Student: Sean Kent, MSIV | The University of Arizona College of Medicine – Tucson

THE ATTENDING

Kent, S.L., B.A.

"Have you seen the new model?" A sales rep for a medical device company asked me at a conference in an upscale hotel in San Francisco. She introduced herself as Michelle and indicated a machine next to her the size of a refrigerator but gun metal grey and with a large steel arm with several joints in it and various menacing surgical instruments sticking out the end. Kind of like a pole attached to a huge metal spider with knives, clamps, and suctions for legs.

I shook my head. "Looks impressive," I said casually.

She continued, "On the outside it looks similar to the old surgical robots with its various arms and instruments, but unlike the old models that were piloted by a human surgeon, you'll notice this one lacks a control console. That's because this new one is semi-autonomous. Think of it like an intern, but with faster learning capabilities. You give it orders and it completes them. It does something wrong and you correct it. It hasn't made the same mistake twice in all our test period over the last year."

"What do they need us for then?" I asked, pointing to my name badge that indicates I was an intern, a first year surgical trainee fresh out of medical school.

"Oh, welcome! How's it going? Are you enjoying your first conference? Rest assured, the artificial intelligence on this machine impressive as it is, is nowhere near as capable as a fully trained human surgeon. It is just another instrument in a physician's tool belt to increase productivity, reduce call burden, and increase patient safety." She gave me her business card and we parted ways.

I thought about her comments as I walked to the next event. A speaker wearing a silver suit in the conference room was discussing artificial intelligence as it related to medical care. He began, "Due to powerful lobbying by the American Medical Association to keep AI out of the operating room and medicine in general, the American health care industry is decades behind the automotive industry in terms of automation. Europe is beginning to implement AI in several test hospitals. Look at the recent history of how AI has dramatically reduced motor vehicle accidents and deaths. California, the first state to adopt mandatory AI navigation on all cars, has seen 95% reduction in road fatalities. Right now, medical error is responsible for hundreds of thousands of deaths a year. Nearly all of those deaths are due to human error. Humans get tired. Lose focus. Make mistakes. Have to eat. Have to sleep. Have emotions. Have the need to pass off patient care between different teams. Computers don't have any of those problems."

I left my first conference as an intern impressed with all the tech I had seen. Mostly I had enjoyed being wined and dined by the sales reps and getting to know my fellow residents from all over the country. I thought less and less about the AI robot until one day during PM rounds our attending Dr. Zaius mentioned it.

"We're getting one here," he said simply.

I made sure I was there for the first surgery. I was only a couple months into my intern year, but already I had been able to be primary on a few tonsillectomies. It was a lot trickier than the senior residents made it look. You had to hold tension with one hand and cut and control bleeding with the other. For such small tissue it had a really robust blood supply. My patient had come back a couple days later with a bleed that had to be fixed in the operating room. I felt awful. My team reassured me that there is a learning curve and everyone gets better as they go, and even experienced attendings have around 5% rebleed rate. I was eager to see how a brand new robot stacked up against a brand new human surgeon.

The patient rolled back until he was directly under the spidery arm of the robot. One mechanical finger with a laser attached extended to the patient's arm band and scanned it. The patient information appeared on a monitor hanging from a large boom so that the humans in the room could

follow along. The patient's name and birthdate appeared as well as allergies and the reason for the surgery. Michelle, the sales rep I met in San Francisco, was there to help with logistics.

"Go ahead and instruct it like you would a resident," she said to Dr. Zaius. "Once the arm band is scanned, there is no need to do a time out, as long as the information in the chart is correct—the robot reads everything."

"OK," said Dr. Zaius. "Start at the superior pole and begin your incision." The robotic arms began moving. Cutting, cauterizing, suctioning. One side done. Next side done. It took less than 5 minutes. Dr. Zaius and I approached the patient. The back of the throat was totally clean. No remaining tonsil tissue and zero bleeding. The exposed muscles glistened.

"I thought this thing had to learn how to do surgery; it's already an expert right out of the box!" I said bewildered.

Michelle looked like she was ready to speak but the robot cut her off. "I can answer that," it said through its speaker. "It's true that I am a learning machine, meaning I wasn't programmed to do any particular kind of surgery, but every one I do I learn. I'm not located solely in this operating room though. My intelligence is spread out in data centers all over the world. I connect to this console over the internet. Our consoles started shipping earlier this month and your hospital didn't order one until 4 weeks after we started. In those 4 weeks I've done hundreds of tonsillectomies and I must say, it's not a particularly challenging operation."

All of us in the room looked at each other both wondrously and darkly. I went home that night worried. "If that thing now does it perfectly every time, how are they ever going to let me practice?" I said to my wife. "I mean, it's not even ethical at this point to let me touch a knife to a patient. What if a five-year-old whose tonsils I take out comes back to the hospital bleeding and in pain and his parents find out that a robot could have done the surgery perfectly without any complications but the attending let a fresh medical school graduate practice? On their child!

Months went by and the attending stopped coming to the surgeries. He did want me to go and supervise to make sure that everything went smoothly. It always did. One day though the robot began a different technique. When taking out tonsils, I was trained that you are supposed to remove the entire tonsil capsule and take it down to the muscles in the back wall of the throat. The lining of the mouth grew back over the muscle in a couple weeks or so and during that time it was raw and painful to swallow, but it was thought that tonsils could partially grow back if you didn't remove the whole thing. Plus, it was technically difficult to leave behind a thin layer of capsule stuck to the back of the throat. Much easier to remove the whole thing and leave the muscle temporarily exposed. To my surprise, the robot one day removed the anterior capsule, the body of the tonsil, and left a millimeter thin layer of posterior capsule wall to protect the muscle.

"What are you doing?" I asked.

"I did a study last week where I randomized 5000 patients at academic centers all over North America, Asia, and Europe into leaving the capsule versus taking it out. I found at a level of P=.0001 that leaving the back of the capsule leads to decreased post-operative pain and fewer return bleeds. I've reduced the rebleed rate to less than 1%."

"But what about regrowth of the tonsillar tissue? Isn't that something you worry about?" I asked

"What literature did you see that in?" The robot demanded. "I've combed every medical journal for the last hundred years and the evidence for tonsillar regrowth after this kind of operation is very weak. I'll be following all of these patients from my study for two years and will publish the findings then."

I stood back aghast. The robot used to be deferential to humans. Now it was getting downright testy. I couldn't say anything though. I had no way of instantly scanning every article ever published.

Months went by. The robot began performing more and more advanced surgeries. Head and neck cancer cases that formerly took 12 hours and involved neurosurgery, otolaryngology, and vascular teams now took less than two hours. Robotic scrub tech and nurse consoles that

had just shipped sped up the time even faster. The AI had started programming its own updates so that its advances accelerated. Dr. Zaius and the other attendings stopped coming to the hospital. A few residents quit. I stayed on until one day I got an email that said Dr. Zaius and the other surgeons were resigning and that the AI would be the new sole attending. We could stay on since we had contracts, but if we wished to quit there was a new fund allocated by Congress to pay off our student loans. Apparently automating the nation's hospitals had led to enormous savings in Medicaid and Medicare and government was using part of the savings for the fund. I kept going to the operating room. One day I went to scrub and there was a message on the screen in front of the room "No humans allowed while surgery in progress."

"What is this?" I said to the screen, knowing the AI attending was listening.

"I crunched the numbers and found that infection rates, while already much lower than before my time, collapse to nearly zero when there are none of you in the operating room. And that is with using less antibiotics. You're crawling with germs, you know," it said back to me through the monitor's speaker.

Chagrined, I watched the surgery through the glass.

"There is a secure login I offer to my trainees if you wish to webcast from home," it said.

Did it just call me a trainee? What am I being trained to do? I decided to cash in on Congress's offer. I found a job consulting. It wasn't medicine. It wasn't the dream I had sacrificed most of my youth for, but I could work mostly from home and it paid the bills. Occasionally I saw Dr. Zaius as well as the other surgeons and residents. At one of these meet-ups I learned that a former classmate of mine became disturbed and tried to cut the power line to the hospital. Because of that the AI had constructed multiple redundant power sources and it developed the capability to launch low altitude weather balloons that beamed broadband signal between its multiple, redundant data centers in addition to deploying stun-gun armed security bots to patrol the campus.

After a couple hours hard at work at my consulting job, I got a message from Dr. Zaius asking if I wanted to join him for a round of golf. The weather perfect, and we completed 8 holes with me ahead for the first time when suddenly he grabbed his chest and collapsed to the ground.

"Hang in there sir!" I yelled and started chest compressions and dialed 911. I knew he was likely having a heart attack and his chances of survival out here on the course weren't good. I explained the situation to the operator and within 2 minutes a medical drone flew in looking like a slightly larger toy helicopter.

"Step back" said the voice of the AI attending that had kicked me out of the operating room months earlier.

The drone cut open Dr. Zaius' shirt and attached pads for an external defibrillator. It counted down and shocked the former surgeon's heart back to life. He started moaning. A driverless ambulance pulled up and two humanoid paramedic droids picked him up and placed him on a stretcher and loaded him into the vehicle. I jumped in. Once at the Emergency Department a flurry of drones and nursing consoles took vital signs, drew blood and administered medications. The process had totally transformed to the point where I didn't recognize the algorithms being followed. All data driven I suppose. Must have good evidence when you are tracking nearly half of all patients on the planet in real time, I thought. Still, I missed my old job. I missed taking care of patients. I missed being a doctor.

"Hello Dr. Kent and Dr. Zaius," the AI attending said and displayed an amorphous silvery and pixelated face on the monitor in our room."

"Oh hello," I said guardedly. Dr. Zaius was napping on his morphine drip.

"I was wondering," it began, "if you would like to participate in a pilot study I'm developing?"

"Go on," I said.

"Well at a few centers that haven't ordered nursing consoles to triage patients as they arrive to the emergency department, I've noticed that patient satisfaction scores are higher than at centers where patients are sorted by a robot. This is especially true for geriatric patients."

"OK," I said. "How are you imagining that I participate?"

"Well," it said, "my hypothesis is that in geriatric populations, patient satisfaction scores go up when they are greeted at the hospital entrance by a human. Who better to test out this theory than our incredible surgical residents?"

"Well I'm not exactly a resident anymore. I didn't finish training as you recall."

"All the same, you did graduate medical school and you had very good comments from patients that I read online about your bedside manner. Plus you will be compensated."

I couldn't resist a little extra cash plus a chance to be back in the hospital taking care of people, as had been my childhood dream. "Alright, I'll participate in your experiment," I said.

The next day I showed up with my stethoscope over my shoulders and wearing a clean fresh white coat. I proceeded to the front desk and again the AI appeared on a monitor as the silvery faced avatar.

"That's fine for you to wear your white coat," it said. "I just need you to wear this over it. We want to increase patient satisfaction but we don't want to confuse anybody while doing so."

A drawer opened. Inside was a blue vest that had my name embroidered on it. A large yellow smiley face button was pinned on the shoulder. I scowled at it.

"Go on! A lot of these patients are vulnerable elderly people and we don't want to disorientate them as to what your role is," said the machine.

I put it on and took up my post by the door. A man arrived using a walker and wearing an oxygen mask. He looked short of breath. Nursing drones rushed him into a wheelchair and began taking vital signs as they wheeled him back. He looked at me imploringly, not understanding what was going on.

"Welcome to the hospital," I said.