



# Experiencing the Future of Surgery

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What molecular biology research is to internal medicine, technological progress is to surgery: Miniaturization, automation, precision imaging, digitalization, and artificial intelligence are opening up new avenues. But what, exactly, will surgery look like in twenty years? Let's listen to what a patient has to say.

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3 March  
2038

**B**ack again, after being quiet for a while. Some of you might know that, years ago, I suffered from colorectal cancer. It was removed successfully at the time and I thought I was done with it, but that doesn't seem to be the case. My doctors just found several liver metastases that need to be removed urgently. It's a tough time for me, as you can imagine. I kind of hope that posting about it will keep me alive, mentally. As always, I welcome your feedback, but don't feel obliged to comment.

5 March  
2038

Let me tell you a little about how they found this thing in my liver. It's not that I was feeling ill or anything. I just received a call from my health coach last week asking me to come in for some detailed MRI and ultrasound imaging. In fact, it was my "digital self" who can claim responsibility for initiating the call. They had created this "twin" of mine when the colorectal tumor was diagnosed and removed years ago. After that episode, my doctors told me to swallow a tiny camera capsule twice a year that records in detail what my guts look like from the inside. It also measures various biomarkers in the intestine and it feeds all this information directly back into a database. Laboratory data from blood samples are part of my digital twin as well, as are various other diagnostic datasets that are gathered every now and then. Don't ask me about details, but basically what happens is that this digital post-cancer self of mine is compared with tens of thousands of other digital post-cancer selves out there. It's all about artificial intelligence: The algorithms calculate probabilities of tumor recurrence based on long-term follow-up data from other patients. Once a certain threshold is crossed, the algorithms issue a warning. This is what happened in my case, and that is where my health coach – a real person btw – came into play and asked me to come in. And the algorithms were right, there are metastases. They have to take a closer look now – I'll keep you posted.

7 March  
2038

The doctors want to operate on the metastases as soon as possible. Preparatory work has already started. They've done some CT, MRI, and ultrasound scans, resulting in a highly impressive and highly interactive 3D model of my liver. They let me navigate it myself. I tell you, it's amazing how complex this organ is! So many blood vessels! The bad news is that the metastases seem to be big. Not really sure what that means at the moment, but I'll find out soon enough.

9 March  
2038

Detailed planning is now well under way. I'm learning a lot about medicine. The doctors told me that small tumors can be "burned" away with a robot-assisted ablation device. This would mean they would only have to place a few needles through the skin, instead of cutting all the way down to the lesion. The other option for small metastases is removing them surgically, which is safer in some situations. This would be a minimally invasive intervention with the help of some fancy guidance tools: The surgeons would use a robot for the dissection with an augmented reality overlay showing them relevant information. To decide between these two options, they would feed my patient dataset into one of these comprehensive international patient databases that I told you about earlier. They would run simulations and then decide on a case-by-case basis. But neither of these minimally invasive approaches will work for me, unfortunately. What's worse, conventional surgery doesn't seem to be an option, either. The problem in my case is that, to treat the metastases safely, I would require a resection so big that there wouldn't be enough liver left for my body to function properly. That's why they are offering me a newer approach now. I'll tell you more about it once I fully understand it.

11 March  
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OK, so here's the deal: They've taken a biopsy from the healthy parts of my liver, and over the coming days and weeks they'll be cultivating these cells to get more of them. Then they'll use some drugs to return the cells to a more primary state known as "pluripotent". That means that the resulting cells can become anything that's needed. As soon as enough of these pluripotent cells are available, I'll be scheduled for the procedure. And it's a major one, I can tell you. They'll essentially "wash out" all the cells in the part of the liver where the tumor is, including the tumor itself of course. To do this, they'll have

to exclude these segments from normal circulation, pretty much like they would do in a heart transplant, but in a small circuit only within the liver. Once there is only the scaffold of the liver segments left, they'll inject the pluripotent cells before restarting normal blood circulation again, which will feed these cells so that they become a normal healthy liver. The procedure takes a few hours. Then I'll have to stay in hospital for a day or two to ensure the liver is working properly, but that will be it!

So, tomorrow's the day. I'm a bit scared, I have to admit. But everybody is so nice, going to great lengths to keep me relaxed. I asked them to run me through the surgery on the simulator again, and it's really amazing. Call me crazy, but I'm kind of sad that I won't be awake to see it all. This is what they've told me: They'll use a robotic system to place all the balloon catheters in the precise locations, and they'll monitor the procedure using fluoroscopy, ultrasound, and MRI to ensure that each step is completed before starting the next. Essentially, the surgeons will be guided by a navigation system that draws on numerous data sources. There is the 3D model of my liver, of course, and then there are sensors all over the place: Every instrument they use, for example, will be equipped with sensors. And there's the MRI sequence that will measure my actual liver function, so that they can constantly update the virtual model with real-time information. Absolutely amazing! Keep your fingers crossed followers!

It's done! So grateful for all your support! You really keep me going! And apologies for not blogging yesterday. LOL. Honestly, I'm feeling good. I have no pain. I can use my tablet. I even had some lunch. And I talked to the surgeons this morning. They said that the procedure went well, but, to make sure that the new liver tissue grows in a healthy place, they opted to remove the tumor anyway – after the washout. As everything was changed by the washout and the liver essentially became transparent, they did the whole resection based on my digital twin, which had the precise location of the tumor and its feeding vessels. So the surgery was even more major than planned.

Back home! To be honest, I left hospital a few days ago, but didn't feel like blogging. Getting better now. And there is good news: I had a follow-up MRI and some other examinations this morning. My liver function seems adequate, and the MRI shows that 80 percent of the washed-out liver has already been replaced by healthy tissue! My liver 2.0 is coming alive. It's like having a partially new liver, but it's all mine! All the information acquired during and after the procedure was fed into the databases. They use the system as some sort of quality check at this stage. The in-silico doctor is satisfied. He said that, in his humble opinion, the result looked as good as it could. So happy!

Just had another follow-up exam. Everything looks fine for the moment, so I'm more or less back to normal life now. Not that the cancer can't come back. It can, but the doctors say that it's more likely that it won't. I was very happy to hear this. Monitoring will have to continue, obviously. I'll swallow my camera capsules, as required, and they'll check lab data more often and do more abdominal imaging than before. But that's fine with me. One more positive thing: Remember I told you that they use these international patient databases to align my case with what they know about diagnosis and therapy from other patients? They've now asked for my consent to feed my data into this network, making it available to other surgeons and health coaches! My surgeons explained that because mine was such a difficult and somewhat unusual case, my data could be pretty valuable to others in similar situations. Needless to say, I agreed. So great to be able to help others this way! Love you all! Stay tuned! ●

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15 May  
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Recorded from the future and for an unknown patient by **Philipp Grätzel von Grätz**, a medical doctor turned independent journalist.

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## Surgical Therapy Suite of the Future



**Simulation training:** Real-world data is used to build learning environments for surgical procedures that look and feel real. They allow surgeons to practice a wide variety of surgical procedures and minimally invasive interventions in silico.



**Personalized therapy planning:** Imaging-based 3D simulations of the individual target organ are created in silico. Depending on the type of surgery, the best approach is chosen based on 3D-printed models and/or virtual reality (VR) models that are explored using VR goggles.



**Intraoperative guidance:** Sophisticated intraoperative guidance tools with various augmented reality (AR) features reduce surgical risk and intervention times. They also help to standardize and partially automate surgical and interventional procedures.



**Artificial intelligence (AI):** AI is used to identify pathologies earlier and to plan therapies based on reference cases. Drawing on large procedural databases, it has become an important component of self-learning guidance tools and next-generation surgical robots that offer far more than expensive instruments without any intelligence.



**Workflow optimization:** Workflow optimization technologies enable surgeons to perform procedures faster, more safely, and with more precision. Sensor information and AI are used to create “digital workflow twins” of individual procedures. This leads to intelligent ORs that “know” the stage of ongoing interventions and provide context-sensitive assistance by making certain tools available or by superimposing relevant information via AR/VR.

