fortune Journals

Review Article

JOURNAL OF BIOTECHNOLOGY AND BIOMEDICINE

ISSN: 2642-9128

How Inappropriate Cabling Prevents Hospitals from Becoming "Smart" and Future Communication System Management Concerns

Eisuke Hanada[1*] and Takato Kudou[2]

Abstract

Most hospitals have introduced Information and Communication Technology (ICT), and the COVID-19 pandemic has resulted in the increased use of wireless communication to achieve a more “contactless” medical environment. The most common applications of wireless communication systems in hospitals include patient data collection and sharing, voice communication, and authentication. Transmission of physician's instructions that are input to the hospital information system can now be done through wireless LAN functions in medical settings. Such systems can be expected to greatly expand in the future. However, problems with the reliability of data transmission in wireless communication systems have arisen. In a survey by the Japanese government, nearly half of the hospitals answered that they had experienced problems with wireless communication. Here, we describe architectural problems that may become obstacles to the future expansion of wireless communication, then propose countermeasures.

Keywords: Hospital Building; Wireless Communication; Cabling; EPS

Progress of ICT introduction in hospitals and wireless communication

Most hospitals have introduced information and communication technology (ICT), such as hospital information systems (HIS) and hospital networks, and the recent COVID-19 pandemic has resulted in the further introduction of wireless communication with the aim of realizing "contactless" communication. This is evident in a survey conducted by the Japanese government, especially in the introduction of wireless communication for "online medical consultation" and "online visitation" [1]. Medical wireless telemetry and wireless LAN are typical systems for wireless communication in Japanese hospitals. RFID and Bluetooth are used for near field communication. In Japan, a Personal Handy-phone System (PHS) has been widely used as an independent in-house telephone network, especially in nurse call systems [2]. However, PHS voice communication service on the public network was terminated in 2021. It is expected that it will be replaced by systems using in-house LTE, in-house 5G, or VoIP. The most common applications of these wireless communication systems are patient data collection and sharing, voice communication, and authentication. By equipping medical devices with wireless LAN functions, the entry and transmission of physician's instructions to the HIS through wireless communication systems can be done, and such applications are expected more prevalent in the future. However, problems about the reliability of data transmission in wireless communication have arisen. In the aforementioned survey [1], nearly half of the hospitals

Affiliation:
[1]Faculty of Science and Engineering, Saga University, Saga-shi, Saga, 840-8502 Japan

[2]Faculty of Science and Technology, Oita University, Oita-shi, Oita, 870-1192 Japan

***Corresponding author:**
Eisuke Hanada, Faculty of Science and Engineering, Saga University, Saga-shi, Saga, 840-8502 Japan.

Citation: Eisuke Hanada, Takato Kudou. How Inappropriate Cabling Prevents Hospitals from Becoming "Smart" and Future Communication System Management Concerns. Journal of Biotechnology and Biomedicine. 7 (2024): 149-152.

Received: February 13, 2024
Accepted: February 21, 2024
Published: February 27, 2024

Hanada E and Kudou T., J Biotechnol Biomed 2024
DOI:10.26502/jbb.2642-91280135

responded that they have experienced problems related to wireless communication. Rapid and accurate information sharing is essential, especially in clinical environments such as that of large hospitals. In this paper, we list architectural and administrative problems that can become obstacles to the future expansion of wireless communication use and propose countermeasures against them.

Interference with wireless communication by hospital building components

In the aforementioned survey [1], many hospitals answered as problematic that "radio waves cannot be received in a specific area" by their medical telemetry system or wireless LAN. Some of these problems are simply due to the attenuation of signals by the distance between the terminal (transmitter in the case of medical telemetry or of laptop PCs, smartphones, or tablets in the case of wireless LAN) and the antenna (access point (AP) in case of wireless LAN). Other problems are due to the presence of things that shield, reflect, or absorb signals between the terminal and the antenna. There were also many responses for wireless LAN, such as "hard to connect" and "slow transfer rate", both of which indicate that the terminal is receiving attenuated signals from the AP. In each of these cases, one of the most common causes is the inappropriate location of the antenna (AP). There is also the possibility of distance attenuation due to inappropriate roaming settings at the terminal.

Wireless communication antennas in hospitals are often installed in the ceiling. If the cables were exposed, patient safety could be compromised, in addition to hygiene and aesthetic considerations. After much research into these factors, we have identified various possible causes for inappropriate antenna locations, as follows:

(1) Inappropriate estimation of the terminal location range during antenna installation

(2) Blockage of the antenna installation path by pillars, beams, etc.

(3) Use of materials that act as radio wave shields (or absorbers) between the antenna and the terminal

(4) Problems in the electromagnetic environment, such as metal objects and electromagnetic noise on the antenna or terminal

Medical telemetry systems are used to collect and monitor patient biological information. The interruption of communication with a wireless medical telemetry system can lead to a delay in the detection of problematic changes in a patient's condition due to the lack of data collection and/or transmission, which may become a serious problem in terms of patient safety. Clinical accidents have been reported that were due to the inability to respond to abnormal signals [3]. In Japan, the output power from transmitters in a wireless medical telemetry system is limited to 1 mW. Therefore, it is recommended that the terminal should be within a range of about seven meters from the antenna to insure normal reception. Radio waves in the frequency range between 420 MHz and 450 MHz used by Japanese wireless medical telemetry systems are known to have low distance attenuation. To date the identification of transmitters has been done only by frequency (channel). This has led to some interference (mainly, crosstalk) due to the reception of signals from other hospitals nearby [4]. There are two types of antennas used in Japanese medical telemetry systems. One is a "multi-antenna system" that uses whip antennas, and the other is called a "leaky coaxial cable system". In the latter case, the cable itself also serves as an antenna, but because the electromagnetic shielding of the cable is not sufficient due to the structure of the cable, it is necessary to install the cable without touching anything that contains metals. When patient information and physician instructions are distributed over wireless LANs, interruption of communication will lead to problems with diagnosis and treatment and a transfer rate reduction will lead to a decrease in operational efficiency. Wireless LANs are now commonly being added to medical devices and, as in the case of wireless medical telemetry systems, events such as failure to detect abnormalities in a medical device itself may occur. As for causes of transfer rate reduction or communication blockage in wireless LANs, there are reports of interference due to conflicting radio waves broadcast over the same channel, as well as communication blockage due to mutual interference with Bluetooth [4]. It is essential to take security measures, mainly to prevent interception, and we believe that it is necessary to control the range of radio waves by using shields specialized for wireless LAN frequencies [5]. Other factors related to these problems are that too often the person in charge of the wireless communication system was not involved in the design phase of the construction, including inappropriate installation in the ceiling or the electrical pipe space/shaft (EPS).

Ceiling design and control

The ceilings of hospitals (especially in hospital wards) contain air ducts and drainpipes for air conditioning equipment, electric power lines, and communication lines. These include wiring for lighting and nurse call-related functions, in addition to the electric power supply to outlets in patient rooms. They may also have antennas for wireless communication (including APs) and fire prevention equipment. In some cases, LAN cables, signal distributors, signal amplifiers, and gas pipes are installed. In Japan, the electric power supply wiring is usually for 100V single-phase alternating current, but higher voltages and currents may be used, depending on the equipment or other special needs. Ceiling spaces should be designed, constructed, and managed in an integrated manner. However, the larger the size of the hospital, the more the design and management

Hanada E and Kudou T., J Biotechnol Biomed 2024
DOI:10.26502/jbb.2642-91280135

tends to be divided between departments responsible for the various aspects of the system. For example, air conditioning is managed by the equipment (mechanical) department, electricity by the electrical department, and antennas and communication wiring by the management department of each system to be used. Each of them makes its own requests to the building maintenance or construction department, often at different times in the process. This is because, especially in large hospitals, orders for construction, equipment, interiors, and fixtures are not placed at the same time, but rather on a fixed schedule as construction progresses. In addition, equipment is divided into categories such as air-conditioning, electricity, and communications, with each component being designed and ordered separately. Equipment handled by the information and communication department (except for telephones) is often treated as equipment rather than facilities, so the wiring design is often done after the framework and ceiling structure are decided.

As a result, "blockage of the antenna path by pillars and beams" and "problems with metal objects and the electromagnetic environment around the antenna" are likely to occur. As specific examples, the antenna of a medical telemetry system needs to be installed in each patient room, but a beam may be placed at the border between the ceiling in the corridor and the patient room ceiling that makes it impossible to run cables to the room or the antenna may be forced to be placed near a metal air-conditioning duct. This can be problematic, such as when the range within which the signal can be received is not as expected due to shielding and reflection [6].

As for the "use of shielding materials between antennas and terminals," not only are ceilings themselves often suspended with metal frames, the increasing number of metal doors currently being used in patient rooms may cause excessive attenuation of radio waves when antennas can only be installed in corridors. In addition, especially in wireless medical telemetry systems, there is a possibility of deterioration of the distribution unit over time.

Problems with EPS and substations

In buildings with multiple floors, shafts are installed for water supply, drainage, electric power supply, and communication wiring. However, because electrical wiring must be kept away from water, EPS is installed as a shaft for electrical wiring. Among the communication cables installed in a hospital, those related to telephones are often ordered under the same contract as the electrical wiring, so they often share the same EPS. LAN cables may also be installed in the EPS because they need to be routed across floors. As a result, both distribution boards and floor switches (routers) are often placed in the EPS.

In Japan, a grounding center should be placed in the distribution board that is based on JIS T1022, a Japanese Industrial Standard (JIS). When this grounding is poor (has high resistance), broadband electromagnetic noise can be generated near the distribution board and electrical outlets. In addition, when an EPS is placed near an elevator, large current power supply wiring for the elevator (power line) may be placed in the EPS. It is possible that an AC magnetic field will be induced around this wiring. In contrast, telephone lines and LAN cables are usually not shielded, and low voltage and small current signals flow through them. Therefore, if the conditions are bad, i.e., the wiring is made of metal and placed near power lines, the induced magnetic field may interfere with the communication lines. Also, if the EPS is connected to the ceiling without shielding, there is a possibility of interference with signals from wires in the ceiling. Many large hospitals have recently been supplying electric power through high-voltage wiring. This is due to the introduction of medical equipment that requires high current, such as magnetic resonance imaging (MRI) systems and linear accelerators (radiotherapy equipment). In this case, it is necessary to install electrical substation facilities on the site. In the case of Japanese university hospitals (600 beds or more), high-voltage power receiving equipment (mainly for receiving 6,600V three-phase AC power) and special high-voltage power receiving equipment (required for power supply exceeding 7,000V, when receiving 22,000V three-phase AC power, for example) are installed. In addition, facilities for transforming the power to 100V single-phase, etc. (sometimes called an "electrical room") may be placed in the building. In this room, wires with large currents are sometimes placed, and if these wires are braided, a strong AC magnetic field may be observed in nearby rooms [6].

Necessary measures for future, large-scale hospital construction

In September 2021, the Architectural Institute of Japan (AIJ) published "Guidelines and descriptions for building plans considering the use of radio wave equipment in medical institutions - For Wireless medical telemetry systems" [7]. These guidelines state that when constructing a new hospital, the model of the medical telemetry system should be decided as early as possible and that information sharing should be promoted. Most of the problems with wireless medical telemetry systems could be solved by involving communication staff from the early stage of construction and selecting the model and estimating the patient's range of activity in the early in the process. This is also true for wireless LAN. However, in consideration of the time required for construction, early selection of the model has the disadvantage that the latest model cannot be introduced at the time of hospital opening, and it may also cause the supplier to hold inventory. However, we believe that hospital administrators (those who place orders, owners) and other concerned parties should raise their awareness of

Hanada E and Kudou T., J Biotechnol Biomed 2024
DOI:10.26502/jbb.2642-91280135

the fact that interruption or quality deterioration of wireless communication will be a major problem for both management and patient safety in future large-scale hospitals.

Apart from this, the ceiling structure should be designed to allow for extra space. After a hospital building opens, it is often a few decades before a major renovation takes place. Medical devices and communication systems are often updated during this time, and new wiring needs to be run through the ceiling. In the case of wireless LANs, it is highly likely that the wiring from APs to routers, etc. will need to be updated due to an increase in the transfer rate. These problems could be ameliorated by the simple act of allowing extra ceiling space at the time of building construction. The location of an EPS should also be designed carefully. It is necessary to separate power lines from other communication wiring and to provide a separate pipe space specifically for communication wiring. If network devices (floor switches, etc.) are to be installed in the EPS, power supply equipment is necessary to drive them. If the network equipment stops, the communication between the terminal and the HIS server will be interrupted, thus, an emergency power supply, such as UPS, is necessary. It is extremely difficult to work in the ceiling of the ward corridors after a hospital opens. Inpatient wards are in operation 24 hours a day, 365 days a year, and the top priority is to ensure patient safety and maintain a good environment for patient care. Normally simple acts such as setting up a stepladder in the corridor may be difficult in the working atmosphere of a hospital. Noise must also be prevented at night, so it is difficult to perform any kind of work at that time in the wards. The establishment of a system, the examination of procedures, and the planning of safety measures during implementation, including daily inspections, should be done carefully. As a part of the establishment of the system, it is important to set up inspection ports, and it is also necessary to attach notes to show the purpose and location of both ends of each cable to be installed. For modern medical care, has become indispensable in hospitals. It is our hope that more consideration to the effective use of ICT will be given from the design stage, so that it can be used safely and securely.

Declarations

Ethical Approval and Consent to participate

Not applicable

Human Ethics

Not applicable

Consent for publication

Both authors agreed. No other persons / companies require consent.

Availability of supporting data

Not applicable (no measurements or experiments are done in this study)

Competing interests

No competing interests exist.

Funding

The Japan Society for the Promotion of Science

Authors' contributions

Hanada had written main text; Kudou reviewed and added the part about shielding technology.

Acknowledgements

This work was supported in part by a Grant-in-Aid for Scientific Research from the Japan Society for the Promotion of Science (Basic Research (C), No. 20K04623).

References

1. Electromagnetic Compatibility Conference Japan. Results of the 2020 survey on the promotion of appropriate radio frequency use in healthcare institutions (2021).
2. Hanada E, Antoku Y, Tani S, et al. Electromagnetic interference on medical equipment by low power mobile telecommunication system. IEEE Transactions on Electromagnetic Compatibility 42 (2000): 470-476
3. Nakamatsu S. Cases of incident regarding radio frequency use in hospitals. Transactions of Japanese Society for Medical and Biological Engineering 57 (2019): 11.
4. Ministry of Internal Affairs and Communications (Japan). Collection of case studies of initiatives to promote the use of radio frequency in medical institutions in 2009 II (case of incidents) (2018).
5. Kudou T, Miura K, Hanada E. Numerical analysis of band-selective electromagnetic shielding by using dielectric square lattice type periodic structure. Proceedings of EMC Sapporo & APEMC (2019): 6-9
6. Hanada E. The electromagnetic environment of hospitals: How it is affected by the strength of electromagnetic fields generated both inside and outside the hospital. Annali dell'Istotuto Superiore di Sanita (Annals of the Italian National Institute of Health) 43 (2007): 208-217
7. Architectural Institute of Japan. Guidelines and descriptions for building plan considering the use of radio wave equipment on medical institution - For Wireless medical telemetry systems. AIJ Environmental Standard AIJES-E0005-2021 (2021).