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CHRISTOPHER B. HUGHES: Hi. I'm Dr. Christopher Hughes. I'm surgical director for liver transplantation at the Starzl Transplant Institute at the University of Pittsburgh. And I'm here to talk to you today about living donor liver transplantation in patients with advanced cancers. Living donor liver transplant procedures have given us an opportunity to transplant patients that otherwise may have no options. Those are patients with advanced cancers.

And the specific ones I'm going to talk about today are advanced hepatocellular carcinoma, cholangiocarcinoma, and colorectal metastasis to the liver. And a lot of this ability to transplant patients with living donor transplants and to do the advanced cancers requires that the state of the transplant program be healthy to be able to handle the risk associated with these patients.

Living donor liver transplant allows us several opportunities. One is to be able to schedule the operation. We know when the patient's going to be transplanted, and it's not going to happen at an unexpected time. We have been increasing our living donor liver transplant program over the past number of years. In the past few years particularly, we've seen an increase in our ability to do these transplants. In 2020, we reached almost 100 living donor liver transplants. And we're on pace for that again in 2021.

Of course, doing patients with advanced cancers means that you have to be able to stay in line with the SRTR data, the Scientific Registry of Transplant Recipients data, which is compiled on every transplant center regarding graft and patient survival to make sure that the transplant center is doing a good job, basically, of taking care of patients. And when you have patients that are high risk, such as these patients with advanced cancers, you have to make sure your program is healthy to be able to support such difficult patients who have potentially more marginal outcomes.

The first patient is a patient with advanced hepatocellular carcinoma. This is a 47-year-old female who was diagnosed with fibrolamellar HCC back in 2001 at the University of Washington. She had a liver resection at that time and then recurred and had another liver resection in September of 2007. She had CT confirmation of progression, and was felt to be a liver transplant candidate at that time, and was listed in California for a liver transplant, but then subsequently developed a right lower lobe lung nodule, which was confirmed metastatic HCC. And she was removed from the transplant list, because this would put her outside Milan criteria.

And she would not be able to receive a deceased donor liver transplant or at least would not be able to receive MELD exception points to get her high enough on the list to receive a deceased donor liver transplant. So she underwent another resection of another liver lesion and followed by a lung ablation and several liver ablations fighting metastatic disease. She was placed on chemotherapy with nexavar for eight weeks and underwent another liver resection in 2014. She was placed on opdivo in 2015. And you can see had another liver resection and two lung ablations in '16 and '17.

Interestingly, this patient was fighting this disease for 17 years. And that persuaded us that this was a favorable biology of tumor in the sense that it was treatable, even if we had to do some repetitive procedure. She obviously has lived 17 years with her disease. We felt that she might potentially be a candidate for a living donor liver transplant as long as we didn't find any further evidence of extrahepatic disease.

And it had been a year since her last treatment. And that was a lung ablation of a small nodule. And she had no evidence of further extrahepatic disease for that year. And she presented to us in 2018. This is her preoperative CT imaging showing some large amount of tumor on the right lobe of her liver. Here's another picture. But her CT scan and chest X-ray showed no evidence of pulmonary disease at that time. You can see her chest X-ray looks relatively normal.

We felt she was a candidate for living donor liver transplant and performed this procedure in April of 2018. We did an exploration first, which we standardly do for patients with advanced cancers. We explore the abdomen of the recipient first before taking the donor to the operating room to make sure that we don't find any evidence of extrahepatic disease, which might make us stop the procedure.

She received a left lobe graft like this drawing here, we add a middle and left hepatic vein with a single cuff, two arteries, two bile ducts, and the left portal vein. We anastomosed the middle and left hepatic vein confluence from the donor to the middle and left hepatic vein confluence of the recipient. Of course, the recipient's right hepatic vein is oversewn, because this was at the time of the explant of her entire native liver.

We did a main portal vein to left portal vein anastomosis. There were two arteries. So we used the right hepatic artery and the gastroduodenal artery to anastomose the two separate arteries from the left lobe. One was from the segment four portion of the left lobe, and the other artery was from segment two, three. So these were sewn as separate anastomoses.

And then we had two left hepatic ducts which were in close proximity. So we sewed these as a single anastomosis to Roux limb, leaving an external biliary catheter in each duct. Total operating time was about 15 hours. Cold ischemia time was 164 minutes, and warm time was 27 minutes. She required six units of blood and one unit of FFP.

This is the explant from the surgery. This is showing the tumor inside her liver on cut section there. She developed a splenic artery steal post transplant. And this caused low flow state in her hepatic artery. Therefore, she had an interventional procedure to coil off the splenic artery, which resolved the steal and returned her hepatic artery flow to normal.

Currently, she has no evidence of intra-abdominal metastasis. This is now more than two years out. But she did develop pulmonary metastasis, which we saw just shortly less than a year after her transplant. So she had multiple small pulmonary nodules. So she had her liver transplant in April of 2018. She underwent a VATS procedure, a right lung VATS, in October of 2018.

In January of '19, she had another small nodule removed. These are the small nodules that were removed. These are on the order of about 8 millimeters. And she had a CT guided left lung cryoablation times two. She's now almost three years post living donor liver transplant and is receiving chemotherapy, but otherwise doing well.

The second patient is another patient with advanced hepatocellular carcinoma, 31-year-old female, again with significant hepatocellular carcinoma confirmed on biopsy. She had lost about 20 pounds since her diagnosis. She had undergone transarterial chemo embolization times two, both in October of 2014. And she received a living donor liver transplant in 2015. Her brother was her donor.

This is the extent of her disease, significant replacement of her liver with hepatocellular carcinoma, with no evidence of extrahepatic disease, which seemed a bit shocking. But she had no evidence of extrahepatic disease. She had a normal preop bone scan, normal chest CT. She had molecular and genomic pathology testing. We do a study called-- that we look for a fractional allelic loss, which is looking for basically genetic disarray within the tissue, the biopsied tissue. A fractional allelic loss of less than 20% suggests a more favorable prognosis, and hers was at 7.7%.

She received a left lobe graft from her brother. We have the middle and left hepatic veins here. There was two bile ducts. One was left duct. One was a small caudate duct. These were close together in close proximity. The left hepatic artery and the left portal vein, we reconstructed the same way we did the last case as far as the outflow and the portal vein inflow. We did a right hepatic artery to donor left hepatic artery anastomosis for the arterial inflow. And again, the bile ducts were in close proximity. And therefore, they were sewn as a single anastomosis to the Roux limb.

Total operating time for this case was 12.3 hours. The graft weight was 492 grams with a flow rate of 1,000 mLs per minute. This is portal vein flow. We like to see a portal vein flow between 100 and 200 mLs per minute per 100 grams of tissue. So she was at the upper limit of normal for that. And her hepatic arterial flow was good at 75 mLs per minute. The transfusion requirements for this case was 2 units of blood with no FFP, no platelets, no cryo.

This is the explant from her liver. It's largely replaced with tumor, as you can see. One year postop, she developed pulmonary nodules. She was started on sorafenib, and later FOLFOX was added. Unfortunately, she subsequently developed metastasis to the cervical vertebrae, L5, T7, and T8, lumbar vertebrae as well. And she died in January of 2019. She survived almost four years after transplant. This was the second case of advanced hepatocellular carcinoma.

Our next case is mixed hepatocellular cholangiocarcinoma. This would be a intrahepatic cholangiocarcinoma. We have a protocol for treating patients with either mixed hepatocellular cholangiocarcinoma or intrahepatic cholangiocarcinoma. And of course, these patients really can only be transplanted with living donor liver transplants, because the United Network for Organ Sharing does not allow MELD exception points for patients with intrahepatic cholangiocarcinoma. So there's really no way for them to get to the top of the waiting list, unless it's by their MELD score which would mean that this patient would be very sick as well as having advanced cancer.

This patient is a 65-year-old female with NASH. She had hepatic encephalopathy, chronic portal vein thrombosis, and a splenal renal shunt. She had an ultrasound in 2018 that showed a 3 and 1/2 centimeter mass in the right lobe and a biopsy that showed a mixed tumor. Her AFP was 105. CA-19-9 actually was less than 2. She was started on gemcitabine cisplatin, which is part of our preoperative regimen for these patients. They're to receive at least six weeks of chemotherapy.

She had transarterial chemoembolization and May of 2019. And she was referred here for possible transplant. She had a negative workup for extrahepatic disease, including a negative bone scan. And she was presented to our transplant committee in October of 2019, where she was approved for living donor transplant. This is her tumor in the right lobe, about a 3 and 1/2 centimeter mass in the right lobe.

She has chronic portal vein thrombosis. This was not a tumor thrombus and was not in the region of the tumor. This was chronic portal vein thrombosis, which had been known. She had a living donor liver transplant in November of 2019. The donor was her son. Again, we explored her first to make sure there was no evidence of extrahepatic disease, and none was found.

This is a drawing of what we saw. This was portal vein, and this is the splenic vein and SMV confluence to make the portal vein, which then branches to the left and the right portal vein. There was thrombus, which extended back to that confluence, which was very dense and unable to be thrombectomized. Therefore, we ligated the portal vein as part of the explant of the disease liver.

We then brought in the allograft, which was a right lobe graft from her son who was her donor. And we created an iliac vein jump graft from the recipient superior mesenteric vein to the donor right portal vein. And this iliac vein graft came from stored vessels from a deceased donor. This was the outflow of her liver from the donor's liver. She had three cut surface veins, two from segment eight and one from segment five, in addition to the right hepatic vein in its normal position. She also had an artery portal vein and two bile ducts.

And if you remember anatomy wise, the [INAUDIBLE] of the right lobe are labeled. They're five, six, seven, and eight. Five and eight of the two anterior segments. They're divided by the plane of their right portal vein. And the segments six and seven of the posterior ones. They're divided from the anterior ones by the plane of the right hepatic vein. When we reconstruct the right hepatic vein, we make an incision [INAUDIBLE] vein to the parenchyma.

And we use a segment of deceased donor iliac vein to create a hood to anastomose to the right hepatic vein to make it larger, because we need a large outflow tract to prevent stenosis. This is very important in living donor liver transplantation that the outflow be excellent. And adding this graft makes us increase the size of the anastomosis, so we don't get stenosis there. We then can take that right hepatic vein with the added hood graft and anastomose it and to side to the recipient vena cava. And that'll provide the primary outflow for the allograft.

Although, we still have to deal with these cut surface veins. For those, we again use deceased donor iliac vein as a graft. And we do sequential anastomoses from these cuts surface veins with 7.0 PROLENE running suture that allows these veins to drain into the iliac vein graft and then we anastomose that to the end of the middle/left hepatic vein of the recipient, which we had left open to be able to anastomose this part of the outflow tube. So the two outflows for this allograft are through right hepatic vein. And through the iliac vein jump graft to the middle left confluence.

We then anastomose the SMV jump graft to the right portal vein. We anastomose the right hepatic artery to the right hepatic artery. And we anastomose the two bile ducts separately as separate anastomoses, because they had more than 2 centimeters distance between them, separately to the Roux limb, leaving an external biliary catheter in each duct.

This operation was nine and a half hours. The graft weight was 980 grams, which is a good size graft. Portal vein flow was 1.64 liters per minute, which is about one and a half-- excuse me-- 150 mLs per minute per 100 grams of tissue, which is right in the range we want it to be. Hepatic artery flow was 70. Portal pressure was 7. Jump graft flow was 0.15 liters per minute. And this patient required no blood transfusion for the procedure.

This is the explanted liver. The explant pathology showed a moderately differentiated primarily hepatocellular carcinoma, but with foci of cholangiolar differentiation. So this just confirmed that this was a mixed tumor. It was actually 5.5 centimeters in its greatest dimension. And the nodes from this liver were negative.

This is the explanted liver with the tumor that you can see here. The patient received no chemo postoperatively. In [INAUDIBLE] when we had originally looked at her follow-up, she had no evidence of mets at six months, and she still has no evidence of recurrent disease. The SMV jump graft is patent. As you can see here, this is a portal vein. These are in different cuts. But you can see where the portal vein is patent there through the SMV jump graft.

Patient four is a patient with cholangiocarcinoma. She is a 46-year-old female with primary sclerosing cholangitis diagnosed in 2007. She presented initially with fatigue, jaundice, and mild encephalopathy. Her MELD score was 11. And there was concern, in her case, for an increasing CA-19-9. This was her CA-19-9 over the course of the few years prior to coming to see us. And when she saw us, her CA-19-9 was over 200.

So being that there was concern for possible hilar cholangiocarcinoma, she underwent ERCP in May of 2017. The brushings were negative. She had next generation sequencing looking to find any genetic mutations, which might help us with the diagnosis. But of course, this diagnosis of hilar cholangiocarcinoma can often be very difficult. She was a candidate for transplant. And we treated her as though she would likely have cholangiocarcinoma. This is her preoperative imaging.

Her living donor liver transplant was scheduled for September of 2017 with her husband as her donor. When we operate on a patient that we think has cholangiocarcinoma, before we take the donor to the operating room, we do three things. Number one, we sample the-- or resect the hepatic arterial node and have pathology do a frozen section to see if there's any tumor in this node. We also do the [INAUDIBLE] node and have pathology do frozen section analysis to ensure that there's no cancer there.

Basically, we're looking for any evidence of extrahepatic disease. And then, the third thing that we do is we resect a segment, a ring, of the common bile duct and ink the distal margin, so that the pathologist can tell us if there's any extension of cholangiocarcinoma down the duct. And the pathology from those showed a lymph node that had metastatic cholangiocarcinoma involving that one node. The other node was negative. And there was no evidence of tumor distally in the bile duct.

Because we had such difficulty diagnosing any tumor in this patient preoperatively, and we only had one node positive, we gave the patient the benefit of the doubt and felt that she would do better with proceeding with transplant. She received a right lobe graft from her husband with a right hepatic vein, a single segment five vein on the cut surface, and then a single artery single portal vein.

We did our reconstruction of the right hepatic vein in a standard manner with a hood graft and anastomosis to the side of the recipient cava. We used deceased donor iliac vein to create a jump graft from the segment five cut surface vein to the middle/left hepatic vein confluence in the recipient. We anastomosed right hepatic artery to right hepatic artery and the single bile duct to the Roux limb with an external biliary catheter. By the way, we leave these about six to eight weeks before we remove them.

Total operating time for this case was nine hours. The graft was over a kilo. Portal vein flow was 1.3 liters per minute, and hepatic arterial flow was 114. Despite that, she still had elevated portal pressures of 19. Standardly, we will ligate the splenic artery to try to decrease that pressure, which we did in this case as well. And jump graft flow was 0.11 liters per minute. And she received no banked blood for this procedure.

This is the gross specimen from the resection of her diseased liver. The explant pathology showed moderately differentiated cholangiocarcinoma infiltrating the right lobe, which is why we didn't see it as a mass effect. It was an infiltrative cancer. There was angiolymphatic and perineural invasion present. There was metastatic tumor present in three of the four lymph nodes that came with the specimen. The surgical margins were free. And the background liver was consistent with primary sclerosing cholangitis with cirrhosis. This is the gross pathology from the explant showing tumor in the region of the hilum.

And postoperatively, her CA-19-9 declined rapidly, of course, after surgery. Post surgery, two and a half years later, she has no abdominal mets and stable pulmonary nodules which had been present previously but had been stable for quite some time. However, she has started to have increase in her CA-19-9 level, very high levels of around 5,000, concerning for recurrence of cholangiocarcinoma.

She received full dose gemcitabine chemotherapy. And she was on and off chemotherapy due to cytopenias. She had no evidence of recurrence by imaging still. She still does not to this day. So she's now about three years out. But she does have this elevated CA-19-9 that we're very concerned about. And she is, like I said, more than three years post transplant.

Patient five is a 40-year-old patient who was diagnosed with primary sclerosing cholangitis in 2012 he didn't really have any symptoms of end stage liver disease in the sense of no encephalopathy, or upper GI bleed, or ascites. He had a history of ulcerative colitis and had had a previous total abdominal colectomy. In January of 2017, he presented to a local hospital here in Pittsburgh with jaundice. And an ERCP showed strictures, and stents were placed.

He had brushings that showed negative cytology, but he did have FISH positive cells for polysomy. And therefore, we suspected that he had cholangiocarcinoma. His CA-19-9 at that time was 20. Pre-transplant, his MRI with Eovist looked like this. It had central to decrease uptake of Eovist. And he had ductal dilatation consistent with biliary obstruction.

He received xeloda and external beam radiation as part of preoperative management according to our protocol. And that was from August to November of 2017. And then, we re-studied him to look for any evidence of extrahepatic disease and didn't find any. Therefore, we scheduled him for living donor liver transplant in December of 2017.

At our exploration, which we did before taking the donor to the operating room, the recipient exploration showed a negative hepatic artery lymph node, a negative bile duct lymph node. But when we did our section of the common bile duct, it showed cholangiocarcinoma at the distal margin. We re-resected the common duct to go further down toward the pancreas. And that segment of common bile duct was also positive for cholangiocarcinoma.

So it appeared that we had negative nodes, but we were not able to clear the bile duct. At that time, we have two options. Either we end the surgery and say, he's not a surgical candidate, or we proceed with resecting the entire bile duct, which means a Whipple procedure. And this is what we did. This is basic anatomy here with bile duct pancreatic duct. You can see within the pancreas, which is here, stomach, and then the first and second parts of the duodenum here coming around the head of the pancreas. And so this is what we resected.

We resected his entire liver, the distal stomach, the pancreas. The head of the pancreas was resected over the superior mesenteric vein. And of course, we took out the duodenum to do a true Whipple procedure. And this is what we were left with once all of the resection had been done. These are intraoperative photos from his liver transplant/Whipple procedure. This is with the liver not in place.

And I will point out some specific things in this picture, so that you can see the anatomy better. This is the vena cava posteriorly. Here's the pancreas outlined. It's difficult to see. So I outlined it here. This is actually the pancreatic duct here. We resected it over where the SMV crosses to join in to form the portal vein. The splenic vein is behind the pancreas. But if you could see it, it would be right here. And then, the hepatic artery is coming out from posteriorly to the left side of the vena cava from the aorta coming up celiac to common hepatic artery. And this is the proper hepatic artery here with the left and right litigated.

So this is what we are left to reconstruct. We brought in a right lobe allograft from the patient's donor. And this had a single right vein, a single eight vein, single segment five vein, single bile duct, single artery, single portal vein. And these were anastomoses. I've shown you previously right hepatic vein with a hood graft to the side of the cava. The five and eight veins reconstructed with an iliac vein jump graft from a deceased donor to the middle and left hepatic vein confluence. So that's all the outflow for the liver.

We then did the portal vein and artery in the standard fashion, as I have shown before. There were two bile ducts which were sewn as a single anastomosis to the Roux limb, which is here. We had a separate Roux limb to the interim of the stomach. And the one that we add to the bile duct curved around to do the end to side pancreatic anastomosis for the pancreatic drainage. So we have our gastrojejunostomy, pancreaticojejunostomy too, hepaticojejunostomies, and then our jejunojejunostomy down for the completion of the [INAUDIBLE] a lot of anastomoses.

Total time for this case was about 16 and 1/2 hours. The graft weight was 915 grams. The flow was 2.3 liters per minute, so quite high flow. Hepatic artery flow was 160 mLs per minute. Portal pressure was 14. And the jump graft flow was 0.57 liters per minute. This is a quite high jump graft flow for more than half of liter per minute. An octreotide drip was started primarily because of the high portal vein flows, even though it really wasn't having an effect through the hepatic arterial buffer response on the hepatic artery flow, because that flow was high at 160. This patient received no blood transfusion, no banked blood for that procedure.

The final pathology was consistent with cholangiocarcinoma involving the common right and left hepatic ducts. So this was a true Klatskin tumor. There was no evidence of microvascular invasion. No lymphovascular invasion was identified. The two lymph nodes that came with the specimen were negative. And there was cholangiocarcinoma in the common bile duct distal to where we had previously resected. So that would be within the pancreas basically. And there are 15 nodes additionally that came with the tumor as part of the Whipple specimen. All of those were negative.

This is an area of the bile duct. You can see the bile duct orifice, and there's tumor around it. This is obviously one of the infiltrating type cholangiocarcinoma patterns. This is the pancreas here with a portion of the duodenum. And you can see the bile duct coming down into the duodenum at the ampulla and the very thickened nature of the bile duct here, especially up here, consistent with infiltrative cholangiocarcinoma down the duct. Post living donor liver transplant, the patient is now about three years out and has had no evidence of recurrence. His CA-19-9 is normal and remains normal. So this was an excellent outcome for this patient.

The next patient is an example of colorectal metastasis. This is a 55-year-old male who had rectal bleeding in November of 2014 and was found to have a rectal adenocarcinoma, 4.2 centimeter tumor with three of 21 regional lymph nodes positive. This was in March of 2015. In August, he developed liver lesions, August of 2015. So soon after his surgery, he developed liver lesions. And biopsy showed them to be consistent with metastatic adenocarcinoma. And he was started on chemotherapy at that time.

He had a left lateral segmentectomy and a caudate resection for three of those lesions in January of 2016 with radiofrequency ablation to a fourth lesion, which was in the right lobe. And the pathology all was consistent with metastatic disease. In September of 2016, he had a VATS procedure for a right upper lobe lung met, which measured 9 millimeters. And in August of 2018, he had RFA to another liver lesion. And then, he had no further evidence of extrahepatic disease for more than two years.

And then in March of 2019, he was referred to us for liver transplant because of progression of his hepatic metastases and no evidence of other disease in his chest or abdomen. The preoperative CT showed a 4 centimeter caudate lesion, obviously abutting the vena cava. This is the preoperative PET scan showing that that's the only active lesion that we could see in his body. These other areas are normal findings on PET scan. And you can see not even in his liver did he have any other evidence of disease.

We felt that he was a candidate for liver transplant. And as we standardly do, we did an exploratory laparotomy of the recipient prior to taking the donor to the operating room. And we found no evidence of tumor outside the liver. In this case, instead of removing the liver off of the vena cava and dividing the short hepatic veins and the hepatic veins to be able to remove the liver leaving the vena cava intact, we decided to resect the inferior vena cava because of how close the caudate lobe tumor was to it.

It was immediately adjacent to it. And we felt that that would potentially provide a site of recurrence if we left the vena cava in place. So we removed the vena cava. In living donor liver transplantation, this presents a little bit more of a problem than it does in deceased donor liver transplantation, because with deceased donor liver transplantation, we would have vena cava from the deceased donor to be able to replace this vena cava with. But we didn't have that in this case, because this is a living donor.

So we created what we called a neocava from iliac vein grafts that were stored in the refrigerator from previous deceased donor procedures where donors had donated their iliac veins. And we kept those in storage to be used for living donor cases. In this case, we used several iliac vein grafts to create a new vena cava, which we then anastomosed. Here is the distal anastomosis and the upper anastomosis to create a new vena cava for the retrohepatic portion of the cava.

We then received the left lobe graft form our donor. It had the middle and left hepatic veins and single artery portal vein and bile duct. This is a picture of the anastomosis. So we anastomosed the middle and left hepatic vein as a single patch to our neocava, which is here. And then, we anastomosed recipient main portal vein to donor left portal vein and recipient left hepatic artery to donor left hepatic artery. And then, we did our biliary anastomosis to the Roux limb, leaving an external biliary catheter.

This case took almost 10 hours. The graft weight was 384 grams. So it was a relatively small graft but with good portal vein flow of 0.82, which is about 200 mLs per minute per 100 grams. And we had good hepatic artery flow at 136 mLs per minute. Our portal pressure was relatively low, given the size of the graft. And we had no jump graft, obviously, because this is a left lobe graft. The patient required no blood transfusion, no banked blood for this procedure.

Final pathology showed moderately differentiated adenocarcinoma consistent with the mets from the patient's known rectal primary. It was 5.3 centimeters in its greatest dimension. They were primarily viable tumor cells with focal areas of fibrosis. And the surgical margins were negative for tumor. Particularly that vena cava margin above and below, those were negative for tumor.

This is the gross pathology. You can see that large tumor there. This is the inferior vena cava. Posterior to that on the anterior surface, you can see where we had to peel the liver off of the patient's diaphragm and colon and omentum because of his previous multiple surgeries. His follow-up imaging, he has stable pulmonary nodules which have been present. You can see one there. These have been present, actually, since well before his transplant.

And his MRI, these pictures are from about a year ago, but he continues to have no evidence of recurrence. This is now 13 months. But he's now about two years post transplant with no evidence of recurrence and a normal CEA. And you can see here his postoperative film. You can see that neocava we created is patent.

The last case is another case of colorectal metastasis. A 66-year-old patient had liver lesion biopsied, which showed adenocarcinoma, which prompted a search for the primary, which showed up as a 3 centimeter rectal adenocarcinoma, which was largely removed by colonoscopy. But the patient also received radiation as well. He was started on FOLFOX. He received Y90 to his liver because of liver lesions present and more chemotherapy. He had an excellent response to his chemotherapy, which is good, because we always want to judge what we think the biology of the tumor is.

He had a negative colonoscopy and biopsies of the previous area, where the primary was, were all negative in May of 2018. In June of 2018, he had had near complete response via PET scan of the mets in the liver. So they were really responding to the chemotherapy. But within a few months after that, he had another recurrence in his right lobe. And he was maintained on his chemotherapy and referred the following year, actually, for transplant, because during all of that time, during this relatively two year period, he had only shown evidence of tumor in the liver, nowhere else.

This is his preoperative scan. You can see multiple areas of either tumor or areas of necrosis from tumor treatment. We felt he was a candidate for living donor liver transplant. And we proceeded with this in November of 2019. We did an exploratory laparotomy and found one mesenteric nodule, which we were concerned might be malignancy. But the frozen section analysis showed that it was just an area of fat necrosis. So we didn't see any gross evidence of extrahepatic disease.

He received a right lobe graft with the anatomy as you can see. The difference in his is he had three right hepatic ducts which were in close proximity. But this is technically a challenge because of the size of these ducts. And he was reconstructed in the usual way with the outflow from the right hepatic vein, a single cut surface vein with a jump graft to the middle and left, the right hepatic artery to right hepatic artery anastomosis, the portal vein to right portal vein. And then, for the three duct anastomoses, these were sewn as a single anastomosis. We left two external biliary catheters in two of them and a short internal biliary catheter, which will come out on its own, in the smallest of the three ducts.

This operation took a little over 11 hours. The graft weight was almost a kilo. Portal vein flow was about 2 liters per minute, which is acceptable, given the size of the graft. Hepatic artery flow was 62. Portal pressure was about 13. And jump graft flow was very good at 0.6 liters per minute. He received no banked blood for his procedure.

The explant pathology showed poorly differentiated carcinoma consistent with what his rectal primary had been. There were four separate lesions partially necrotic, with the largest being 8.3 centimeters. The surgical margins were negative for cancer. There was no PD-L1 expression in the tumor cells, which we looked at for the potential for adjuvant therapy. And we can see the numerous intravascular radioembolic beads from his previous Y90.

This is the explant. You can see multiple areas of tumor within the liver. This slide says now seven months. But he's now a year past that. So he's about a year and a half out with no evidence of recurrent disease. And you can see our grafts are patent. You can see portal vein patent there. And that's all I have. So I hope you agree with us that transplant with the ability to do living donors is taking a little bit of a turn in how we manage oncologic patients. And I think the field of transplant oncology is going to be one which is growing, largely because of our ability to access donors through living donation. Thank you.