NEUROANATOMY OF THE MINOR PELVIS- SIGNIFICANT AREA IN THE SURGERY OF RECTAL CARCINOMA

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For centuries, there are attempts to develop a strategy of appropriate rectal carcinoma management. However, surgery remains the essential element of therapy, being proposed by Morgagni in the eighteenth century.

The anterior rectal resection method established by Dixon, in addition to Total Mesorectal Excision (TME), supplemented by combined therapy (radiotherapy, chemotherapy) initiated modern rectal carcinoma management techniques, aimed at oncological radicalism with sphincter preservation (Sphincter Saving Procedure – SSP, Sphincter Sparing Surgery – SSS, Sphincter Preserving Surgery – SPS) (1).

Surgical intervention is considered as the standard oncological therapeutic method in case of rectal carcinoma patients, supplemented by combined therapy (radiotherapy, chemotherapy), depending on the stage of the disease and biology of the tumor. Surgery consists in the excision of the rectum and tumor (maintained margins free of neoplastic infiltration – R0 resection), as well as mesorectum with its vessels and lymph nodes. In case of tumors localized in the upper part of the rectum, tumor specific mesorectal resection (TSME) is preferred (2). In case of tumors localized in the medial and inferior part of the rectum low anterior resections are performed, in addition to total mesorectal excisions. Intestinal continuity is restored after the anastomosis of bowel segments free of neoplastic infiltration with all preserved techniques of anastomosis surgery (4). In most cases the reservoir part of the rectum is lost (different fragments of the rectal ampulla are preserved). Intestinal continuity restoration consisting in the simple anastomosis of the colon and rectal stump, and the creation of the neorectum cistern (by means of transverse coloplasty or other intestinal cisterns) do not guarantee normal functioning of the anorectum. Dixon’s (promoter of the anterior resection) suggestion that the procedure had no influence on the functioning of the sphincters proved to be erroneous (5).

Combined oncological therapy of rectal carcinoma also exerts a negative effect on the genitourinary system. Urinary bladder and urethral sphincter dysfunction (urine retention and incontinence), as well as sexual disturbances both in male and female patients (impotence, lack of ejaculation, retrograde ejaculation, lack of orgasm) can result from the operation, especially in case of lower rectal carcinomas. The percentage of the above-mentioned postoperative complications ranges between 10 and 60% (6). The described disturbances result from damage to the autonomic innervation of the mentioned organs.

The wide range of the above-mentioned disturbances depends on the experience of the surgeon, thus, being dependent of the learning
Neuroanatomy of the minor pelvis: significant area in the surgery of rectal carcinoma

In order to perform a safe rectal resection combined with total mesorectal excision, the precise topography of the fascial and neural structures of the minor pelvis is required. The preservation of the above-mentioned during preparation exerts direct influence on the degree of anorectal and urogenital function disturbance control following surgery. Due to the key role of autonomic and somatic central nervous system structures in the pathophysiology of the presented dysfunctions, it seems important to show the precise neuroanatomy of the mentioned area.

Mesorectum and pelvis fascia

The rectum is surrounded from the rear and side by the mesorectum, which develops during embryonic development from the distal mesentery of the primary intestine. The borders of the mesorectum are delimited by the mesorectal fascia, the so-called visceral endopelvic fascia - fascia propria of the recti. The above-mentioned consists of the following: tissues surrounding the rectum, fat tissue, fibers supporting the connective tissue, descending branches of the superior rectal artery and corresponding venous vessels, nerve fibers, and lymph system elements (lymphatic vessels and lymph nodes). The shape and thickness of the mesorectum depends on the rectum and structure of the minor pelvis (7). In the upper part of the rectum the mesorectum is simply the continuation of the mesocolon. The mesorectum is only limited to the dorsal part of the intraperitoneal fragment of the rectum. Considering the subperitoneal fragment, the mesorectum surrounds ¾ of the posterior rectal circumference. The anterior part of the rectum adheres to Denonvilliers’ fascia, while in the lower segment it is separated by the mesorectum.

The mesorectum is surrounded by surgically defined connective tissue structures (pelvic fascia). They clearly separate the mesorectum and rectum from surrounding structures (minor pelvis spaces and organs). Detailed knowledge of the above-mentioned is a must for each surgeon operating within the minor pelvis. Preparation near the lateral and posterior parts of the mesorectum enables to minimize the risk of pelvic autonomic nerve and venous presacral plexus damage, as well as reduce the risk of local rectal carcinoma recurrence. Anatomical and histological investigations enabled to precisely identify fascial structures, their distribution, and the localization of pelvic plexuses (8). The anterior surface of the sacral bone and venous presacral plexuses are covered by the parietal endopelvic fascia. At the S1-S2 level they are adjoined by hypogastric nerves covered by connective tissue on the abdominal side. In the posterolateral part of the pelvis the parietal endopelvic fascia covers the abdominal surface of the sphincters. At the level of S3-S4 the layers of the fascia are thinner, and the hypogastric nerves pass in the direct vicinity of the mesorectal fascia. They are joined by pelvic splanchnic nerves (branches of S2-S4 sacral nerves) and together form the pelvic plexus. The parietal endopelvic and mesorectal fascia designate a vessel-free curved space extending on both sides. The above-mentioned delineates the safe plane of rectal surgical preparation (9). The rectosacral fascia crosses the plane in its lower part. The plane extends from the presacral fascia of the lower part of the sacral bone connecting to the mesorectal fascia 3-5cm above the anorectal junction. In the lateral part of the pelvis the parietal endopelvic fascia divides into numerous connective tissue fascicles (fig. 1).

Fig. 1. Topography of the fascial and neural structures (pudendal nerve, pelvic splanchnic nerves, hypogastric nerves, pelvic plexus, neurovascular bundle), and mesorectum of the posterolateral area of the minor pelvis: PF – parietal presacral fascia, PRE-HGF – pre-hypogastric nerve fascia, FRP – fascia propria of the rectum, DVF – Denonvilliers fascia, HGN’s – hypogastric nerve, PN – pudendal nerve, PSN – pelvic splanchnic nerve, PX – pelvic plexus, NVB – neurovascular bundle, LA – levator ani, PM – piriformis muscle, SRA – superior rectal artery, SRV – superior rectal vein.
The fascicles adhering to the posterolateral pelvic wall cover the levator ani muscle (part of the superior and abdominal surface) surrounding the pudendal nerve and internal pudendal vessels, and pelvic plexus structures considering the latero-abdominal part. Just below the peritoneum neural branches from the pelvic plexus run towards the rectal wall.

The nerves supplying the urinary bladder, prostate gland and seminal vesicles originate in the antero-inferior part of the pelvic plexus. Medially, the inferior hypogastric plexus adheres to the mesorectal fascia of the lower rectum. Medially to the pelvic plexus the mesorectal fascia is connected to the parietal endopelvic fascia. Such a structure is sometimes called „the lateral ligament” with possible presence of medial rectal vessels. The topography of structures adhering to the subperitoneal fragment of the rectal anterior wall is also important. One can observe the presence of numerous fascial tissues comprising collagen fibers, smooth muscle cells, and elastin fibers creating the urogenital septum. The above-mentioned structure was identified for the first time in 1836 by Denonvilliers (10). In male patients Denonvilliers’ fascia tightly adheres to the seminal vesicles and prostate gland from the front and its posterior surface adjoins to the thin layer of the mesorectum and its fascia. In female patients on the other hand, the thin rectovaginal fascia separates the rectum from the uterine cervix and posterior wall of the vagina.

The shape of the pelvis, spatial distribution of fascial and pelvic diaphragm muscle structures, and neighboring organs are responsible for the fact that the mesorectum takes the shape of a cone. The planes surrounding the mesorectal fascia after omitting the arc of the puborectal muscle lead to the intersphincteric fascia. The above-mentioned is limited by the external sphincter muscle and internal anal sphincter. The intersphincteric groove sets the entrance of the surgical intervention into the intersphincteric space.

Neuroanatomy of the minor pelvis and anorectal region

Minor pelvis organ functioning, sphincter, and muscular structure control consists of local and systemic mechanisms. The unique coordination of the peripheral nervous system autonomic and somatic structures (pudendal nerves and autonomic system fibers), and their modulation at the level of the spine seem most significant (11). Control over the complex mechanisms is exercised by the central nervous system-CNS, containing sensory and motor areas (responsible for defecation), associative cortex, and emotional centers. The motor centers of the cerebral cortex are localized in the precentral area of the frontal lobe (field 4 according to Brodmann), and are directly connected with the motor nuclei of the pelvis floor muscles in the sacral segment of the spinal cord. Sensory and motor innervation of the external anal sphincter and pelvic floor muscles stems from the lateral gray matter of the anterior horns of the spinal cord, mostly in the S2-S4 segment, where Onuf’s nucleus is localized, being directly connected to the hypothalamus. Within the nucleus one can observe the presence of motor neurons responsible for the control of the external anal and urethral sphincters.

The course of the pudendal nerve and its branches, the localization of the plexuses and nerves of the autonomic system seem important.

Pudendal nerve

The pudendal nerve is created from neural fibers derived from the S2 to S4 sacral roots. It contains somatic and autonomic fibers. It is the only nerve of the sacral plexus that contains both autonomic components (parasympathetic and sympathetic) (12). The pudendal nerve passes through the infrapiriform opening and penetrates towards the gluteal area. It wraps around the ischial spine and returns to the pelvis passing through the lesser sciatic foramen. It runs in the lateral wall of the ischiorectal fossa within Alcock’s canal (13). The nerve branches to the minor pelvic organs, perineum, and muscles (14). In the upper part of the pudendal nerve branches penetrate to the sphincter and coccygeal muscles. Within the pudendal canal the neural trunk is divided into the perineal nerve and dorsal nerve of the penis or clitoris. The perineal nerve divides into the scrotal or greater labial nerve, and muscular branches supplying the external urethral sphincter. Within the posterior part of the pudendal canal one can observe inferior rectal branches. The above-mentioned, run through
the ischiorectal fossa towards the anal canal with motor supply of the external anal sphincter, and sensory supply of the peripheral part of the anal canal and anoderm (15, 16, 17).

Autonomic nervous system plexus of the minor pelvis

Autonomic innervation of the minor pelvis organs is derived from peripheral nervous system structures. The above-mentioned consists of nerves (hypogastric and splanchnic) and neural plexuses (superior hypogastric and inferior hypogastric) (15).

Sympathetic innervation is derived from Th11-12 and L1-L2 segments. Neural fibers branching from the sympathetic trunks reach the aortic bifurcation creating the superior hypogastric plexus (SHP). The superior hypogastric plexus is subject to division below the promontorium into two neural strands corresponding to hypogastric nerves (HN). At this level they only contain the sympathetic component, being separated from the mesorectum by the proper fascia (mesorectal fascia) with isolated branches supplying the rectum. Stimulation of the sympathetic system leads towards reduced intestinal secretion and slowed peristalsis. During further course hypogastric nerves are accompanied by pelvic splanchnic nerves forming the left and right inferior hypogastric plexus-IHP, also called “pelvic plexus”. Sacral splanchnic nerves are responsible for the additional sympathetic way, branching of the sympathetic trunk of sacral ganglia. The parasympathetic component of the pelvic plexus is derived from parasympathetic centers localized in the gray matter of the spinal cord (S2-S4). Pelvic splanchnic nerves originate from the abdominal branches of S2-S4 and supply the distal third of the transverse colon, the rectum, urinary bladder, urethra, and genital organs. The parasympathetic component of the left colon is attained via ascending fibers, from the pelvic plexus through the superior hypogastric plexus, aortic plexus, and inferior mesenteric plexus. Propulsive and secretory stimulation is observed.

Detailed topography of the pelvic plexus seems important during pelvis minor surgery, due to possible complications (18, 19, 20). It is localized above the levator ani muscle, on both sides of the rectum, laterally to the internal iliac artery branches, posteriorly to the presacral area, being covered by the peritoneum, anteriorly to the posterolateral part of the prostate gland, and medially, adjacent to the mesorectal fascia and seminal vesicles. The right and left part of the pelvic plexus is joined by transverse branches that pass posteriorly from the rectum. Rectal plexus branches (superior, medial, inferior) supply the entire rectum. Neural fibers branching off the above-mentioned plexuses communicate with intraparietal plexus neural processes. Neural fibers of the antero-medial part of the pelvic plexus are at risk of damage during the preparation of the anterolateral wall of the rectum. The above-mentioned are composed of fibers localized on the lateral surface of the seminal vesicles, small branches on the lateral wall of the prostate gland, and fibers localized posteriorly to the seminal vesicles. Fibers that pass (neurovascular bundle- Walsh’s bundle) (21, 22) between the rectum and posterior surface of the prostate gland supply the levator muscle of the anus, the rectum, prostate gland, and cavernous bodies of the penis (cavernous nerves – nervi erigentes). The bundle covers Denonvilliers’ fascia being most prone to iatrogenic damage (10).

The pelvic plexus, apart from the centrifugal fibers possesses numerous centripetal neurons and isolated somatic fibers branching of the pudendal nerve, whose role remains to be explained (21, 23).

CONCLUSIONS

During rectal resection the following autonomic system structures can be subject to damage: 1) lymphangiectomy of the area of the inferior mesenteric trunk near Toldt’s fascia (damage to the hypogastric plexus), 2) preparation of the posterior mesorectum (damage to the pelvic nerves), 3) preparation of the lateral mesorectum in Richet’s space (damage to the pelvic plexus), 4) preparation of the anterior rectal wall in front of Denonvillier’s fascia-de Quenu – Hartmann’s space (damage to Walsh’s bundle) (10, 20).

Anatomical variants have also important significance connected with variability and topography disturbances, as a consequence of induction radiotherapy and tumor infiltration. The most common anatomical variant is connected with the localization of the inferior hypogastric plexus. In male patients it is local-
ized between the urinary bladder and rectum in 73% of cases, while in 27%-laterally towards Richet’s space. In female patients its localization is as follows: 57% in the uterosacral ligament, 30%-peritroperine, 11% between the urinary bladder and rectum, and in 2% laterally to the rectum (20).

Thanks to the surgical technique consisting in total mesorectal excision with automatic nerve preservation the number of anorectal dysfunction, urinary and sexual function disturbances was significantly reduced (24). The development of surgical techniques has reached a critical limit (25). It seems that further reduction of functional disturbances will be possible after the application of technologies enabling intraoperative neuromonitoring (26, 27).

REFERENCES

25. Heald RJ: Surgical management of rectal cancer: a multidisciplinary approach to technical and


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