ICT and Wireless communication in the clinical setting: problems and solutions

Modern clinical medicine will be improved through the use of ICT, IoT, and AI

Information and Communication Technologies (ICT) have become common in various fields and provide great benefits to the efficient operation of modern hospitals. Eliminating paper based patient record systems by inputting and storing them on the database (DB) of the hospital information system (HIS) revolutionised hospital administration, as has being able to store the results of patient examinations and staff reports in patient DB. To enable the input of and referral to patient records at bedside, wireless data communication is essential as it enables busy physicians, nurses, and other medical staff smooth access to the latest patient information.

The Internet of Things (IoT) is also becoming a focal point of clinical medicine, with nurse call systems and wireless medical telemetry systems increasingly based on the concept of IoT. At present, most of the hospital systems that use IoT sensor networks are still in the trial phase because of difficulty meshing them with the wireless communication systems currently in use at hospitals. To realise systems for hospitals that can effectively use these technologies and ensure their safe use and compatibility with medical devices, an appropriate infrastructure that integrates the capabilities of the various types of wireless communication systems has become increasingly important.

According to the IEEE 802.11 series standards, the most popular wireless communication protocol, the data transfer rate depends on the intensity of the received signal. This means that it is imperative to maintain the intensity of signals from an antenna/access point (AP) for wireless communication at the place where they are received by medical devices or PC's. Causes of

weakened signal intensity are distance, noise, reflections, and absorbance. Effective planning and testing in the initial stages of hospital construction or remodelling is important for eliminating the possibility of an unintended decrease of the transfer rate.

Moreover, because most medical devices are driven by electric power, providing and maintaining a high-quality electric power supply is of utmost importance, especially with devices that gather and output biomedical signals. Some devices, such as Electroencephalographs (EEG) and Electromyographs (EMG), can be affected by electro-magnetic fields (EMF) and distortion of the power supply. Noise sources that cause distortion include devices such as AC/DC convertors for battery chargers and motors. I have been working to establish the safe use of wireless communication in hospitals through research into ways to identify and provide solutions to problems with the electromagnetic environment.

Works on electromagnetic fields and wireless communication

In early 1990's, cellular phones became a focus of research because of possibility that they might cause 'Electro-Magnetic Interference' (EMI), which is also called 'Electro-Magnetic Disturbance' (EMD). The first EMD identified was associated with the malfunction of a defibrillator when a cellular phone was used in close proximity. Although there were no reports of patient deaths, the use of cellular phones near medical devices came to be thought to be dangerous, and many hospitals prohibited their use inside the hospital building.

I began to research the electromagnetic environment of hospitals and related areas in 1996. For over 18 years I have worked in two university hospitals as an engineer, assistant professor, and associate professor in the Department of Medical Informatics, which is responsible for HIS, the networks for HIS and its sub-systems, electronic patient records, the HIS database, software related to the HIS, and the management of HIS data, including the prevention of information leaks. In addition, I developed a telemedicine system and various systems for the hospital staff and patients. Fortunately, I was involved in the construction and remodelling of hospital both hospital buildings. Furthermore, I worked as a board

member of an NPO on the development of a regional patient information sharing system.

At my first hospital, the nurse call system had adopted a Japanese cellular-type wireless voice communication system called a 'Personal-Handy Phone' (PHS). In this system, the output power of the antenna could not exceed 160mW and that of the terminal was 80mW maximum. Our research confirmed the safety of PHS in hospitals by examining the electro-magnetic compatibility (EMC) of PHS terminals and various medical devices.[1]

After completing this work, I began to search for possible noise sources inside/outside the hospital that might cause EMD with medical devices. I found EMF emissions from automatic conveyance systems, residual magnetisation, and EMF that had invaded from outside of the hospital building.[2-4] In parallel research, I was able to add projects on static magnetic fields, surge, and the quality of the electric power supply, including the quality of groundings, to our original research on problems related to (alternating current) EMF emissions.[5]

Variety of noise sources and means for preventing EMD

As mentioned above, there are numerous possible electromagnetic noise sources in and near a hospital. To prevent EMD from such noise, medical devices must have 'immunity'. Medical devices can be shielded, but this makes them heavier and more difficult to use, so weakening EMF is recommended. I have done research into metal mesh shielding,[6] but the use of weak output voice communication devices, such as PHS, and maintaining possible noise sources a safe distance from the device are simple, cost effective solutions to the problem.[1]

Other possible solutions are walls, doors, and flooring that reflect or absorb the signal. I have researched the shielding quality of many materials commonly used in hospitals.[7] Unfortunately, most of staff involved in hospital construction or administration pays little attention to the effects of the materials used in walls, doors, and floors on the reception of adequate signal intensity or blocking unwanted signals.

Through the research projects discussed above, wireless communication systems have evolved to the point where it is safe and effective. As mentioned in the beginning, wireless data communication systems, including wireless LAN, are an integral part of the modern hospital. Although systems are often installed, they can be ineffective because of a lack of consideration at planning or staff training due to financial/time reasons. The safety of medical devices (EMC) and patient data protection from leakage are critical in a hospital system; therefore, I have done much research on how to create a safer and better environment for wireless communication. Working together with my colleague Professor Kudou of Oita University, a specialist in theoretical electromagnetism, especially for simulating electromagnetic propagation, I began to research how we can install wireless communication safely and effectively. This involves ensuring that signals from an AP reach their intended destination at the required intensity. We found that the materials of the hospital building sometimes affect the signals by reflection or absorbance. When using an IEEE802.11 series wireless LAN, channel management (frequency management) is important to managing the data transfer rate.

We are currently trying to identify new research areas related to the establishment of the installation of the evolving technologies of wireless communication systems into hospitals.[8,9] My experience has shown the importance of interdisciplinary collaboration among network engineers, medical device managers, and the construction/maintenance section in the management of a safe and effective electromagnetic environment.[10] At the same time, we are continuing our search for new noise sources.[11]

My hope for utilising wireless communication in clinical settings

Modern clinical medicine will be improved through the use of ICT, IoT, and AI. Tele-medicine and tele-consulting will become more prominent. Sensor networks will be increasingly used for healthcare data acquisition.

To achieve the safe and effective use of these technologies, the electromagnetic environment is the most fundamental issue. Careful management of the electromagnetic environment will ensure smooth signal propagation and enable greater signal intensity. I hope all hospitals will be able to install the latest communications technologies while following appropriate strategies in their installation. Careful management of the electromagnetic environment will be essential for the effective use of the evolving technologies used in the high-tech medical devices rapidly being introduced into hospitals. All patients expect safe and reliable clinical medicine, which we can provide with cutting edge medicine and collaboration among the various hospital departments. I hope the best possible clinical medicine will be realised and provided to every patient.

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