HHS Public Access

Author manuscript

Gastrointest Endosc. Author manuscript; available in PMC 2020 January 01.

Published in final edited form as:

Gastrointest Endosc. 2019 January ; 89(1): 115–123. doi:10.1016/j.gie.2018.08.012.

Simethicone is retained in endoscopes despite reprocessing: impact of its use on working channel fluid retention and adenosine triphosphate bioluminescence values (with video)

Monique T. Barakat, MD, PhD, **Robert J. Huang, MD**, **Subhas Banerjee, MD**

Division of Gastroenterology and Hepatology, Stanford University School of Medicine, Stanford, California, USA.

Abstract

Background and Aims: Studies from our group and others demonstrate residual fluid in 42% to 95% of endoscope working channels despite high-level disinfection and drying. Additionally, persistent simethicone has been reported in endoscope channels despite reprocessing.

Methods: Endoscopy was performed by using water or varied simethicone concentrations (0.5%, 1%, 3%) for flushing. After high-level disinfection/drying, we inspected endoscope working channels for retained fluid by using the SteriCam borescope. Working channel rinsates were evaluated for adenosine triphosphate (ATP) bioluminescence. Fourier transform infrared spectroscopy was performed on fluid droplets gathered from a colonoscope in which low-concentration simethicone was used.

Results: Use of medium/high concentrations of simethicone resulted in a higher mean number of fluid droplets (13.5/17.3 droplets, respectively) and ATP bioluminescence values (20.6/23 relative light units [RLUs], respectively) compared with that of procedures using only water (6.3 droplets/10.9 RLUs; $P < .001$). Two automated endoscope reprocessing cycles resulted in return of a fluid droplet and ATP bioluminescence values to ranges similar to that of procedures that used only water ($P = .56$). Low-concentration simethicone did not increase the mean residual fluid or ATP bioluminescence values compared with procedures that used only water (5.8 droplets/15.6 RLUs). Fourier transform infrared analysis revealed simethicone in the endoscope working channel after use of low-concentration simethicone.

Conclusions: Use of medium/high concentrations of simethicone is associated with retention of increased fluid droplets and higher ATP bioluminescence values in endoscope working channels, compared with endoscopes in which water or low concentration simethicone was used. However, simethicone is detectable in endoscopes despite reprocessing, even when it is utilized in low concentrations. Our data suggest that when simethicone is used, it should be used in the lowest concentration possible. Facilities may consider 2 automated endoscope reprocessor cycles for reprocessing of endoscopes when simethicone has been used. (Gastrointest Endosc 2019;89:115–23.)

Reprint requests: Subhas Banerjee, MD, Division of Gastroenterology and Hepatology, Stanford University School of Medicine, 300 Pasteur Drive, MC 5244, Stanford, CA 94305.

DISCLOSURE: *All other authors disclosed no financial relationships relevant to this publication.*

Simethicone $(CH_3)_2SiO$ is a fully methylated silicone-based polymer that reduces surface tension, thereby allowing bubbles to coalesce and disperse. It is ubiquitous in endoscopy units worldwide where it is used as a de-foaming agent to improve visualization of mucosa during endoscopic procedures.[1] A common mode of delivery into the GI lumen is by injection of discrete volumes of the agent through the endoscope working channel when necessary. In some institutions, it is added to the irrigation water bottle and is administered through the endoscope water jet channel.

Simethicone is insoluble in both alcohol and water, which has raised concerns regarding possible retention within endoscopes and its potential impact on endoscope reprocessing. This has prompted recommendations for caution from endoscope manufacturers. Olympus (Olympus America, Center Valley, Pa) has recommended using the lowest concentration of simethicone possible when simethicone is deemed necessary during a procedure.[2] Pentax (Pentax Medical, Montvale, NJ) and Fujinon (Fujinon Medical Systems USA, Wayne, NJ) have recommended avoiding simethicone use during endoscopy.[3,4]

A single recent study reported abundant fluid residue compatible with simethicone within endoscope working channels despite high-level disinfection (HLD) and drying.[5] A further single study from another institution where simethicone was routinely added to the irrigation water bottle, reported simethicone-associated crystals within water jet channels of all colonoscopes in use.[6] These reports sparked considerable concern within the endoscopy community; however, no subsequent data have been reported on this subject.

To address this ongoing concern, we evaluated the impact of intraprocedural simethicone use on fluid retention within working channels of gastroscopes and colonoscopes and on the efficacy of HLD. We evaluated the impact of concentration, volume, and mode of delivery of simethicone to the GI lumen. We additionally studied the potential modulating effects of the quality of bowel preparation and the mode of colon insufflation (air or water) during colonoscope advancement.

METHODS

In this study we used an ultra-slim flexible inspection bore-scope (SteriCam; Sanovas Inc, San Rafael, Calif) to inspect endoscope working channels, as we have previously described,[7] to evaluate for retained residual fluid after completion of a single cycle and 2 sequential cycles of reprocessing. Borescope inspections were performed in batches, with the investigator blinded to study parameters and simethicone concentration. We additionally evaluated adenosine triphosphate (ATP) bioluminescence values on rinsates collected from these endoscopes as previously reported,[7–9] after these cycles of reprocessing. This study was approved by the Stanford Institutional Review Board (Protocol no. 40603).

Endoscopes and procedures

Six gastroscopes and 6 colonoscopes manufactured by Pentax (5 gastroscopes, 4 colonoscopes) and Olympus (1 gastroscope, 2 colonoscopes) were included in this study, and each endoscope evaluation was performed in triplicate for each indicated condition. Each triplicate evaluation was performed after independent use under the designated study

parameters and an independent cycle of reprocessing. This was a clinical study in which various study concentrations of simethicone were used during endoscopic procedures and endoscopes evaluated after the subsequent reprocessing cycle. Evaluated gastroscopes were limited to those used in diagnostic upper GI procedures only. Evaluated colonoscopes were limited to those used in screening and/or surveillance procedures only, in patients with a Boston Bowel Preparation Scale (BBPS) rating of ≥6. Study endoscopes were preselected after SteriCam evaluation, such that half exhibited “minimal” and half exhibited “mild” working channel damage. This range of “wear and tear” changes is typical of endoscopes in our endoscopy unit.[7]

Endoscope reprocessing and drying protocol

At our institution, endoscope reprocessing begins with point-of-use pre-cleaning performed by an endoscopy unit technician. Manual cleaning and HLD are then performed by designated personnel in our centralized sterile processing department. HLD is performed by using a Medivators Advantage Plus (Minntech, Minneapolis, Minn) automated endoscope reprocessor (AER) with per-acetic acid as the disinfectant. The HLD cycle ends with isopropyl alcohol flushes followed by an automated 1-minute air purge within the AER. After HLD in the AER, all endoscopes undergo 10 minutes of manual drying with forced high-efficiency particulate filtered air. This is administered by using a forced air administration apparatus (Safety Air Gun, LZR600; Guard Air Corporation, Chicopee, Mass). After drying, study endoscopes were stored vertically in air circulation cabinets before borescope inspection. The interval between HLD/drying and inspection was kept at approximately 6 hours to enhance consistency of findings and to coordinate logistics of borescope evaluations.

Simethicone volume and concentration

We predetermined the mean simethicone volume used by 5 endoscopists at our institution over a total of 50 observed colonoscopy and EGD procedures. These mean volumes of 180 mL for colonoscopy and 120 mL for EGD were then used during this study. Administration of this entire volume was necessary during the procedure and was accomplished by injection through the endoscope working channel. Additionally, unrestricted volumes of sterile water delivered via the endoscope water jet channel from the water bottle could be used as necessary during procedures.

Simethicone (20 mg/0.3 mL; Major Pharmaceuticals, Livonia, Mich) was studied in 3 concentrations: 0.5 mL simethicone in 99.5 mL water (0.5%, low), 1 mL simethicone in 99 mL water (1%, medium), and 3 mL simethicone in 97 mL water (3%, high). Concentrations of simethicone used in this study were similarly determined based on observation of technicians preparing simethicone solutions at our institution during the 50 observed procedures, to establish our institutional range of practice.

For evaluation of the impact of simethicone concentration, use of water alone and use of a standard volume of simethicone in each concentration (low/medium/high), 6 gastroscopes and 6 colonoscopes were evaluated after 3 independent cycles of use and reprocessing

(triplicate), for a total of 18 gastroscope and 18 colonoscope inspections/ rinsate evaluations per condition.

Characterization of appearance of simethicone and water in endoscope working channels

After visual confirmation of the absence of fluid droplets in a reprocessed endoscope, either water or 3% simethicone solution was injected into endoscope working channels of 3 endoscopes each. The endoscopes were then immediately re-examined to establish the borescope appearance of retained water and of simethicone. Because HLD may be expected to impact the presence and appearance of potential residual simethicone, the endoscopes underwent repeat borescope inspection after a cycle of reprocessing.

Factors that may modulate simethicone/fluid residue and retained bioburden

We evaluated procedure parameters that may indirectly modulate simethicone retention within colonoscope working channels, including colon insufflation technique (ie, air vs water) and the quality of bowel preparation (BBPS ratings of 6/7 vs 8/9). These parameters affect the volume of water used and subsequently suctioned during the colonoscopy, which in turn may impact the amount of simethicone retained within working channels. Similarly, the mode of delivery of simethicone (injection via the working channel vs via the water jet channel from the water bottle) with subsequent suctioning may impact the amount of simethicone retained within working channels. We therefore evaluated the impact of these factors on simethicone/fluid residue and ATP bioluminescence values.

For each modulating factor described earlier, water and each concentration of simethicone (low/medium/high) were evaluated in 6 colonoscopes after 3 independent cycles of use and reprocessing (triplicate), for a total of 18 colonoscope inspection/rinsate evaluations per water or simethicone concentration.

Fourier transform infrared spectroscopy

Borescope evaluation of a single colonoscope was performed after utilization of low-concentration simethicone and a single reprocessing cycle. Semi-opalescent fluid droplets were visualized in the working channel and were sampled for Fourier transform infrared (FTIR) spectroscopy, which was performed by a commercial company (Nelson Labs, Salt Lake City, Utah) by using an internal reference sample (simethicone from our institution) and commercial simethicone reference samples. FTIR spectroscopy included 32 scans of attenuated total reflectance with a 4.000 resolution diamond crystal.

Statistical analysis

Analyses were conducted by using SAS Enterprise Guide version 7.11 HF3 (SAS Institute Inc, Cary, NC) and Microsoft Excel (Redmond, Wash). Values were compared by using a 2-tailed t test assuming unequal variance. Reported P values are 2-sided, with statistical significance at $P < .05$, and adjustment was made for multiple comparisons by using the method of Bonferroni. Regression analysis was performed by using generalized linear models.

RESULTS

Characterization of borescope inspection appearances of simethicone and water

Immediately after injection of a small amount of 3% simethicone into the endoscope working channel, opaque fluid droplets were visualized. With injection of larger amounts of simethicone, larger, shallow, coalescing collections with occasional focal occlusion of the working channel lumen were noted (Fig. 1). Reinspection of the same endoscope working channel after standard reprocessing revealed only a sparsely distributed mix of clear and semi-opalescent droplets (Video 1, available online at www.giejournal.org). Injection of water alone into the endoscope working channel resulted in a similar mix of visually indistinguishable clear and semi-opalescent fluid droplets (Fig. 1).

Working channel fluid analysis

After a single cycle of HLD/drying, we collected and analyzed semi-opalescent fluid droplets from a colonoscope working channel in which low-concentration simethicone had been used. FTIR spectroscopy analysis of this semi-opalescent fluid revealed spectra fully consistent with both a commercial standard reference simethicone sample and a sample of simethicone used at our institution (Fig. 2).

Borescope visualization and ATP bioluminescence in study endoscopes

The mean time interval from completion of HLD/drying to endoscope evaluation was similar for the sterile water, low-concentration, medium-concentration, and high- concentration simethicone groups (6.4 vs 6.6 vs 6.3 vs 6.4 hours). When sterile water alone was used for irrigation during the procedure, a mean (± standard deviation [SD]) of 6.3 (± 3.5) fluid droplets were observed within the endoscope working channel, despite a single cycle of HLD/drying (Table 1, Fig. 4). These endoscopes were associated with a mean (± SD) ATP bioluminescence value of 10.9 (± 7.8) relative light units (RLUs) (Table 1). The mean ATP bioluminescence value for sterile water validation controls was 3 (± 1.1) RLUs, and the mean ATP bioluminescence value for simethicone suspensions was 3.2 (± 1.0) RLUs for low-concentration, 2.9 (± 1.2) RLUs for medium-concentration, and 3.4 (± 1.1) RLUs for high-concentration simethicone (Fig. 5).

Impact of use of simethicone in different concentrations

Low-concentration (0.5%) simethicone.—When a low-concentration suspension of simethicone in water was used for syringe irrigation during the procedure, a mean of 5.8 (± 2.8) fluid droplets were observed within the endoscope working channel, despite a single cycle of HLD/drying. These endoscopes were associated with a mean ATP bioluminescence value of 15.6 (± 10.4) RLUs. There was no significant difference in mean fluid droplets or ATP bioluminescence values for procedures in which low-concentration simethicone compared with those using sterile water alone *(P* = .56 for fluid droplets; *P* = .06 for ATP bioluminescence values) (Table 1).

Medium-concentration (1%) simethicone.—When a medium-concentration suspension of simethicone in water was used for syringe irrigation during the procedure, a mean of 13.5 (± 5.6) fluid droplets were observed within the endoscope working channel,

despite a single cycle of HLD/drying. These endoscopes were associated with a mean ATP bioluminescence value of 20.6 (± 10.1) RLUs. Use of medium-concentration simethicone resulted in significantly more fluid droplets and in significantly higher ATP bioluminescence values compared with both water and low-concentration simethicone ($P < .01$ for droplets and ATP bioluminescence values) (Table 1).

High-concentration (3%) simethicone.—When a high-concentration suspension of simethicone in water was used for syringe irrigation during the procedure, a mean of 17.3 (± 6.6) fluid droplets were observed within the endoscope working channel, despite a single cycle of HLD/drying. These endoscopes were associated with a mean ATP bioluminescence value of 23.0 (± 10.6) RLUs. Use of high-concentration simethicone resulted in no significant difference in mean number of water droplet ($P = .19$) and ATP bioluminescence values ($P = .81$) relative to medium-concentration simethicone. Use of high-concentration simethicone resulted in significantly more fluid droplets and significantly higher ATP bioluminescence values compared with both water and low-concentration simethicone ($P < .001$ for both droplets and ATP bioluminescence values). (Table 1).

Impact of 2 AER reprocessing cycles

One cycle of precleaning/manual cleaning followed by 2 AER cycles appeared beneficial for endoscopes in which either medium- or high-concentration simethicone was used. After the second AER cycle/drying, lower numbers of fluid droplets and lower ATP bioluminescence values were noted in these endoscopes; these did not differ significantly from endoscopes in which either water or low-concentration simethicone was used ($P = .88$ for fluid droplets; $P = .26$ for ATP bioluminescence values relative to water/low-concentration simethicone).

Impact of simethicone on image quality

Simethicone use sporadically affected image clarity during endoscopy, potentially because of deposition on the endoscope lens. Intermittent blurring of the endoscopic image requiring protracted washing of the lens was noted with all concentrations of simethicone in water. Such protracted blurring of the endoscopic image was not observed in procedures with sterile water alone. Prolonged image blurring was seen in 5.5% of procedures using low concentration, in 22.2% of procedures using medium concentration, and in 16.7% of procedures using high-concentration simethicone (Fig. 3).

Impact of endoscope type and severity of working channel damage

Regression analysis revealed that endoscope type (colonoscope vs gastroscope) did not predict residual fluid ($P = .19$) or ATP bioluminescence values ($P = .12$) for procedures using sterile water or the any of the simethicone concentrations studied. Regression analysis also revealed that the working channel damage rating (within the range of mild damage evaluated in this study) did not predict residual fluid ($P = .64$) or ATP bioluminescence values ($P = .16$) for procedures using sterile water or any of the simethicone concentrations studied (Table 2).

Impact of colon insufflation technique

The mean volume of water injected during the entirety of each colonoscopy (insertion + withdrawal) was expectedly higher for water insufflation procedures relative to air insufflation procedures (1020 mL vs 530 mL, respectively; $P < .001$), but time to cecum and withdrawal time did not significantly differ between air and water insufflation procedures ($P = .32$).

Regression analysis revealed that water insufflation versus air insufflation did not predict the presence of residual fluid ($P = .91$) or ATP bioluminescence values ($P = .74$) in study endoscopes (Table 2).

Impact of bowel preparation

The mean total volume of water injected was expectedly higher for procedures with BBPS ratings of 6/7 compared with those with BBPS ratings of 8/9 (1140 mL vs 860 mL, respectively; $P < .01$), but time to cecum and withdrawal time did not significantly differ based on bowel preparation for any simethicone concentration.

Regression analysis to compare fair/moderate (BBPS 6/ 7) with good/excellent (BBPS 8/9) bowel preparations revealed that BBPS rating did not predict the presence/ amount of residual fluid ($P = .81$) or ATP bioluminescence values ($P = .67$) in study endoscopes (Table 2).

Impact of mode of simethicone delivery

As expected, the mean volume of simethicone solution used during the course of the procedure was much higher when simethicone was added to the irrigation water bottle, compared with injection irrigation by using our standardized volumes (940 mL vs 180 mL, respectively; $P < .001$). The higher volume of simethicone delivered via the water bottle/ water jet channel only impacted fluid droplet and ATP bioluminescence values when low-concentration simethicone was used. For low-concentration simethicone, a mean of 13.5 (± 5.2) droplets and a mean ATP bioluminescence value of 32.3 (± 11.9) RLUs were noted when simethicone was added to the water bottle compared with 6.8 (± 3.6) droplets and 18.4 (± 11.3) RLUs, respectively ($P < .05$ for both) when simethicone suspension was injected via the working channel. For medium-concentration simethicone, there was no significant difference between water bottle/water jet and syringe injection of simethicone, for fluid residue (mean of 14.7 vs 12 droplets, respectively; $P = .11$) or ATP bioluminescence values (mean of 28.0 vs 24.7 RLUs, respectively, $P = .33$). For high-concentration simethicone, no significant difference was evident between water bottle/water jet and syringe injection of simethicone for fluid residue (20 vs 16.2 droplets, respectively, $P = .16$) or mean ATP bioluminescence values (30.2 vs 20.8 RLUs, respectively; $P = .09$).

DISCUSSION

Multisociety guidelines for endoscope reprocessing emphasize drying of endoscope working channels after HLD with alcohol flushes followed by forced filtered air.[10] The presence of residual fluid within endoscope channels is undesirable, because it may promote bacterial

proliferation.[11] However, the threshold at which retained fluid becomes a risk for bacterial proliferation or infection transmission remains undefined. Previously, there has been no direct method to confirm adequate drying of endoscope working channels. A major recent advance has been the development of small-diameter bore-scopes, which permit direct examination of endoscope channels and visualization of channel damage and residual fluid.[7,12,13] Studies performed by us and others using bore-scopes have indicated residual fluid in the working channels of 42% to 95% of reprocessed endoscopes despite alcohol flushes and drying,[7,12,13] indicating that current recommendations may be insufficient to ensure complete drying of endoscopes immediately after reprocessing.

An emerging concern has been that of simethicone persisting in endoscope channels despite reprocessing[5,6] and its potential impact on the adequacy of HLD. Although a previous borescope study conducted at an ambulatory surgery center visualized large amounts of persistent simethicone occluding working channels of endoscopes despite reprocessing,[5] we only visualized such extensive simethicone burden on borescope examination immediately after injection of high-concentration simethicone into the endoscope working channel and before reprocessing. Once endoscopes underwent reprocessing at our institution, only a few small discrete drops of fluid were visualized within endoscope working channels.

Retained fluid droplets in endoscope working channels after reprocessing may be a mix of water, HLD solution residue, and/or simethicone, if used. Although simethicone droplets have been reported to be opaque on borescope evaluation,[5] we found that this opaque character was most evident before manual cleaning/HLD. After reprocessing, we found that the opalescence of the fluid droplets was variable and dependent on the angle of the incident light beam from the borescope. Visual differentiation of fluid droplets based on opacity was difficult after reprocessing, with a similar indistinguishable mix of clear semi-opalescent droplets seen both in endoscopes in which simethicone plus water or water alone had been used. Distinguishing simethicone from water droplets after HLD seemed beyond the capacity of borescope optics.

We demonstrated that use of medium/high concentrations of simethicone resulted in retention of more fluid droplets within endoscope working channels, with higher associated ATP bioluminescence values than when water alone was used. Subjecting these endoscopes to 2 AER cycles resulted in return of retained fluid droplet and ATP bioluminescence values to ranges that did not differ from those after water/low-concentration simethicone use. We found no evidence that bowel preparation, endoscope type, or colonoscope insufflation technique interacted with simethicone to modulate retained fluid droplet or ATP bioluminescence values. The higher volume of low-concentration simethicone suspension delivered via the water bottle/water jet channel resulted in higher retained fluid droplet and ATP bioluminescence values compared with lower-volume standardized flushes delivered via the working channel. This mode of delivery effect was not evident for medium/high concentration simethicone, with similarly elevated retained fluid droplet and ATP bioluminescence values noted with either delivery method. A potential explanation for this observation may be that, in our real-world study design, the volume of simethicone suspension injected via the water bottle could not be restricted because of concerns that visualization and procedure quality could be negatively impacted. Volume of injected

simethicone was therefore not controlled for each simethicone concentration and may have led to confounding of these results.

Because it was not feasible to submit every visualized fluid droplet for analysis, we submitted semi-opalescent endoscope working channel droplets collected after use of low-concentration simethicone only. FTIR analysis of these droplets confirmed the presence of simethicone. Thus, although the number of fluid droplets in low- concentration simethicone endoscopes did not differ from those in which water alone was used, simethicone residue was nevertheless detected in these endoscopes. It therefore appears that despite use in low concentrations, simethicone may persist in endoscopes even after the reprocessing steps of pre-cleaning, manual cleaning, and HLD. Simethicone used in low concentrations in endoscopes had less of an impact on the efficacy of HLD, because ATP levels did not differ significantly compared with endoscopes in which only water was used. Whereas this may relate to an overall smaller burden of simethicone in these endoscopes, this phenomenon requires further study.

The use of simethicone for endoscopic procedures is controversial and in some ways problematical. Careful visualization of the GI mucosa is important during endoscopy, and bubbles hampering mucosa visualization have been reported in 32% to 57% of patients.[14] Simethicone is used primarily to improve mucosa visualization during upper GI endoscopy[15,16] and colonoscopy.[17,18] This benefit must now be weighed against current concerns regarding simethicone retention and its potential impact on HLD, particularly because the effect of simethicone on diagnostic yield and the adenoma detection rate during colonoscopy remain controversial.[15,17,18]

An alternative approach for optimizing mucosa visualization that avoids simethicone delivery via the colonoscope has been addition of the agent to the bowel preparation before colonoscopy.[1,16] This approach has been endorsed by The European Society of Gastrointestinal Endoscopy.[14] However, it is unclear whether simethicone will persist within the colon after bowel preparation and consequently contaminate endoscope working channels. The impact of this approach on simethicone residue within endoscopes requires further study.

Although we demonstrate retained simethicone within endoscope working channels after HLD/drying, even when it is used in low concentrations, with increased fluid droplets and ATP bioluminescence values when simethicone is used in medium/high concentrations, the clinical significance of these findings is unclear. Recent outbreaks of endoscopy-associated infection predominately have been linked to duodenoscopes[10] and are thought related to difficulties in cleaning the elevator mechanism in these endoscopes. In contrast, despite the nationwide performance of >20 million endoscopic procedures annually and widespread use of simethicone, most reported infections associated with gastroscope or colonoscope use have been related to breaches in compliance with reprocessing guidelines or to defective equipment.[19] Thus, the true clinical impact of simethicone on the adequacy of HLD and on the risk of transmission of infection remains unclear and requires further study.

Limitations of our study include the fact that it was conducted at a single institution. The lower amount of simethicone we observed within endoscope working channels compared with previous reports from a commercial research group may be explained by our academic institution's centralized rigorous sterile processing department or by the limited range of simethicone concentrations used in this study. A larger multicenter study would have been more effective in assessing whether these divergent findings are site-specific or broadly representative of findings at ambulatory surgery centers and hospital-based endoscopy units. We created and previously reported a rating scale for evaluation of endoscope working channel findings, and we applied this same scale to our study. However, given the novelty of borescope examination, this scale has not been validated by other centers.[7] We evaluated ATP bioluminescence to assess for microbial residue instead of bacterial cultures. ATP bioluminescence was previously validated as a method for surveillance of flexible endoscopes after manual cleaning.[9,20] Our group and others also have described ATP bioluminescence for surveillance of flexible endoscopes after HLD.[8,21,22] Although low ATP bioluminescence values are reassuring, they do not reliably indicate that endoscope working channels are free of microbial residue.[9,23] Nevertheless, endoscope cultures for microbial surveillance remain contro-versial and susceptible to environmental contamination[24] and have not been endorsed in the 2016 multisociety guidelines for endoscope reprocessing.[10]

In conclusion, our study indicates that use of medium and high concentrations of simethicone is associated with increased fluid droplets within endoscope working channels, with an associated increase in ATP bioluminescence values. We demonstrated that, even when used in low concentrations, simethicone is detectable within endoscope working channels despite reprocessing. However, the clinical relevance of this residue remains debatable. Until more data are available, it would be prudent to follow current manufacturer recommendations to avoid or to use simethicone in the lowest concentration possible. Strong consideration should be given to the suggestion of the Canadian Association of Gastroenterology that if simethicone is used it should be administered through the endoscope working channel and not added to the water bottle.[25] When simethicone is used, facilities may consider 2 cycles of reprocessing. Future multicenter studies are needed to further define potential risks associated with simethicone use.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

Acknowledgments

This work was supported by an NIH T32 training grant (DK007056) to M. Barakat. The DriScope Aid and SteriCam devices were loaned to investigators for this study; however, the study design, data collection analysis and interpretation were entirely investigator initiated.

Abbreviations:

AER	automated endoscope reprocessor
ATP	adenosine triphosphate

BBPS	Boston Bowel Preparation Scale
FTIR	Fourier transform infrared
HLD	high-level disinfection
RLU	relative light unit

REFERENCES

1. Chang WK, Yeh MK, Hsu HC, et al. Efficacy of simethicone and N-acetylcysteine as premedication in improving visibility during upper endoscopy. J Gastroenterol Hepatol 2014;29:769–74. [PubMed: 24325147]
2. Catalone BJ. Simethicone: letter to health care practitioner. Center Valley (Pa): Olympus; 2009.
3. PENTAX Medical Company [instructions for use]. Pentax Video GI Scopes 90i Series 90K Series. Tokyo, Japan: Hoya Corporation; 2014.
4. Fujinon Films USA ED [reprocessing summary and guide for Fujinon/Fujifilm flexible GI endoscopes]. 2012.
5. Ofstead CL, Wetzler HP, Johnson EA, et al. Simethicone residue remains inside gastrointestinal endoscopes despite reprocessing. Am J Infect Control 2016;44:1237–40. [PubMed: 27497824]
6. van Stiphout SH, Laros IF, van Wezel RA, et al. Crystallization in the waterjet channel in colonoscopes due to simethicone. Endoscopy 2016;48:E394–5. [PubMed: 27912222]
7. Barakat MT, Girotra M, Huang RJ, et al. Scoping the scope: endoscopic evaluation of endoscope working channels with a new high-resolution inspection endoscope (with video). Gastrointest Endosc. Epub 2018 Feb 6.
8. Sethi S, Huang RJ, Barakat MT, et al. Adenosine triphosphate bioluminescence for bacteriologic surveillance and reprocessing strategies for minimizing risk of infection transmission by duodenoscopes. Gastrointest Endosc 2017;85:1180–7.e1. [PubMed: 27818222]
9. Alfa MJ, Fatima I, Olson N. The adenosine triphosphate test is a rapid and reliable audit tool to assess manual cleaning adequacy of flexible endoscope channels. Am J Infect Control 2013;41:249–53. [PubMed: 22975364]
10. Reprocessing Guideline Task Force; Petersen BT, Cohen J, Hambrick RD 3rd, et al. Multisociety guideline on reprocessing flexible GI endoscopes: 2016 update. Gastrointest Endosc. Epub 2017 Jan 6.
11. Kovaleva J Endoscope drying and its pitfalls. J Hosp Infect. Epub 2017 Jul 17.
12. Ofstead CL, Wetzler HP, Eiland JE, et al. Assessing residual contamination and damage inside flexible endoscopes over time. Am J Infect Control 2016;44:1675–7. [PubMed: 27614710]
13. Ofstead CL, Wetzler HP, Heymann OL, et al. Longitudinal assessment of reprocessing effectiveness for colonoscopes and gastroscopes: results of visual inspections, biochemical markers, and microbial cultures. Am J Infect Control 2017;45:e26–33. [PubMed: 28159069]
14. Hassan C, Bretthauer M, Kaminski MF, et al. Bowel preparation for colonoscopy: European Society of Gastrointestinal Endoscopy (ESGE) guideline. Endoscopy 2013;45:142–50. [PubMed: 23335011]
15. Zhang LY, Li WY, Ji M, et al. Efficacy and safety of using premedication with simethicone/Pronase during upper gastrointestinal endoscopy examination with sedation: a single center, prospective, single blinded, randomized controlled trial. Dig Endosc 2018;30:57–64. [PubMed: 28816373]
16. Elvas L, Areia M, Brito D, et al. Premedication with simethicone and N-acetylcysteine in improving visibility during upper endoscopy: a double-blind randomized trial. Endoscopy 2017;49: 139–45. [PubMed: 27852098]
17. Wu L, Cao Y, Liao C, et al. Systematic review and meta-analysis of randomized controlled trials of Simethicone for gastrointestinal endoscopic visibility. Scand J Gastroenterol 2011;46:227–35. [PubMed: 20977386]

18. Matro R, Tupchong K, Daskalakis C, et al. The effect on colon visualization during colonoscopy of the addition of simethicone to polyethylene glycol-electrolyte solution: a randomized single-blind study. Clin Transl Gastroenterol 2012;3:e26. [PubMed: 23238113]
19. Kovaleva J, Peters FT, van der Mei HC, et al. Transmission of infection by flexible gastrointestinal endoscopy and bronchoscopy. Clin Microbiol Rev 2013;26:231–54. [PubMed: 23554415]
20. Alfa MJ, Fatima I, Olson N. Validation of adenosine triphosphate to audit manual cleaning of flexible endoscope channels. Am J Infect Control 2013;41:245–8. [PubMed: 22980510]
21. Hansen D, Benner D, Hilgenhoner M, et al. ATP measurement as method to monitor the quality of reprocessing flexible endoscopes. Ger Med Sci 2004;2:Doc04.
22. Bommarito M, Stahl J, Morse, et al. Monitoring the efficacy of the cleaning and disinfection process for flexible endoscopes by quantification of multiple biological markers. Antimicrob Resist Infect Control 2015;4:56. [PubMed: 26688720]
23. Turner DE, Daugherity EK, Altier C, et al. Efficacy and limitations of an ATP-based monitoring system. J Am Assoc Lab Anim Sci 2010;49: 190–5. [PubMed: 20353694]
24. Visrodia K, Hanada Y, Pennington KM, et al. Duodenoscope reprocessing surveillance with adenosine triphosphate testing and terminal cultures: a clinical pilot study. Gastrointest Endosc 2017;86:180–6. [PubMed: 28396277]
25. Benmassaoud Amine, Parent Josée. CAG position statement: the impact of simethicone on endoscope reprocessing. Canadian Association of Gastroenterology 2017:1–4.

This video can be viewed directly from the GIE website or by using the QR code and your mobile device. Download a free QR code scanner by searching “QR Scanner” in your mobile device’s app store.

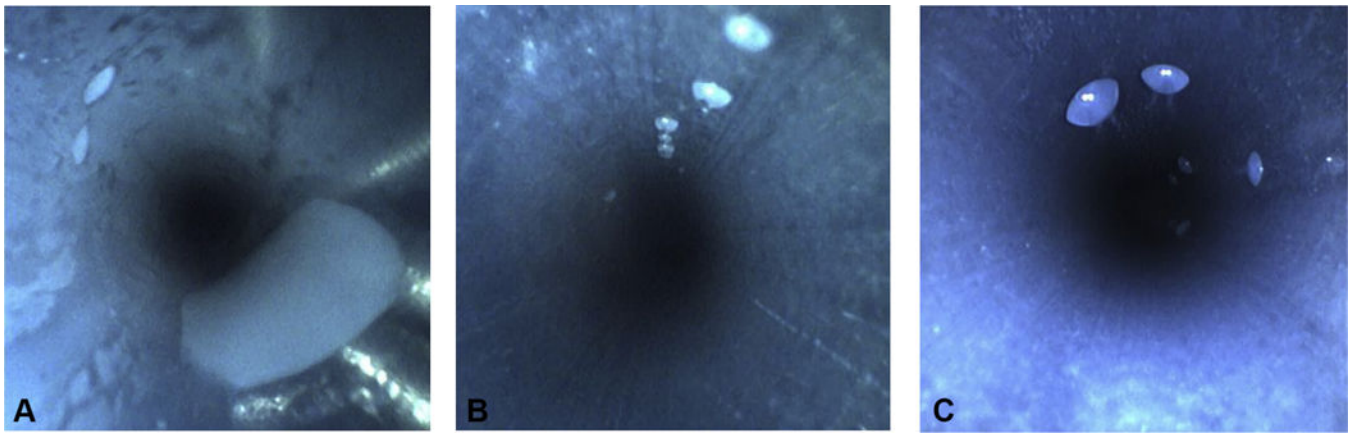

Figure 1.

A, Borescope examination demonstrating a large, shallow, opaque pool of fluid immediately after injection of 3% simethicone suspension into the colonoscope working channel. **B,** Relatively clear fluid droplets after manual cleaning/HLD/drying. **C,** Relatively opalescent fluid droplets after manual cleaning/HLD/drying.

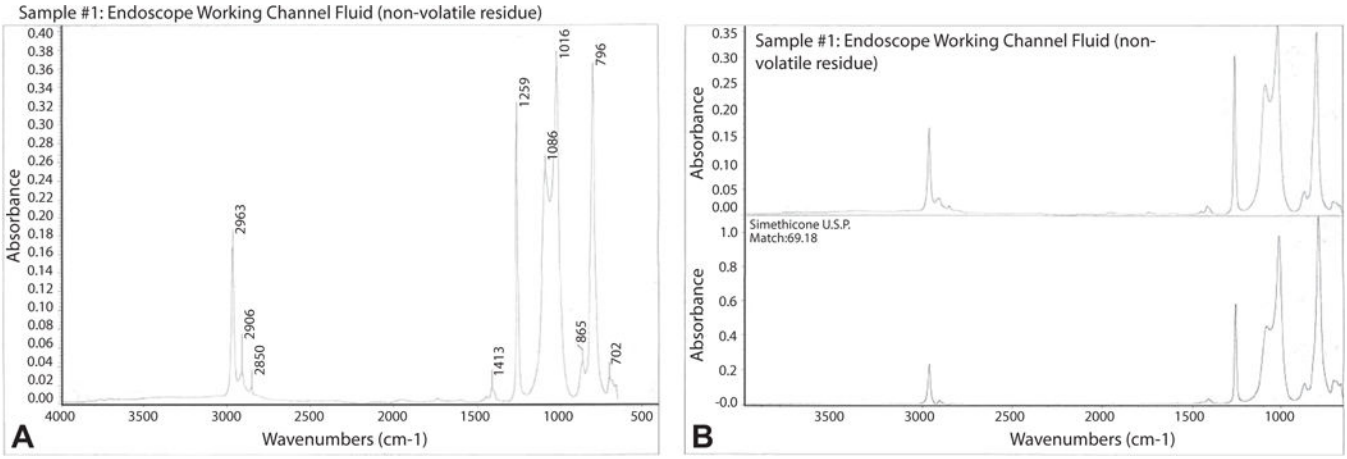

Figure 2.

A, Fourier transform infrared analysis of residual working channel fluid droplets despite HLD/drying after use of low-concentration simethicone. **B,** Comparison of the working channel fluid droplets with a commercial standard reference simethicone sample confirming spectra.

Figure 3.

Intermittent blurring of the endoscopic image after use of 3% simethicone. Endoscopic appearance of rectal mucosa when initially affected by blurring (*far left*) and after 5, 10, and 15 seconds of washing by using the lens water jet apparatus.

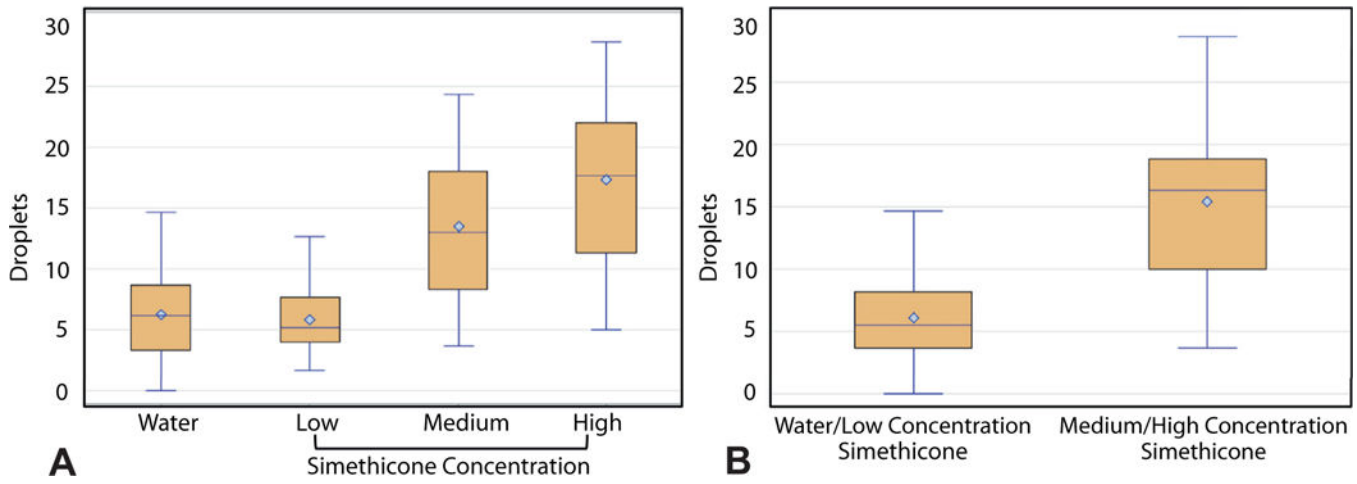

Figure 4.

A, Boxplot representation of residual fluid droplet abundance (number of droplets) after use of water and low, medium, and high concentrations of simethicone. **B,** Boxplot representation of fluid droplet abundance for water/low concentration simethicone and medium/high concentration simethicone flushes. Boxes represent interquartile ranges. Whiskers represent the lowsest or highest data point still within a 1.5 multiple of the interquartile range.

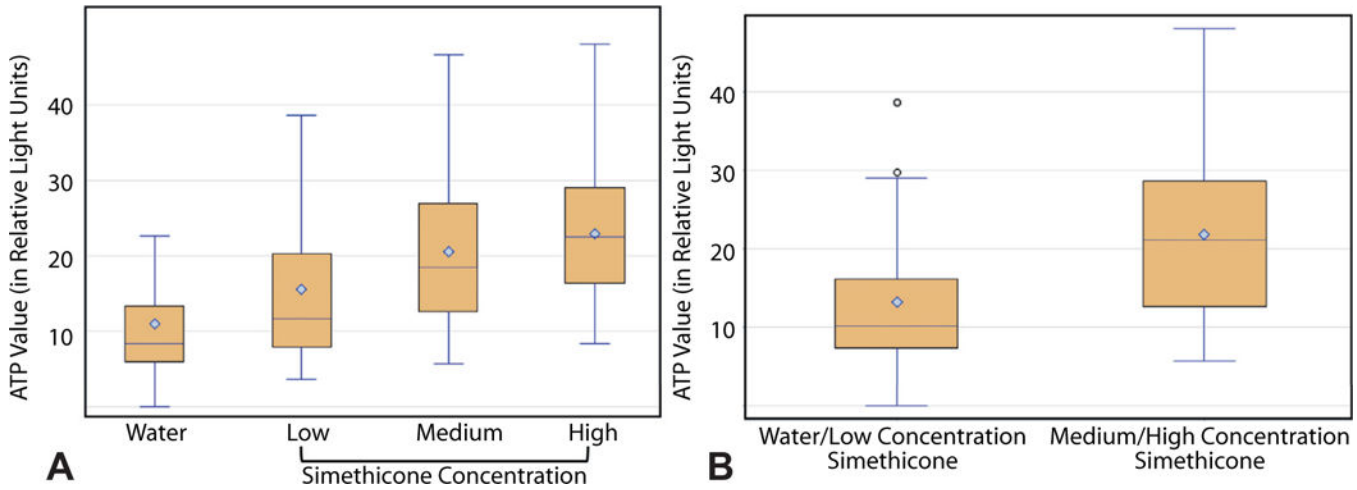

Figure 5.

A, Boxplot representation of adenosine triphosphate (ATP) bioluminescence values in Relative Light Units (RLU) after use of water and low, medium, and high concentrations of simethicone. **B,** Boxplot representation of ATP bioluminescence values for water/low concentration simethicone and medium/high concentration simethicone. Boxes represent interquartile range. Whiskers represent the lowest or highest data point still within a 1.5 multiple of the interquartile range.

TABLE 1.

Impact of simethicone use and concentration on fluid residue and ATP values

Variables, n = 36 **18 colonoscope, 18 gastroscope**	**No. droplets mean (± SD)**	***P* values**	**ATP value mean (± SD)**	***P* values**
Water	6.30 (3.52)		10.97 (7.84)	
Simethicone, low concentration (0.5%)	5.81 (2.77)	Low vs water (NS)	15.56 (10.37)	Low vs water (NS)
Simethicone, medium concentration (1%)	13.47 (5.64)	Medium vs water ($P < .001$) Medium vs low ($P < .001$)	20.58 (10.12)	Medium vs water ($P < .001$) Medium vs low ($P < .01$)
Simethicone, high concentration (3%)	17.30 (6.61)	High vs water ($P < .001$) High vs low ($P < .001$) High vs medium (NS)	23.00 (10.60)	High vs water ($P < .001$) High vs low ($P < .001$) High vs medium (NS)

SD, Standard deviation; *ATP*, adenosine triphosphate; *NS*, not significant.

TABLE 2.

Predictors of residual fluid droplets and ATP values

	Droplets		ATP values	
Predictor	**Estimate**	***P* value**	**Estimate**	***P* value**
Damage (per rating scale point), (n = 144)	0.98	.64	4.65	.16
Endoscope type, vs gastroscope, (n = 144)	3.21	.19	−0.79	.12
BBPS 6–7 (vs BBPS 8–9), (n = 72)	0.31	.81	−0.84	.67
Water insufflation (vs air insufflation) (n = 72)	−0.14	.91	0.67	.74

ATP, Adenosine triphosphate; *BBPS,* Boston Bowel Preparation Scale.