Analysis of Learning Curve of Robot-Assisted Sacrocolpopexy

Jeong Min Song M.D., Eun-Hee Yoo M.D

Department of Obstetrics and Gynecology, Kyung Hee University Hospital at Gangdong, Kyung Hee University, Seoul, Korea

Introduction

Sacrocolpopexy (SCP) with mesh interposition is one of the most effective surgical procedures for level I apical defects of pelvic organ prolapse. Recent enthusiasm has been gained for use of robot-assisted laparoscopic surgery to perform various gynecologic surgery including sacrocolpopexy(RSCP). The aim of this study was to analyze the learning curve of RSCP based on the operation time, complication rate and conversion rate to open surgery in a set-up period.

Methods and Materials

A retrospective study was conducted with women who underwent RSCP at our institution from June 2018 and June 2023 by a well-trained and experience surgeon. Total operative time spanned the time from incision to final closure. Demographic data, intraoperative parameters, as well as postoperative outcomes were analyzed. CUSUMOT was plotted against the number of operations in chronological orders to calculated the running total of differences in RSCP operative times between each individual operation (xi) and the mean of all operations (u) using the equation as CUSUM= $\sum_{i=1}^{n}(xi-u)$ The calculation proceeded until the CUSUM value of all cases were obtained. The breakpoints in the learning curves were determined post-hoc using piecewise linear regression and the learning curve changes in phases, from Learning (phase 1) to Proficiency (phase 2), and Competency (phase 3) based on operative times were identified. Presence of any intra- and post-operative complication was determined. Continuous variables were reported as mean (standard deviation) and compared using one-way analysis of variance (ANOVA) and categorial variables were reported as percentage values and analyzed using the chi-square tests. The CUSUM learning curves were constructed and piecewise linear regression was conducted using RStudio, version 4.2.2.

Results

A total of 50 cases of RSCP was analyzed after excluding one case of conversion as a result of severe pelvic adhesion. Patient's baseline characteristics, intraoperative and postoperative parameters are summarized in Table 1. The mean age was 57.7 years (SD 8.6) and the proportions of POP-Q stage 2, 3 and 4 were 56%, 40% and 4%, respectively. The overall mean operative time was 222.4 ± 64.3 minutes. There were no intra-operative and short-term post-operative complications. As shown in Figure 1, the line of best fit of the learning curve is represented. Piecewise linear regression of CUSUM of RSCP identified the break points at which the learning phase changes at 8th and 34.4th cases (Figure 2). The learning, proficiency and competency phases consisted of 8, 26, and 16 cases. It indicates that the surgeon achieved proficiency between 9th case and 34th case and was competent after 35th case. Table 2 compares the pre-operative variables among the three phases. There were no significant differences in baseline variables except operative time and POP-Q stage. However, the CUSUM analysis based on the complications or conversion was not available in this study due to no case of complication and a case of conversion even in the small case series.
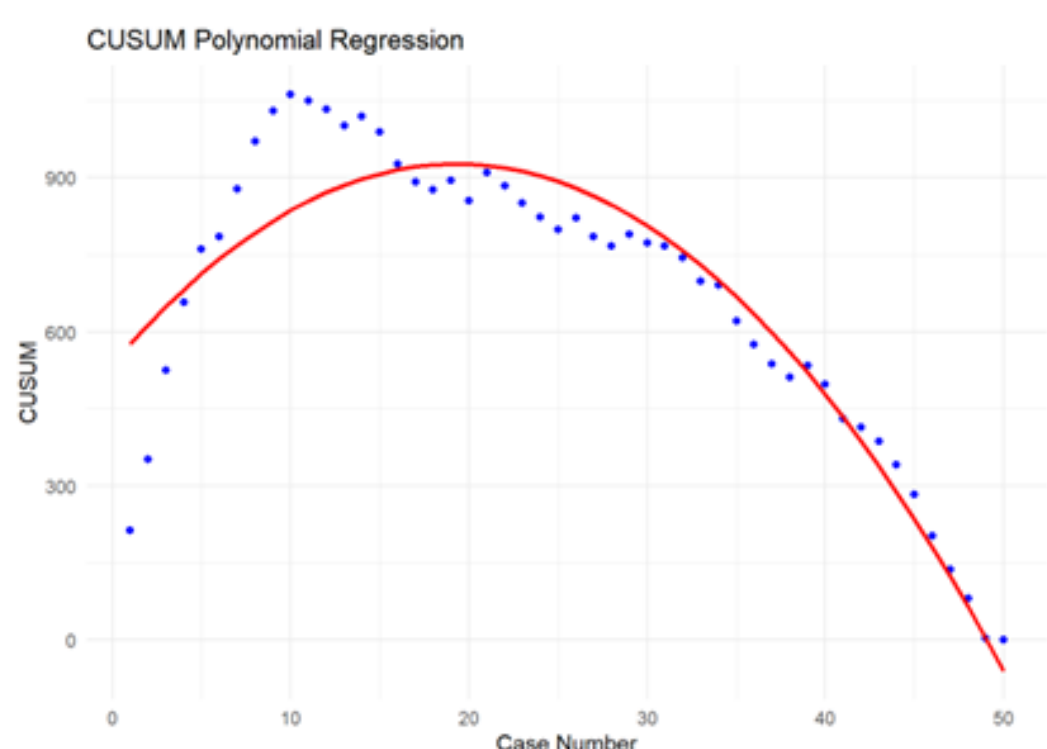

Figure 1. The learning curve of RSCP(red) represented with line of best fit of a second-order polynomial equation : $CUSUM_{OT}$ =668.5-1325.5 x case number-1376.9x case number^2 with an R^2 value of 0.87
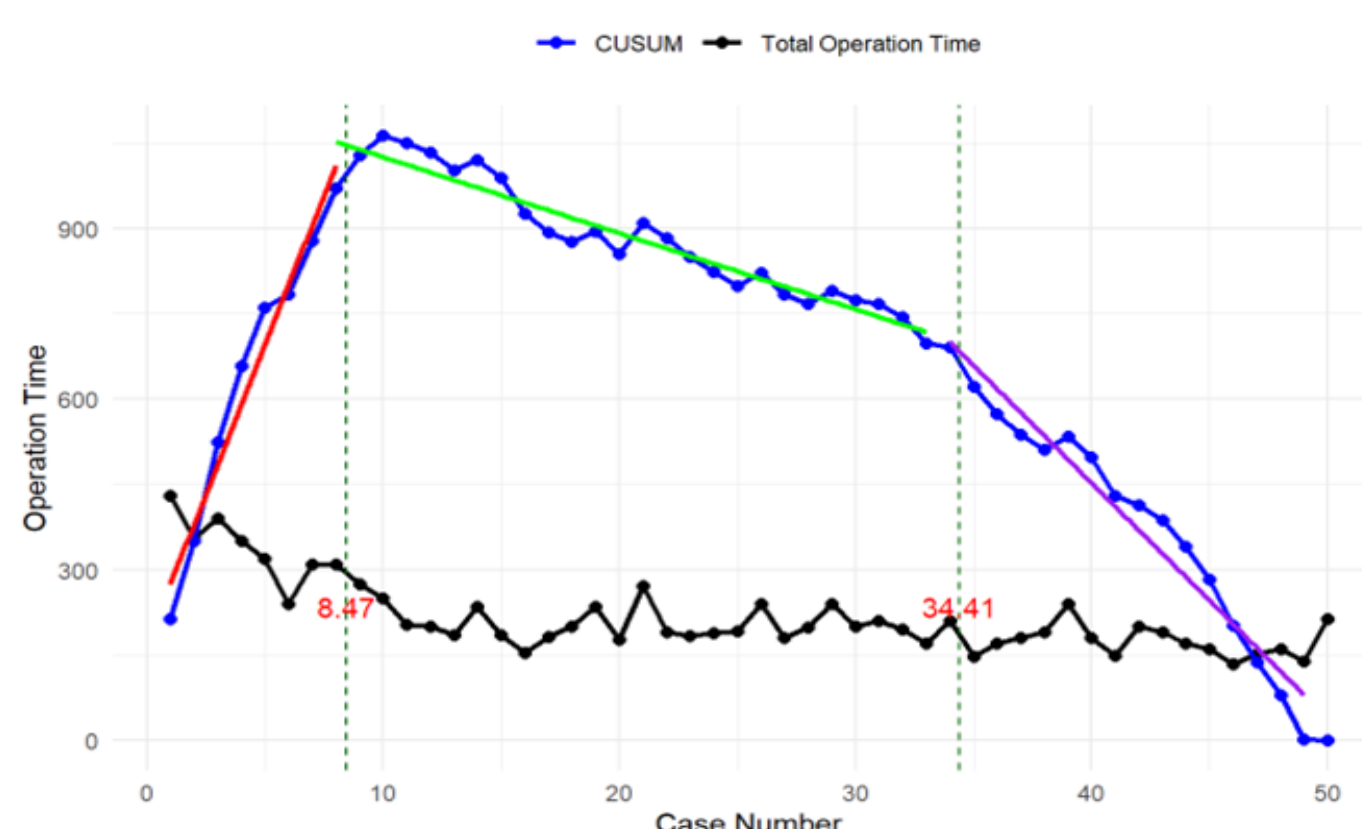

Figure 2. Piecewise linear regression of CUSUM(blue dots) of RSCP operative times(black dots) with breakpoints at case 8.4, 95% CI (8.0, 9.0) and case 34.4, 95% CI (32.7,36.1)and R^2 value of 0.87. The learning, proficiency and competency phases are described by the equations:1)$CUSUM_{OT}$=105.0 x case number+170.4(R^2=0.96) 2)$CUSUM_{OT}$= -13.4xcase number+1159.0(R^2=0.92) 3)$CUSUM_{OT}$= -41.3 x case number+2105.31(R^2=0.95), respectively

Table 1. Patient characteristic and perioperative parameters.

Variables	Parameter	Mean, SD	Range	Median
Patient characteristics	Age (years)	57.8, 8.1	38,70	59
	BMI (Kg/m2)	24.2, 2.5	19,31	24.3
	Parity	2.2, 0.6	1,4	2
	Postmenopausal, n(%)	40 (80%)		
	Diabetes, n(%)	8 (16%)		
	ASA, n(%)			
	1	22 (44%)		
	2	26 (52%)		
	3	1 (2%)		
	Previous prolapse surgery, n(%)	9 (18%)		
	Previous anti-incontinence surgery, n(%)	8 (16%)		
	Other abdominal surgery, n(%)	15 (30%)		
	Pelvic organ prolapse quantification stage, n(%)			
	2	28 (56%)		
	3	20 (40%)		
	4	2 (4%)		
Intraoperative parameters	Concomitant procedures, n(%)			
	Total hysterectomy	41 (82%)		
	Subtotal hysterectomy	4 (8%)		
	Bilateral salphingo-ophorectomy	15 (30%)		
	Anti-incontinence surgery	5 (10%)		
	Repair of rectocele	7 (14%)		
	Operative time (minutes)	222.4, 64.3	135,430	204
	Change of hematocrit (%)	-6.4, 2.6	-1.5, -13.4	-6.5
	Presence of uterine pathology, n(%)	30 (60%)		
	Complication, n(%)	0		
Postoperative parameters	Length of hospitalization (days)	5.7, 0.8	5,7	6
	Short-term postoperative complication, n(%)	0		

Table 2. Comparison of patient characteristic and perioperative parameters among learning, proficiency and competency phases

Variables	Learning (1-8, n=8)	Proficiency (9-34, n=26)	Competency (35-50, n=16)	p value
Op time (minutes)	338.1, 57.4	213.0, 34.3	179..9, 28.0	0.000
Age (years)	53.2, 7.8	57.9, 7.6	59.6, 8.7	0.193
Parity	2.5, 0.5	2.1, 0.6	2.1, 0.6	0.258
BMI(kg/m^2)	23.8, 0.8	24.7, 3.0	23.5, 2.1	0.273
Menopause	5/8(62.5%)	21/26(80.8%)	14/16(87.5%)	0.349
Diabetes	1/8(12.5%)	6/26(23.1%)	1/16(6.3%)	0.337
Hypertension	1/8(12.5%)	13/26(50%)	5/16(31.3%)	0.128
Ba	0.5, 1.2	1.0, 1.1	2.4, 1.6	0.005
Bp	-1.9, 0.4	-0.6, 1.8	-0.9, 2.6	0.259
C/D	0.4, 1.3	1.3, 1.7	1.7, 2.1	0.248
TVL	7.3, 1.3	7.3, 0.8	7.9, 0.8	0.218
POP-Q stage (2-3-4)	6-2-0	13-11-2	9-7-0	0.546
ASA (1-2-3)	6-2-0	11-14-1	5-11-0	0.270
Prior abdomen-pelvic surgery (0-1-2)	6-1-1	18-7-1	11-5-0	0.582
Prior prolapse surgery	2/8(25%)	4/26(15.4%)	3/16(18.8%)	0.822
Prior anti-incontinence surgery	3/8(37.5%)	2/26(7.7%)	3/16(18.8%)	0.124

Conclusions

CUSUM analysis showed surgical proficiency of RSCP is attainable after 8 cases and operative time can be stabilized after 34 cases. This portrays that transition from laparoscopic SCP to robot-assisted operation can be achievable with small number of cases, although it may depend on surgeon's skills. In order to generalize the results of this paper, it seems that further studies that integrates and compares many cases of other researchers or institutions with well-organized training program are needed.

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