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Review Article

Hospital Practices and Research

The Future of Healthcare Facilities: How Technology and Medical Advances May Shape Hospitals of the Future

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Abstract

In this review article, we aim to depict how healthcare facilities may look in the near future from an architectural design point of view. For this purpose, we review newly introduced technology and medical advances in the field of healthcare, such as artificial intelligence (AI), robotic surgery, 3D printing, and information technology (IT), and suggest how those advances may affect the architectural design of future healthcare facilities. In future hospitals, less space will be required; there will be no need for waiting areas. Most care will be given far from the hospital. Every human might have a computer chip attached to his body, with all his medical data ready and monitored by AI. In the future, all processes may be done by robots and AI, from reception to detection (radiology, scans, etc.). Nearly all surgery will be done by robots, so the architectural design of operation departments will need to be changed accordingly. AI is faster and better in disease detection than man; thus, there will be no need for laboratories or detection departments as we know them now. 3D printers are able to print almost everything from medical equipment to parts of the human body; thus, space will be needed for scanning and 3D printing in future hospitals. 3D printers might change the pharmaceutical industries, and drugs will be produced for any human individually.

Keywords: Architecture, Technology, Facility Design Construction, AI (Artificial Intelligence), Robotic Surgical Procedures, 3D Printing

1. Introduction

Today, hospitals are where people go for diagnoses of their ills and for care. Physicians, with the aid of pricy machinery and medical techniques, provide consultations for patients. Likewise, people go for surgery and medical interventions such as chemotherapy in much the same manner, for monitoring and care. In the near future, however, advances in artificial intelligence (AI), information technologies, high-speed internet, remote-monitoring technology, and developments in 3D-printing and robotics will change all that. A revolution in diagnosis and care provision will take place. In the coming years, most of these tasks—and nearly all monitoring and care—could be moved elsewhere. The technological revolution and medical advances made by combining vast amounts of available data, cloud computing services, and machine learning are creating AI-based solutions to provide expert insight and analysis on a mass scale and at a relatively low cost. Major alterations have already been made in the way the healthcare industry works by connected medical devices.

In the coming years, with the adaptation of technology-enabled care, the concept of the "Future Hospital" will become a reality. In this paper, advances in technology and medication, i.e. AI, 3D-printing, robotic surgery, and information technology (IT), in healthcare are noted. Following that, suggestions as to how these rapid advances in technology and medication may affect the architectural design of future healthcare facilities are presented.

2. Technology and Medical Advances and Their Impact on the Architectural Design of Healthcare Facilities

2.1. Artificial Intelligence

Advances in AI have been made farther and faster than anyone could have anticipated. Today, AI can perform complicated activities such as image classification, speech recognition, translation, object detection, driving, gaming, finance, and even decision-making in law. Recently, a work of art was created by AI. Such activities require complex computing and decision making; previously they could only be performed by well-trained human beings.

Much effort has been made recently by scientists and researchers to apply AI in diagnosis, treatment, and medical care. It seems that AI will soon change the landscape of healthcare completely. Medical physics predicts that AI will improve overall healthcare extensively. Some scientists believe that AI will impact medical physics research and practice, while others consider these expectations as unrealistic because of the technical validation and practical limitations of AI.[1-3] AI is able to diagnose diseases by employing complex algorithms provided through the use of millions of patients' imaging results, hundreds of biomarkers, data extracted from electronic health records (EHRs), and clinical research results published in PubMed.[4]

Even though AI is still at the very first stages of development, it is as capable as (if not more capable than) physicians in diagnosing illness.[5,6] According to Ibragimov,[7] Wang,[8] and Xing,[1] AI can be applied in radiology and radiation therapy for image classification, object detection, image reconstruction and analysis, image guidance, tumor detection and characterization, therapeutic response and toxicity prediction, treatment decision-making, and related tasks.

Wang, a university professor and researcher at the Biomedical Imaging Center of New York,[8] reports there is optimism that "machine learning will have a major impact on medical physics and radiology within the next five years." He further states, "I have little doubt that machine intelligence will reshape medical physics and radiology, and we should immediately make major efforts towards this direction."

The Medical Futurist Bertalan Meskó[9] has called artificial intelligence "the stethoscope of the 21st century." His appraisement seems to be more reliable than first expected.

2.1.1. Diagnosis of Skin Cancer

Researchers from Stanford University[10] reported that in diagnosing skin cancer, machine learning (an algorithm) can perform equally as well as board-certified dermatologists. That the artificial neural network was "trained" on a dataset of 129 450 clinical images consisting of 2032 different diseases indicates the potential of AI for handling extremely variable tasks.

2.1.2. Radiology Automated

According to numerous reports from researchers (e.g., Suzuki,[6] Rajpurkar et al,[11] and Mesanovic et al[12]), machine learning (ML) is ready for use in the automated detection of lung nodules on CT scans and pneumonia on chest x-rays. A research paper from MIT[13] proved that the collaboration of human and AI agents makes more accurate predictions than humans (specialists) or even AI alone. While we discover how gene expression is related to imaging features of tumors, ML will aid in probing vast amounts of data extracted from imaging to evaluate tumor genetics and behavior as well as tumor response to treatment .[14-17]

2.1.3. Alzheimer's and Coronary Heart Disease Detection

It is imaginable that precision diagnostics will be applied to severe and degenerative diseases such as Alzheimer's and coronary heart disease in addition to cancer. It is conceivably applicable for any disease related to genetics or imaging biomarkers.[18]

2.1.4. AI in Breast Cancer Detection

To make mammography screening practices more efficient ("smarter"), AI can be trained using large complex datasets. AI has the potential to perform image interpretation with highly specific capabilities, yet possibly unintended (and poorly understood) consequences.[19]

A study published in *JAMA* presented deep learning algorithms capable of diagnosing metastatic breast cancer better than radiologists (human) in an equal amount of time.[20] Correct interpretation of mammography for breast cancer (BC) screening provides better treatment and a better chance for a cure through early detection. Misinterpretation may lead to missed cancer that is present or fast-growing or to false positives. To improve theAI interpretation of screening, efforts have been focused on enhancing and intensifying imaging practices, such as double instead of single readings, more frequent screening, or supplemental imaging. Such policies may add to significant resource expenditures and affect the cost of population screening.

2.1.5. Colon Cancer

A study from the Department of Computer and Information Sciences from the Pakistan Institute of Engineering and Applied Sciences[21] used a hybrid method to detect breast and colon cancers by ML, and the results were sufficiently accurate. The authors found that the hybrid MTD-SVM (mega-trend diffusion-support vector machines) method is very useful considering its performance in cancer prediction and computational cost.

2.1.6. Diagnosing Heart Disease

At John Radcliffe Hospital in Oxford, England, researchers developed a diagnostics system based on AI. Based on the reported results, this system is able to diagnosis heart disease 80% of the time; that is more accurate than a specialist's results.[22]

A research team at Oxford University has published data and claim that they have developed the world's most accurate echocardiography software which is able to diagnose coronary heart disease. Since the data is updated from a decade of imaging research, it is accurate 90% of the time.[23]

Researchers at the Firat University of Turkey[24] have proposed a method of diagnosing heart disease based on neural networks ensembles. The method consists of applying SAS base software 9.1.3 for diagnosing with the neural networks. In this method, the predicted values (posterior probabilities) from multiple predecessor models were combined. The results of diagnosing heart disease were 80.95%.

Researchers at the Department of Cardiopulmonary Sciences, University Hospital Santa Maria della

Misericordia, Udine, Italy[25] developed a three-dimensional echocardiography by applying real-time three-dimensional echocardiography (3DE) with software which measures left ventricular (LV) volumes and ejection fraction (EF). The results indicated that this proposed system was as accurate as the more time-consuming 4D TomTec software.

2.1.7. Blood Infections

At a Harvard University teaching hospital, a system composed of a microscope and AI was able to diagnose blood infection and categorize 93% of the samples without human intervention.[26]

2.1.8. Typhoid Fever Detection

To produce explainable rules for the diagnosis of typhoid fever, researchers in Nigeria[27] developed a system consisting of AI (a ML technique) for labeling a set of typhoid fever conditional variables. The classification was done in five different levels of severity of typhoid fever. The results were satisfactory: 95% on the training set, and 96% on the testing set.

2.1.9. Tumor Detection

Deep Variant is an open-source program based on AI provided by Google for the analysis of genetic data, which claims that it is the most accurate tool of its kind.[28]

2.2. Robotic Hospitals

2.2.1. Robotic Surgery

Applying robotics in surgery is a recent innovation. It seems that robotics has the potential to alter the face of surgery, medication, and care. One critical application of robots is to assist surgeons in operations which may lead to better treatment and less hospitalization time for the patient. According to Bryant, a robotic lobectomy because of ergonomics, mediastinal lymph node dissection, and intraoperative blood loss is more effective than a VATS (video-assisted thoracoscopic surgical) lobectomy. Since results of robotic lobectomy for anatomic pulmonary resections has been satisfactory, the use of this type of robotic surgery is increasing.[29] Some studies suggest that soon, all minimally invasive surgeries will be done by robotics or with robotic assistance. Moreover, the use of robotic technology for the performance of anatomic lung resection is expanding.

A teleoperated snake-like robot was developed by a Chinese researcher[30] for minimally invasive radiosurgery of gastrointestinal tumors. Delicate dynamic models have been suggested for the effective control and performance of the robot.

2.2.2. A Remote-Controlled Robot for Laparoscopic Radical Prostatectomy

This robot provides all 6 degrees of freedom at instrument tips. It also conquers the problems with fixed port sites by developing new possibilities for miniaturization of surgical tasks and enables remote controlled surgery (Figure 1).[31]

2.2.3. Microsurgery Robots

At present, one of the trending subjects in healthcare research is microsurgery. Microrobots have been presented in many surgeries, and recently, supermicro- and nanorobots have been suggested for use in healthcare, some examples are depicted in Figure 2 and Figure 3.[32-36]

Van Mulken has listed the current applications of

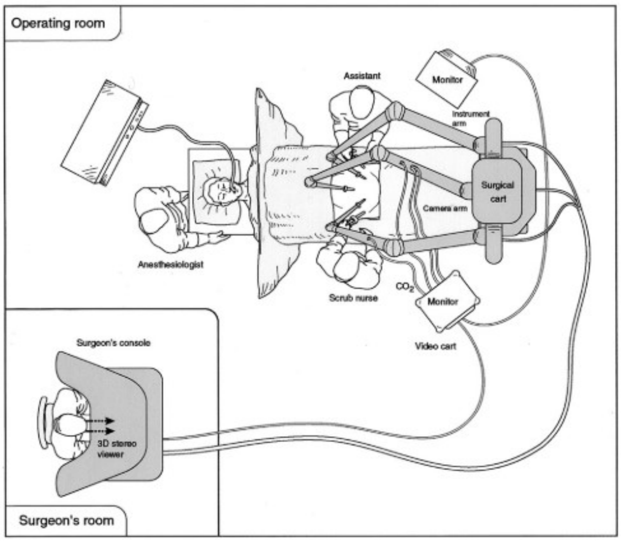

Figure 1. da Vinci system in the operating room.[31]

Figure 2. Schematic set up of the Microsure Tobot. The system can be attached to a surgical microscope or the operation table.[32]

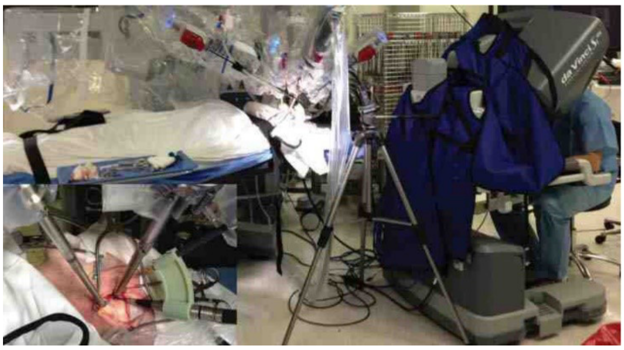

Figure 3. Da Vinci System in an Operation Room During Cochlear Implantation Surgery as cited by Dahroug et al.[33]

microsurgery as cardiac surgery, transoral surgery, otolaryngology, ophthalmology, neurosurgery, urology, plastic and reconstructive surgery.[32] According to Mattos et al,[37] other microsurgery applications could be reconstructive plastic surgery, ophthalmology, otology, and laryngology. Mattos et al believe that microsurgery will influence a range of surgical specialties comparable to innovative technologies which have previously enabled experts to perform diagnoses and treatments.

In 2014, the Eindhoven University of Technology in cooperation with the Maastricht University Medical Center proposed the MicroSure robot (MSR0) which is capable of performing microsurgery. It works in a master-slave platform and is ready to be attached to a surgical microscope or the operation table (Figure 2).

2.2.4. Robot-Assisted Head and Neck Surgery

Soon, patients will be able to take advantage of new robot-assisted head and neck surgery; surgeons will become expert in robotic surgery while technological improvement continues.[19,38]

2.2.5. The Outcome of Robotic Surgery Versus Human Surgery

In a study by researchers from Richmond University Medical Center,[39] survival outcomes of robotic-assisted laparoscopic were compared with abdominal surgery in the management of ovarian cancer. The results showed that 122 cases (patients who received the robotic approach) were similar to those who had abdominal surgery (49 cases). The overall progression-free survival rate was at least as good in patients who underwent robotic-assisted surgery as in those who had human-performed abdominal surgery.

2.2.6. Future of Robotic Surgery

How may these technological and medical advances affect our future hospitals? We must prepare for a robotic future; we need to plan for the role of robotics in our hospitals. The future might hold factory-like hospitals, where nearly all healthcare procedures from reception (Figure 4) to surgery will be performed by robots or be at least robot-assisted.

Today robotic systems have been adopted for minimally invasive surgery in some developed countries like the United States. Despite some mistakes and flaws, this technology is advancing rapidly, and in the near future, advanced techniques must be considered in the design of hospitals and operation rooms.

Considering the results from many studies, such as[41-43] and those mentioned in this paper, it can be concluded that robotic surgery has been successful in healthcare, but still more development is needed. Not all of the machines are performing flawlessly, but like other technologies, e.g., autopilots in aircraft and self-driving cars, medical robots do not need to be perfect; they just have to be better than humans.

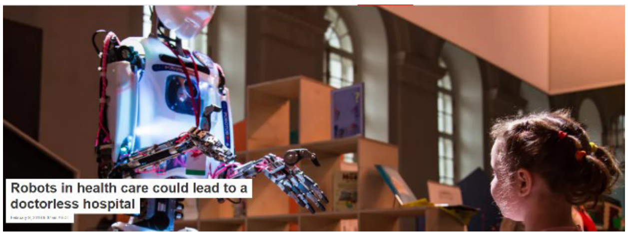

Figure 4. Robotic Hospitals - a Robot Says Hi to Children in the Main Lobby of a public hospital.[40]

2.3. 3D Printing

Another technology which has already caused much change in all other areas of our lives is 3D-printing. It seems it also has the potential to truly change medicine and healthcare. This change could become real by making care affordable, accessible, and personalized. If 3D printers become more sophisticated, printing biomaterials become safely regulated, and the general public accepts this new technology, a new era may begin.[44-48] The main applications of 3D printing in healthcare as depicted in Figure 5 and Figure 6 are:

- Generating medical equipment
- Replicating human parts (such as ears)
- Preparing 3D models of tumors
- Replacing finger splints
- Printing casts on broken limbs

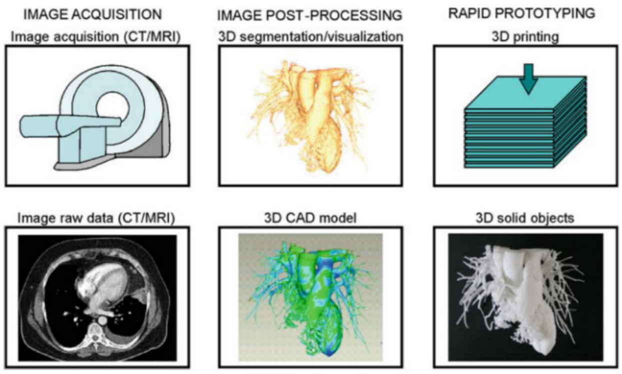

Figure 5. Some Aspects of 3D Modeling and 3D Printing in Healthcare.[49]

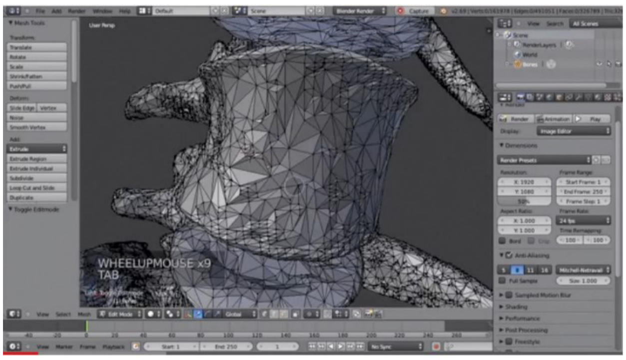

Figure 6. Radiographic images can be converted to 3D print files to create complex, customized anatomical and medical structures.[44]

- Preparing artificial heart valves
- Preparing 3D-printed drugs

A 3D model of a human ear was created in a collaboration between Lawrence Bonassar and partners of Cornell University. This ear was 3D-printed from 3D molds (Figure 7); then it was completed with a gel containing bovine cartilage cells. The 3D-printed ear was suspended in collagen to fix the shape of the ear at the time that cells grew their extracellular matrix.[50]

Applications of 3D printing are now providing aid to medical research and to the results of complex operations (Figure 8). According to reports from researchers, 3D-printed models of cancerous tumors provide aid in the discovery of new anticancer drugs and help medical experts better understand how tumors develop, grow, and spread.[51-53]

2.3.1. Medical Equipment

With 3D printing, operating room equipment such as made-to-order jigs and fixtures, custom-made implants, fixtures, and surgical tools can be produced. Such production may lead to a greater surgery success rate and less time needed for both the surgery and the recovery of the patient.[44,54]

2.3.2. Tumor Models

To study tumors more accurately, to simultaneously find better alternative solutions, and to discuss how to deal with a particular tumor, physicians use 3D tumor models made from tumors that are 3D-scanned and printed. Vitro 3D tumor models along with the novel 3D cell printing technology may lead to a better understanding of cancer.[55] In a study by a group of researchers in an international collaboration, a 3D model of kidney tumor was printed to facilitate the study of the impact of renal tumor on patient's and for understanding conditions of the patient.[56]

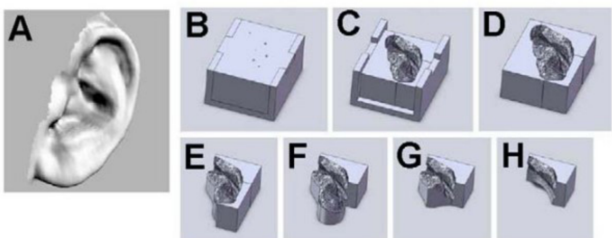

Figure 7. 3D Printed Human Ear Concepts.[50]

Figure 8. A heart is modeled and is being printed, this could be used for study the pre-operation planning and medical commission.

2.3.3. Customized Implants and Prostheses

One application of 3D printers is the making of customized prosthetics and implants for use in spinal, dental, or craniofacial disorders. These customized parts have been proven to be of great value to patients and physicians alike.[44] Because the cost of custom-print 3D objects is minimal and not related to the number of items to be generated, the first item printed is as inexpensive as the last. This has many benefits for companies that have low production volumes. In healthcare, implants and prostheses should be tailored to each patient. 3D printers make possible the production of these highly complex items which require frequent modifications.

2.3.4. 3D-Printed Heart Valve

Researchers at Cornell University have successfully generated a heart valve with a 3D printer which has the same anatomical architecture as the original valve. They intended to test that heart valve in sheep. To control the valve's stiffness, they generated it by combining cells and biomaterials. researchers think that in five years, bio-printing has the potential in tissue engineering and in the biomedical community to become the standard in complex tissue fabrication.[57,58]

2.3.5. 3D Printed Casts on a Broken Limb

One of the potentially vast uses of 3D printers is the generation of a cast on a broken limb, which ultimately could be made to fit every person. 3D-printed casts are light and durable compared with regular ones.[59]

2.3.6. Tissue Engineering With the Aid of Printers

With tissue engineering, the creation of revolutionary new therapies for tissue and organ regeneration would be possible. The scope of this emerging field is exceedingly vast in its various approaches.[60,61] According to Nagarajan et al[62] and Campbell & Weiss,[63] tissue engineering is considered regenerative medicine, which employs science, engineering, and clinical disciplines to discover the biology of tissue and how tissue develops, homeostasis, and how tissue repairs itself. The results of research can be used to develop therapies that re-establish tissue and organ function hindered by disease, trauma, or congenital abnormality (Figure 9).

Rapid development in this field would make 3D-printed organs possible, such as personalized implants and controllable bio-systems (Figure 10).[62,64-66] Another achievement in this field is the creation of a soft scaffold from a liquid hydrogel, developed by a 3D cryogenic printing technique by scientists from Imperial College and King's College London (Figure 11).[67,68]

2.3.7. 3D-Printed Drugs

With 3D-printing technology, the creation of highly

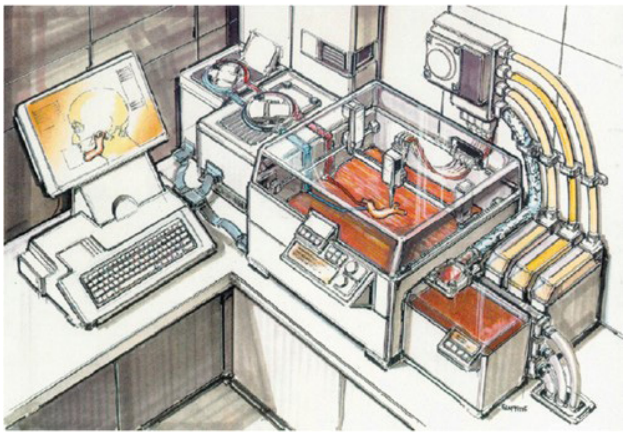

Figure 9. Conceptual Vision of Bio-printing System for Manufacturing Tissue-Engineered Constructs From 1995 as Cited Campbell and Weiss.[63]

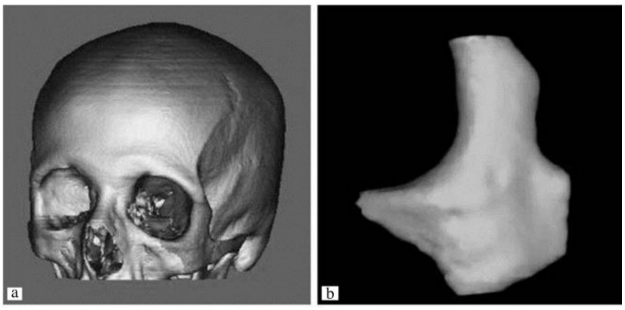

Figure 10. 3D printed scaffolds can be patient-specific.[68]

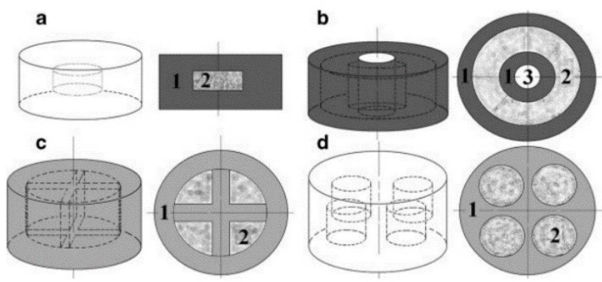

Figure 11. A 3D printed Drug- Fast-Disintegrating Tablet With Loose Powder in Them.[72]

reproducible pharmaceutical dosage forms with precise control of droplet size and complex drug release profiles will be possible. According to,[46,69-71] 3D-printing technology will provide special drugs for patients whose medications require narrow therapeutic indices or a higher predilection which would be influenced by genetic polymorphisms (Figure 12).[72,73] Recently, the USFDA approved "Spritam", an epilepsy drug made by 3D printers.

2.4. Information Technology

According to Grimson et al,[75] "healthcare is an information-intensive business." The scale of data gathered in hospitals, laboratories, clinics, and surgery departments is so vast that managing it is a crucial task. Sharing that information is also important as it is used to empower and better engage the patient (Figure 13).[76,77]

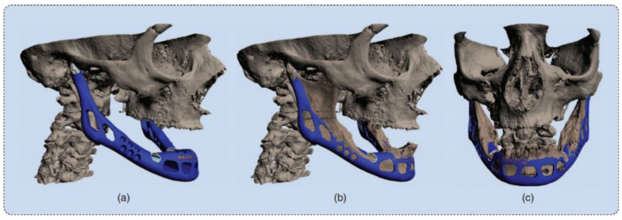

Figure 12. Application of 3D Printers in Producing Costume Made (Tailored) Organs of the Patient.[74]

2.4.1. Telemedicine

Telemedicine consists of providing rapid access to share information remotely for medical expertise and delivery of health services through remote telecommunication. Many studies have emphasized that telemedicine can provide a fast and accurate replacement to patients and families. In his article, Abel et al[78] recommends telemedicine as an alternative for the first post-operation visit for knee arthroscopy in adolescents.

Dayal et al[79] studied and compared children admitted from emergency departments to pediatric intensive care units with and without access to pediatric critical care consultation using telemedicine. Results showed that telemedicine was useful in their health results. Telemedicine can also be applied when physicians discharge infants from the neonatal intensive care unit (NICU) and send them home. Providing infants with the complex care they require is challenging for caregivers. Telemedicine can provide access to caregivers shortly after discharge for more support and guidance.[80]

2.4.2. Telecare

Telecare is providing the elderly and physically less abled persons with the care and reassurance they need to let them live in their own homes while still under care.[82,83] For example, the use of sensors is useful and supportive for people with illnesses such as dementia and those at risk of falling (Figure 14).[84]

By delivering care at home, telecare not only cuts the cost of healthcare delivery, but also decentralizes it, leading to a shift from in-hospital care to more advanced home healthcare.[85] Because more people want to manage their health themselves, telecare can also provide self-managing healthcare that allows for follow-up treatment in the patient's own home instead of in an institution.[86-88]

Biotelemetry is the collection of data such as heart rate, blood pressure, and other vital signs by sensors in order to monitor and analyze a patient's health status instantly. Koehler et al[90] evaluated remote patient management (RPM) for detecting early signs and symptoms of cardiac decompensation over a 12-month period. The results indicated that RPM trial is able to gather and analyze potentially important data which is effective in monitoring patient status and preventing unplanned cardiovascular hospitalizations or mortality in heart failure patients. Devices under development or already presented in the marketplace as part of the telecare system include

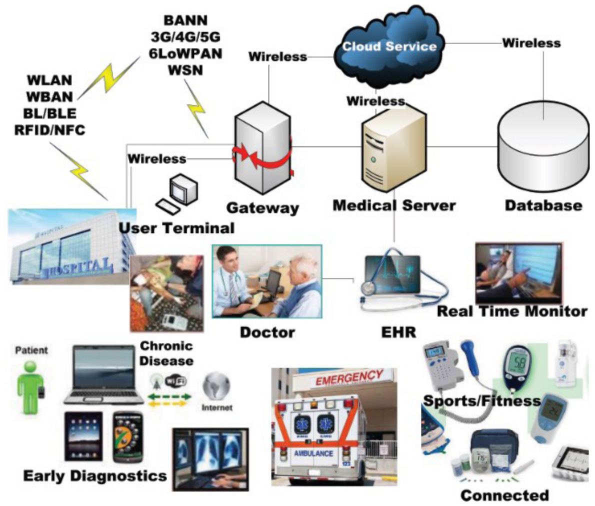

Figure 13. IT in Health care.[81]

Figure 14. Telecare Solutions in Healthcare.[89]

wearable technology, smart watches, eyeglass displays, and electroluminescent clothing.[91-93]

2.4.3. E-Healthcare

E-healthcare can deliver health services to patients in remote areas and to share information between primary care physicians and specialists over long distances through remote telecommunication, which involves the use of modern information technology, especially 2-way interactive audio/video communications, computers, and telemetry. To shape an integrated E-healthcare system, experts from multiple disciplines such as computer science, health, social sciences, cloud computing and big data, engineering, Internet of things must collaborate simultaneously.[94-96]

2.4.4. M-Healthcare

M-healthcare can be defined as mobile communications and network technologies for healthcare systems. With this definition in mind, M-healthcare appears to be the result of the evolution of e-health systems which result from advances in biomedicine, wireless and information technology, and computing.[82] To develop next-generation m-health systems, advances in nanotechnologies, compact biosensors, wearable, pervasive, and ubiquitous computing systems must be applied in this field. The vision of empowered healthcare on the move consists of all these technologies for future healthcare delivery services.[97,98]

2.4.5. Nanotechnology

With the aid of different smart devices, nanotechnology is developed in healthcare systems to monitor, diagnose, and treat patients. By applying those devices which rely on body-centric nanonetworks, sufficient information regarding the individual's health is provided in real-time.[99]

2.4.6. Genomics and Big Data

The development of drugs and precision medicine based on genomics and big data is one of the advancements in healthcare which is continuously under development. Drug development is very costly and develops very slowly because of medications failing, a lack of efficacy, or the presence of toxicity; thus, pharmacogenomics seeks tailoring therapeutics and medicines based on an individual's genetic structure, and explores rational drug development and repurposing medications.[100]

Advancements in research in the field of medicine and combining EHR data with new findings in genetic variants may lead to the prediction of drug action which would support Mendelian randomization experiments to show drug efficacy and suggest new indications for existing medications. The identification of complex phenotypes and subpopulations of patients will be provided by advancements in biomedical informatics and machine-learning in interpreting clinical information.[100-103]

3. In Search of the Future; the Vision for Hospitals in 2030

Now we envision the look of future healing centers. Based on the current healthcare trends mentioned above and considering the medical and technological advances that will be made in the near future, healthcare facilities in 2030 will probably be very different from those available now. In future hospitals, less space will be required;there will be no need for waiting areas as most care will be given far from the hospital. Each human will have a computer chip attached to his/her body containing all his/her medical data, which will be monitored by AI (a giant computer which monitors and controls all human health conditions). With future medical advances, most of the diseases we currently know will no longer affect humans, because vaccinations and drugs will prevent human infection.

In the future, all hospital procedures will be done by robots and AI, from reception to detection (radiology, scans, etc.) to surgery. Moreover, because robotic surgery is more reliable than human surgeons, nearly all surgeries will be done by robots, and the architectural design of operation departments and operating rooms will be changed accordingly. AI is faster and better than humans in detecting disease; thus, there will be no need for laboratory or detection departments as we now know them in future hospitals. 3D printers will be able to print almost everything, from medical equipment to human body parts such as artificial ears. Thus, space for scanning and 3D printing will be a requirement in future hospitals. 3D printers may also change the pharmaceutical industry. In the near future, drugs will be produced for any human species, and every patient can order his/her medication online, have it printed by 3D printers, and have it delivered directly to them.

4. Conclusion

The effect of technological and medical advances in the architectural design of future healthcare facilities can be summarized as follows:

- Future hospitals will be fully robotic.
- Nearly all procedures will be done by AI and robots, from electronic registration (e-healthcare) to diagnosis (AI) to surgery (by a robot, not a human).
- 3D printers will be placed in hospitals to produce almost everything, from medical equipment to human body parts, like artificial ears.
- AI will be used to diagnose, eliminating the need for MRIs and another scans.
- The use of telecare and E-healthcare will mean shorter waiting times for patients and less space needed for waiting areas.
- Telecare and E-healthcare will allow patients to remain at home rather than stay in a hospital, eliminating the need for more hospital beds.
- 3D printing will be used to produce medicine, eliminating the need for pharmacies; patients will be able to download their prescriptions which are obtained by AI, print his/her medication by 3D printer, and then receive it in a favorite place.
- Computer chips placed in every human body will allow for all diseases to be diagnosed at an early stage; all the health information of each individual will be readily available.
- Large- and small-scale decentralization in hospitals and healthcare facilities may lead to a different architectural layout than current trends.
- Robotic systems are already used for some surgeries, and other prototypes are being explored. To maintain safe and effective robotic surgery, surgeons must continue to design evidence-based pathways to the credentialing of robotic surgical teams. Despite the small number of studies from several single centers and a handful of surgeons, the results show good intraoperative results with robotic surgery. In the near future, all surgeries will be done by robots.
- While it is unlikely that AI will entirely replace physicians, it can assist in many ways.
- The future of pharma will be 3D-printed drugs.
- Telemedicine will be used as an appropriate alternative for the first post-operation visit in adolescents.
- Although the application of AI in healthcare is in the early stages, numerous efforts have been made in this area, such as detecting and diagnosing skin cancer, interpreting radiology, detecting tumors, and diagnosing breast cancer at early stages. AI can also assist physicians in tracing Alzheimer's and coronary heart disease.
- A wide range of new robotic systems are expected to come into clinical use in the near future, some of which have been successfully tested and are mentioned above. Microsurgery also has the potential to gain importance in a growing range of surgical specialties.
- Robotics has the potential to enhance the capacity and efficiency of healthcare systems. Robots can assist surgeons in operations, which may lead to reducing hospitalization times and eliminating the impact of surgery on patients' post-operative quality of life.
- 3D printing has the potential to alter medicine and healthcare by making care affordable, accessible, and personalized.
- Bioprinting has the potential to become the standard in complex tissue fabrication, increasing the need for 3D printing in healthcare in the coming years.
- 3D printing technologies allow for the creation of highly reproducible pharmaceutical dosage forms with precise control of droplet size and complex drug release profiles.
- New robotic systems will be proposed into clinical use in the near future.

Review Highlights

What Is Already Known?

The current architectural layout and configuration of healthcare facilities/systems are known.

What This Study Adds?

This study aims to depict how the futures healthcare facilities can be organized based on healthcare technological advances such as Artificial Intelligence (AI), Information Technology (IT), robotic surgery and 3D printing.

Authors' Contributions

All authors contributed equally to this study.

Conflict of Interest Disclosures

The authors declare that they have no conflicts of interest.

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