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Implementation of an ERAS program in elective minimally-invasive surgery for colorectal surgery: An outcomes and learning curve analysis

Chun-Yen Hung, M.D., Feng-Fan Chiang, M.D., Ph.D.,

Division of Colon Rectal Surgery, Department of Surgery, Taichung Veterans General Hospital , Taichung, Taiwan, R.O.C

Background

1. Enhanced recovery after surgery (ERAS) protocols are multimodal perioperative care pathways designed to achieve early recovery after surgical procedures and have been widely accepted worldwide.
2. However, the effective implementation of ERAS required close multidisciplinary teamwork and learning curves to adjust the protocols into a daily practice.
3. This primary objective of this study was to present our real-world experience and establish the learning curves for the implementation of an ERAS program in minimally invasive surgery for colorectal resection, while also evaluate the impact of developing robotic technique to the outcomes of ERAS.

Method

1. We collected adult patients who received elective minimally invasive surgery including laparoscopic and robotic surgery for colorectal resection with ERAS care during June 2019 to September 2021. Patients required conversion to open surgery and immediate postoperative intensive care were all excluded. Overall, a total of 155 patients were included in this retrospective analysis.
2. All patients had received the same ERAS programs and equivalent treatment by the same multidisciplinary team. Our tailored ERAS had 18 core programs consists of 4 preadmission items, 4 preoperative items, 3 intraoperative items and 7 postoperative items.
3. Patient were divided into 5 group chronologically (31 cases per quintile). Patient demographics, perioperative data, tumor characteristics, surgical outcomes and ERAS compliance were compared among quintiles. Learning curves were evaluated based on surgical outcomes and ERAS compliance.
4. All statistical analyzes were performed using the PASW Statistics software (SPSS version 22.0). Continuous variables were expressed as mean ± SD or median (interquartile range; IQR) and were compared among groups using one-way analysis of variance (ANOVA) or the Kruskal-Wallis test. Categorical data were expressed as number (percentage) and were compared using the Pearson Chi-square test or Fisher exact probability test. A P-value of <0.05 was considered statistically significant

Result

Table 1. Demographic analysis of patient groups

Parameters	Overall	Group 1	Group 2	Group 3	Group 4	Group 5	P value
Number of patients, *n*	155	31	31	31	31	31	
Males, *n* (%)	85 (54.8%)	22 (71%)	17 (54.8%)	17 (54.8%)	16 (51.6%)	13 (41.9%)	0.242[a]
Mean age, years ± SD	61.3±14.2	61.4±13.6	64.4±16.0	63.8±13.4	60.4±12.8	56.4±14.3	0.176[b]
BMI, kg/m2 ± SD	24.9±4.2	25.3±4.0	24.4±5.1	25.3±3.6	24.4±3.2	24.9±4.9	0.577[b]
ASA ≧2, *n* (%)	117 (75.5%)	26 (83.9%)	23 (74.2%)	24 (77.4%)	23 (74.2%)	21 (67.7%)	0.681[a]
Cigarette use, *n* (%)	35 (22.6%)	12 (38.7%)	5 (16.1%)	6 (19.4%)	7 (22.6%)	5 (16.1%)	0.180[a]
Any comorbidity, *n* (%)	94 (60.6%)	19 (61.3%)	19 (61.3%)	22 (71.0%)	18 (58.1%)	16 (51.6%)	0.637[a]
Hypertension, *n* (%)	70 (45.2%)	13 (41.9%)	15 (48.4%)	16 (51.6%)	14 (45.2%)	12 (38.7%)	0.861[a]
Diabetes, *n* (%)	39 (25.2%)	7 (22.6%)	5 (16.1%)	9 (29.0%)	9 (29.0%)	9 (29.0%)	0.700[a]
Cardiovascular, *n* (%)	15 (9.7%)	1 (3.2%)	4 (12.9%)	6 (19.4%)	1 (3.2%)	3 (9.7%)	0.156[a]
Multiple primary cancers, *n* (%)	7 (4.5%)	3 (9.7%)	1 (3.2%)	1 (3.2%)	1 (3.2%)	1 (3.2%)	0.664[a]
Median pre-op hemoglobin, gm/dl (IQR)	13.1 (11.8-14.5)	13.4 (11.9-14.8)	13.5 (11.5-14.9)	13.1 (11.9-13.8)	13.5 (12.0-14.5)	13.0 (11.6-14.1)	0.290[b]
Median pre-op CEA, ng/ml (IQR)	3.5(2.2-7.2)	4.1 (2.9-8.7)	3.3 (2.2-17.8)	4.1 (2.7-6.0)	2.9 (1.9-7.6)	2.5 (1.7-3.5)	0.061[b]
Previous abdominopelvic surgery, *n* (%)	32 (20.6%)	5 (16.1%)	6 (19.4%)	8 (25.8%)	6 (19.4%)	7 (22.6%)	0.906[a]
Neoadjuvant CCRT, *n* (%)	22 (14.2%)	6 (19.4%)	2 (6.5%)	2 (6.5%)	8 (25.8%)	4 (12.9%)	0.125[a]

SD: standard deviation; IQR: interquartile range; CEA:Carcinoembryonic Antigen; CCRT: Concurrent Chemoradiotherapy

[a] Kruskal Wallis test. [b] chi-squared test. [c] ANOVA test.

Table 2. Perioperative data and clinical outcomes analysis of patient groups

Parameters	Overall (n=155)	Group 1 (n=31)	Group 2 (n=31)	Group 3 (n=31)	Group4 (n=31)	Group 5 (n=31)	P value
Laparoscopic method, *n* (%)	76 (49%)	31 (100%)	18 (58%)	16 (51.6%)	8 (25.8%)	3 (9.7%)	<0.0001[a]
Operative time, minutes							0.088[c]
Mean ± SD	250.3±83.3	229.3±92.6	242.7±96.0	258.1±75.3	262.7±87.0	258.9±61.5	
Median (IQR)	235(195-297.5)	220 (182.5-232.5)	225 (169-285)	250 (210-310)	242 (195.5-315.5)	255 (207-282.5)	
Minimal blood loss, *n* (%)	129 (83.2%)	22 (71%)	25 (80.6%)	28 (90.3%)	25 (80.6%)	29 (93.5%)	0.130[a]
Stoma construction, *n* (%)	29 (18.7%)	5 (16.1%)	2 (6.5%)	5 (16.1%)	11 (35.5%)	6 (19.4%)	0.059[a]
Drainage tube placement, *n* (%)	73 (47.1%)	29 (93.5%)	28 (90.3%)	5 (16.1%)	5 (16.1%)	6 (19.4%)	<0.0001[a]
Visual Pain scale ≧3, *n* (%)	127 (81.9%)	25 (80.6%)	24 (77.4%)	23 (74.2%)	29 (93.5%)	26 (83.9%)	0.329[a]
First oral intake within 24hrs, *n* (%)	137 (88.4%)	26 (83.9%)	21 (67.7%)	30 (96.8%)	30 (96.8%)	30 (96.8%)	0.001[a]
Median duration of first stool*, day ± SD	2.5±1.8	3.9±1.8	2.8±2.0	2.1±1.2	2.0±2.0	1.6±1.0	<0.0001[b]
Mean IV amount, ml ± SD							
POD-0	1,573.4±810.3	1,145.4±555.6	1,822.9±738.4	1,658.1±929.6	1,511.3±707.1	1,729.3±928.7	0.005[c]
POD-1	1,478.5±728.3	1,533.4±822.1	1,811.8±1,013.4	1,277.6±638.6	1,312.3±390.6	1,457.2±520.3	0.230[c]
POD-2	927.3±904.8	1,198.1±905.2	1,448.4±1,104.0	551.6±680.1	782.1±852.5	656.5±613.0	0.001[c]
POD-3	644.3±945.9	1,034.6±935.7	1,461.7±1,045.5	304.0±640.4	275.8±738.6	145.5±551.0	<0.0001[c]
Mean urine amount, ml ± SD							
POD-1	1,771.5±884.6	1,714.8±794.9	2,029.2±1,065.1	1,410.8±764.1	1,662.7±739.0	2,046.6±912.7	0.029[c]
POD-2	2,019.9±902.0	2,253.8±1,069.7	2,109.6±958.7	1,621.0±593.9	2,010.7±852.3	2,115.4±902.4	0.139[c]
POD-3	2,039.5±879.6	2,178.6±916.9	2,104.1±894.5	1,837.9±672.4	1,978.7±711.4	2,139.7±1,232.0	0.663[c]

VAS: Visual Analogue Scale; *Patient with stoma construction were excluded

Table 2. *Cont.*

Parameters	Overall (n=155)	Group 1 (n=31)	Group 2 (n=31)	Group 3 (n=31)	Group4 (n=31)	Group 5 (n=31)	P value
*Any complications, *n* (%)	24 (15.5%)	9 (29.0%)	7 (22.6%)	4 (12.9%)	1 (3.2%)	3 (9.7%)	0.078[a]
High grade (3-5)	8 (5.2%)	5 (16.1%)	2 (6.5%)	1 (3.2%)	0	0	
Low grade (1-2)	16 (10.3%)	4 (12.9%)	5 (16.1%)	3 (9.7%)	1 (3.2%)	3 (9.7%)	
Reoperation rate, *n* (%)	7 (4.5%)	4 (12.9%)	3 (9.7%)	0	0	0	0.023[a]
Hospital stays after surgery, days							<0.0001[a]
Mean ± SD	6.7±5.5	10.5±9.4	7.9±4.2	5.8±4.4	4.7±1.4	4.7±1.8	
Median (IQR)	5 (4-7)	8 (6-9)	7 (5-10)	5 (4-6)	4 (4-5)	4 (4-5)	
Readmission within 30 days, *n* (%)	7 (4.5%)	3 (9.7%)	2 (6.5%)	1 (3.2%)	0	1 (3.2%)	0.421[a]

*Complications were graded by Calvin-Dindo classification

[a] Kruskal Wallis test. [b] chi-squared test.

Table 3. Tumor histopathological characteristics

Parameters	Overall (n=155)	Group 1 (n=31)	Group 2 (n=31)	Group 3 (n=31)	Group4 (n=31)	Group 5 (n=31)	P value
Tumor location							0.313[a]
Right-sided colon, *n* (%)	29 (18.7%)	5 (16.1%)	8 (25.8%)	9 (29.0%)	2 (6.5%)	5 (16.1%)	
Left-sided colon, *n* (%)	65 (41.9%)	14 (45.2%)	14 (45.2%)	11 (35.5%)	10 (32.3%)	16 (51.6%)	
Rectum, *n* (%)	61 (39.4%)	12 (38.7%)	9 (29.0%)	11 (35.5%)	13 (41.9%)	16 (51.6%)	
Malignant tumor, *n* (%)	136 (87.7%)	28 (90.3%)	25 (80.6%)	27 (87.1%)	29 (93.5%)	27 (87.1%)	0.620[a]
T4 lesion	16 (10.3%)	1 (3.2%)	4 (12.9%)	4 (12.9%)	3 (9.7%)	4 (12.9%)	0.668[a]
Stage							0.462[a]
*Stage 0	10 (6.5%)	3 (9.7%)	1 (3.2%)	2 (6.5%)	2 (6.5%)	2 (6.5%)	
Stage I	26 (16.8%)	6 (19.4%)	1 (3.2%)	5 (16.1%)	5 (16.1%)	9 (29.0%)	
Stage II	33 (21.3%)	9 (29.0%)	7 (22.6%)	8 (25.8%)	3 (9.7%)	6 (19.4%)	
Stage III	49 (31.6%)	5 (16.1%)	13 (41.9%)	10 (32.3%)	12 (38.7%)	9 (29.0%)	
Stage IV	9 (5.8%)	3 (9.7%)	2 (6.5%)	1 (3.2%)	2 (6.5%)	1 (3.2%)	
Median length of safe margin, cm (IQR)	2.4 (1.5-4.0)	2.3 (1.9-4.1)	4.0 (1.8-4.5)	2.2 (1.0-4.0)	2.8 (2.0-3.5)	2.0 (1.0-3.0)	0.173[a]
No residual tumor after neoadjuvant therapy	9 (5.8%)	5 (16.1%)	7 (22.6%)	5 (16.1%)	7 (22.6%)	4 (12.9%)	0.814[a]

*Stage 0= pTisN0M0

[a] Kruskal Wallis test. [b] chi-squared test.

Table 5. ERAS compliance rate

Parameters	Overall (n=155)	Group 1 (n=31)	Group 2 (n=31)	Group 3 (n=31)	Group4 (n=31)	Group 5 (n=31)	P value
Total ERAS protocol, % (Median, range)	83.3% (50.0-94.4)	72.2% (50.0-88.9)	83.3% (66.7-94.4)	83.3% (72.2-88.9)	83.3% (72.2-94.4)	83.3% (72.2-94.4)	<0.0001[a]
Preadmission items	100% (50.0-100)	75.0% (75.0-100)	100% (50.0-100)	100% (50.0-100)	100% (50.0-100)	100% (50.0-100)	0.486[a]
Preoperative items	100% (75.0-100)	100% (75.0-100)	100% (75.0-100)	100% (75.0-100)	100% (75.0-100)	100% (75.0-100)	0.161[a]
Intraoperative items	100% (33.3-100)	66.7% (33.3-100)	66.7% (33.3-100)	100% (66.7-100)	100% (66.7-100)	100% (66.7-100)	<0.0001[a]
Postoperative items	71.4% (14.3-100)	57.1% (14.3-85.7)	71.4% (28.6-100)	71.4% (28.6-100)	71.4% (42.9-100)	71.4% (42.9-100)	<0.0001[a]

[a] Kruskal Wallis test.

Figure 1. Elements of tailored ERAS protocol and overall compliance rate

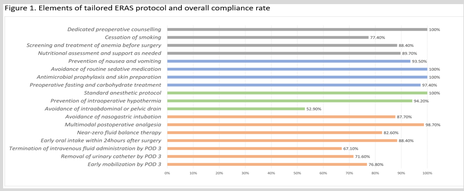
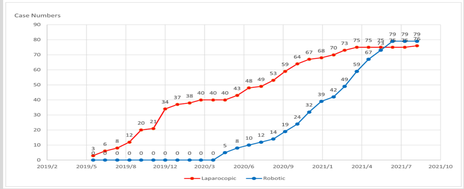


Figure 2. Cumulative numbers between Laparoscopic and Robotic group



Discussion

1. There is a growing trend worldwide in the adoption of robotic approach to colorectal surgery in the past decade. Robotic surgery has been proved to provide better clinical and oncological outcomes for colorectal cancer patients as compared to the conventional laparoscopic surgery. We developed robotic approach and executive ERAS care simultaneously on patients undergoing colorectal tumor resection since May 2020. The case numbers of robotic group grew fast and exceeded that of laparoscopic group by July 2021 [Fig 2].
2. A prospective study of early implementation of ERAS program in laparoscopic colorectal surgery has demonstrated that at least 30 patients and a period of 6 months are required to achieve an ERAS compliance of 80% or more. However, the learning curve of ERAS program in robotic colorectal surgery has not been validated to date.
3. In our study, compliance of total ERAS programs achieved a significant progress from 71.1% in group 1 to 81.2% in group 2 and was relatively constant from group 3 to group 5 (p value:<0.0001). Reoperation rate (p value:0.023) and hospital stays after surgery (p value: <0.0001) also achieved a significant reduction between group 1 and group 2. A number of 31 patients required to achieved better clinical outcomes and higher compliance of ERAS programs are compatible to former study. In addition, robotic approach being in the majority of the letter group indicated that development of robotic colorectal surgery had no impact on learning curve of ERAS care.

Conclusion

Both robotic surgery and ERAS protocol care are prominent creation to colorectal surgery and become a global trend with rapid progress on safety and efficacy over the past decade. Our experience indicate that the combination of robotic approach and ERAS protocol care is a promising surgical approach and there is no impact on learning curve of ERAS care despite the early development of robotic surgery.