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Influence of individual surgeon volume on early postoperative outcomes after rectal cancer resection

Uticaj individualnog hirurškog volumena na rane postoperativne ishode posle resekcije rektuma zbog karcinoma

[1]Zoran Aleksić*, [1]Maja Vulović[†‡], Bojan Milošević[§‖], Aleksandar Cvetković[§‖], Dragan Tomić*, Nebojša Trkulja*, Milan Simatović*, Andjelka Stojković[¶], Anita Ivošević**

University Clinical Center of the Republic of Srpska, *Clinic for General and Abdominal Surgery, Banjaluka, Bosnia and Herzegovina; University of Kragujevac, Faculty of Medical Sciences, [†]Department of Anatomy and Forensic Medicine, [‖]Department of Surgery, [¶]Department of Pediatrics, **Department of Internal Medicine, Kragujevac, Serbia; University of Defence, [‡]Faculty of Medicine of the Military Medical Academy, Belgrade, Serbia; Clinical Center Kragujevac, [§]General and Thoracic Surgery Department, Kragujevac, Serbia

[1]Equally contributed first author

Abstract

Background/Aim. Surgeon-specific experience as measured by procedure volume can have a significant impact on survival of patients with rectal cancer (RC). The aim of this study was to determine whether an individual surgeon-specific volume of procedure influences early postoperative outcomes as well as to determine the strength of different groups of annual surgeon volume (ASV), as a predictor of outcomes in patients after RC resection up to 30 days postoperatively. **Methods.** This retrospective observational single center study involved a cohort of 546 patients of both sexes, operated for a 10-year period due to RC. Patients were divided into three groups, according to the annual volume of RC procedures of a surgeon who operated them. Seven outcomes were analyzed: the incidence of colorectal anastomotic dehiscence (CRAD), operative time, intraoperative blood loss, hospital stay, in-hospital death, the status of the circumferential resection margin (CRM) and the total mesorectal excision (TME) with number of lymph nodes, as well as some risk factors (several independent, dependent and "confusing" variables) of importance for the outcome, to explain the difference. The strength of each group of surgeons and their effect on early outcome of treatment were determined. **Results.** The majority of surgeons (77.7%) belonged to the low and medium ASV, which performed a slightly higher number of surgeries (281) than the high volume group. The high-volume surgeon group was associated with significantly better results in four outcomes (CRAD, operating time, CRM, TME and number of lymph nodes). **Conclusion.** In our surgical institution, the high volume surgeon remains an important predictor of success of the RC surgery.

Key words:
hemorrhage; length of stay; surgeons; surgical procedures, operative; surgical wound dehiscence; rectal neoplasms; survival; treatment outcome.

Apstrakt

Uvod/Cilj. Individualno hirurško iskustvo mereno brojem procedura može značajno uticati na preživljavanje bolesnika sa karcinomom rektuma (KR). Cilj ovog rada bio je da se utvrdi da li individualni volumen procedure hirurga utiče na rane postoperativne ishode i da li jačina različitih grupa procedura hirurškog volumena, kao predskazatelja ishoda kod bolesnika sa KR do 30 dana posle hirurškog lečenja. **Metode.** Sprovedena je retrospektivna jednocentrična studija sa kohortom od 546 bolesnika oba pola, elektivno operisanih u 10-godišnjem period zbog KR. Bolesnici su bili podeljeni u tri grupe, shodno godišnjem volumenu procedura 18 ordinirajućih hirurga u kolorektalnoj hirurgiji. Analizirano je sedam ishoda: stopa dehiscencije kolorektalne anastomoze (DKRA), vreme trajanja operacije, intraoperativni gubitak

Correspondence to: Bojan Milošević, University of Kragujevac, Faculty of Medical Sciences, Department of Surgery, Svetozara Markovića 69, 34 000 Kragujevac, Serbia. E-mail: drbojanzm@gmail.com

krvi, dužina hospitalizacije, intrahospitalna smrtnost, patohistološki status cirkumferencijalne resekcione margine (CRM) i totalna mezorektalna ekscizija (TME) sa brojem limfnih nodusa, kao i drugi faktori rizika (više nezavisnih, zavisnih i "zbunjujućih" varijabli) od značaja za ishod operativnog lečenja i objašnjenje razlike. Utvrđivana je jačina svake grupe hirurga i njihov uticaj na rane ishode lečenja. **Rezultati.** Većina hirurga (77,7%) pripadala je grupi sa niskim i srednjim volumenom procedura koja je izvela nešto veći broj operacija (281). Grupa hirurga sa visokim volumenom imala je značajno bolje rezultate u četiri ishoda (stopa DKRA, vreme trajanja operacije, status CRM I TME sa brojem limfnih nodusa). **Zaključak.** U našoj hirurškoj ustanovi, visoki hirurški volumen je važan predskazatelj uspešnog ishoda u hirurškom lečenju karcinoma rektuma.

Ključne reči:
krvarenje; hospitalizacija, dužina; hirurzi; hirurgija, operativne procedure; rana, hirurška, dehiscencija; rektum, neoplazme; preživljavanje; lečenje, ishod.

Introduction

Since the anterior resection has become the method of choice for treatment of rectal cancer (RC), the effect of anastomotic dehiscence (AD) on postoperative morbidity, mortality and the cost of treatment is the growing concern among surgeons [1–3]. The colorectal AD (CRAD) is the most common and the most severe complication for all reconstructions and represents the "Achilles heel" of each surgeon [4, 5]. The frequency of CRAD varies in patients' series of different authors, ranging between 3% and 19%, after elective surgery, and in operations with total mesorectal excision (TME) it is usually higher, 10–24%. The rate of postoperative mortality due to CRAD is between 12% and 27%, which is the cause of death in up to one third of the deaths after the RC surgery [5–10]. In order to heal anastomosis, in addition to systemic and local factors, operating technique (technical factors) plays a crucial role. Operating technique varies from school to school and from surgeon to surgeon in fulfilling the basic conditions of anastomosis [10, 11]. Many studies [12–15] examined risk factors for CRAD, but there is no consensus on the role of each of them. The development of CRAD remains unpredictable in many patients [16]. Some authors identify intraoperative blood loss of 200 mL or more and operative time of 200 minutes or longer as factors the increased risk of postoperative AD [16]. The quality of surgical resection plays a critical role in the outcome of patients with colon and RC. Adequate surgical resection is important for regional cancer control [17]. A negative (R0) circumferential resection margin (CRM) is described as one of the most important factors that decrease the rate of local recurrence in RC [18]. The rate of CRM positivity is widely used as a quality indicator in RC care [19] and serves as a useful indicator of the quality of surgery [20]. The American College of Surgeons and the American Society of Clinical Oncology endorsed a minimum 12-lymph node count as a quality measure for better outcome in colon cancer patients [17]. It is important to adhere to strict oncologic principles for cancer resections, including high vascular ligation and complete 'en bloc' resection of the mesocolon, lymphadenectomy and CRM (for RC) [17].

Numerous studies have examined the association between the surgeon case volume and clinical outcome for various procedures and have shown higher surgeon volume to be associated with better outcomes [10]. Surgeon-specific experience as measured by procedure volume can have a significant impact on survival in patients with RC [21]. The best early postoperative surgical outcomes are achieved in centres where there are high annual volume surgeons attending these patients [22].

Despite the considerable body of research in this area, little is known about the mechanisms underlying the observed associations between the surgical volume and postoperative outcomes in patients with RC [23].

The aim of our retrospective observational study was to show that individual surgeon-specific volume of procedure influences early postoperative outcome and determine the strength of different groups of annual surgical volume (ASV), as a predictor of outcome in patients after RC resection, up to 30 days postoperatively.

Methods

Retrospective, single center study, with a cohort of 546 patients operated in the period between January 1st, 2007 and December 30th, 2016 at the Clinic for General and Abdominal Surgery of the Clinical Center in Banjaluka the Republic of srpska, Bosnia and Herzegovina.

The trial included patients of both sexes with RC, clinical stages T1 N0, T2 N0-2 and T3 N0-2. The study did not include patients in the stage T4, with a local irresectable process, local recurrence and dissemination of the disease. In all patients the anterior resection of the rectum with an open approach was performed. Colorectal anastomosis (CRA) was hand-sewn in 208 patients (single inverting extramucosal sutures in a single layer) and in 338 patients – a stapler technique (ILP 29–33 mm). Anastomotic technique and the creation of protective ileo- or transverse colostomies (in selective cases) depended exclusively on the individual assessment and the skill of the operating surgeon. Primary chemotherapy and radiotherapy were carried out individually in accordance with the decision of the multidisciplinary team. Clinical parameters of CRAD were: appearance of purulent or fecal content in drainage tube, pelvic abscess, peritonitis, rectovaginal fistula and the appearance of purulent discharge per *recti*. For the detection of eventual AD, a digital rectal examination, anoscopy and/or proctoscopy (for low rectal anastomoses) and radiographic contrast control were used in selective cases (grade "B" of CRAD).

Eighteen surgeons who operated the patients were classified into three groups based on their annual volume of colorectal procedures: low volume of the surgeon (≤ 5 procedures), medium (6–10 procedures) and high volume (> 10 procedures) [10].

Seven outcomes were analyzed: the incidence of CRAD, operative time, intraoperative blood loss, hospital stay, in-hospital death, the status of the CRM and the TME with number of lymph nodes, as well as some risk factors (several independent, dependent and "confusing" variables) of importance for the outcome.

All collected data were analyzed using commercial statistical software SPSS Statistics for Windows version 21. Depending on the results of the Kolmogorov-Smirnov test, the statistical significance between the groups was checked by *t*-test for independent groups, or alternatively by ANOVA. Some variables are presented in the form of frequencies of particular features (categories), and the significance of difference was determined using the χ^2 test or the Mann-Whitney test and the Kruskal-Wallis test. A value of $p < 0.05$ was considered statistically significant.

Results

During the 10 year study period, 18 surgeons in a single hospital performed 546 resections for RC. The majority of surgeons were in the low and medium volume groups (Table 1). A statistically significant difference was found among the groups.

Patients were mostly male (61.53%). The largest number of RC operations was performed in the period from 2013 to 2015 (60, 73, 62, respectively), and the largest number of patients was in the seventh and eighth decade of life (351). Compared to the age groups of patients, an approximately equal burden of surgeons in all three ASV groups was found ($\chi^2 = 14.76$; $p = 0.255$). Although surgeons from a high volume group more frequently operated patients with the Charlson Comorbidity Index (CCI) ≥ 3, no statistically significant difference was found among surgeon volume groups ($x^2 = 5.723$; $p = 0.214$).

Most of the patients (396 or 72.5%) had the loss of body weight over 15% from the beginning of the disease until the operation. Surgeons from low volume group operated a slightly higher number of patients whose weight loss was registered. Statistical analysis showed no significant difference, but a clear tendency ($p = 0.054$) amongsurgeon volume groups.

Most of the patients belonged to the American Society Anesthesiologists (ASA) risk classification system scores II and III (432 or 79.12%). All three surgeon volume groups operated patients with ASA II ($\chi^2 = 6.286$, $p = 0.347$) in over 50% of cases.

Table 2 shows the distribution of RC to the segments of the rectum. All of the patients with RC in the distal segment were operated by surgeons from high volume group. The highest percentage of low anastomosis (≤ 12 cm from the anal verge) was performed in the group with the highest ASV (210/326). There was a statistically significant correlation between the volume groups.

Table 1
Annual surgical volume (ASV) of 18 surgeons in colorectal resections

Parameter	Surgens (n)	Annual surgical procedures	
		mean ± SD	min-max
Surgeon volume group			
low (≤ 5)	8	4.54 ± 0.27	4.20–5.00
medium (6–10)	6	8.83 ± 0.83	7.30–9.86
high (> 10)	4	18.33 ± 1.17	16.60–19.20
Total	18	9.03 ± 5.50	4.20–19.20
Comparison (ANOVA)		F = 465.8; $p < 0.001$	
Tukey test		$p < 0.001$	

min – minimum; max – maximum; SD – standard deviation.

Table 2
Anatomic location of rectal cancer (RC) according to annual surgical volume

Rectal segment	ASV			Total
	≤ 5	6–10	> 10	
Lower				
number	0	0	99	99
rows (%)	0.0	0.0	100.0	100.0
columns (%)	0.0	0.0	37.4	18.1
Middle				
number	48	68	111	227
rows (%)	21.1	30.0	48.9	100.0
columns (%)	36.1	45.9	41.9	41.6
Upper				
number	85	80	55	220
rows (%)	38.6	36.3	25.0	100.0
columns (%)	63.9	54.0	20.7	40.3
Total				
number	133	148	265	546
rows (%)	24.4	27.1	48.5	100.0
columns (%)	100.0	100.0	100.0	100.0
Comparison	$\chi^2 = 21.85$; $p < 0.001$			

The majority of patients had an T3 N0-2 stage of RC (69%, 377/546). There was no significant association between the TNM tumor stage and ASV ($\chi^2 = 8.58$, $p = 0.072$).

All three of the surgeon volume groups relative to the type of newly discovered abdomen conditions during the operation did not differ significantly. Higher number of newly discovered states (n = 83) in the high volume group correlates with a large number of performed surgeries ($\chi 2 = 5.24$, $p = 0.983$).

After anterior resection of the rectum, CRA was created by manual sewing in 208 patients and in 338 with a stapler technique. Statistically significantly was lesser use of hand-sewn technique by surgeons within the low annual volume group. In patients with CRA stapling technique hospitalization lasted up to 8 days in 61.5% of cases ($p < 0.001$). There was no statistically significant difference between techniques of anastomosis and mortally outcome (hand-sewn 4.3%, stapler 5.0%). Regardless of the age of the surgeon, the application of stapler technique was dominant.

There was a statistically significant correlation between the type of mesorectal excision and localization of RC. TME is applied for carcinomas in the distal third and for carcinomas in the middle third in a significant number of patients (Table 3).

There was no statistically significant correlation between the type of mesorectal excision and CRAD ($\chi^2 = 0.48$; $p = 0.48$), as well between the type of mesorectal excision and in-hospital mortality ($\chi^2 = 0.55$; $p = 0.457$).

A statistically significantly lower number of tissue stapler rings with defect was registered in the high volume group of surgeons (Table 4).

Table 3

Relation between rectal cancer and type of mesorectal excision (ME)

Rectal segment	Type of ME		Total
	partial	total	
Lower			
number	0	99	99
rows (%)	0.0	100.0	100.0
columns (%)	0.0	41.6	20.8
Middle			
number	95	132	227
rows (%)	41.9	58.1	100.0
columns (%)	30.8	55.5	43.1
Upper			
number	213	7	220
rows (%)	96.8	3.2	100.0
columns (%)	69.2	2.9	36.1
Total			
number	308	238	546
rows (%)	56.4	43.6	100.0
columns (%)	100.0	100.0	100.0
Comparison	$\chi^2 = 293.77$; $p < 0.001$		

Table 4

Relation between annual surgical volume (ASV) and the status of tissue stapler rings

ASV (number of operations)	Stapler rings		Total
	complete	with defect	
0 ≤5			
number	90	12	102
rows (%)	88.2	11.8	100.0
columns (%)	28.7	48.0	38.3
6–10			
number	85	8	93
rows (%)	91.4	8.6	100.0
columns (%)	27.2	32.0	29.6
≥ 10			
number	138	5	143
rows (%)	96.5	3.5	100.0
columns (%)	44.1	20.0	32.1
Total			
number	313	25	338
rows (%)	92.6	7.4	100.0
columns (%)	100.0	100.0	100.0
Comparison	$\chi^2 = 6.21$; $p = 0.045$		

The average number of removed lymph nodes in the low volume group was 11 (133 operations), in the medium 13 (148 operations) and in the high volume group 16 (256 operations).

There was no statistically significant difference in the number of patients with intraoperative finding of significant fecal content in the colorectum compared with ASV (χ^2 = 1.359; p = 0.507). A significant amount of fecal content was registered in a total of 20.9% of patients. The majority of patients had fecal trace amounts in the colorectal lumen at the operation (468).

There was no statistically significant difference in percentage of patients with fecal contamination of peritoneum and operative wounds (78) compared to ASV (χ^2 = 2.154; p = 0.341).

The used colon segments for reconstruction were sigma (387), descendens (125) and transversum (34). Relation of ASV (χ^2 = 6.966; p = 0.138) and anastomosis type (p = 1.00) was not statistically significant, but the relation between the type of anastomosis and the used colon segment was statistically significant (χ^2 = 62.414; p < 0.001). A high percentage of using sigma for CRA with stapler technique (72.4%) was detected. Also, no statistically significant difference in the association between the occurrence of CRAD (χ^2 = 2.054; p = 0.374) and lethal outcome (χ^2 = 1.299; p = 0.562) was established.

A statistically significant association between ASV and the decision for the formation of a protective stoma was not established (χ^2 = 1.416; p = 0.852), but there was statistically significant association with the height of anastomosis to 6 cm from the anal edge (χ^2 = 115.77; p < 0.001), when protective ileostomes were used in 70.2% of cases. In the hand-sewn technique of CRA creation, in 87.5% no protective stoma was made, but the stapler technique in 84.0% of cases followed the creation of ileostomy. There was statistically significant association with CRA (χ^2 = 36.927; p < 0.001). Also, the appearance of CRAD in 62.5% of cases was followed by diverting colostoma (χ^2 = 32.837; p < 0.001). Statistically significant association existed with a lethal outcome (χ^2 = 9.953; p = 0.005), in 25% of cases with colostoma.

The highest percentage of colorectal resections was performed by surgeons from a high volume group in a period of less than 3 hours (Table 5). Statistical analysis confirmed the significant difference in this parameter among groups (χ^2 = 6.357; p = 0.042).

There was statistically significantly higher percentage of patients with blood loss during surgery (> 200 mL) in the group of high volume surgeons (Table 6). The CRAD and lethal outcome were statistically significantly related to blood loss (p < 0.001).

Table 5
Distribution of operation time according to the annual surgical volume (ASV)

Operation interval	ASV (number of operations)			Total
	≤ 5	6–10	> 10	
1–3 hours				
number	37	48	106	191
rows (%)	19.4	25.1	55.5	100.0
columns (%)	27.8	32.4	40.0	35.0
> 3 hours				
number	96	100	159	355
rows (%)	27.0	28.2	44.8	100.0
columns (%)	72.2	67.6	60.0	65.0
Total				
number	133	148	265	546
rows (%)	24.4	27.1	48.5	100.0
columns (%)	100.0	100.0	100.0	100.0
Comparison	χ^2 = 6.357; p = 0.042			

Table 6
Relation of annual surgical volume (ASV) and intraoperative blood loss

Surgeon volume groups (per number of operations)	Blood loss (> 200 mL)		Total
	no	yes	
0 ≤5			
number	94	39	133
rows (%)	70.7	29.3	100.0
columns (%)	23.9	25.5	24.4
6–10			
number	119	29	148
rows (%)	80.4	19.6	100.0
columns (%)	30.3	19.0	27.1
≥ 10			
number	180	85	265
rows (%)	67.9	32.1	100.0
columns (%)	45.8	55.6	48.5
Total			
number	393	153	546
rows (%)	72.0	28.0	100.0
columns (%)	100.0	100.0	100.0
Comparison	χ^2 = 7.482; p = 0.024		

The CRAD of grade B and C (according to the International Study Group of Rectal Cancer – ISGRC) was verified in 53 (9.7%) of patients. The smallest percentage of CRAD was verified in the high volume surgeon group. Statistical analysis confirmed the significance among the groups (χ^2 = 6.992; p = 0.030) (Table 7).

A statistically significant association between ASV and early/late CRAD was not established, neither was the statistically significant association of early/late CRAD and lethal outcome (χ^2 = 1.657; p = 0.198).

A statistically significantly lower percentage of positive CRMs was determined after a resection procedure by the high volume surgeons (Table 8).

There was a significant difference in the length of hospitalization between the low and medium volume group. There was no significant difference between the medium and the high volume group (Table 9). The longest stay in the Intensive Care Unit (ICU) and in the hospital were registered in patients operated by surgeons from the high volume group. Between a surgeon of the medium and high volume groups, no statistically significant difference was found.

The total mortality rate of up to 30 days was 4.8% (26/546). Although the incidence of the lethal outcome was the smallest in the high volume group (3.8%), there was no statistically significant difference among the groups (Table 10).

There was no statistically significant association between ASV and preoperative radiotherapy (Table 11). However, these patients had a statistically significant increase of CRAD ($p < 0.001$). Out of 42 patients with preoperative radiotherapy, 11 (26.2%) developed CRAD. More frequent deaths in this group (7.1%) were noted, but without a statistically significant difference compared to the group without preoperative radiotherapy.

Table 7

Distribution of colorectal anastomotic dehiscence (CRAD) according to the annual surgical volume (ASV)

CRAD	ASV (number of operations)			Total
	≤ 5	6–10	> 10	
No				
number	114	131	248	493
rows	23.1	26.6	50.3	100.0
columns	85.7	88.5	93.6	90.3
Yes				
number	19	17	17	53
rows (%)	35.8	32.1	32.1	100.0
columns (%)	14.3	11.5	6.4	9.7
Total				
number	133	148	265	546
rows (%)	24.4	27.1	48.5	100.0
columns (%)	100.0	100.0	100.0	100.0
Comparison	χ^2 = 6.992; p = 0.030			

Table 8

Relation of annual surgical volume (ASV) and the status of circumferential resection margin (CRM)

ASV (number of operations)	CRM		Total
	negative (R0)	positive (R1/2)	
0 ≤ 5			
number	114	19	133
rows (%)	85.7	14.3	100.0
columns (%)	23.1	36.5	29.8
6–10			
number	132	16	148
rows (%)	89.2	10.8	100.0
columns (%)	26.7	30.8	28.7
≥ 10			
number	248	17	265
rows (%)	93.6	6.4	100.0
columns (%)	50.2	32.7	41.5
Total			
number	494	52	546
rows (%)	90.5	9.5	100.0
columns (%)	100.0	100.0	100.0
Comparison	χ^2 = 6.785; p = 0.034		

Table 9

Days in the Intensive Care Unit (ICU) and in the hospital according to the annual surgical volume (ASV)

ASV (number of operations)	Days, mean ± SD	
	ICU	Hospital
[1] ≤ 5	0.87 ± 0.77	8.88 ± 3.23
[2] 6–10	1.26 ± 0.97	9.70 ± 4.70
[3] > 10	1.34 ± 1.49	10.35 ± 5.41
Comparison between ASV groups:		
[1] : [2]	z = 3.66 $p < 0.001$	z = 1.90 $p = 0.057$
[1] : [3]	z = 4.47 $p < 0.001$	z = 3.81 $p < 0.001$
[2] : [3]	z = 0.55 $p = 0.58$	z = 1.84 $p = 0.065$

SD – standard deviation.

Table 10

Distribution of deaths (during 30 postoperative days) according to the annual surgical volume (ASV)

Deaths	ASV (number of operations)			Total
	≤ 5	6–10	> 10	
No				
number	127	138	255	520
rows (%)	24.4	26.5	49.0	1000
columns (%)	95.5	93.2	96.2	95.2
Yes				
number	6	10	10	26
rows (%)	23.1	38.5	38.5	100.0
columns (%)	4.5	6.8	3.8	4.8
Total				
number	133	148	265	546
rows (%)	24.4	27.1	48.5	100.0
columns (%)	100.0	100.0	100.0	100.0
Comparison	$\chi^2 = 1.88$; $p = 0.389$			

Table 11

Relation of annual surgical volume (ASV) according to preoperative radiation therapy

ASV (number of operations)	Preoperative radiotherapy		Total
	no	yes	
0 ≤ 5			
number	127	6	133
rows (%)	95.5	4.5	100.0
columns (%)	25.2	14.3	24.4
6–10			
number	132	16	148
rows (%)	89.2	10.8	100.0
columns (%)	26.2	38.1	27.1
≥ 10			
number	245	20	265
rows (%)	92.5	7.5	100.0
columns (%)	48.6	47.6	48.5
Total			
number	504	42	546
rows (%)	92.3	7.7	100.0
columns (%)	100.0	100.0	100.0
Comparison	$\chi^2 = 3.930$; $p = 0.140$		

Discussion

This study examined the early outcomes of surgical treatment for RC in patients with observation period of up to 30 days postoperatively, in order to show the link between ASV and early outcomes in this field of surgery, especially with the appearance of CRAD. The effect of ASV on the outcome of surgical treatment in RC remains uncertain and it is not clear whether the volume of a hospital or a surgeon is an important predictor of the outcome. It is considered that the surgeon's specific experience, measured by ASV, can have a significant effect on the survival of patients with RC [21].

The development of AD remains unpredictable in many patients undergoing RC surgery. In the analysis of our patients, only clinical criteria for determining AD were used. CRAD was registered in 53 (9.7%) of our patients. AD was nonoperatively treated in 34 patients, while others were surgically treated. The smallest percentage of CRAD is verified in the high volume group. A statistically significant association between ASV and early/late CRAD was not established, nor was a statistically significant association of early/late CRAD and lethal outcome.

The total mortality rate up to 30 days in our patient's series was 4.8% (26/546). Although the incidence of lethal outcome was the smallest in the high volume group (3.8%), no statistically significant difference was found among the groups. CRAD was the direct cause of death in 6 (23%) patients.

There was a significant difference in the length of hospitalization between the low and the medium volume group. There was no significant difference between the medium and high volume group. The longest stay in the ICU was registered in patients operated by surgeons from the high volume group. They were patients with significant comorbidities (CCI $\geq$ 3) and over 70 years of age. Between surgeons of the medium and high volume group no statistically significant difference was found. The mean length of stay in the hospital for our patients with AD was approximately 4 times longer than for patients without AD, which is also consistent with the experience of other authors [6–10].

In this field of surgery as well as for all surgical procedures sex, age, constitution, comorbidity and other factors significantly influence the decision of the surgeon for the type of surgery and the postoperative outcome. The age over 70 years (most of the patients in our study – 351/546) is a significant risk factor for AD [24]. This population of patients, with numerous risk factors, has a higher rate of AD, a more severe clinical course and higher morbidity and mortality [4].

Recent studies have confirmed that weight loss of more than 15% over a period of 6 months preoperatively, due to the associated metabolic imbalance, increases the incidence of complications and mortality [25]. Males (most of our patients) with their anatomical characteristics of the pelvis (narrow pelvis) have increased risk for CRAD, but also propensity for good local disease control (local recurrence) and preservation of vegetative nervous structures. The difficult working conditions in deep and narrow pelvis often make it impossible for a surgeon to technically create anastomosis, so that the rate of CRAD in males is higher in comparison to women who naturally have a broad and shallow pelvis [11].

Most of our RC patients who underwent extensive surgical treatment at the same time had one or more comorbidities. In our study, CCI was used to evaluate preoperative comorbidities [6]. Increased comorbidity was present in ASA patients with $\geq$ 3, causing them to have an increased risk for CRAD [4]. Buchs et al. [14] showed that, with each degree of increase in ASA score, there is a 2.5 times increase in frequency of CRAD.

According to tumor localization, the height of anastomosis is a known independent prognostic factor, not only for the appearance of dehiscence, but also for the local recurrence of the disease. With an increase in the distance of anastomosis from the anal edge, the frequency of dehiscence decreases (distal third 14.1%, mean 8.1% and upper 2.6%) [4].

In T3 and T4 disease stages, especially when there is penetration and infiltration of surrounding tissues, there is a higher incidence of anastomosis dehiscence. Because of that patients staged T4 were not included in our study.

The decision on the selection of the reconstruction colon segment is made by the surgeon during surgery [26]. In our series in 387 (70.9%) patients the sigmoid colon was used for CRA creation. After a low resection of the rectum, the creation of termino-terminal anastomosis as one of the reconstructive methods is technically the simplest, but postoperative functional results (emptying frequency, urgency, continence, fragmentation, use of medicaments) are worse than reconstruction with the reservoir [4].

A meta-analysis of 9 randomized, controlled studies, published in 2001 [27], concluded that there was no proven superiority of the stapler technique over hand-sewn, regardless of the level of anastomosis. In our study, younger surgeons, who more quickly and easily accept advanced techniques in surgery, used a stapler technique more often. According to our results, as well as other authors, AD was similar in both groups. This demonstrates that sutures and stapler technique are equally suitable for colorectal anastomosis. Which anastomosis technique will be applied is decided based on individual surgical experience and the personal preference of surgeons [27–30].

Preoperative neoadjuvant chemoradiotherapy is nowadays often a part of the treatment protocol for patients with RC in order to reduce tumor and its stages, and thus prevent local relapse and achieve greater percentage of sphincter-preserving operations. Radiation adversely affects the healing of anastomosis by causing microangiopathy, so the timing of irradiation is critical. Importantly, negative effects of short-term preoperative radiation and chemotherapy on the healing process of CRA were not observed [31].

Mechanical bowel preparation is an integral part of the general preoperative preparation of the patient. The issue of mechanical intestinal cleansing is the topic of controversy: from the point that it is a requisite for the prevention of complications on anastomosis [32–34], to the point that it is of no importance in elective surgery and that the frequency of dehiscence is twice as higher after mechanical cleaning of the bowel as without it (8.1% : 4%) [32–34]. It has been reliably proven that this preparation, for resection of the colon, is not as important as it is desirable for resection of the rectum. However, these controversies do not change the attitude of

most surgeons today that surgery on the empty bowel is more comfortable and easier [4]. Intraoperative contamination of the operative complex and incision wounds with fecal content containing bacterial flora can seriously compromise the outcome of surgery, which imposes the obligation on all members of the surgical team for careful and pedantic work. If the intestinal lumen at the operation is filled with fecal content, it is necessary to empty and lavage, in order to make the primary CRA possible and safe. In patients with ileus the bowel wall is stretched and edematous which, with increased intraluminal pressure due to the presence of fecal masses and degradation gases, may impair the healing of CRA. Also, in such circumstances and whenever possible, the application of the "double stapler" technique reduces the possibility of contamination as manipulated by a closed lumen hose [35].

The height of the CRA relative to the anal edge is a significant independent risk factor for the appearance of dehiscence, the frequency of which increases with the approach of the anus [4]. Vignali et al. [35] reported on a series of 1,014 CRA stapler surgeries, with a total of 2.9% dehiscence, 7.7% below and 1% above 7 cm from the anal edge. In their multivariance analysis, only the height of anastomosis was an independent prognostic factor.

Higher blood loss during surgery and intraoperative blood transfusion have shown adverse effects on the healing of intestinal anastomosis in experimental and clinical trials [4, 6, 36–39]. In our study, surgeons from the high volume group had a statistically significant increase in blood loss during surgery. This could be due to the fact that they predominantly operated older patients, T3 tumors in the distal third of the rectum with distal anastomoses and the patients with larger CCI.

The duration of the operation depends on several factors: surgical technique, intraoperative complications, previous abdominal surgery, experience of a surgeon and an operational team. More studies have shown that the extended time of over 200 minutes causes changes in the activity of inflammatory mediators and, consequently, ischemic and septic complications [37, 40]. In our study, the largest percentage of surgeries were performed by surgeons from the high volume group over a period of less than 3 hours.

The option of creating a diverting stoma is today controversial. Stoma is a temporary solution, in the case of low CRA in males, in patients with significant comorbidity, neoadjuvant chemoradiotherapy, or in the presence of peritonitis, in order to minimize complications. Protective stoma is a procedure with complications (ischemia, prolapse, stenosis) and therefore this option must be objectively justified [4, 37, 40]. In our study, the statistically significant association of ASV and the decision to form a diverting stoma was not established, but statistically significant association with the height of anastomosis was found, up to 6 cm from the anal edge, where the protective ileostomas were applied in 70.2% of cases. In the hand-sewn technique of CRA in 87.5% of the patients no diverting stoma was made, but 84.0% of cases with the stapler technique followed by the creation of an ileostomy. There was a statistically significant relationship with CRA. Also, the appearance of CRAD in 62.5% of cases was followed by performing diverting colostoma. There was statistically significant association between performing colostomawith lethal outcome (25% of the patients with colostomy).

The outcome of surgery for RC has improved substantially during the past two decades because of the introduction of TME [41]. The leakage rate following TME was 2.7–17% and multivariance analysis showed that the risk of leakage was significantly higher in men, in patients undergoing neoadjuvant radiotherapy, and in anastomoses that were ≤ 6 cm from the anal verge. The authors concluded that low anastomoses created after TME should be protected by a diverting stoma [42, 43]. In our study there was no statistically significant correlation between the type of mesorectal excision and CRAD.

The rate of CRMs positivity is widely used as a quality indicator in RC care. The survival in RC has been shown to be very variable between surgeons and institutions. One of the major factors influencing survival is local recurrence, and this in turn is strongly related to inadequate tumor excision, particularly at the CRM. Fortunately, this is one parameter that the operating surgeon has the power to control. The quality of surgery in particular the skill of resection of the mesorectum at the CRM becomes one of the most important aspects of management. Of 586 patients on whom full clinical follow up was obtained 165 (28.2%) had CRM involvement by carcinoma on pathologic examination [19, 20]. A positive CRM was noted in 2,859 (17.2%) of the 16,619 patients in another study [44]. In a study with 192 patients [18] the R1 rate was 3.6%. In our study, after stapler creating CRA, surgeons checked the integrity of the tissue stapler rings. The observed defects were solved by additional stitching of anastomosis, creating a protective stoma for larger defects, or the formation of a new anastomosis.

Numerous hospitals in the world are considering setting minimum standards for colorectal surgery. One meta-analysis [45] including 47 studies with 1,122,303 patients from 9,649 hospitals and 9,649 surgeons showed that there is an influence of surgeon volume on the outcome with large volumes of high volume surgeons favoring better outcomes. The best outcomes occur in the high-volume hospitals with high-volume surgeons, followed by hospitals with low volume and high-volume surgeons. Also, this meta-analysis showed that mortality rates were not the lowest in studies with high annual volumes of hospitals and surgeons. Studies with a volume of 100 operations per year, compared to the lowest group, had a lower reduction in mortality among groups, than a study where a high group had more than 20 operations compared to a low group. Identifying a clear threshold effect, that is, estimating the relationship between volume and improvement in any outcome is difficult. A potential reason for this may be the high number of hospital with multiple surgeons, so each individual volume is low, while fewer hospitals with few surgeons have each single volume high. Therefore, a high volume for individual surgeons in hospitals can also be a surrogate for quality interventions and whether the volume of the hospital can be a surrogate for the volume of a surgeon. A high-volume surgeon is probably an important predictor of outcomes, but there may be other surgeon groups that achieve excellent results [10, 46]. From the outcome

point, it would be desirable that most cases are operated by high-volume surgeons in high-volume hospitals. It is considered that 10 procedures per year are sufficient. In a hospital with at least 70 cases per year, surgeons who make up to 5 operations per year can get the best results. This could be a message of optimism [10].

Profiling the results of individual surgeons can help identify a surgeon with better results in order to improve the outcome of surgical treatment. Our goal was to give our own contribution to the debate about referring patients with RC to surgeons with a higher annual volume of operations for better outcome.

The limitations of this study may be due to the lack of information on some specificities of the surgeon during surgery and the follow-up on patients after 30 days of observation.

Conclusion

Development of AD is unpredictable in many patients after surgical treatment of RC. In our surgical institution with a high annual volume of colorectal surgery, most surgeons belonged to groups with low and medium annual volume of procedures in colorectal surgery (77.7%), with statistically significant difference among groups. In our patients series, the high-volume surgeon group was associated with significantly better results in four (CRAD, operating time, CRM, TME and number of lymph nodes), out of seven analyzed early postoperative outcomes. The high-volume surgeon remains an important predictor of success in the surgical treatment of RC.

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