



Extrapelvic bowel resection and anastomosis in cytoreductive surgery for ovarian cancer

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Abstract: Ovarian cancer is known as the second most common cause of death among gynecologic cancers. Survival outcome has been reported to be significantly associated with the efforts to minimize residual disease after cytoreductive surgery. As ovarian cancer often invades the small and large bowel without boundary, bowel surgery has been a crucial part of the cytoreductive surgery to achieve complete tumor removal. The scope of surgical resections has progressively expanded to include small and large bowel resections, making advanced surgical skills essential for gynecologic oncologists. In this review, we discuss the extra-pelvic bowel resection in cytoreductive surgery, with a focus on the regional anatomy and surgical techniques.

Keywords: Bowel resection; advanced ovarian cancer; anastomosis; cytoreductive surgery

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Introduction

Approximately 70% of ovarian cancer patients are diagnosed at an advanced stage by the detection of intra-abdominal metastases. Contemporary data suggest that the amount of postoperative residual tumor is the most significant factor for the survival of patients with advanced ovarian cancer (1,2). Ovarian cancer frequently invades the small and large intestines, making bowel resection a crucial part of cytoreductive surgery (1,3-6). As tumors invade multifocal areas of the bowel serosa and mesentery without clear boundaries, gynecologic oncology surgeons often need to make intraoperative decisions regarding the extent of bowel resection, taking into consideration the preservation of bowel function and technical feasibility.

In previously published studies, colon resections were performed in 30% to 70% of patients with advanced ovarian cancer (7-10). The rectosigmoid colon was the most frequently involved portion of the bowel, followed by the

ileocecum (5,11,12). In case of a more extensive involvement of the ileocecum, a right hemicolectomy may be required. Transverse colectomy may be needed for management of bulky omental disease involving the transverse colon or mesenteric invasion. To achieve optimal tumor removal, a subset of patients may require extended procedures, including multiple bowel resections or a subtotal colectomy (10-12).

In this review, we discuss extra-pelvic bowel resection and anastomoses performed in cytoreductive surgery, with a focus on the regional anatomy and surgical techniques.

Small bowel resection

Advanced ovarian cancer commonly involves the serosal surface or mesentery. Small or localized superficial tumors in these tissue layers can be removed using Russian forceps or Metzenbaum scissors. However, if the tumor has spread to surrounding tissues (including the segments of the

jejunum or ileum), resection of the segmental small bowel should be considered.

Prior to the resection of the small bowel, uninvolved sections should be thoroughly inspected for the presence of obscured tumor, vascular supply, and potential for post-surgery bowel obstruction. The next step should be the division of the mesentery at the point where the gross tumor-free bowel on either side can be preserved. When dividing the mesentery, adequate mesenteric blood supply should be identified using transillumination or palpation of an arterial pulse. Mesenteric defects are subsequently created through the avascular space (windows of Deaver) by carefully excising the mesenteric fat adjacent to the serosa of each bowel resection points. Then, the small bowel is divided between non-crushing intestinal clamps or two applications of the linear gastrointestinal anastomosis (GIA) stapling device. The antimesenteric part of the intestine is the portion most susceptible to changes in mesenteric blood perfusion. Therefore, transecting the bowel at an oblique angle with the greater portion removed from the antimesenteric part ensures adequate blood supply to the entire anastomotic site.

When ligating the base of the mesentery, including the jejunal or ileal vessels, they are individually ligated using permanent or delated absorbable ties. Care should be taken not to damage the superior mesentery artery or middle colic artery either directly or by undue traction. For the anastomosis, a side-to-side functional end-to-end anastomosis (EEA) can be safely made using GIA or transverse anastomosis (TA) staplers. Alternatively, traditional hand-sewn anastomosis can be utilized in an end-to-end manner. The mesenteric defect is closed using permanent or absorbable suture to prevent internal herniation.

Ileocecal resection

The rectosigmoid colon and, less commonly, the ileocecum are the sections of the bowel that are reported to be most frequently involved in ovarian cancer, reflecting their proximity to the ovaries (6,10,11). Ileocecal resection should be considered in cases in which tumor involvement is detected in this region or an obstruction of the terminal ileum is expected. If the distal part of the ileum is found to be involved with cancer, the ileum should be removed with the cecum because the region could have a compromised blood supply, which may result in an anastomotic leakage.

For this procedure, the portion of the bowel to be

resected must be adequately mobilized. Proper bowel mobilization is a crucial first step for facilitating the resection and achieving tension-free anastomosis. The mobilization is started by opening the parietal peritoneum around the cecum, and the white line of Toldt (fusion of the colonic mesentery with the parietal peritoneum). To achieve further mobility, the hepatic flexure can be freed by transecting a portion of the gastrocolic ligament and its attachments to the retroperitoneum by using a combination of careful finger and sharp dissection with electrocautery. During mobilization, the surgeon should be careful not to damage the duodenum, kidney, and ureter proximal to the colon. The extent of tissue to be resected can then be identified and the specimen can be divided using either Kocher clamps (proximal and distal) or a GIA stapling device. The mesentery should be divided and the vascular pedicles should be tied or secured using vessel-sealing devices. During this procedure, it should be ensured not to damage the regional branches of the superior mesenteric artery (right and middle colic arteries) perfusing the remaining colon.

A functional end-to-end ileo-ascending colon anastomosis is commonly used and provides a wide patent lumen. The anastomosis can be performed using the traditional hand-sewing technique or a GIA stapling device. While either technique can be used, stapled anastomosis using the GIA and TA stapling devices is faster and easier to perform for most surgeons. The stapled ileocolic anastomosis was reported to be associated with a lower rate of anastomotic leaks than the hand-sewn technique (13,14). In case the ascending colon is not adequately mobilized, an end-to-side anastomosis can be the preferred technique for reestablishing luminal continuity of the bowel.

Transverse colectomy

The transverse colon and its mesocolon can be infiltrated by bulky omental disease. In these cases, *en bloc* omentectomy with transverse colectomy should be considered. If the lesions are limited to the transverse colon, isolated transverse colectomy is an option. As metastases may involve any organ, including the spleen, stomach, or pancreas, it is essential to understand the anatomy of the surrounding structure of the transverse colon and the potential pitfalls of the planned surgery. The goal of the operation is to resect the transverse colon and create a tension-free, well-vascularized bowel anastomosis.

To achieve this goal, a surgeon first needs to mobilize

the hepatic and splenic flexures. The common strategy for mobilization of the hepatic flexure starts by dividing the peritoneal attachments of the ascending colon with the line of Toldt. An excessive traction near the end of the mobilization may cause avulsion injury to the middle colic vein, resulting in a difficult-to-control hemorrhage. Mobilization of the splenic flexure is accomplished by division of the avascular lateral attachment of the descending colon to the retroperitoneum along the white line of Toldt. Care should be taken in executing this procedure, as aggressive downward traction on the flexure can cause avulsion injury to the splenic capsule, resulting in dangerous bleeding that may, in rare cases, require a splenectomy. If the omentum is separated from the lateral side of the transverse colon, the left posterior intraperitoneal space-lesser sac-is accessible. Then, full mobilization of the transverse colon can be achieved by transecting the gastrocolic ligament from the greater curvature of the stomach. Prior to the mesenteric dissection, the surgeon may need to dissect the omentum from the colon. Performing this step provides better control of the mesenteric vessels during the subsequent dissection. Separation of the middle colic artery and vein is the most difficult aspect of a transverse colectomy, owing to the potential for rapid and difficult-to-control hemorrhage. At this stage, it should be ensured that the marginal artery of the remained colon is intact, and blood supply to the planned anastomotic site is adequate. Once both flexures are mobilized, the omentum is dissected, and the middle colic artery and vein are ligated, the bowel is divided to create a tension-free, well-vascularized anastomosis. If the marginal artery of the colon is unconnected at the splenic flexure, the resection should encompass the distal transverse and proximal descending colon. To reestablish the luminal continuity of the colon, an end-to-end or a functional EEA can be performed using a stapling device or hand-sewing approaches.

Right colectomy

If extensive tumor involvement is found in the ascending colon or hepatic flexure, a right hemicolectomy should be considered. In this case, the distal extent of the right hemicolectomy can vary depending on the site of the tumor lesion.

As the first step, the terminal ileum, cecum, ascending colon, and hepatic flexure are mobilized as described above. When approaching the line of Toldt from a superior

direction, it is important to stay close to the colon just inside the white line. On the lateral side of the line of Toldt, it is easy to migrate into the retroperitoneum and behind the kidney. Staying immediately on the colon side of the line of Toldt can help prevent entry into the incorrect plane. Dissection is typically continued inferiorly to the cecum, just inside the line of Toldt, while preserving the fascia propria of the mesocolon. After colonic mobilization, the omentum is dissected from the transverse colon, the lesser sac is accessed and the gastrocolic ligament is divided.

Appropriate isolation of the ileocolic and right colic arteries is an essential part of the procedure; The arteries should be carefully ligated and divided. If a tumor is located at the hepatic flexure or proximal transverse colon, it may be necessary to resect all branches of the middle colic artery with high ligation. In general, however, only the right-sided branches of the middle colic artery are sacrificed in the course of a typical hemicolectomy. In addition, it is also important to free the mesentery extending to the bowel wall to achieve a tension-free anastomosis.

For the creation of the anastomosis, one of the several anastomotic techniques can be performed by using a stapling device or hand-sewn approach. While a functional EEA is preferred, end-to-end or end-to-side anastomosis may also be utilized in selected situations to reestablish the continuity between the terminal ileum and the proximal transverse colon.

Left colectomy

Extensive tumor involvement of the rectosigmoid bowel sometimes necessitates a left hemicolectomy. Terms such as left hemicolectomy, sigmoid colectomy, and sigmoid wedge resection are all applied to a left-sided colonic resection.

For left colonic resection, the sigmoid and descending colon, splenic flexure, and distal transverse colon all need to be mobilized. Although no sequence has been established to performing the procedure, a common first step is the retraction of the descending colon by a medial incision along the white line of Toldt. Toldt's fascia continues superiorly, posterior to the body of the pancreas. Therefore, at the inferior border of the pancreas, the surgeon must discontinue the use of this anatomical marker as the plane of dissection and instead release the transverse mesocolon from the anterior surface of the pancreas.

Sufficient mobilization of the splenic flexure is one of the essential steps to accomplish tension-free anastomosis. The splenic flexure can be freed from the left diaphragm

by transecting the phrenicocolic ligament. Subsequently, the splenocolic and lienocolic ligaments are divided, and mobilization of the splenic flexure is completed. A surgeon should be careful to minimize undue downward traction, which could result in splenic injury and bleeding.

If the left colon is mobilized, the ends of the colonic segment are separated using a GIA stapler or clamps. Vascular supply to the left colon also should be carefully identified. The left colic artery and left-sided middle colic artery can be ligated and divided distal to its origin. For re-establishing the continuity, end to end anastomosis using a circular stapling device is commonly adopted.

Extensive bowel resection

As ovarian cancer often presents in the advanced stage and frequently involves the bowel in an unpredictable manner, multiple bowel resections or a subtotal colectomy may be required. In previous studies, the most frequent bowel resection sites were the rectosigmoid colon and ileocecal area (6,11,15). If the tumor involves the small and large bowel separately, resection of the two segments can be offered as the specific situation dictates.

However, if the tumor invades the transverse colon either with the rectosigmoid or ileocecum, surgical decision-making is not straightforward. The segments may be resected one by one, and the continuity can be reestablished with the two bowel anastomoses. Alternately, an *en bloc* resection combined with-subtotal colectomy, which requires only a single anastomosis, may be performed. For the intraoperative decision, the surgeon should consider several factors, including the length of the remaining colon, blood perfusion of the anastomotic sites, the technical feasibility of each approach, condition of the bowel, and the overall status of the patient. Extensive multifocal involvement of the colon is relatively rare. When several bowel segments are involved, intervening segments could be preserved with a multi-segmental resection. However, this approach requires more than two colonic anastomoses. In this situation, a subtotal colectomy with an ileorectal anastomosis should be considered as an alternative approach (15).

The perioperative risks associated with extensive bowel resections have been reported to be acceptable when the procedures are performed by experienced gynecologic oncologists at high-volume institutions. Son *et al.* reported the results of extensive bowel resection in patients with advanced ovarian cancer. In their study, patients who received extensive bowel resection (defined as multiple

bowel resection or subtotal colectomy) had a significantly longer operative time ($P<0.001$), higher blood transfusion rate ($P=0.006$), higher postoperative bleeding rate ($P=0.007$), and lower rate of no gross residual disease status ($P=0.004$) than patients who underwent a single-segment bowel resection. However, other postoperative outcomes such as length of hospital stay, wound dehiscence, and postoperative death were not significantly different. Although not significant, the highest risk of anastomotic leakage was found in patients who received a subtotal colectomy (11). Considering these findings, subtotal colectomy needs to be considered in a selected subset of patients.

Conclusions

Gynecologic oncology has seen a remarkable expansion in the extent of surgical procedures used in the management of ovarian cancer over the past decades. Today's gynecologic oncologist should be able to perform procedures that go beyond radical pelvic surgery. The scope of surgical resections has progressively expanded to include small and large bowel resections, making advanced surgical skills essential for gynecologic oncologists, especially those in high-volume centers. Considering that the pattern of tumor spread varies between patients, bowel resection should be highly individualized. A gynecologic oncologist is highly recommended to be familiar with the bowel manipulation techniques described earlier and be able to make intraoperative decisions to achieve optimal surgical outcomes.

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