71 Robotic Hepatic Resection

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71.1 Introduction

With changes in healthcare innovation, minimally invasive surgery has become a staple of most surgical subspecialties. However, minimally invasive techniques in liver surgery have not yet been adopted as a standard practice by hepatobiliary surgeons. Even though these surgeries have been shown to yield less postoperative pain with smaller incisions, the resistance to adopt the approach as a common practice is likely due to the complexity of liver surgery and concerns over intraoperative complications like bleeding, renal function impairment, or gas embolism.

More recently, there has been an increase in minimally invasive hepatic surgery with advances in robotic techniques as well as improvements on laparoscopic approaches that may have previously deterred physicians from adopting a non-open surgical technique. This chapter aims to summarize the basic technique of robotic-assisted hepatectomies, both the preoperative and postoperative courses for the patient, the indications and contraindications of employing a robotic approach, as well as the overall advantages and disadvantages of performing a robotic hepatectomy.

71.2 Indications and Contraindications

The indications and contraindications for robotic-assisted hepatic resection are similar to those in place for a laparoscopic liver resection. As defined by the Louisville consensus statement, the indications for laparoscopic liver resection include patients who have solitary lesions that are 5 cm or less located in liver segments 2 through 6 and patients who have colorectal metastases that are fully resectable with negative margins. In order to be eligible for the operation, all patients must be able to have an adequate liver remnant after resection in order to prevent postoperative mortality and complications. It is important to understand the impact the resection has on the evolution of many diseases and to consider the treatment course of the patient when evaluating for possible eligibility.

For contraindications, there are no absolutes that would preclude a patient from consideration for a robotic or laparoscopic hepatic resection. There are, however, relative indications that would limit aspects of both laparoscopic and robotic repairs. Primarily, this includes any conditions that predispose individuals to decreased tolerance of increased abdominal pressure and CO_2 peritoneum. If these kinds of contraindications do exist in a patient, then both pulmonary and hemodynamic status should be monitored and assessed by the surgeon and anesthesiologist during the initial stages of procedure. If the patient tolerates the initial stages, then it is usually acceptable to continue with the operation.

The list of indications and contraindications have allowed for a more selective and particular patient selection process. Now, surgeons can more appropriately find candidates for robotic-assisted hepatectomy, so those patients would more greatly benefit from this technique.

71.3 Preoperative Assessment

Even with the use of robotic equipment, liver surgery is high-risk, and therefore, it is imperative to do appropriate preoperative assessment and optimization prior to surgery. Preoperative planning should be focused on the following three areas:

- Appropriate indications for the procedure
- Evaluation of operative risk based on comorbidities
- Optimization of comorbidities to reduce postoperative morbidity

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All surgeons should employ appropriate clinical judgment when considering whether to do a robotic hepatic resection. There are no specific differences that necessitate a robotic approach over a laparoscopic or open approach to the hepatectomy. All three techniques have similar pathologies that they aim to treat which include hepatocellular carcinoma, colorectal liver metastases, hepatic cysts, intrahepatic cholangiocarcinoma, gallbladder cancer, and symptomatic hemangiomas.

First, determining liver function is integral when determining patient eligibility for hepatic resection. Preoperative laboratory testing should be conducted when considering surgical care, and scores such as the MELD score and Child-Pugh scores can be used to standardize and quantify the degree of liver function in order to ensure a safe resection and to avoid complications such as liver insufficiency, failure, or mortality after surgery. For a safe resection, at least two consecutive liver segments with sufficient vascularity, biliary drainage, and preserved regeneration capability must be left in vivo.

It is also imperative to conduct appropriate imaging studies to assess the resectability of the liver, the possibility of an appropriate future liver remnant, and if there is any vascular invasion or metastases that need to be considered. Imaging modalities that are most commonly used in this setting are contrast-enhanced CT, MRI, and PET-CT. Currently, a triple-phase helical CT is considered to be the most accurate and beneficial when mapping out liver anatomy and course of resections.

Optimization and management of the patient's comorbidities is at the discretion of the physician team's clinical judgement. Regardless of whether the case is robotic, laparoscopic, or open, hepatic resection is still a high-risk procedure, and all candidates must be assessed prior to surgery.

The patient should have adequate vascular access during the procedure. This usually includes two large bore intravenous catheters or a central and arterial line. The placement of these access points is to ensure appropriate monitoring throughout the case by the anesthesiologists.

71.4 Operative Technique

Robotic-assisted hepatic resection surgery is a stand-alone procedure that requires no reconstruction or anastomoses after resection. This approach has little difference in technique from what has been demonstrated and explained in an open surgical hepatic resection. Per recommendations, it is ideal that two experienced hepatobiliary surgeons work together on these robotic cases with one assisting at the operating table and the other at the robotic console. The purpose of this is to maximize efficiency and safety during the course of the procedure. Both the left and right robotic-assisted hepatectomies begin by using a laparoscopic approach before the robot is docked and employed.

71.5 Room Setup

After the patient is brought back to the operating room, they are placed supine on the operating table with their arms and legs appropriately positioned. The undocked robot is positioned depending on surrounding room setup and what works for the surgeon, anesthesiologist, and scrub nurse. Commonly, the robot is set up along one side of the patient, and the surgeon assisting at the operating table is facing the arms so that they can manipulate and adjust them as needed. Next to the assisting surgeon, the scrub nurse will be situated with all the required instruments for the laparoscopic steps, the robotic steps, and anything that might be needed if conversion to an open case is necessary. Anesthesia will be located behind the head of the patient with all of their required setup. The primary surgeon will be located at the console after the case has transitioned from laparoscopic to robotic. Monitors showing what is being viewed in the console will be set up at the discretion of the assistant surgeon, anesthesiologist, and scrub nurse and are usually located alongside the robot facing the surgeon at the operating table.

71.6 Right Hepatectomy

To begin the procedure, access is achieved in the left upper quadrant with a 5-mm optical trocar. Once into the peritoneal space, a pneumoperitoneum using 12 mmHg of pressure is created. Next, using a 5-mm 30-degree scope for visualization, additional port sites are placed 8–10 cm from one another. These port sites include the following:

1. A 12-mm port to the right of the umbilicus for the robotic camera
2. A robotic port to the left of the umbilicus
3. A robotic port on the anterior axillary line at the right mid-abdomen
4. A 12-mm port 8–10 cm inferolaterally to the port described in number 3 for assistance with larger instruments

After placement of these four ports, the 5-mm scope is changed to a 10-mm 30-degree scope and is placed in the camera port. The initial left upper quadrant port should be exchanged for a robotic port. Once all ports are placed, the patient should be repositioned in 30-degree reverse Trendelenburg until completion of the procedure.

It is important to note that the initial steps of the right hepatectomy are done via laparoscopy. The robot remains undocked at this time and will be docked after a liver ultrasound is performed. Once set up and the liver visualized, an initial exploration of the abdominal cavity should be performed. This inspection is to assess for any peritoneal or extrahepatic spread of the lesions. Any suspicious masses or nodules should be biopsied and sent to pathology for evaluation. The resection would only be applicable, for most pathologies, if there were no metastases or extrahepatic disease. Next the round, falciform, and coronary ligaments are divided. This exposes the anterior surface of the hepatic veins and is done by using a cautery device. After dissection of the right liver attachments, the gallbladder fundus is retracted superiorly with a grasper from the port in the left upper quadrant. With a grasper in the mid-abdominal port, the right liver is retracted anteriorly. The colon is reflected inferiorly after dissection of the hepatic flexure, and duodenal attachments are freed as necessary. The right triangular and coronary ligaments are divided up to the confluence of the right hepatic vein and inferior vena cava using cautery devices.

Using the 12-mm assist port, an ultrasound of the liver is completed. This is to both confirm liver anatomy and lesion location intraoperatively and to ensure that complete lesion resection can occur. If the appropriate resection cannot occur, then the hepatectomy will not continue. After finishing the ultrasound, the robot is docked with the camera placed in the camera port, Arm 1 in the port to the left of the umbilicus, Arm 2 in the right port, and Arm 3 in the left upper quadrant port.

For the cholecystectomy and portal dissection, a grasper should be placed in robotic Arm 3, a bipolar grasper in Arm 2, and a robotic hook in Arm 1. With Arm 3, the fundus of the gallbladder is retracted toward the patient's right shoulder, while the instrument in Arm 2 is used to retract the infundibulum laterally. During retraction, a robotic hook in Arm 1 dissects out the cystic duct and artery. The cystic duct and artery are clipped transected with equipment through the 12-mm port. The gallbladder will not be removed until after portal dissection is finished as it helps retract the liver. It should be noted that this is a deviation in protocol from the open procedure. Retraction is maintained and the porta hepatis is exposed. Using the grasper in Arm 2, the hepatoduodenal ligament is retracted laterally, and with the cautery device in Arm 1, the ligament is dissected.

Following dissection of the hepatoduodenal ligaments, both the right hepatic artery and right portal vein are identified and transected. Specifically, the right hepatic artery is either stapled using a vascular load through the 12-mm port or tied or clipped through Arm 1. The right portal vein is encircled with a silk tie so that Arm 2 can use it to retract the vein superolaterally to expose its length, and a vascular load can be used to transect it. Next, robotic dissecting forceps or a hook is used to dissect out the right hepatic duct, which is then clipped and transected. If needed, other instruments can be used through the assist port to help in manipulation and dissection. Once the dissections of all of these structures are over, the gallbladder can be dissected and removed using a laparoscopic bag.

Now that the gallbladder has been removed from the abdominal cavity, the inferior vena cava can be exposed and dissected. Using Arm 3, a sponge can be placed in a grasper and used to superiorly displace the gallbladder fossa, while an instrument in the 12-mm port can be used to displace the kidney posteriorly. In order to separate the inferior vena cava and the liver, the short hepatic veins must be identified and ligated. This is done via a dissector in Arm 2 and a cautery in Arm 1. The short hepatic vessels can either be clipped or tied. In order to clip, an applier is used via Arm 1, and to tie, a needle driver is in Arm 1 and a dissector in Arm 2. The short hepatic vessels are ligated up to the right hepatic vein.

To transect the liver parenchyma, follow the line of demarcation, and use hook cautery to delineate the line of transection. Ultrasound should be repeated to ensure that the lesion will be included in the resection. On either side of the line of transection, tie a figure-of-eight stitch with size zero absorbable stitch. These will be used to retract. Along the already delineated line of transection, the parenchyma is coagulated using argon beam coagulation, and laparoscopic clips are placed as needed. Coagulation of the parenchyma is done up until the right hepatic vein, whereupon the vein is stapled with a vascular load.

When the parenchyma is completely divided, hemostasis of the liver must be ensured, and the falciform ligament must be reattached to the diaphragm. The robot can then be undocked and the specimen removed from the abdomen in a laparoscopic bag. All of the ports are then taken out of the abdomen under laparoscopic visualization. Lastly both the fascia and skin are closed appropriately.

71.7 Left Hepatectomy

To begin the procedure, access is achieved in the left upper quadrant with a 5-mm optical trocar. Once into the peritoneal space, a pneumoperitoneum using 12 mmHg of pressure is created. Next, using a 5-mm 30-degree scope for visualization, additional port sites are placed 8–10 cm from one another. These port sites include the following:

1. A 12-mm port above the umbilicus for the robotic camera
2. A robotic port at the right subcostal region at the midclavicular line
3. A robotic port at the left subcostal region at the anterior axillary line
4. A 12-mm port 8–10 cm inferolateral to the camera port for assistance with larger instruments
5. A 5-mm left-side assist port 8–10 cm inferolateral to the camera

After placement of these five ports, the 5-mm scope is changed to a 10-mm 30-degree scope and is placed in the camera port. The initial left upper quadrant port should be exchanged for a robotic port. Once all ports are placed, the patient should be repositioned in 30-degree reverse Trendelenburg until completion of the procedure.

The overall approach to the left hepatectomy is similar to that of the right side. Once set up and the liver visualized, an initial exploration of the abdominal cavity should be performed. This inspection is to assess for any peritoneal or extrahepatic spread of the lesions. Any suspicious masses or nodules should be biopsied and sent to pathology for evaluation. The resection would only be applicable, for most pathologies, if there were no metastases or extrahepatic disease. First, the round, falciform, and coronary ligaments are dissected up to the left hepatic vein using a cautery instrument. Using a grasper through the right subcostal port, the left liver is moved anteriorly to expose the undersurface of the area. Using a cautery device through one of the left side ports, the gastrohepatic ligament is divided until the left lateral segment and caudate lobe. At the same time, a grasper through the assist port holds lateral traction. If the left hepatic artery can be visualized, then it should be separated at this point in the procedure.

An ultrasound used through the 12-mm assist port should be used next to assess both the anatomy of the liver and the location of the lesion and its resectability. Once resectability is confirmed, the robot is docked with Arm 1 in the left subcostal port, Arm 2 in the right robotic port, and Arm 3 in the left port that is located at the anterior axillary line.

Using the now docked robot, the portal dissection is started. A grasper in Arm 2 retracts the left liver anteriorly, while a cautery instrument in Arm 1 delineates the portal structures. Simultaneously, a grasper through the 12 mm port assists with retraction. The portal structures important to identify and isolate are the left hepatic artery, the left portal vein, and left hepatic duct. Once identified and isolated, the left hepatic artery is tied or clipped with a clip applier through Arm 1 and transected. In order to identify the left portal vein, the ligamentum teres is grasped by Arm 3 and retracted, so the left liver is pulled anteriorly. A grasper in Arm 2 is used to retract portal tissue to help isolate the vein. Once isolated, a silk tie is encircled around the vein but not tied, so it can be used to retract the vessel. A grasper in Arm 1 retracts the vein superiorly and to the left as to expose the total length of the vessel. The portal vein can then be ligated and transected using a vascular load via the 12-mm assist port. Next, the left hepatic duct is isolated with forceps in Arm 1, while Arm 2 continues to hold lateral traction of the portal tissue. The hepatic duct can then be clipped and transected.

To transect the liver parenchyma, follow the line of demarcation and use hook cautery to delineate the line of transection. The left hepatic vein is managed intraparenchymally during this process. Ultrasound should be repeated to ensure that the lesion will be included in the resection. On either side of the line of transection, tie a figure-of-eight stitch with size zero absorbable stitch. These will be used to retract. Along the already delineated line of transection, the parenchyma is coagulated using argon beam coagulation, and laparoscopic clips are placed as needed. Coagulation of the parenchyma is done up until the left hepatic vein, whereupon the vein is stapled with a vascular load through the 12-mm assist port.

When the parenchyma is completely divided, hemostasis of the liver must be ensured. As compared to the right hepatectomy, the falciform does not have to be reattached to the diaphragm in this operation. The robot can then be undocked and the specimen removed from the abdomen in a laparoscopic bag. All of the ports are then taken out of the abdomen under laparoscopic visualization. Lastly both the fascia and skin are closed appropriately.

71.8 Postoperative Management

Robotic surgery patients have a similar postoperative course of care to laparoscopic patients. Both modalities of surgery carry similar postoperative risks such as CO_2 embolism, pneumothorax, bleeding, bile leak, and hepatic insufficiency. Overall, robotic procedures appear to have lower needs for intraoperative intravenous fluids likely due to decreased blood and insensible fluid loss associated with minimally invasive surgery. Also, with decreased blood and fluid loss, postoperative labs should not be negatively influenced. Considering this, there is a likelihood that opting for a robotic procedure will have a positive impact on the patient's overall hospital course. The floor placement of the patient postoperatively is dictated by patient comorbidities and intraoperative factors and events, not on whether the case was done robotically or via other approaches. Therefore, postsurgical placement varies based on patient needs and medical status. Patients can be placed in the intensive care unit, an intermediate care floor, or a surgical step-down unit after the operation.

71.9 Advantages and Disadvantages of Robotic Approach to Hepatectomies

The advantages to robotic surgery, like the indications, are similar to the clinical benefits of a laparoscopic approach. It has been shown that minimally invasive surgeries of the liver yield improved outcomes with decreased blood loss, decreased length of postoperative hospital stay, and reduced morbidity in what is fundamentally a high-risk procedure.

There are also case-cohort studies that provide evidence that patients after minimally invasive surgeries, as compared to patients after open resections, receive less packed red blood cell transfusions, have a faster return to a normal diet, need less pain medication and pain management, spend less time in the hospital post-operation, yield better cosmetic results, and have fewer postoperative complications and a lower physiologic stress response. Also, between the two approaches, it has not been shown to have a significant difference in malignant tumor reoccurrence.

Advantages specific to robotic-assisted hepatectomy are that the robot allows surgeons to have better instrument control via wristed instruments and more degrees of freedom and the steady camera and improved vision allow for greater depth perception. This technology ideally allows for a more confident intraoperative course with suturing, vessel isolation, and blood loss control. Lastly, the use of the robot would possibly allow for resection of right posterior segments of the liver as well as central hepatectomies in areas that are not able to be accessed via the laparoscopic approach due to limited movements.

However, there are also disadvantages to employing a robotic approach to hepatectomies that should be considered. This includes access to the robot and the ability of the surgeon to use the new technology effectively. Depending on the surgeon's location and patient population, there also may be a lack of appropriate low-risk cases to prepare the physician on use of the robot. Also, it must be considered that the robot may impede responses to any intraoperative complications like hemorrhage due to the increased time it would take to convert the case to an open approach. However, employing the robot in a case has a lower risk of conversion to an open procedure than the laparoscopic equivalent. This trade-off must be weighed against the increased operative time that comes with doing a robotic case and the increased cost of the procedure.

71.10 Summary

In summary, the robotic approach to hepatic surgery, while relatively newer than other approaches, is both a growing technique and one that offers the benefits as discussed previously in this chapter. Robotic-assisted hepatectomies are still developing as technology and treatment patterns evolve. While there are no clear-cut recommendations on laparoscopic versus robot-assisted surgeries, the use of robotic technology should be considered when a patient must undergo hepatic resection, and the outcomes of these patients should be continued to be studied.