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# The Technology of Sustaining Life

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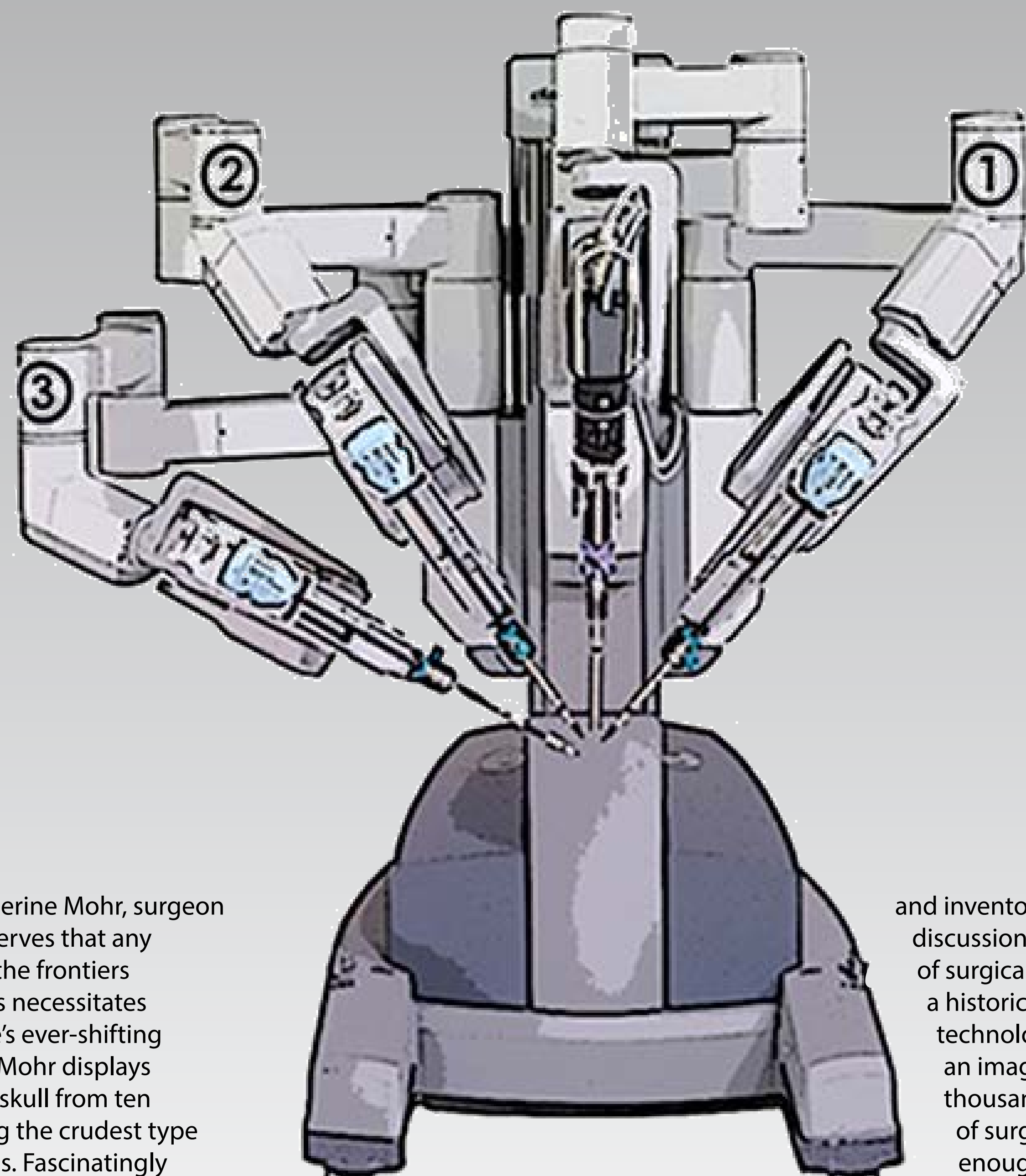
**Death is a biological reality concomitant with life, but the way that humans react to death is a social reality.** The ideal of Western medicine has been to combat death, and the constant development of novel technologies has assisted physicians with actualizing this ideal. Humans today are able to live significantly longer than ever before; this is both an accomplishment of preventative medicine, as well a prelude to medical technologies that will continue to be developed and enhanced. However, with the advent of these groundbreaking inventions came an increased dependency of humans on technology that was nonexistent only a few years ago. Surgical robotic systems serve as assistants that allow doctors to perform operations with an ease and precision that were previously inconceivable. While human-robot interactions have been sensationalized in science fiction past, countless scientists in this field today predict that such interactions will become commonplace in hospitals and daily life, perhaps making the clinician's current skills seem superfluous. As it stands now, many Americans have come to expect or rely on the use of current life sustaining technologies that rush to the rescue when the body fails to perform its duties. In these cases, the body cannot carry on without the help of some novel technology, such as dialysis for people with severe kidney diseases like renal cancer. And in the most extreme case, the human becomes a hybrid with technology when it is simply impossible to live in the absence of the devices. Thus, the designation "life sustaining" is quite literal in meaning. While these specific advancements only represent a small portion of the growing field of biotechnology, they adequately suggest the potential for humans to displace their own manual craftsmanship with the introduction of increasingly helpful and reliable forms of medical technology – all for the sake of postponing the death and dying experience.

# Surgical Robots




Catherine Mohr, surgeon and inventor, astutely observes that any discussion concerning the frontiers of surgical technologies necessitates a historical survey of life's ever-shifting technological landscapes. Mohr displays an image of a trephinated skull from ten thousand years ago, showing the crudest type of surgery from ancient times. Fascinatingly enough, the skull showed evidence of long-term healing around the border of the hole, meaning the surgery was actually successful in keeping the patient alive. Since prehistoric days, surgical techniques have been utilized to prolong lives, and new methods consistently emerge over time. Mohr describes the first laparoscopic surgery and how doctors were thrilled with this minimally invasive, safer style of operation, but failed to anticipate the frustration and difficulties that would accompany the tricky procedure (Mohr 2009). This is where surgical robots come into play.



Laparoscopic surgery provides vast benefits over laparotomy, which involves completely opening a portion of the body; laparoscopy requires only two small incisions and therefore cuts down on recovery time and risk of infection. Although seemingly ideal, doctors soon encountered obstacles – the procedure requires exceeding amounts of skill and coordination to operate counterintuitive equipment. Robots, however, can cover the ground that humans struggle with. The Puma 560 was the first of its kind, and was capable of performing neurosurgeries with high levels of precision. It was soon followed by the ROBODOC, the first surgical robot approved by the FDA. A rise in popularity caused NASA and the U.S. Army to begin researching the possibilities of using the technology more commercially. Current devices in use are the AESOP, a voice-activated endoscope, and the Zeus and da Vinci systems, which are operated on a master-slave basis. A common misconception is that these surgical robots serve as substitutes for doctors, but this is far from the truth – robots are simply highly precise assistants that can be controlled and supervised by human doctors. The mutualistic relationship between humans and robots generally improves the effectiveness of medical procedures; the robot works under the control and supervision of the doctor. However, technology always comes with a price. The robots lack haptic feedback, a touch sensation that doctors are accustomed to and sometimes rely on during surgical procedures. With no gauge for force, doctors have trouble performing surgeries even with the advanced technology the robots provide. The devices are also expensive and require further study before they can be used on a larger scale (Lafranco, et. al. 2004).

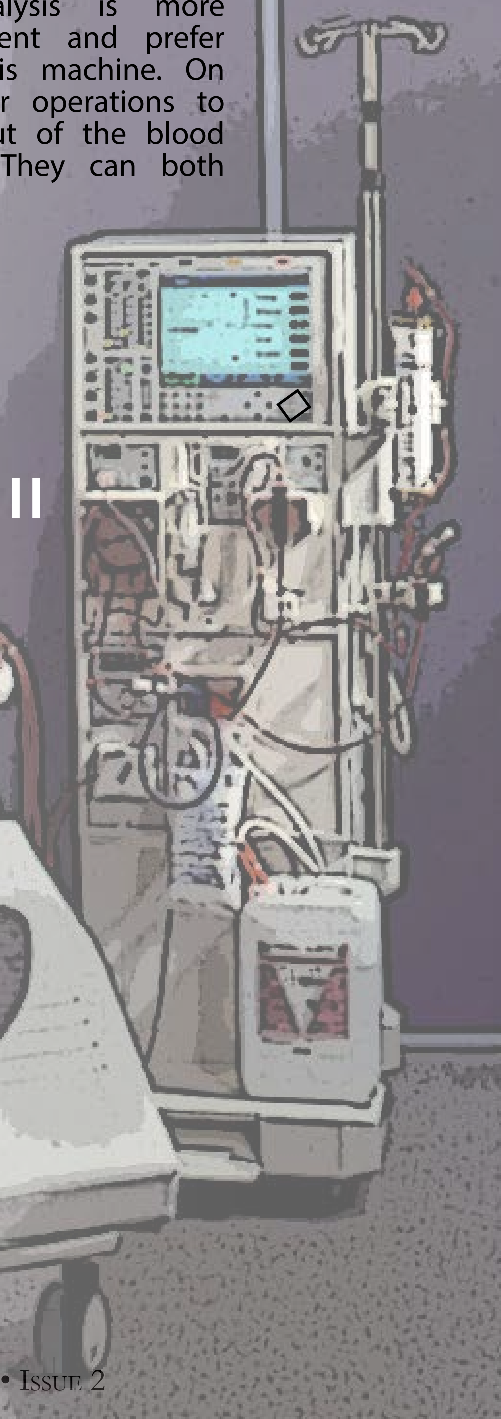
> "The mutualistic relationship between humans and robots generally improves the effectiveness of medical procedures."

The U.S. Army has shown special interest in the prospects of this technology and implemented the da Vinci in the Walter Reed Army Medical Center (WRAMC). It was used over one hundred times in the first year, mostly for cardiothoracic surgery. In a military context, surgical robots could potentially be major lifesavers; they can be sent into "hostile environments" with "clear applicability." For soldiers, surgical robots could be a real breakthrough in aiding the wounded without putting others in danger. They did, however, encounter issues, as with any new technology. They found that the da Vinci requires a large team of dedicated operators, and they experienced similar physical limitations as previous users. Ambitious with the relative success of these pursuits, a team of scientists under Professor Jacques Marescaux managed to perform the first telerobotic surgery across the ocean, exemplifying a new level of medical revolution to look for in the future (Marohn, et. al. 2004).

UC Berkeley's own Professor Ken Goldberg studies problems in robotics, and currently works on the RAVEN surgical robotic system in conjunction with researchers at other universities. He predicts that robots in the medical field will reaching a "tipping point" and will soon become "more and more acceptable" in society (Goldberg 2013). Research in the field of surgical robotics is young, so many scientists and robot enthusiasts like Goldberg are optimistic about their prospects. In Goldberg's TedTalk at Berkeley, he claimed that robots make us better humans for a variety of reasons (Goldberg 2012). On an even broader level, robots allow us to remain human by keeping us alive.

# DIALYSIS

Many victims of kidney failure, particularly cancer patients, rely on a technology that can perform functions when their bodies have ceased to do so on their own. Kidneys are meant to clean blood like a filter and produce required hormones, and there are two types of dialysis that can be implemented to accomplish these tasks. Peritoneal dialysis uses the abdominal lining membrane as a filter for blood, bodily fluids, and other dissolved substances, while hemodialysis implements a machine for the same purpose. Peritoneal dialysis is more commonly used for people who are still comparatively self-sufficient and prefer the convenience, or cannot handle the strength of the hemodialysis machine. On the other hand, hemodialysis occurs in hospitals and requires minor operations to gain access to blood vessels. Basically, waste products are filtered out of the blood system, while the major blood cells and proteins are left intact. They can both cause side effects such as infections and physical weakening; the ethical dimensions of dialysis become acute when trying to weigh the benefits against the costs. For some people, dialysis is a vital part of their survival, and the choice to forego dialysis treatment is, oftentimes, simultaneously a decision to allow oneself to die. Such a decision is never easy to make, and patients as a result are forced to speculate as to the quality of life on a strict dialysis regimen.

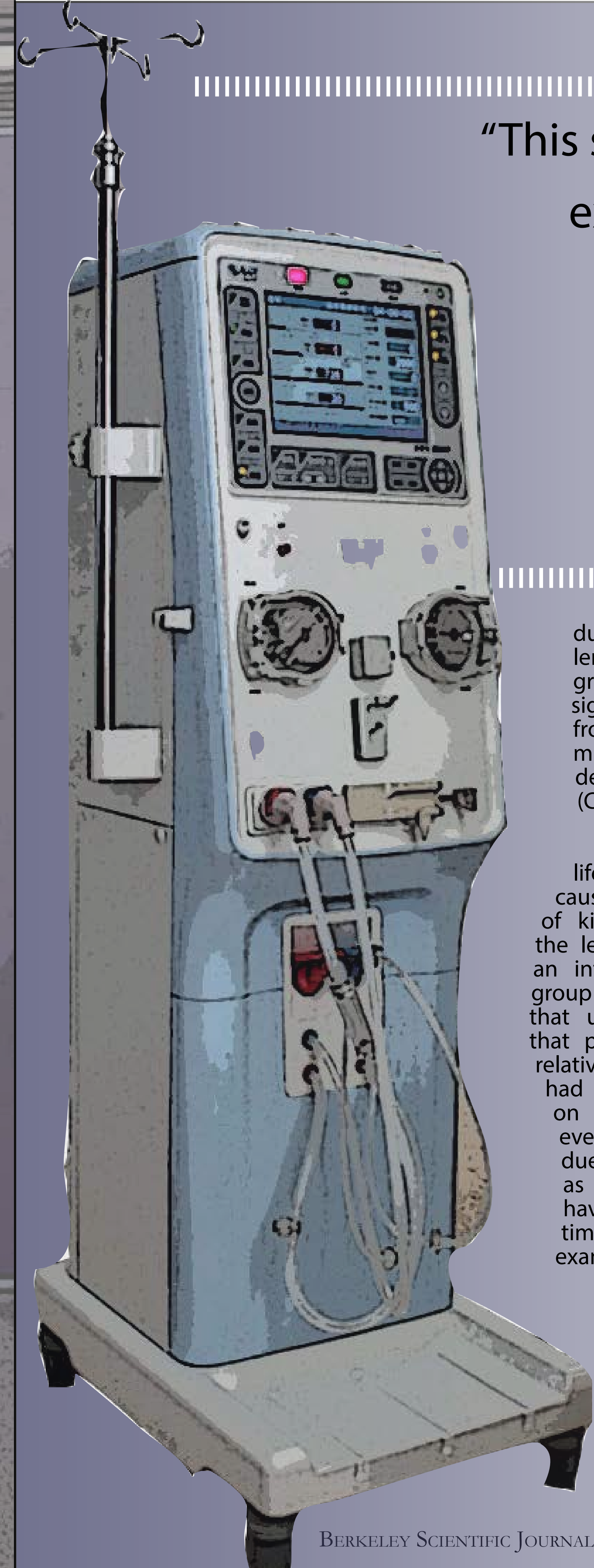


More advanced technology in recent times has shown that dialysis can majorly reduce deaths in patients with severe renal diseases. Hemodiafiltration is essentially a more precise version of dialysis that removes larger toxins than the older techniques could detect, and therefore reduces the risk of infection. Researchers think, “larger toxins could play a role in inflammation and cholesterol buildup,” which can lead to death, especially for older patients at high risk of succumbing to other diseases. So many people in the world depend on dialysis as they wait for a kidney donor; according to the article, about 350,000 patients use dialysis. To test the effectiveness of a higher precision technology, a team in Spain tested hemodiafiltration against conventional dialysis methods and found that the death rate of dialysis patients dropped from 27 to 18-19 percent. The calculations showed that for every eight people that switched over, one death would be prevented per year (Pittman 2013).

To understand how completely critical dialysis is to certain patients, many researchers have conducted experiments regarding their survival rates. It is important to note that data is scarce since these patients are difficult to track, which may cause a bias in the study despite careful methods and procedures. Barring these issues, however, the results are quite striking. It seems that especially for older patients, life spans increase with dialysis







> “This situation is the perfect example of one that begs the question: do the benefits of new medical technology really trump increased dependency?”

due to better normalized blood pressures. The length of time for each dialysis treatment is of great importance as well; if the time is reduced significantly, the patient may suffer negatively from the adjustment, possibly fatally. Patients must follow a strict schedule and remain highly dependent on this machine that keeps them alive (Charra, et. al. 1992).

Technology like dialysis can be seen as simply a lifesaver – how could anyone possibly argue that it causes harm? Another study by scientists on the rates of kidney transplantation patient survival depending on the levels of dialysis given before the operation illustrated an interesting point. After doing extensive studies on a group of adults receiving cadaveric kidney transplants that underwent varying degrees of dialysis, it turns out that patients who used no dialysis at all had the lowest relative mortality rates. In fact, the people who never had to rely on technology managed to live the longest on average. Those who used dialysis consistently, even for years on end, had the lowest survival rates due to side effects of the dialysis machinery such as severe infections, though the technology might have been instrumental in saving their lives at the time (Cosio, et. al. 1998). This situation is the perfect example of one that begs the question: do the benefits of new medical technology really trump increased dependency? Even when ignoring the shocking mortality statistics, one must consider the disparate lifestyles of a patient that relies on regular dialysis treatments and a patient that can function independently. The issue can be more easily explored in the most extreme case of reliance on technology – that is, when human and technology completely fuse together, as seen with artificial hearts.

# Artificial Hearts

Mechanical cardiac assistants in the past could only be used to the extent of supplying oxygen to the heart, but modern times have introduced highly advanced innovations. Now, various types of cutting-edge blood pumps and completely artificial hearts have been introduced into hospitals. Scientists believe that "mechanical cardiac support systems have reached the threshold of long-term applicability," meaning that these machines are really turning the tides of the medical field (Akdis, et. al. 2005). In the past, the only artificial hearts available were those that could serve as a bridge between heart failure and heart transplantation, but now there is a solid possibility of a permanent piece of machinery that a patient could go home with, not just as a temporary stabilizer. While this device would reduce hospital time enormously and create the illusion of increased autonomy, it raises a question of independence. Despite being out of clinical care, the patient's heartbeat would not be his own. This would be the epitome of human dependency on technology, both a frightening and exhilarating prospect.

About 5 million people in the United States alone suffer from terminal cardiac failure, which is also the leading cause of death. In the past, the only method of treating this problem was by a complete heart transplant, which was not readily available for all patients. Ever since the first successful cardiac support system appeared in 1966, cardiac assistance technology has advanced at a swift pace. The first total artificial heart was implanted in 1982, and since then, all of the devices have been used to keep the patient alive during the short time between removal and transplantation. The research evolved from simple pumps to pumps that provide continuous flow, and now to safe, small, and sophisticated devices that might be able to replace the others altogether (Leprince, et. al. 2008).

"Despite being out of clinical care, the patient's heartbeat would not be his own."

Today, cardiac pumps can be manufactured to maintain a decent quality of life from a range of several months to a couple years. Researchers are experimenting with different types of devices, including rotary pumps, to test which technology is best at allowing the patient to return to a normal lifestyle. One of the primary causes of death after intense cardiac surgery is low cardiac output, but micro-axial pumps, which are minimally invasive and quick, are capable of solving this issue (Akdis, et. al. 2005).

The various types of heart sustaining devices represent the most extreme case of dependency on technology by humans. If artificial hearts ever become fully self-sustainable and can serve as transplants into the human body, the ultimate form of hybridization between human and machine would occur. The bioethics of this now plausible future becomes complex and multifaceted; on one end of the spectrum, being able to save lives with this technology would be a discovery on the grandest scale, but it also introduces the highest form of reliance to date. With the rapidly developing technology in current times, this future may not be very far off.

# The Big Picture

There exists a dichotomy when it comes to discussing medical technology – there are vast amounts of benefits, possibilities, and hope when new innovations swoop in to save the day, but a high dependency on biotechnology can also be less than ideal. Medical technologies are keeping people alive, but do they have a positive impact on the quality of their lives? Scientists did psychological studies on men with Duchenne muscular dystrophy who had to rely on mechanical ventrilators for their entire lives. They suggest that assistive technology may be beneficial, but it has a "paradoxical effect" because it can also lead to social "stigmatization." The men they interviewed began to take the technology for granted, to the point that it became a part of their self-identities (Gibson, et. al. 2007). On the surface level, new technologies are positives in the medical field; they are the strongest weapons researchers are equipped with to grapple with death, and have served their purpose very effectively since they first emerged. However, as they have advanced and evolved from helpful but peripheral tools to essential, life-altering devices, the concept of bioethics has arisen to question technology's impact on human independence and quality of life. The debate about the ramifications of this dependency verges toward fusing ethical philosophy with science, but the issue is nevertheless vital for all to consider in the rapidly developing medical technology field.

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