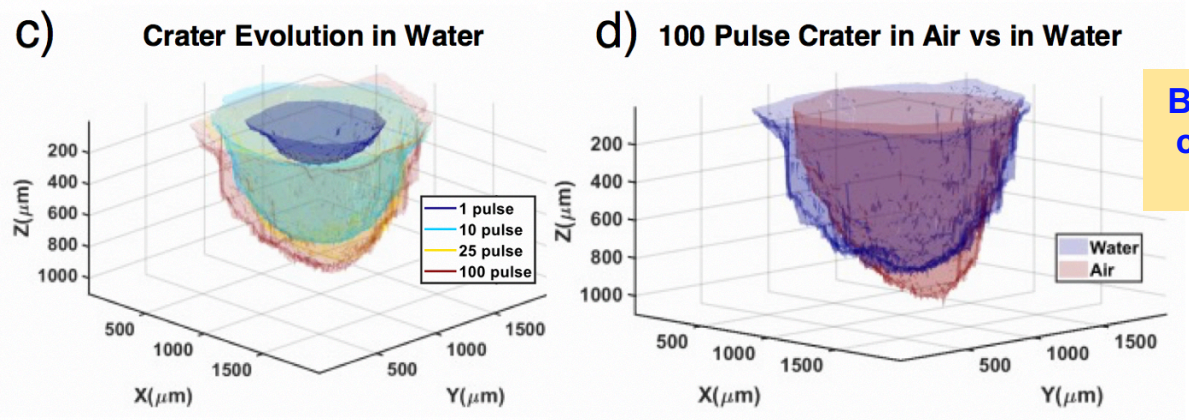


Fragmenting Mode (0.8 J and 10 Hz)

Dornier Medilas H Solvo 35 Laser



3D OCT Rendering of Crater Volume

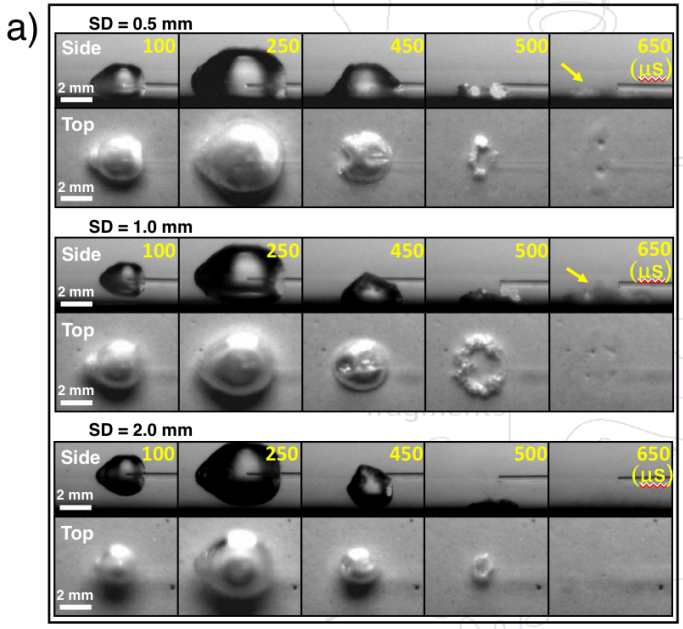


Broadening of crater area in water !!!

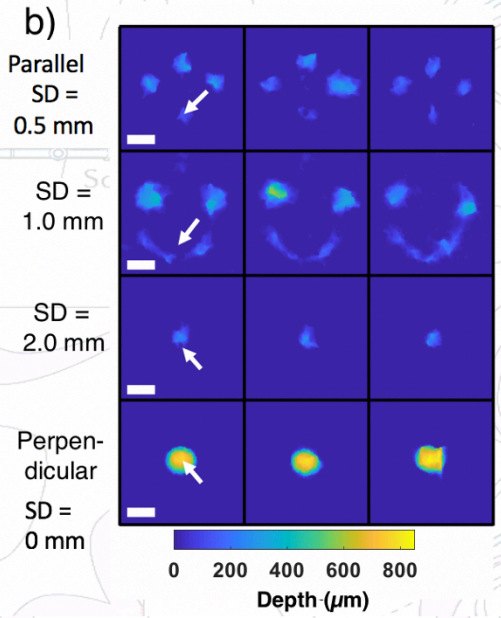
New Evidence – Part II

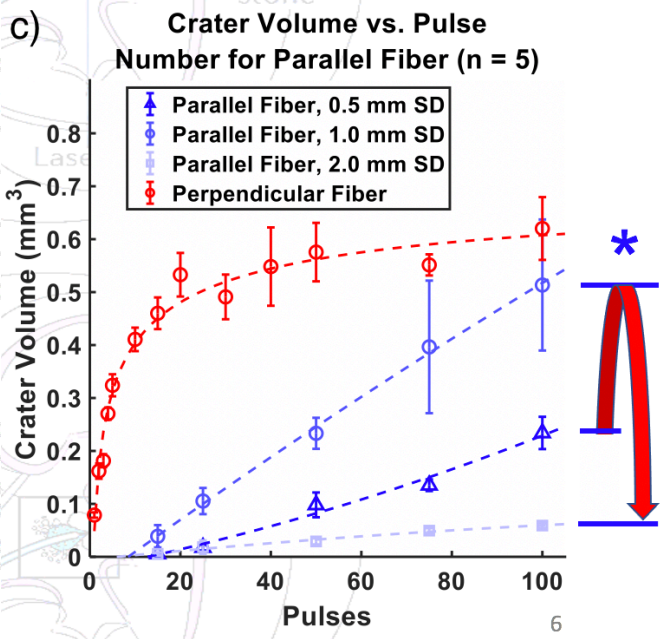
Parallel fiber experiments confirm cavitation damage in LL
- when the photothermal ablation mechanism is virtually eliminated

High-Speed Photography



OCT



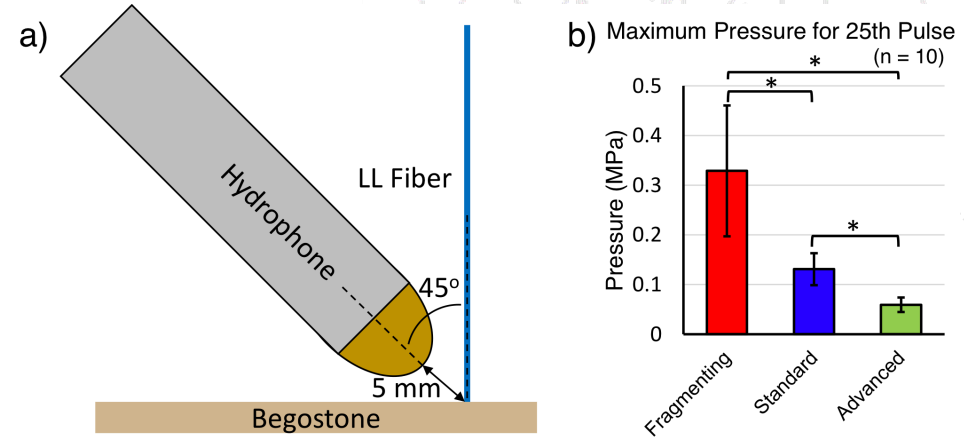


Fragmenting Mode (0.8 J and 10 Hz)

SD: standoff distance

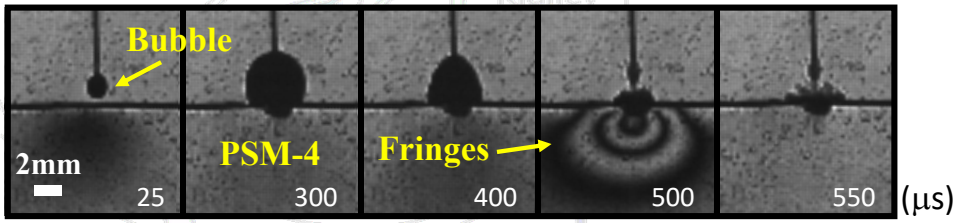
OCT: Optical Coherence Tomography

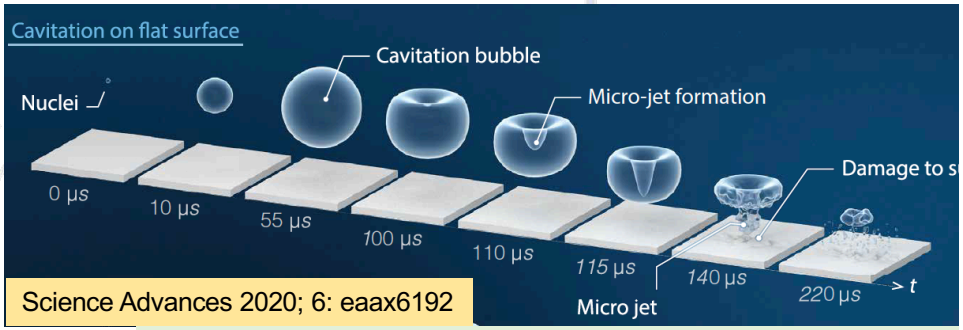
Cavitation Damage Mechanism During LL



Hydrophone measurements show weak shock wave emission upon bubble collapse

High-Speed Photoelastic Imaging





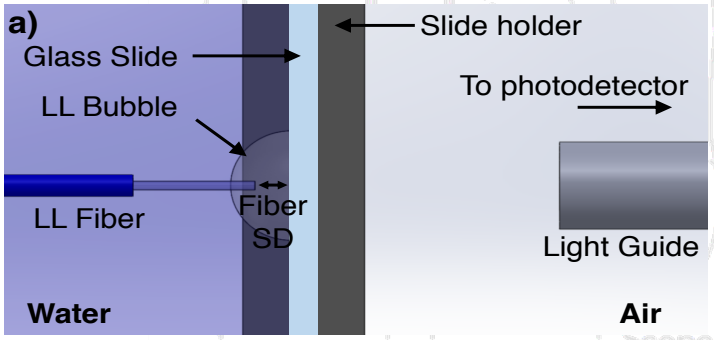
Science Advances 2020; 6: eaax6192

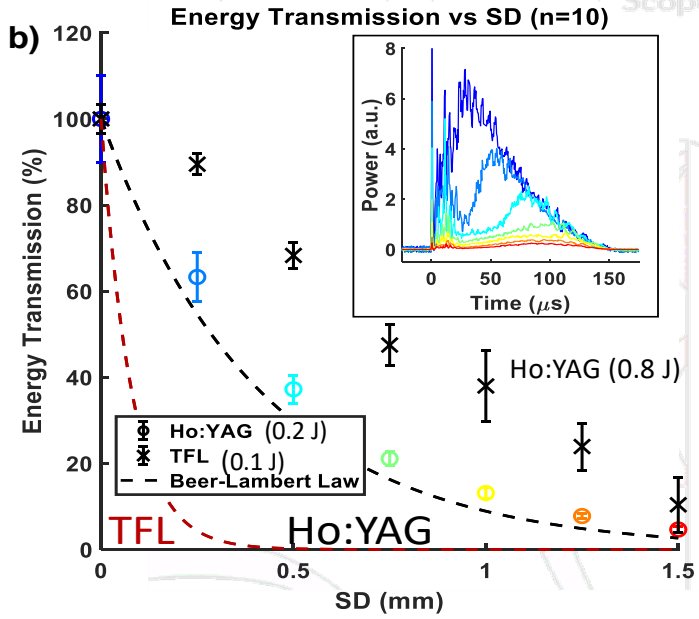
Damage caused by microjet impact and water hammer pressure

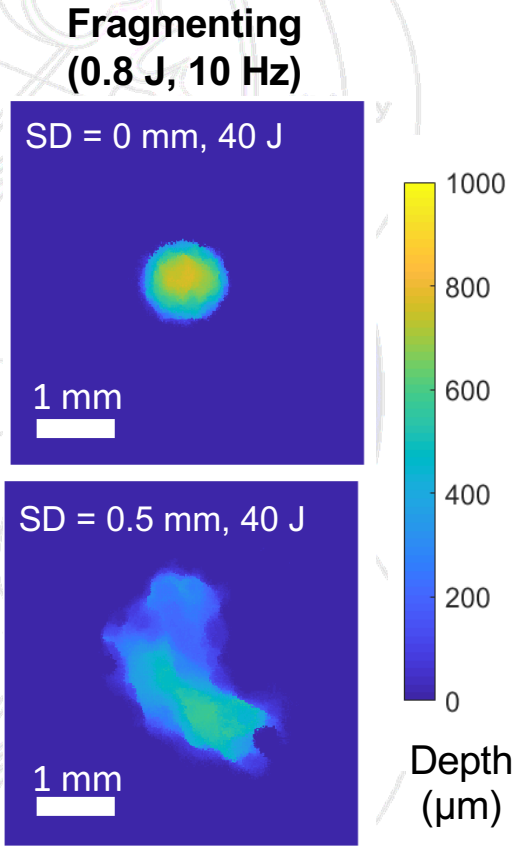
Photoelastic imaging demonstrates stress concentration at bubble collapse site in the stone

Ho:YAG LL – Energy Transmission

(Fragmenting vs. Dusting)

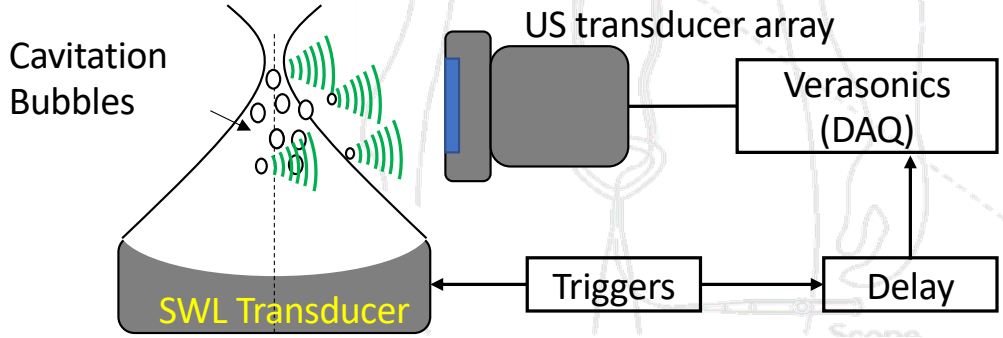


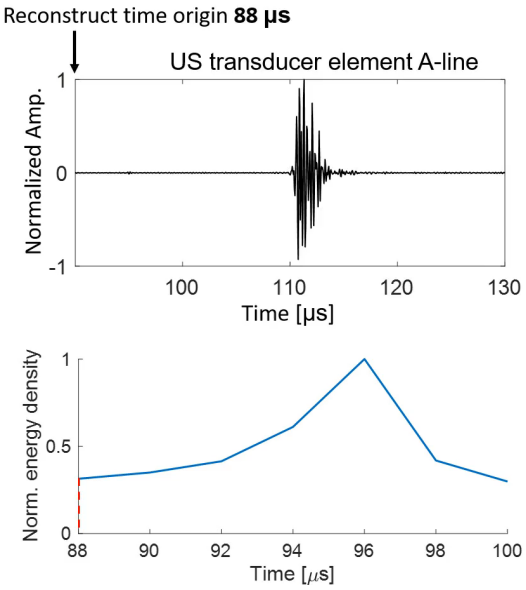


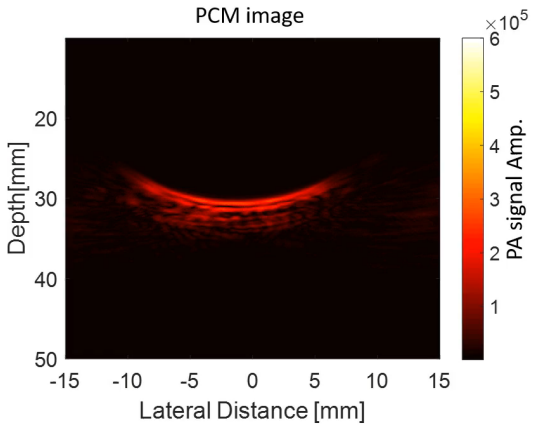


Sliding-Window Passive Cavitation Mapping (SW-PCM)

Shock Wave Lithotripsy (SWL)

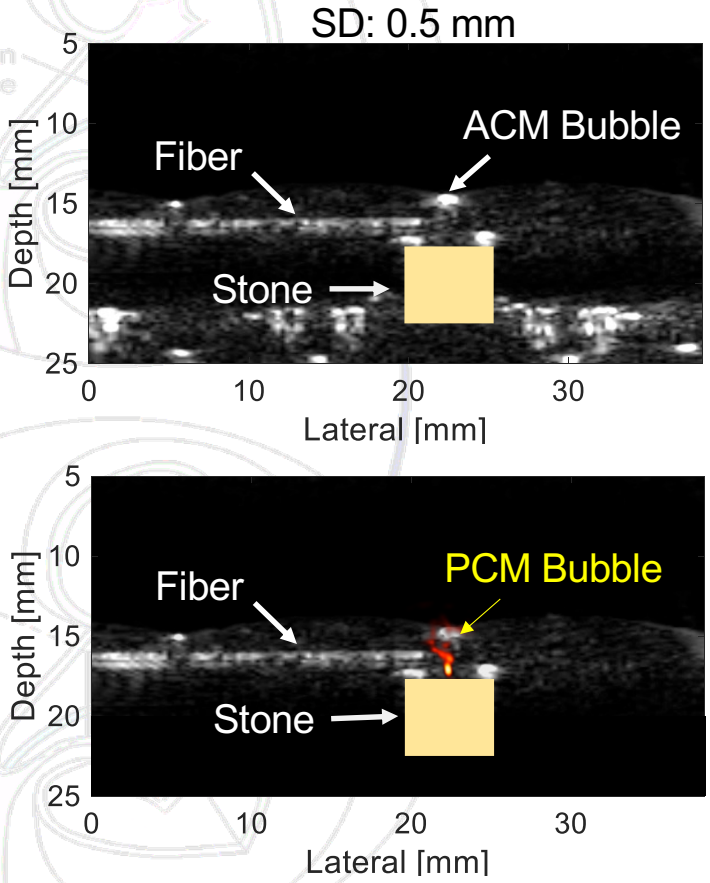






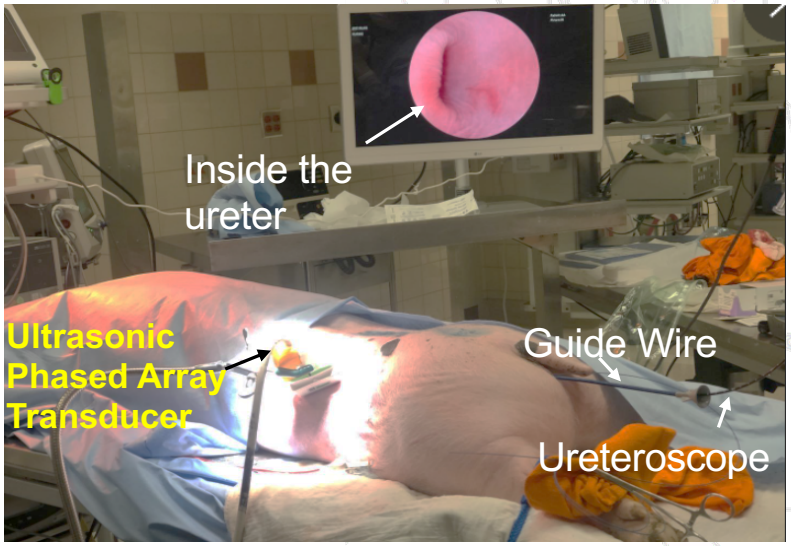
PCM: Passive Cavitation Mapping

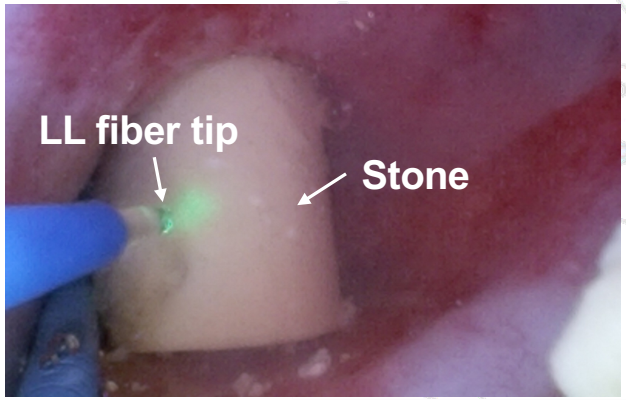
Laser Lithotripsy (LL)

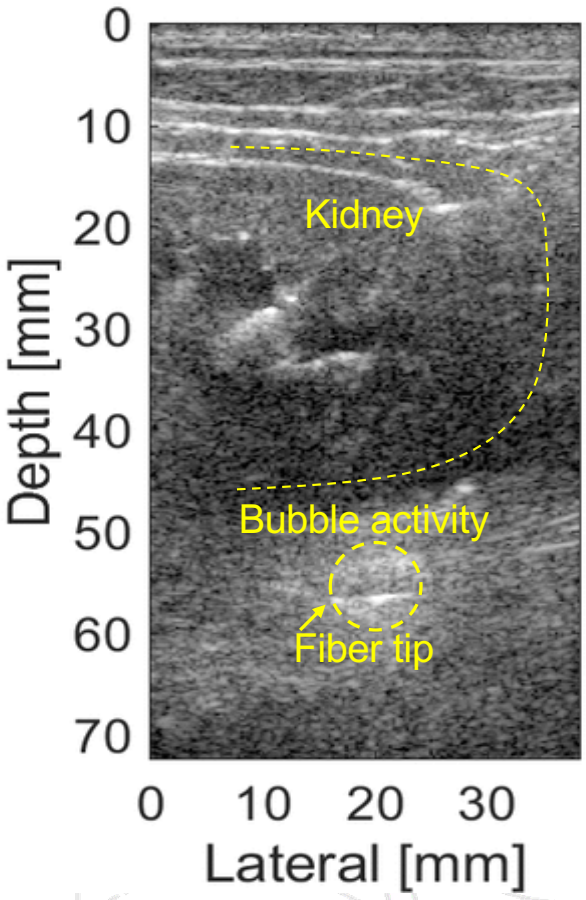


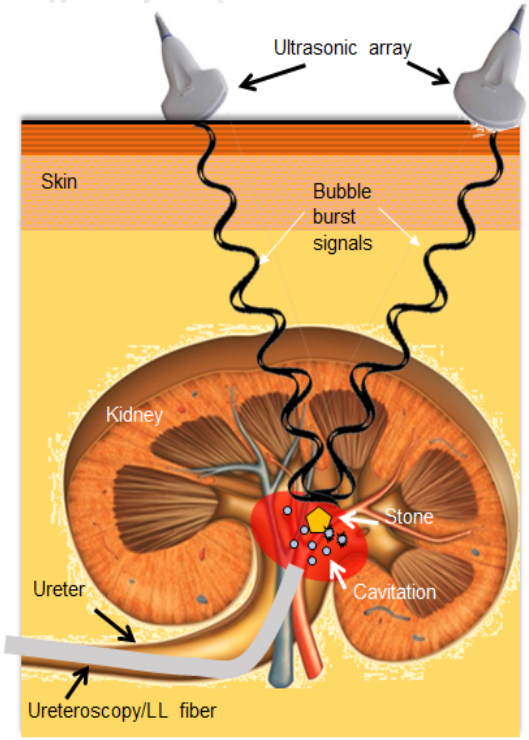
ACM: Active Cavitation Mapping

Ultrasonic Detection of LL-induced Bubble *In Vivo*









Conclusions

1. Re-evaluate comprehensively the mechanism of stone damage in LL

2. Besides photothermal ablation, cavitation (asymmetric bubble collapse with microjet impact) plays a significant role in stone damage during LL

3. This paradigm-changing observation opens up opportunities for improving LL treatment efficiency and patient outcomes based on optimization of bubble dynamics, instead maximizing laser energy delivery to the stone

4. A multidisciplinary collaboration is urgently needed to advance the knowledge and technology development in LL to benefit the clinical treatment of USD patients in the new era of LL

Thank You