Perpendicular Blood Vessel Sealing in Surgical Practice

Andrew I Brill, MD
Director of Minimally Invasive Gynecology and Surgical Training
California Pacific Medical Center
San Francisco, CA

Michael J Stamos, MD
The John E Connolly Professor and Chair
Department of Surgery
University of California, Irvine
Orange, CA
Dr Brill and Dr Stamos are paid consultants for Ethicon Endo-Surgery, Inc.

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The Perpendicular Approach to Retroperitoneal Tissue Dissection and Hemostasis with Bipolar Electrosurgery

Andrew I Brill, MD
Director of Minimally Invasive Gynecology and Surgical Training
California Pacific Medical Center
San Francisco, CA

Author biography
Dr Andrew I Brill is the director of Minimally Invasive Gynecology and Surgical Training at California Pacific Medical Center in San Francisco, CA. He is an internationally recognized pioneer and expert in gynecologic endoscopy and minimally invasive surgical techniques. His numerous publications, textbook chapters, and a recently published textbook cover a wide range of subjects, including basic to advanced techniques in operative laparoscopy and hysteroscopy, risk reduction during minimally invasive surgery, surgical ergonomics, and the science of energy-based surgical devices. He is the past president of both the American Association of Gynecologic Laparoscopists (AAGL) and the Board of Directors of the AAGL/Society of Reproductive Surgeons Fellowship in Minimally Invasive Gynecology. Dr Brill is a consultant and speaker for Ethicon Endo-Surgery.

Introduction
While surgical outcome is often defined macroscopically by measuring clinical results such as the use of blood transfusion or need for readmission, attention to more microscopic elements of surgical outcome is equally worthy of our critical attention, including the extent of surgical hemostasis, the volume of thermal necrosis from energy-based surgical devices, and any tissue products that may lead to adhesion formation. Hence, clinical outcome is also inextricably linked to the technical conduct of the procedure.

The Halstedian principles of surgery were conceived to reduce the potentially adverse effects arising from tissue manipulation and injury. Moreover, this approach implores the surgeon to take every opportunity to reduce tissue injury by incorporating sound surgical techniques into his or her surgical armamentarium. This is only possible through a clear understanding of the following factors:
• the relationships between tissue structure and architecture in the surgical field;
• the different effects of mechanical manipulation of these structures by surgical instrumentation; and
• the biophysical principles that determine the surgical tissue endpoints from any applied energy-based surgical device.

The technical minutiae of surgery in the female pelvis are primarily concerned with the recognition, definition, and hemostatic separation of key anatomical structures within the field of dissection. The surgical endpoint for all procedures in the pelvis is based on the most...
hemostatic mobilization of visceral structures, such as the peritoneum, bladder, ureter and bowel, and closure of vascular structures, including the ovarian and uterine vasculature. Moreover, all of these key anatomical structures are best clarified by judiciously adhering to a set system of surgical dissection designed to minimize surgical bleeding, which can quickly reduce the critical advantages of anatomical clarity and change the natural color of different types of normal and abnormal tissue.

Nearly all benign procedures during gynecologic laparoscopy require dissection of the peritoneum using one of the following approaches:

- anteriorly along the vesico-uterine plane;
- lateral to the uterus along the anterior and posterior leaflets of the broad ligaments;
- posteriorly between the uterosacral ligaments or into the cul-de-sac; or
- laterally along the pelvic sidewall and retro-ovarian fossae.

During these dissections, tissue manipulation should be based on hemostatic dissection that reduces risk to adjacent visceral or vascular structures. Whereas there are many surgical techniques that can be used, ergonomics and intrinsic anatomical relationships dictate that certain technical sequences are more efficient and potentially less morbid.

The primacy of the perpendicular approach

Surgical dissection

Located immediately beneath the pelvic peritoneum is a separable surgical layer of endopelvic fascia interlaced with recognizable fat that contains all of the retroperitoneal visceral structures, blood vessels, lymphatics, and nerves. The natural interface between this fat and the overlying peritoneum is the key to both safe and hemostatic mobilization of these structures. Moreover, this also helps to outline the uterine vessels in preparation for surgical ligation or to mobilize the bladder along with its tissue investments during laparoscopic hysterectomy. Given these anatomic relationships, the peritoneum near the tissue target is incised along a transverse plane to create a peritoneal edge that can be used for a traction point. A grasper from a contralateral position is used to securely grasp and tract the peritoneum at right angles or perpendicular to the underlying target such as endometriosis (Figure 1), a vascular structure such as the uterine artery, or a visceral structure such as the ureter. At the same time, the underlying retroperitoneal structures are progressively mobilized out of harm’s way in a bloodless fashion by progressively counter-tracting with a blunt instrument at the fat/nonfat interface. The right angle or perpendicular approach to peritoneal dissection takes advantage of ergonomic principles and the underlying anatomical relationships.

Bipolar electrosurgery

The ultimate aim of energy-assisted surgery is the attainment of anatomical dissection and hemostasis with the least amount of collateral damage and subsequent scar tissue formation. Ideally, the surgeon’s final view of the operative field should accurately approximate the topography discoverable after postoperative healing. Ultimately, the reduction of unwanted thermal injury is inherently linked to good surgical judgment and technique, a sound comprehension of the applied energy modality, and the surgeon’s ability to recognize anatomical structures within the field of surgical dissection as well as those within the zone of significant thermal change.

The gynecological surgeon customarily engages two larger vascular surgical targets: the uterine artery, which is relatively fixed at the location of typical ligation...
and division; and the ovarian vessels, which are easily mobilized from surrounding tissues. Given that the benefits of advanced bipolar electrosurgery are based on complete occlusion of the vessel lumen under high pressure, while minimizing undue torque to the tissue pedicle, the ideal use of these devices to secure and divide the uterine vessels requires a keen attention to the applied surgical technique [1].

Advanced bipolar devices are capable of sealing a 7-mm vessel [2], well within the range of these pelvic vessels. Consistent with time-honored surgical doctrines used for both abdominal and vaginal hysterectomy, control of the uterine blood supply is customarily performed by employing a perpendicular approach to the uterine vessels; by pressing the tips of an open clamp to the underlying fascia on either side of a skeletonized vascular bundle and then mechanically sealing by closing the clamp at right angles to the pedicle in preparation for mechanical division (Figure 2).

**Figure 2 Uterine vessel sealing and transection.**

The use of a perpendicular approach to seal (A) and transect (B) uterine vessels.

Finally, using a perpendicular approach to lift, flatten, and reduce pillowing of adjacent tissue may minimize the extent of lateral thermal damage by decreasing the tissue surface area of electrosurgical and thermal contact (Figure 4).

**Uterine vessel sealing and transection**

These conventional techniques are in keeping with methodologies that optimize vessel sealing with advanced bipolar electrosurgery. For example, using a perpendicular approach for advanced bipolar electrosurgery optimizes vessel sealing by insuring that blood flow is completely interrupted to preserve the current density and to obviate the cooling effects from heat conduction and convection [3,4]. Also, the perpendicular approach is more apt to mechanically capture the full vessel with a singular purchase while minimizing the entrapment of extraneous tissue into the distal pedicle (Figure 3).

**Figure 3 Complete transection of the vessel.**
The perpendicular division allows for complete transection of the vessel in one firing.
Surgical case

Case presentation

A 47-year-old nulliparous female is referred by a colleague to undergo a possible hysterectomy with adnexectomy as the definitive treatment for progressively symptomatic uterine fibroids and bilateral cystic adnexal masses that appear as endometriomata by sonomorphology. She has suffered from progressively heavy menses along with acyclic pelvic pain. The examination findings reveal a 14-week-sized fibroid uterus with bilateral cystic adnexal enlargement, and no palpable evidence for cul-de-sac disease. After reviewing various nonsurgical and surgical options, she affirmed her interest in undergoing a laparoscopic supracervical hysterectomy with bilateral salpingoophorectomy.

After inserting a uterine manipulator, peritoneal access is attained via direct trocar insertion. Accessory ports are placed in both lower quadrants and suprapublically. An enlarged leiomyomatous uterus is confirmed and found to be adherent posteriorly to both ovaries, which are cystic with multiple cortical implants. The cul-de-sac and vesico-uterine space are without visible disease.

Surgical techniques

Initially, anatomical relationships are normalized using blunt traction and sharp adhesiolysis with mechanical scissors. Various bleeding points are controlled using compression alone with a grasper. The right and left ureters are identified as they enter at the pelvic brim. The peritoneum adjacent to the right ureter is elevated and caudally incised in a linear fashion with an advanced ultrasonic device. After extending this defect with mechanical traction, the medial peritoneal edge is placed on traction using a grasper from the contralateral port. Along the under surface of the parietal peritoneum, the fibro-fatty layer is mobilized with a blunt probe by applying force perpendicularly to the tissue interface to displace the ureter along with its vital investments laterally. In a similar fashion, while placing the rectosigmoid on medial traction, the peritoneum adjacent to the left ureter is incised and...
then mobilized laterally using blunt force at an angle perpendicular to the interface between the peritoneum and the fibro-fatty tissue. With both ureters now clearly identified and laterally displaced, the ovaries are then carefully dislodged from the pelvic sidewalls using a blunt dissector to roll upward in a curvilinear fashion. During separation, chocolate cysts are entered bilaterally. Employing a perpendicular approach to clarify and mobilize the underlying tissue interface, ureterolysis is hemostatically extended downward just lateral to each uterosacral ligament.

The uterus is placed on traction to the left using the intrauterine manipulator, as a probe from the suprapubic port is positioned just behind the proximal round ligament, placing the fundus on medial traction to place all ligaments in a stretched position. At the mid-portion of the right round ligament, an advanced bipolar device is positioned perpendicularly to grasp, desiccate, and cut until the anterior and posterior leaflets of the broad ligament are manifest and separate. The advanced bipolar device is used sequentially to divide the mesosalpinx, proximal fallopian tube, and then the utero-ovarian ligament by grasping perpendicular to the intended tissue pedicle followed by desiccation and incision. Separating the adnexa from the uterus at this stage of the surgery maximizes subsequent visual access to the posterior lower uterine segment. Transection of the utero-ovarian ligament creates an open tissue plane along the posterior broad ligament that can be subsequently extended to over the uterosacral ligament, ultimately skeletonizing the posterior aspect of the right uterine vessels.

The uterus is manipulated posteriorly toward the sacrum to provide access and tissue stretch along the vesicouterine space. Using the advanced bipolar device through the right lower port to create the bladder flap, the right anterior leaflet is then elevated and incised in a curvilinear fashion below the white line and down to the pubocervical fascia. The bladder and its fatty investments are mobilized downward by elevating the uterus while a blunt probe from the suprapubic port is positioned perpendicular to the tissue interface for countertension along the vesico-uterine plane. Using the advanced bipolar device, the bladder flap is extended upward over the left uterine vessels in a curvilinear fashion by elevating and incising the anterior leaflet of the left broad ligament. The laparoscopic view is redirected to the right lower uterine segment while placing the uterus on traction to the left side of the pelvis. Using blunt dissection and advanced bipolar electrosurgery, the right uterine vessels at the level of the isthmus are systematically skeletonized from the surrounding fibro-areolar tissue. While tracting the uterus to the left, the right uterine vessels are successively desiccated and cut using advanced bipolar electrosurgery from the right lower port. Vessel sealing is best insured by positioning the jaws of the device as perpendicular as possible to the course of the vessels with each purchase of tissue until the vessels along with potential back-bleeders have been secured.

The uterus is placed on traction to the right using the intrauterine manipulator, as a probe via the suprapubic port is positioned along the proximal uterus, placing it on medial traction to place all ligaments in a stretched position. An advanced bipolar device is positioned over the mid-portion of the left round ligament in a perpendicular fashion to desiccate and cut tissue until the anterior and posterior leaflets are opened and separated. With the uterus tracted posteriorly toward the sacrum, the incision is continued downward to meet the apex of the bladder flap. The uterus is repositioned to the midposition and again medially tracted. The advanced bipolar device is used to successively divide the mesosalpinx, fallopian tube, and then utero-ovarian ligament by grasping perpendicular to the intended tissue pedicle followed by desiccation and incision. Transection of the utero-ovarian ligament creates an open tissue plane along the posterior broad ligament that can be subsequently extended over the uterosacral ligament to skeletonize the posterior aspect of the ascending left uterine vessels. The uterus is tracted medially to better expose the remaining vascular supply. The left uterine vessels are now skeletonized using a blunt instrument by stroking off the fibro-areolar tissue in a curvilinear fashion at an angle perpendicular to the vascular plane. Using advanced bipolar electrosurgery through the left lower port, the left uterine vessels are successively desiccated and cut by positioning the jaws of the device as perpendicular as possible to the course of the vessels for each purchase until the entire vascular bundle
as well as potential uterine back-bleeders have been secured. The pale blush from uterine ischemia confirms bilateral uterine vessel occlusion.

Using a single tooth tenaculum via the right lower port, the fundus is tracted cranially to expose the left lower uterine segment. Amputation is initiated with an advanced ultrasonic device from the left lower port, across the isthmus, medial to the vascular pedicle, and just above the nexus of the uterosacral ligament with the pericervical fascia. Soft tissue incision is purposefully performed in a counterclockwise fashion to create a reverse-cone in order to reduce the chance for residual endometrial tissue. The uterine manipulator is gently withdrawn to obviate obstruction. Once the midline of the isthmus is traversed, the tenaculum is removed to regrasp the fundus using the left lower port, and amputation is completed in the same fashion from the right lower port. The amputated fundus is then placed into an accessible location within the upper abdomen. The cervical stump is lavaged, and bleeders are clarified with hydrolavage and controlled using bipolar electrocautery. Using the midline suprapubic port to align the bipolar device, the endocervical canal is circumferentially desiccated to help reduce the potential for cyclical spotting from residual endometrial tissue.

Attention is then paid to performing bilateral adnexectomy. Using a grasper from the left lower port, the cystic right adnexa is placed on medial traction to provide visual and mechanical access. From the right lower port, an advanced bipolar device is positioned perpendicularly across the right infundibulopelvic ligament just below the base of the ovary. With exposed ureter well out of harm’s way, the ligament is then sequentially desiccated and cut. The remaining broad ligament attachments are similarly approached using desiccation and incision, completely freeing the adnexa which is placed into the cul-de-sac for later retrieval. In a likewise fashion, the left cystic adnexa is placed on traction medially using a grasper placed through the right lower port. With the rectosigmoid tracted medially using a blunt probe from the left lower port, the exposed ureter is noted to be well medial to the intended ligation. The blunt probe is replaced with an advanced bipolar device which is carefully positioned perpendicularly across the left infundibulopelvic ligament just below the base of the cystic ovary. The ligament is then sequentially desiccated and cut. As on the right, the remaining broad ligament attachments are then desiccated and cut to free and store the adnexa.

Attention is focused on mass tissue removal using techniques for mechanical extraction and electromechanical morcellation. Using the left lower port as a view point, a 5-mm lens is used to visualize the umbilicus. A tissue collection sac is placed through the umbilical trocar down to the cul-de-sac. Using a grasper via the right lower port, both adnexae are placed into the base of the sac. After cinching, it is withdrawn into the umbilical trocar for exterior removal. The umbilical trocar site is then used to pass an electromechanical morcellator to systematically remove the uterine fundus under direct vision.

All of the tissue pedicles, the pelvic sidewall, and the cervical stump are then copiously lavaged to critically assess for any remaining tissue fragments and for hemostasis both with and without significant pneumoperitoneal pressure.

Case summary

The conduct and outcome of this laparoscopic surgery was vitally dependent upon a consistent strategy serving to reduce risk and maximize tissue outcomes. Using techniques for anatomical manipulation that exploit access for tissue dissection, the uterine and ovarian attachments were systematically freed and secured by combining ergonomic and biophysical principles. Whereas there are many techniques that can be successfully used for this type of laparoscopic supracervical hysterectomy and bilateral salpingoophorectomy, both technical accuracy and the security of vessel sealing are best accomplished using a perpendicular approach for the clarification of key anatomy and the optimal use of advanced bipolar electrosurgery.
References


The Perpendicular Approach in the Difficult Laparoscopic Colectomy

Michael J Stamos, MD
The John E Connolly Professor and Chair
Department of Surgery
University of California, Irvine
Orange, CA

Author biography
Dr Michael J Stamos is The John E Connolly Professor and Chair of the Department of Surgery at the University of California, Irvine School of Medicine. He treats a wide range of conditions, including rectal and colon cancers, pelvic floor disorders and inflammatory bowel disease. Dr Stamos and his team of colon and rectal surgeons are experts in the treatment of colorectal cancer using minimally invasive surgery and sphincter-preserving techniques. Dr Stamos received his undergraduate and MD degrees from Case Western Reserve University in Cleveland, OH. He completed his internship and residency at the University of Miami/Jackson Memorial Medical Center in Miami, FL, and received his Colon and Rectal Surgery fellowship training at the Ochsner Clinic in New Orleans, LA. Dr Stamos then moved west where he joined the University of California, Los Angeles faculty and worked primarily at Harbor UCLA Medical Center in Torrance, CA, for 11 years. In 2002 he moved to the UC Irvine Medical Center to establish the Division of Colon & Rectal Surgery. In 2010 he assumed the position of the chairman of the Department of Surgery. He is currently the president of the American Board of Colon and Rectal Surgery and president-elect of the American Society of Colon and Rectal Surgeons. Dr Stamos is a consultant and speaker for and a training grant recipient from Ethicon Endo-Surgery.

Introduction
Although laparoscopic colectomy was first described over 20 years ago, it is only recently that we have seen evidence of significant adoption of this technique at a national level [1,2]. There are many reasons for slow adoption, including the complexity and difficulty of a multi-quadrant laparoscopic operation. Increased adoption of laparoscopic colectomy has been facilitated by a number of advances in technology, including improved optics, improved surgical trocars with better fixation, and widespread utilization of energy sealing devices.

This section will describe some of the challenges that continue to thwart the full adoption of minimally invasive approaches.

Technique background
Over the past decade, bipolar vessel sealing has revolutionized surgical treatment almost as much as minimally invasive surgery. Introduced into minimally invasive surgery in 1998 [3], it has established itself in the market based on its speed, simplicity, and efficacy [4]. Nevertheless, there are some misconceptions and indeed some misgivings regarding its utilization as the sole method of vessel sealing. A number of surgeons still rely on older techniques such as stapling and/or clip application. While these techniques are certainly effective, vessel sealing, when properly utilized, is both safe and effective [4,5].
Advanced training in vessel sealing promotes the learning of fundamental principles. A few of such principles exist – first, the importance of vessel sealing with the vessel relaxed or under no tension [6,7]. In my experience, creating a seal with the vessel under tension is the most common misapplication. This is probably due to prior experience using the ultrasonic cutting device, the use of which is indeed facilitated by tension on the tissue [8].

The second fundamental principle involves adequate division of the vessel due to mass ligation of the vascular pedicle with its perivascular fat. While this technique can be effective, some surgeons perform a partial ligation/transection of this vascular pedicle with this technique and then put tension on one side to expose the partially ligated pedicle. This causes a tear at the “crotch” of the previous partial division of the vessel, leading to bleeding from the vessel. If mass ligation is chosen, it is important to avoid the temptation to put tension on the partially transected vessels, but rather to simply open the bipolar device jaw following the initial firing, and then advance the jaw without any additional actions. Generally, refiring will now complete a safe sealing and transecting of the vascular pedicle.

The third fundamental principle involves perpendicular firing of the energy device across the blood vessel. The perpendicular approach to division of the vessel has several advantages, including:

- more complete transection of the vessel in one firing (Figure 1) due to smaller surface area; and
- less cross-sectional surface area of the seal point of the vascular transection (Figure 2).
**Surgical case**

**Case presentation**

A 68-year-old male patient presented to his primary care physician with epigastric abdominal pain, which had been present for approximately 2 months. On initial workup he was noted to have significant iron-deficiency anemia, thus an esophagogastroduodenoscopy and colonoscopy were recommended and performed. The esophagogastroduodenoscopy was unremarkable except for some mild gastritis; however, the colonoscopy showed a nearly obstructive tumor in transverse colon, which did not allow passage of the colonoscope. A CT scan was performed and revealed a large hepatic flexure mass with local enlarged peritumoral lymph nodes.

The main surgical challenge in a tumor of the hepatic flexure is exposure and avoidance of injury to the surrounding structures, including the pancreas, duodenum, distal stomach, and gallbladder. A decision was made to proceed with a laparoscopic approach.

**Right colectomy via media lateral approach**

Standard Veress needle insufflation was performed, with inflation of the abdomen to 15 mm of mercury. Three 5-mm trocars were then inserted:

- the initial one was placed in the left abdomen 2-finger breadths lateral to the umbilicus;
- the second one in the left lower quadrant (LLQ) region; and
- the third one in the upper abdomen just below the costal margin and just left of midline.

The abdominal exploration was then conducted. The tumor was clearly visible in the distal transverse colon/hepatic flexure region. There was no evidence of any peritoneal or liver metastases, and the patient was then placed into moderate Trendelenburg position with the right side elevated. This “gravity assist” is required to facilitate a laparoscopic operation. However, it is important to adequately secure the patient to the bed to avoid potentially hazardous shifting of the patient during extreme table positions.

The cecum and ileocolic vessels were identified by grasping the mesocolon medial to the cecum and reflecting the small intestine downward into the pelvis and to the patient’s left side. The transverse colon was elevated to expose the right mesocolon. The duodenum is usually visible just below the right side of the transverse mesocolon with this exposure, but may not be immediately evident in an obese patient.

The ileocolic vessels are grasped at their approximate mid-portion using an instrument via the LLQ port, and the camera remains in the periumbilical port. The upper abdominal trocar is therefore the working one. The base of the ileocolic vessels is identified just distal to its takeoff from the superior mesenteric artery. To the right of this takeoff will be the duodenum behind the thin surface of the ascending or right mesocolon. If the duodenum is visible, this plane is dissected initially, scoring the mesocolon and exposing the duodenum fully. The key maneuver is to stay anterior to the duodenum, allowing the duodenum to drop down or remain down in the retroperitoneum. If the duodenum is not clearly visible, an alternative is to score the mesocolon just to the left and below the ileocolic vessel, exposing the retroperitoneum through that approach. A key landmark here is the right iliac vessels. Once the retroperitoneum is identified, the mesocolon is elevated off of the retroperitoneum, taking care to stay in the proper tissue plane. The tendency is to go too deep and to risk injury to the ileac and gonadal vessels and the right ureter. Further dissection in a cranial direction in this retroperitoneal tissue plane will expose the duodenum quite readily. An angled scope is essential to allow adequate and safe visualization of these structures.

Once the duodenum is identified, the key maneuver once again, is to stay anterior to the duodenum, so that the ileocolic vessels can be safely isolated and ligated or can be ligated en-masse. These vessels are ligated using a bipolar sealing device. It is helpful to obtain a perpendicular or right angle division of these vessels to maximize efficiency of the vessel division, and also to minimize the chance of bleeding due to incomplete transection. When applying the bipolar sealing device on the pedicle it is critical to relax tension both proximal and distal to the division point to allow effective sealing.
to occur. If the vessel pedicle is not completely divided with one firing of the bipolar sealing device, it should simply be opened and advanced without withdrawing the device and without putting undue tension on the vessels. Following the complete division of the pedicle, the entire right mesocolon can then be elevated and the medial lateral dissection can be completed.

The extent of the dissection should continue all the way over to the ascending colon, which should be visible from the posterior or retroperitoneal aspect. The dissection should continue in a cranial fashion to completely free the duodenum from the mesocolon, again staying anterior to the duodenum the entire time and trying to leave the duodenum completely undisturbed. A large heavy tumor may make this dissection somewhat difficult as you reach the second portion of the duodenum, and therefore that part of the dissection can be completed at a later point in time. Great care must be taken in the area of the second portion of the duodenum as you may encounter some collateral veins between the right colic mesentery and the pancreatic or duodenal arcade known as the gastrocolic trunk of Henle. Significant bleeding can result if these vessels are torn or injured. Typically this vascular arcade will be visible running through the thin layer of the right colon or transverse colon mesentery.

The proximal division point of the transverse colon should now be selected based on the location of the tumor. In this case, the middle colic vessels were chosen to be completely transected at a high level to fulfill the oncologic principles important in treating curative colon cancer via laparoscopic or open approach. These vessels can be identified by using the same medial lateral approach by simply continuing the dissection plane medially and by elevating the transverse colon and/or transverse mesocolon.

The most difficult part of a transverse colectomy is often the management of the middle colic vessels, partly due to the limited exposure inherent in this part of the operation. This limited exposure is due to a number of factors, including:

- relative limitation of excursion of the abdominal wall at that location because of the lower ribcage;
- the short length of most transverse colon mesenteries/middle colic vessels;
- the intimacy of the transverse colon with the omentum; and
- the need for full exposure of the lesser sac.

If the middle colic vessels are not easily exposed via the extension of the medial lateral approach, it is best to leave that part of the dissection/operation for a later step as will be detailed below.

The next step is to complete lateral mobilization of the right colon and hepatic flexure. This is best conducted with the patient in the same position as for the medial lateral dissection. Typically, this part of the operation is commenced at the caudal aspect of the cecum, freeing up the cecal attachments, and then extending this plane up cranially all the way to the hepatic flexure and around into the right side of the transverse colon. If the medial lateral dissection has been adequate, this part of the operation is quite easy, as there is only a peritoneal layer to divide in order to open up the entire tissue plane. The medial lateral dissection will have stained this tissue plane a dark blue or purple color, which will facilitate its identification.

An alternative approach to complete the mobilization of the right colon is an inferior to superior approach, which requires a more extreme Trendelenburg position and mobilization of the entire small bowel into the upper abdomen. The cecal and terminal ileum are then elevated anteriorly, and the plane is established behind the cecum and terminal ilium and in front of the retroperitoneum (the latter is easily identified by the iliac vessels and the right ureter). This allows direct access to the lateral attachments, which can be further mobilized from this inferior to superior approach up until the level of the hepatic flexure.

At this point, the patient is placed into a slight reverse Trendelenburg or neutral position. If the tumor is locally advanced, it is best to take the right side of the omentum with the specimen for oncologic reasons. Once the region of the planned transection of the transverse colon is identified, the lesser sac is located and entered above the transverse colon, and the omentum can be divided at that location.

Once the hepatic flexure has been fully mobilized, the middle colic vessels, if not previously divided, can now be divided. They can be approached from a variety of directions. Either from above through the lesser sac,
laterally (once the hepatic flexure has been taken down), or from an inferior to superior direction, which is essentially an extension of the medial lateral approach. Once again, a key landmark is the anterior aspect of the duodenum and the head of the pancreas, which will be readily visible in most patients at this point of the operation.

References


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Andrew I Brill, MD
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