The Evolution of Telemedicine and Nano-Technology

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ABSTRACT

This paper will cover definition and history of telemedicine, changes in medical paradigm and roll of telemedicine and roll of nano-technology for evolution of telemedicine. Hypothetically, telemedicine is distance communication for medical purpose and modern definition explains telemedicine as 'a system of health care delivery in which physicians examine distant patients through the use of telecommunications technology. Medical service will change to personalized medicine based on gene information to prevent and manage diseases due to decrease of acute diseases, population aging and increase of prevalence in chronic diseases, which means current medical services based on manualized treatment for diseases will change to personalized medicine based on individual gene information. Also, international healthcare will be activated to provide high quality medical services with low cost using developed transportation. Moreover, hospital centered medical services will change to patients centered medical service due to increase of patient's rights. Development in sensor technology is required for telemedicine to be applied as basic infrastructure for medical services. Various researches in nano-biosensor field are conducted due to introduction of new technologies. However, most researches are in fundamental levels that requires more researches for stability and clinical usefulness. Nano technology is expected to achieve innovative development and define new criteria for disease prevention and management.

Keywords: Telemedicine, Nano-technology, Wireless sensor, Remote monitoring, Biosensor, Bio-signal, Healthcare, Tele-consulting

1. TELEMEDICINE : DEFINITION AND HISTORY

Hypothetically, telemedicine is distance communication for medical purpose and modern definition explains telemedicine as 'a system of health care delivery in which physicians examine distant patients through the use of telecommunications technology. In the initial stage, telemedicine was mostly tele-consultation, tele-care, and tele-education. After development of communication technology and medical devices, telemedicine developed to tele-diganosis, tele-radiology, tele-pathology and developing to tele-monitoring and tele-surgery.

In a broad sense, telemedicine existed from ancient times. Efforts to avoid damages from hazards such as infectious diseases and famine were conducted by using smoke, flag, mirrors

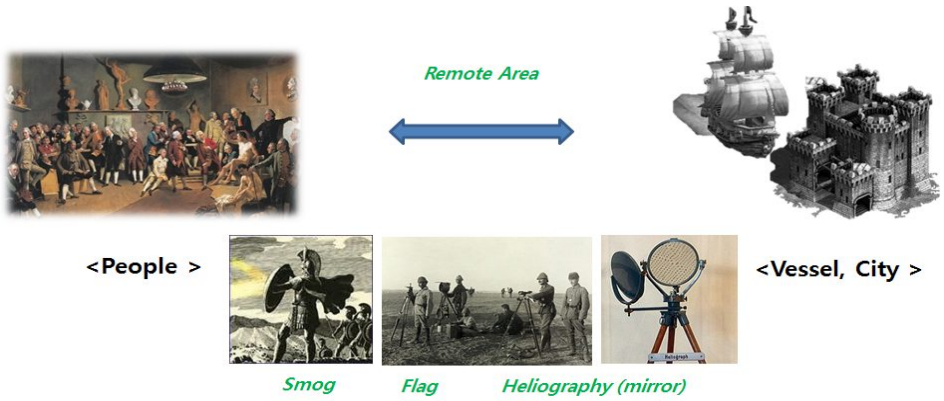

Figure 1. Telemedicine in the past.

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For example, African villagers used smoke signals to warn people to stay away from the village in case of serious disease. Also, information about bubonic plague was transmitted across Europe by heliograph or bonfires to spread information about war and famine.

Telemedicine was born in modern period. In 1862, telegraphy was used to supply medical resources and transfer patients. In 1905, Einthoven used telephone line to send electrocardiogram which could be the beginning of telemedicine. In 1920, radio frequency was used to provide emergency medical services in maritime area. Regular telemedicine was started in 1954 by providing psychiatry telemedicine using two way closed circuit TV and telemedicine in 26 Alaska area was conducted using satellite.

The telemedicine can be sent data more quick and farther by development of data transfer, contents, devices, data processing technologies. But, fundamentally telemedicine is only used in situation when doctor can't directly see a patient. Because developing countries don't have the basic infrastructure for telemedicine. The necessity of traditional telemedicine is reducing by increasing developed medical infrastructure in developed country and decreasing scope or cases when doctor can't see a patient in.

2. CHANGED MEDICAL PARADIGM AND TELEMEDICINE

Medical paradigm is changing and changes in roll of telemedicine followed by the paradigm. Medical service will change to personalized medicine based on gene information to prevent and manage disease due to decrease of acute diseases, population aging and increase of prevalence in chronic diseases, which means current medical services based on manualized treatment for diseases will change to personalized medicine based on individual gene information. Also, international healthcare will be activated to provide high quality medical services with low cost using developed transportation. Moreover, hospital centered medical services will changed to patients centered medical service due to increase of patients′ rights.

Table 1. Changed medical paradigm

Past	Present and Future	
Acute disease care	Prevention & Management	Chronic disease management service
General care	Personalized care	Personalized medicine based on genetic
Hospital centered	Cheap & High quality care	Vitalization of international medicine
	Patient centered	Increase right of patient

It is essential to monitor bio-signals in daily life to manage chronic diseases and needs of telemedicine using attached and implanted sensors are growing. Because effective international medicine requires accurate diagnosis and after surgery management, cross border tele-diagnosis and tele-consultation will spread widely. In America, remote readings of X-ray examination using radiology doctor from low cost country, increased cost efficiency and promoted quality of medical services in emergency medicine. Also, need of multilateral tele-consulting is increasing because of activation of total care service which is treating patients in more than two departments.

Tele-monitoring can monitor heartrate and ECG(Electrocardiogram) using wireless wearable sensor and pulse by attaching electrode on skin. Also, viral sign, asthma attack can be monitored using wireless sensor. Monitor ECG, pulse by attaching electrode on skin. Also, for Diabetes, implanted device in body can monitor blood sugar and provide treatment by interfacing insulin pump.

Figure 2. Devices for sensing

Premise of telemedicine is to send measured bio-signals to distant place by using telecommunications technology. To provide health management services, medical experts can diagnose patients by analyzing bio-signals monitored on daily life. Therefore, current telemedicine which is used as alternative treatments, will change to crucial medical service infrastructure in the future.

As patients' rights promoted and IT technology developed, number of computers per person is increasing and developed to ubiquitous computing generation. As such, present medical services are provided by various experts such as doctors, pharmacists, nutritionists for single patient. To activate this system, establishing video conference system for multiple locations is essential and will be used for basic infrastructure.

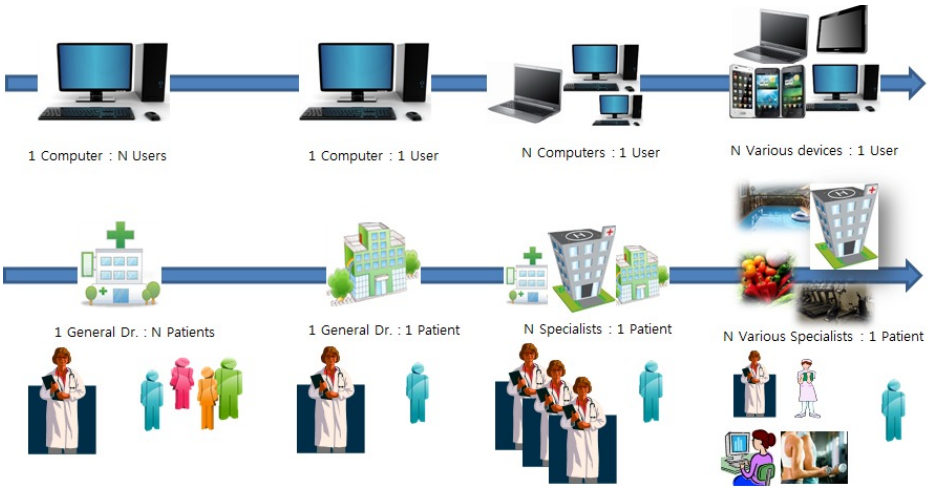

Figure 3. Multiple tele-consulting

Telemedicine has been used in special situations to provide medical service, only when face to face treatment is impossible due to location. However, due to changing medical paradigm and invigoration of bio-signal information monitoring, international medicine and outsourcing of various readings from examinations, telemedicine will settle as a basic infrastructure for providing medical services.

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3. TELEMEDICINE AND NANO TECHNOLO

Telemedicine is consists of three levels. Measuring bio-signals from various sensors, collecting and sending data analysis and feedback of data. Processing speed data has made rapid progress starting 21st century which is crucial for analysis and feedback. Data transferring speed is also very important factor, which shows rapid development from 1980s. However, development in types, performance and stability in the field of sensor is insignificant from initial stage.

The most popular sensors measure blood pressure, pulse, ECG, body temperature, body fat, oxygen saturation, body activity, electrodermal activity and so on. Development of nano-technology enables to create smaller and more precise medical devices, suggesting new concept and definitions for bio-signals.

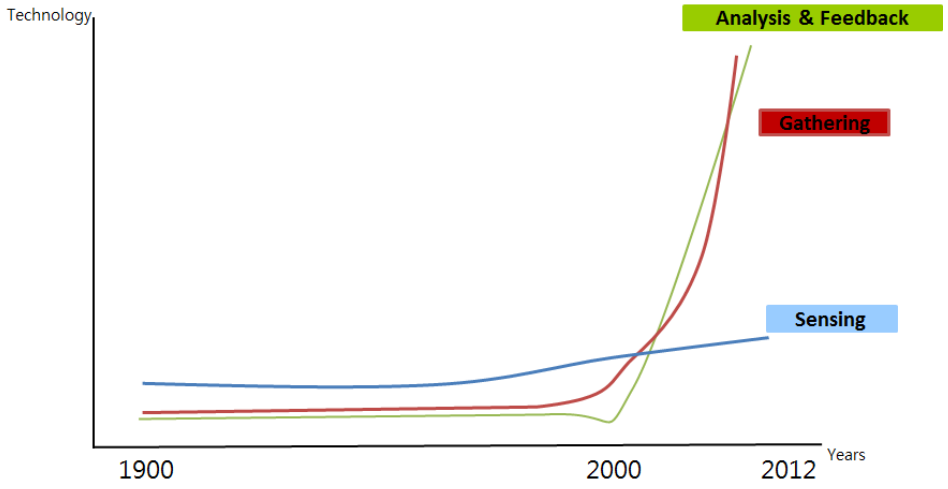

Figure 4. Technology growth of three stages

There are various sensors using nano-technology such as Biosensor, nano-biosensor, lens-free on chip microscopy/tomography, cantilevers with functionalized tips. Biosensors measure existence and quantity of cell, enzyme, virus, protein, DNA, bacteria using microscopic bio-receptors. Implanted biosensors enable continuous blood glucose monitoring for diabetes, continuous monitoring for Asthma patients, checking food poisoning such as salmonella, E coli 0157 in school feeding and cancer detection using screening kit.

Nano biosensor is a compact, economic version of biosensors by applying nano-technology. For example, if attached DNA on gold particles that are complementary to bacillus anthracis DNA, the color of gold nano-biosensor particles changed their color when bacillus anthracis is nearby, which can be used to prevent terror using mail.

Also, for Cystic fibrosis, which is hereditary disease that causes abnormal concentration of secretions, attached nano-biosensor to a wristwatch for sodium and chloride enables to analyze DNA and concentration and alarms users when the concentration increase over normal range which can prevent pancreatitis and pneumonia.

Using Nano Hair, which is highly sensitive and flexible sensor developed by Korean researchers, development of wireless heart rate monitor would be possible.

Lensfree on chip microscopy/ tomography is new microscope that generates holographic images of microparticles, cells and any material being observed. This technology enables automated counting of whole blood cells counting of circulating tumor cells monitoring. And through CD4 and CD8 T cell monitoring for HIV patients. Detection of waterborne parasites rapid screening of water quality detection of circulating tumor cells high-throughput screening of DNA/protein micro-arrays.

Nano-techonology applied sensor is cantilevers with functionalized tips. The enhanced spatial, force and chemical resolution of the atomic force microscope and chemical force microscope can be taken into advantage for designing nano-scale diagnostic assays. The probe is attached to a piezoelectric scanner tube, which scans the probe across a selected area of the sample surface. Applying this technology can probe a molecular structure of interest in drug discovery and measure biochemical interactions such as those between antigens and antibodies.

Development in sensor technology is required for telemedicine to be applied as basic infrastructure for medical services. Various researches in nano-biosensor field are conducted due to introduction of new technologies. However, most researches are in fundamental levels that requires more researches in stability and clinical usefulness.

Comparing with sensor field with others, it is discouraging rapid growth of telemedicine. However, bio-nano sensors show high potential and possibilities that can encourage development of telemedicine.

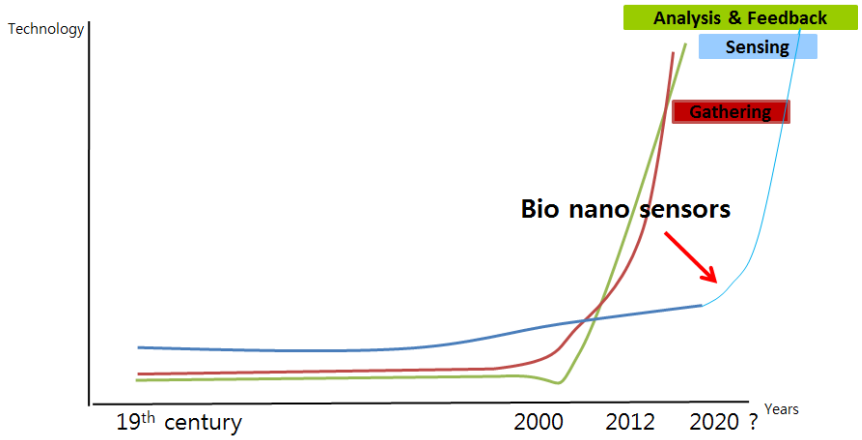

Figure 5. Technology growth of three stages in the future

4. CONCLUSION

There have been development and evaluation of telemedicine from 1970s to the present. Telemedicine was developed with communication technology to complement the special situation that the doctors can′t see patients. Monitoring bio-signals in daily life will be the most essential service because future medical services will be focused on preventing and managing diseases. Innovative development is required to monitor more precisely and various types of bio-signals. Nano-technology is expected to achieve innovative development and define new criteria for disease prevention and management.

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REFERENCES

[1] Borow W., "medical television: prescription for progress", The Journal of the American Medical Association, 270(13), 1601-2, (1993).
[2] D. N. Breslauer, R. N. Maamari, N. A. Switz, W. A. Lam, D. A. Fletcher, "Mobile phone based on clinical microscopy for global health applications", PLoS One, 4, e6320, (200).
[3] Elizabeth A. Krupinski, "Telemedicine and e-Health", 15(8), 804-805, (2009).
[4] High W, Houston M, Calobrisi S, Drage L, McEvoy M., "Assessment of the accuracy of low-cost store-and forward teledermatology consultation", J Am Acad Dermatol, 42, 776–83, (2000).
[5] Michael Ackerman, Richard Craft, Frank Ferrante, Mary Kratz, Salah Mandil, and Hasan Sapci. "Telemedicine Journal and e-Health", 8(1), 71-78, (2002).
[6] Nordal E, Moseng D, Kvammen B, Lochen M-L, "A comparative study of teleconsultations versus face-to-face consultations", J Telemed Telecare, **7,** 257–65, (2001).
[7] Isikman, S. O., "Lensfree On-Chip Microscopy and Tomography for Biomedical Applications", IEEE JOURNAL OF SELECTED TOPICS IN QUANTUM ELECTRONICS, 18(3), 1059-1072, (2012).
[8] K M Zundel, "Telemedicine: history, applications, and impact on librarianship", Bull Med Libr Assoc, 84(1), 71-79, (1996) .
[9] Perednia DA, Allen A., "Telemedicine technology and clinical applications", The Journal of the American Medical Association, 8(6), (1995) .
[10] R. L. Bashshur, G. W. Shannon, "History of Telemedicine", The National Library of Medicine, (2009)
[11] W. P. Mutter and R. S. Brown, "Point-of-care photomicroscopy of urine", N. Egl. J. Med, 364, 1880-1881, (2011).
[12] Zdravkovic svetozar, "Telemedicine: Perspectives and expectations", Oncology Institute of Vojvodina Sremska Kamenica, 16(3-4), 69-73, (2008).
[13] http://alivecor.com/
[14] http://asthmapolis.com/
[15] http://www.irhythmtech.com/
[16] http://www.soterawireless.com/