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# Evaluation of the learning curve of robot-assisted laparoscopic ventral mesh rectopexy

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## Abstract

**Background** The current standard treatment for external rectal prolapse and symptomatic high-grade internal rectal prolapse is surgical correction with minimally invasive ventral mesh rectopexy using either laparoscopy or robotic assistance. This study examines the number of procedures needed to complete the learning curve for robot-assisted ventral mesh rectopexy (RVMR) and reach adequate performance.

**Methods** A retrospective analysis of all primary RVMR from 2011 to 2019 performed in a tertiary pelvic floor clinic by two colorectal surgeons (A and B) was performed. Both surgeons had previous experience with laparoscopic rectopexy, but no robotic experience. Skin-to-skin operating times (OT) were assessed using LC-CUSUM analyses. Intraoperative and postoperative complications were analyzed using CUSUM analyses.

**Results** A total of 182 (surgeon A) and 91 (surgeon B) RVMRs were performed in total. There were no relevant differences in patient characteristics between the two surgeons. Median OT was 75 min (range 46–155; surgeon A) and 90 min (range 63–139; surgeon B). The learning curve regarding OT was completed after 36 procedures for surgeon A and 55 procedures for surgeon B. Both before and after completion of the learning curve, intraoperative and postoperative complication rates remained below a predefined acceptable level of performance.

**Conclusions** 36 to 55 procedures are required to complete the learning curve for RVMR. The implementation of robotic surgery does not inflict any additional risks on patients at the beginning of a surgeon's learning curve.


**Keywords** Learning curve · Ventral mesh rectopexy · Rectal prolapse · Robotic surgery · LC-CUSUM · CUSUM

A widely accepted treatment in surgical management for rectal prolapse is the laparoscopic ventral mesh rectopexy (LVMR) [1–4]. This technique was introduced in the early 2000's and soon was followed by the introduction of the robot-assisted ventral mesh rectopexy (RVMR). During this operation a surgical mesh is placed in the rectovaginal septum (RVS). To assure adequate anatomic correction of the prolapsed rectum, the mesh must be securely fixed at the deepest part of the RVS and sutured to the ventral rectal wall. This involves complex maneuvers such as dissection of the RVS and suturing in a narrow and distant space at the end of reach of the laparoscopic instruments. It is believed that robot assistance during this procedure can be of support and improve technical performance. Superiority regarding clinical outcome of RVMR versus LVMR has not yet been proven [5–7].

Innovative surgical technologies require learning and adaptation of a surgeon. Information on the extent of this learning process is helpful during the implementation of robotic surgery in pelvic floor centers as the availability of robotic systems and evaluation of techniques is rapidly increasing. Only two studies on a learning curve for LVMR exist and conclude that the learning curve is approximately 25–88 procedures per surgeon [8, 9]. A consensus statement made by an international panel of experts stated that adequate performance was reached after 50 procedures

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[1]. There are no papers reporting on the learning curve of RVMR.

Information on learning curves of surgical procedures is valuable when implementing new surgical techniques. Furthermore, when used in a prospective manner, it can function as a feedback system of a surgeon's performance. Unfortunately, consensus on how to measure this learning process is lacking. Information regarding safety, efficacy and efficiency during the process of mastering a new technique should be considered. Of paramount importance, the implementation of a new technique should not subject a patient to additional morbidity. The aim of this study is to analyze the learning curve of RVMR using a dedicated statistical method (learning curve cumulative sum (LC-CUSUM)). It studies the individual development of two laparoscopic trained colorectal surgeons in performing RVMR over the course of a nine-year period. In addition, the cumulative sum (CUSUM) was used to monitor the intraoperative and postoperative complications of the surgical procedure.

## Materials and methods

This observational study was conducted in a large teaching hospital with a tertiary referral center for pelvic floor pathology. The study protocol was approved by the institutional review board and requirement for informed consent was waived due to the retrospective nature of the study. All primary RVMRs of two robot-naïve colorectal surgeons were included between March 2011 and December 2019. In March 2019, the Da Vinci Si Surgical System (Intuitive Surgical Inc., Sunnyvale, CA) was replaced by an Xi model.

### Surgical technique, experience and implementation

The surgical technique and materials have been described previously and were according to the procedure originally described by D'Hoore and Penninckx [10, 11]. The two surgeons described in our paper had a special interest in pelvic floor surgery and were previously involved in LVMR in the same center. Next to a standard training course by Intuitive, the surgeons were proctored briefly by a third surgeon of our center that already had experience in robot-assisted surgery including RVMR.

### Learning curve and performance indicators

Primary outcome of this study was the length of the learning curve defined as the number of cases needed to reach adequate performance. Adequate performance was based on three clinical outcomes: (1) operative time (OT) defined as time from incision to skin closure; (2) intraoperative safety defined by the absence of intraoperative complications; and (3) postoperative safety as defined by the absence of postoperative complications within 90 days.

Postoperative morbidity was defined as any deviation from the normal postoperative course during admission and/or noticed during the 90-day postoperative course. Postoperative morbidity was graded following the Clavien–Dindo (CD) classification for postoperative complications [12]. Major postoperative morbidity was defined as CD grade > 2.

Secondly, characteristics of patients operated before and after completion of the learning curve per surgeon were compared.

### Patient and case selection

Patients that underwent concomitant surgery were excluded for OT analyses, since OT would not reflect pure RVMR times. Patients treated for multicompartment prolapse with robot-assisted laparoscopic sacrocolpo-rectopexy (RSCR; with or without subtotal hysterectomy) were only considered for analysis of intraoperative safety of the rectopexy part, considering the substantial extra OT and burdening imposed by the additional sacrocolpopexy and subtotal hysterectomy. The rectopexy part of this procedure is identical to RVMR and has been described previously [13, 14].

### Statistical analyses

Baseline characteristics are presented as mean or median for continuous variables depending on their distribution, and frequency with percentage for categoric variables. OT was graphically displayed by moving average ten analysis (MAA-10). An MAA-10 makes an average of ten subsequent cases and changes with the addition of new data. This smoothens the curve by filtering out big fluctuations and helps visualizing trends in OT.

Multiple statistical methods have been used in the surgical field to analyze learning curves, with each method having its advantages and drawbacks. For this study a combination of methods was used:

- LC-CUSUM analysis regarding OT;
- CUSUM analysis regarding intraoperative and postoperative complications.

Important in selecting the optimal statistical method for learning curve analyses, is the individual's level of performance at the start of monitoring. It can be either a performance indicator that is assumed to start at an *out-of-control* state, that by the process of learning reaches an *in-control* state, or vice versa.

For a surgeon commencing with RVMR, OT can be assumed to start at an out-of-control state. LC-CUSUM has been designed to detect a change from a predefined level of inadequate performance to adequate performance [15]. It tests the null hypothesis that the performance is inadequate (out-of-control). LC-CUSUM can be graphically displayed against the chronologic case number, where the LC-CUSUM increases with every successful case and decreases with every failure. The null hypothesis is rejected once a predefined control limit is reached, indicating that the surgeon is performing competently. Based on the literature on RVMR, an OT of 110 min or less was deemed competent [10, 16–19]. Adequate performance was defined as a ≤ 20% failure rate and inadequate was defined as a ≥ 30% failure rate. The performance of the LC-CUSUM is described by the probability of a false alarm occurring (type I error) and the probability of true alarm occurring (1 - type II error). These probabilities are based on simulations of 10,000 samples of 170 procedures (based on the longest series in this database) under the adequate and inadequate performance level under a certain control limit. Here a control limit of 1.35 was chosen, giving a probability of a false alarm of 13% and of true alarm of 87%.

Learning a new technique should not result in an additional risk for the patient. Therefore, gaining proficiency in RVMR should not be accompanied by a learning curve in intraoperative and postoperative safety. Only a substantial decline from the accepted level of performance could indicate exceptional performance. Hence an in-control state is assumed and deviation to an out-of-control state should raise an alarm. CUSUM analyses are a suitable and frequently applied method to investigate such a decline in quality [20]. In contrast to the LC-CUSUM, CUSUM tests the null hypothesis that performance is acceptable. Graphically, this translates to an increase for every failure and a decrease for every success. A change in performance to an out-of-control state is signaled when the CUSUM crosses a predefined control limit. This control limit is determined by the false alarm probability (type I error), acceptable failure probability, the detection level (the unacceptable failure probability), and the number of procedures performed. As suggested by Hubig et al. false alarm probability was set at 5% with a detection level of a two-fold of the acceptable failure probabilities [20]. Acceptable failure probabilities were based on reported rates in literature regarding minimally invasive ventral mesh rectopexy and were set at 2%, 11% and 2% regarding intraoperative complication rate, all-round postoperative complication rate (CD 1 – 5), and major postoperative complication rate (CD > grade 2) ,respectively [2, 10, 16–19].

Characteristics of the series before and after completion of the individual learning phases based on OT were assessed to look for changes in patient and case risk profiles. Unpaired parametric and non-parametric tests were used as appropriately. A p-value < 0.05 was considered statistically significant. Statistical analyses were conducted using SPSS version 24.0 (IBM, Armonk, NY) and R (R Foundation for Statistical Computing, Vienna, Austria).

## Results

In total, 273 primary RVMRs were performed of which 182 by surgeon A and 91 by surgeon B. In 13 patients another procedure was added to the RVMR (Table 1). During the same period, surgeon A took part in 90 RSCRs (± subtotal hysterectomy) and surgeon B in 66 procedures.

Baseline characteristics are summarized in Table 1. The mean age was 58 years (SD 16) and the cohort counted 282 (93%) female patients. Fifty-eight percent of patients had a history of one or more surgeries of the abdomen or pelvis. There were no significant differences in baseline characteristics between the two surgeons apart from a larger proportion of previous anterior colporrhaphy patients with surgeon B (p-value 0.023).

Median OT was 75 min (range 46–155) for surgeon A and 90 min (range 63–139) for surgeon B. MAA-10 plots are depicted in Fig. 1.

### Learning curve–operating times

After excluding cases with concomitant surgery, 171 and 87 procedures were eligible for analysis of OT with LC-CUSUM for surgeon A and B, respectively. Figure 2 displays the LC-CUSUM plotted against chronologic case number. Surgeon A crossed the control limit after 36 procedures and surgeon B after 55 procedures.

Case risk mix before and after the 36th and 55th case is shown in Table 2. For both surgeons, a statistically significant increase was seen in the percentage of operations where a fellow surgeon or senior resident participated (surgeon A from 22 to 64% and surgeon B from 49 to 81%, p-value 0.001 and 0.028, respectively). Other variables to assess differences in case risk profiles did not change.

### Intraoperative complications and 90-day postoperative morbidity

For CUSUM analysis of safety measures, all 182 and 91 RVMRs performed by surgeon A and B, respectively, were evaluated. For intraoperative safety, RSCRs cases were added to these numbers giving a total of 272 cases for surgeon A and 157 for surgeon B.

In total, ten (2.3%) intraoperative complications occurred, of which six in primary RVMR procedures (Table 3). Four intraoperative complications happened during the rectopexy part of RSCR procedures. This included one conversion to laparoscopy at the beginning of surgery due to an error in the robotic system. Nine out of these ten patients had an

**Table 1** Baseline characteristics of primary RVMR procedures

| | Total ($N=273$) | Surgeon A ($N=182$) | Surgeon B ($N=91$) | *p*-value |
|---|---|---|---|---|
| Age (years), mean ± SD | 58 ± 16 | 58 ± 16 | 58 ± 15 | 0.834 |
| Sex (female, %) | 250 (91.6%) | 166 (91.2%) | 84 (92.3%) | 0.758 |
| BMI (kg/m$^2$), median [IQR] | 24.6 [22.0–28.6] | 24.2 [22.0–28.2] | 25.0 [21.9–29.5] | 0.455 |
| ASA (%) | | | | |
| 1 | 96 (35.2%) | 70 (38.5%) | 26 (28.6%) | |
| 2 | 148 (54.2%) | 95 (52.2%) | 53 (58.2%) | 0.088 |
| 3 | 27 (9.9%) | 16 (8.8%) | 11 (12.1%) | |
| 4 | 2 (0.7%) | 1 (0.5%) | 1 (1.1%) | |
| Patients with history of pelvic floor or abdominal surgery (%) | 154 (56.4%) | 105 (57.7%) | 49 (53.8%) | 0.546 |
| Hysterectomy | 68 (24.9%) | 51 (28.0%) | 17 (18.7%) | 0.093 |
| Anterior colporrhaphy | 24 (8.8%) | 11 (6.0%) | 13 (14.3%) | 0.023 |
| Posterior colporrhaphy | 31 (11.4%) | 18 (9.9%) | 13 (14.3%) | 0.281 |
| Sacropexy | 4 (1.5%) | 2 (1.1%) | 2 (2.2%) | 0.603 |
| Cystopexy | 10 (3.7%) | 8 (4.4%) | 2 (2.2%) | 0.504 |
| TVT-O | 13 (4.8%) | 10 (5.5%) | 3 (3.3%) | 0.554 |
| Perineal procedure | 5 (1.8%) | 4 (2.2%) | 1 (1.1%) | 0.668 |
| Other abdominal surgeries | 99 (36.3%) | 67 (36.8%) | 32 (35.2%) | 0.789 |
| Type of prolapse (%) | | | | |
| ERP | 73 (26.7%) | 45 (24.7%) | 28 (30.8%) | 0.288 |
| IRP/rectocele | 200 (73.3%) | 137 (75.3%) | 63 (69.2%) | |
| Concomitant procedures (%) | 13 (4.8%) | 9 (4.9%) | 4 (4.4%) | 1.000 |
| Colporrhaphy | 4 | 4 | – | |
| TVT-O | 3 | 2 | 1 | |
| Other | 6 | 3 | 3 | |

*ASA* American society of anesthesiologists, *BMI* Body mass index, *ERP* external rectal prolapse, *IRP* internal rectal prolapse, *IQR* interquartile range, *N* number, *SD* standard deviation, *TVT-O* Transvaginal obturator tape

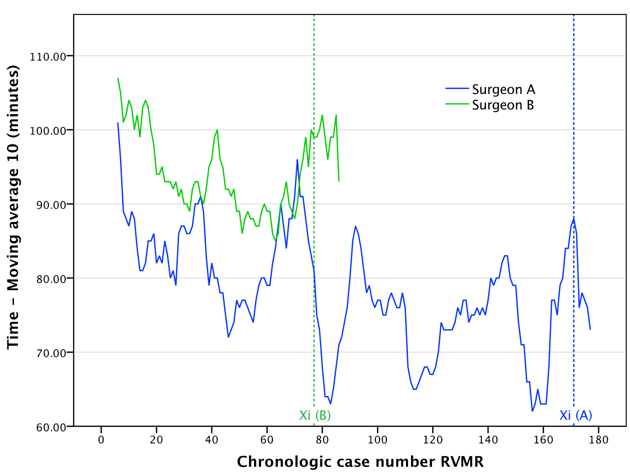


**Fig. 1** Moving average 10 plot for chronologic RVMR for surgeon A (blue) and surgeon B (green). The vertical dashed lines indicate the case for surgeon A (blue) and B (green) where the Da Vinci Si was replaced for the Xi model (Color figure online)

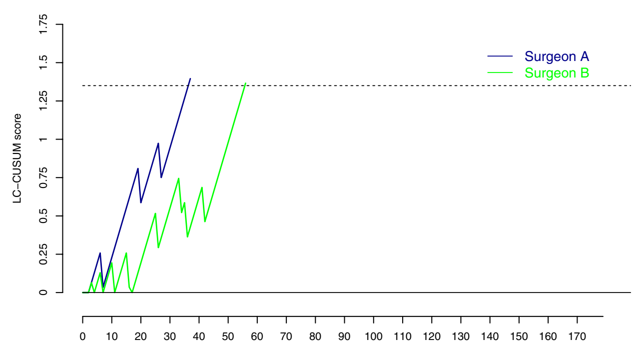


**Fig. 2** LC-CUSUM plot of operating times per surgeon

uneventful recovery from surgery. One patient, in which surgery was complicated by a lesion of the posterior vaginal wall, developed an abscess in the RVS for which two reinventions took place during the study period: surgical drainage and temporary colostomy to treat a rectovesical fistula (both complications scored as Clavien–Dindo IIIb). Further details on 90-day postoperative morbidity are depicted in

**Table 2** Case mix before and after completion of the learning curve based on operating time

| Case characteristics | Surgeon A | | | |
|---|---|---|---|---|
| | Total ($N=173$) | Case 1–36 ($N=36$) | Case 37–173 ($N=137$) | $p$-value |
| Age (years), mean ± SD | 58 ± 16 | 60 ± 17 | 57 ± 16 | 0.427 |
| Sex (female, %) | 157 (90.8) | 33 (91.7) | 124 (90.5) | 1.000 |
| BMI (kg/m$^2$), median [IQR] | 24.1 [21.9–28.1] | 25.0 [22.3–28.2] | 23.7 [21.5–28.0] | 0.342 |
| ASA (%) | | | | |
| 1–2 | 156 (90.2) | 32 (88.9) | 124 (90.5) | 0.757 |
| 3–4 | 17 (9.8) | 4 (10.1) | 13 (9.5) | |
| History of pelvic floor or abdominal surgery (%) | 100 (57.8) | 23 (63.9) | 77 (56.2) | 0.406 |
| Fellow/senior resident involved (%) | 99 (57.2) | 12 (33.3) | 87 (63.5) | 0.001 |
| Case characteristics | Surgeon B | | | |
| | Total ($N=87$) | Case 1–55 ($N=55$) | Case 56–87 ($N=32$) | $p$-value |
| Age (years), mean ± SD | 58 ± 15 | 57 ± 16 | 61 ± 12 | 0.165 |
| Sex (female, %) | 81 (93.1) | 51 (92.7) | 30 (93.8) | 1.000 |
| BMI (kg/m$^2$), median [IQR] | 25.2 [22.0–29.5] | 25.0 [22.1–30.0] | 25.7 [21.3–29.1] | 0.644 |
| ASA | | | | |
| 1–2 (%) | 75 (86.2) | 48 (87.3) | 27 (84.4) | 0.753 |
| 3–4 (%) | 12 (13.8) | 7 (12.7) | 5 (15.6) | |
| History of pelvic floor or abdominal surgery (%) | 47 (54.0) | 28 (50.9) | 19 (59.4) | 0.445 |
| Fellow/senior resident involved (%) | 55 (63.2) | 30 (54.5) | 25 (78.1) | 0.028 |

*ASA* American society of anesthesiologists, *BMI* Body mass index, *IQR* interquartile range, *LOS* length of stay, *N* number, *SD* standard deviation

Table 3. There was one case of early recurrence which was treated with redo-RVMR. This was a case of surgeon B and happened before completion of the learning curve regarding OT.

Intraoperative and postoperative complication rates (CD grade 1–5 and CD grade > 2) were analyzed with CUSUM analyses and are plotted in Fig. 3. For both surgeons, all CUSUM graphs remained below the control limits, indicating that performance marked by intraoperative and postoperative safety stayed at an acceptable level of performance throughout the process of learning.

## Discussion

This study assessed the learning curve in RVMR of two robot-naïve surgeons in a tertiary referral center for pelvic floor pathology. It illustrates a clear learning curve for this robot-assisted procedure, even though the surgeons were proficient in its laparoscopic performance. The learning curve as defined by OT ranged between 36 and 55 procedures. Throughout the study period, intraoperative complication rates and 90-day morbidity remained at an acceptable level of performance. This means the procedural change did not lead to a decline in quality.

For both surgeons an initial gradual decline was seen in OT, after which some fluctuations were observed (Fig. 1). One of these fluctuations was probably caused by the transition from the Da Vinci Si to Xi, as can be seen by an increase and subsequent decrease in the MA-10 graph around the moment of transition. Other fluctuations could be due to participation of fellow surgeons or senior surgical residents. In our center, RVMR is an operation where fellow surgeons and senior residents with a special interest in robotic surgery make their first steps in robot-assisted surgery. Due to the retrospective nature of this study, it could not be assessed to what extent a procedure was performed by the fellow/resident and thus how much their training influenced the OT of surgeon A and B. A gradual incline was seen in frequency of fellows/residents joining a procedure with 13% in the first year to 87% in 2019. For both surgeons a statistically significant difference was seen in number of surgeries joined by a fellow/resident before and after completion of the learning curves. Despite this incline, the intra- and postoperative complication rates stayed at an acceptable level as illustrated by the CUSUM analyses based on rates of 2% for intraoperative complications and 11% for postoperative

**Table 3** Intraoperative complications and 90-day postoperative morbidity

| Intraoperative complication - treatment | *N* = 429* | |
|---|---|---|
| Total intraoperative complications | 10 (2.3%) | |
| Bleeding complication – suture/pressure/diathermic | 4 (0.9%) | |
| Serosa lesion rectum or sigmoid – suture[a] | 3 (0.7%) | |
| Posterior vaginal wall lesion – suture | 1 (0.2%) | |
| Losing needle – radiological localisation (unsuccessful) | 1 (0.2%) | |
| Conversion to laparoscopy | 1 (0.2%) | |
| 90-day postoperative complications - treatment | *N* = 273** | CD grade |
| Total minor complications | 31 (11.4%) | I-II |
| Unusual postoperative pain e.c.i. - pain medication | 6 (2.2%) | I |
| Electrolyte imbalance - electrolytes | 1 (0.4%) | I |
| Anal fissure - conservative | 2 (0.7%) | I |
| Urinary retention - catheter | 2 (0.7%) | II |
| UTI - antibiotics | 6 (2.2%) | II |
| Constipation - laxative and/or enema | 5 (1.8%) | II |
| Anemia - blood transfusion | 1 (0.4%) | II |
| Wound infection - antibiotics | 1 (0.4%) | II |
| Spondylodiscitis - antibiotics | 1 (0.4%) | II |
| Delirium - antipsychotics | 1 (0.4%) | II |
| Abdominal pain e.c.i. – antibiotics and enema | 1 (0.4%) | II |
| Paralytic ileus - transparental feeding | 1 (0.4%) | II |
| Pneumonia – antibiotics | 1 (0.4%) | II |
| Decompensation - diuretics | 1 (0.4%) | II |
| Atrium fibrillation de novo - anticoagulants | 1 (0.4%) | II |
| Total major complications | 6 (2.2%) | III-V |
| Suture visible vaginal wall - transvaginal excision | 1 (0.4%) | IIIa |
| Bowel obstruction - adhesiolysis | 2 (0.7%) | IIIb |
| Early recurrence (distal mesh detachment) - redo surgery | 1 (0.4%) | IIIb |
| Abscess rectovaginal septum - surgical drainage[b] | 1 (0.4%) | IIIb |
| Rectovesical fistula - temporary colostomy[b] | 1 (0.4%) | IIIb |

*CD* Clavien–Dindo, *e.c.i.* e causa ignota (of unknown origin), *N* number, *UTI* urinary tract infection

*Combined total of primary ventral mesh rectopexies (*N* = 273) and sacrocolpo-rectopexies (*N* = 156)

**Total number of primary ventral mesh rectopexies

[a]Operation was aborted due to a frozen pelvis

[b]Complications were in the same patient and were related to each other

complications (Fig. 3) [2, 10, 16–19]. This indicates that not only implementation of robot assistance, but the training of fellows and senior residents happened safely. Other case characteristics that could have had an impact on the difficulty of the surgery did not change after completion of the individual learning curves (Table 2).

Perrenot et al. previously reported on the learning curve for robot-assisted surgery for rectal prolapse [21]. In their series, analysis of 48 procedures performed by one surgeon showed a learning curve of 18 procedures. The shorter learning curve found in their study could be explained partially by the different method used to assess the learning curve. In the study by Perrenot et al., as in many other studies investigating learning curves of surgical procedures, operating time is analyzed using CUSUM analysis. CUSUM analyses that study a continuous variable such as procedural time, largely depend on the mean of the observed variable and thus the size of the series being investigated (the larger the series, the less the mean is influenced by the early cases where proficiency has yet to be obtained). By the nature of this method, the inflection point of the CUSUM chart, indicating the end of the learning phase, occurs earlier in series with smaller sample sizes. LC-CUSUM analysis is not influenced by the sample size and is therefore a better and more reliable method to assess a learning curve depending on OT. Furthermore, their learning curve comprised three types of robot-assisted POP surgery and operating time after completion of the learning curve still counted a considerable 175 min compared to 74 to 90 min in our study. All these

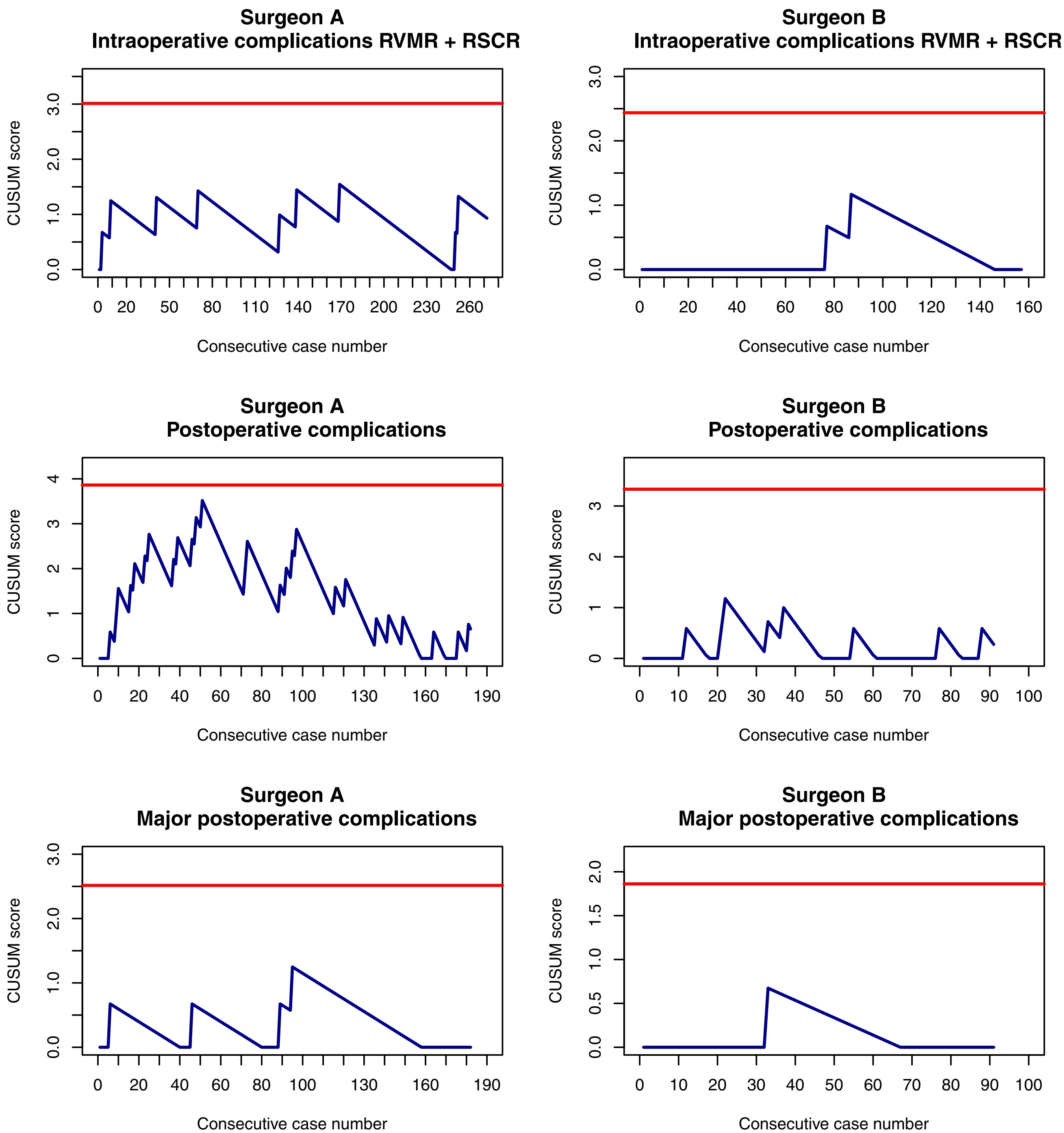


**Fig. 3** CUSUM plots for surgeon A (left) and B (right) regarding intraoperative complications, postoperative overall 90-day morbidity, and major postoperative 90-day morbidity

factors make their study difficult to be compared to results found in our study.

A study on the learning curve of implementation of robot assistance to gynecologic prolapse surgery (sacrocolpopexy) in our center by Van Zanten et al. reported a learning curve of 26 procedures defined by CUSUM analyses of OT [22]. The disparity with our results could be due to the different method of analyses in combination with the absence of participation of fellow gynecologists or gynecology residents in their series.

A limitation of our study is the influence other robot-assisted surgeries may have had on the learning curve of RVMR. This accounts especially for experience gained with RSCR. Although intraoperative complications during

RSCR were included in our analyses, the necessary exclusion of these cases for LC-CUSUM analyses for OT could have influenced our results. To a lesser extent, experience gained in performing robot-assisted oncologic rectal resections could have had a positive impact on the analyses of OT and safety measures.

The strength of our study is the assessment of two individual learning curves using a large cohort of patients. Insight in the learning course of two individuals makes these results more useful for other hospitals considering a change from LVMR to RVMR. No two individuals are identical regarding their performances, neither during the learning phase nor thereafter. This is caused by personal qualities as well as by the given external circumstances. External circumstances that lead to shorter OT are the repetition rate of performing the surgery of interest and the absence of fellow surgeons or senior residents. This was reflected by the shorter median OT and learning curve found for surgeon A compared to surgeon B. Between 2011 to 2019, surgeon A performed more RVMRs than surgeon B (182 vs 91, respectively) and was less often accompanied by a fellow surgeon or resident during the individual learning curve (33% vs 55%, respectively). However, it is of important notice that even though these circumstances were more inconvenient for surgeon B, they did not have any impact on the peri- and postoperative safety.

We realize that the high volume of RVMR in our center and previous experience in LVMR might have positively influenced the learning curve of both surgeons. This should be considered when interpreting these results for implementation of robot-assisted surgery in other pelvic floor centers. Since our data show that the transition did not inflict additional risks, this should not be seen as an obstacle for implementation of robot assistance.

Apart from using the results of this study for planning and implementing robotic surgery in other pelvic floor clinics, surgeons can use the same analyses to monitor their performance prospectively. When CUSUM is used in a prospective way, it can signal an unacceptable increase in complications at an early stage. Thereby it can be used as a feedback system of a surgeon's individual performance and help signal the possible need for additional training. Additionally, prospective LC-CUSUM analysis can help determine the end of the learning phase of a new procedure.

In conclusion, evaluation of OT can be useful when investigating the process of gaining proficiency in a new surgical technique. However, perioperative and postoperative safety should always be an important part of the analysis too. When changing from LVMR to RVMR, the learning phase was completed after 36–55 cases based on LC-CUSUM analysis of OT, without a decline in quality defined by CUSUM analysis of intraoperative and postoperative complications. Participation of a fellow surgeon can prolong OT and slow down the pace of the learning process without a negative impact on the procedural safety. Furthermore, these methods of analysis can serve as a useful tool in self-monitoring performance during the implementation phase of a new procedure and thereafter.

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## Declarations

**Disclosures** Dr. I.A.M.J. Broeders, P.M.Verheijen, and E.C.J. Consten are proctors for Intuitive Surgical. Dr M. El Moumni and Drs. E.M. van der Schans have no conflicts of interest or financial ties to disclose.

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