Review (Narrative)

The Once and Future of Medicine

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SUMMARY

The development of new therapies in medicine has a very rich history, and evolves quickly with society changes along some trends, and will definitely have an exciting future. In the last century, there has been an exponential increase in complex interactions between medical practitioners, pharmaceutical companies, governments and patients. It is believed that technology and societal expectations will open up a world of opportunity for more individuals to participate as information becomes freely available and inequality less acceptable. Corporations must recognize that usual market forces do not function ideally in a setting where health is regarded as a human right, and as modern consumers, patients will increasingly take control of their own data, wellbeing, and even the means of production for developing their own treatments. Ethics and legislation will increasingly impact the processes that facilitate drug development, distribution and administration. As Artificial Intelligence becomes more wide spread in healthcare sector, and also take the place of current digital clinical decision support systems, the role of the doctor as the primary diagnostician will slowly be taken over by more and smarter machines. The journey has already began with the creation of advance laboratory and radiology systems that are being used, and will extend to the bedside, and then to primary care system. AI will also be able to formulate the best practice treatment plans available, customize this for the individuals. Proceduralists may still be needed, and supported by robotics, however, even simple surgical interventions may, at some point, be replaced by advanced robots.∎

KEYWORDS Medicine; Life; Arts; Science; Technique

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TO dissect the future of medicine, it is pertinent to first of all dissect the past and present success of medicine before foretelling the future of medicine.

MEDICINE IN THE PAST

The history of medicine elucidates how societies have evolved in their approach to illness and diseases from ancient trends to the present. Medicine was practice early in Babylon's, China, Egypt and India. For instance, the Greeks introduced medical diagnosis, prognosis and even advanced medical ethics.

Egypt then developed a wide and fruitful medical tradition. Herodotus described the Egyptians as "the healthiest of all men, next to the Libyans" (1), because they possessed try climate and notable health system. Egyptian medicine for a long time dealt with supernatural (2), before it finally developed a practical application in anatomy, public health, and clinical diagnosis.

In Babylon, chief scholar, Esagil-kin-apli of Borsippa 3 developed the Diagnostic Handbook during the reign of the Babylonian king Adad-apla-iddina (1069-1046 BCE) (3). The book shows that it is possible to determine patient's disease, its cause and also future development and as well the chances of patients recovery. Patient was treated via therapeutic means such as bandages, herbs and also creams (4).

In India, Early Iron Age was the first Indian text to deal with medicine. As at 18th century CE, Sanskrit medical wisdom still dominated India. Muslim elders built hospitals in 1595 in Hyderabbad, and also in Delhi in 1719 (5).

China was not left out, also developed a large body of traditional medicine. Most of the empirical observations of disease and illness were gotten form traditional Chinese medicine. The text of Chinese medicine is the Huangdi Neijing, written 5th century to 3rd century BCE (6). During the 18th century, there was a proliferation of popular books as well as more advanced encyclopedias on traditional medicine practice. The missionaries introduced Western science and medicine to the royal court, the Chinese physicians ignored them (7).

In general, during the 19th century, the rapid growth of cities required systematic sanitary measures; hence public health measures were introduced, while in the 20th century and mid-20th century, new biological treatments and antibiotics were introduced. These developments along side advances in chemistry, genetics, and laboratory technology for example X-ray led to modern medicine.

PRESENT MEDICINE

Presently, modern medicine focuses on diagnosis, treatment, and prevention of diseases. Modern scientific medicine is highly advanced in Western world. Physicians assess patients in order to diagnose, treat, and prevent disease using clinical judgment. There's an improvement in doctor-patient relationship, which typically begins with an interaction with examination of patients medical history followed by medical interview (8) and of course physical examination. This may follow further medical test e.g. blood test, prescribe pharmaceutical drugs or take a biopsy. All these are documented in medical record which is a legal document in many jurisdictions (9). The sections of medical interview (10) and encounter are as follows:

- Chief complaints (CC), here the reason for the medical visit is stated, these includes symptoms and it's recorded along with duration of each symptom.
- History of illness, the events of the symptoms are arranged chronologically
- The occupation, hobbies and whatever the patients those in and around his/her environment is documented.
- The type of drugs the patient takes is also noted, this includes home remedy, over-the-counter prescriptions as well as herbal medicine/remedies are also documented.
- Past medical history of the patient is noted, including injuries, infections or vaccination.
- Family history, here they note if there is any lingering family disease that may impact the patient.
- Also, birth place, habits, economic status, residences, marital history are recorded.

The clinical test involves the observation of the following:

- Vital signs (weight, height, blood pressure, respiration rate etc.)
- Checking out for nutritional status, presence of jaundice, parllor or clubbing.
- Skin, head, ear, nose and throat
- Heart and blood pressure
- Others include:

- Respiratory, abdomen and rectum, orientation, mental state.

For treatments, further medical laboratory test may be ordered by the doctor depending on the severity of the case. Also included are medical imaging studies, starting therapy ad follow up may be advised.

However, patients today are still suffering from preventable adverse events and medical errors in the hospitals. It is the third leading cause of death in the US (10). However, recent innovation like checklist, which part of the standard operating procedures in the aeronautical space industry leading to profound improvement in recent records. The use of behavioral economics to influence behavior is another strategy being used by doctors, for example via positive peer pressure by publishing performance results, and increasing consumer empowerment, through the use of patient portals, have also been shown to be effective. Funding of healthcare also matters a lot; the way it is funded will also drive healthcare practitioners' behavior and outcomes. Clinical communication, documentation and standard care have also been improved with the use of Electronic Medical Records (EMRs). Also the use of telemedicine and telehealth has improved access for patients.

THE FUTURE OF MEDICINE

Improvements in hygiene and therapeutics will always continue as much is the world is changing trends. Oncology for example, has greatly advanced with immunotherapy, genomics and genetic engineering technology all playing a part to prevent, manage and cure cancers in the not future. Stem cell therapy could restore sight and neural damage (11).

Eminence-based, practitioner-dependent medicine has developed to become evidence-based, best practice medicine. However, this recent move to reduce differences and make everyone go down the same pathway will pave way to personalized medicine, which is based on each individual's genotype, including epigenetic factors, that will lead to individualized therapies that avoids the trial-and-error method of medication choice and dosing.

Genetic engineering can potentially edit out our hereditary diseases. Robotics and neural interfaces may lead to cybernetic artificial limbs. Brain-computer interfaces (BCIs) are also being developed e.g. invasive interfaces, using new nanomaterials that provide two-way neural communications; and non-invasive interfaces,

based on EEGs that will allow the paralyzed patients to type out words or control devices with their thoughts alone (12).

In addition, there have been profound improvement in anti-senescence and aging reversal therapies and recent papers on them has been published on therapeutics like Rapamycin, genetic therapies and telomere modification that could prolong life more.

However, with all these successes there are still additional challenges. The Healthcare sector is faced with a series of challenges that threaten to undermine its ability to meet them without a complete paradigm shift. World population is growing, ageing and becoming more obese, and people are living longer and surviving severe illnesses with chronic disease, dementia and other long-term disabilities.

The healthcare system cannot possibly manage the ever increasing challenges on its limited resources, limited workforce and as well limited finances, without a complete transformation. The models of care need to be looked into again, and the hospital-based acute system that we greatly rely on, needs to transit into a community, home-based framework of care. Care can then be decentralized to the home level, but technology needs to be leveraged so that data can be transmitted back to centers of excellence for monitoring processes and decision-making.

The role doctors' play will need to be supported by machines. Artificial intelligence (AI) is simply intelligence exhibited by machines, in the form of computers or even robots. When an Artificial Intelligence is able to learn from data, this process is also called machine learning. Also, deep learning is what happens when machine learning improves through the use of greatly advanced statistical techniques applied to numerous data.

AI is drastically changing all aspects of every industry, and also it is increasingly being used in healthcare system. AI is able to consider, gather data and sieve through the enormous amount of data available and, at this point, able to equal the diagnostic power of doctors in certain areas. For instance the deep learning systems are now able to review radiological and pathological images and also provide diagnoses that are equal to radiologists (13) and pathologists (14), respectively. Other trials methods have also shown similar results in oncology, dermatology and psychiatry. AI is more superior to humans in the area of patter-recognition and using algorithms to synthesize and analyze big data. This certainly

can lead to more accurate diagnoses and better treatments, faster and of course cheaper.

KEY AREAS OF FUTURE MEDICINE

3-D Printed Biomaterials and Drugs

More objects can now be printed using the 3D printers and the bio-tech industry is keeping an eye on the potentials of this wonderful opportunity. Printing of medical devices in underdeveloped areas and printing living tissues, cells or drugs might not be far away from the everyday use. This will re-structure the whole pharmaceutical industry and the ever growing world of bio-technology, but the challenge here will be regulation since anyone will be able to print drugs containing patented molecules at comfort of their home. Bionic ears and other simpler organs will be printed at the patient's bedside while printing transplantable human organs could eliminate waiting lists. Current technical issues for example, the lack of available models and blueprints will be resolved through crowd sourced and open access databases from communities of designers.

Adherence Control

Adherence and compliance represent very crucial issues in a bid to improving the patients' health and also decreasing the cost of delivering healthcare services. Several start-ups have targeted this issue and come up with different solutions such as the pill bottle that glows blue when a medication should be taken and then red when a dose is missed by the patient alerting the family members about it. Another example is that tiny digestible sensors can be placed in pills and transmit pill digestion data to physicians and family members and in the future, it is going to be extremely difficult not to completely comply with the prescribed therapy. Moreover, full compliance with medication is as simple and comfortable for patients as possible.

Artificial Intelligence in Medical Decision Support

The knowledge of even the most pronounced professors cannot compete favorably with cognitive computer machines and as the amount of information is steadily growing, the use of such machine solutions in assisting medical decision making is imminent. A physician can keep a few papers in mind, maybe a few dozens of papers but with digital solutions, IBM's supercomputer named Watson can process well over 200 million pages in split seconds. For this reason, Watson has been tested in oncology centers to see if it could be used in the decision making process of doctors regarding cancer treatments.

Artificial Organs

An artificial organ is simply a device or biological material that is implanted into the body in other to replace a natural organ or its function. Moreover, 3D printing is not the only solution for creating body parts and artificial organs, such organs can also be grown in laboratory setup under standard conditions. Surgeons have been able to successfully implant artificial skin, synthetic windpipes and artificial blood vessels. We will be able not only to replace the functionality of our organs with biomaterials and synthetic devices, but to grow organs which can replace a non-functioning natural organ in its full physiological capacity in the near future.

Curated Online Information

In the future, not minding whether it is the right or reliable medical information, dynamic resources or medical records online, everything simply will be available to everyone and anyone which would purely be the most important development in the history of medicine. Since people most cases have to deal with false or unreliable information and resources, curating these with medical professionals and expert patients are the way forward.

Customized Mobile Apps

Over the years, the number of medical mobile applications has been raising, therefore patients and doctors find it even more difficult to choose the right app for their health management or work. Now, customized mobile apps for example, the pApp that lets doctors create mobile apps for their patients could be the next big step. The functions the app should have for instance, logging blood pressure or medications can be gotten from menu and the patient can simply download the app right away.

Digestible Sensors

It is possible to swallow digital devices and tiny sensors for gathering and storing data, transmitting body temperature, and heart and respiration rate to an external device. In diseases related to our gastrointestinal system, it could give instant diagnosis by combining the results of lab markers and colonoscopy only by swallowing the device that includes a video camera as well.

Digital Literacy in Medical Education

The only sure way to prepare healthcare providers for the digital technologies coming to medicine is to include digital education and the main trends of the future of medicine should be included in the official medical curriculum. The Social media course at Semmelweis University has for long been teaching medical students about the use of social media and even mobile applications. Medical students can as well access these materials in a gamification based e-learning platform, and thus answer questions about the topics covered in the lectures on a Facebook page for bonus points. Also, a new course: Disruptive Technologies in Medicine is aimed at introducing students to the technologies from genomics to telemedicine they will use by the time they start practicing medicine. All these courses should be made available in every medical school worldwide.

DIY Biotechnology

In the past couple of years the materials and methods of biotechnology have been becoming more available to anyone interested in them. Very expensive laboratory equipment is not so much needed for carrying out biological experiments, components of the experiments can be ordered on demand and the data or information required are more accessible than before. The iGem events made it point blank that the number of opportunities available in using biotech for different purposes is almost infinite.

Embedded Sensors

In addition to digestible and wearable sensors, tooth embedded sensors can also recognize jaw movements, coughing, speaking and even smoking. Just imagine the same wireless technology that is used in organs that provide real-time data from artificial pancreas to recording EEG (electroencephalography) constantly.

Full Physiological Simulation

What if it is very much possible to examine the human body with all its physiological functions without trying experimenting with people? Of course, one of the most potential applications developed in this area is the Virtual Physiological Human (VPH); it's a framework that enables collaborative investigation into the human body. Students of medicine would be able to study and analyze the human body in details like never before and understand the core concepts of how the body works and the pathology of diseases.

Microchips Modeling Clinical Trials

Changing from long and extremely more expensive clinical trials to tiny microchips which can be used as models of human organs or whole physiological systems provides clear advantages. Drugs or components could be tested on these without limitations which would make clinical trials faster and even more accurate (in each case the conditions and circumstances would be the same). Microchips with living cells that model how a lung works are already available. The Organs-on-Chips technology has been developed for years and provides now a range of chips modeling organs. More complicated microchips that can mimic the whole human body are needed, and this ultimate solution could arrive soon.

Multi-functional Radiology

Radiology will be quite different in about 10 years' time from what it is now as it is probably going to be a combination of imaging techniques and personalized diagnostics with real-time interventions. One multifunctional machine will be able to detect plenty of medical problems, biomarkers and symptoms at once. The machine used in the film, Elysium, tells the patient what percentage of their cells is cancerous with one quick check up. Further examples could include resting state and task functional MRI for examining cognitive patterns; large scale initiatives involving neuroimaging and the brain macro-connectome. The recently launched Human Brain Project could become even bigger than the Human Genome Project.

CONCLUSIONS

It is most likely that technology will replace, not all, but 80%, of what doctors do (15). In the future, it is very likely that the use of medicines will be greatly influenced by technology, consumer education and self-awareness regarding lifestyle and diseases (16). Technology will be a key driver for change in the future, enhancing the medical skillset of healthcare professionals facilitating updates and change in parallel with consumers (17). This could influence the way people use medicines and how healthcare professionals manage patients. Novel change could include tailor-made drugs on the basis of pharmacogenomic data or medicines manufactured locally and on demand through 3D printing (18). Future personalized sensors could measure clinical parameters and blood biomarkers transmitting data in real

time to a cloud or, for instance, sending alerts when a stroke is in its earliest stages (19).

The big question now is "will machines replace doctors? Some commentators have argued that AI will inevitably replace many doctors, lawyers and other professionals (20). Some have argued that machines can and will never replace doctors since they lack the "human touch" of "compassion and kindness", but industrial training (IT) experts use the "personal banker" and the "travel agent" as examples of professions that are being slowly replaced by computer systems.

Support from technologies will free up the future doctor to be the human face of the healthcare system to provide the personalized care and compassion that are just as important as the technical answers being sought out for. The doctor can as well be freed up to lead the healthcare system as a whole. This is because machines can manage information, and provide a prioritized list of options based but machines can never lead people, in other words, people would not want to follow a machine, people follow people and not the other way round. In the same way, a doctor's role as a health systems leader will never be replaced by technology.

Why wait for the future? Be the human face of the healthcare system now, and show a high level of compassion and kindness to your patients. And also rise up and lead the health system. Because this is the one thing that no one can take away from your role as a doctor.■

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