Salvaging Poorly Prepared Colonoscopies Using Endoluminal Ultrasound: A Pilot Study

Lyndon V. Hernandez1, George Triadafilopoulos2, Joseph Kost3, Robert A. Ganz4, Martin Ton5, Dominic Klyve6, George K. Lewis7

GI Associates, LLC1, Stanford University2, Ben-Gurion University3, Minnesota Gastroenterology4, Cornell University5, Central Washington University6, ZetrOZ, LLC7

**Background:**
A need exists to clean poorly prepared colonoscopies safely and efficiently during the procedure to minimize aborting and rescheduling the examination.

**Objective:**
To explore the efficacy and safety of a novel, miniaturized endoluminal ultrasound to dissolve stools, as a means to salvage poor bowel preparation.

**Design:**
Proof of concept experimental study

**Setting:**
University and private animal laboratory

**Interventions:**
Low frequency ultrasound

**Main Outcome Measurements:**
Feasibility, efficacy, and safety to US to liquefy stools ex vivo

**Method I:**
For our feasibility study, we placed 20 mL of canine stools of solid consistency in a glass beaker filled with 40mL of saline an ultrasound transducer (VXC-400, SonicS & Materials, Newtown, CT) operating at a frequency of 20 kHz equipped with 26 mm diameter probe was immersed in the water without touching the stool and ultrasound was applied 40% duty cycle for one minute at an intensity of 3.2 W/cm². Stool discission was measured in terms of weight of stool before and after liquefication. The stool samples were categorized as Type 4 as defined on the Bristol stool scale. After recording initial mass of our stool sample, we placed the sample into water, then either exposed the sample to ultrasound or left alone for control. After exposure, we aspirated the water and debris, recorded the weight of left over stool, and calculated the percent change of the initial and final weight.

**Method II:**
We then carried out an ex vivo study on freshly harvested porcine colon, divided into three groups. Ultrasound treated with waterspray (n=3), waterspray alone (n=3) and control (n=3). For the sonicated group, a 2x2 cm section of colon segment was mounted onto a petri dish which was then inverted and placed onto the surface of saline solution with the transducer at a height of 2.5 cm. Sonification was produced by a VWR Scientific Aquasonic sonicator (Model 50HT; ETL Testing Laboratories, Cortland, NY, USA,) which operates at a frequency of ≈ 80 kHz and produces ≈ 173 kPa of acoustic pressure for a 30 minute time period. This acoustic pressure is a far harsher exposure than what living tissue will be exposed to. Waterspray was applied at a rate of 300mL/min of water which is about three times the flow rate of standard colonoscope watersprays. Histological analysis using H&E stain obtained. Higher frequencies (over 100 kHz) did not affect viscosity of stools, thus we set out to use sub 200 kHz in later iterations.

**Results:**
Solid stool samples in saline turned into a fully dispersed liquid sludge within seconds (Figure 1D) An identical procedure was done without ultrasound (passive control) and upon decanting the material, there was no detectable change in consistency after 10 minutes of exposure to water. Depending on parameters such as pulse rate, acoustic intensity, and duration, an increase in liquefaction speed by a factor of 50 and 100 times compared to control was obtained. Higher frequencies (over 100 kHz) did not affect viscosity of stools, thus we set out to use sub 200 kHz in later iterations. Parametric exposure times and intensities were utilized to explore ultrasound effectiveness on liquefying solid, dry porcine stool and possible injury to colonic sections. Figure 2 compares the time course of multiple transducers and their dichotomous efficacy when compared to waterspray (control). Controls and 231 kHz samples actually swelled and increased in weight while 85 kHz at 50 kHz exposure to ultrasound increased significantly by greater than 50 times. On the other hand, there was a significant difference in change in weight between the 20 kHz treated sample compared to controls (p=0.0001) 231 kHz (p=0.0001) and 85 kHz (p=0.0001).

There was also no difference in temperature among the active transducers compared to control. Histological examination showed no difference between waterspray and ultrasound-treated tissue. There was minor acute damage and slight sloughing of mucosa for all groups, and proper anatomical structure was maintained throughout the mucosa.

**Conclusion:**
Endoluminal ultrasound can efficiently liquefy stools at acoustic exposure levels that do not damage ex vivo colonic mucosa, and should be able to dissolve stools more rapidly than water-spray alone and optimize colonoscopic evaluation towards its successful completion.