LIVER RESECTION FOR TREATMENT OF CANCER
MASSACHUSETTS GENERAL HOSPITAL, BOSTON, MA
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NARRATOR

Welcome to a live webcast from Massachusetts General Hospital in Boston. During this live webcast, surgeons will demonstrate a liver resection to treat cancer. Today’s program is part of Massachusetts General Hospital’s ongoing educational efforts to bring the latest information in health care to patients and physicians. During this program, you may send your questions to the OR surgeons at any time. Just click the MDirectAccess button on the screen.

SAM YOON, M.D.

Good afternoon and welcome to Massachusetts General Hospital. I’m Dr. Sam Yoon. I’m one of the surgical oncologists at the Mass. General Hospital. I’m sitting outside OR 43. Today we’re going to show you portions of a right liver resection or right hepatectomy. The patient today is a 69-year-old woman who actually was diagnosed in 1995 with obstructing colon cancer, for which she was treated. She was doing fine until October of this year, when she was noted to have a rising CEA. CEA is a blood test that can be diagnostic for colon cancer. She underwent a CT scan and MRI which demonstrated an isolated tumor in the right half of her liver. This was biopsied and confirmed to be a metastatic colorectal cancer. She had some other studies to rule out any other sites of metastatic disease and is now brought here for resection. So with that background, let’s go into the OR and talk with Dr. Tanabe.

KENNETH TANABE, M.D.

Welcome to the Massachusetts General Hospital. We’re in operating room 43 here. This is a relatively large operating room. It happens to be the one that houses the linear accelerator, when we use intraoperative radiation therapy. We won’t be using that for today’s operation, but we certainly appreciate the large space in the room today. Let me introduce you to the members of the operative team here. Dr. Jason Hall is one of our fourth year general surgery residents. Dr. Jim Cusack, one of my partners in surgical oncology. Our scrub technician, Ardina here. On this side of the ether screen over here, we have Dr. Chris D’Avignon, our anesthesiologist, and circulating nurses Chris and Amy.

We have already embarked on the operation a little bit. If I can get the overhead cancer to peek in here, we can show you a little site about what’s going on. We have the abdomen
open, retracted up on the rib cage here so we can peer in. This organ here indeed is the liver. The tumor, which you can’t quite see yet, is tucked way up underneath the rib cage, up in here, and these little white ties are called vessel loops or spaghettios, that we’ve put around specific structures. The blood flow into the liver, into the right lobe of the liver here, that we will be removing, needs to be divided before we go through the liver tissue and we’ll take that out. So one of the first things that we plan to do here is intraoperative liver ultrasound examination. One of the benefits of performing ultrasound examination here in the operating room is that this transducer we can put directly on the liver. We don’t have to shine it through the abdominal wall, but rather, we can place it directly on the liver. Here you can see, we’re looking at an ultrasound of the liver. The liver tissue itself is somewhat grainy in appearance and you can see some blood vessels crossing there. Right here we see in cross-sectional view the vena cava and one of the large veins draining the right lobe of the liver, coming in to the vena cava. Scanning over a little bit this way, we see some of the other large veins draining into the vena cava, that we will leave behind as we drain the left lobe of the liver.

Further down in this area, here, the black structures are blood vessels and the white, shiny echogenicity around it is the fat that tends to envelop these portal blood vessels. The liver has a couple of different blood supplies. One is called the portal vein, which brings blood back from the intestines into the liver. The other is the hepatic artery, which brings fresh arterial blood, so with the dual blood supply to the liver, we’ll need to cut off the blood supply to the lob that we’re removing. Here we’re looking at that blood supply and the white stripes around those black blood vessels are what we call echogenicity and represent, again, a little bit of fat that is around the blood vessels.

So we’ve looked at the liver quite carefully already with Dr. Duhant* Sahani* prior to coming into the operating room and we found no other liver metastasis, except for the one that we had seen on preoperative CT scan and MRI scan. We did find a variety of cysts and I’m showing you a cyst right there. We did find a variety of cysts, which are common in the liver. They’re benign and there’s no need to remove them. In addition, we found a large tumor, which I’m showing here. The subtle difference in gray scale on that screen is demonstrating the liver tumor here. It’s a fairly obvious tumor when we just look at the liver, which I’ll show you a little bit later, but in careful scanning of the entire liver, we found no other metastasis and we have learned that this is one of the more sensitive tests to look for other liver tumors.

I’m going to turn it back to Dr. Yoon right now, while we start preparing for a little bit more work right here.

SAM YOON, M.D.

There should be some slides next to me on your webcast that demonstrate some of the steps that Dr. Tanabe has already performed to get to where he is currently in the liver resection. The incision that Dr. Tanabe made is called a chevron incision. It’s a subcostal incision that goes below primarily the right side and extends over to the left side and there’s a midline extension from that subcostal incision in the midline, up toward the
sternum. Following that incision, Dr. Tanabe went in and explored the entire abdomen to ensure that the only site of disease is the single metastasis in the right lobe. That would include examining the colon for primary disease, as well as examining the peritoneal cavity for peritoneal disease. He did not find any other sites of disease and then went on to perform mobilization of the liver.

The liver is situated high up in the right upper quadrant of the abdomen. To operate on the liver, you have to bring it down from high up in the abdomen to work on it. There are various ligamentous structures that attach it to the retroperitoneum, to the diaphragm. He has mobilized significantly the right lobe of the liver. Of course, he has already shown you the intraoperative ultrasound that he performed to exclude other lesions and also to identify the tumor itself and to exclude other lesions. Another advantage of the ultrasound is that we can assess the vascular structures that flow into the liver, as well as the vascular structures that flow out of the liver and assess the relationship of the metastasis to these structures so one can perform a safe liver resection and not get into bleeding. Also, if you identify other smaller lesions within the liver, it can help you with biopsy. You can also, at the end of the procedure, if you’re worried about the vessels, use the ultrasound in combination with what’s called a Doppler to assess blood flow within the vessel.

KENNETH TANABE, M.D.

Sam, I can show our viewers here, one of the things that we’ve also already done is taken out the gallbladder, as it’s right in the line of where we’re going to be going through the liver. I can show you some of the structures that provide blood inflow to the liver here. This structure right here is called the portal vein. It’s one of the two blood supplies into the liver. It splits here, going to the right side and going to the left side. We have a vessel loop right here, around the right side, the right portal vein, and we’ll be dividing that. Interestingly, we almost got fooled, but didn’t. We assumed that this was the left branch, and indeed it is, but as we follow it up a little higher, we found another branch arising from that, heading to the right liver. Dr. Cusack is holding that up with the spaghettio, so this branch also we’ll divide before we go through the liver tissue.

Then, the anatomy here of the arteries is somewhat unusual. She has an accessory right hepatic artery that we found in its characteristic location posterolaterally in the porta hepatis and we have a spaghettio around that. In addition, right here is her usual hepatic artery. She has a left hepatic artery in here that you can’t really see, but up in the gastrohepatic ligament here, she also has an accessory left hepatic artery that we have a spaghettio around and this is arising from the left gastric artery. The value of getting these all dissected out is that by shutting down the blood flow to the liver before we go through it, we’ll have a heck of a lot less bleeding. The other thing to point out is that this is where her gallbladder went into the bile duct. This fairly large structure you see on top is her common hepatic duct. It’s actually quite large. We shot a cholangiogram x-ray to define the anatomy of her bile duct before going any further. Although the duct is a little bit on the large side, there are no abnormalities seen on that cholangiogram. Then we have a spaghettio here, around the right hepatic duct, because of course we’ll divide that
as well, so we’re going to get working here and we’re going to start dividing the artery, portal vein, and bile duct before we divide the liver tissue.

SAM YOON, M.D.

There should be a schematic possibly to the right of the live picture, showing the porta hepatis. The porta hepatis contains the structures that flow into the liver. There’s three structures, the bile duct or the common hepatic duct, the portal vein, and the hepatic artery, and these structures travel within the porta hepatis, which is covered with fat, which is the left side of the slide. Dr. Tanabe has already dissected off this fat in the porta hepatis and the view that you see on the screen is more similar to the right half of the slide, where you see the three structures flowing into the hilum of the liver. The common hepatic duct is on the right aspect of the porta hepatis and travels right and anterior. The artery is on the left, which is the red structure, and travels anteriorly as well. The portal vein, which is the largest structure posteriorly, travels behind the artery and the duct. Near the hilum, all three of these structures branch into a right branch and a left branch. Dr. Tanabe has shown you several anomalies that have occurred, both with the arterial system and with the venous system. Anomalies can also occur with the biliary system and this is one of the things that makes liver surgery quite difficult. There can be quite a number of anomalies that occur at the porta hepatis.

KENNETH TANABE, M.D.

Right now we’re just dividing the accessory right hepatic artery, the one that is arising from the superior mesenteric artery. We’ve already divided the usual right hepatic artery. Sam, I think we’ll use a stapler here to divide the right portal vein.

SAM YOON, M.D.

I guess I’ll talk a little bit about staplers used in liver surgery. I believe we have a slide that Dr. Tanabe prepared regarding staplers. It used to be, in the past, that all these structures would be dissected cleanly, clamped, divided, and tied with a suture. There has been, in the recent past, a lot more use of these what are called endovascular staplers. Actually, these were originally designed for laparoscopic surgery, designed to put through ports for minimally invasive surgery, but many liver surgeons have found these to be quite useful in dividing arteries, veins, and bile ducts. You just place the stapler over the vessel and fire, and the stapler applies a row of staples, both on one end and the other end, or a few rows of staples, both on one end and the other end.

KENNETH TANABE, M.D.

I can actually show them that right here, Sam, where perhaps you can see that this is the vessel that we divided, right here. I don’t know if the camera will be able to zoom in a little bit and you can see a row of staples right here and another row of staples right there. After stapling it, the device also slid a knife right down through it and divided that fairly large vessel that way.
SAM YOON, M.D.

So Dr. Tanabe has divided the right portal vein now with the stapler. This is the anomaly that he described earlier. This is an anomalous branch, the portal vein going to the right side, that he’s going to use just traditional suture tying on either side, followed by cutting.

I would encourage the audience, if they have any questions, to go ahead and email them. Beth, our handy assistant on my left, who you can’t see, is fielding your emails and giving us various questions from the audience.

Once person in the audience has asked, “Does the liver have to regenerate after a resection? How much does cirrhosis play in that regenerative process? What is the size of the largest tumor that one can remove?” The liver is one of the few organs in the body that, as an adult, has a relatively large capacity to regenerate. One can actually remove 70-80% of the liver and 70-80% of the liver will grow back. The primary period of that regeneration is usually within the first 1-2 weeks and we depend on that regeneration to prevent liver failure in the postoperative period. There is persistent regeneration after that, but the essential regeneration occurs early on, within the first couple of weeks.

Cirrhosis is essentially a chronic damage, a fibrous and inflammatory process of the liver, that severely limits the regenerative capacity of the liver. It’s induced by either hepatitis, chronic hepatitis B or C, or alcohol, or some other uncommon diseases. Cirrhosis does play a significant part in how we do liver resections. In general, depending on the severity of the cirrhosis, it really limits the amount of liver we can take out. As far as the size of the liver tumor, it’s not really the size of the tumor that really counts. It’s actually the location of the tumor. There are actually some relatively small tumors that, if located in a difficult spot adjacent to a major vessel, cannot be removed, and there are some very large tumors that, if located peripherally, can be removed.

KENNETH TANABE, M.D.

We’re dividing the right hepatic duct here. Dr. Cusack put a tie on the side that’s coming out and we’re about to clamp this other side.

SAM YOON, M.D.

Just to reiterate, there’s three primary structures that go into the liver, the portal vein, the hepatic artery, and the hepatic duct. He has already taken the right portal vein, as well as the anomalous branch. Now he’s taking the right hepatic duct. After that, he’ll take the artery and that would finish what we call the inflow to the liver.

I guess I’ll take this opportunity to go over some of the history of liver surgery. The liver traditionally has been thought to be a very difficult organ to operate on. Possibly those in the audience see a big brownish mass without much parts to it. Actually, it wasn’t until 1954 that a French surgeon and anatomist named Claude Funaud* described the segmental anatomy of the liver. The liver is actually divided into eight anatomic
segments that all have their own portal inflow and venous outflow. He described that segmental anatomy and that was really key to the blossoming of liver surgery and performing liver surgery safely. In the 1950s, the first anatomic liver resections were described. In the 1970s, we started identifying a lot more liver lesions and better classifying them through better imaging. CT scan and MRI have essentially revolutionized liver surgery. It enables us to see the lesion and the relationship to the inflow structures and the outflow structures, as well as the location in terms of which segment the lesion is in. Since the advent of those technologies in the 1970s, there has been a rapid increase in the number of liver surgeries that have been performed. From the 1970s to now, we have really been refining the techniques with which we divide the liver parenchyma and avoid blood loss, and also improved our perioperative care, such that now, in major centers, the operative mortality or death rate from liver resection is 3% or less, whereas prior to the 1970s there are some series that described mortality up to 50%.

I’m going to put up a schematic of the segmental anatomy of the liver. When you look at the liver, you see kind of a brown amorphous structure, but when a liver surgeon looks at the liver, they see the eight segments of the liver. Segments 2, 3, and 4 comprise the left side of the liver. Segments 5, 6, 7, and 8 comprise the right side of the liver. Segment 1 sits in the back of the liver and has components both on the right and left side. This understanding of the segmental anatomy really allows for the safe performance of liver surgery and minimization of bleeding.

I have another email question. One of them is, is there any bleeding in this operation. I guess we’re going to find out. That was one of the major problems with liver surgery in the past, has been life threatening hemorrhage. I talked about understanding the segmental anatomy of the liver and that really allows us to minimize bleeding. If you go in the correct planes and you know where the major blood vessels are in relation to those segments, one can avoid bleeding.

KENNETH TANABE, M.D.

We have divided all of the blood flow into the right lobe of the liver here, which is necessary before taking out the right lobe. I’m working a little bit in the inferior side of the principal plane here, that we’ll cleave the liver in.

SAM YOON, M.D.

It looks like Dr. Tanabe has divided all three structures. Now the hepatic duct has been divided and now he is dissecting out.

KENNETH TANABE, M.D.

Looks like we found yet one more somewhat anomalous branch to the right here, Sam, that we’re going to have to get around. I can point it out to you right here. Here’s the main portal vein. Here’s the stump of the right portal vein. Here’s a portion of what we
felt was the left but may actually end up being the anterior right coming up this way here. The anatomy in this region can be quite variable, individual to individual.

SAM YOON, M.D.

I’ll go over the maneuvers to reduce blood loss that we have learned over the past decades and, most recently, in the past few years. One of the things that really reduces blood loss, especially when you go across the liver parenchyma, is to reduce the venous pressure in the liver, the hepatic venous pressure. The hepatic veins take blood from the liver and return blood to the heart. Those veins seem to be the primary source of bleeding. If you can reduce the pressure in the hepatic veins, one can significantly reduce the amount of bleeding as one goes across the parenchyma of the liver. Things one can do is reduce the central venous pressure, which is essentially the pressure on the right side of the heart, which is where the hepatic veins go. That reduces hepatic venous pressure. One can also elevate the liver up off the back of the abdomen and that is performed by mobilizing the liver, as Dr. Tanabe has done, and also putting packs in the back of the liver to elevate it. That also reduces the venous pressure. There is also a technique called complete vascular isolation, where one can clamp the inferior vena cava above and below the liver and sometimes that requires shunting of blood around the liver. That is sometimes performed by liver surgeons. We often don’t do that here.

Another technique to reduce bleeding is to reduce the amount of blood flowing into the liver. We already were showing you the porta hepatis here, where the portal vein and the hepatic artery go through. You’ll see Dr. Tanabe, as he goes through the liver, perform what’s called a Pringle maneuver, where he puts a tourniquet around the porta hepatis and blocks off the blood flow into the liver.

KENNETH TANABE, M.D.

This is the device here that we will use to block off the remaining blood flow to the liver temporarily while we operate on it. Again, because she happens to have a bit of anomalous distal anatomy, one of the blood vessels doesn’t run in the portal triad here. She has an accessory left hepatic artery that we found out here, arising from her left gastric artery, and I have put a spaghettio around that, so as we come to the liver, we’ll occlude that as well. You can see on the undersurface of the liver here, perhaps, here’s one of these benign cysts that is just a variety of lesions that we find in the liver that have nothing to do with cancer.

So we’ve finished dividing the inflow to the right side of the liver and divided the right bile duct. This is the right bile duct here, that we’ve divided, and this is the right portal vein here, that we’ve divided, and the right hepatic artery is here, that we’ve divided. We’re now going to rotate the liver so that you can see what the backside looks like. One of the most important things in liver surgery is being able to move the liver, so we have purposefully cleared out and taken down all the adhesions from the prior operation to be able to displace the left lobe under the abdominal wall here.
You can already begin to see, perhaps...maybe not...It’s hard to see on the monitor but we’re already beginning to see demarcation of the liver where the left half of the liver, which is on this side, is relatively pink and well perfused, whereas on the other side, here, this is looking a bit dusky because we have cut off its blood supply. We’re now going to rotate the liver and look at its backside, where the venous drainage goes. Here, now, you can get a pretty good look at this tumor. This is the tumor that we’re taking out today. It’s a fairly large tumor. You can see it here, at about 4 cm on the surface, but it’s much larger than that underneath and residing in the right lobe of the liver here. As I continue to rotate the liver over, the reason we can do this is that we’ve already done a lot of the work in dividing some of the attachments to the liver back here, the right triangular ligament and so on and so forth. You can see back down here, perhaps, where the tip of my sucker is, the vena cava. This is the main blood vessel that returns blood back to the heart. The little clips along here are small veins that return blood from the liver back to the vena cava, that we’ve divided, to allow us to give it this exposure. She had yet one more vascular anomaly where she has an accessory right hepatic vein. Most people have one dominant vein that drains the right lobe. Maybe 15% of people will have a second dominant vein and she was one of those 15%. It’s a little bit hard to show you, but right here at the tip of my sucker is where a large hepatic vein, accessory right hepatic vein, was divided, where it went into the vena cava, down here. We’ve left the main right hepatic vein here for you to see, with this spaghettio around it. This is how blood gets out of the liver, back into the vena cava and back to the heart. This structure we’re going to go ahead and divide right now. Again, I think it’s relatively useful to use a vascular stapler her to do this.

SAM YOON, M.D.

I believe there’s a schematic of what you’ve done, Dr. Tanabe, rotating the right lobe of the liver all the way to the left and exposing the inferior vena cava and the short hepatic veins that have been divided already. I’ll put up another schematic, which shows how you’re dividing the main right hepatic vein from the inferior vena cava, using the stapler.

KENNETH TANABE, M.D.

Perhaps you can see, again, the staple line down here, where the stapler has divided the vessel and left a nice row of staples there, that prevents blood from coming out. So now we can look at our liver here and see a very nice line that demarcates the right lobe and the left lobe, which is exactly what we expect when we divide the blood vessels heading into the right lobe and the blood vessels coming out of the right lobe, so now we need to go through the liver tissue. The device that we have chosen for today is made by a company called Esculap. Basically, it disrupts tissue using ultrasonic energy and simultaneously it has an aspirator on it, suction on it, so it sucks up the tissue and simultaneously irrigates, if we need to, to prevent it from clogging up.

SAM YOON, M.D.
In terms of the liver parenchyma resection, there are several goals that we try to attain when we come across the liver. One is to try to use a technique where we can visualize the blood vessels that we come across so that we can tie them off or clip them to prevent postoperative bleeding. There are also multiple small bile ducts that we will come across during this dissection. We want a technique where we can actually see those ducts and tie them or clip them off to prevent a bile leak after the operation. In addition, we want to try to minimize the amount of ischemia that we subject the remaining lobe of the liver to.

The methods, if you have this slide up adjacent to the live picture, Dr. Tanabe has chosen the Cusa* technique. There are multiple other techniques, including what is called the water jet dissector. There’s also a clamp fracture technique where we use a Kelley clamp to come across, which is a very commonly used technique. There are a variety of other things that many people have tried. Dr. Tanabe’s favorite technique is probably using the Cusa*.

KENNETH TANABE, M.D.

Here we’re using electrocautery to come through the capsule of the liver, pretty much along the plane or line that we plan to come through. This is a so-called dotted line for us to follow while we’re heading through the liver here. You can see that even with just a superficial cut to the liver, it really kind of wants to bleed, so we’re going to do a couple of things here to reduce the bleeding as we come through the liver. One of the things that we’ve done here already is that we’re running very low central venous pressure. It’s really an important principle to work together as a team with Dr. D’Avignon, our anesthesiologist here. It would be all too easy for him to essentially tank the patient up and start out with a lot of fluid on board, recognizing that perhaps we’re going to lose some blood. We’ve learned, though, that by giving all of the fluid ahead of time and raising the PVT, that it also raises the hepatic venous pressure and that causes more bleeding. We can stop bleeding from the portal veins and hepatic arteries. We’ve already divided those. We can also use the Pringle maneuver that Dr. Yoon described, but what we can’t do is, it’s more difficult to control bleeding from the hepatic veins, so by keeping the hepatic venous pressure relatively low, we can dramatically minimize bleeding from the hepatic veins. Another thing that I think we’re going to do here, in this case, is we’re going to raise the position of the liver relative to the heart so that, by having the liver higher than the right atrium, the hepatic venous pressure will be lower.

So here we are going to lop off the blood inflow to the entire liver here with this tourniquet. I guess it’s akin to shutting down the water supply to your bathroom before you start working on the pipes there.

SAM YOON, M.D.

I will add a word of caution about using the Pringle maneuver when you’re doing a liver resection. You have to remember that the structures in the porta hepatis, the artery and vein, are supplying the blood flow to the liver. By using the Pringle maneuver, you’re excluding the blood flow to the liver, the normal liver on the left side, that you want to regenerate after the operation, so one must be quite careful in the amount of time that you
apply the Pringle. Some surgeons apply it for just five minutes and then release it for a minute. Others apply it for 15 minutes, then release it for 5 minutes or so. It has been described that you can apply it for up to 45 minutes or even an hour, but in general we do not do that for fear of liver failure postoperatively.

One of the other caveats to doing the Pringle maneuver is, when you’ve denuded the porta hepatis of all its fat and things, you can apply that a little bit too tight and the bile duct can actually form a stricture afterwards, so you have to be quite careful in the amount of tension that you apply to the Pringle maneuver.

As Dr. Tanabe goes through the liver parenchyma here with the Cuza* and as he places clips on bile ducts and veins that he identifies on either side, I think I’ll answer one more email question from the audience so they don’t feel we’re ignoring them. Somebody asked, do you perform preoperative portal vein embolization? The answer to that is yes, we do perform preoperative portal vein embolization. The theory behind portal vein embolization is that we know we can remove 70-80% of the liver and it will regenerate, but sometimes the anatomy of the tumor or because there are several tumors, you have to resect more than that, or we may feel that the liver’s regenerative capacity is compromised due to cirrhosis or some other liver damage, so you can embolize the portal vein going into the side that you’re ultimately going to resect. That causes, over the next several weeks, hypertrophy of the opposite side, so you have more liver that’s generated on the opposite side, so you can extend the boundaries of liver resection, so we do do that here in selected cases to increase the resectability of certain tumors. There are other techniques that are utilized here for borderline cases, including doing staged hepatic resections, giving new adjuvant therapy to reduce the size of the tumor, and performing resections in combination with radio frequency ablation.

KENNETH TANABE, M.D.

As we go through the liver tissue here, I think you can see that perhaps it is a lot drier than the average viewer might have thought it was going to be. There’s really no blood pouring out here. We’re able to identify individual vessels and ligate them, or identify and divide them individually here, which is the key to liver surgery. We teach the residents that it’s not how fast you go through the liver. It’s how well you identify the vessels ahead of time and control them ahead of time so you don’t have a lot of blood loss. One of the maneuvers that Dr. D’Avignon used here to help reduce blood loss also is hemodilution. Before starting this portion of the operation, Dr. D’Avignon took of 750 cc of blood into a bag, if you will, and then replaced that with crystalloid solution, so her blood is a little bit thinner right now. Her central venous pressure is lower. Her tank is less filled as well. But it also means that the concentration of red cells, if you will, in the blood that we lose is a lot less. We’ve hemodiluted her. Once we finish the portion of the operation that involves blood loss, we’ll go ahead and give her that blood back. So again, you can see that the Cusa* device that I have in hand here is quite nice at using the ultrasound energy to disrupt the tissue and then on the tip of it is a little sucker that sucks up the tissue. Then Dr. Cusack here, as I dissect off vessels for him to see, he’s able to
either use small titanium clips or use the electrocautery to burn the vessel. In the case of larger vessels, we’ll go ahead and tie them off with suture material.

We also have at our disposal here something called the argon beam coagulator, which I’ve got in my hand here. You can see here that this is a nice device to provide cautery without actually touching the tissue. It’s like electrocautery, but with the electrocautery, we have to make direct tissue contact to close the circuit. In this case, the argon gas flows from the tip of the argon beam coagulator and it’s argon gas that’s ionized, where basically electricity flows through the ion gas, so it’s not a laser beam, but it sort of seems like a laser beam, the way we can use it to cauterize tissue without even touching it.

So peripherally out here in the liver, it’s pretty straightforward. There are usually few, if any, large blood vessels and the going is fairly smooth. It’s as we get further down into the liver that we start running into the larger hepatic veins, and those are the ones that we have to be careful how we control. The other thing is that we’ll keep mindful of the clock here in that we have shut off the blood flow to the liver with our Pringle maneuver, so we’re going to limit that in this first time around here to 15 minutes or so.

SAM YOON, M.D.

As you’re taking off the Pringle, I’ll answer one more email question. A viewer writes that she is having a partial hepatic lobectomy for a malignant plum-sized tumor. She wants to know what her hospital stay is going to be like. We do have a slide on topical hospital admission for liver resection. Most patients, as was this patient, are admitted on the day of surgery and usually undergo surgery in the morning. These are often long operations. Usually for standard liver resection, patients go to the recovery room. Then, based on how they do in the recovery room, usually later that day or the next day, they go to the floor. We do periodically have patients who have underlying medical conditions or other issues that necessitates them going to the intensive care unit for a number of days, just to have a higher monitored care setting, to make sure that they recover well in the immediate postoperative period. Essentially, for the average patient, on the first postoperative day, they go up to the floor. We get them out of bed and sit them in a chair. If they can, they can get up and ambulate a bit. On the second postoperative day, we definitely get them out of the chair and walking around a bit, and even give them some liquids to start off. That regimen is continued and advanced over the next 5 days or so. By the time they leave the hospital, after 5-10 days, you’re drinking liquids, you’re eating something, although you’re probably not eating normally and you’re probably passing gas out your bottom and able to walk around a bit. One of the big things that people complain about after major liver surgery is fatigue and probably that fatigue for a major liver resection will last 8-10 weeks. For a smaller resection, it may last only about a month.

Oftentimes, when you’re going through the liver, you’ll hit a vessel that will bleed. If you don’t get across it fully and just come across it harshly, that’ll bleed and we often control that with suture ligation.
I guess I’ll go to yet another email question. Someone asked, if a tumor invades a big vessel, do you continue the operation? One of the points I tried to make earlier is that we often don’t run into very many surprises these days as to where the tumor is in its relationship to major blood vessels. The imaging quality with CT scans and MRI lets us know very accurately the location of the tumor and relation to the large blood vessels that are in the liver. Also, as Dr. Tanabe demonstrated, we can use ultrasound to identify the tumor and relationship to the major portal veins, hepatic arteries, and hepatic veins, so we can pretty well delineate in the operating room as well the relationship to the major vessels. So the answer is, we probably wouldn’t encounter a situation where a tumor that we are looking at is invading a vessel unexpectedly. Now, it is possible that we would find a second tumor that may be close to a vessel and we can assess that by ultrasound at the time of the operation.

I guess I’ll talk a little bit about some of the liver surgery, in particular, that is done here at Mass. General. We have the Tucker Gosnell Hepatobiliary Cancer Clinic here and we have medical oncologists, radiation oncologists, and surgeons that all have a special interest in taking care of patients with liver cancer and tumors in the liver. We see a relatively high volume of liver surgery here. One of the viewers has asked, how do I pick a hospital to go to regarding liver surgery? It’s clearly been demonstrated that places that do more liver surgery have better outcomes and lower mortalities, so I think one of the primary issues regarding that question is to go to a place that sees a fair number of these lesions and has specialists, liver surgeons, hepatologists, as well as medical oncologists and radiation oncologists. Actually, GI radiologists too. The radiologists here give us a lot of help in looking at these tumors and identifying relationship to important structures and looking for other lesions as well. We also have good interventional radiologists to help us out when we run into issues regarding the need for biliary stenting, biliary procedures, or for drainage of collections.

KENNETH TANABE, M.D.

I’m taking off the Pringle clamp for a second here to so-called give the rest of the liver a drink. Again, I think the viewers can probably get a good sense for the difference in color of the right lobe and the left lobe here. Where this white sponge is right now, tamponading blood vessels, that’s where we’re making our split, if you will, to go through the liver. It is important, as Dr. Yoon had mentioned, to try to give the liver a little bit of a drink once in a while, some fresh blood inflow to keep it rejuvenated. You can probably intermittently cut off the blood flow in a normal liver, someone without cirrhosis, for a couple of hours, as long as you give it intermittent drinks. We tend to keep it at well below 60 minutes total, though, in most of our cases. You can see that the blood loss is really quite minimal. You can’t see the suction canisters from the TV monitors, but they have very little blood in them. My guess is that it would be pretty unlikely that this patient is going to need a blood transfusion associated with this major liver resection.
Here is this tourniquet that we’re going to go ahead and cinch down again to block off the blood flow to the liver. We have a replaced left hepatic artery that’s not in that tourniquet and we’ll occlude that with a separate little clamp there.

SAM YOON, M.D.

Obviously when we take the Pringle off, there’s increased bleeding from the portion of the liver that is staying on the left because it now has the portal venous inflow and hepatic arterial inflow. We use that time to take a break a little bit and Cuza* the raw edge of the liver. Now Dr. Tanabe is going through the liver parenchyma again using the Cuza*.

One of the viewers has asked what types of liver tumors can we resect. The most common liver resection we perform here for tumors is actually what this woman has, for isolated colorectal cancer or liver metastases. Essentially someone is an operative candidate if they have disease limited to their liver and this disease is situation such that all the metastases can be removed and we can leave enough liver behind that it’s going to regenerate and the patient will not go into liver failure. There are some other tumors that we perform liver resections on. Those include primary liver tumors, hepatocellular carcinoma, or hepatoma that occurs often in cirrhotic patients. As we talked about before, though, cirrhosis really limits the amount of liver resection we would perform. There is also cholangiocarcinomas that occur within the liver. There are also some other metastases that we sometimes consider resecting if they’re isolated to the liver. Those include sarcomas, breast cancer, or even melanomas, but again, the caveat is that the metastatic disease has to be isolated to the liver. We have to be able to get rid of all of the metastatic disease and leave enough normal liver behind to regenerate and prevent liver failure.

I’ll put up on the screen some of the studies looking at the results of liver resection for metastatic colorectal cancer. There are numerous surgical series with many patients and the number of patients increases as you get to more recent series, as the use of liver resection for metastatic colorectal cancer has increases, but you can see that in the series, the five-year survival, five years after operation, is anywhere from 25 to 39%. As you see in the more recent series, the operative mortality is quite low, usually less than 6% and often closer to 3%, so the results for liver resection are quite good in a temporary series. Clearly this is an effective treatment modality for patients with colorectal cancer.

KENNETH TANABE, M.D.

We’re going to use the stapler here to finish this last little segment, if you will. Visibility here is a little bit limited, so the safest thing, knowing there could be some large hepatic veins there, is to use the stapler. With that maneuver, here comes this right lobe of the liver. While Dr. Cusack shows you the right lobe of the liver there, I’m going to keep a little bit of pressure here on the left lobe to minimize any bleeding.

JAMES CUSACK, M.D.
This is the right lobe of the liver. Here’s the area that we had great difficulty in seeing, up near the dome of the right lobe of the liver, at the location of the tumor, and then our cut surface of the liver here.

KENNETH TANABE, M.D.

So let’s see here, Jim. Here’s the cut surface of the right lobe of the liver here. This is the tissue we went through. You can see barely right here, this is the staple line where we stapled off the right hepatic vein, that was draining the right lobe of the liver into the vena cava. As we turn it over this way, you can see here the tumor again. I don’t think you get a good sense that underneath what you can see here, this tumor is probably, I can feel it more out along there, which is why we decided to do the full right lobe of the liver resection. This down here, where we cut through, this is the principal plane dividing the right lobe and the left lobe. This is right where the gallbladder lies. You didn’t have the opportunity to see the gallbladder because we had taken it out prior to your joining us here in the operating room, but in the operating room, we draw a line between the gallbladder and the suprahepatic vena cava and it’s that line that divides the right lobe. Those are surface landmarks that help us divide the right lobe and the left lobe, which Dr. Yoon had pointed out is actually anatomically divided by the middle hepatic vein.

We’ll come back to the overhead camera and take a peek into the wound to see how things are going here. Here we can look at the edge of the remaining left lobe of the liver here and you can see that it is relatively dry. From your vantage point, you may not be able to pick up what I can see, which is that there’s just a little bit of bile, a little bit of green staining right down here. I think I’ll over-sew that, or maybe just put a clamp on that. One of the complications of this operation is bile leaks and it collects in the abdomen. One of the ways that we have minimized bile leaks is by specifically looking for them at the end of the liver operation. We’re going to put a cannula into the cystic duct and inject methylene blue to look and see if we see any leakage here from the raw surface of the liver. If we do, at that time we’ll over-sew the little bile duct leaks. I’ve found this to be an exceedingly effective way of reducing the incidence of these leaks. At the very top of the liver here, you may be able to see the middle and left hepatic vein draining the left lobe of the liver back into the vena cava. One of the things that you may also notice here is, you may see this structure bouncing around here. That’s the vena cava and the fact that you can see it bouncing around means that it’s really not that full, and that’s exactly the way Dr. D’Avignon has helped us out, by keeping the patient a little bit dry. You can see the vena cava almost completely collapses at times. During a breath, the respiration, it fills up, but the rest of the time, it almost collapses flat. That means we have a lot less blood in the veins of our liver and it means a lot less bleeding. I believe you can see here the raw surface of the liver. There’s essentially no blood. I think our blood loss in this case is 100 cc, 100 ml or something like that.

So we’re going to let the blood flow back into the liver here and take another look and simultaneously we’ll get ready to cannulate our cystic duct and look for those bile duct leaks. It’s certainly anticipated and hoped that this patient will have a pretty smooth
recovery. Again, the argon beam coagulator is nice because, unlike the electrocautery, we can cauterize the tissue without actually touching it because the argon gas flows from the tip and is ionized and basically completes the electrical circuit.

So now, having completed what could have been the blood-losing portion of the operation and actually turned out not to be blood-losing, but Dr. D’Avignon is also going to reinfuse her own blood back into her. We’ll probably spend 10-15 minutes here, drying up, to make sure that this liver edge is perfectly dry before we start closing.

We don’t use any fibrin glue. We found that to be (a) expensive and (b) not helpful with this technique, keeping the CVP* nice and low, identifying blood vessels before you cut through them, controlling them before you cut through them, and keeping blood loss to a minimum, so we’ve really not found a need for use of fibrin glue. On occasion when there’s an oozy part, we might use something called a munchy, which we refer to, which is basically Surgicel wrapped around gelfoam, and we’ll apply that topically to the liver. Here’s a munchy, which is a sheet of gel foam broken up and wrapped with Surgicel. We apply it to the liver like this, with a little pressure over it. What we’re going to do now is, we’re just going to go ahead and pack the liver off like this to help with our hemostasis. Then we’re going to cannulate our cystic head so we can inject some methylene blue here.

SAM YOON, M.D.

Some of the potential complications, as Dr. Tanabe is going over that, that we’re trying to take care to avoid include, for liver resections, bleeding, leaks from the bile duct, which could cause biloma or collection of bile. It’s called a biliary fistula if it comes out through the skin. If we have some postop collections from either blood or bile, they can become infected and cause an abscess. Some of the other complications include liver failure. If for one reason or other the liver doesn’t regenerate properly, that can be a fatal complication.

KENNETH TANABE, M.D.

I’m going to put this cholangiocath into the cystic duct right here. I’m going to loop a tie around this to make sure that we have a fairly watertight seal. This is actually the second time we’re doing this in this case because early on we shot a cholangiogram. We put this catheter in and put dye in and took x-rays because we were a little bit concerned about the size of the common bile duct in the setting of many gallstones. We were afraid that possibly a gallstone passed into the common bile duct. Here, I’m going to occlude with my fingers here, distally, and see if the saline goes in. I’m struggling a little bit here. I’m trying to get distal to my catheter and we’ll inject this way. Okay, so that goes in well.

We’re now going to switch over to this syringe that has methylene blue in it and I’m going to introduce methylene blue into the bile duct this way. After we inject half of it, we’ll take a look here at the raw surface of the liver. What’s nice about the methylene blue is that it’s pretty easy to spot. As a matter of fact, we can go ahead and put a nice
white sponge over the liver and I’ll occlude distally and, Jason, you can go ahead and inject the rest of that methylene blue there. That looks good. Let’s take a look at the liver here and nothing blue. We certainly don’t see any blue leaks and Dr. Hall is injecting it under a fairly high pressure as well, so I think it means that the little bile ducts that we came across while going through the liver, we successfully identified ahead of time and tied them off or put clips on them, so this means that our chances of having a bile leak later on are exceedingly low, low enough where we’re not even going to leave a drain in the patient. We’ve learned that leaving a drain in under these circumstances doesn’t reduce the risk of a biloma or bile leak and it doesn’t change the likelihood that we would, if she did develop a biloma, need to drain it under CT scan guidance, so you can see a little bit of the blue dye there squirt out because it was under pressure. So we’ll irrigate a little bit here and then close up.

So my thoughts are that fortunately today’s liver resection went quite smoothly and, nicely, we found only the one tumor that we were expecting to find. It came out with very good surgical margins. Dr. Yoon explained to you a little bit about her tumor biology and she has an excellent chance of being cured. Of those that relapse, most commonly it’s because the disease is present right now and we just can’t diagnose it. We have looked at her liver as carefully as we can, including intraoperative ultrasound exam, and find no other evidence of disease, so we and the family will keep our fingers crossed that this keeps her out of trouble for a long time.

SAM YOON, M.D.

That was very nice, Ken, and very nice for the whole surgical team. This is a team effort and I think that liver resection went very well. I want to thank everyone for tuning in and watching this webcast of this right hepatectomy. I believe there are some links on your screen that you can click on if you have questions or further emails or want some contact information. We’re happy to respond to those at a later time.

With that, I’d like to thank the audience for joining us. Have a good night.

NARRATOR

Thank you for watching the live liver resection procedure from Massachusetts General Hospital in Boston. To make a referral, make an appointment, or request more information, please click the buttons below.