2018 Management & Professional Liability Conference
June 20-22, 2018
Boston, MA

Are Humans Becoming Obsolete: Robots, Drones, and 3D Printing

I. Introduction

Integration of medical technology is required to meet evidence-based medicine standards. Robots are being used to support, assist, and extend healthcare services. Robots, mostly known for their use in surgery, are also responsible for a 70% drop in hospital acquired infections with their fast and effective systematic disinfection of healthcare facilities. In jobs of repetitive nature, they are predicted to completely replace humans. Similarly, drones are being used in lieu of humans to transport blood for transfusions or to deliver medicine to rural areas, among numerous other uses. 3D Printing, or additive manufacturing, enables the construction of human tissue used for burn victims, or organ prosthetics for those in need of transplants. Again, lessening the manpower required to deliver healthcare. Such innovations are mandated by evidenced-based standards, yet, there exits a pushback from healthcare clinicians who are fearful that such integration of technology will make their positions obsolete. This session will address the available technology, the legal requirements involved in providing evidence-based medicine, the potential risk exposure, and analysis of case law which suggests that the failure to incorporate technology, even in the face of minority support, can constitute a breach of the standard of care.

II. New Technological Developments

The advancements in medicine are segueing into technological advancements that are increasing tenfold and are estimated to enter mainstream medicine in the next five years. Primary uses in the three mediums that will be addressed all result in medical devices negating the need for certain staffing. To translate, this results in the decrease in jobs for healthcare providers. To utilize this technology effectively and to negate the fear of job insecurity, it is important to understand the benefits of these advancements.

A. Robots

Robots can be used to support, assist, and extend medical services. Robots are widely used in jobs that require monotonous and repetitive activity and are thought to be able to completely negate the need for humans in this capacity. Humans engaged in daily activity of this nature

suffer, fatigue and burn-out, high turnover, and on-the job injury. Robots used as assistants aid in the common shortage of staffing and can be more economical in long-run returns. The healthcare professional can benefit from understanding the capabilities and possible functions of robotics which in fact, can compliment the daily tasks and perhaps hold steadfast the proposition that humans cannot be replaced after all.

The fact that cannot be disputed is the efficacy of the use of robotics which when evidence demonstrates its superiority to human action, must be employed from a legal and ethical obligation. One such key example of the remarkable strides the medical profession has made with the use of robotics is well demonstrated by the following facts and statistics.

According to the Centers for Disease Control and Prevention, 1 in every 25 patients in the United States will contract hospital-acquired infections and 1 in every 9 will die. The use of robotics for systematic disinfection of health care facilities has shown to result in a dramatic drop of hospital infections by an astonishing 70%. The robot destroys deadly microorganisms by utilizing UV disinfection methodologies.

Robots used as assistants are able to recognize various languages and can discern adult from child voices and female from male voices. They are being used abroad as receptionists and can understand 20 languages. Since the receptionist is considered to have a repetitive job of greeting guests and providing instructions, this type of "social" robot is thought to better handle this task while the human receptionist can be put to use in more thought-provoking and productive tasks.

Robots have been used for quite some time in minimally invasive surgery. Major advances now include unmanned surgery. The robotic system is equipped with a high definition visual system and near microscopic instruments that bend and rotate with dramatic ability compared to the human hand. With the assistance of robotics, the surgeon's ability to perform more precise surgical procedures is thought to result in less operative errors. Further, robotic surgery, whether manned or unmanned, results in greater precision, smaller incisions, decreased pain and blood loss, a lower infection rate, and a speedier recovery time. It is predicted that in the next few years, the use of robots in surgery will become a billion dollar industry.

Robots are being used not only for their "brain" power but for their brawn as well. Robots are being used to transport everything from blood and tissue samples to medication and supplies. It pushes carts that can weigh up to nearly 1,0000 pounds. The robot receives its delivery instructions per computerized instructions via a touchscreen mechanism. The robot is then sent on its mission throughout the facility to make its deliveries. These robots work around the clock so fewer employees are needed, which provides relief to last minute short staffing and night shifts which can be difficult to staff. Staff are freed up to spend more time with patients and assist in nursing rather than delivering goods. Further, nurses do not have to push heavy carts or carry weighty items, resulting in less on-the-job injuries.

Other robots are built to lift, turn, and reposition patients. Such robots can aid in lifting patients out of their beds and wheelchairs. The physicality required of lifting and repositioning patients has become a leading cause of on-the-job injury for nursing staff. This use of robots to assist in the nursing care in this manner has relieved staff of this repetitive motion and lowers the incident rate of injury. Such robots can also be used in the home to provide needed assistance

when the daily cost of personal nursing care is unaffordable or when providers are incapable of heavy lifting. These robots are equipped to move and lift patients out of bed 40 times a day.

Perhaps the most astonishing use of robotics is the subject of certain research experts who are experimenting with robots that are smaller than a millimeter in size and will be able to "swim" through our bodily fluids such as the blood stream and the lymphatic system, with the goal of delivering medication in a targeted area.

Robots are being developed to draw blood and ultimately will be able to draw blood with more precision and less needle sticks and in expedited fashion, within one minute. The robot is able to detect the best vein for blood withdrawal within 83% accuracy. Such rate of accuracy is believed to be the best one can expect of a well trained phlebotomist. The use of robots in this manner is hoped to take the unpleasantness out of the typical blood draw. The downside certainly is the angst it may cause to some when first having to entrust a machine to insert a needle to accomplish the blood draw. Nevertheless, the precision and ease within which it can do so, ultimately will be convincing to the patient.

B. Drones

Drones are becoming widely used recreationally and in what some might regard as extravagant personal uses (think delivering sunscreen to a conference in Palm Springs or pizza to New Zealand), but these devices are finding use in dire medical situations at home and abroad. In future medical emergencies, the fastest response likely will be as a result of our use of drones to deliver blood, medications, vaccines and even organs for transplant procedures.

Drones can deliver life support equipment such as defibrillators faster than an ambulance or helicopter. According to the Journal of American Medical Association, a team of researchers in Sweden simulated emergency transport of defibrillators by ambulance and by drone and discovered that the drones were able to deliver the equipment within 16 minutes faster which, in the face of a myocardial infarction, can be life saving minutes. Of course, there are many restrictions placed on the use of drones due to Federal Aviation Administration regulations, which have placed a temporary halt on what is predicted to be a growing number of uses, all of which will make an impact on reducing mortality statistics, as well as costs.

In an initial effort approved only a few years ago, a Virginia based medical clinic partnered with NASA researchers to obtain approval by the FAA to deliver medication to rural areas. Although the FAA has still restricted use of drones in this fashion, it is anticipated that such use is on the horizon.

The United Nations has utilized drones to air drop medical supplies and contraceptives over rural Ghana, while other underdeveloped areas such as Rwanda and Ethiopia are also considering the use of drones for this cause. These deliveries can occur in a matter of minutes versus conventional air transportation which can take days. Similarly, in the same countries, blood products are being transported via drones to those in need of transfusions. Providers working in remote areas can request blood via text and receive blood units by airdrop as soon as 15 minutes versus the vast number of hours it would typically require via automobile. Moreover, such relief efforts can be readily made by drones which can fly over areas with rugged terrain and otherwise avoid closed roads, all within the safety of an unmanned craft

which can drop the goods without risking additional lives of a flight crew. Of course, there are challenges with the transport of blood products and medication such as antivenin which require safe temperatures and storage. For example, blood will require the use of coolers to keep it at the appropriate temperature and it must be maintained in sterile packaging. Hence, the risk of tampering must be considered.

It is anticipated that drones, as they become approved by the FAA, will also be used in the United States in disaster relief efforts where blood products will be needed or, to bring aid to otherwise rural areas. Locally, in Mississippi, drones are being designed to deliver telemedicine kits to those areas subject to disaster or terrorist attack. The kits can be airdropped with instructions for bystander use until medical assistance arrived. In one test flight, drones flew blood across the Arizona desert for approximately, 160 miles in a three hour flight. It is said to have handily broken records for transport of medical product. The blood was specially packed in a foam cushioned cooler to avoid destruction by the drone's vibrating engine and to keep the blood at the necessary temperature. In rural areas, individuals are not readily able to travel to seek medical care and can reside miles away from a clinic or hospital. Drones will be the necessary answer to transportation of medicine, the acquisition of blood samples for testing, and deliverance of blood for transfusions. Current drones used for this purpose abroad can travel approximately 93 miles. Drones will be equipped with relief kits and instruction for use for different circumstances.

In the United States, large hospitals receive daily shipments of blood by conventional means of transport, while smaller hospitals receive blood weekly and rely upon larger hospitals or regional blood banks to restock their supply between shipments. With the use of drones, necessary blood products can be transmitted immediately to the hospital once the EMS request call is made.

Currently, California based Zipline, is bringing its drone delivery system to rural areas of Maryland, Nevada, and Washington. It is anticipated that it will also serve certain Native American reservations as well. Further, the company plans to make up to 150 deliveries per day overbroad. Zipline's drones are electric and fly up to 75 miles while carrying 3 pounds of goods. The providers participating in the use of drones can order the blood products or medicine needed, via text message. The drones are navigated through cellular networks and GPS and can make the deliveries within 30 minutes.

Although the use of drones will undoubtedly be employed for medical purposes, there are certain limitations which will limit its use. Average drones which cost $10,000, are estimated to carry 5 pounds for two miles or a two hour trip. There will be limitations on weight restrictions which will limit the ability of a drone to safely transport certain medical equipment due to its bulk and weight. Drones may not tolerate extreme weather conditions and certain limitations. Further, if the drones are carrying hazardous material and were to crash, exposing people to a dangerous condition.

Again, due to required FAA concerns, such use is still in its infancy and restricted. Organizations such as UNICEF, have publicly supported the use of drones and predict that drones will be more cost-effective and speedier than the current mode of transport of medical supplies, devices, and drugs. This will equate to saving more lives.

C. 3D Printing

3D printing, also known as additive manufacturing, involves the production of three dimensional objects from a digital file. The printer uses a layering process whereby several layers are applied until a solid object is formed. Through the use of special software, a blueprint of the desired object is created, and the completed design is sent to a specialized printer. The printer for this process has an application that pulls the data through a melting process followed by application to a rapid cooling plate. It allows for the design and engineering of parts in a much more economical and more timely fashion than other manufacturing methods. The developments in 3D printing are vast and the possible uses are endless. These include not only medical models, medication, and prostheses, but organs and tissue as well.

Imagine the case of an infant born with an anomaly of the heart who requires urgent lifesaving surgery. With 3D printing, one can build an exact replica of an organ which enables the surgeon to study the model in his or her pre-plan of the complicated surgery. Prosthetics and implants can be created with the use of this technology. In one known case, a 22-year-old female suffered a rare condition that caused her skull to grow extraneous bone which ultimately placed damaging pressure on her brain resulting in a loss of vision and motor control. In a life-saving procedure, Dutch surgeons replaced the entire top portion of the patient's skull with a customized printed implant.

It is estimated that approximately, 80% of the world's amputees do not have access to modern prosthetics. Traditional prosthetics are not only costly, but also require a time-consuming process of tailor-making the prosthetic to fit the individual's needs. As the prosthesis requires modification, the original molds become useless, and new molds are required. Researchers in Canada through the use of 3D printing, are creating inexpensive and easily customizable prostheses. A company based in California has provided 3D printers and training to war-torn countries such as Sudan where amputation of limbs is common place, for use in creating replacement limbs. These are patient specific limbs produced swiftly and with inexpensive production costs.

Perhaps the most impressive use is the advent of tissue engineering.
Through the use of 3D technology researchers at Harvard University were the first to create a swatch of tissue that contains skin cells interwoven with structural material that can potentially function as blood vessels. This requires vascularity that allows for the perfusion of fluids, nutrients and cell growth components. At Cornell University, heart valves are being tested in sheep and are anticipated to be perfected for use in humans in the ensuing five years. Cornell University researchers have also been able to replicate human ears through the use of 3D photographs.

At Wake Forest School of Medicine, 3D printers have been used to create synthetic skin which has been deemed adequate for transplantation to patients who have suffered burn injuries. Other planned use of the synthetic skin includes the ability to use it for testing for chemical, pharmaceutical, and cosmetic products. Thousands of patients are awaiting organ placement for transplant which could be solved once the synthetic organ is perfected and approved by the FDA. It is anticipated to be perfected within the ensuing year. Synthetic organs such as the liver, heart and kidney needed for transplant, can also be used for various testing in lieu of live animals.

Other uses include the enhancement of implantable orthopedic devices. At Washington State University, chemicals combined with a ceramic powder are being used to create ceramic scaffolds that will promote bone growth. This process results in a calcium phosphate coating that will be used for application on implant materials. It is thought to possibly double the life of cemented implants used in hip and knee replacements which currently have a life span of approximately, 10 years.

Finally, chemists are also working with 3D printing to develop chemical compounds at the molecular level for printable medication. The plan for the future is to enable patients with prescriptions to enlist in an on-line drugstore. With their digital prescription, they will be allowed to purchase the blueprint and chemical ink and print the drug at home. Such ability would provide ease for the home bound as well as those in rural areas.

In the United States, it is estimated that well over $150 billion has been spent on medical devices. Hence, it follows that the use of 3D printers in this industry is on the rise.

III. Ethical and Medical Considerations/Applying evidence-based medicine

Essentially, the use of robotics, drones and 3D printing, all reduce the work load of human providers and on the face, appear to have much more beneficial outcomes than risks. The purpose of the practice of evidence-based medicine is to ensure that known science regarding optimal management of a patient's condition is applied both reasonably and consistently. It is comprised of the combination of clinical expertise, patient values and preferences, and the ongoing research-based developments. As the adage states, medicine is not an exact science. Rather, it is forever evolving as new technological advances arise. Evidence-based medicine offers a model of improved quality of care, improved patient satisfaction, and reduced costs. The provider must assess the strength of the evidence as well as the risks and benefits. Due to the ongoing medical advancements, there is an increasing need for clinicians to keep apprised of the developments and consider these in the overall assessment and care plan for the patient.

As the application of robotics, drones, and 3D printing becomes more widespread, the clinician will face obligation to consider these methods of treatment as they apply to his or her patients' needs. Hence, although new technology likely will reduce the need for humans for certain health care processes and procedures, best practices will prevail and application of new advances will continue to improve our health care system.

V. Conclusion

With the integration of innovative medical technology through the use of robots, drones, and 3D printing, the need for humans is decreased. Application of enterprise risk management and evidence-based medicine principles are an effective way to determine whether providers can benefit from new technology. When evidence-based medicine standards demonstrate benefits outweighing the risks, the Integration of medical technology is required.