Langenbeck's Arch Surg (2001) 386:183–187
DOI 10.1007/s004230100205

ORIGINAL ARTICLE

Marco Sailer
Martin Fein
Karl-Hermann Fuchs
Dieter Bussen
Claudia Grun
Arnulf Thiede

Morphologic changes of the anal sphincter musculature during and after temporary stool deviation

Received: 19 July 2000
Accepted: 8 January 2001
Published online: 31 March 2001

M. Sailer (✉) · M. Fein · K.-H. Fuchs
D. Bussen · C. Grun · A. Thiede
Department of Surgery,
University School of Medicine Würzburg,
Josef Schneider Strasse 2,
97080 Würzburg, Germany
e-mail: m.sailer@mail.uni-wuerzburg.de
Tel.: +49-931-2011
Fax: +49-931-2013483

Abstract *Background and aims:* Temporary stool deviation, using a stoma, is a well-known surgical principle to protect low colorectal or coloanal anastomoses. The purpose of this study was to evaluate any morphologic changes with regard to the anal sphincter muscles during and after temporary ileostomy. *Patients and methods:* Forty-four patients with rectal carcinomas were studied prospectively. All patients underwent low anterior resection. Reconstruction was performed using either a coloanal pouch or a straight end-to-end anastomosis. A protective stoma was fashioned in all 44 patients (ileostomy *n*=41; colostomy *n*=3). Stoma closure was carried out after a median of 85 days (41–330 days). Using a standard protocol, anal-sphincter thickness [*m. puborectalis*, external anal sphincter (EAS) and internal anal (IAS) sphincter] was assessed by means of endoanal ultrasonography preoperatively, at the time of stoma closure, and every 3 months thereafter for 1 year. *Results:* The diameter of the puborectal muscle decreased from a median preoperative value of 6.3 mm to 5.7 mm at the time of stoma closure (*P*=0.03). After 3 months, 6.2 mm was measured. This value remained stable for the complete follow-up period. Similar results were recorded for the EAS. The IAS thickness remained stable throughout the study period, measuring between 2.1 mm and 2.4 mm. *Conclusion:* Temporary stool deviation does lead to morphologic changes of the anal sphincter. While the smooth muscle remains unchanged, the striated counterpart undergoes atrophic transformation. However, after passage reconstruction, i.e., stoma closure, a rapid regeneration of the voluntary muscles is observed.

Keywords Anal sphincter · Temporary stoma · Endoanal ultrasound

Introduction

Sphincter-saving procedures have become standard treatment in the surgical approach to cancers situated in the middle and even lower third of the rectum [1, 2]. Total mesorectal excision is mandatory for obtaining local radicality in these tumors [3, 4]. Irrespective of the tumor level, this operative technique requires transection of the rectum at the levator plane, resulting in an anastomosis at or just above the dentate line. However, significant morbidity and mortality do occur, with anastomotic dehiscence being the primary concern. Temporary stool deviation, using either an ileostomy or a colostomy, is a well-known surgical principle to protect low colorectal or coloanal anastomoses in an attempt to reduce anastomotic complications and/or its consequences [5, 6].

While there are many studies [7, 8, 9, 10] that have evaluated functional changes and alterations in anorectal physiology after rectal surgery, no data exist concerning the potential morphologic changes of the anal sphincter musculature. With the advent of anal endosonography, an imaging technique has evolved that enables visualization of the various components of the sphincter muscles. Many authors have demonstrated that endosonography provides detailed information about the anatomy of the anal canal and that this method is a valuable tool in detecting sphincter changes and/or defects with a high degree of accuracy [11, 12, 13, 14, 15]. The purpose of this study was to evaluate any morphologic changes with regard to the anal sphincter muscles during and after temporary stool deviation.

Patients and methods

Patients

A total of 44 patients with rectal carcinomas of the lower and middle third of the rectum were studied prospectively. During the study period, patients with preoperative sphincter defects (*n*=2) or postoperative scarring (*n*=4) of the sphincter muscles were excluded from the study. There were 23 (42%) men and 21 (48%) women with a median age of 67 years (range 30–83 years) with intact sphincter structures pre- as well as postoperatively. All patients underwent low anterior resection with total mesorectal excision and primary low colorectal or coloanal anastomosis. Reconstruction was performed using either a coloanal J-pouch (*n*=23) or a straight end-to-end anastomosis (*n*=21). In six (14%) patients, the anastomosis was created using a transanal hand-suture technique, while circular stapling devices were used in all other cases (86%). A protective stoma was fashioned in all cases (ileostomy *n*=41; colostomy *n*=3). Stoma closure was carried out after a median of 85 days (range 41–330 days). The length of time before the stoma closure in any individual patient was primarily determined by whether or not an adjuvant treatment was added. A total of eight (18%) patients received some form of adjuvant therapy (combined radio/chemotherapy *n*=5; only chemotherapy *n*=3). For these patients, the median time before stoma closure was 183 days (range 143–330 days) as opposed to 79 days (range 41–154 days) in patients without adjuvant treatment.

Endoanal ultrasound

Using a standard protocol, anal-sphincter thickness was assessed using endoanal ultrasound preoperatively (OP I) during the initial staging examination of the tumor, again at the time of stoma closure (OP II), and thereafter at 3-month intervals (3, 6, 9, and 12 months) for a total of 1 year after stoma closure as part of the routine endosonographic follow-up examinations. The puborectal

Fig. 2 Endosonographic image of the external anal sphincter (pars subcutanea) which appears hyperechoic. Thickness is measured in all quadrants resulting in a mean value of 6.2 mm in this case

Fig. 1 Endosonographic appearance of the internal anal sphincter seen as the inner, hypoechoic circular layer. To avoid a systematic error, the diameter is measured in all quadrants and the mean value is calculated (2.1 mm in this patient)

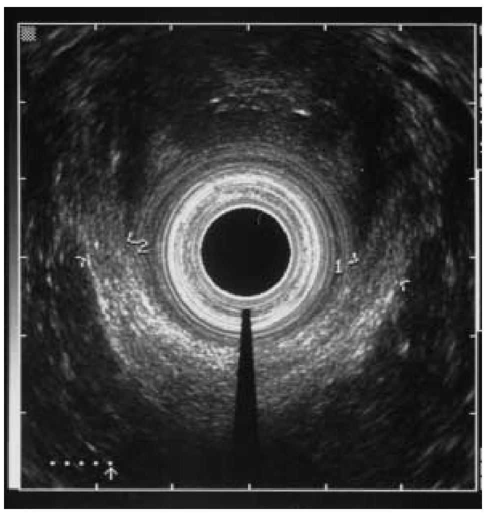

Fig. 3 Puborectal muscle (hyperechoic structure) as seen by endoanal ultrasound. The sling wraps around the posterior aspect of the rectum. Muscle thickness is measured on both sides with a mean value of 6.4 mm in this patient

muscle, external anal sphincter (EAS), and internal anal sphincter (IAS) were measured. The EAS was further subdivided into deep (pars profunda), superficial (pars superficialis), and subcutaneous (pars subcutanea) layers, and each of these structures was assessed separately. Sphincter diameters were measured in all four quadrants for the IAS (Fig. 1) and the EAS (Fig. 2); the values are expressed as means. Puborectal muscles were measured on both sides, also calculating the mean thickness (Fig. 3).

Endoluminal ultrasound was performed using a rotating scanner (Combison 310+, Zipf, Austria). The rectal probe measured 16 cm in length, with a head diameter of 21 mm. Resolution at 7.5 MHz was less than 1 mm. The transducer rotated at a speed of 12 cycles per second, generating a 360° real-time image. Two enemas were used in preparation of the patients and examination was done in the lithotomy position. Typically, the IAS is seen as a circular hypoechoic layer (Fig. 1), as opposed to the EAS which appears hyperechoic (Fig. 3).

Statistical analysis

Median values for muscle diameters were calculated. Statistical analysis was assayed using the Wilcoxon test. A P value of <0.05 was considered significant.

Results

Data of all muscles are summarized in Table 1. The thickness of the puborectal muscle decreased from a median OP I value of 6.2 mm to 5.8 mm at OP II. After 3 months, 6.3 mm was measured. This value remained stable for the complete follow-up period (Fig. 4). Similar results were obtained for the various parts of the EAS (Fig. 5). All constituents of the EAS decreased significantly in diameter between the first (OP I) and second (OP II) operation. The IAS thickness remained stable throughout the study period, ranging between 2.1 mm and 2.2 mm (Fig. 6).

Discussion

Owing to its high resolution, endoluminal ultrasound is a valuable imaging technique in the evaluation of the anal-sphincter complex. It allows visualization of the anal canal and pelvic floor anatomy in great detail [16]. The various muscle layers of the sphincter apparatus can eas-

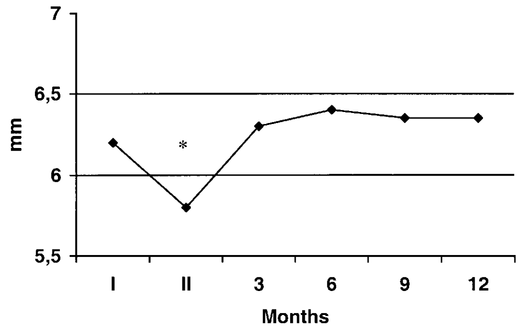

Fig. 4 Muscle thickness (mm) of the puborectal muscle. *P<0.05 I vs II. *I* primary operation; *II* stoma closure

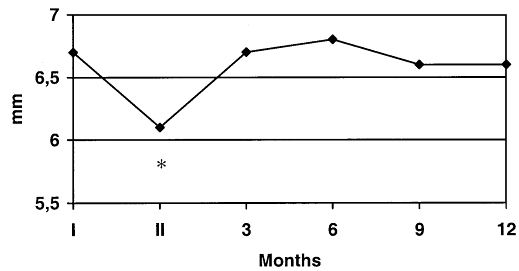

Fig. 5 Muscle thickness (mm) of the external anal sphincter (pars superficialis). *P<0.05 I vs II. *I* primary operation; *II* stoma closure

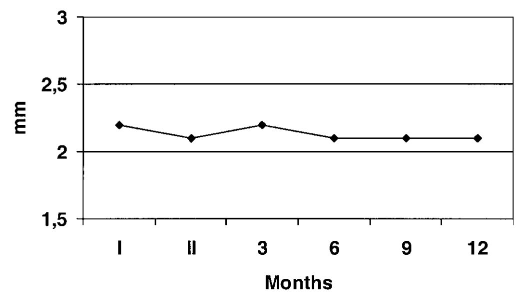

Fig. 6 Muscle thickness (mm) of the internal anal sphincter. *I* primary operation; *II* stoma closure

Table 1 Median values (range) of muscle diameter (mm) as measured by endoanal ultrasound. *OP I* primary operation; *OP II* stoma closure; *Months* time after OP II; *EAS* external anal sphincter; *IAS* internal anal sphincter

	OP I	OP II	3 Months	6 Months	9 Months	12 Months	P value, OP I vs OP II*
Puborectal muscle	6.2 (3.5–9.0)	5.8 (2.8–8.9)	6.3 (3.5–9.4)	6.4 (4.3–8.7)	6.4 (4.6–9.3)	6.4 (5.0–8.9)	0.033
EAS pars profunda	6.4 (4.0–8.4)	5.8 (3.6–7.8)	6.2 (4.4–8.3)	6.7 (4.9–9.1)	6.7 (5.0–9.6)	6.5 (4.5–8.5)	0.0002
EAS pars superficialis	6.8 (4.0–8.7)	6.1 (4.0–8.8)	6.6 (5.0–9.0)	6.8 (5.0–8.6)	6.8 (4.9–7.7)	6.8 (4.9–7.9)	0.008
EAS pars subcutanea	7.2 (4.5–9.5)	6.7 (3.5–8.2)	7.0 (4.6–10.8)	7.3 (5.9–9.2)	7.3 (5.8–9.5)	7.2 (5.0–9.8)	0.018
IAS	2.2 (1.4–3.6)	2.1 (1.3–3.3)	2.2 (1.8–3.3)	2.1 (1.8–3.0)	2.1 (1.3–2.9)	2.1 (1.6–2.9)	0.203

*P<0.05 was considered significant; Wilcoxon test

ily be inspected; this method has been used in numerous studies for assessment of the IAS and EAS [11, 12, 13]. Most notably, endoanal ultrasound plays an important role in the evaluation of sphincter integrity in patients with fecal incontinence [14, 15, 16, 17, 18].

While anorectal physiology has been studied extensively in patients undergoing rectal resection, little is known about the effect of temporary stool deviation on the morphology of the sphincter complex. Interestingly, the IAS which is composed of smooth muscle fibers does not change its thickness during temporary stool deviation. However, it is well known that the anal resting pressure – which is closely related to the IAS – generally decreases after rectal resection [19, 20, 21, 22, 23]. Obviously, this may be the result of direct trauma to the IAS during the operation, a fact which has been observed in several studies [17, 18], or else may be a consequence of neural injury of the pelvic nerves [24]. However, IAS muscle thickness itself cannot be correlated with anal resting tone. This is in accordance with a study reported by Schäfer et al. [25] in which they compared endosonographic muscle thickness with manometry results. Among 152 consecutive patients, of whom 92 suffered from fecal incontinence, there was no correlation between IAS diameters and manometry findings.

In contrast to the IAS, all parts of the EAS as well as the puborectal muscle – all striated muscles – undergo substantial morphologic changes in terms of involutional hypotrophy during the resting period. In the case of the EAS the decrease in muscle thickness is reflected in a significant reduction of the squeeze pressure, as observed in a study reported by Schiessel and co-workers [22]. They also demonstrated a recovery of the squeeze pressure back to preoperative values during their follow-up, which would correspond with our observation that the striated muscles regain their previous thickness and strength within 3 months after stoma closure. A significant correlation between EAS diameter and anorectal squeeze pressure was also observed in the afore-mentioned study by Schäfer and co-workers [25]. As with other striated muscles, this shows the ability of the puborectal muscle and the EAS to completely recover once they are used, and therefore exercised again, provided there is no structural or nerve damage to these muscles.

To facilitate and/or accelerate recovery of postoperative anorectal function after rectal surgery, it seems prudent to advise the patient to train the muscles during the time of temporary stool deviation. This could either be done by formal biofeedback training or, more appropriately, by simply instructing the patient to repeatedly contract and relax the anal sphincter several times a day.

Conclusion

We demonstrated that temporary stool deviation does lead to substantial morphologic changes of the anal sphincter. While the smooth muscle (IAS) remains unchanged, the striated muscles (puborectal muscle and EAS) undergo hypotrophic transformation. However, after passage reconstruction, i.e., stoma closure, a rapid regeneration of these muscles is observed.

References

1. Heald RJ, Karanjia ND (1992) Results of radical surgery for rectal cancer. World J Surg 16:848–857
2. Kwok SPY, Lau WY, Leung KL, Liew CT, Li AKC (1996) Prospective analysis of the distal margin of clearance in anterior resection for rectal carcinoma. Br J Surg 83:969–972
3. MacFarlane JK, Ryall RDH, Heald RJ (1993) Mesorectal excision for rectal cancer. Lancet 34:457–460
4. Enker WE, Merchant N, Cohen AM, Lanouette NM, Swallow C, Guillem J, Paty P, Minsky B, Weyrauch K, Quan S (1999) Safety and efficacy of low anterior resection for rectal cancer. Ann Surg 230:544–554
5. Dehni N, Schlegel RD, Cunningham C, Guiguet M, Tiret E, Parc R (1998) Influence of a defunctioning stoma on leakage rates after low colorectal anastomosis and colonic J pouch-anal anastomosis. Br J Surg 85:1114–1117
6. Karanjia ND, Corder AP, Holdsworth PJ, Heald RJ (1991) Risk of peritonitis and fatal septicaemia and the need to defunction the low anastomosis. Br J Surg 78:196–198
7. Hida J, Yastutomi M, Fujimoto K, Okuno K, Ieda S, Machidera N, Kubo R, Shindo K, Koh K (1996) Functional outcome after low anterior resection with low anastomosis for rectal cancer using the colonic J-pouch: prospective randomized study for determination of optimum pouch size. Dis Colon Rectum 39:986–991
8. Ikecuhi H, Kusunoki M, Shoji Y, Yamamur T, Utsunomiya J (1996) Clinico-physiological results after sphincter-saving resection for rectal carcinoma. Int J Colorect Dis 11:172–176
9. Lewis WG, Holdsworth PJ, Sagar PM, Stephenson BM, Finan PJ, Johnston D (1994) Coordinated activity of the new “rectum” and anal sphincter after sphincter-saving resection of the rectum for colitis or carcinoma. Dis Colon Rectum 37:1012–1019
10. Otto IC, Ito K, Ye C, Hibi K, Akiyama S, Takagi H (1996) Causes of rectal incontinence after sphincter-preserving operations for rectal cancer. Dis Colon Rectum 39:1423–1427
11. Deen KI, Williams JG, Hutchinson R, Keighley MRB, Kumar D (1993) The prevalence of anal sphincter defects in faecal incontinence: a prospective endosonic study. Gut 34:685–688

12. Emblem R, Dhaenens G, Stien R, Morkrid L, Aasen AO, Bergan A (1994) The importance of anal endosonography in the evaluation of idiopathic fecal incontinence. Dis Colon Rectum 37:42–48
13. Falk PM, Blatchford GJ, Cali RL, Christensen MA, Thorson AG (1994) Transanal ultrasound and manometry in the evaluation of fecal incontinence. Dis Colon Rectum 37:468–472
14. Speakman CT, Burnett SJ, Kamm MA, Bartram CI (1991) Sphincter injury after dilatation demonstrated by anal endosonography. Br J Surg 78:1429–1430
15. Sultan AH, Kamm MA, Hudson CN, Thomas JM, Bartram CI (1993) Anal sphincter disruption during vaginal delivery. N Engl J Med 329:1905–1911
16. Schäfer A, Enck P, Fürst G, Kahn T, Frieling T, Lübke HJ (1994) Anatomy of the anal sphincters: comparison of anal endosonography to magnetic resonance imaging. Dis Colon Rectum 37:777–781
17. Farouk R, Drew PJ, Duthie DS, Lee PW, Monson JRT (1996) Disruption of the internal anal sphincter can occur after transanal stapling. Br J Surg 83:96
18. Ho YH, Tsang C, Tang CL, Nyam D, Eu KW, Seow-Choen F (2000) Anal sphincter injuries from stapling instruments introduced transanally: randomized, controlled study with endoanal ultrasound and anorectal manometry. Dis Colon Rectum 43:169–173
19. Nakahara S, Itoh H, Mibu R, Ikeda S, Oohata Y, Kitano K, Nakamura Y (1988) Clinical and manometric evaluation of anorectal function following low anterior resection with low anastomotic line using an EEA™ stapler for rectal cancer. Dis Colon Rectum 31:762–766
20. Hallböölk O, Sjödahl R (1997) Comparison between the colonic J-pouch-anal anastomosis and healthy rectum: clinical and physiological function. Br J Surg 84:1437–1441
21. Pakkastie TE, Luukkonen PE, Järvinen HJ (1997) Changes in anal pressures and function after low anterior resection. Dig Surg 14:299–303
22. Schiessel R, Karner-Hanusch J, Herbst F, Teleky B, Wunderlich M (1994) Intersphincteric resection for low rectal tumors. Br J Surg 81:1376–1378
23. Williamson MER, Lewing WG, Finan PJ, Miller AS, Holdsworth PJ, Johnston D (1995) Recovery of physiologic and clinical function after low anterior resection of the rectum for carcinoma: myth or reality. Dis Colon Rectum 38:411–418
24. Rao GN, Drew PJ, Lee PW, Monson JRT, Duthie GS (1996) Anterior resection syndrome is secondary to sympathetic denervation. Int J Colorect Dis 11:250–258
25. Schäfer R, Heyer T, Gantke B, Schäfer A, Frieling T, Häussinger D, Enck P (1997) Anal endosonography and manometry: comparison in patients with defecation problems. Dis Colon Rectum 40:293–297