MINIMALLY INVASIVE THERAPY & ALLIED TECHNOLOGIES, 2016
VOL. 25, NO. 5, 241–246
http://dx.doi.org/10.1080/13645706.2016.1197269

Taylor & Francis
Taylor & Francis Group

ORIGINAL ARTICLE

OPEN ACCESS

Surgeons' assessment of internal anal sphincter nerve supply during TaTME - inbetween expectations and reality

Werner Kneist, Laura Hanke, Daniel W. Kauff and Hauke Lang

Department of General, Visceral and Transplant Surgery, University Medical Center, Johannes Gutenberg-University Mainz, Mainz, Germany

ABSTRACT

Background: Intraoperative identification of nerve fibers heading from the inferior rectal plexus (IRP) to the internal anal sphincter (IAS) is challenging. The transanal total mesorectal excision (TaTME) is said to better preserve pelvic autonomic nerves. The aim of this study was to investigate the nerve identification rates during TaTME by transanal visual and electrophysiological assessment.
Material and methods: A total of 52 patients underwent TaTME for malignant conditions. The IRP with its posterior branches to the IAS and the pelvic splanchnic nerves (PSN) were visually assessed in 20 patients (v-TaTME). Electrophysiological nerve identification was performed in 32 patients using electric stimulation under processed electromyography of IAS (e-TaTME).
Results: The indication profile for TaTME was comparable between the v-TaTME and the e-TaTME group. The identification of IRP was more meaningful under electrophysiological assessment than under visual assessment for the left pelvic side (81% *vs.* 45%, $p = 0.008$) as well as the right pelvic side (78% *vs.* 45%, $p = 0.016$). The identification rates for PSN did not significantly differ between both groups, respectively (81% *vs.* 75%, $p = 0.420$ and 84% *vs.* 70%, $p = 0.187$).
Conclusions: The transanal approach facilitated visual identification of IAS nerve supply. In combination with electrophysiological nerve assessment the identification rate almost doubled. For further insights functional data are needed.

ARTICLE HISTORY
Received 16 May 2016
Accepted 23 May 2016

KEYWORDS
Rectal cancer; total mesorectal excision; transanal surgery; TaTME; autonomic nerves

Introduction

Urogenital and ano-neorectal dysfunction also referred to as "pelvic unhappiness" occur frequently after total mesorectal excision (TME) for rectal cancer. Patients report a tremendous impact on their daily life. One of the major causes is intraoperative pelvic autonomic nerve damage. Current international guidelines and consensus panels define the nerve-sparing dimension as a crucial part of the TME concept. In particular the nerve fibers emerging from the inferior hypogastric plexus to the internal anal sphincter (IAS) are at the focus of ongoing scientific discussion. Their existence with its subsidiary plexus, the so-called inferior rectal plexus (IRP) has been described anatomically (Figure 1) and, more precisely, immunohistochemically (1–5). Novel computer-assisted anatomic dissection techniques have further facilitated quite elegantly the creation of a 3D-cartography of the complex IAS innervation (6). This gives the surgeon at least an idea as to where one should be cautious when it comes to preservation of internal anal sphincter nerve supply.

Even under today's favorable examination conditions in laparoscopic and robotic rectal cancer surgery, the intraoperative identification of IRP nerve outflow is challenging. Hence, particular attention is paid to the status of surgical technology with respect to intraoperative electrophysiological measurements (7–10). The trend towards transanal TME (TaTME) conveys amongst others that nerve-sparing may be better achieved transanally (11). Reflecting the difficult intraoperative conditions, the aim of this study was to investigate surgeons' nerve identification rates during TaTME by visual and electrophysiological assessment.

Material and methods

Patients

From February 2014 to May 2016, 52 patients with malignant conditions were selectively considered for TaTME in case of difficult anatomical and oncological conditions. Patient characteristics are summarized in Table 1. Preoperative assessment and treatment

CONTACT W. Kneist werner.kneist@unimedizin-mainz.de Department of General, Visceral and Transplant Surgery, University Medicine, Johannes Gutenberg-University Mainz, Langenbeckstraße 1, D-55131 Mainz, Germany

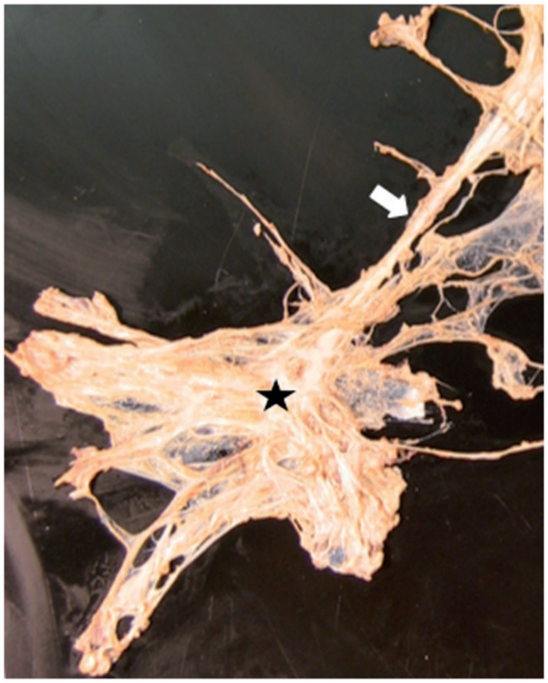

Figure 1. Vertical organized inferior hypogastric plexus (star) with superior, central and inferior branches and its sympathetic/parasympathetic sources. Hypogastric nerve marked with arrow. Cadaver dissection via abdominal surgical approach with Prof. Dr. med. M. Herrmann (Institute of Anatomy, University of Ulm)

algorithm were based on a colorectal-specific multidisciplinary team discussion. Patients were preoperatively categorized with regard to the intraoperative difficulty level for pelvic autonomic nerve preservation based on surgery- and patient-related factors (12). Forty-four patients were preoperatively categorized as grade III (more problematic) and nine as grade IV (very problematic). None of the patients was attributed to grade I (ideal) or grade II (not entirely ideal), respectively. Local anatomical and pathological factors indicating TaTME as stated by a panel of international experts (13) were assessed.

Table 1. Patient characteristics

Gender (male/female)	36/16
Age in years (median)	60 (23, 79)
BMI (median)	26.2 (18.3, 41.8)
ASA I/II/III/IV	2/31/15/3
Malignancy	
Primary rectal cancer	47
Recurrent rectal cancer§	1
Colitis associated colon cancer	2
Rectal GIST	1
Left-sided colon cancer†	1
Neoadjuvant long-term chemo-radiotherapy	27
Neoadjuvant short-term radiotherapy	1
Preoperative chemotherapy	5
Operation	
LAR	29
pISR	20
Proctocolectomy	3
Anastomosis technique	
Hand-sewn	35
Stapled	11
Hartmann	6
Trans-anal specimen extraction	42
Tumor size in mm (median, range)#*	28 (9, 90)
Distal resection margin in mm (median, range)#	11 (1, 120)
Circumferential resection margin ($\leq$1 mm)#	2
M.E.R.C.U.R.Y Grading#	
I° / II°/ III°	39/8/0
(y)pT-category (*n*)#	
pCR	7
Tis-T1	3
T2	15
T3	21
T4	1
(y)pN-category#	
N0	26
N1	11
N2	10
cM-category#	
M0	38
M1	9

BMI: body mass index; ASA: American Society of Anesthesiologists; GIST: gastro-intestinal stromal tumour; LAR: low anterior resection; pISR: partial intersphincteric resection; pCR: pathological complete response.
§History of transanal endoscopic microsurgery for low-risk pT1 rectal cancer.
†History of low anterior resection for rectal cancer.
#Primary rectal cancer.
*On fixed specimen.

Surgery

Transabdominal assisted TaTME was mainly performed with a one-team approach by an experienced colorectal surgeon (WK). In one patient with carcinoma of the left-sided colon and history of open low anterior resection for rectal cancer an open abdominal approach was used. All other patients underwent multiport laparoscopy. The abdominal part included mobilization of the splenic flexure, high tie of the inferior mesenteric artery, and central ligation of the mesenteric vein. The peritoneal fold was opened circumferentially with mesorectal dissection down to the level of the midrectum.

For the transanal part, a Lone Star retractor (CooperSurgical, Trumbull, CT, USA) was inserted. After irrigation with iodine solution a purse-string suture was placed to occlude the rectum. Circumferential full-thickness incision of the rectal wall was performed above the dentate line ($\geq$1 cm distal resection margin) in patients with a supra-anal tumor. In case of juxta-anal tumours (<1 cm from the anorectal junction), the incision was made at the level of the dentate line for partial intersphincteric resection (pISR). Different transanal access platforms were applied (SILS™ Port; Covidien, Inc., Norwalk, CT, USA; GelPOINT path transanal platform; Applied Medical, European Union; D-PORT, K. Storz, Tuttlingen, Germany; TEO® with flexible working end, K. Storz, Tuttlingen, Germany). A 30° angled laparoscope (K. Storz, Tuttlingen, Germany) was used (Ø10mm or 30 mm; length 30 cm or 60 cm). CO_2 was continuously insufflated to a pressure of 9–16 mmHg. Transanal mesorectal dissection was achieved with a monopolar hook, bipolar scissors, and LigaSure^{TM} (Covidien).

Transanal visual and electrophysiological nerve identification

The surgical team visually assessed the pelvic autonomic nerves by videoendoscopy during transanal mesorectal dissection in 20 patients. The integrity of the inferior rectal plexus with its posterior branches to the internal anal sphincter (IRP) and the pelvic splanchnic nerves (PSN) was documented for both pelvic sides. Transanal electrophysiological nerve evaluation was performed in 32 patients using the current standard methodological setup (14). Electric stimulations were carried out under processed electromyography (EMG) of the internal anal sphincter. The stimulations were performed bilaterally above the level of the pelvic floor and along the pelvic side with a hand-guided bipolar microfork probe inserted through one of the trocars of the transanal access platform. Currents of 6 mA, frequency of 30 Hz, and monophasic rectangular pulses with pulse duration of 200 µs were chosen. A stimulation-induced increase in EMG amplitude (V) was rated as identified nervous tissue. The nerve identification rates based on visual (v-TaTME) and electrophysiological (e-TaTME) controlled procedure were compared.

Statistical analysis

Statistical analysis was performed using SPSS version 23.0 (SPSS, Chicago, IL, USA). For comparison of the v-TATME and e-TaTME group the chi-squared test (χ^2) was used for categorical variables and the Mann-Whitney *U*-test for continuous variables. A *p* values <0.05 was considered statistically significant.

Complete nerve assessment on one pelvic side was defined by identification of IRP and PSN. If at least one of them could not be identified the evaluation was considered as incomplete. For further analysis patients were dichotomized based on the number of observed factors indicating TaTME according to Motson et al. (13) ($\leq$4 factors referring to less difficult conditions for transanal nerve identification *vs.* >4 factors referring to more difficult conditions).

Results

The indication profile for TaTME was comparable between the v-TaTME and the e-TaTME group. The median number of factors that may make the transanal procedure a preferred approach was four (range 1–6) in each group ($p = 0.829$). Further potential risk factors were also equally distributed (Table 2). There was no conversion from the planned minimally invasive approach.

In the v-TaTME group posterior branches of the IRP could be identified bilaterally in eight and unilaterally in two of 20 patients (Figure 2). PSN were recognized bilaterally in 14 patients and unilaterally in one patient (Figure 3). In the e-TaTME group IRP branches could be identified electrophysiologically on both pelvic sides in 24 and on one pelvic side in four of the 32 patients (Figure 4). Identification of PSN was accomplished bilaterally in 24 and unilaterally in five patients.

The identification of IRP with its posterior branches heading to the internal anal sphincter was more meaningful under electrophysiological assessment than under visual assessment for both pelvic sides ($p < 0.05$). The identification rates for PSN did not

Table 2. Factors (1–8) according to Motson et al. (13) indicating TaTME in 52 consecutive patients: Comparison of visually (v-TaTME) and electrophysiologically (e-TaTME) controlled transanal total mesorectal excision.

Anatomical and pathological factors	Total	v-TaTME (20 patients)	e-TaTME (32 patients)	p values
1. Male gender	36	15 (79%)	21 (66%)	0.347
2. Tumor <12cm from AV (including very low cancers)†	47 (45)	19 (95%)	28 (88%)	0.354
3. Narrow and/or deep pelvis	32	14 (74%)	18 (56%)	0.244
4. Visceral obesity (and / or BMI >30kg/m^2)	22 (12)	8 (42%)	14 (44%)	0.510
5. Prostatic hypertrophy	16	8 (42%)	8 (25%)	0.202
6. Tumor diameter >4 cm#	16	6 (32%)	10 (31%)	0.588
7. Distorted tissue planes due to neoadjuvant radiotherapy	15	4 (21%)	11 (34%)	0.214
8. Impalpable, low primary tumor requiring accurate placement of the distal resection margin	7	2 (11%)	5 (16%)	0.447
Further potential factors*	13	5 (25%)	8 (25%)	0.624

TaTME: transanal total mesorectal excision; AV: anal verge, BMI: body mass index.
†Tumor location within 6 cm from anal verge.
#Measured on fixed specimen.
*Prior pelvic surgery ($n = 5$), myomatous uterus ($n = 1$), peritumoral fibrosis ($n = 3$), T4 ($n = 1$), extraluminal tumor ($n = 2$), distal positive lymph node ($n = 1$).

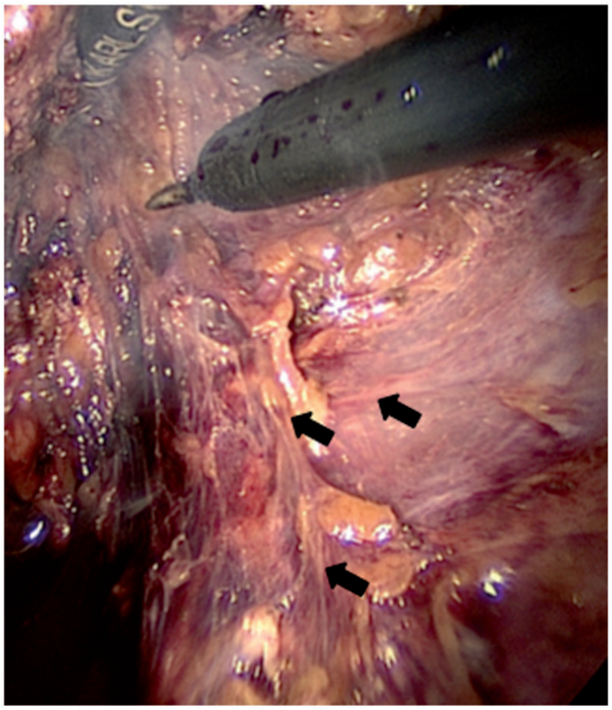

Figure 2. Visually assessed tiny nerve fibers heading to the internal anal sphincter (arrows)

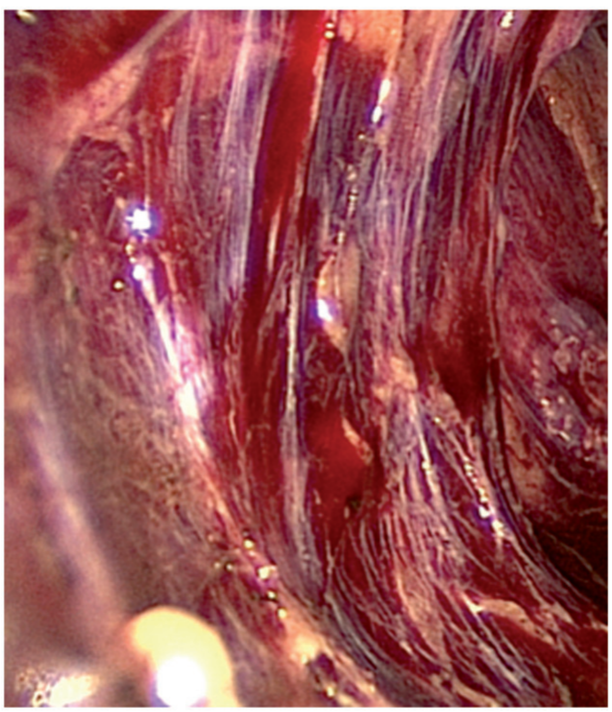

Figure 3. Pelvic splanchnic nerves located posterolaterally running along the right pelvic side wall to intermingle with the inferior hypogastric plexus.

differ significantly between the v-TaTME and e-TaTME group (Table 3).

Based on the above mentioned assessment criteria, complete nerve assessment in the v-TaTME group could be achieved in nine of 20 patients (45%) on either pelvic side. In the e-TaTME group 25 of 32 patients (78%) on the right pelvic side and 26 of 32 (81%) on the left pelvic side, respectively. Overall, patients with more than four factors indicating TaTME had a significantly lower nerve identification rate than those with equal to or less than four factors (complete nerve assessment rate for 104 pelvic sides: 46% vs. 68%, $p = 0.038$).

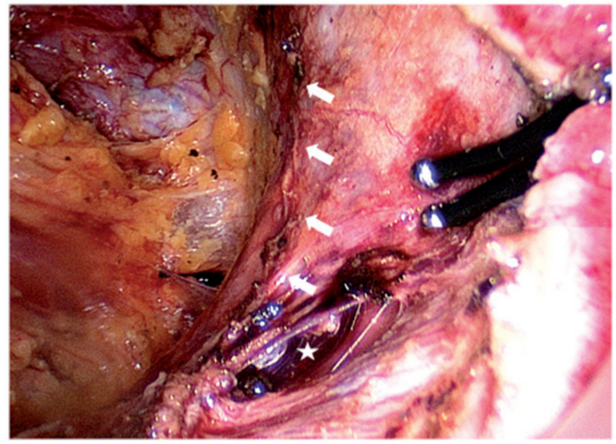

Figure 4. Electrophysiologically assessed posterior branches of the inferior rectal plexus (arrows). Former exidental opening of levators fascia (star)

Table 3. Identification of extrinsic internal anal sphincter nerve supply: Comparison of visually (v-TaTME) and electrophysiologically (e-TaTME) controlled transanal total mesorectal excision

	v-TaTME (20 patients)	e-TaTME (32 patients)	p values
Left pelvic side			
IRP	9/20 (45%)	26/32 (81%)	0.008
PSN	15/20 (75%)	26/32 (81%)	0.420
Right pelvic side			
IRP	9/20 (45%)	25/32 (78%)	0.016
PSN	14/20 (70%)	27/32 (84%)	0.187

TaTME: transanal total mesorectal excision; IRP: inferior rectal plexus with its posterior branches heading to the internal anal sphincter; PSN: pelvic splanchnic nerves.

Discussion

The present study demonstrates in a consecutive series of TaTME cases the surgeon's quantitative visual evaluation of internal anal sphincter nerve supply in 20 patients on the one hand and a more qualitative electrophysiological assessment in 32 patients on the other hand. The tiny neurogenic pathways could be visually identified in up to 45% on each pelvic side and were found tracing the pelvic floor in posterolateral (4–5 and 7–8 o'clock lithotomy position) to anterolateral direction on the supralevatoric pelvic sidewall (3 and 9 o'clock lithotomy position) up to the IRP. Cadaver dissection via non-surgical approach demonstrated variations of the branches in terms of number (three to six nerve fibers), diameter (up to 1.1 ± 0.2 mm) and length (up to 37.3 ± 13.6 mm) (2). Recently, video-endoscopic supported cadaver dissections with a "bottom up" approach revealed them to reach the most distal rectum constituting nerve fibers to the IAS (15). On the basis of adult anatomical dissection, 3D reconstructions of fetal pelvic neuroanatomy as well as surgical experience pioneering TaTME, it was stated that neurological lesions could easily occur at the level where nervous tissue is situated in a virtual space between levator ani muscle fascia and fascia recti. Furthermore, it was emphasized that there is no risk of nerve damage during posterolateral dissection between visceral and parietal pelvic fascia at the level of the middle rectal third (16). The intraoperative findings in the present study support this statement as PSN could be visually assessed in more than two thirds for both pelvic sides with even higher rates under electrophysiological assessment. Nevertheless, we would not preclude the risk of damage at this side completely. In comparison to the v-TaTME group the identification rates for the IRP branches were significantly higher in the e-TaTME group on the left and right pelvic side (81% and 84% *vs.* 45% for both sides). The lower amount of visual confirmation of nervous tissue should be interpreted with caution. There are two main reasons for this finding: On the one hand in the e-TaTME group a distinct identification of initially undefined structures was possible, and, on the other hand, intact neural pathways covered or embedded in connective tissue layers of the thin endopelvic fascia could be confirmed (Figure 4).

The "down to up" approach requires excellent technical skills and a special knowledge of surgical anatomy. Besides the ongoing discussion on pelvic fascias and the highly complex and partly not entirely clarified pelvic neuroanatomy, it should be considered that intraoperative conditions are often severely hampered by patient-, tumor- and surgery-related factors. Lacy et al. pointed out a huge variability when selecting patients for TaTME (17). There is no doubt that the present study included only patients with technically advanced situations according to oncological as well as functional aspects (i.e. sphincter-saving and nerve-sparing). Acceptable oncological surrogates in terms of quality of specimen and free resection margins were achieved with a satisfactory valuable intraoperative nerve identification rate of 68%. The rate still remains 46% even if more than four advanced criteria indicating TaTME exist. To the best of the author's knowledge, comparable data are not available to date, neither for ordinary nor for challenging situations, which indicates the need for further research. Consequently, particular attention must be given to the superior and central branches of the inferior hypogastric plexus responsible for urogenital innervation. Noteworthy is a recent prospective study comparing visualization of the neurovascular bundles between 18 TaTME and 15 laparoscopic TME procedures (18). The authors observed a significantly higher amount of visualization with TaTME (78% *vs.* 33%).

The present study has several limitations. First, multifactorial analysis of functional data is necessary to be able to draw more reliable conclusions on surgeons' nerve-sparing efforts (19). Second, data were registered along the learning phase of TaTME. The technique was not standardized, in particular with regard to access and insufflation platforms as well as dissection instruments. Furthermore, a possible learning curve effect for nerve assessment cannot be ruled out.

In conclusion, there is definitely a need for special skill acquisition in order to disseminate TaTME (20–22). Therefore, it is worth thinking about including nerve-preservation during the transanal phase as an element of training. The combination with electrophysiological assessment may be considered as an additional helpful modality in order to meet current expectations. Even though this was not a comparative study, we can promote and encourage a crucial aspect of TaTME: PSN heading to IHP and posterior branches of the IRP could be identified during the most difficult part of mesorectal dissection. However, this needs conscious effort.

Disclosure statement

Werner Kneist, Laura Hanke, Daniel W. Kauff and Hauke Lang report no financial interests or potential conflicts of interest. The authors alone are responsible for the content and writing of the paper.

Ethical approval

This research was performed following the Declaration of Helsinki guidelines. Informed consent was obtained from all individual participants included in the study. Patient information was collected prospectively and entered into an international registry database for TaTME (LOREC Low Rectal Cancer Development Program, www.lorec.nhs.uk) with approval by the local board of ethics (Rhineland Palatinate, Germany).

References

1. Baader B, Herrmann M. Topography of the pelvic autonomic nervous system and its potential impact on surgical intervention in the pelvis. Clin Anat 2003;16:119–30.
2. He JH, Wang Q, Cai QP, Dang RS, Jiang EP, Huang HL, et al. Quantitative anatomical study of male pelvic autonomic plexus and its clinical potential in rectal resection. Surg Radiol Anat 2010;32:783–90.
3. Hieda K, Cho KH, Arakawa T, Fujimiya M, Murakami G, Matsubara A. Nerves in the intersphincteric space of the human anal canal with special reference to their continuation to the enteric nerve plexus of the rectum. Clin Anat 2013;26:843–54.
4. Kinugasa Y, Arakawa T, Murakami G, Fujimiya M, Sugihara K. Nerve supply to the internal anal sphincter differs from that to the distal rectum: An immunohistochemical study of cadavers. Int J Colorectal Dis 2014;29:429–36.
5. Ishiyama G, Hinata N, Kinugasa Y, Murakami G, Fujimiya M. Nerves supplying the internal anal sphincter: an immunohistochemical study using donated elderly cadavers. Surg Radiol Anat 2014;36:1033–42.
6. Moszkowicz D, Peschaud F, Bessede T, Benoit G, Alsaid B. Internal anal sphincter parasympathetic-nitrergic and sympathetic-adrenergic innervation: A 3-dimensional morphological and functional analysis. Dis Colon Rectum 2012;55:473–81.
7. Runkel N, Reiser H. Nerve-oriented mesorectal excision (NOME): Autonomic nerves as landmarks for laparoscopic rectal resection. Int J Colorectal Dis 2013;28:1367–75.
8. Kneist W, Kauff DW, Lang H. Laparoscopic neuromapping in pelvic surgery: Scopes of application. Surg Innov 2014;21:213–20.
9. Fang JF, Wei B, Zheng ZH, Chen TF, Huang Y, Huang JL, et al. Effect of intra-operative autonomic nerve stimulation on pelvic nerve preservation during radical laparoscopic proctectomy. Colorectal Dis 2015;17:O268–76.
10. Grade M, Beham AW, Schüler P, Kneist W, Ghadimi BM. Pelvic intraoperative neuromonitoring during robotic-assisted low anterior resection for rectal cancer. J Robot Surg 2016;10:157–60.
11. de Lacy AM, Rattner DW, Adelsdorfer C, Tasende MM, Fernández M, Delgado S, et al. Transanal natural orifice transluminal endoscopic surgery (NOTES) rectal resection: "down-to-up" total mesorectal excision (TME)–short-term outcomes in the first 20 cases. Surg Endosc 2013;27:3165–72.
12. Kauff DW, Wachter N, Bettzieche R, Lang H, Kneist W. Electrophysiology-based quality assurance of nerve-sparing in laparoscopic rectal cancer surgery: Is it worth the effort? Surg Endosc 2016. doi: 10.1007/s00464-016-4787-z.
13. Motson RW, Whiteford MH, Hompes R, Albert M, Miles WF, Expert Group. Current status of trans-anal total mesorectal excision (TaTME) following the Second International Consensus Conference. Colorectal Dis 2016;18:13–18.
14. Kneist W, Rink AD, Kauff DW, Konerding MA, Lang H. Topography of the extrinsic internal anal sphincter nerve supply during laparoscopic-assisted TAMIS TME: Five key zones of risk from the surgeons' view. Int J Colorectal Dis 2015;30:71–8.
15. Aigner F, Hörmann R, Fritsch H, Pratschke J, D'Hoore A, Brenner E, et al. Anatomical considerations for transanal minimal-invasive surgery: The caudal to cephalic approach. Colorectal Dis 2015;17: O47–53.
16. Bertrand MM, Colombo PE, Alsaid B, Prudhomme M, Rouanet P. Transanal endoscopic proctectomy and nerve injury risk: Bottom to top surgical anatomy, key points. Dis Colon Rectum 2014;57:1145–8.
17. Lacy AM, Tasende MM, Delgado S, Fernandez-Hevia M, Jimenez M, De Lacy B, et al. Transanal total mesorectal excision for rectal cancer: Outcomes after 140 patients. J Am Coll Surg 2015;221:415–23.
18. Chouillard E, Regnier A, Vitte RL, Bonnet BV, Greco V, Chahine E, et al. Transanal NOTES total mesorectal excision (TME) in patients with rectal cancer: Is anatomy better preserved? Tech Coloproctol 2016. [Epub ahead of print]. doi: 10.1007/s10151-016-1449-z.
19. Kneist W, Wachter N, Paschold M, Kauff DW, Rink AD, Lang H. Midterm functional results of taTME with neuromapping for low rectal cancer. Tech Coloproctol 2016;20:41–9.
20. McLemore EC, Harnsberger CR, Broderick RC, Leland H, Sylla P, Coker AM, et al. Transanal total mesorectal excision (taTME) for rectal cancer: a training pathway. Surg Endosc 2015. [Epub ahead of print]. doi: 10.1007/s00464-015-4680-1.
21. Penna M, Hompes R, Mackenzie H, Carter F, Francis NK. First international training and assessment consensus workshop on transanal total mesorectal excision (taTME). Tech Coloproctol 2016;20:343–52.
22. Atallah S, Albert M, Monson JR. Critical concepts and important anatomic landmarks encountered during transanal total mesorectal excision (taTME): toward the mastery of a new operation for rectal cancer surgery. Tech Coloproctol 2016. [Epub ahead of print]. doi: 10.1007/s10151-016-1475-x.