Intrauterine pressure during hysteroscopic morcellation.

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Abstract

Background: Our objective was to compare intrauterine pressures during resection and aspiration modes among three types of hysteroscopic morcellators.

Method: This was a bench-top study. A silicone uterine model was attached to a manometer via a tubing where the tip was inside the cavity to allow for intra-cavity pressure measurements. Each hysteroscopic morcellator was then introduced and intra-cavity pressures were recorded continuously in 3 modes (static, resection and aspiration) and at 3 set point pressures (45, 85, and 125mmHg).

Results: Using mixed effects linear regression, the mean observed intrauterine pressure was not greater than the set pressure for each of the three devices. This result held true in both aspiration and resection mode. In our statistical models, the coefficient on the terms representing the interaction between device and time were not statistically significant in either resection or aspiration mode. This indicates that statistically, the change in intrauterine pressure over time was not significantly different across the three devices.

Conclusion: In this bench top, head to head study, we found that all three commercially available hysteroscopic morcellators appear to be non-inferior to each other in terms of the risk of intravasation. This is important because many gynecologists do not have a choice as to which device they can use.

Introduction

Hysteroscopy is a commonly used minimally invasive gynecological procedure, utilized in both clinical and operating settings. An endoscopic optical lens is inserted through the cervix into the endometrial cavity to directly visualize and treat pathology. Operative hysteroscopy became popular after improvements in endoscopic technology and instruments in the 1970s and after introduction of fluid distension medial in the 1980s. Since that time, the development of new hysteroscopic instruments, fiber optics, and digital video equipment has continued to provide more varied, efficacious, and less invasive procedures. [1]

Operative hysteroscopy is overall a safe procedure resulting in complication in 0.95-3% of cases.[2-4] The most frequently observed complications include hemorrhage (2.4%), uterine perforation (1.5%), and cervical laceration (1-11%).[5] Another rare complication is excessive fluid absorption with or without resulting hyponatremia (0.2-0.76%).[3,4,6] Fluid deficits should be carefully managed during hysteroscopy to prevent intravasation. Lower uterine filling pressures have been associated with lower patient pain scores but a higher trend towards inadequate visibility.[7]

The purpose of this non-human benchtop study was to compare intrauterine pressures during resection and aspiration modes among the three commercially available hysteroscopic morcellators. No prior study has compared these three devices in a head to head manner using a clinically relevant outcome measure.

Method

Intrauterine pressure and accuracy was compared utilizing Boston Scientific Symphion™, Hologic Myosure™, and Smith & Nephew Truclear™ systems in three modes (static, aspiration, and resection) at different pressure settings. This was performed using a silicone uterine model, a manometer to measure continuous intrauterine pressure, and porcine heart tissue to represent intrauterine fibroid material. Each arm was performed three times (to account for possible variability between individual devices), each time with a new device, and results were averaged.

Pressure Control Setup

First, a 20-gauge dispensing tip (manufactured by Nordsen EFD) was used to pierce the thickened section of the simulated uterine cavity model (Figure 1). Next, the endoscope was introduced into the clear cavity model without the resection device attached. Then, the manometer was connected to the dispensing tip and this was connected to a computer using a USB cable provided with the manometer. This allowed for measurement of actual pressure in the cavity model which was compared to the set pressure on the controller graphical user interface(GUI). Sper Scientific data acquisition software was used to measure intrauterine pressure.

Static Pressure Control

The cavity pressure on the controller was set to 45mmHg. Infusion pump was run and cavity pressure was measured after 30 seconds. Cavity pressure was increased in 10mHg increments every 30 seconds until 125 mmHg was reached. Pressure was measured at each step. These steps were performed equally for all three device systems. The primary purpose of this paper was to evaluate the intrauterine pressure observed during aspiration and resection, which are described in the following sections.

Aspiration Pressure Control

The cavity pressure on the controller was set to 45mmHg. Infusion pump was run and aspiration was performed for 10 seconds. Cavity pressure was measured throughout. This was repeated at cavity pressures of 85 and 125mmHg with all three device systems.

Resection Pressure Control

Porcine heart tissue was used to simulate human uterine fibroid tissue. Two 1.5-inch portions of tissue were inserted into the silicone model and the endoscope with resection device were inserted. Cavity pressure was set to 45mmHg at the controller. Cut mode was activated for 10 seconds and cavity pressure was monitored. This was repeated at set cavity pressures of 85 and 125mmHg for all three device systems.

Statistical methodology

For each device there were three trials. During each trial the set point pressure was systematically increased from one predetermined level to another. Intrauterine pressure measurements were then repeatedly taken, essentially every second, for each given set point pressure. Therefore, the data consisted of “repeated measures” and as such, multi-level modeling was used to analyze the data.

In constructing our mixed effects multilevel model, we specified dummy variables representing device as the fixed effect. Symphion™ was set to be the reference category for each of the two dummy variables representing Myosure™ and Truclear™. In addition to dummy variables representing the device, we also included an interaction term as a covariate, representing the interaction between device and time. The purpose of this interaction term was to be able to assess whether the variation in intrauterine pressure over time was different for the three devices. The stratification variable used was mode. We conducted a separate model for aspiration and resection mode.

The dependent variable in our models was the measured intrauterine pressure. We centered the observed intrauterine pressure reading by subtracting the set point pressure from the obtained value. For example, if the observed intrauterine pressure was 100 mmHg and the set point pressure was 85 mmHg, then the centered pressure would be 15 mmHg (100 – 85 mmHg). We did this to allow the dependent variable to be continuous, thereby maintaining statistical power, while allowing the interpretation of the results from the model to be more clinically meaningful. In our linear mixed models, our main clinical concern was whether the predicted mean intrauterine pressure during use of each device was significantly higher than the set pressure, as this would put the patient at higher risk for intravasation.

Finally, we used graphical methods to construct two sets of plots. First, we constructed plots of centered intrauterine pressure against time in seconds for each device in each mode. In the second set of plots, we plotted centered intrauterine pressure against set pressure for each device (irrespective of mode). We used the *Mixed* command in STATA (College Station, TX; Version 14) to do the above models and the LOWESS command to obtain smoothed plots. Our detailed statistical codes are available upon request.

Results.

In appendix 1, the characteristics of the experiment (the aspiration and resection modes) are summarized. In aspiration mode, at set point pressure of 45 mmHg, each trial lasted 29-30 seconds for each device. For the 85 mmHg set point pressure, each trial lasted 37-48 seconds. For the 125 mmHg set point pressure, each trial lasted 40-64 seconds. In resection mode, there was an overall similar pattern.

Mean intrauterine pressure across the three devices.

The predicted mean centered intrauterine pressures obtained from our linear mixed models are shown in Table 1. The clinically meaningful outcome is whether the mean intrauterine pressure is greater than the set pressure. In this scenario the patient would be at risk for intravasation of fluids. In this study, in aspiration mode, the mean centered intrauterine pressure was never higher than zero, regardless of which device was used. In other words, for each of the three devices, the mean observed intrauterine pressure was not greater than the set pressure. The confidence intervals around the mean centered intrauterine pressure for each device all overlap indicating that the difference between the mean intrauterine pressure and the set pressure was not statistically different across the three devices.

In resection mode, the same pattern was observed. The predicted mean centered intrauterine pressure was never greater than zero, regardless of which device was studied. Also, the confidence intervals around the mean centered intrauterine pressure for each device all overlapped with each other.

It is worth noting that in both resection and aspiration mode the confidence interval around the mean intrauterine pressure for Myosure appeared to be much wider than the confidence interval around the mean intrauterine pressure for Symphion and Truclear.

Variation of intrauterine pressure over time.

In figure 2, we show the variation in intrauterine pressure over time for each device in each mode. In both aspiration and resection mode, the variation in intrauterine pressure over time graphically appears to be lower for Symphion™ compared to the other two devices (Myosure™ and Truclear™). However, in our statistical models, the coefficient on the terms representing the interaction between device and time were not statistically significant in either resection or aspiration mode. This indicates that statistically, the change in intrauterine pressure over time was not significantly different across the three devices.

Variation of intrauterine pressure by set pressure.

In figure 3, we show the variation of intrauterine pressure by set pressure (for all modes combined). In aspiration and resection mode, only 3 set pressures were used (45, 85 and 125 mmHg) and so, not surprisingly, more variability was observed at these three set pressures. However, the variation in intrauterine pressures at these three set pressures, graphically speaking, appeared to be lower for Symphion™ compared to the other two competitor devices (Myosure™ and Truclear™). We did not formally test whether the *variation* in the intrauterine pressure at each set pressure was statistically different across the three devices.

Discussion

In this non-human benchtop study of three competitor hysteroscopic morcellating devices we observed clinically meaningful trends. For all three devices, regardless of whether the mode was aspiration or resection, the mean measured intrauterine pressure was below the set pressure. This would lend support to the basic conclusion that all three devices are equally safe in terms of the risk of intravasation.

This is the first head to head bench top study comparing the three commercially available hysteroscopic morcellators in the United States. We believe this to be a very well thought out experiment with a large number of data points and we believe our statistical methods were rigorous.

The main limitation with this study is that it is ex-vivo and not in-vivo. It is unknown how much the results of an experiment conducted using a silicone model to simulate the uterus will translate to a real hysteroscopic procedure on a real patient. However, some experiments are very difficult to execute in-vivo and consequently ex-vivo studies such as ours still play an important role in informing clinical practice. It would be extremely challenging technically to conduct an in-vivo study that involves continuous intra-uterine pressure measurement while a hysteroscopic procedure is conducted.

The main unanswered question is whether variation in intrauterine pressure over time has clinical relevance. Although the change in pressure over time was not statistically different across the three devices, based on statistical models, we still could not help but notice that the confidence interval around the mean intrauterine pressure was much wider for Myosure™ compared to Truclear and Symphion™ .In aspiration mode, for example, the width of the confidence interval was 33.4mmHg whereas for Symphion™ it was only 4.7mmHg. We believe that future studies should explore whether there is any clinical relevance to variations in intrauterine pressure over time during hysteroscopic morcellation.

Another observation that deserves further exploration is the fact that in aspiration mode, the entire confidence interval around the mean intrauterine pressure for the Symphion device was below the mean intrauterine pressure for the other two devices. Does this indicate a potential tendency of Symphion™ to "under-pressurize" the uterus compared to the other two devices? And if so, does this have clinical relevance? Further studies are needed to more carefully answer these questions.

In conclusion, this detailed bench top head to head study lends support to the notion that all three commercially available hysteroscopic morcellators appear to be non-inferior to each other in terms of the risk of intravasation as a result of the observed intrauterine pressure being greater than the set pressure selected. This is important for clinical practice because many gynecologists do not have a choice as to which device they can use—their choice is dictated by contracts signed between their hospital and the manufacturers of the devices.

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Tables

Table 1. Association between intrauterine pressure and type of device based on mixed effects multi-level regression modeling.

	Aspiration		Resection	
	Predicted centered intrauterine pressure*	95% CI	Predicted centered intrauterine pressure*	95%CI
Device				
Myosure	-14.2	-30.9, 2.5	-12.4	-23.4, -1.4
Symphion	-18.4	-20.7, -16.0	-18.3	-23.3, -13.3
Truclear	-9.4	-17.1, -1.7	-18.9	-23.9, -13.9

* Obtained from models that were constructed as linear mixed effects multi-level models. Dependent variable was the centered intrauterine pressure in mmHg.

Figure legend

Figure 1. Pressure Control Test Setup

Figure 2. Centered intrauterine pressure versus time in static, resection and aspiration modes for three hysteroscopic morcellators.

Figure 3. Variation of intrauterine pressure by set pressure, for all modes combined, for three hysteroscopic morcellators.