Assessment of Tissue Damage from Ultrasonic, Pneumatic and Combination Lithotripsy

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Introduction

Percutaneous surgery is now a commonly used treatment for large or complex renal calculi (kidney stones). During a percutaneous nephrolithotomy (PCNL), a lithotripter is placed into the urinary tract through a small puncture wound (up to approximately 1 cm) through the skin. A lithotripter can use two different energy sources to break up renal calculi, the pieces of which are suctioned out of the urinary tract. Ultrasonic and pneumatic energy are the two sources of energy commonly used in the urological field. The purpose of this experiment is to conduct a comparative evaluation of ultrasonic, pneumatic, and dual ultrasonic lithotripsy to predict the safety of probes on urinary tract tissue.

The damage of tissue was graded on a score of 0 to 6 based on the time it took to perforate the tissue with 0 being the least damage and 6 being the most. The final score of each combination of independent variables was averaged among repeat trials. The detailed breakdown is shown in the following table.

Score	0	1	2	3	4	5	6
Time of perforation (sec)	No perforation in 180 sec	151-180	121-150	91-120	61-90	31-60	0-30

Comparison of three operating modes at 700 gm of equivalent pressure

	renal pelvis		ureter		bladder	
	3 sec	5 sec	3 sec	5 sec	3 sec	5 sec
US	0	0	0	0	0	0
US+P	0	0	40%	80%	0	0
CyberWand	0	0	20%	40%	40%	40%

Materials and Methods

Lithotriptors tested were the Swiss Lithoclast Ultra (ultrasonic only - US, and ultrasonic-pneumatic combination US+P), and the Gyrus ACMI Cyberwand (dual ultrasonic). Fresh porcine ureters, bladders, and renal pelvis tissues were used for testing.

A hands-free set up was used with each probe to vertically apply no pressure, 400 g, or 700 g of pressure for duration of 3 seconds, 5 seconds or 180 seconds. Repetitive testing of each tissue, pressure and time combination was performed, for a total of 351 trials.

Experimental results

The damage score of all samples were zero at zero pressure, and renal pelvis tissues were only significantly damaged by Cyberwand dual ultrasonic operating mode at an equivalent pressure of 700 gm. Therefore, more analysis is done focusing on ureter and bladder tissue at 400 and 700 gm for the three devices. The comparison is presented in the following figures.

Comparison of three operating modes at 400 gm of equivalent pressure

Conclusions

All devices afforded a level of safety at tissue durations typical of inadvertent intraoperative contact (3-5 seconds) at low pressures, though the Lithoclast US-only was superior with regard to perforation for all tissue types. Overall, Cyberwand is more damaging to urinary tract tissues than Lithoclast US+P than Lithoclast US-only.

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