Definition of Total Mesorectal Excision, Including the Perineal Phase: Technical Considerations

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Key Words

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Abstract

Background: Total mesorectal excision (TME) has contributed to a decline in local recurrence. The operation is difficult because of the complicated anatomy of the pelvis and the narrow spaces in the pelvis. We review the anatomy related to TME and we present our surgical technique. **Anatomy:** The pelvis can be divided into a parietal compartment and a visceral compartment. Both compartments are covered by a fascial layer: the parietal and the visceral fascia. A space between these fascial layers can be opened by dividing loose areolar tissue. The pelvic autonomic nerves consist of the sympathetic hypogastric nerve and the parasympathetic sacral splanchnic nerve. At the pelvic sidewall these nerves join in the inferior hypogastric plexus. **Surgery:** We present our surgical technique based on careful dissection under direct vision and describe our approach to abdominoperineal resection in the knee-chest position. This position enables en bloc resection of the levator ani muscle with the mesorectum, preventing positive circumferential margins in distal rectal tumor. **Conclusion:** TME is a difficult and challenging operation. Continuous attention to surgical technique and anatomy is important to keep up the high standards of contemporary rectal surgery.

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Introduction

The mesorectum is the fatty tissue envelop of the rectum, containing blood and lymph vessels, lymph nodes and autonomic nerves. The majority of patients with rectal cancer present with disease confined to the mesorectal package. Intact removal of this package is necessary to obtain cure for the disease.

This concept of total mesorectal excision (TME) in rectal cancer surgery was introduced by Heald [1] in 1979. The technique of TME is based on sharp dissection under direct vision following the lipoma-like surface of the mesorectum. This plane is usually avascular and enables identification and preservation of the autonomic nerve plexus [2]. In their landmark paper in the *Lancet* (1993), MacFarlane et al. [3] analyzed the results of the first 13 years of experience with TME presenting a hitherto unprecedented local recurrence rate of 4%. These results were backed up by the personal series of Enker et al. [4] who presented a 7.4% local recurrence rate in 1995. In Japan, Moriya et al. [5] published excellent local control (9.3%) after TME combined with extended lymphadenectomy.

In the mid 1990s, TME was introduced in The Netherlands and in Scandinavia by workshops, live video demonstrations of operations and tutoring of individual surgeons. In the Dutch TME trial, local recurrence after a median follow-up of 2 years was reduced to 2.4% after 5 × 5 Gy radiation therapy and TME and to 8.2% after

Fig. 1. Transverse section of the pelvis demonstrating the prevesical and retrorectal space. Note the exaggerated width of the loose areolar tissue layer [from W. Waldeyer: Das Becken. Bonn, Friedrich Cohen, 1899, fig. 59b, p. 227].

TME alone [6]. Compared to historical controls, local recurrence was reduced from 28 to 8% after introduction of TME in Norway [7].

Autonomic nerve preservation seems to be successful in maintaining sexual function, although abdominoperineal resection and older age are associated with an increased likelihood on impotence [8]. Identification of the pelvic autonomic nerves and nerve plexus is difficult however, as the nerves are small and visibility in the pelvis is limited, especially in typical obese Western males.

Several reports indicate poor results of abdominoperineal resection for distal rectal tumors [9–11]. In the Dutch TME study, abdominoperineal resection was associated with a higher positive circumferential margin (APR 30.4%, LAR 10.7%). It has been proposed that a wider ‘cylindrical’ resection should be performed in the case of APR to overcome this problem [12].

TME is a difficult operation because of the complicated anatomy with multiple possible surgical dissection planes and the narrow spaces in the pelvis. There is a definite need for continuous education in rectal cancer surgery to keep up the accomplished high standard of surgery. To contribute to this we review the anatomical details of mesorectal excision in this paper. Subsequently, we will present a detailed description of the operation as we perform it, with special emphasis to the perineal phase.

Anatomy and Embryology

The pelvis may be considered as a two-compartment structure. The outer compartment is the parietal compartment, i.e. the pelvic wall. This compartment consists of the bony and muscular pelvic wall: posteriorly the sacrum and coccyx, the piriformis muscle and coccygeal muscle; inferiorly the levator ani muscle; anteriorly the pubic and iliac bone and the obturator muscle. The inner compartment is the visceral compartment. This compartment consists of the rectum, the bladder and the uterus and vagina in females or the prostate and seminal vesicles in male. The parietal compartment is covered with a parietal fascia. This fascia is continuous with the fascia of the piriformis muscle, the coccygeal muscle and the levator ani muscle. On the sacrum, the parietal fascia is at some places fixed to or identical to the periosteum, at other places a presacral venous plexus is found under the parietal fascia.

The visceral compartment is enveloped in the visceral fascia. Posteriorly the visceral fascia covers the mesorectum, forming its shiny outer surface. The visceral fascia is connected with a layer of loose areolar tissue which can be easily divided. Division of this loose areolar tissue opens the space of Retzius anteriorly (between bladder and pubic bone). Posteriorly, division of this layer of areolar tissue opens the retrorectal space, in surgical literature this dissection plane is referred to as the holy plane

Fig. 2. Midsagittal section of a male pelvis. Detail of the rectosacral fascia (RF). DC = Douglas' cavity.

Fig. 3. Midsagittal section of a male pelvis. The mesorectum is removed. IHP = Inferior hypogastric plexus; SSN = sacral splanchnic nerve; SV = seminal vesicle.

[13] or the TME plane. Laterally, the visceral fascia adheres to the pelvic side wall in a zone over and along the iliac vessels (fig. 1).

For a correct understanding of the visceral fascia of the rectum and the organization of the mesorectum, knowledge of the embryology is helpful. Fritsch [14, 15] demonstrated that the mesorectum and the visceral fascia originate from a layer of dense mesenchyme found in 9- to 12-week-old fetuses. In a later stage (13–20 weeks of age) this mesenchyme has organized itself in circular and semicircular lamellae of connective tissue. In the 21- to 38-week-old fetus adipose tissue develops within these connective tissue layers. The most external lamellae however remain dense and may be regarded as the visceral fascia.

Boundaries of the Retrorectal Space. As mentioned above, the visceral fascia adheres to the pelvic sidewall in

a zone overlying the iliac vessels. As the iliac vessels originate from the aortic bifurcation, this defines the cranial boundary of the retrorectal space. Caudally, the retrorectal space extends to the anus. A double layer of the visceral fascia is found at the level of S3 where a posterior leaf of the visceral fascia forms a firm attachment to sacrum. This fascia is called the retrorectal fascia (fig. 2). In many publications this fascia is identified as Waldeyer's fascia. In Waldeyer's book 'Das Becken' (The Pelvis), this fascia is not mentioned however.

Pelvic Autonomic Nerves (fig. 3). The pelvic autonomic nerves have a sympathetic and a parasympathetic component. The sympathetic component originates from ventral roots of L2 and L3 to form a preaortic superior hypogastric plexus. At the level of the aortic bifurcation, or a little lower at the level of the promontory, this superior hypogastric plexus forms two hypogastric nerves

Fig. 4. Sagittal hemisection of a male pelvis. View from above to the right side of the pelvis. The parietal fascia and the visceral fascia are demonstrated. The hypogastric nerve is situated within the outer perimeter of the mesorectum, ventral to the visceral fascia.

which run laterally and caudally, parallel to the ureter. At the level of the promontory these hypogastric nerves are usually situated 1 cm lateral to the midline and 2 cm medial to the ureter. The hypogastric nerve is situated within the periphery of the mesorectum: the visceral fascia of the mesorectum can be demonstrated dorsal to the nerve (fig. 4).

The parasympathetic sacral splanchnic nerves (SSNs) originate from the roots of S3 and S4 and sometimes from S2. The S3 root is usually the largest. These SSNs enter the pelvis through their respective sacral foramen. The SSNs remain in the parietal compartment of the pelvis, posterior to the parietal fascia to a point about 3 cm lateral to the foramen. Here they penetrate the parietal fascia and continue laterally and caudally in the visceral compartment, close to the pelvic side wall, where they meet the hypogastric nerve to form the inferior hypogastric plexus.

Surgical Considerations

In open surgery, rectal resection requires optimal exposure. An incision is made from the pubic bone to approximately 5 cm cranial of the umbilicus. After careful inspection of the abdominal cavity and the liver, a self-retaining retractor is installed. Dissection is started with the incision of the line of Toldt, mobilizing the sigmoid colon from Toldt's fascia. Throughout the operation, careful dissection based on traction and countertraction

is performed. Dissection itself is performed by diathermia or scissors. If performed carefully, this mobilization of the sigmoid colon does not breach Toldt's fascia which covers the ureter and the spermatic or ovarian vessels. As the left ureter can be clearly identified this way, we do not advocate routine looping of the ureter.

The mesosigmoid is inspected and transected at a level usually just distal to the first or second sigmoidal artery. The sigmoid is divided with a linear stapler/cutter. Now the peritoneum is opened just medial to the right iliac artery. Careful dissection of the loose areolar tissue at the level of the promontory just posterior to the superior rectal artery mobilizes the most cranial mesorectum while preserving the superior hypogastric plexus and nervus. It is possible to extend the dissection cranially to include the base of the inferior mesenteric artery (IMA) in the specimen. The IMA should be divided leaving a small stump of approximately 1 cm in order to avoid damage to the superior hypogastric plexus at this level. The inferior mesenteric vein is divided at the same level.

In case of a low anastomosis, care has to be given to make a well-circulated loop of descending colon and/or sigmoid with enough length to reach the distal stump without tension. In many cases the sigmoid arteries are too short to allow the colon to reach the rectal stump. We divide the superior rectal artery at its origin from the IMA, and we divide the IMA between its origin from the aorta and the confluents of left colic artery and sigmoid artery. In this way an extra level of collateral circulation to the colon loop is preserved, beside the marginal artery. Furthermore, the length of the colon loop is not limited by a rather short sigmoid artery. Mobilization of the splenic flexure is still often necessary in these cases however.

After the sigmoid colon loop is put behind a blade of the self-retaining retractor, the distal sigmoid/rectal loop is gently lifted ventrally and caudally. Now both hypogastric nerves should be identified. Careful dissection of the hypogastric nerves is performed, taking the mesorectum away from the nerves but leaving the nerves on the sacrum. As the dissection continues downward, the left and right hypogastric nerves diverge. Usually a fascial layer can be divided in the space between the left and right hypogastric nerve. Dividing this fascial layer opens the plane between the most peripheral layer of the mesorectum (the visceral fascia) and the parietal fascia. A step in level of dissection is made at this point at the hypogastric nerve as the hypogastric nerve is located just inside the visceral fascia of the mesorectum. This step is made close to the lateral boundary of the retrorectal space and

has usually no clinical significance. When the tumor is close to the hypogastric nerve, it is obvious that resection of the tumor necessitates the sacrifice of the hypogastric nerve. Furthermore, when a total pelvic exenteration is planned, the resection plane is posterior to both hypogastric nerves, extending to the plane posterior to the ureter at the level of the common iliac artery, as preservation of the pelvic autonomic nerves is no issue in these cases.

As the dissection continues downward the retrorectal space is opened. Some small veins cross this space and should be coagulated. Exposure in this plane can be facilitated by using a St Mark's retractor. In most cases, except for slim female patients, exposure gets poor after some progress in this plane. Attention will be shifted to the ventral plane. The incision in the peritoneum is extended ventrally and medially. In male patients the peritoneum is divided some centimeters cranial to the peritoneal reflection on the seminal vesicles. In female patients a corresponding location is found on the posterior fornix of the vagina. To obtain exposure of this area in female patients, it is helpful to elevate the uterus to the abdominal wall with a stitch. Stretching the vagina with a sponge-holding forceps is helpful to identify the posterior fornix. In case of a large uterus, it may be necessary to perform a hysterectomy in order to obtain exposure.

After opening the peritoneum the seminal vesicles in males or the posterior vaginal wall in females is identified. Dissection is continued on the seminal vesicles or posterior vaginal wall. In this way, Denonvilliers' fascia is retained to the specimen as advised by Heald et al. [16]. After developing the anterior plane for some distance, posterior exposure is improved as the mesorectum can be lifted somewhat more from the pelvis. It is frequently necessary or helpful to shift the focus of dissection from time to time during the operation.

The posterior dissection continues to expose the parietal fascia overlying the piriformis muscle. Just caudal to the piriformis muscle the third SSN is located. The SSN originates from the sacral foramen, it enters the pelvis 2–3 cm from the midline. As the SSN runs laterally, it is covered by parietal fascia for another 3 cm before entering a double layer of visceral fascia. Visible identification of the SSN may be difficult because of limited vision into the operating field. If the correct plane in the retrorectal space is followed, damage to the SSNs is unlikely in the median 8 cm of the sacrum, because of the location of the SSN posterior to the parietal fascia. In many cases, it is possible to continue the posterior dissection at this point before the lateral dissection is undertaken. At the level of

S3 the rectosacral fascia is encountered. Sharp division of this fascia is necessary in order to prevent a shift of the dissection into the distal mesorectal tissue. Avulsion of the rectosacral fascia from the sacrum may cause serious bleeding from the presacral venous plexus. Distal to the rectosacral fascia the sacrum curves forward towards the anus. Opening of the retrorectal space at this point requires cutting of rather strong, fibrous adhesions. Because of the depth of the dissection, extended diathermia may be too short: long scissors are more practical in that case. We use combined aspiration-illumination devices to facilitate this deep dissection.

Now the lateral dissection may be started. Medial and anterior traction of the specimen allows dissection over the piriformis muscle and on the hypogastric nerve. The hypogastric nerve leads to the inferior hypogastric plexus on the pelvic side wall, just lateral and dorsal to the seminal vesicles in males. The SSN also leads to the inferior hypogastric plexus. At the inferior hypogastric plexus, autonomic nerve branches enter the mesorectum. These branches should be divided in case of TME. (In case of posterior rectopexy division of the autonomic branches to the mesorectum will cause obstipation.) It is easy to dissect into the inferior hypogastric plexus as median traction on the specimen will displace this plexus medial. If tumor is suspected close to the inferior hypogastric plexus (by means of palpation or MRI scan), or if a total pelvic exenteration is performed, a plane lateral to the inferior hypogastric plexus can be chosen.

At this point in the operation, the mesorectum is mobilized to an imaginary transverse ring extending to the distal sacrum posteriorly, the prostate or posterior vaginal wall ventrally and distal to the SSNs and inferior hypogastric plexus laterally. Continuation of the dissection posteriorly and laterally opens the plane between the mesorectum and coccygeal muscle and levator ani muscle. In the case of a low anterior resection, this plane will be dissected until the distal rectum is reached, just above the anus. The mesorectal fatty layer covering the distal rectum thins out to a point it is no longer existent. Here the rectum may be divided using a right angle stapler or right angle stapler/cutter. The specimen is now delivered in the case of a low anterior resection.

If the tumor is located in the proximal rectum, above the peritoneal reflection, the rectum may be divided at a higher point, at least 5 cm below the tumor. This will put the anastomosis at a greater distance from the anus which will reduce the likelihood of incontinence or anastomotic leakage.

If the tumor is located in the distal third of the rectum, the circumferential margin to the mesorectal surface is small, especially in T3 tumors. In our opinion it is not wise to perform a low anterior resection in these cases. Instead, we perform an abdominoperineal resection with en bloc resection of the levator ani muscle. After the anterior resection has reached the transverse line to the distal sacrum and prostate as described above, we finish the abdominal phase. We routinely perform an omentoplasty with the stalk on the right gastroepiploic vessels. The omentoplasty is brought to the pelvis through a small hole in the transverse mesocolon. A colostomy on the descending colon or sigmoid is made and the abdomen is closed.

We then turn the patient in the knee-chest position. Special care has to be given to this positioning. Gravity will cause maximal flexion of the knees, causing damage. To prevent this we put a roll under the upper legs. The operation table is put to some degrees of anti-Trendelenburg to balance the patient in a way that most of the weight is transferred to the knees. The chest is supported with a large, firm but soft roll. In this way the abdomen is hanging freely, facilitating ventilation.

Performing the perineal phase in the knee-chest position instead of the standard position in stirrups has several advantages: (a) exposure to the operative field is better; (b) hydrostatic venous pressure is lower, reducing bleeding; (c) assistance and tutoring is feasible, and (d) gravity will pull the perineum downwards, flattening the pelvic floor.

The perineal phase is started with closure of the anus with a strong pursestring stitch. The perineal skin is incised in an ellipse extending to the perineum ventrally, and extending some centimeters lateral to the anus. Dorsally the incision extends to below the coccyx. In selected cases we extend this incision to include the coccyx or distal sacrum. Ventrally, the posterior vaginal wall in female patients may be included in the resection. The ischiorectal fat is then divided using diathermia. Some branches of the inferior rectal artery and vein are encountered. Continuing this dissection will expose the inferior-outer surface of the levator ani muscle and its insertion to the obturator muscle. Ventrally the perineal muscle will be divided. This will expose the bulbus of the penis in male patients or the posterior vaginal wall in female patients. In male patients the ventral plane leads from the bulbus to the urethra. A transurethral catheter is helpful to identify the urethra by palpation. After dissecting the urethra it may be difficult to continue in the correct plane on the prostate because of a sharp angle in the dissection plane.

As dissection on the bulbus, urethra and prostate is carried out, the left and right levator muscle stands out as vertical columns which can be divided. Step by step the prostate is dissected and the levator is divided. On the posterior side the dissection plane of the laparotomy will be met. In some cases some upward dissection has to be made to reach this plane. Some authors advocate entering the retrorectal plane below the tip of the coccyx. The levator ani muscle can then be divided by hooking this muscle by a finger. We believe this maneuver carries the risk of exposing the distal mesorectal surface and possibly the tumor. Our technique of the perineal phase ensures that the levator ani muscle is resected en bloc with the specimen, avoiding a positive margin in distal T3 tumors because of a thin distal mesorectal layer.

The specimen can now be removed. As the levator is completely resected, the perineal wound presents as a large defect in the pelvic floor. We use the omentoplasty to close this perineal defect. If it is not possible to make an omentoplasty, a rectus abdominus flap will be used.

After fixating the omentoplasty or rectus flap in the perineal defect the subcutaneous fascia is approximated. Finally, the skin is closed with interrupted sutures.

Conclusion

TME for rectal cancer is a difficult and challenging operation. Detailed knowledge of the anatomy is of crucial importance to perform this operation. We presented our technique of the operation. We would invite others to present their technical approach to the operation. It is important to discuss and study surgical techniques to maintain surgical quality at a high level. It is the patient who will benefit by a reduced risk of local recurrence.

References

- 1 Heald RJ: A new approach to rectal cancer. *Br J Hosp Med* 1979;22:277–281.
- 2 Heald RJ, Husband EM, Ryall RD: The mesorectum in rectal cancer surgery – the clue to pelvic recurrence? *Br J Surg* 1982;69:613–616.
- 3 MacFarlane JK, Ryall RD, Heald RJ: Mesorectal excision for rectal cancer. *Lancet* 1993;341:457–460.
- 4 Enker WE, Thaler HT, Cranor ML, Polyak T: Total mesorectal excision in the operative treatment of carcinoma of the rectum. *J Am Coll Surg* 1995;181:335–346.
- 5 Moriya Y, Sugihara K, Akasu T, Fujita S: Importance of extended lymphadenectomy with lateral node dissection for advanced lower rectal cancer. *World J Surg* 1997;21:728–732.
- 6 Kapiteijn E, Marijnen CA, Nagtegaal ID, Putter H, Steup WH, Wiggers T, et al: Preoperative radiotherapy combined with total mesorectal excision for resectable rectal cancer. *N Engl J Med* 2001;345:638–646.
- 7 Wibe A, Eriksen MT, Syse A, Myrvold HE, Soreide O: Total mesorectal excision for rectal cancer – what can be achieved by a national audit? *Colorectal Dis* 2003;5:471–477.
- 8 Havenga K, Enker WE, McDermott K, Cohen AM, Minsky BD, Guillem J: Male and female sexual and urinary function after total mesorectal excision with autonomic nerve preservation for carcinoma of the rectum. *J Am Coll Surg* 1996;182:495–502.
- 9 Law WL, Chu KW: Abdominoperineal resection is associated with poor oncological outcome. *Br J Surg* 2004;91:1493–1499.
- 10 Nagtegaal ID, van de Velde CJ, Marijnen CA, van Krieken JH, Quirke P: Low rectal cancer: a call for a change of approach in abdominoperineal resection. *J Clin Oncol* 2005;23:9257–9264.
- 11 Marr R, Birbeck K, Garvican J, Macklin CP, Tiffin NJ, Parsons WJ, et al: The modern abdominoperineal excision: the next challenge after total mesorectal excision. *Ann Surg* 2005;242:74–82.
- 12 Daniels IR, Strassburg J, Moran BJ: The need for future surgical low rectal cancer studies. *Colorectal Dis* 2006;8(suppl 3):25–29.
- 13 Heald RJ: The 'holy plane' of rectal surgery. *J R Soc Med* 1988;81:503–508.
- 14 Fritsch H: Development of the rectal fascia (in German). *Anat Anz* 1990;170:273–280.
- 15 Fritsch H: Development and organization of the pelvic connective tissue in the human fetus. *Ann Anat* 1993;175:531–539.
- 16 Heald RJ, Moran BJ, Brown G, Daniels IR: Optimal total mesorectal excision for rectal cancer is by dissection in front of Denonvilliers' fascia. *Br J Surg* 2004;91:121–123.