

# Colon Polyps and the Prevention of Colorectal Cancer

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## Preface

Today, lethal diseases have been determined by the help of advances in medical knowledge. The risk factors which cause these diseases have been also determined along with the advance in preventive medicine. I want to impress that more researches are needed on this field. The lung cancer is one of the most frequently lethal cancers in men. Smoking is the leading one among the factors causing lung cancer. Cessation or decrease of smoking results in decrease in lung cancer incidence.

The most frequent cancer-dependent cause is breast cancer in female. Breast ultrasonography and mammography screenings have provided early diagnosis of this disease, and early diagnosis increases success of treatment.

The second most common cancer-dependent cause of death in both male and female is colon cancer. Some polyps may transform into colon cancer by time.

These polyps can be detected and polypectomy can be performed by colonoscopy. Owing to this, development of colon cancer can be prevented.

Also, early diagnosis of colon cancer can be done by means of colonoscopy.

Polyps, risk factors of colon cancer and knowledge about colonoscopy have been explained in the book. Colonoscopy is not only used in the diagnosis of colon cancer but also in other cancer types. The details of colonoscopy and the preparation period have been explained widely in our book. We prepared this book based on my 12 years of experience on endoscopy and 21 years of experience on surgery at government hospitals and training and research hospitals (Taksim Training and Research Hospital, Bozyaka Training and Research Hospital, Tepecik Training and Research Hospital), combining the experience of my colleagues who are experts on their fields. The content of the book has been prepared to address both the academic staff and our patients. I thank all my colleagues who worked on the preparation of this book. Have a nice reading.

Izmir  
2015

Omer Engin



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## Embryology

### Colon Embryology

The primitive intestinal tube develops from the yolk sac's endodermal roof. Primitive intestines begin as a simple tube suspended by a common mesentery on a sagittal plane. This tube is split into three regions during the third week of development: the cranial fold foregut; the hindgut, at the smaller caudal fold with the ventral allantoic eminence, and midgut, which is positioned between these two; and the front, which is the opening to the yolk sac [1].

Embryologic development is completed in three phases. The first phase of the rotation starts between the sixth and eighth weeks of intrauterine life. It takes place over the primitive intestinal tube mesentery, around the superior mesenteric artery and protrudes into the umbilical cord. This event is called temporary physiological intestinal herniation. This intraumbilical part rotates 90° counterclockwise, from the sagittal plane to the horizontal plane, at the eighth week of embryological development [2].

The second phase of the rotation occurs at the 10th week. At this phase, the midgut part returns to the peritoneal cavity from the umbilical cord and, at the same time, turns 180° counterclockwise around the pedicle made by the mesenteric root. The pre-arterial segment of the midgut, or the duodenojejunal loop, comes back to the abdominal cavity. Thus, the duodenum stays behind the superior mesenteric artery. The post-arterial segment, or cecocolic part, descends and settles in front of the arteria mesenterica superior. Anomalies are more common in the second phase

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than in the first phase. Nonrotation, malrotation, adverse rotation, intestinal hernia, and omphalocele are some of these anomalies [3].

The third phase of rotation is the fixation of the midgut. This starts with the return to the peritoneal cavity and ends with birth. While the total rotation of  $270^\circ$  counterclockwise continues, the cecum, which is situated at the epigastrium, moves to the right bottom quadrant. Fixation starts after the gastrointestinal rotation is completed, during the first trimester. The primitive mesentery parts combine in time and the duodenum and ascending and descending colon settle into their final places. Anomalies of this phase are common, including mobile cecum, subhepatic or undescended cecum, hyperdescended cecum, and persistent colonic mesentery. This segment is fed by the arteria mesenterica superior, with venous and lymphatic drainage via the relevant veins.

Neuroenteric ganglion cells move from the neural crest to the upper part of the alimentary canal and then follow the vagal neuron fibers downward. Sympathetic innervations of the midgut and hindgut come from T8-L2 with the splanchnic nerves and autonomic abdominopelvic plexuses. The 10th cranial nerve connects the parasympathetic system to the midgut. The part of the distal colon, rectum, and anal canal that is above the linea dentalis is composed of hindgut. Therefore, this segment is fed by the a. hindgut (inferior mesenteric artery) and drained by the relevant lymph and veins. Parasympathetic innervation is provided by the n. splanchnicus from S2-S3-S4 [4].

## Anus and Rectum Embryology

The linea dentalis indicates the intersection of the endodermal and ectodermal tubes. Here, the end part of hindgut (or cloaca) comes together with the proctodeum. The cloaca is formed of the part of the rectum that rests below the pubococcygeal line. The hindgut develops from the upper part of this point. Before the 5th week of development, the intestinal and urogenital tracts are combined at their bottom parts into the cloaca. Between the 6th and 8th weeks, the urorectal septum of Tourneux moves to the caudal and separates the cloaca into two parts: the urogenital plate in front and the anorectal plate in the posterior. A little shift of the septum more posterior during the migration leads to a smaller anal cavity and, thus, anorectal problems. The cloacal part of the anal canal includes both endodermal and ectodermal elements, and this part forms the transition region after the membrane comes down. At the 10th week, the anal condyluses, which are a pair of eminences around the proctodeal fossa, combine toward the dorsal side and make a horseshoe structure. They form the perineal corpuscle in the front. This corpuscle separates the cloacal sphincter into urogenital and anal parts. This forms the outer anal sphincter. The inner anal sphincter is formed afterward, between the 6th and 12th weeks, by the widening of the circular muscle line of the rectum. In females, the müllerian ducts, which form the uterus and vagina by combining, arrive in the urogenital sinus at the 16th week by moving downward. In males, the region where the urogenital membrane exists is filled by the combination of genital folds and forms the sinus urethra [5].

## Colon Anatomy

The colon is the tubular structure that extends from the end of the ileum to the junction between the sigmoid colon and rectum, including the ileocecal valve and appendix, and wraps the small intestines like an arch. Together with the rectum and anus, it forms the whole large intestine. Classical divisions of the colon are the cecum, ascending colon, transverse colon, descending colon, and sigmoid colon. The colon is approximately one fourth the length of the small intestines, with a length of 150 cm (120–200 cm). It is widest at the cecum (7.5 cm) and narrowest at the rectosigmoid junction (2.5 cm) [6].

Three structures are helpful in making the macroscopic differentiation of the colon from the small intestine: the tenia coli, haustra coli, and appendix epiploica. The tenia coli is formed by the concentration of longitudinal muscular layer of large intestines in the form of three bands and continues from the appendix root to the rectosigmoid junction [7]. As these tenias are shorter than the intestine length, they form the haustras that give the colon its saccular appearance [8]. Except for the appendix and the cecum, most parts of the colon are surrounded by the appendix epiploica formed by the adipose tissue, which is mostly covered by peritoneum.

## Cecum

The cecum is the widest part of the colon, situated on the right iliac fossa and starting at the termination of the terminal ileum. It is approximately 6–8 cm diameter. As the cecum and ascending colon are close to the psoas major muscle posteriorly, the lateral femoral cutaneous nerve, the femoral nerve, the genitofemoral nerves, the gonadal arteries and veins, and the ureter, caution must be exercised to preserve these structures while the right colon is liberalized. The cecum is adjacent to the anterior abdominal wall anteriorly [9].

In many people, more than 90 % of the cecum's surface is covered by peritoneum. A peritoneal fold separated from terminal ileum mesentery may cross over the ileum to attach to the bottom part of the colon and cecum. This is called the superior ileocecal fold, and the anterior cecal artery passes through it. On the anterior part of the terminal ileum and anterior to the appendix mesentery, the inferior ileocecal fold is present, and no anatomic structure passes through it [10].

The ileum opens by a conical papillary eminence, called the ileocecal valve in humans, extending toward the cecum. Kumar and Philips noted that the superior and inferior ileocecal ligaments were responsible for the ileocecal valve's competence [11]. This valve not only prevents the cecum's contents from refluxing into the ileum, but also prevents ileal content from passing too quickly to the cecum [12]. Bogers and Van Mark stated that this valve has a sphincter function [13]. However, barium enema studies have shown that ileocecal valve function is often not sufficient, even in people without any disease.

The appendix vermiformis is a blind-ended tubular structure situated approximately 3 cm from the ileocecal junction. Its length is 2–20 cm (average of 8–10 cm)

and its diameter is 5 mm. Because of its high mobility, the appendix may be in many positions. While it is in the posteromedial position in 85 % of humans, it may be in the retrocecal, pelvic, subcecal, preileal, or retroileal position [14]. The point where three tenias conjoin on the cecum may assist in locating the appendix root.

The wall of the cecum is thin compared with the walls of other colonic segments. For this reason, tenias are the most appropriate parts for such surgical procedures as anastomoses and cecopexy. Cecum volvulus is rarely seen because of posterior fixations.

## Ascending Colon

The ascending colon extends at the right side of the cavity in front of the quadratus lumborum and transverses the abdominis muscle. The ascending colon, which is the division between the cecum and the hepatic flexure, is 12–20 cm long on average. It is in relation with the m. iliacus, ileolumbar ligament, m. quadratus lumborum, transversus abdominis, perirenal fat tissue, right kidney, lateral cutaneous nerve, and ilioinguinal and iliohypogastric nerves posteriorly. It resides near the ureter, which extends over the psoas muscle and gonadal veins. Anteriorly, it neighbors the small intestines, omentum, and anterior abdominal wall. The ascending colon is covered with peritoneum, except at its posterior surface, but it is not rare that it is fully covered and has a short mesocolon. Reduced mobility of the colon may be because of abnormal connective tissue bands that crosscut the ascending colon under the peritoneum. If the band is wide enough to cover a large part of the colon, it is called Jackson's membrane. Treves determined that there was mesocolon in 12 % of the ascending colon and 22 % of the descending colon of the cadavers [15].

The ascending colon forms the hepatic flexure by turning to the left below the inferior part of the liver, lateral to the gallbladder. Sometimes, it extends over the second part of the duodenum by attaching to it via a peritoneal fold called a duodenocolic ligament. The hepatic flexure may move between 2.5 and 7.5 cm vertically during respiration [16].

## Transverse Colon

The transverse colon starts at the point where the colon sharply turns to left (hepatic flexure), just below the right lobe inferior face of the liver. Its approximate length is 45 cm, and it is the longest segment of the colon. Almost all of the transverse colon is covered with peritoneum, and it is attached to the posterior abdominal wall with a long mesentery, which gives it mobility [17].

The root of the transverse mesocolon begins at the inferior pole of the right kidney and crosses over the second part of duodenum, continues past the pancreas head, body, and tail, and ends at the hilus of the left kidney. This is generally accepted as an anatomic landmark separating the supramesocolic and inframesocolic compartments. This region is like a barrier separating both compartments in infectious situations.

Different from the ascending and descending colon, the transverse colon has a mesentery that is formed by the subsequent junction with the omental bursa's posterior face. Because of the splenic flexure's proximity to the inferior face of the spleen and its relation with the diaphragm through the phrenocolic ligament, caution must be exercised during mobilization. Dissection should be performed from the transverse colon toward the splenic flexure. The transverse mesocolon includes the middle colic artery and vein along with the lymph nodes and nerves. Sometimes, the transverse mesocolon's superior fold attaches to the stomach's posterior wall. Gastric ulcers and benign or malignant tumors may tightly attach to the mesocolon, and the middle colic artery may be damaged during the separation of the stomach wall from the mesocolon [18].

## Descending Colon

The descending colon, approximately 25 cm length, is the colonic segment extending from the splenic flexure to the pelvic unit. It arrives at the iliac crest by descending vertically from the lateral border of the left kidney between the psoas and quadratus and ends at the sigmoid colon, turning medially on the anterior of the psoas muscle and iliac bone. Like the ascending colon, the descending colon is surrounded by peritoneum on the anterior, medial, and lateral surfaces and has a short mesocolon. Existence of the fascia of Toldt, which provides posterior fixation of the colon in many people, enables dissection with little bleeding during an operation.

At its posterior face, the descending colon neighbors the lower pole of the left kidney, the origin of the transversus abdominis muscle, the quadratus lumborum, the iliac and psoas major muscles, the subcostal vein and nerves, the iliohypogastric and ilioinguinal nerves, the 4th lumbar artery, the lateral femoral, femoral, and genitofemoral nerves, the gonadal veins, and the external iliac artery. Anteriorly, however, it neighbors the small intestines and anterior abdominal wall anteroinferiorly. Having a deeper settlement compared with the ascending colon, the descending colon is more posterolaterally settled, especially in young females [19].

## Sigmoid Colon

When the descending colon comes to the iliac crest level, it becomes the sigmoid colon and has a mesentery. Sigmoid colon, with an average length of 35–40 cm, may show variations in terms of length, position, and fixation. The sigmoid colon has two parts; the iliac part is settled and fixed in the left iliac fossa while the pelvic part is mobile. The sigmoid colon starts at the level of iliac crest and ends at the level of the 3rd sacral vertebra [20].

The sigmoid colon, which is fully covered with peritoneum, generally has a V-shaped and sometimes U-shaped mesocolon, extending from the left iliac fossa to the pelvic unit. The apex of the "V" points at the bifurcation point of the common iliac veins extending over the sacroiliac junction. The left ureter passes at this point

between the peritoneum and the common iliac artery and is an important landmark in the detection of the ureter. The sigmoid mesocolon is longer at the center, whereas it is shorter in the rectum and descending colon junctions, and this causes a relative fixation at the tips of the sigmoid.

In the 1800s, because it was observed that the sigmoid colon was generally empty and contracted, this part of the colon was thought to have a role in continence as a fecal reservoir [21]. Later, as the thickening of the circular muscular layer between the rectum and sigmoid was noted, the terms “sphincter ani,” “tertius rectosigmoid sphincter,” and “piloris sigmoido rectalis” came into use [22].

The rectosigmoid junction may be described by surgeons as a zone between the last 5–8 cm of the sigmoid and the upper 5 cm of the rectum [23]. By endoscopists, however, it is seen as a narrow and sharp-angled segment, in spite of knowledge that it is a well-identified segment that is the narrowest part of the large intestine [24]. In a study on cadavers, the rectosigmoid junction was identified as the zone where the tenia libera and the tenia omentalis form a single anterior tenia below 6–7 cm of the promontorium and the haustra and mesocolon disappear [25]. Although it does not fit the definition of an anatomic sphincter formed by thickened circular muscle layers closing the lumen by rectosigmoid contraction, this segment may be accepted as a functional sphincter because of its active dilatation and passive closing mechanisms [26].

## Rectum

The proximal and distal borders of the rectum are controversial. While the rectosigmoid junction is at the 3rd vertebra level according to anatomists and at the sacral promontorium level according to surgeons, the distal border is the dentate line for anatomists and the anorectal ring for surgeons. The rectum is approximately 12–14 cm in length and has three curves. While the upper and lower parts are curved to the right, the middle part is curved to the left. These curves are intraluminally related to Houston’s valves. The middle valve (Kohlrausch plica) is the most stable, at the level of the anterior perineal reflection. As the rectal valves do not include all muscle layers, performing a rectal biopsy at this location is quite convenient because of the low risk of perforation [8, 27]. The rectum mucosa is soft, pink, and transparent, enabling visualization of all mucosal veins. This characteristic vascular pattern disappears in inflammatory cases and melanosis coli.

The rectum is characterized by its wide and stretchable structure, having no tenia, epiploic appendix, haustra, or mesentery. As it is normally extraperitoneal, the rectum is attached to the sacral groove. Actually, what is falsely termed the “mesorectum” by surgeons is the perirectal areolar tissue, which is covered by fascia propria and includes the inferior mesenteric veins’ terminal branches [28, 29]. Mesorectum may be the metastatic zone for rectal cancers and, as no functional nerve passes through, it may be removed in rectal cancer surgery without any sequel. Generally, we may say of the rectum that the upper one-third is covered by peritoneum on its anterior and lateral, the middle one-third is covered by peritoneum at the anterior face, and the inferior one third is extraperitoneal. The rectum continues

along the sacral concavity and ends 2–3 cm anterolaterally to the tip of the coccyx. At this point, it forms the anal canal between the levators with a sharp angle [6]. The rectum is close to the uterine cervix in females. In males, anteriorly it is neighbor to the bladder, seminal duct, seminal vesicle, and prostate. Posteriorly, it is adjacent to the median sacral veins and sacral nerve plexuses.

## Anal Canal

There are two definitions of the anal canal. The anatomic anal canal is a segment of 2 cm length near the proctodeal membrane extending from the anal verge to the dentate line; surgically or functionally the anal canal is the 4 cm length from the anal verge to the anorectal ring. This second definition of the anal canal was first described by Milligan and Morgan [30]. The anorectal ring is at the distal level of the ampullar part of the rectum and forms the anorectal angle. This is the zone where high intraluminal pressure begins.

The anal canal neighbors the coccyx posteriorly and, anteriorly, the perineal body, and, in females, the posterior vaginal wall and, in males, the urethra. It neighbors the ischium and ischiorectal fossa on both its sides. This fossa includes inferior rectal veins and nerves passing through lipid tissue and the anal canal wall. The muscular component of the continence mechanism is listed in three functional groups as the lateral compression of the pubococcygeus muscle, the circumferential closing of the internal and external anal sphincters, and the angling of the puborectalis muscle. The anal canal has upper mucosal (endoderm) and lower cutaneous (ectoderm) segments. The dentate line is a sawtooth-shaped junction zone separating venous and lymphatic drainage, innervations, and the epithelial surface of these two regions. The innervation is provided by sympathetic and parasympathetic systems above this line, and the blood supply and lymphatic drainage are provided by hypogastric vessels. The part below this line is innervated by the somatic nervous system, and the blood supply and lymphatic drainage are provided by the inferior hemorrhoidal vessels. This difference is quite important in the classification and treatment of hemorrhoids [31].

The dentate line is related to the anal valves formed by proctodeal membrane residues. There are small pockets known as anal sinuses or crypts on the upper part of each valve. These crypts are connected to six glands on average [32]. While more than one gland may open to the same crypt, some crypts have no connection at all. Anal gland canals penetrate into the submucosa downward and upward. Two-thirds of them penetrate into the internal anal sphincter and the rest enter the intersphincteric zone [33]. Blockage of these canals leads to perianal abscess and fistula formation [34]. There are 8–14 longitudinal folds on the dentate line known as columns of Morgagni. At the end of the columns, there are anal papillae. The mucosa of the columns is formed by multi-folded cuboid cells and has a pink color because of the internal hemorrhoidal plexus under it. This area of 0.5–1 cm on the dentate line is known as the anal transition or cloacogenic area. The cutaneous part of the anal canal is covered with modified squamous epithelium, which is a thin and soft structure. The terms pecten and pecten band are used for this segment [35].

## Arterial Supply

The superior mesenteric artery (SMA) is a large-diameter artery that originates from a narrow opening on the aorta. This situation makes it the mesenteric vessel that is most prone to embolic events. It is the second largest intraabdominal branch of the aorta and supplies the whole embryologic midgut. Generally, the AMS has many more branches supplying the distal intestine. This creates a higher potential for distal anastomoses. The AMS originates 1 cm below the a. coeliacus, at the L1 vertebra level, travels down and rightward, and ends as the a. ileocolica. Its main branches are the a. pancreaticoduodenale inferior, the a. colica media, the a. colica dextra, and 4–6 jejunal and 9–13 ileal branches. The a. colica media typically originates from the AMS's proximal part, supplies the transverse colon, and forms anastomoses with the branches of the a. mesenterica inferior. The splenic flexure is a border zone between these two mesenteric veins. Therefore, ischemic colitis is seen more commonly here [36].

The inferior mesenteric artery (IMA) is the smallest of the mesenteric arteries and originates 6–7 cm below the AMS at the L3 level and supplies the distal transverse colon, splenic flexure, descending colon, and rectosigmoid. The IMA is a small diameter artery and its branching angle to the aorta protects it against embolic events. Its main branches are the a. colica sinistra, the sigmoid, and the hemorrhoidal arteries. The branches of the a. colica sinistra reach the splenic flexure in 80–85 % and extend to middle transverse colon in 15–20 % of population. At this point, they anastomose with the branches of the a. colica media, coming from the AMS. Its sigmoid branches anastomose with the a. colica sinistra and a. hemorrhoidalis superior. The a. hemorrhoidalis superior supplies the upper two-thirds wall of rectum and the mucosa of the lower one-third. The a. hemorrhoidalis media originates from the anterior face of the a. iliaca or its vesical branch. It crosses over the infraperitoneal pelvis at the lateral ligaments and supplies the middle one-third of the rectum. The a. hemorrhoidalis inferior is a branch of the a. iliaca internas' anterior face. After traveling for a short distance at the hip, it turns toward the pelvis by passing the ischiarectal fossa. This may lead to significant bleeding during abdominal-peritoneal rectum resection. This artery supplies the m. levator ani and sphincters as well as the lower rectum and anal canal [37].

### A. marginalis (Drummond)

The a. marginalis is composed of a line that is made of the intersecting branches of the a. ileocolica, a. colica dextra, a. colica sinistra, a. colica media, and a. sigmoidalis. These arteries form a single and arching vessel. The a. marginalis passes parallel to its mesenteric border, roughly 1–8 cm from the large intestines. It may end at the a. rectalis superior.

Griffith identified a point on the splenic flexure where circulation was weak [38]. Michel et al. found 61 % good and 32 % weak anastomoses in a 200-patient study [39]. In 7 % of the cases, no anastomosis was found.

## Venous Drainage

The colon's veins escort the arteries. On the right (cecum, descending, and right transverse colon), veins join and form the v. mesenterica. The hepatic flexure veins and right side veins of the transverse colon pour into v. gastroepiploica and v. pancreaticoduodenale anterior superior. Voiglio was the first to identify v. gastrocolica and reported two avulsion cases that were secondary to abdominal trauma [40]. It is a short (<25 mm) (3–10 mm) vein that is present in 70 % of population. It is situated in front of the pancreatic head, under the transverse mesocolon's root and at the intersection point of the v. gastroepiploica dextra and the right upper colic vein. The importance of this vein in abdominal trauma, pancreas surgeries, and portal hypertension has been reported. The left side of the transverse colon drains into the v. mesenterica inferior. The v. rectalis superior drains the ascending and sigmoid colon, ascends, and forms the v. mesenteric inferior [41].

Rectal veins drain into the v. rectalis, which drains into the v. mesenterica inferior. This part drains into the portal system. The v. rectalis inferior and v. rectalis media drain into the iliac vein and thereby into the systemic venous circulation [41].

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## Lymphatic Drainage

Gastrointestinal system lymphatics show reverse flow along the arteries toward the lymphatic nodes. Colonic lymphatics are studied in four groups. The lymphatics on the colon walls primarily drain into epiploic appendix and subserosal epiploic nodes. The epiploic nodes drain into the paracolic nodes, which are on the posterior part of the peritoneum, located at the upper level of the transverse colon and the mesentery of the colon segments. Intermediate nodes are the third lymphatic stations and are related to the main colonic arteries such as the ileocolic artery (ICA), right colic artery (RCA), middle colic artery (MCA), left colic artery (LCA), and sigmoid branches. The intermediate lymph nodes become involved in the two main colonic flows (SMA and IMA) and lymphatic drainage occurs through these two main ways into the paraaortic lymph nodes, cisterna chyli, and ductus thoracicus. The lymphatic vessels of the left colon drain into the lymph nodes in the inferior mesenteric truncus and into the SMA lymph nodes, into which most of the right colon and small intestinal lymphatics drain. The lymphatics of the appendix drain into the lymph nodes of the mesoappendix and into paracolic nodes that are around the ileocolic artery [42].

The lymphatics of the cecum and ascending colon drain into the epicolic nodes that pass at the left side of the intestines and into the ileocolic nodes situated behind the peritoneum and into the paracolic nodes situated along the right colic artery. The transverse colon drains into the epicolic nodes and paracolic nodes situated along the middle colic artery, located at the transverse mesocolon. Drainage of the left part of the colon from splenic flexure to the beginning of the rectum drains into the epicolic nodes located at the right side of left kidney. From there, they drain into the paracolic nodes that extend along the branches of the IMA located behind the peritoneum and into the inferior mesenteric nodes in order.

The upper two-thirds of the rectum drains into the inferior mesenteric nodes and the paraaortic nodes, in order. The lower third drains not only upward through the superior hemorrhoidal and inferior mesenteric vessels but also to the iliac nodes through the middle hemorrhoidal veins. The dentate line is a landmark for these two different lymphatic drainages in the anal canal. They drain into the inferior mesenteric and internal iliac nodes above and into the inguinal nodes with the inferior rectal lymphatics below. In females, drainage at 5 cm above the anal verge may spread to the posterior vaginal wall, uterus, cervix, broad ligament, fallopian tubes, ovaries, and cul-de-sac at the same time. At 10 cm, it is only to the broad ligament and cul-de-sac [43].

Yada et al. analyzed vascular anatomy in colon cancer and lymph node metastasis as follows [44]. As the ileocecal artery always originates from the superior mesenteric artery and lymph node metastasis in cecum cancers is limited to nodes along the ileocolic artery, ileocecal resection is curative in surgical treatment of cecum cancer. When the origin of the right colic artery shows variations, lymph node metastasis in colon cancers may follow different paths. For this reason, right hemicolectomy should be performed in colon cancers. The right colic artery is divided into right and left branches and every branch shows a different branching pattern; if the right colic and middle colic arteries have a common stem, a right hemicolectomy can be performed in cancers of the right side of the transverse colon. If the left branch of the middle colic artery shows independent relocation, lymph node dissection should be changed according to the variation. If the left colic artery and first sigmoidal artery have a common stem, lymph nodes extending along this common stem have to be resected in descending colon and sigmoid colon cancers.

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## Innervation

The colon is innervated by both sympathetic (11th and 12th thoracic, 1st and 2nd lumbar) and parasympathetic (vagus and 2nd, 3rd, and 4th sacral nerves) systems. While sympathetic nerves show an inhibitor effect on colon peristalsis and secretion, parasympathetic stimuli increases the colon peristalsis and secretion. Sympathetic preganglionic nerves are organized in branches that will form the origin of splanchnic nerves by advancing toward paravertebral chains of the ganglion. Splanchnic nerves form such network-like structures as the celiac superior and inferior mesenteric that form synapses with the paravertebral ganglions [45].

The proximal part of the colon is innervated by the celiac plexus via the superior mesenteric plexus; however, the descending colon takes its sympathetic fibers from the superior hypogastric plexus that provides nerve fibers via the lumbar part of the sympathetic tract and parallel to branches of IMA [46].

The parasympathetic innervation of the proximal colon is provided by the celiac branch of the right vagus. The branches coming to the preaortic and superior mesenteric plexuses reach the intestinal wall by following the route of the SMA. The distal colon and rectum receive their parasympathetic stimuli from pelvic splanchnic nerves, originating from S2 and S4. The nerve fibers extending to the superior hypogastric plexus (nerves going to the rectum and anus continue to the inferior hypogastric plexus) innervate the distal transverse, descending colon, and sigmoid colon in the neighborhood of the IMA [45, 46].

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# Preoperative, Intraoperative and Postoperative Management of Colonoscopic Procedure

# 2

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## Evaluation of the Patient Who Will Be Given Endoscopic Sedation

To avoid unexpected situations and adverse effects of sedation in patients who will undergo sedation and endoscopy, medical history of patient should be taken and physical examination should be performed. A preformed medical anamnesis form will make it easier and safer. An anamnesis form should include the basic questions described below [1]:

- Previous history of anaesthesia and sedation
- History of previous anaesthesia or sedation-dependent adverse effects
- History of serious heart and respiratory diseases
- Drugs that the patient uses
- Smoking and alcohol use
- Presence of currently active respiratory disease
- Presence of snoring and sleep apnoea
- History of allergy to drugs, food or alike
- History of neurologic disease
- The last time of oral food or liquid consumption
- Presence of teeth prosthesis
- Presence of pregnancy

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The patient who will undergo endoscopy should cease liquid consumption at least 2 h and light food consumption at least 6 h before the procedure [2]. Pregnancy should not be skipped because it affects choice of drugs; makes incidence of vomiting higher and necessary precautions should be taken. If it is an elective endoscopy, it should be cancelled.

Physical examination should include heart and lung auscultation and evaluation of heart rate and rhythm. Airway evaluation is important. Evaluation and recording of the data given below are important and these data might provide us to be prepared for intubation earlier to keep airway open during sedation.

- Evaluation of mouth opening
- Visualization of uvula and soft palate
- Teeth construction
- Evaluation if mandible is short or not
- Evaluation if temporomandibular joint movement is restricted
- Evaluation if short neck and restriction in neck movements are present
- Obesity

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## Management of Patients in Colonoscopic Examination

Although endoscopy is the gold standard in examination, diagnosis and treatment of the gastrointestinal tract diseases, the pain during procedure is a problem. So, sedoanalgesia demand has got increased more in endoscopic procedures. Sedation and analgesia means decreasing pain and relaxing patient by giving some anaesthetics during painful diagnostic or therapeutic procedures. Sedoanalgesic drugs must be safe for patient, minimize anxiety, make patient stand-still during procedure, provide a good quality sleep and recovery, have acceptable side effects and inactive metabolites and not lengthen hospital period (Table 2.1). For this purpose, lots of drugs such as opioids, benzodiazepines, barbiturates, propofol and anti-psychotics have been used in single or combined forms. The most frequently used sedatives and analgesics in colonoscopy are midazolam, propofol and opioids either in single or combined forms. But, optimal method and combination forms have not been found yet. Combinations of these drugs should be individual for each patient, because these combinations may cause a variety of side effects such as paradoxical agitation, vaso-vagal reaction, dysrhythmia, hyper or hypotension, chest pain, laryngospasm, respiratory depression, desaturation, myocardial infarction and cardiac arrest. The safety of patient should be provided by ECG, non-invasive hemodynamic and respiratory monitoring by an experienced staff [2–6].

Having analgesic, sedative and anxiolytic properties, dexmedetomidine is a new sedoanalgesic, alternative candidate to frequently used midazolam-propofol or midazolam-opioid combinations [7].

Sedation is the level of consciousness, changing from awareness to complete loss of consciousness. Sedation levels are classically classified into four levels: minimal sedation or anxiolysis, moderate sedation, deep sedation, and general

**Table 2.1** ASA physical status classification system

|                       |                                                                                 |                                                                                                                                                                                                                                                                                                            |
|-----------------------|---------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| ASA physical status 1 | Normal healthy patient                                                          | No organic, physiologic, or psychiatric disturbance; excludes the very young and very old; healthy with good exercise tolerance                                                                                                                                                                            |
| ASA physical status 2 | Patients with mild systemic disease                                             | No functional limitations; has a well-controlled disease of one-body system; controlled hypertension or diabetes without systemic effects, cigarette smoking without COPD; mild obesity, pregnancy                                                                                                         |
| ASA physical status 3 | Patients with severe systemic disease                                           | Some functional limitation; has a controlled disease of >one-body system or one major system; no immediate danger of death; controlled CHF, stable angina, previous heart attack, poorly controlled hypertension, morbid obesity, chronic renal failure; bronchospastic disease with intermittent symptoms |
| ASA physical status 4 | Patients with severe systemic disease that is a constant threat to life         | Has at least one severe disease that is poorly controlled or at end stage; possible risk of death; unstable angina, symptomatic COPD, symptomatic CHF, hepatorenal failure                                                                                                                                 |
| ASA physical status 5 | Moribund patients who are not expected to survive without the operation         | Not expected to survive >24 h without surgery; imminent risk of death; multiorgan failure, sepsis syndrome with hemodynamic instability, hypothermia, poorly controlled coagulopathy                                                                                                                       |
| ASA physical status 6 | A declared brain-dead patient whose organs are being removed for donor purposes |                                                                                                                                                                                                                                                                                                            |

ASA American Society of Anesthesiologists, *COPD* chronic obstructive pulmonary disease, *CHF* congestive heart failure

anaesthesia. In minimal sedation, patients can response to verbal stimulus and there is no effect on cardiopulmonary system. In moderate sedation, response to the verbal stimuli is minimal and may necessitate light tactile stimulus. Deep sedation means there is no response to verbal or tactile stimuli, but may be a weak response to painful one. These patients need support for airway clearance and nasal oxygen must be given. General anaesthesia describes the deepest level of sedation and the patient is not responsive to painful stimuli. Another current approach is ‘conscious sedation’ or ‘monitored anaesthesia care’. It is a kind of sedation under which very painful procedures can be performed and there is not a real situation of consciousness. But, cardiopulmonary system is stable and it is a sedation level that needs monitoring and experienced staff. “The American Society of Anesthesiologists (ASA)” scale is frequently used to choose drug, dose and method of application (Table 2.1). A moderate sedation and analgesia are enough to perform most of the painful procedures according to ASA. But, this spectrum may vary from minimal to deep sedation depending on condition of patient, conditions for monitoring and experience of staff. Gas insufflation in colonoscopy may cause both pain and perforation. Deep sedation both relaxes intestinal wall and provides patient comfort [8–10].