UNIVERSITY OF CALIFORNIA

Los Angeles

Statistical Analysis on Robotic Assisted Minimally Invasive Two Stage Anastomosis with Fistula Repair and a Diverting Loop Ileostomy Treatment of Diverticulitis

A thesis submitted in partial satisfaction
of the requirements for the degree
Master of Applied Statistics

by

Sophie Lellis-Petrie

2020

ABSTRACT OF THE THESIS

Statistical Analysis on
Robotic Assisted Minimally Invasive Two Stage Anastomosis with
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by

Sophie Lellis-Petrie
Master of Applied Statistics
University of California, Los Angeles, 2020
Professor Hongquan Xu, Chair

Our procedure uses advanced technology paired with what we've learnt from prior Primary Anastomosis procedures to treat diverticulitis through a robotic assisted minimally invasive two stage anastomosis with fistula repair and a diverting loop ileostomy. In this study, we compare our procedure with Primary Anastomosis, Hartmann, Laparotomy, Laparoscopy, and other Minimally Invasive Robotic procedures.

We performed a meta-analysis and compared 95% confidence intervals of our procedure's outcome variables with other research paper's outcome variables. Outcome variables were length of stay in hospital (days), operation time (min.), and blood loss (ml). In order to

check the validity of comparing our study with other research paper's results, we compared 95% confidence intervals of our study's raw data and 95% confidence intervals of bootstrap samples from our study's data.

Our minimally invasive robotic procedure tended to have shorter lengths of time in the hospital than other Hartmann and Primary Anastomosis procedures. Our study's 95% confidence interval (CI) for blood loss (ml) was also less than the Hartmann and Primary Anastomosis procedures and in line with gynecologic and hysterectomy MIS robotic procedures. There were three Hartmann and Primary Anastomosis studies with 95% CI for operation time (minutes) that overlap with our study's operation time and the remainder research papers have CI with longer operation times than our procedure.

We can not conclusively say our minimally invasive robotic procedure to cure diverticulitis is better than other procedures. The trends in the current study with sample size 20 show there are a lot of benefits to this procedure and it is not harmful. An increase in sample size would allow causal findings.

The thesis of Sophie Lellis-Petrie is approved.

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2020

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Introduction

Diverticula occurs in many people over the age of 40 in the western world [1]. Diverticula are small sacs that create bulges in the intestine from pressure and turns into diverticulitis when the bulges turn into an abscess, there's a tear creating a fistula between the intestine and other organs, or when it ruptures [1]. Diverticulitis is one of the most common causes for gastrointestinal hospitalization [2].

Laparotomic (open) Hartmann and Primary Anastomosis are well known surgeries for treating diverticulitis. Hartmann procedure requires an additional step but typically has a patient under anesthesia for less time [3]. Primary Anastomosis has less procedures but typically extends operation time [3]. There have been a few remedies to the Primary Anastomosis procedure such as a diverting loop but people still worry of anastomotic leak [4]. There is little research on implementing more advanced technology for diverticulitis procedures.

Our procedure uses advanced technology paired with what we've learnt from Primary Anastomosis. Our procedure is robotic assisted minimally invasive two stage anastomosis with fistula repair and a diverting loop ileostomy.

Methods

This is a retrospective cohort study of patients from one centre (Valley Hospital) by one surgeon (Dr. Browder). Twenty patients who had complex diverticulitis with abscess formation, colovaginal or colovesical fistulas underwent robotic assisted minimally invasive two stage anastomosis with fistula repair and a diverting loop ileostomy. Data was collected from 4/4/2015 to 1/28/2020. Patients with cancer at the time of the procedure were excluded from the study.

This study is unique since it only has the results of one type of procedure. This makes it difficult to perform causal statistics or use a typical experimental design. We compare the outcomes in the current study with other diverticulitis procedure outcomes found in research papers. We can not say there are significant differences but can speak to trends and patterns we see. It is also difficult to find significant variable relations within the data because the study size is small (n = 20).

Since we'd like to compare our procedure with other established complex diverticulitis procedures, a meta analysis was performed. We used the keywords "Hartmann Procedure", "Primary Anastomosis", "Complex Diverticulitis", "Laparotomy", and "Laparoscopy" to find relevant research papers. Research papers provided study size (n), and summary statistics of the results such as hospital length of stay (days), operation length (minutes), and blood loss (ml). The summary statistics were provided as mean, standard deviation, median, and range.

In order to account for other factors that impact surgery outcomes, we looked at the number of comorbidities, comorbidity, age, and BMI in relation to operation time (min.), hospital length of stay (days), and blood loss (ml). We performed bootstrap sampling using our study's data to test this.

Statistical Analysis

95% confidence intervals (CI) are used to compare the results of our study with results of Hartmann, Primary Anastomosis, Laparotomy, Laparoscopy, and Minimally Invasive Robotic procedures. The 95% CI formula is $\overline{x} \pm t \frac{s}{\sqrt{n}}$ (1). When research papers provided results as a median and range, we calculated mean and standard deviation using the formulas (2), (3), (4), (5), and (6) in Figures 1 and 2 [5].

Fig 1. **Calculating $\overline{x}$ from Median**

Study Size (n)	**Formula**
$n \leq 25$	$\overline{x} = \frac{a+2m+b}{4}$ (2)
$n > 25$	$\overline{x}$ = median (3)

$a = minimum\ value,\ b = maximum\ value,\ m = median$

Fig 2. **Calculating Standard Deviation from Range**

Study Size (n)	**Formula**
$n \leq 15$	$s = \sqrt{\frac{1}{12}\left(\frac{(a-2m+b)}{4}^{2} + (b-a)^{2}\right)}$ (4)
$15 < n \leq 70$	$s = range/4$ (5)
$n > 70$	$s = range/6$ (6)

$a = minimum\ value,\ b = maximum\ value,\ m = median,\ range = b - a$

95% confidence intervals use the t distribution, which assumes the data are distributed normally and are randomly and independently chosen. Our study does not satisfy the normality assumption and has a small sample size (n=20). Also, since we only have the summary data for research papers in the meta analysis, we don’t know the research papers data distribution. In order to test the validity of using a 95% confidence interval using formula (1), we compare formula (1) with the confidence interval based on bootstrap sampling from our study’s results.

Bootstrap sampling does not assume normality in the data and allows us to perform a 95% CI on the bootstrap samples from the law of large numbers and the Central Limit Theorem

(CLT). The only assumption used for bootstrap sampling is random sampling of the population. We took 2,000 bootstrap samples of operation time (min.), hospital length of stay (days), blood loss (ml), age (years), and BMI (kg/m^2). We used normal (7), percentile (8), and BCa (bias-corrected and accelerated) (9) formulas in Figure 3 to calculate the 95% confidence interval from bootstrap samples and used the library(boot) and function boot.ci() [6].

The normal confidence interval (7) assumes the distribution of the bootstrap samples are normal. The percentile confidence interval (8) does not assume normality and chooses the 2.5% and the 97.5% percentiles from the bootstrap sample estimates. BCa (9) introduced by Efron and Tibshirani is the percentile confidence interval with bias correction and acceleration [6]. The bias correction is the proportion of bootstrap replications less than the mean of the raw data [6]. The acceleration component uses the jackknife estimate and accounts for the rate of change in the standard error of the mean of the original data in respect to the mean of the true population [6].

Fig 3. **95% Confidence interval formulas from Bootstrap Samples**

	Formulas
Normal (7)	$[(\widehat{\mu} - bias) - z^{(1-\alpha)} \cdot se,\ (\widehat{\mu} - bias) - z^{(\alpha)} \cdot se]$ where $\widehat{\mu} = \frac{\Sigma x}{n}$ *of the raw data* , $bias = \widehat{\mu}_b^* - \widehat{\mu}$, where $\widehat{\mu}_b^* = \frac{\Sigma \widehat{u}^*}{B}$, B = number of bootstraps, $\widehat{u}^*$ = *random bootstrap drawn from raw data*
Percentile (8)	$[\widehat{u}^{*(\alpha)}, \widehat{u}^{*(1-\alpha)}]$ $\widehat{u}^{*(\alpha)} = 100 \cdot \alpha^{th}$ *percentile of* $\widehat{u}^*$*'s distribution* $\widehat{u}^{*(1-\alpha)} = 100 \cdot (1-\alpha)^{th}$ *percentile of* $\widehat{u}^*$*'s distribution* $\widehat{u}^*$ = *random bootstrap drawn from raw data*
BCa (Bias-Corrected and Accelerated) (9)	$[\widehat{u}^{*(\alpha_1)}, \widehat{u}^{*(\alpha_2)}]$ $\widehat{u}^*$ = *random bootstrap drawn from raw data* where $\alpha_1 = \Phi(\widehat{z}_0 + \frac{\widehat{z}_0 + z^{\alpha}}{1 - \widehat{a}(\widehat{z}_0 + z^{\alpha})})$ $\alpha_2 = \Phi(\widehat{z}_0 + \frac{\widehat{z}_0 + z^{(1-\alpha)}}{1 - \widehat{a}(\widehat{z}_0 + z^{(1-\alpha)})})$ Φ = standard normal cumulative distribution z^{α} = 100 α*th* percentile point of standard normal distribution $\widehat{a} = \frac{\sum_{i=1}^{n} (\widehat{\mu}_{(\cdot)} - \widehat{\mu}_{(i)})^3}{6\{\sum_{i=1}^{n} (\widehat{\mu}_{(\cdot)} - \widehat{\mu}_{(i)})^2\}^{3/2}}$ where $\widehat{\mu}_{(\cdot)}$ = mean of bootstrap estimates $\widehat{\mu}_{(i)}$ = estimate after deleting the ith case $\widehat{z}_0 = \Phi^{-1}(\frac{\#\{\widehat{\mu}_b^* < \widehat{\mu}\}}{B})$ where # = counting operator

The means of the bootstrap sample and the raw data differed by at most 0.21. All normal and percentile 95% confidence intervals based on bootstrap samples were within the 95% CI of the raw data. This provides a level of assurance the raw data confidence interval contains the true population mean. Two of the BCa 95% confidence intervals extend a small amount outside of the raw data 95% CI. BCa BMI CI extends 0.91 kg/m2 above the raw data interval, and BCa blood loss (ml) confidence interval extends 1.12 ml above the raw data interval. BCa accounts for skewed data so these small variations could be due to the small size of our data, which are slightly skewed. These are small variances but are kept in mind when performing parametric testing in the remainder of the paper.

Fig 4. **95% Confidence Intervals**

	Study (Raw data)	**Normal**	**Percentile**	**BCa**
Age (years)	59.50 - 69.90 (64.7)	59.82 - 69.49 (64.74)	60.00-69.80 (64.74)	59.93 - 69.71 (64.74)
BMI (kg/m^2)	24.70 - 30.92 (27.81)	25.07 - 30.63 (27.77)	25.39-30.79 (27.77)	25.75 - 31.83 (27.77)
Operation Time (min)	116.54 - 163.36 (139.95)	118.20 - 161.30 (140.16)	118.40-161.70 (140.16)	118.90 - 162.20 (140.16)
Blood Loss (ml)	59.62 - 97.38 (78.5)	61.20 - 95.39 (78.71)	63.00-97.25 (78.71)	63.50 - 98.50 (78.71)
Length of Stay (days)	3.90 - 6.20 (5.05)	4.01 - 6.10 (5.04)	4.05-6.15 (5.04)	4.10 - 6.20 (5.04)

$confidence\ interval\ lower\ bound\ -\ confidence\ interval\ upper\ bound\ (mean)$

Since all of the outcome variables using the normal, and percentile 95% CI based on bootstrapping fell within the 95% CI using the t statistic, we used the 95% confidence interval using the t statistic to compare our study with other research papers. We conducted 95% CI intervals for the research papers assuming the 95% CI using the t statistic based on the raw data would approximately encompass the true mean like in our study.

Practicality

Age and BMI are used to account for potential noise in the results. Age alone does not decide risk of surgical procedures but does typically increase risk factors in surgery [7]. After reaching out to one of the leads in our surgical study, we decided patients 70 and older are more likely to have surgical risks and we split age into patients 70 years and older and patients younger than 70. This variable was used to compare outcome variables within our study. There were 5 (25%) out of 20 people in the study that were 70 or older.

Patients with BMI 30 kg/m2 and over also have higher risks during surgery such as longer operation time and complications shortly after procedures [8]. BMI was split into BMI below 30 kg/m2 and BMI 30 kg/m2 and over when comparing outcome variables within our study. Only 4 patients had BMI higher than 30 kg/m2.

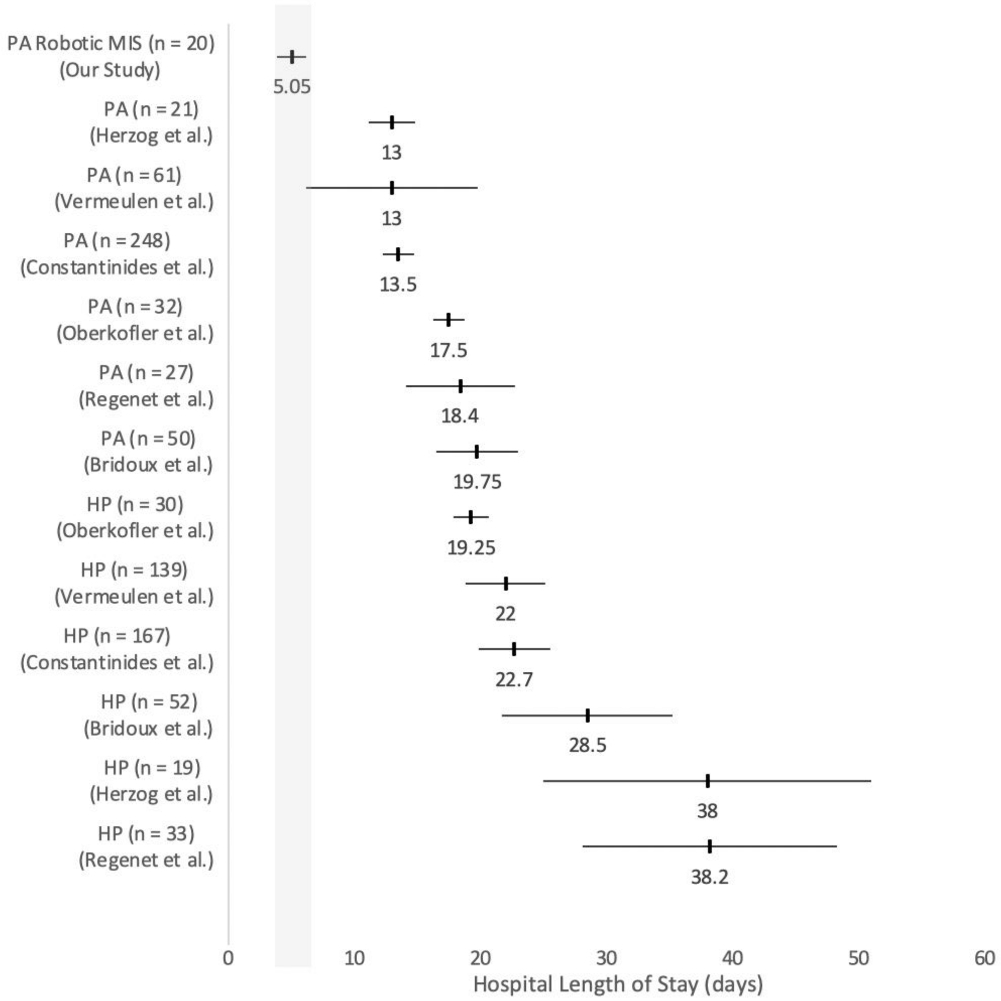
Blood loss is another outcome variable and is used in order to measure the success of our study's minimally invasive technique. Blood management is necessary for surgeries that have blood loss greater than 500 ml [9]. Blood loss greater than 500 ml leads to complications in the procedure and creates problems when there are blood shortages [9]. Our study had an average 78.5 ml of blood loss with maximum 200 ml blood loss, which is below the 500 ml threshold needed for blood management during a procedure. This is why we don't focus on blood loss within the study but compare blood loss of other procedures to our study.

Since our study is minimally invasive, it is beneficial to see whether it follows similar patterns as other laparoscopic procedures. A study on closed and open appendectomy shows there are less complications, and less days spent in the hospital for closed procedures but the procedure is typically longer [10].We compare abdominal MIS robotic research with our study to see how our study compares to other MIS robotic procedures.

Results

Our procedure has a mean hospital stay of 5.05 days. The 95% confidence interval is 3.9 to 6.2 days in the hospital, which is a relatively small interval for a small sample size. None of the other 95% confidence intervals in Figure 5 overlap with the current study's confidence interval. A Primary Anastomosis (PA) procedure from Vermeulen et al. has a 95% CI 6.21 to 19.79 days with an average of 13 days [12]. This almost overlaps with our study's confidence interval but does not. Our procedure's CI upper bound is less than the other studies' length of stay confidence intervals.

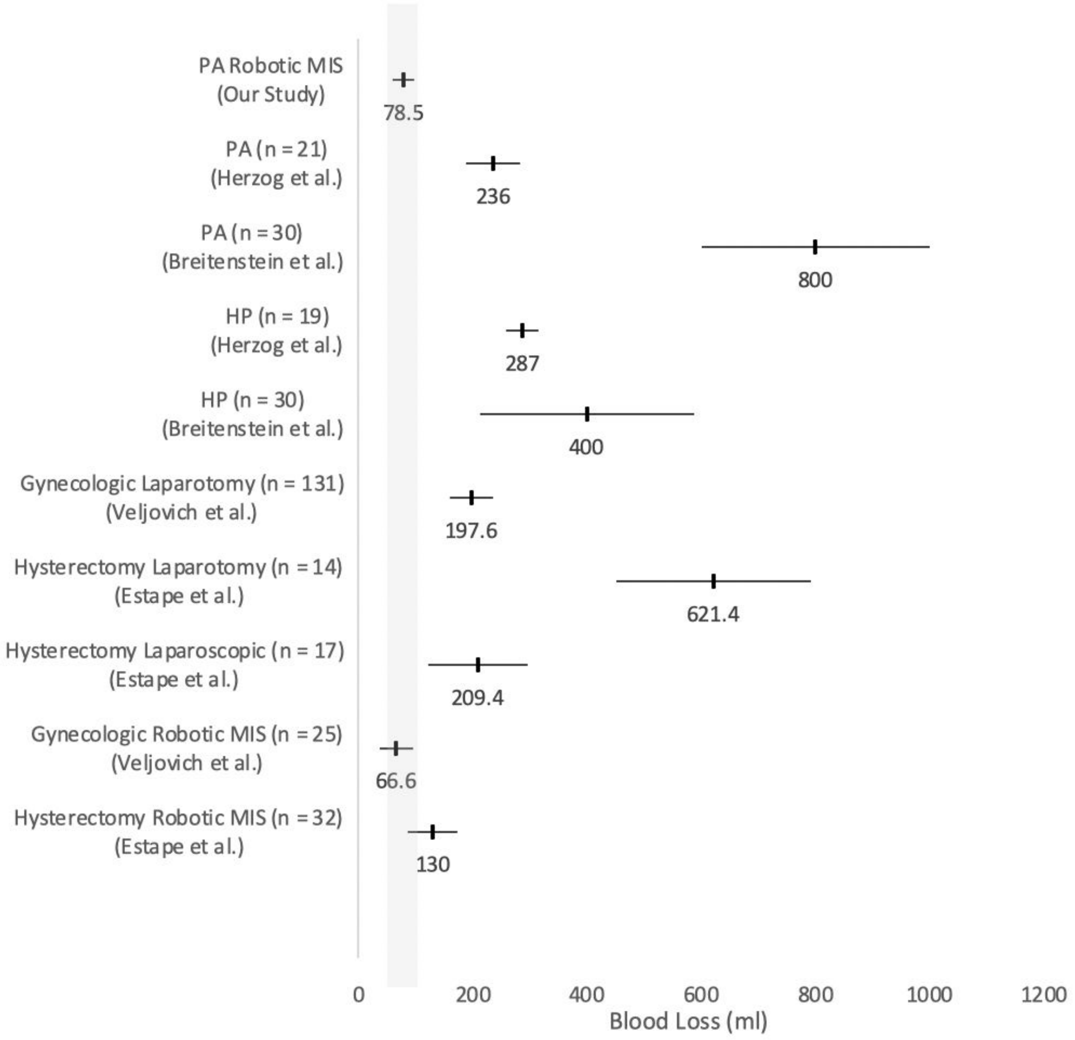
Fig 5. **95% Confidence Intervals for Hospital Length of Stay (days) for PA and HP Procedures**



Primary Anastomosis (PA) is a two stage procedure that does a colonic resection with an ileostomy followed with a stoma reversal. Hartmann Procedure (HP) is a three stage procedure that does a colonic resection with a temporary end colostomy and diverting the bowel with a stoma.

Our procedure has an average 78.5 ml blood loss with a 95% CI 59.62 ml to 97.34 ml. The open procedures in Figure 6 tend to have more blood loss. Our study's interval also does not overlap with the Estape et al. laparoscopic (closed) procedure [18]. Our procedure's blood loss confidence intervals overlap with the other gynecologic, and hysterectomy robotic MIS procedures [17,18].

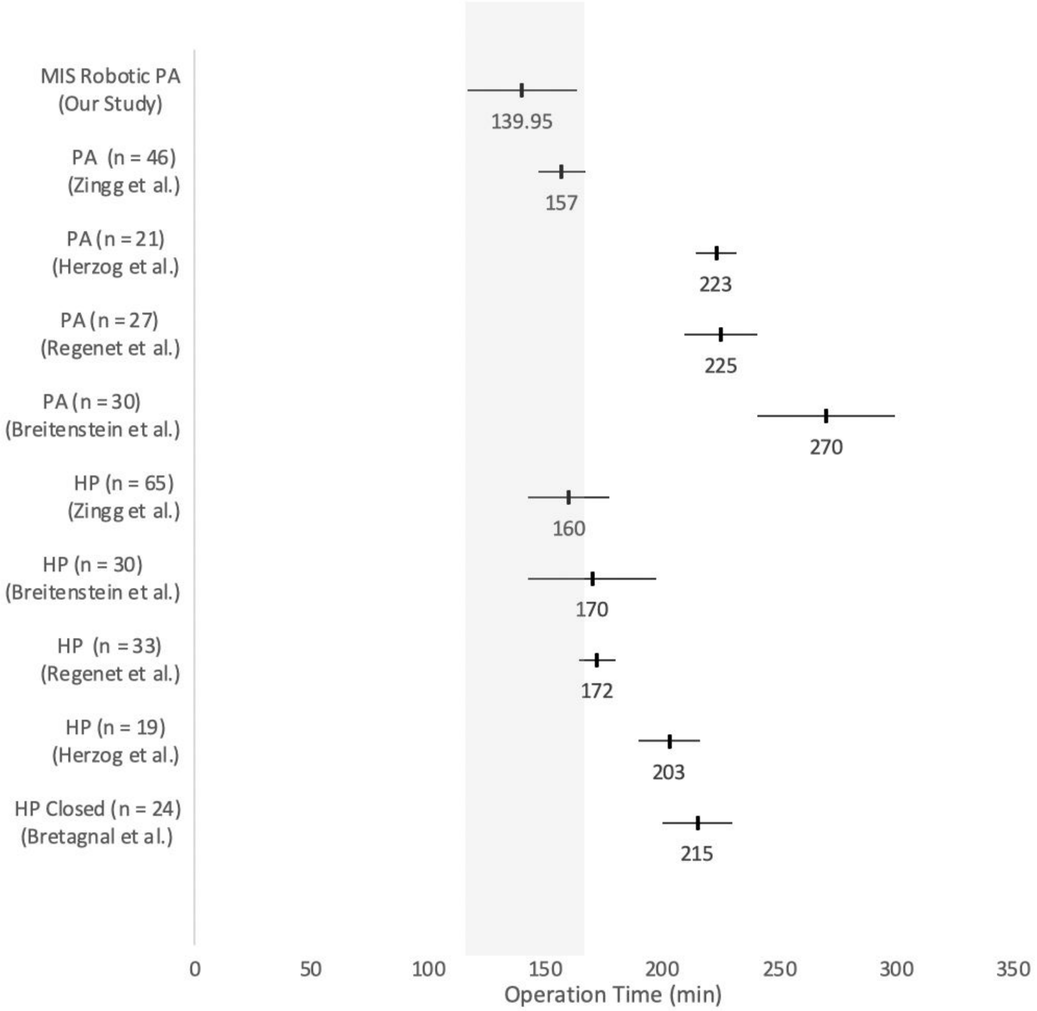
Fig 6. **95% Confidence Intervals for Blood Loss (ml) for PA, HP, Laparotomy, Laparoscopic and Robotic MIS**



Primary Anastomosis (PA) is a two stage procedure that does a colonic resection with an ileostomy followed with a stoma reversal. Hartmann Procedure (HP) is a three stage procedure that does a colonic resection with a temporary end colostomy and diverting the bowel with a stoma. Laparotomy is an open procedure in the abdominal region. Laparoscopy is a closed procedure in the abdominal region. Robotic MIS are robotic minimally invasive procedures.

Our study has an average operation time of 139.95 minutes with a 95% CI 116.54 min to 163.36 min (Figure 7). Our PA Robotic MIS procedure overlaps with three of the other operation length's confidence intervals. Zingg et al's HP and PA procedures' CI of operation time overlaps with our CI of operation time and so does Breitenstein et al's HP operation time's CI [19,3]. The six other intervals that do not overlap with our study's CI have higher operation times.

Fig 7. **95% Confidence Intervals for Operation Time (min) for PA and HP Procedures**

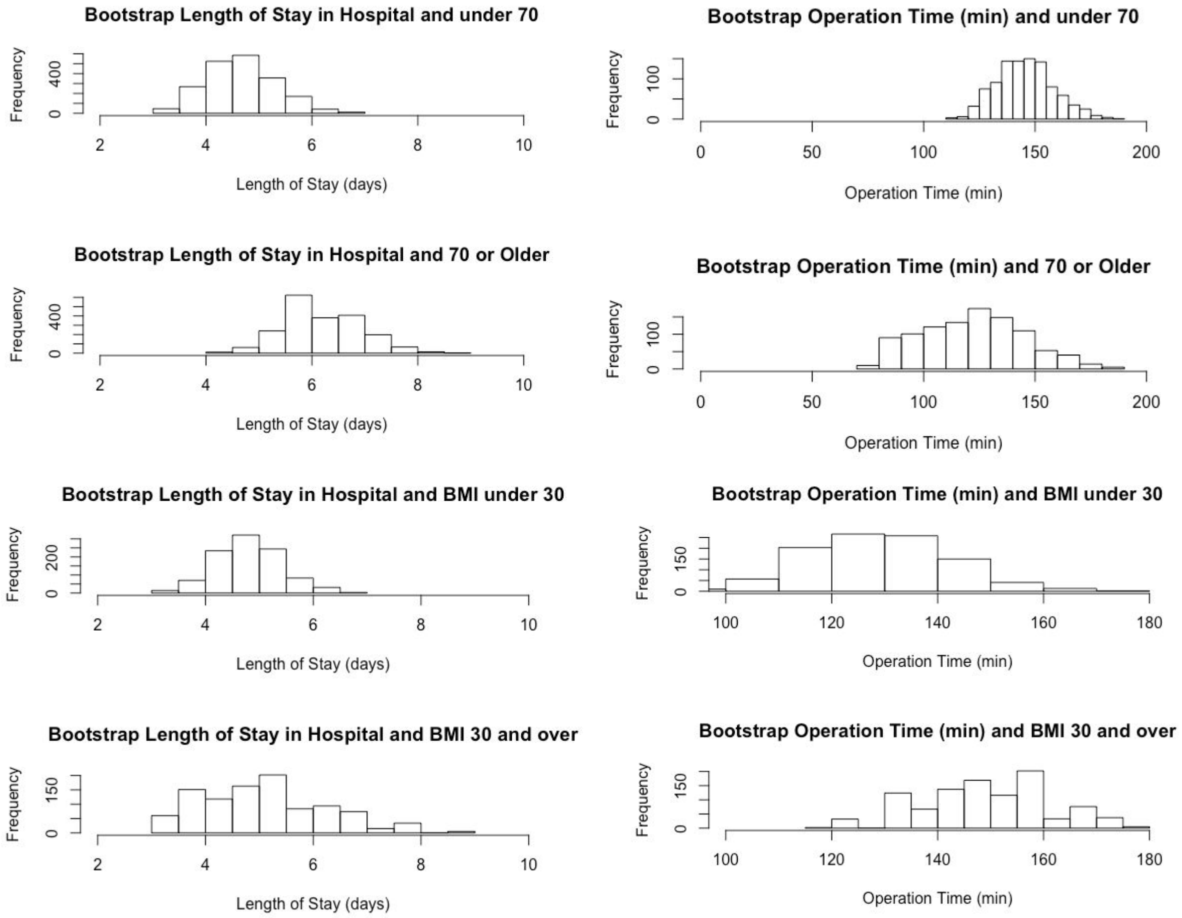


P*rimary Anastomosis (PA) is a two stage procedure that does a colonic resection with an ileostomy followed with a stoma reversal. Hartmann Procedure (HP) is a three stage procedure that does a colonic resection with a temporary end colostomy and diverting the bowel with a stoma.*

Secondary Results

Bootstrap samples for length of stay in hospital from our study overlap when comparing patients 70 and older with patients under 70 (Figure 8). Length of stay bootstrap samples also overlap for BMI less than 30 kg/m2 versus BMI 30 kg/m2 or greater. Bootstrap samples for operation time (min) also overlap when comparing patients 70 and older with patients under 70. Operation time bootstrap samples overlap for BMI less than 30 kg/m2 versus BMI greater than 30 kg/m2. The bootstrap samples from our study all overlap and seem to show BMI and age do not impact length of stay or operation time.

Fig 8. **Bootstrap Samples of Hospital Length of Stay (days) and Operation Time (min) by Age (years) and BMI (kg/m2)**



Bootstrap Length of Stay in Hospital and under 70

Bootstrap Operation Time (min) and under 70

Bootstrap Length of Stay in Hospital and 70 or Older

Bootstrap Operation Time (min) and 70 or Older

Bootstrap Length of Stay in Hospital and BMI under 30

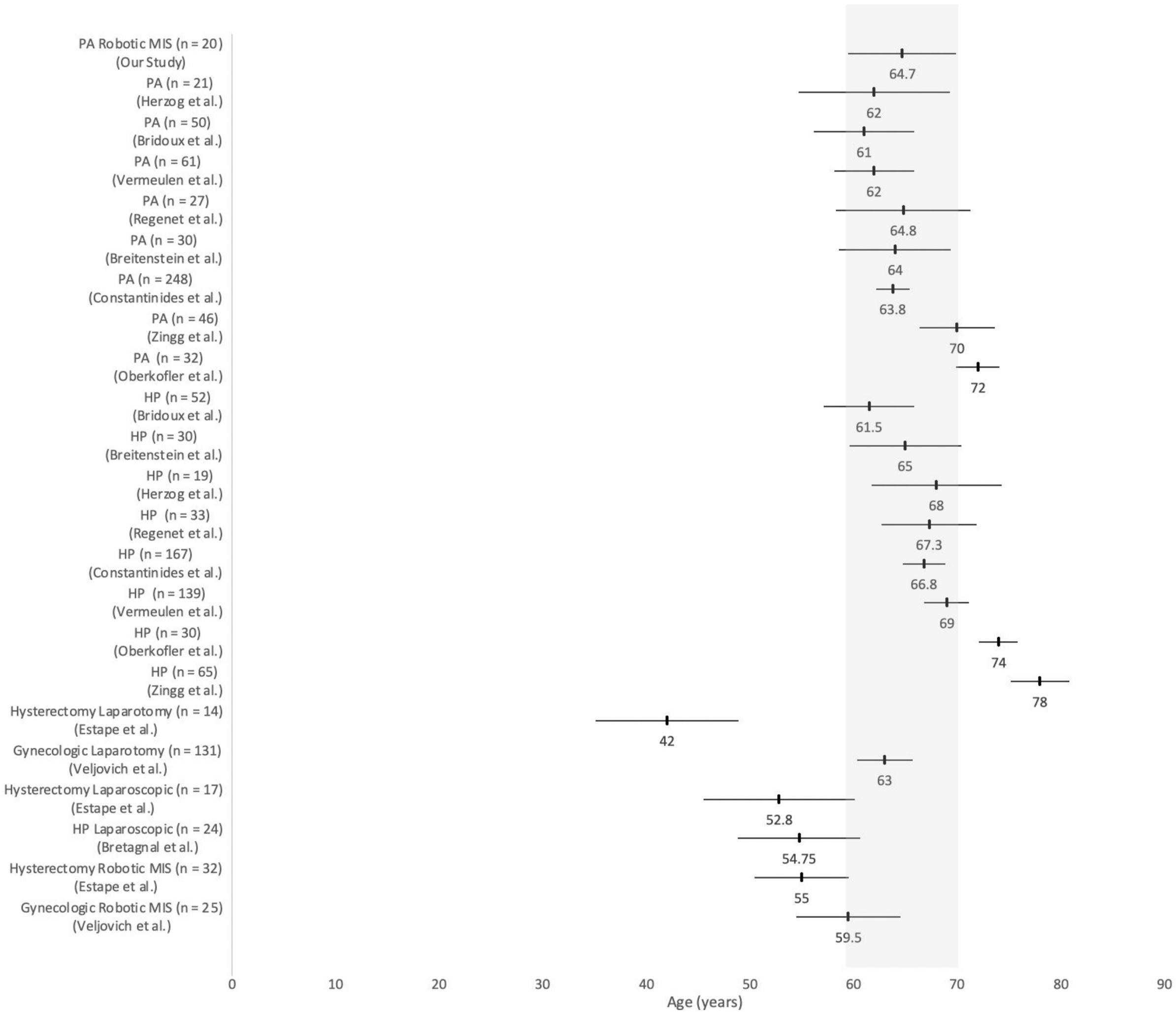
Bootstrap Operation Time (min) and BMI under 30

Bootstrap Length of Stay in Hospital and BMI 30 and over

Bootstrap Operation Time (min) and BMI 30 and over

Our study's patients are on average 65.7 years old with CI 59.50 to 69.90 years. Most of the age confidence intervals in Figure 9 overlap with our study's age confidence interval. There are three procedures with age confidence intervals that do not overlap with ours that are older than our study. Oberkofler et al's PA and HP patients' age intervals and Zingg et al's HP patients' age intervals do not overlap with our age's interval and are older than our study's patients [14, 19]. The Hysterectomy Laparotomy procedure in Estape et al's study has an average age of 42 and is younger than our study's patients [18].

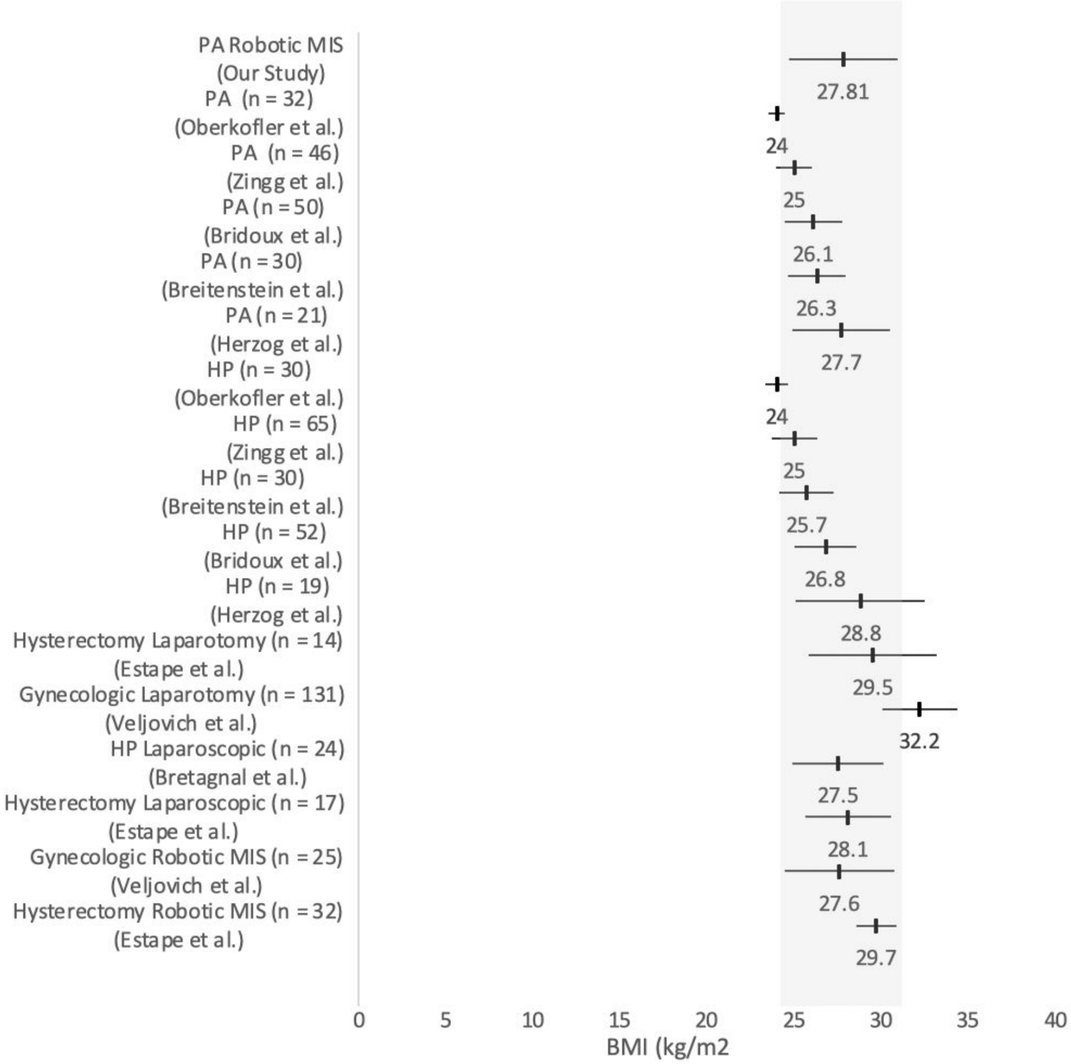
Fig 9. **95% Confidence Intervals for Age (years) for PA, HP, Laparotomy, Laparoscopic and Robotic MIS**



Primary Anastomosis (PA) is a two stage procedure that does a colonic resection with an ileostomy followed with a stoma reversal. Hartmann Procedure (HP) is a three stage procedure that does a colonic resection with a temporary end colostomy and diverting the bowel with a stoma. Laparotomy is an open procedure in the abdominal region. Laparoscopy is a closed procedure in the abdominal region. Robotic MIS are robotic minimally invasive procedures.

Our study has a mean 27.81 kg/m2 BMI with CI 24.70 to 30.92 kg/m2. Most of the BMI 95% confidence intervals in Figure 10 overlap with our study's BMI CI. There are two procedures in the Oberkofler et al. study with BMI confidence intervals that do not overlap with ours and have lower BMI than our study [14].

Fig 10. **95% Confidence Intervals for BMI (kg/m2) for PA, HP, Laparotomy, Laparoscopic and Robotic MIS**



Primary Anastomosis (PA) is a two stage procedure that does a colonic resection with an ileostomy followed with a stoma reversal. Hartmann Procedure (HP) is a three stage procedure that does a colonic resection with a temporary end colostomy and diverting the bowel with a stoma. Laparotomy is an open procedure in the abdominal region. Laparoscopy is a closed procedure in the abdominal region. Robotic MIS are robotic minimally invasive procedures.

Discussion

In order to account for other factors that impact surgery outcomes, age and BMI were tested to see if they had an impact on our procedure's results. Bootstrap samples of age and BMI on length of stay, operation time, and blood loss had overlap. This pattern has us believe age and BMI don't have a large impact on the outcome variables in our study. The meta-analysis looked at 18 papers with 95% confidence intervals for age that overlapped with our study's age CI. There were three procedures that had 95% CI for age with older patients than in our study [14,19]. We kept this in mind when comparing the benefits of our robotic minimally invasive procedure and those papers. Of the 16 procedures that provided BMI, there were two procedures that had BMI CI less than our BMI CI [14]. Patients with higher BMI have higher risks during surgery so the two procedures with less BMI don't concern us that our outcomes will inaccurately look better [8]. Since our study's 95% CI for age and BMI overlap with a majority of the research papers, and age and BMI do not impact our study's outcomes, we felt it was reasonable to compare the outcome variables confidence intervals.

A shorter length of stay in the hospital shows the patient is able to recover quickly with relatively less complications. The average length of days in the hospital for our study is 5.05 days with CI 3.9 to 6.2 days, which was less than other studies' 95% CI.

Our study on average had 78.5 ml of blood loss with CI 59.62 ml to 97.34 ml, which was less than the other HP and PA 95% CI. There were three studies we compared our procedure with that had 95% CI containing 500 ml blood loss. Our PA MIS robotic procedure's blood loss was in line with the gynecologic and hysterectomy MIS robotic procedures highlighting MIS robotic procedures typically have less blood loss in general.

Some robotic procedures have longer operation times than non robotic so we compare our robotic procedure’s operation time to open PA and HP procedures [21]. Our study has an average operation time of 139.95 minutes with a 95% CI 116.54 min to 163.36 min, which overlaps with three studies' operation time’s intervals. The six other procedures CI have longer operation times. This is promising, showing that our robotic procedure’s operation time is in line or even shorter than other open PA and HP procedures.

Next Steps

Since the study provided one type of procedure with 20 patients, it was not possible to provide causal statistics. We compared our study, the MIS Robotic PA procedure, to other research paper’s results. We can do a deeper analysis that would lead to more causal results with a larger study. A diverticulitis severity score for our study would also be beneficial to better compare results of similar complexity levels of other research papers. Hinchey is typically used in determining the grades of diverticulitis [12].

Appendix

This R code is used to generate 95% confidence intervals based on the raw data, bootstrap samples, 95% confidence intervals based on bootstrap samples, and figures.

Figure 4 Confidence Intervals

Age (Raw, Normal BCa)

```
set.seed(2020)
boots <- boot(mis$Age.when.procedure.performed,
              function(x,i) mean(x[i]),
              R=2000)

t.test(mis$Age.when.procedure.performed)

boot.ci(boots,conf = 0.95,
        type = "norm")
boot.ci(boots,conf = 0.95,
        type = "perc")
boot.ci(boots,conf = 0.95,
        type = "bca")


mean(boots$t)
```

Figure 4 BMI (Raw, Normal BCa)

```
set.seed(2020)
mis_bmi <- mis %>% filter(is.na(BMI) == FALSE)
boots <- boot(mis_bmi$BMI,
              function(x,i) mean(x[i]),
              R=2000)

t.test(mis_bmi$BMI)

boot.ci(boots,conf = 0.95,
        type = "norm")
boot.ci(boots,conf = 0.95,
        type = "perc")
boot.ci(boots,conf = 0.95,
        type = "bca")


mean(boots$t)
```

Figure 4 Operation Time (Raw, Normal BCa)

```
set.seed(2020)
boots <- boot(mis$op.time.min,
              function(x,i) mean(x[i]),
              R=2000)

t.test(mis$op.time.min)

boot.ci(boots,conf = 0.95,
        type = "norm")
boot.ci(boots,conf = 0.95,
        type = "perc")
boot.ci(boots,conf = 0.95,
        type = "bca")


mean(boots$t)
```

Figure 4 Blood Loss ml (Raw, Normal BCa)

```
set.seed(2020)
boots <- boot(mis$Blood.loss.ml.v2,
              function(x,i) mean(x[i]),
              R=2000)

t.test(mis$Blood.loss.ml.v2)

boot.ci(boots,conf = 0.95,
        type = "norm")
boot.ci(boots,conf = 0.95,
        type = "perc")
boot.ci(boots,conf = 0.95,
        type = "bca")


mean(boots$t)
```

Figure 4 Length of Stay (days) (Raw, Normal BCa)

```
set.seed(2020)
boots <- boot(mis$Length.of.stay.in.hopsital,
              function(x,i) mean(x[i]),
              R=2000)

t.test(mis$Length.of.stay.in.hopsital)

boot.ci(boots,conf = 0.95,
        type = "norm")
boot.ci(boots,conf = 0.95,
        type = "perc")
boot.ci(boots,conf = 0.95,
        type = "bca")


mean(boots$t)
```

Figure 8 Bootstrap Samples of Length of Stay in Hospital, and Operation Time comparing age and BMI.

Length of Stay and Age

```r
og_less70 <- mis %>% filter(Age.when.procedure.performed < 70)
og_more70 <- mis %>% filter(Age.when.procedure.performed >= 70)

#bootstrap
less70 <- rep(0,1000)
more70 <- rep(0,1000)
boot <- rep(0,1000)
set.seed(2020)
for(i in 1:1000)
{
  m <- sample(og_less70$Length.of.stay.in.hopsital,replace=T)
  less70[i] <- mean(m)
  f <- sample(og_more70$Length.of.stay.in.hopsital,replace=T)
  more70[i] <- mean(f)
  boot[i] <- mean(f) - mean(m)
}
```

Operation Time and Age

```r
og_less70 <- mis %>% filter(Age.when.procedure.performed < 70)
og_more70 <- mis %>% filter(Age.when.procedure.performed >= 70)

#bootstrap
less70 <- rep(0,1000)
more70 <- rep(0,1000)
boot <- rep(0,1000)
set.seed(2020)
for(i in 1:1000)
{
  m <- sample(og_less70$op.time.min,replace=T)
  less70[i] <- mean(m)
  f <- sample(og_more70$op.time.min,replace=T)
  more70[i] <- mean(f)
  boot[i] <- mean(f) - mean(m)
}
```

BMI and Operation Time

```r
og_less30 <- mis %>% filter(BMI < 30)
og_more30 <- mis %>% filter(BMI >= 30)

#bootstrap
less30 <- rep(0,1000)
more30 <- rep(0,1000)
boot <- rep(0,1000)

set.seed(2020)
for(i in 1:1000)
```

```
{
  m <- sample(og_less30$op.time.min,replace=T)
  less30[i] <- mean(m)
  f <- sample(og_more30$op.time.min,replace=T)
  more30[i] <- mean(f)
  boot[i] <- mean(f) - mean(m)
}
```

BMI and Length of Stay

```
og_less30 <- mis %>% filter(BMI < 30)
og_more30 <- mis %>% filter(BMI >= 30)

#bootstrap
less30 <- rep(0,1000)
more30 <- rep(0,1000)
boot <- rep(0,1000)
set.seed(2020)
for(i in 1:1000)
{
  m <- sample(og_less30$Length.of.stay.in.hopsital,replace=T)
  less30[i] <- mean(m)
  f <- sample(og_more30$Length.of.stay.in.hopsital,replace=T)
  more30[i] <- mean(f)
  boot[i] <- mean(f) - mean(m)
}
```

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