Post-surgical fecal incontinence.

Updates in Surgery
https://doi.org/10.1007/s13304-017-0508-y

ORIGINAL ARTICLE

Post-surgical fecal incontinence

Filippo Pucciani[1]

Received: 3 July 2017 / Accepted: 14 December 2017

Abstract
The primary endpoint of this work was to understand the pathophysiology of fecal incontinence manifested after rectal and anal surgery. A retrospective cohort study with negative colonoscopy patients was created and 169 postoperative incontinent patients were analyzed (114 women and 55 men: mean age 58.9 ± 6.3): clinical evaluation, endoanal ultrasound and anorectal manometry reports were scanned. The duration of incontinence was very long, with a mean of 21.7 months. The mean number of bowel movements/week was 18.2 ± 7.2. Urge incontinence was present in 82.2% of patients, mixed with passive incontinence in 44 patients. Patients' Fecal Incontinence Severity Index (FISI) score was 27.0 ± 6.6. Operated patients had significantly lower anal resting pressure ($P < 0.01$) than controls while patients with colo-anal anastomosis and those who underwent Delorme operation had lowest values ($P < 0.01$). Maximal tolerated volume and rectal compliance were significantly impaired in operated patients with rectum involvement (colo-anal anastomosis, Delorme, restorative procto-colectomy and STARR). External anal sphincter (EAS) defects were present in 33.1% of all patients and internal anal sphincter (IAS) was damaged in 44.3%: a combined lesion of anal sphincters was detected in 39 patients (23.0%). A positive correlation was found between patients' FISI score and thickness of both sphincters (EAS: $\rho_s = 73$; IAS: $\rho_s = 81$). Malfunctioning continence factors may induce fecal incontinence involving each time, in a different way, the volumetric capacity and/or the motility of the rectum, the perception of the fecal bolus and anal sphincter contraction.

Keywords Fecal incontinence · Surgery · Post-surgical complications · Anal lesions

Introduction

Fecal incontinence is related to many etiologic factors. One of the most frequent causes is secondary to pelvic and/or rectoanal surgery, often as a consequence of negligent professional activity. Post-surgical fecal incontinence (PSFI) may be elicited by many pelvic, rectal and anal surgical procedures which contribute through different mechanisms to incontinence. The primary aim of this study was to understand and explain the pathophysiology of fecal incontinence which manifested after rectal and anal surgery; the secondary endpoint was to extrapolate useful tips from pathophysiological data to help prevent fecal incontinence.

✉ Filippo Pucciani
pucciani@unifi.it

[1] Department of Surgery and Translational Medicine, University of Florence, Largo Brambilla 3, 50134 Florence, Italy

Materials and methods

Between January 2010 and February 2016, 1632 patients affected by anorectal diseases were seen at the outpatient unit of the Surgery Clinic of the University of Florence. All patients were entered into a prospectively constructed database, which contained 3124 patients at the time of the study.

646 patients had fecal incontinence and 181 of them had PSFI. A retrospective cohort study with negative colonoscopy patients was created and 169 incontinent patients were analyzed (114 women and 55 men: mean age 58.9 ± 6.3): clinical evaluations, endoanal ultrasounds and anorectal manometry reports were scanned. The study was carried out in accordance with the Helsinki Declaration (Sixth Revision, Seoul 2008). A signed informed consent was obtained from each participant.

Clinical evaluation

Information regarding stool form according to the Bristol scale [1], number of bowel movements/week, pathological

Published online: 30 December 2017

conditions and procedures of former rectal and/or anal surgery were collected from previous outpatient charts. The surgical operations were categorized according to type of surgical procedure, operation date, underlying disease, time elapsed between surgical procedure and outpatient observation.

Fecal incontinence was defined as the uncontrolled passage of fecal material recurring for > 3 months [2]. The duration of incontinence was noted and fecal incontinence was classified according to the Fecal Incontinence Severity Index (FISI) score (0 → 61) [3]. The pattern of incontinence was defined according to Engel's criteria: fecal incontinence was classified as urge incontinence, passive incontinence, mixed incontinence, and post-defecatory incontinence [4]. Inspection of the ano-perineal region and digital rectal examination were also carried out to detect any signs of organic disease.

Anorectal manometry

Perfusion anorectal manometry was performed in all patients using standard techniques [5]. The computerized analysis identified the maximal anal pressure (P_{max}) and the mean pressure (P_m) of the anal canal. The maximal voluntary contraction (MVC) was examined by evaluating the voluntary contractions of the anal sphincter and the computer quantified the amplitude (MVC-A) in millimeters of mercury (mmHg) and duration (MVC-T) in seconds. The rectoanal inhibitory reflex (RAIR) was monitored according to Martelli et al. [6]. The RAIR threshold, identified as the first distension volume at which internal sphincter relaxation occurred, and the conscious rectal sensitivity threshold (CRST), measured as the distension volume for which an initial transient sensation occurred, were determined in all patients. The maximal tolerated volume (MTV) was also measured in all patients and was considered an expression of rectal reservoir capacity. Compliance of the rectum (expression of the ratio mmHg/ml of inflated air) was detected by means of the pressure/volume curve. The manometric procedure was completed by measuring anal pressure when the patient was asked to attempt defecation (straining test). The straining test was considered positive if an inappropriate increase or < 20% relaxation of basal resting pressure occurred. Patients values were compared with those of normal subjects reported in a previous paper [2].

Endoanal ultrasound

Endoanal ultrasound was performed and analyzed according to a previously described technique [2]. The thickness of both anal sphincters in the middle level of the anal canal, where the complete ring of the superficial external anal sphincter (EAS) (concentric band of mixed echogenicity) and the complete ring of the internal anal sphincter (IAS) are visualized [7], was measured in mm. A discontinuity of the muscle, with an area of mixed echogenicity due to replacement of muscle cells by fibrous tissue, was read as a defect of IAS or EAS. The sphincter defect was measured in degrees. Sphincter quality was described as homogeneous or heterogeneous if signs of sphincter atrophy were present. Diffuse thinning and/or replacement of muscle fibers by fat defined external anal sphincter atrophy. Internal anal sphincter atrophy was identified as diffuse thinning of the sphincter.

Statistical analysis

Data were analyzed by means of the SAS® System for Windows, version 9.2. The results are expressed as the mean ± SD. Student's *t* test for paired and unpaired samples was used for statistical analyses. All correlations were evaluated using Spearman's rank correlation coefficient (ρ_s). All statistical tests were performed with a two-sided significance level $\alpha = 0.05$, so that *P* values lower than 0.05 were considered statistically significant.

Results

The 169 patients in our study had been operated on by 36 different surgeons, 71 of whom were from other regions of Italy besides Tuscany. We found many different types of surgical operations, which are illustrated in Fig. 1.

51 patients (30% of all patients) underwent surgery for hemorrhoids; 31 had stapled hemorrhoidopexy and 20 hemorrhoidectomy. Twenty-one per cent of all patients had anterior rectal resection (ARR): ten patients had colo-anal anastomosis and five of them had intersphincteric resection. The clinical data are reported in Table 1.

Incontinence lasted for a long time in our study population, almost 2 years (mean 21.7 months). The number of

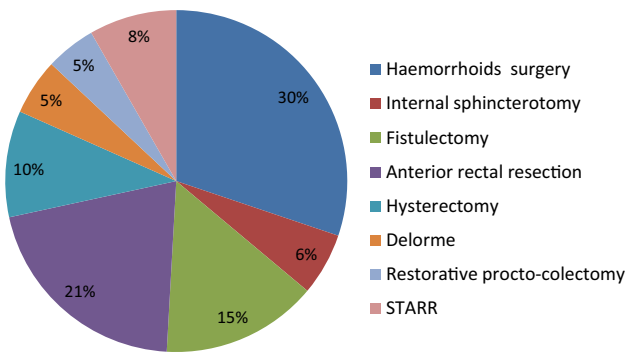

Fig. 1 Types and percentage of surgical operations carried out in incontinent patients

Table 1 Patients' clinical data, according to types of surgery

	Age (years)	Duration of incontinence (months)	Stool frequency ($n°$/week)	Types of incontinence			FISI
				Urge ($n°$)	Passive ($n°$)	Mixed ($n°$)	
Hemorrhoids							
Hemorrhoidectomy	52.3 ± 9.7	23.3 ± 7.2	11.6 ± 2.6	15	3	2	16.7 ± 5,4
Hemorrhoidopexy	59.2 ± 7.5	17.4 ± 9.1	20.5 ± 6.4*	23	2	6	25.6 ± 6.6*
Lateral internal sphincterotomy	65.4 ± 8.2	16.3 ± 8.6	13.2 ± 4.9	2	6	2	18.7 ± 8.9
Fistulectomy	63.3 ± 6.1	20.1 ± 6.5	11.8 ± 3.5	12	7	6	17.3 ± 5.7
Anterior rectal resection							
Colo-rectal anastomosis	68.9 ± 8.9	12.2 ± 4.3	18.9 ± 8.3	9	3	13	27.8 ± 7.5
Colo-anal anastomosis	66.2 ± 5.7	11.7 ± 5.6	22.6 ± 7.6	4	2	4	39.2 ± 9.3**
Hysterectomy	69.2 ± 6.2	14.3 ± 5.9	12.5 ± 4.8	11	3	3	19.8 ± 6.3
Delorme	62.3 ± 4.8	16.6 ± 4.9	17.9 ± 6.1	6	1	2	31.3 ± 3.6
Restorative procto-colectomy	54.5 ± 5.5	13.5 ± 6.7	31.4 ± 8.8°	3	1	4	26.8 ± 5.5
STARR	53.5 ± 7.3	9.7 ± 4.6	22.2 ± 5.6	10	2	2	31.8 ± 7.4
Total patients (169)	58.9 ± 6.3	21.7 ± 5.7	18.2 ± 7.2	95/169	30/169	44/169	27.0 ± 6.6

*Hemorrhoidopexy vs hemorrhoidectomy: $P < 0.05$; ** Colo-anal anastomosis vs colo-rectal anastomosis $P < 0.04$; ° restorative procto-colectomy vs total patients $P < 0.01$

bowel movements/week was within the range that of the normal Italian population [8]. Urge incontinence was the most frequent type of fecal incontinence (82.2%), together with passive incontinence in 44 patients. Of the patients operated for hemorrhoids those who underwent hemorrhoidopexy had the worst FISI which was significantly different ($P < 0.05$) from that of patients who underwent hemorrhoidectomy. Patients having undergone anterior rectal resection and colo-anal anastomosis had the worst incontinence profile with more than 3 bowel movements per day and more than one episode per day of fecal incontinence: FISI was 39.2 ± 9.3 which was significantly different ($P < 0.04$) from that of patients who had colo-rectal anastomosis. 26 patients had loose stool (Bristol scale 6–7) and all of them had urge incontinence.

The results of anorectal manometry are reported in Table 2.

Operated patients had significantly lower anal resting pressure ($P < 0.01$) than controls: patients with colo-anal anastomosis and those with Delorme operation had the lowest values of P_m and P_{max}. The amplitude ($P < 0.01$) and duration ($P < 0.02$) of maximal voluntary contraction were significantly impaired: those undergoing fistulectomy, hysterectomy, Delorme and STARR having the lowest data. RAIR was not detected in 16 patients because of very low anal resting pressure; 8 colo-anal patients and 2 restorative procto-colectomy patients experienced increased pressure after distension of the neorectum. The straining test was positive in 21 patients, 11 of whom were operated for hemorrhoids. Rectal sensation was substantially preserved in operated patients but MTV values, indicative of rectal volumetric capacity, were significantly lower than those of controls ($P < 0.05$): this parameter was significantly lowest ($P < 0.01$) in patients who had Delorme operation and in those who underwent STARR. Rectal compliance was impaired in 33.7% of all patients with 70–80% of patients who were operated at the level of the rectum (colo-anal anastomosis, Delorme, restorative procto-colectomy and STARR) experiencing damaged rectal compliance.

Results of endoanal ultrasound are reported in Table 3.

EAS and IAS measures were carried out in all 169 patients and showed that EAS and IAS thickness values were significantly lower in operated patients than in controls ($P < 0.04$). There was a positive correlation between FISI score and thickness of both sphincters (EAS: $\rho_s = 73$; IAS: $\rho_s = 81$). EAS defects were present in 33.1% of all patients and the IAS was damaged in 44.3%: 39 patients (23.0%) had a combined lesion of both internal and external anal sphincters. The worst findings were noted in patients who underwent the Delorme procedure for rectal prolapse. Their EAS and IAS were very thin, often because atrophy: both sphincters were are also damaged in 77.7% of patients, with combined sphincteric lesions in five patients.

Discussion

The prevalence of fecal incontinence varies from 1.4 to 19.5% [9]. Its etiology is multifactorial [10] and may appear after surgical procedures. Its pathophysiology is related to impairment of anal and/or rectal and/or pelvic floor continence mechanisms. Evaluation of fecal incontinence can be biased: data collection method and two factors in its definition (type of stool and frequency of FI episodes) are the most

Table 2 Results of anorectal manometry

	P_m	P_{max}	MVC		CRST	MTV	Compliance impairment ($n°$ patients)
			P	T			
Hemorrhoids							
Hemorrhoidectomy	28.3 ± 9.6*	53.6 ± 14.6**	150.2 ± 30.6	23.5 ± 16.4	56.0 ± 8.9	172.0 ± 17.8	2/20
Hemorrhoidopexy	40.3 ± 8.5	76.3 ± 13.7	165.8 ± 34.6	20.3 ± 14.1	45.0 ± 9.2	142.5 ± 32.8°	11/31**
Lateral internal sphincterotomy	29.1 ± 6.4	60.0 ± 11.6	163.0 ± 26.9	15.3 ± 8.8	57.0 ± 8.3	190.0 ± 24.9	0
Fistulectomy	37.5 ± 13.5	70.8 ± 25.9	143.6 ± 31.9	13.3 ± 9.1	53.1 ± 10.3	163.3 ± 23.3	0
Anterior rectal resection							
Colo-rectal anastomosis	20.6 ± 7.3	66.9 ± 17.8	167.1 ± 25.3	20.0 ± 11.3	64.0 ± 28.8	170.0 ± 16.6	12/25
Colo-anal anastomosis	13.1 ± 5.9°	25.4 ± 10.5°°	150.6 ± 38.1	22.6 ± 15.5	55.0 ± 17.8	128.0 ± 20.9°°	8/10°
Hysterectomy	27.3 ± 8.5	52.5 ± 7.1	136.0 ± 15.2	8.0 ± 5.2	66.6 ± 35.2	183.3 ± 16.2	2/17
Delorme	19.6 ± 3.4	33.4 ± 4.7	132.9 ± 11.9	8.8 ± 4.4	60.0 ± 24.1	120.5 ± 32.8°°	6/9
Restorative procto-colectomy	20.0 ± 5.9	31.9 ± 13.8	157.9 ± 22.3	14.3 ± 5.8	53.0 ± 11.3	140.5 ± 20.5°	5/8
STARR	25.8 ± 10.3	45.0 ± 16.3	133.8 ± 7.7	16.6 ± 8.3	40.0 ± 10.5	120.0 ± 13.2°°	11/14
Total patients (169)	27.1 ± 7.2°°	52.7 ± 12.3°°	152.1 ± 23.2**	15.2 ± 8.9°°	55.4 ± 14.9	156.28 ± 19.9°	57/169
Controls	47.8 ± 7.6	88.2 ± 10.1	200.0 ± 20.0	35.6 ± 4.2	50.7 ± 10.3	205.1 ± 23.4	0

Hemorrhoidectomy vs: hemorrhoidopexy * $P < 0.03$; ** $P < 0.02$; hemorrhoidopexy vs hemorrhoidectomy; °° $P < 0.01$

Colo-anal anastomosis vs colo-rectal anastomosis ° $P < 0.05$; °° $P < 0.01$

Total patients vs controls ° $P < 0.05$; °° $P < 0.01$; single operation vs controls °° $P < 0.01$

Table 3 Results of endoanal ultrasounds

	External anal sphincter			Internal anal sphincter		
	Thickness (mm)	Defects $n°$ patients	Atrophy	Thickness (mm)	Defects $n°$ patients	Atrophy
Hemorrhoids						
Hemorrhoidectomy	3.06 ± 0.31	5/20	0	2.12 ± 0.26	3/20	0
Hemorrhoidopexy	2.86 ± 0.27	6/31	1	1.94 ± 0.35	12/31	0
Lateral internal sphincterotomy	3.14 ± 0.46	0	1	2.05 ± 0.37	10/10	0
Fistulectomy	2.96 ± 0.49	25/25	0	1.85 ± 0.43	25/25	1/25
Anterior rectal resection						
Colo-rectal anastomosis	3.32 ± 0.27	6/25	0	1.83 ± 0.48	5/25	2/25
Colo-anal anastomosis	3.04 ± 0.38	3/10	1	1.72 ± 0.36	7/10	1
Hysterectomy	2.86 ± 0.41	2/17	2	2.03 ± 0.28	1/17	0
Delorme	2.13 ± 0.52	4/9	4	1.66 ± 0.55	3/9	1
Restorative procto-colectomy	3.01 ± 0.33	2/8	0	1.96 ± 0.42	3/8	0
STARR	3.27 ± 0.22	2/14	1	2.01 ± 0.31	5/14	0
Total patients (168)	2.96 ± 0.36*	56/169	10/169	1.91 ± 0.38*	75/169	5/169
Controls	4.80 ± 0.68	0	0	2.82 ± 0.53	0	0

*$P < 0.04$

relevant which can influence the outcome of a fecal incontinence study [9]. Although it is not possible to avoid these obstacles and while we understand these limitations, nevertheless we have attempted to illuminate the post-surgical fecal incontinence phenomenon in our study. Unfortunately, preoperative instrumental evaluation is lacking. The 36 different surgeons did not adopt the same diagnostic criteria for operative selection. This is reflected in two important aspects: (1) it was not possible to tell how continence factors were already weakened preoperatively by indicating precise risk factors for subsequent fecal incontinence; (2) preoperative evaluation was not considered a factor influencing the choice of the surgical technique adopted. We have discovered that the pathogenetic profile depends on the type of surgery carried out on different anatomical/functional tissue structures, and it is possible to identify a common

pathogenetic denominator related to a single specific surgical technique. Therefore, our discussion analyzes separately the ten types of surgery which we studied and found be associated with fecal incontinence. The 169 patients were entered into the study over a period of 6 years. This group of patients with surgical incontinence was numerous although the modest numerical presence after some types of surgery depended on the scarcity of matching surgical performances done in the national Italian context.

Hemorrhoidectomy

Fecal incontinence lasted longer after hemorrhoidectomy than any other of the surgical techniques studied, and urge incontinence was clinically the most frequent type. The FISI score was low, which could be the reason why patients delayed contacting health facilities. The mean and maximal resting pressures at the high-pressure zone were significantly reduced in this group of patients when compared to that of of hemorrhoidopexy ($P < 0.03$ and $P < 0.02$, respectively). Sphincter injuries were detected in 8 (40%) of 20 subjects and 5 of them had lesions of the external anal sphincter. These data are similar to those of other papers which provide useful suggestion for understanding the pathophysiology of incontinence [11]. Excision of hemorrhoids may lead to reduced resting anal pressure because of loss of the anal cushions and when this is combined with internal anal sphincter injuries passive fecal incontinence can occur. On the other hand, urge incontinence may be related to impairment of the external anal sphincter. The mechanism of injury may be traction of the skin, which is transmitted to the subcutaneous portion of the external sphincter: the superficial part of the sphincter is incidentally angulated outward and could be injured during excision. In addition, the excision of the hemorrhoid cushions, together with accidental injury to the external sphincter, can also damage the most superficial component of the longitudinal conjoined muscle, the corrugator ani muscle, which, because of its intersphincteric position, contributes to the function of the anus. When injured, this damaged muscle might help to induce incontinence. We have two suggestions regarding this situation. The first is to select patients better and avoid using this surgical technique on those who have a sphincteric lesion. The second is to pay close attention to the traction and excision of the skin.

Stapled hemorrhoidopexy

Incontinent patients who underwent stapled hemorrhoidopexy showed significantly higher stool frequency and FISI score than incontinent patients with hemorrhoidectomy ($P < 0.05$). Urge incontinence was the predominant clinical expression (93.5%), mixed with passive incontinence in six patients. When hemorrhoidopexy is compared to hemorrhoidectomy, the most important data emerging were the significantly impaired maximal tolerated volume ($P < 0.03$), index of volumetric capacity of the rectum, and rectal compliance ($P < 0.01$), an index of rectal wall tonic adaptation to its volumetric intraluminal distension. Morphological anal reports showed sphincteric injuries in 58.0% of patients: 12 of whom (38.1%) had internal anal sphincter lesions. Muscle incorporation in the resected rectal rings is often present following stapled hemorrhoidopexy (74.1% in according to Hong et al. [12]). This report could be the demonstration of the possible lesion of the rectum wall with urge incontinence being due to impaired rectal function: the rectum is smaller, and therefore accepts less feces and, if does not adapt to its contents, it contracts immediately. If this motility model, already capable of inducing urgency, also acts against an impaired sphincter, urge incontinence is the consequence. Rectal resected specimens after stapled hemorrhoidopexy are about 3 cm long: while this length usually does not impair rectal capacity, in some patients the resection of the rectal wall may be disastrous, if performed on a damaged rectum. For example sexually transmitted proctitis, previous rectal surgery and actinic proctitis are all contraindications to stapled hemorrhoidopexy. Therefore one of the dangers of the technique is that surgeons could include IAS in the purse string: for example, if a stapled anastomosis is close to the dentate line, the IAS will be damaged. Surgeons should try to avoid injuring the internal sphincter during stapled hemorrhoidopexy.

Lateral internal sphincterotomy

All our patients had open lateral internal sphincterotomy and passive incontinence was the predominant clinical expression (80.0%), mixed with urge incontinence in two patients. A low anal resting pressure was found while rectum physiology was preserved. An IAS lesion, the anatomical effect of sphincterotomy, was present in all patients of this group. These data suggest that passive incontinence results from sphincter injury, that measured 57° medial width and 1.2 cm medial length. Experimental studies in rabbits have shown that healing after sphincter injury does not improve function [13]: post-surgical scarring is not functionally active and indeed it does not allow the coordinated and integrated contraction of the muscle cells marginal to the scar. This healing impairs sphincter function, but the effects on continence may be unclear because it depends on the coordinated interaction of all the continence mechanisms. We do not know if the injury size found in our patients impaired continence in all open lateral internal sphincterotomy subjects but surely their resting sphincter activity after open lateral internal sphincterotomy is lower than in healthy subjects [14]. The risk of incontinence also has been found to be correlated with the extent of transection of the sphincter muscle [15]. Based on

data from the study by Murad-Regadas et al. the safe extent of division is less than 25% of the total sphincter length, which in women corresponds to less than 1 cm [16]. Beyond this length, we can hypothesize that a sphincterotomy of excessive length can cause fecal incontinence. Furthermore, sphincterotomy does not seem the best surgical option for fissure in some patients. Patients with chronic anal fissures may have several anal pressure profiles and the anal canal is often normotonic [17]. Sphincterotomy should be excluded in these patients.

Fistulectomy

The clinical profile of fecal incontinence in these patients was primarily expressed by urge incontinence (72.0% of patients) although 13 patients (52.0% of patients) experienced passive incontinence, alone or combined with urge incontinence. Anal function impairment was the main functional report and damage of maximal voluntary contraction was the most important measurement. All patients had combined IAS and EAS damage, with a significant reduction in sphincteric thickness when compared to controls ($P < 0.04$). Function and morphology of the rectum did not show significant impairment. A systematic review has shown that significantly larger IAS and EAS defects were detected by endoanal ultrasound in 40 patients randomized to fistulectomy compared with fistulotomy [18]. This observation may explain why several surgeons included primary sphincteroplasty with fistulectomy for complex fistula in order to minimize the sphincteric lacuna [19]. Nevertheless, fecal incontinence can appear (12.4%). Thus, sphincter division and anal deformity may play a role in inducing fecal incontinence but other factors also come into play: elderly patients and multiparous females are at higher risk for incontinence. In this type of patient a shift to sphincter-sparing procedures appears warranted.

Anterior rectal resection

One study reports that after sphincter-saving surgery minor leaking occurred in 23%, and significant leaking in 5% of patients [20]. Our ARR incontinent patients had a high FISI score which was highest in patients with ARR and colo-anal anastomosis ($P < 0.04$). Colo-anal anastomosis patients had the worst incontinence profile: stool frequency was more than three bowel movements per day and fecal incontinence occurred more than once daily. Their clinical profile matched the functional profile: colo-anal anastomosis showed a significantly lower anal resting pressure ($P < 0.05$), lower MTV ($P < 0.01$) and impaired compliance ($P < 0.05$) when compared to colo-rectal anastomosis. All ARR patients with colo-anal anastomosis showed sphincter injuries, mainly IAS lesions (70%). ARR patients' sphincteric thickness was significantly thinner when compared to controls ($P < 0.03$). These results confirm that the main incontinence mechanism in sphincter-saving surgery is due to the small neorectal capacity which acts on weakened sphincters. This brief description makes it possible to highlight two other factors: the first relates to the fact that the lower the anastomosis is, the worse are the influences on continence; the second confirms that clinical and functional findings are far worse in patients with colo-anal anastomosis. We do not know if colonic dysmotility also occurs upstream: it is well known that patients with ultra-low anterior resection, in addition to reduction of the length of the large intestine, can also have altered colonic motility. Both conditions may result in a more liquid effluent reaching the anal canal quickly and, therefore, frequent bowel action and liquid stools occur. It is very difficult to know how much this mechanism can favor fecal incontinence, but it is easy to understand that several factors work together to induce incontinence. To help prevent fecal incontinence after ultra-low anterior resection, surgeons should exclude patients affected by irritable bowel syndrome with liquid stools, patients with previous colonic resections and, of course, those with anal sphincter injuries from this type of surgery.

Hysterectomy

A recent study by Kocaay et al. showed that hysterectomy may induce alterations in the function of the pelvic floor: fecal incontinence can affect up to 5.2% of operated patients [21]. Our incontinent patients all had abdominal hysterectomy, 15 with open technique and two with laparoscopic access. Most patients (82.3%) had urge incontinence and three of them also had passive incontinence. Their FISI score was low with less than one episode/week of fecal incontinence. Anorectal manometry showed a low anal resting pressure and a short duration of MVC: only two patients also had impaired rectal compliance. These reports could explain complaints about incontinence and the presence of urgency that are usually not due to anal sphincter injuries. We were not able to establish whether hysterectomy was the direct or indirect cause of fecal incontinence`, but the surgical procedure may be considered a risk factor if performed in women with a weak pelvic floor. Women undergoing a hysterectomy are more likely to have excessive floor descent than those who have never undergone the procedure [22] and patients with a descending perineum show a significant presence of fecal incontinence associated with abdominal hysterectomy [23]. Pudendal neuropathy may play a role: stretch injury to the pudendal nerves can occur during perineal descent, and this can lead to denervation and weakness of the external anal sphincter muscle [24]: fecal incontinence may appear. A useful suggestion is to accurately select patients for abdominal hysterectomy: much attention should

be focused on those patients with disorders of the pelvic floor, especially if there is an evident descending perineum with an enlarged levator hiatus.

Delorme

Delorme's procedure has been used either for rectal prolapse or, a few years ago, for obstructed defecation syndrome. All our patients had surgery for rectal prolapse and three of them experienced relapse. The frequent clinical profile was that of urge fecal incontinence (77.7%), but two patients had mixed incontinence. Their FISI score was high, more than 30/61, and five patients had a stool frequency of about 3.4/day. Anorectal functional profile was related to impairment of both anal and rectal function: low anal resting pressure, MVC damage, low rectal capacity (MTV) and impaired rectal compliance all worked together as incontinence pathophysiological factors. Anal malfunctioning was due to anal sphincter injuries: lesions of the internal and external anal sphincters were often combined with signs of sphincteric atrophy. A recent prospective randomized trial assigned postoperative fecal incontinence to 28.6% of patients who underwent Delorme's procedure for rectal prolapse [25]. This paper reported that preoperative fecal incontinence was present in 66% of patients, but was not addressed the reason for the persistence of fecal incontinence after the surgical procedure. We do not know how many patients had preoperative fecal incontinence, but surgery surely impaired their rectal capacity and damaged rectal compliance. The plication of the muscular layer of the rectum had an adverse influence on these two functions, and it is no wonder that the result was overriding defecation with urge incontinence. Anal function was also weakened by atrophy and sphincteric injuries, whereby emergency continence was not working. For all these reasons, in patients with rectal prolapse with fecal incontinence, it is better to use surgical procedures other than Delorme's procedure or to perform a simultaneous treatment for fecal incontinence such as prosthetic intersphincteric implant [26].

Restorative procto-colectomy

Restorative procto-colectomy (RPC) with ileal pouch–anal anastomosis is performed in patients with ulcerative colitis or familial adenomatous polyposis. The purpose of this type of surgery is to avoid a permanent stoma. All our patients had a J-pouch configuration and three of them had laparoscopic surgery. Our incontinent RPC patients had stool frequency which was significantly higher when compared to that of all patients ($P < 0.01$) and half of them (50%) were affected by mixed incontinence. Nocturnal seepage plagued five patients (62.5%). Anorectal manometry revealed a combined damage of anal and rectal continence mechanisms: anal resting pressure, MVC, MTV and compliance were all severely damaged. This functional profile often augmented by sphincter damage (75%). Our results are related only to RPC patients who are incontinent and not to all generically operated RPC patients. This explains why our data are different from those of other studies, where fecal incontinence is reported in about 5% of RPC patients [27]. The basic element that alters the functional profile of PRC is that the ileum is used to replace the rectum. The ileum is not suitable to support this function. It is in fact a bowel that has no volumetric containment capacity, nor even of content storage. Added to this there are two other important factors: first, the ileal content is liquid and, second, the transport of intraluminal fluid is constant until reaching the anal canal. Even if a pouch is created to implement the storage, ileal motility and content fluid type are little influenced. In this environment, fecal incontinence is the obvious consequence when impaired anal function occurs. The correct procedure is to study preoperatively the structure and function of the patients' anal sphincters.

STARR

Stapled transanal rectal resection is usually performed for obstructed defecation supported by rectocele and/or rectoanal intussusception. Our postoperative incontinent patients had more than three bowel movements/day with urge incontinence being the predominant type (85.7%). Their FISI score was high, more than 31/61. Anorectal manometry revealed a combined malfunctioning of the anus and rectum: anal resting pressure, MVC, MTV and rectal compliance were all involved. The IAS was injured in five patients (35.7%). STARR may involve the removal of a slice of rectum that is about 6.5 cm long and 3.0 cm wide [28]. This ablation decreases the volumetric capacity of the rectum, as suggested by altered MTV according to anorectal manometry [29], and can impair rectal compliance. The consequence may be defecatory urgency: the European stapled transanal rectal resection registry reports urgency in 20% of operated patients [30]. Defecatory urgency may be easily transformed into urge fecal incontinence by the presence of anal malfunctioning. Thence preoperative study of the patient, using endoanal ultrasound and anorectal manometry, is mandatory to assess the morphological and functional framework of the patient's anus.

Conclusions

Rectal and anal surgery may impair fecal continence mechanisms. Our study explains how malfunctioning factors induce fecal incontinence affecting the volumetric capacity and/or the motility of the rectum, the perception of the fecal

bolus and anal sphincter contraction each time in a different way. One limitation of our study is that we could not compare the patient's preoperative functional situation with the postoperative. In any case it was possible to detect the common background for the pathophysiology of fecal incontinence which appeared after certain surgical procedures. In this way we were able to suggest that a careful clinical, morphological and functional assessment is mandatory for the prevention of postoperative fecal incontinence.

Compliance with ethical standards

Source of support No funding.

Conflict of interest No potential and real conflict of interest.

Research involving human participants and/or animals This article does not contain any experimental studies with human participants or animals performed by author.

Informed consent In the presence of a physician, each patient signs an informed consent to surgical procedure, which underlines that the procedures correspond to the ethical standard criteria and in which the patient also gives permission for medical data to be used for scientific publications.

References

1. O'Donnell LJ, Virjee J, Heaton KW (1988) Pseudo-diarrhoea in the irritable bowel syndrome: patients' records of stool form reflect transit time while stool frequency does not. Gut 29:A1455
2. Pucciani F (2013) Faecal soiling: pathophysiology of postdefaecatory incontinence. Colorectal Dis 15:987–992
3. Rockwood TH, Church JM, Fleshman JW et al (1999) Patient and surgeon ranking of the severity of symptoms associated with fecal incontinence: the fecal incontinence severity index. Dis Colon Rectum 42:1525–1532
4. Engel AF, Kamm MA, Bartram CI, Nicholls RJ (1995) Relationship of symptoms in faecal incontinence to specific sphincter abnormalities. Int J Colorectal Dis 10:152–155
5. Pucciani F, Rottoli ML, Bologna A et al (1996) Anterior rectocele and anorectal dysfunction. Int J Colorectal Dis 11:1–9
6. Martelli H, Devroede G, Arhan P et al (1978) Some parameters of large bowel motility in normal man. Gastroenterology 75:612–618
7. Santoro GA, Wieczorek AP, Dietz HP et al (2011) State of the art: an integrated approach to pelvic floor ultrasonography. Ultrasound Obstet Gynecol 37:381–396
8. Bellini M, Alduini P, Bassotti G et al (2006) Self-perceived normality in defecation habits. Dig Liver Dis 38:103–108
9. Sharma A, Yuan L, Marshall RJ et al (2016) Systematic review of the prevalence of faecal incontinence. Br J Surg 103:1589–1597
10. Bharucha A (2003) Fecal incontinence. Gastroenterology 124:1672–1685
11. Johannsson HÖ, Påhlman L, Graf W (2013) Functional and structural abnormalities after Milligan hemorrhoidectomy: a comparison with healthy subjects. Dis Colon Rectum 56:903–908
12. Hong YK, Choi YJ, Kang JG (2013) Correlation of histopathology with anorectal manometry following stapled hemorrhoidopexy. Ann Coloproctol 29:198–204
13. Rajasekaran MR, Seo Y, Salehi M et al (2013) Myoarchitectural and functional alteration in the external anal sphincter muscle following experimental surgical myotomy. Gastroenterology 144:S-83 **(abstr)**
14. Peker K, Yilmaz I, Demiryilmaz I et al (2014) The effect of lateral internal sphincterotomy on resting anal sphincter pressures. Turk J Med Sci 44:691–695
15. García-Aguilar J, Belmonte Montes C, Perez JJ et al (1998) Incontinence after lateral internal sphincterotomy: anatomic and functional evaluation. Dis Colon Rectum 41:423–427
16. Murad-Regadas SM, Fernandes GO, Regadas FS et al (2013) How much of the internal sphincter may be divided during lateral sphincterotomy for chronic anal fissure in women? Morphologic and functional evaluation after sphincterotomy. Dis Colon Rectum 56:645–651
17. Bove A, Balzano A, Perrotti P et al (2004) Different anal pressure profiles in patients with anal fissure. Tech Coloproctol 8:151–157
18. Malik AI, Nelson RL (2008) Surgical management of anal fistulae: a systematic review. Colorectal Dis 10:420–430
19. Ratto C, Litta F, Donisi L, Parello A (2015) Fistulotomy or fistulectomy and primary sphincteroplasty for anal fistula (FIPS): a systematic review. Tech Coloproctol 19:391–400
20. Pary PB, Enker WE, Cohen AM (1994) Long-term functional results of colorectal anastomosis for rectal cancer. Am J Surg 167:90–94
21. Kocaay AF, Oztuna D, Su FA et al (2017) Effects of hysterectomy on pelvic floor disorders: a longitudinal study. Dis Colon Rectum 60:303–310
22. Karasick S, Spettell CM (1997) The role of parity and hysterectomy on the development of pelvic floor abnormalities revealed by defecography. AJR Am J Roentgenol 169:1555–1558
23. Pucciani F, Boni D, Perna F et al (2005) Descending perineum syndrome: are abdominal hysterectomy and bowel habits linked? Dis Colon Rectum 48:2094–2099
24. Ho YH, Goh HS (1995) The neurophysiological significance of perineal descent. Int J Colorectal Dis 10:107–111
25. Emile SH, Elbanna H, Youssef M et al (2017) Laparoscopic ventral mesh rectopexy vs Delorme's operation in management of complete rectal prolapse: a prospective randomized study. Colorectal Dis 19:50–57
26. Cavazzoni E, Rosati E, Zavagno V et al (2015) Simultaneous Delorme's procedure and inter-sphincteric prosthetic implant for the treatment of rectal prolapse and faecal incontinence: preliminary experience and literature review. Int J Surg 14:45–48
27. Ramage L, Qiu S, Georgiou P et al (2016) Functional outcomes following ileal pouch-anal anastomosis (IPAA) in older patients: a systematic review. Int J Colorectal Dis 31:481-a92
28. Boccasanta P, Venturi M, Roviaro G (2011) What is the benefit of a new stapler device in the surgical treatment of obstructed defecation? Three year outcomes from a randomized controlled trial. Dis Colon Rectum 54:77–84
29. Meurette G, Wong M, Frampas E (2011) Anatomical and functional results after stapled transanal rectal resection (STARR) for obstructed defecation syndrome. Colorectal Dis 13:e6–e11
30. Jayne DG, Schwandner O, Stuto A (2009) Stapled transanal rectal resection for obstructed defecation syndrome: one-year results of the European STARR registry. Dis Colon Rectum 52:1205–1212