JOURNAL OF THE AMERICAN COLLEGE OF CARDIOLOGY
© 2016 BY THE AMERICAN COLLEGE OF CARDIOLOGY FOUNDATION
PUBLISHED BY ELSEVIER

VOL. 68, NO. 2, 2016
ISSN 0735-1097/$36.00
http://dx.doi.org/10.1016/j.jacc.2016.05.035

LEADERSHIP PAGE

Reading the Tea Leaves

Where Will Cardiology Be in 2050?

Richard A. Chazal, MD, FACC, *ACC President*

During a period of rapid change, all of us are trying to emulate "The Great One" in "skating to the puck" (1). Few areas of life are likely to change as much as medicine in general—and cardiovascular medicine in particular. The ability to identify meaningful change and have the flexibility to positively adapt to such change is a characteristic of successful individuals (and species), and thoughtful views of our past often prove valuable.

In 2000, the topic of such prognostication was approached by a team comprised of health care futurist Joe Flower, MA; past American College of Cardiology (ACC) President Leonard Dreifus, MD, MACC; (then) future ACC President Fred Bove, MD, PhD, MACC; and prominent ACC member Bill Weintraub, MD, MACC. "Technological Advances and the Next 50 years of Cardiology" was published in the *Journal* as part of a special ACC Forum on the Future that examined the historic advances in cardiovascular medicine being made at that time and that offered possible scenarios for 2050 (2). Now, 16 years later, it is interesting to compare today's evolving health care landscape against their predictions and provide some thoughts on where we might be in 2050 on the basis of what we know today.

Flower et al. (2) predicted a 2009 landscape where a cardiology appointment would consist of a technician taking a drop of blood, immediately scanning it, and 2 min later sending the patient on to a "lifestylist" because of a genome indicating a risk for heart disease. Technology for genetic testing has not yet reached this level of utility, but one can envision such a scenario in the not-too-distant future. In 2000, the authors spoke of arteries "swarming with 'smart dust' that constantly reports on [a patient's] condition, directly over the Internet, to [a] physician's database" (2); they predicted this would likely occur by 2024. Implantable technology and nanotechnology could indeed confirm this prediction.

The jury is still out on whether the 100-year-old in 2050 will still "feel better than he/she did at 50 because of exercise, plenty of sleep, and moderate habits as well as breakthroughs in antiglycosylation therapy, wholesale organ replacement in [their] 80's, and the nanolabs in [their] blood stream that manufacture pharmaceuticals as needed and constantly top up [their] telomerase, the enzyme that makes cells immortal" (2). At this point in time, the hope of more "exercise, plenty of sleep, and moderate habits" has not been fulfilled; we certainly know that physicians and patients must improve in these areas.

What these cardiologists/futurists clearly predicted is the notion that "the combination of demographic shifts and cost pressures and a flood of new technologies—both biological and digital—promise that the new century and the coming generation will see the creative destruction and rebirth of what we know today as healthcare" (2). They were 100% correct in their assessment that cardiovascular medicine will never be the same because of "radical changes in technique and understanding, even as health care undergoes radical changes in structure, payment systems, and information flow" (2). Flower et al. (2) had impressive insight in 2000. Given events since then, one can reasonably surmise some updated predictions.

For millennia, physicians and healers practiced their art and science largely on the basis of observation, anecdote, and experience (*intuitive medicine*). We are currently in an environment with an abundance of scientific information and population pattern data (*evidence-based medicine*). The impending evolution is individual algorithm-based practice (*personalized* or *precision medicine*) (**Figure 1**). What, then, do the next 50 years look like given what we

From the American College of Cardiology, Washington, DC.

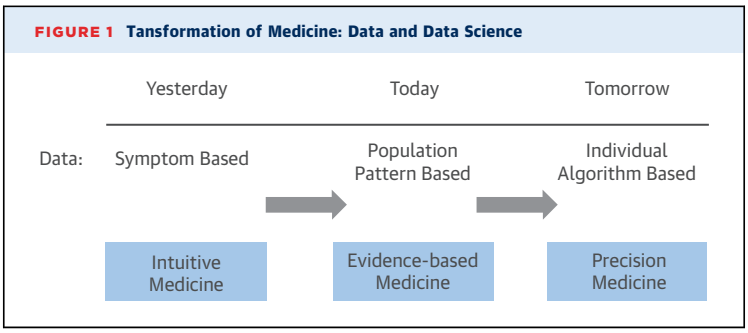

FIGURE 1 Tansformation of Medicine: Data and Data Science

now know today? Are there trends that can help us predict how health care delivery will look? Can we utilize future predictions to improve patient care today?

Practice settings are changing rapidly. The increased use of nontraditional venues for health care is expanding with pharmacies, local health clinics, and big box stores entering the field. Telemedicine also continues to gain traction as a means for follow-up of patients, particularly following hospital admissions. Additionally, broader use of electronic health records is putting physicians and other health care professionals in constant contact with patients. One would expect to see these trends continue as we evolve into a digital society.

By 2024 and beyond, it would not be surprising to have virtual teams engaging with patients using telemedicine technologies in lieu of follow-up appointments or even basic wellness checks. This seems particularly attractive as there is adoption of a U.S. payment system that rewards value, outcomes, and cost-savings over procedural volume in the near future. By 2030, one might not need appointments as we know them today.

Wearable technology, already a fitness trend, is likely to continue expansion in the health care space. Peter Fitzgerald, MD, PhD, director of the Center for Cardiovascular Technology and Innovation, and director of the Core Cardiovascular Analysis Laboratory, Stanford University, notes that although wearable health and fitness devices and applications are primarily a consumer trend at this juncture, they will move into medicine and "have a major impact on the future of healthcare" (3). Smart watches and fitness trackers can currently detect when a person has been inactive and send reminders—in some cases even little shocks—to get a person moving. Implantable devices that monitor heart rate and pulmonary artery pressure are in use in the medical space currently (4). We are only a few years away from wearable technologies that can remotely monitor patients and also notify them of a need to increase medications or to contact their physician. Expect these devices to become smaller and more affordable in the years to come (consider the "smart dust" envisioned in 2000).

Another near-term technology with great potential is 3-dimensional (3D) printing. Currently, this technology is being used in training and to help plan complex cardiovascular surgical procedures. On the near horizon are 3D printed structures with live cells or biocompatible polymers to create replacement valves and vessels—and perhaps complete organs. If successful, this technology could allow creation of "replacement parts" customized for each patient with minimal rejection risk.

Widespread genetic testing is not yet available, but this is an area of particular interest. Currently, several online genetic service companies provide limited reports on the basis of deoxyribonucleic acid testing from saliva samples. One company, 23andMe, provides carrier status, wellness, trait, and ancestry reports that meet U.S. Food and Drug Administration standards. This type of screening, if more broadly accepted and covered by Medicare and other payers, could help identify patients who are at risk for cardiovascular (and other) diseases well in advance of signs or symptoms. Further into the future, this type of testing should lead to the development of personalized drugs and treatments on the basis of genetic profiling. A recent article in *ET-Trends* predicts that by 2045, we will be able to synthesize gene-specific drugs that will treat specific ailments even if the malady affects only 1 person on the planet (5).

Robotics, already commonly used in industry, are likely to play an increasing role in medicine. The use of nanotechnology to develop microscopic robots or nanobots will likely be available for broad use by the mid-2020s (6). The ability of nanobots to reach places within the human body currently inaccessible to conventional surgical instruments has huge potential for surgeons and interventionalists, who strive for increased precision in their efforts to repair heart defects, unblock arteries, and treat complex arrhythmias. "These medi-bots will be the next 'big' small thing bringing new meaning to internal medicine," says Ken Gilleo of *ET-Trends*. "Small enough to be injected into the blood stream, the self-propelled submarine-like devices will navigate the tributaries of your body. … Equipped with micro-surgical tools and nano-lasers, the bots will keep your 'plumbing' clear" (5).

The merger of nanotechnology, microsensors, and "pharmacy on a chip" technology is likely to alter medical care as it is currently understood. Toxin and

biometric sensors in the blood may be able to detect pathology that can be treated automatically by implanted or circulating pharmacy "mini factories." Pneumonia (or acute thrombosis) may be rapidly detected and treated before symptom onset with feedback provided to the patient and physician via telemetry.

It is safe to expect that between now and 2050 medicine will increasingly continue to focus on electronics and emerging technologies. The pace of technology is so rapid that many changes cannot be fully anticipated. Real opportunity and real challenge are inevitable. Among the greatest challenges will be our ability to answer the inherent ethical questions involved in taking these technologies to the next level. How will the sale of organs created by 3D printers be regulated (or can/will it be regulated)? Who can use and access the genetic and personal health data being downloaded every second by the micro-electromechanical systems or nanotechnology embedded in a patient? How does one prevent hacking of these systems and ensure patient privacy? What are the cost implications associated with personalized drugs and devices? How can society (and the cardiovascular care team) help guarantee equal access to these services and not further broaden the disparities in care that we are working so hard to eliminate?

The questions raised with regard to the use of newer technologies rival the complexity of the American health care system that so many of us are currently trying to navigate. Anticipating some of these challenges, the ACC is continuing to search for ways to work with industry, government, medical specialty societies, and patients to get ahead of many of these technologies and issues and bring the "medicine of the future" into current practice. Opportunities exist to begin the transformation of care, leveraging what we know today.

Considering evolving changes in care models, the increased use of team-based care offers advantages to both practitioners and patients. The integration of advanced care practitioners into delivery systems provides expertise in areas where these practitioners have been demonstrated to excel in quality, while improving efficiency in care. Increasing use of clinical pharmacists, genetic counselors, and other team members brings essential elements of patient care to the forefront (7).

Remote monitoring and implantable telemetry are a reality in our practices today. Innovations continue to advance their use in daily management, particularly in heart failure and arrhythmia evaluation (4,8). Mobile device applications are frequently utilized by patients to monitor physical activity, calorie consumption, blood pressure, and even heart rhythm. Such information, when shared with the cardiovascular specialist, can potentially become a cost-effective adjuvant of care.

An increasing emphasis on population health management is 1 response to changes in health care finance, such as the new Medicare Access and CHIP Reauthorization Act of 2015 rules. The skills to understand the nuances of managing not just individual patients, but also pools of patients will become essential in the very near future.

Genetic testing is beginning to bear clinical relevance. Specific cardiac conditions such as sudden death/long QT syndrome, some cardiomyopathies, and familial hyperlipidemia are just a few examples where testing is now available and may be applicable now.

The College continues to develop consensus documents, training statements, and guidelines to help guide appropriate use and to help cardiovascular specialists adopt new transformational therapies. The newest registries—the LAAO (Left Atrial Appendage Occlusion) Registry and AFib (Atrial Fibrillation) Ablation Registry—are in direct response to new emerging therapies that will benefit from data collection and research. ACC members and leaders are also actively engaged in discussions with members of Congress and key regulatory agencies regarding programs and laws addressing personalized medicine, prevention, and research, and closing gaps in health care disparities.

Drs. Flower, Dreifus, Bové, and Weintraub said it well: "Imagination is rapid, but progress is often both uncertain and slow because of the many constraints of cost, regulation, and time needed to test and evaluate new developments. Yet we can now foresee a future in which medical science might actually defeat cardiovascular disease the way it has defeated polio, smallpox, and other serious scourges of the past" (2). There is little doubt that the days of cardiovascular disease being the number 1 killer around the world are numbered. I also have no doubt that the College's members will play a significant role in making this happen.

ADDRESS CORRESPONDENCE TO: Richard A. Chazal, MD, FACC, American College of Cardiology, 2400 N Street NW, Washington, DC 20037. E-mail: richard.chazal@leememorial.org.

JACC VOL. 68, NO. 2, 2016
JULY 12, 2016:227–30

REFERENCES

1. BrainyQuote.com. Wayne Gretzky quotes. Available at: http://www.brainyquote.com/quotes/quotes/w/waynegretz131510.html. Accessed May 18, 2016.

2. Flower J, Dreifus L, Bové A, Weintraub W. Technological advances and the next 50 years of cardiology. J Am Coll Cardiol 2000;35:1082–91.

3. Fornell D. Cardiovascular advances to watch in the next decade. Diagnostic and Interventional Cardiology. April 29, 2015. Available at: http://www.dicardiology.com/article/cardiovascular-advances-watch-next-decade. Accessed May 4, 2016.

4. Abraham WT, Stevenson LW, Bourge RC, Lindenfeld JA, Bauman JG, Adamson PB, for the CHAMPION Trial Study Group. Sustained efficacy of pulmonary artery pressure to guide adjustment of chronic heart failure therapy: complete follow-up results from the CHAMPION randomised trial. Lancet 2016;387:453–61.

5. Gilleo K. The sci-fi future of medicine…the next 50 years. ET-Trends. Available at: http://www.allflexinc.com/the-sci-fi-future-of-medicine/. Accessed May 4, 2016.

6. FutureTimeline.net. 2020-2029 timeline contents. Available at: http://www.futuretimeline.net/21stcentury/2020-2029.htm. Accessed May 12, 2016.

7. Brush JE Jr., Handberg EM, Biga C, et al. 2015 ACC health policy statement on cardiovascular team-based care and the role of advanced practice providers. J Am Coll Cardiol 2015;65:2118–36.

8. Leshem-Rubinow E, Assa E, Shacham Y, et al. Telemedicine to expedite medical contact following symptom onset (abstr). J Am Coll Cardiol 2014;63 Suppl 12:A1425.