Journal of
Electrical & Electronic Systems

Hanada, J Electr Electron Syst 2014, 3:1
DOI: 10.4172/2332-0796.1000122

Review Article Open Access

The Necessity of Interdisciplinary Collaboration for the Improvement of the Electromagnetic Environment in Medical Settings

Eisuke Hanada*

Division of Medical Informatics, Shimane University Hospital, Enya-cho 89-1, Izumo, 693-8501, Japan

Abstract

Modern clinical medicine uses a wide variety of highly technical medical devices on which advanced medicine increasingly relies. These devices often use internet and communication technology. Some medical devices pick up weak biomedical signals and others function by generating a powerful magnetic field. Wireless LAN and wireless voice communication are useful in clinical settings.

Because of the recent availability of technical reports and our educational efforts to show that medical devices and wireless communication apparatus are safe and compatible, there is reduced anxiety among medical professionals and thus demand is increasing for technically advanced systems. For safety and security reasons, it is necessary to prevent both the radiation of strong electromagnetic waves from apparatus inside the hospital and to block the invasion of electromagnetic waves from outside. These problems can be solved by the use of electromagnetic shielding technology. The above are all related to the necessity of controlling electromagnetic fields. At present, adequate techniques for the control of the fields commonly found in medical settings have not been established. The best results will be attained if collaboration is done with people from the variety of fields working on or who will work on the project, such as those involved in material, architectural, and structural engineering, as well as the medical staff.

In order to insure the safe use of wireless communications in medical settings it will be necessary to improve the EMC standards and to disseminate information about electromagnetic field control to the medical staff. To insure safety and meet the needs of this rapidly changing environment, electromagnetic field control techniques must be established and constantly improved to meet the requirements of the environment in which medical devices are used. To achieve this, interdisciplinary collaboration is indispensable.

Keywords: Electromagnetism; Medical devices; Wireless LAN; Electromagnetic field propagation simulation

Introduction

The possibility of malfunction (Electromagnetic Interference, EMI) of medical devices caused by electromagnetic waves generated by mobile phones has been treated as a serious problem since the 1990s [1,2], and concern about medical accidents caused by malfunctioning devices has slowed the introduction of public wireless communications into hospitals. Portable phone system terminals with outputs of 0.8W were banned in Japan in 2012, and the strongest currently allowed output is 0.25W. This has reduced the possibility of EMI, which has resulted in improved medical safety and efficiency. Because of these improvements, the practical use of wireless communications in hospitals has expanded dramatically over the past few years.

In addition to mobile communication terminals, the design of some medical devices causes them to emit electromagnetic waves [3]. Measures against electromagnetic wave invasion from outside the hospital are also required as a result of the rapid spread of wireless communication infrastructures, including public wireless LAN [4,5]. In the future, controlling electromagnetic fields and ensuring the compatibility of medical devices will become increasingly technical and important.

The Introduction of ICT into Clinical Medicine and its Related Electromagnetic Environment

Modern clinical medicine uses a wide variety of highly technical medical devices on which advanced medicine increasingly relies. Medical devices can be categorized roughly into testing, treatment, or monitoring apparatus.

Some testing apparatus, such as electrocardiographs, electroencephalographs, and electromyographs, pick up weak biomedical signals from the body of a patient. Biomedical signals are measured as millivolts or microvolts. It has been shown that the electromagnetic field around this type of apparatus can affect the test results [6]. Other testing apparatus, such as MRI, function by generating a powerful magnetic field, thus the associated problems are more obvious. There are also treatment apparatus, microwave therapy equipment for example, that emit powerful electromagnetic fields into open space [3]. It is important to remember that medical devices themselves can become sources of electromagnetism noise. Wireless sensor network technology is now being introduced into both clinical and home medicine [7]. This will allow patients more freedom of movement, rather than being confined to bed by connections to machines, which will greatly improve the Quality Of Life (QOL). However, because the sensor network uses wireless communication, it is very important to ensure signal reachability from each sensor to the communicator and to prevent crosstalk or interference by electromagnetic noise.

The introduction of advanced computer systems is progressing rapidly in modern hospitals. Patient information in huge computer databases has created a situation in which reference to and the input of

***Corresponding author:** Eisuke Hanada, Division of Medical Informatics, Shimane University Hospital Enya-cho 89-1, Izumo, 693-8501, Japan, Tel: +81-853-20-2399; E-mail: e-hanada@med.shimane-u.ac.jp

Received January 10, 2014; **Accepted** March 05, 2014; **Published** March 07, 2014

Citation: Hanada E (2014) The Necessity of Interdisciplinary Collaboration for the Improvement of the Electromagnetic Environment in Medical Settings. J Electr Electron Syst 3: 122. doi:10.4172/2332-0796.1000122

information is possible "anywhere, anytime." In large hospitals, "team medicine" in which staff members with many occupational descriptions cooperate in the treatment of one patient is being widely promoted. The coordination required makes quick and accurate information sharing among the staff imperative. This complexity has led to the construction of improved data transmission infrastructures based on wireless LAN technology. In hospitals with critical care facilities, the use of wireless voice communication systems that include highly technical devices, such as modern smart phones, is absolutely necessary [8]. This type of wireless communication is especially effective when a patient's condition changes suddenly. In addition, medical devices with built in wireless communication functions, such as patient information monitors, are currently being introduced into hospitals. The introduction of radiological equipment, etc. that has built in wireless communication functions is also expected to progress rapidly [9].

Because of the availability of technical reports and our educational efforts to show that medical devices and wireless communication apparatus are safe and compatible, there is reduced anxiety among medical professionals and thus demand is increasing for technically advanced systems [5,10].

A Comprehensive Electromagnetic Environment in Modern Medicine

The main object of discussions of the "electromagnetic environment" in medicine has been radiated electromagnetic fields. Obviously, the electromagnetic environment is not constituted only of radiated electromagnetic fields. For example, it is known that a static magnetic field can affect the display and other functions of medical devices [11]. It is also known that medical devices and computers can malfunction from surges caused by lightning or static electricity. The power supply of a hospital is its lifeline. Most current medical devices are driven by electricity. At the time of a disaster, an uninterrupted power supply is important to the continuation of critical medical services. The power supply is also indispensable to facilitate communication. Grounding is an important but neglected element of the power supply. It is well documented that poor grounding is a danger to medical device use and ultimately to patients [12]. To me, it is important to carefully consider the comprehensive electromagnetic environment in modern medicine to realize that it consists of radiated electromagnetic fields, static magnetic fields, a well grounded electric power supply, and static electricity, including lightning [11].

There are a number of electromagnetic compatibility (EMC) standards for the electromagnetic fields to keep safe use of medical devices, and the target frequency band is limited for each standard. The target frequency bands specified in EMC standards for medical devices are as follows: 80 MHz - 2.5 GHz, which is specified by IEC61000-4-3 and 150 kHz - 80 MHz, which is specified by IEC61000-4-6. However, an example of radiation by an electromagnetic field below 150 kHz is the electromagnetic field of a commercial frequency generated by power supply equipment with poor grounding [12]. For commercial frequency magnetic fields of 50Hz and 60Hz, IEC61000-4-8 specifies the EMC standards. However, an electromagnetic field that exceeds 2.5 GHz is also used, represented by the 5.2 GHz of wireless LAN. Revisions of the EMC standards are ongoing, and expansion of the application frequency can be expected.

Application Field Expansion and the Improvement of the Medical Electromagnetic Environment

In recent years, the number of patients has grown who are dependent on medical devices in their daily life, such as artificial pacemakers and infusion pumps inside or on the surface of the body. The purposes of implanting or wearing medical devices are social rehabilitation and to improve QOL. Unfortunately, these medical devices can be influenced by the emissions of RFID tag readers, such as the "antitheft devices" commonly seen at the entrances of stores.

The use of dialyzers and respirators in patient homes is also increasing. It is problematic that in many cases the power supply systems of houses are not divided in such a way that there is an electric socket dedicated for medical device use. Also, few homes are equipped with an Uninterruptible Power Supply (UPS) or a backup electric generator. Few homes have measures against surges and they are often not equipped with the necessary grounding. Because sources of electromagnetic field radiation often exist inside a house or in the near area around it, careful research into the electromagnetic environment is necessary before using a home medical device.

To me, a safe medical electromagnetic environment needs to be carefully implemented to insure the safe operation of medical devices used outside hospitals. To accomplish this, it is necessary to collect detailed information about the electromagnetic environment, including the strength of electromagnetic fields generated by common telecommunication instruments and by the local transportation environment.

The Necessity of Interdisciplinary Study of Electromagnetic Wave Utilization

Currently, as mentioned above, it is becoming increasingly necessary to introduce wireless communication to a wide variety of clinical settings. This includes ensuring that signals are used that are of the strength required for the target range. IP-ization of speech communication shows great promise for the future. Although breaks in data transmission can be recovered by resending the data, in the case of speech communication uninterrupted communication must be insured. For speech communication in a hospital, if communication stops even for one second, a doctor's instructions that might affect a patient's life may not be correctly transmitted. If reconnection is necessary, a loss of valuable treatment time can occur that can affect the success of the treatment.

Electromagnetic noise can block signal reception. It is necessary to prevent both the radiation of strong electromagnetic waves from apparatus inside the hospital and to block the invasion of electromagnetic waves from outside. These problems can be solved by the use of electromagnetic shielding technology. Dielectric constants and the permeability of the building components, such as walls, doors, floors, and ceilings, should be investigated in order to guarantee that the area will receive or reject electromagnetic signals, as necessary. It is important to do a simulation of the reach of signals and to use the results to design and install the communication infrastructure. At Shimane University we experienced the following when planning the number of Access Points (AP) necessary for introducing the wireless LAN infrastructure to our new hospital building [5]. The architect assumed that six AP would be sufficient to cover one floor (38 m x 51 m, Figure 1). However, the results of our electromagnetic field propagation simulation showed that an average of 12 AP per floor was required, as shown in Figure 2 and Table 1. The reasons for this difference are thought to be that the doors of the patient rooms are made metal and that there are many more walls than in office buildings such as the architect was used to designing.

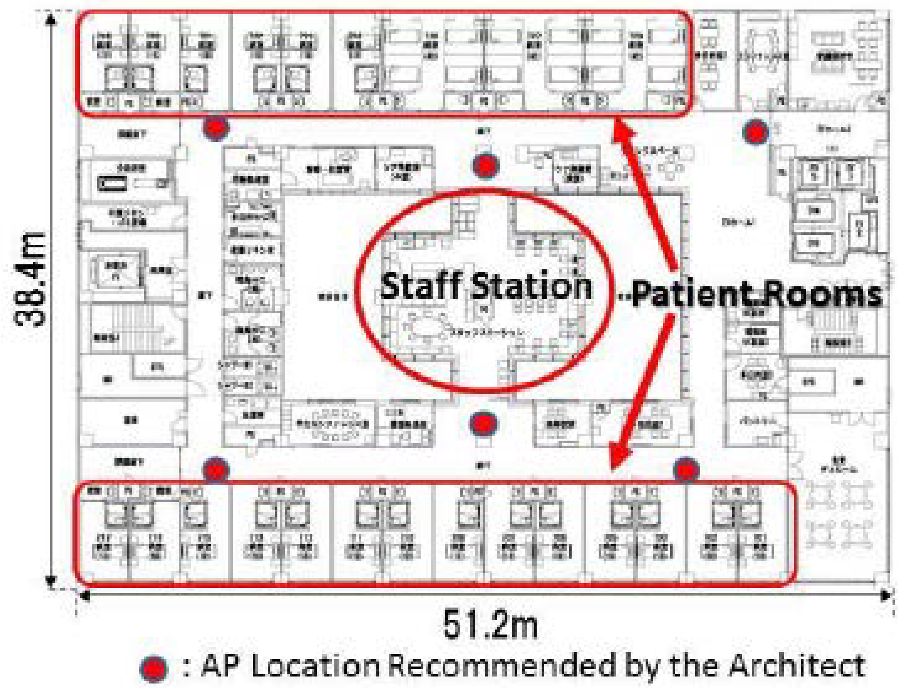

Figure 1: Floor plan of the target building (7F).

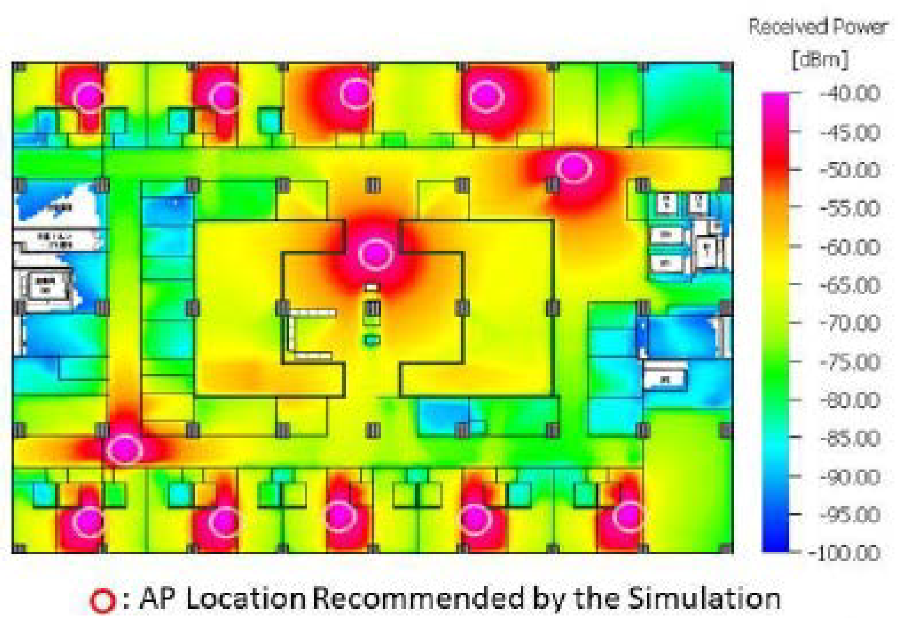

Figure 2: An example of the simulation result (7F).

Floor	5	6	7	8	9
Recommended number	12	11	12	13	12

Table 1: AP number according to the simulation results.

An additional consideration is that a hospital deals with a great deal of personal information. It is imperative that wireless communication signals that if intercepted could result in the illegal disclosure of patient information be protected. Although measures based on software, such as signal encryption, are important and generally effective, blocking signals by electromagnetic shielding should also be considered.

The above are all related to the necessity of controlling electromagnetic fields. At present, adequate techniques for the control of the fields commonly found in medical settings have not been established. Electromagnetic field propagation simulation in the design phase and the collection of information about the building components necessary for doing an accurate simulation are required. In order to improve the precision of a simulation, the properties of the material, a dielectric constant, and the permeability of each component are required. This information should be available from the structural engineer and the building company. Unfortunately, in almost all cases, the information is not shared with the network staff that does the electromagnetic wave propagation simulation. Within the construction company, the section that manages the quality of the building materials often does not share the necessary information with their sections responsible for designing the communication systems. Such sharing is absolutely necessary when introducing wireless communications, with the best results attained if collaboration is done with people from the variety of fields working on or who will work on the project, such as those involved in material, architectural, and structural engineering, as well as the end users; the medical and co-medical staff.

Conclusion

The pace of introduction of ICT (Information and Communication Technology) into the field of medicine has been remarkable. The quickest communication means available to a doctor ten years ago was a pager. Mobile phones have almost completely replaced this type of technology. Wireless LAN, such as SNS, is currently being extensively used. However, there are drawbacks in that there is the possibility of medical device malfunction if the environment in which wireless LAN signals are used is not correctly designed and implemented. The danger can depend on the output from an apparatus or on the distance between the apparatus and a medical device. In order to insure the safe use of wireless communications in medical settings it will be necessary to improve the EMC standards and to disseminate information about electromagnetic field control to the medical staff.

Hospital staff members have traditionally shown either too little, or too much, concern about EMC, based on reports of EMI on medical devices by mobile phones. The staff members of hospitals tend to give priority to effectiveness, although the consideration of safety is imperative. The field of clinical medicine is rapidly adopting new technologies, so it is important that we keep pace with the kind of medical devices that will be introduced into our hospitals in the near future, both inside and outside of the hospital. To insure safety and meet the needs of this rapidly changing environment, electromagnetic field control techniques must be established and constantly improved to meet the requirements of the environment in which medical devices are used. To achieve this, interdisciplinary collaboration is indispensable.

Acknowledgement

This work was partially supported by the Japan Society for the Promotion of Science (Basic research (B) No.24390129).

References

1. Silberberg J (1993) Performance Degradation of Electronic Medical Devices Due to Electromagnetic Interference. Compliance Engineering, Fall.
2. Health Protection Branch (Canada) (1995) Digital Cellular Phone Interference with Cardiac Pacemakers Medical Devices, Publications, Alerts I.L. No. 108.
3. Hanada E, Itoga S, Tamai H, Nagae Y, Kurosawa H, et al. (2010) "Unnecessary" Electromagnetic Field Radiated From Medical Devices. Proceedings of ISMICT 2010 (The 4th International Symposium on Medical Information and Communication Technology), A1-5, Taipei, Taiwan.
4. Hanada E, Kodama K, Takano K, Watanabe Y, Nose Y (2001) Possible electromagnetic interference with electronic medical equipment by radio waves coming from outside the hospital. J Med Syst 25: 257-267.
5. Hanada E, Kudou T, Tsumoto S (2013) Installation of Secure, Always Available Wireless LAN Systems as a Component of the Hospital Communication Infrastructure. J Med Syst 37: 9939.
6. Hanada E, Sumi T, Ishitobi F, Kudou T (2012) Improving the clinical physiological examination environment - Avoiding EMD on medical equipment used for detecting biological signals-. Przeglad Elektrotechniczny (Electrical Review) 2012: 64-66
7. Darwish A, Hassanien AE (2011) Wearable and implantable wireless sensor network solutions for healthcare monitoring. Sensors 11: 5561-5595.
8. Hanada E, Takano K, Antoku Y, Matsumura K, Kenjo Y, et al. (2000) Advantages of low output mobile communication systems in hospitals. J Med Syst 24: 53-59
9. Heslop L, Weeding S, Dawson L, Fisher J, Howard A (2010) Implementation issues for mobile-wireless infrastructure and mobile health care computing devices for a hospital ward setting. J Med Syst 34: 509-518.
10. Hanada E (2007) The electromagnetic environment of hospitals: How it is affected by the strength of electromagnetic fields generated both inside and outside the hospital. Ann Ist Super Sanita 43: 208-217.
11. Hanada E, Nakakuni H, Kudou T, Kano T (2009) Electric field intensity emitted from medical devices and its potential electromotive force according to the quality of grounding. IEEE EMC Society Newsletter 222: 48-53.
12. Tiikkaja M, Alanko T, Lindholm H, Hietanen M, Hartikainen J, et al. (2012) Experimental study on malfunction of pacemakers due to exposure to different external magnetic fields. J Interv Card Electrophysiol 34: 19-27.

This article was originally published in a special issue, **Electromagnetic Wave Theory** handled by Editor(s). Dr. Cheng-Wei Qiu, National University of Sin-
gapore, Singapore.