Progress of wireless communication installation in Japanese hospitals

Eisuke Hanada[#1], Takato Kudou[*2]

[#] *Division of Medical Informatics, Shimane University Hospital*
Enya-cho 89-1, Izumo, 693-8501, Japan
[1]e-hanada @med.shimane-u.ac.jp

[*] *Department of Electrical and Electronic Engineering, Faculty of Engineering, Oita University*
Dannoharu 700, Oita, 870-1192, Japan
[2]tkudou@cc.oita-u.ac.jp

***Abstract*— Patient records have been written on paper for many years. It has become increasingly important that the medical staff at modern hospitals share information. Because of the progress of information and communications technology (ICT), high quality, high-speed data transfer using radio waves has been realized. Telecommunications systems using electromagnetic waves based on common specifications, such as public cellular phones, wireless LAN, and RF-ID, have been developed and have come into wide use. The use of these modern technologies has made possible an "ubiquitous environment," "an environment in which one can access information anytime, anywhere". Research aimed at utilizing ICT in medicine has progressed with the development of hospital information systems. This has enabled the input and sharing of patient information in a ubiquitous environment. As cellular phone use has become widespread, patients and doctors have begun to use cellular phones in medical settings. There are high expectations for the introduction of wireless communications in hospitals. In this paper, we describe the introduction of wireless communication technology into Japanese hospitals in recent years.**

Key words: Wireless Communication, EMI, EMC, Cellular phone, PHS, RF-ID

I. THE BACKGROUND OF WIRELESS COMMUNICATION INSTALLATION IN HOSPITALS

For many years, patient records, including personal information about patients, medical examinations, and medical treatment given the patient have been written on paper, as have the instructions for medical examinations and prescriptions. Moving them was done by messenger or by transmission by pneumatic tube etc. When a telephone was used for communication between doctors and their co-medical staff, such as nurses, pharmacists, and laboratory staff, misunderstandings and mishearing of the directions given by voice often occurred, which at times resulted in serious medical mishaps. For communication between patients and nurses, a voice communication system, a "nurse call system" that uses a cable similar to a telephone is often used.

The scope of medical examinations and treatments has developed greatly in recent years. Thus, it has become even more important that the medical staff at a hospital share information. In large-scale hospitals in which the laboratory staff and pharmacists are in different sections than the doctors, the accuracy and the speed of information transfer has become increasingly important, which has placed increased importance on equipment and its capability for communication and information sharing.

Because of the progress of information and communications technology (ICT), high quality, high-speed data transfer using radio waves has been realized. Telecommunications systems using electromagnetic waves based on common specifications, such as public cellular phones, wireless LAN, and RF-ID, have been developed and have come into wide use. The use of these modern technologies has made possible an "ubiquitous environment," "an environment in which one can access information anytime, anywhere". The Japanese government is promoting the realization of an ubiquitous environment.

Research aimed at utilizing ICT in medicine has progressed with the development of hospital information systems (HIS). With the great fall of the price of personal computers (PC), many HIS, which require a great number of PCs for use as terminals, have been built. This has enabled the input and sharing of patient information in a ubiquitous environment. As cell phone use has become widespread, patients and doctors have begun to use cellular phones in medical settings.

There are high expectations for the introduction of wireless communications in hospitals, both voice and data, Much activity related to the introduction of ICT, such as cellular phones and wireless LAN, into hospitals has been seen over the past several years.

II. HAZARDS AND REGULATIONS FOR WIRELESS COMMUNICATION INTRODUCTION TO HOSPITALS

Electro-magnetic interference (EMI) with medical devices by cellular phones has been widely reported since 1993 [1-5]. , To prevent EMI, some countries have taken the extreme measure of forbidding the use of cellular phones near medical devices or in hospitals. In Japan, the Ministry of Internal Affairs and Communications (MIC) announced guidelines for the use of cellular phones in hospitals in 1997 [6]. The guidelines have since been revised based on additional experiments [7, 8]. Now, as shown in Table 1, electromagnetic wave radiation sources are to be kept beyond

a fixed distance to maintain separation from medical devices. The minimum distance that should be secured is 22 cm. This value was determined in a large-scale experiment conducted from 1996 to 1997. In this experiment, electromagnetic signals were irradiated from a mobile communications device to approximately 350 kinds of medical devices, including 15 kinds of implantable cardiac pacemakers. One pacemaker had a malfunction caused by electromagnetic signal irradiation from a cellular phone 15 cm from the pacemaker. The safe distance was calculated by multiplying the distance (15 cm) by the square root of 2 to make the electric field intensity half. However, the electromagnetic wave radiation source by which this value was obtained was a cellular phone handset based on a specification unique to Japan (PDC, 800 mW of maximum output). Public PDC cellular phone service will end soon. Most of the cellular phone services in Japan have adopted CDMA. The maximum output from a CDMA cellular phone handset is about 250 mW in Japan; low compared with that of PDC. The maximum distance at which EMI with medical device results, also written in the MIC report, is short. This means that the possibility of EMI generated on medical devices by the use of a CDMA cellular phone is small.

TABLE I
SAFE DISTANCE TO BE KEPT FROM ELECTROMAGNETIC SIGNALS ORIGINATING FROM MEDICAL DEVICES

Type of EM field origin		Safe distance
Cellular Phone		22 cm
PHS		
Settled RF-ID tag reader/writer	High-power 950MHz Band Passive system	1 m
	Other than above	22 cm
Handy/embedded RF-ID tag reader/writer		

In areas other than medical field, wireless system use is spreading greatly in Japan. In addition to the cellular phone, wireless LAN (the maximum output of a terminal is about 150 mW), RF-ID, etc. are used by various industries. Therefore, we have great expectations for the introduction of these systems into hospitals. However, most hospitals are apprehensive about EMI and are asking for safety guidelines. Thus, MIC is conducting irradiation experiments on medical devices using various radio communication systems. However, the principle of "keeping 22 cm at least" will remain, regardless of the experimental results.

Radio communications systems, however, have been used in hospitals for many years. "Patient condition monitoring systems" consisting of servers and bedside terminals have been used for about 30 years.. In these systems, the biomedical information of patients, such as pulse and blood pressure, is transmitted from a bedside terminal using radio waves and is received and displayed at a nurse station terminal. The frequency used for the system is from 420 MHz to 450 MHz.

III. INTRODUCTION AND SPREAD OF WIRELESS COMMUNICATION IN HOSPITALS

At EMC'04/Sendai in 2004, we introduced the PHS and wireless LAN system used at Shimane University Hospital [9]. Since that time, PHS and wireless LAN have spread to middle and large-scale hospitals in Japan.

PHS is a totally digital mobile communications system developed uniquely in Japan. Since the terminal output is weak, 80 mW maximum, the influence of PHS on medical equipment is small. Therefore, PHS can be safely used in hospitals. By connecting a nurse call system to a telephone exchanger and giving PHS to nurses, many hospitals have made it possible to reply to patient calls anytime, anywhere. Doctors working in Japanese hospitals move around quite a lot. Hospitals that give doctors PHS are increasing. By having PHS, a doctor can be found quickly and can respond to patients more efficiently [10].

Also, the introduction of wireless LAN has enabled bedside reference to and input of patient information. Some hospitals place a desktop terminal at each bedside. However, there are problems, including installation and maintenance costs and data protection involved with placing PC at the bedside. In wireless LAN, the technology for preventing signal interception and illegal connection has improved, as has data enciphering technology. With these technologies, an environment in which wireless LAN can be safely and comfortably used has been realized [9].

In addition, in 2006 the "Study group for medical electromagnetic environments" of the Japanese Society of Biomedical Engineering drew up a guidebook concerning the use of cellular phones in hospitals [11]. This guidebook showed that cellular phones can safely be used in hospitals if certain conditions and regulations are followed. In Japan, many persons use an E-mail function on their cellular phones. An advantage of permitting the use of a cellular phone is that it allows inpatient E-mail exchanges of information with family and friends possible, a valuable patient service.

IV. THE FUTURE

Currently, RF-ID is attracting attention as useful wireless communication technology tool and is widely used in Japanese hospitals. Examples of its application include inpatient identification by an RF-ID tag inserted in a wristband, location management of medical devices by attaching an RF-ID tag to each medical device, and confirming things that are assigned to a patient, such as by placing an RF-ID tag on a transfusion bag, etc. The use of RF-ID contributes to increased efficiency [12-14]. However, many of its applications substitute for the work currently done by bar codes. RF-ID is disadvantageous both from the vantage points of installation and operating costs compared with bar code.

Hospitals sometimes introduce wireless communication technology without properly confirming safety. Because of the seriousness of EMI, hospitals should confirm safety in

advance, and only after making rules for safe use should they introduce wireless communication technology.

For EMC between medical devices and wireless apparatus, the experiments done by MIC are the only formal examinations in Japan. MIC has irradiated electromagnetic signals to various medical devices using an experimental output based on Japanese law, and has checked and reported the existence of EMI. However, if a hospital follows the MIC guidelines, almost no wireless communication devices can be used. Because the guidelines are not law, no punishment is given, even if they are not followed. Essentially, a hospital director should do an irradiation examination of all medical devices used in the hospital before installing wireless communication technology. However, implementation of an experiment is difficult in terms of cost and time. Thus, hospitals might do well to refer to the guidebook of the "Study group for medical electromagnetic environments" or to the various experimental results that are available and be responsible for their judgments on the propriety of the technologies they introduce.

V. CONCLUSION

In this paper, we have described the introduction of wireless communication technology into Japanese hospitals in recent years. In Japan the government bureaucracy is quite strong. MIC has jurisdiction over wireless communications and the Ministry of Health, Labour and Welfare has jurisdiction over hospital administration, and each jealously guards its territory. This is one of the major factors delaying the introduction of wireless communication in hospitals. However, the introduction of wireless communication technology should continue to be promoted, along with continuing efforts to confirm its safety. There is still much research work to be done in our scientific / academic field.

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