RFID Usage in the Patient Care Environment

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Abstract

The use of radio frequency identification equipment in the clinical setting has become prevalent. This study examines the effects of two common, passive RFID antennas, near field and far field, and five general types of patient care equipment in real use scenarios. Data was collected regarding the function of the patient care equipment in the radio frequency fields of the antennas in situations which resemble common use. Devices performed without interference.

RFID in the Clinical Setting and Experimental Design

The goal of the project was to collect data which could be used to evaluate the impact of RFID technology, as it is currently employed in many systems today, within a traditional patient care area of a hospital or clinic. To replicate common configurations, tags were placed on equipment and antennas were placed in locations which might resemble common use cases. As an example, infant security systems often place their antennas behind ceiling tiles so as to limit an intruder's ability to disable the system. As a result, the design of the experiment closely matched actual practice.

Materials and Methods

RFID testing was completed on March 10, 2008 at Community North Hospital, Indianapolis, Indiana. A patient care room was selected to conduct the tests to best replicate the setting in which both antennas and clinical devices would be used. The medical devices (see Table 2) were operated in a normal manner using a patient simulator or test subject when necessary. Table 1 identifies the equipment used to establish the RFID tag identification. Equipment included in this study were non-invasive blood pressure monitors (NIBP), pulse oximetry monitors, intravenous pumps, EKG Monitors, and sequential compression devices.

Antenna Configurations

For this study, two RFID systems were used. One system (host computer, transceiver, antenna, and tag) contained a Near-Field antenna operating in a "dense reader mode" and a Near-Field tag. The other system contained a Far-Field antenna operating in a "high throughput" mode and a Far-Field tag. The transceivers were connected to the host computers through crossover cable and accessed through TCP/IP. The antennas were connected to the transceivers through coaxial cable using TNC connectors. The antennas were placed side-by-side facing the same direction toward the medical devices. Tags were placed on the face of each piece of equipment. Throughout the entire test for each piece of equipment, not only were the antennas and tags facing each other, but the antennas were emitting the RF signal at the same height level as the tags. This ensured that the highest powered RF signals were emitting directly at the face of each piece of equipment which ensured the highest possibility for interference.

The maximum power delivered to the antennas can be quantified using the technical specifications for the transceiver and antennas. The transceiver was set to output the maximum power deliverance of 30 dBm to the antenna. The default non-extended cables add a maximum gain of 6dBi (6dB relative to an isotropic antenna), which results in a maximum power deliverance of 36dBm to the antenna. This calculation will work for any RFID system, but due to the environment, antenna set-up, and components, the actual power delivered to the RFID tag will vary in each system.

Distance interval selection

Radiation power density falls off at a rate of $1/D^2$ (inverse of distance squared) in free space. This means that in an open area, if there was no interference at one foot, none would be expected at larger distances. Taking into account that the hospital environment is not an open space, there was a need to take samples at a variety of distances. Reflections from room elements can cause both constructive and destructive interference. Therefore, there could be interference a two feet even if there was no interference at one foot. Distances were selected of 1, 2, 4, and 6 feet (30, 60, 120, and 180 cm respectively) from the antenna to ensure adequate exploration of any potential constructive interference. Diagram 1 illustrates the dramatic roll off in magnetic field as distance from the antenna increases.

Careful consideration of actual practice and device use were included in distance selection for equipment testing. The use of RFID is meant to allow the tracking of devices, disposables, patients or other items at a distance, without physical contact. With this goal in mind, 30 cm was selected as the closest distance interval to be tested.

Testing Procedure for each category of device

1. device was selected from the patient care area, powered and connected to simulator or IV apparatus
2. two RFID tags were placed on the lower front of the device
3. the near field antenna was powered on to verify the detection of the tag
4. the device was located six feet from the near field antenna
5. device performance was assessed and recorded
6. the device was moved through 1, 2, 4 and 6 foot (30, 60, 120, and 180 cm respectively) intervals verifying device performance at each interval
7. repeat steps 1-6 eight times
8. the near field antenna was powered off and the far field antenna was powered on then steps 1-7 were repeated
9. steps 1-8 were repeated for another device of the same type for a total of 5 devices of one category

A total of 32 tests were performed using each antenna for each device. Each device was evaluated 64 times (at different distances) in the presence of the antennas. A total of 25 devices were placed into the RFID fields. A total of 320 evaluations were performed on each of the five categories of devices, overall resulting in 1,600 performance assessments.

Results

This study involved common clinical equipment located in a typical patient care room. Devices were selected to be included in the study based on frequency of use with general patient populations. Various device manufacturers and models were used to add variability and similarity to the clinical setting. Tests were conducted on a patient care floor within a hospital and in a patient care room to simulate a typical use case scenario. Other patient care areas such as the operating room and intensive care units were not included in this study.

The data in Table 3 summarizes the observations made regarding equipment performance. In all, 1600 performance assessments were conducted and no interference from the RFID devices was observed. All devices performed as expected.

The Possibility of Interference

The fields which are induced around RFID antennas can be powerful at very close distances. While collecting data, a 12 lead Marquette MAC VU became available. Although not part of the designated equipment list identified for evaluation, it was decided to place the device in the field of the antennas to observe any effects. The EKG recorder was connected to a 10 wire EKG simulator. Interestingly, tremendous interference was observed in the EKG display when the patient cable wires were coiled and placed between the RFID tags and the near field antenna within a one foot (30 cm) distance between the device and the antenna. To further explore this problem, a second 12 lead EKG recorder, a Marquette Mac 5000 was connected in a similar manner. Less interference was noted however some views were overwhelmed with interference, enough to significantly impact the diagnostic value of the recording (see Photo 3).

Essentially, the coils of wire created inductive interference. Any electrical wiring and components can have this effect when close to the source of energy. Because power and distance have a non-linear relationship, the closer a device is to the antenna, the greatly likelihood of interference. Placing an antenna directly in contact with any electrical device would almost certainly generate interference which could alter that device's performance.

Conclusion

This study determined that RFID systems, including near and far field antennas and passive tags, when used in typical and ordinary arrangements, did not influence the performance of commonly used medical devices such as physiological monitors and intravenous pumps. The use of RFID systems to manage inventory, track items and ease patient billing data collection can be used in general patient care rooms without concern of adverse device performance. As institutional polices are created for the use of RFID in the clinical setting, the results of these tests should support the implementation of this technology. That said, as new RFID components and systems are introduced, further study may be necessary to evaluate evolving RFID technology and its impact on medical equipment.

Table 1
RFID equipment

2	Gateway Laptop PCs running Windows XP operating system
2	Aluminum Stands (to hold antennas)
1	Impinj Speedway Reader (Transceiver)
1	Alien 915 MHz Linear Far-Field Antenna *(P/N ALR-9611-CR)*
1	Impinj Brickyard Near-Field Antenna *(P/N CS-777)*
1	Alien Far-Field RFID Tag
1	Impinj Near-Field RFID Tag

Miscellaneous cables

Table 2 Clinical Equipment Tested

Device	Model	No of devices	Manufacturer
NIBP	Dinamap Procare400	1	GE Medical, Jupiter, FL
	Welch Allyn 5200	4	Welch Allyn, Skaneateles, NY
Pulse Oximetry	Radical 5	1	Masimo, Irvine, CA
	Radical 7	4	Masimo, Irvine, CA
Pumps	Medley PC unit	3	Alaris, San Diego, CA
	Gemini PC-1	1	Imed, United Kingdom
	Kangaroo Control	1	Tyco-Healthcare, United Kingdom
EKG Monitors	GE Dash 4000	4	GE Medical, Jupiter, FL
	M-Series	1	Zoll, Chelmsford, MA
Sequential Compression Devices	Venaflow System 30A	5	Aircast, Summit, NJ

Table 3
Results Summary - Interference Assessment

Category of device	short range				long range			
	1 ft 30 cm	2 ft 60 cm	4 ft 120 cm	6 ft 180 cm	1 ft 30 cm	2 ft 60 cm	4 ft 120 cm	6 ft 180 cm
NIBP - 5 devices	0	0	0	0	0	0	0	0
pulse oximeter - 5 devices	0	0	0	0	0	0	0	0
Pumps - 5 devices	0	0	0	0	0	0	0	0
EKG monitor - 5 devices	0	0	0	0	0	0	0	0
Sequential Compression Devices - 5 devices	0	0	0	0	0	0	0	0

0 = no interference
1 = interference

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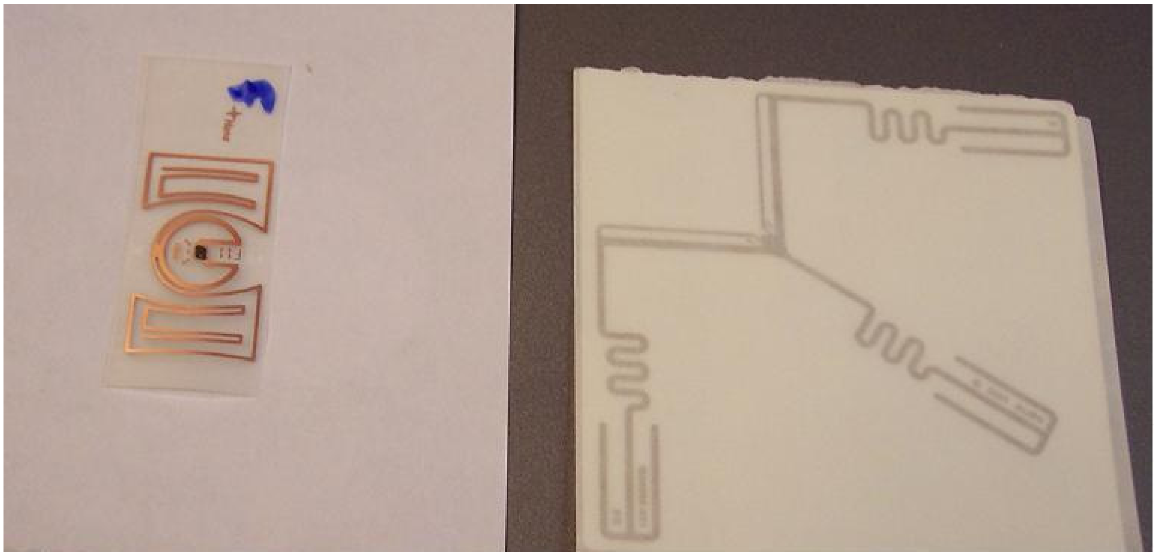

Photo 1

Tags: left, near field tag right, far field tag

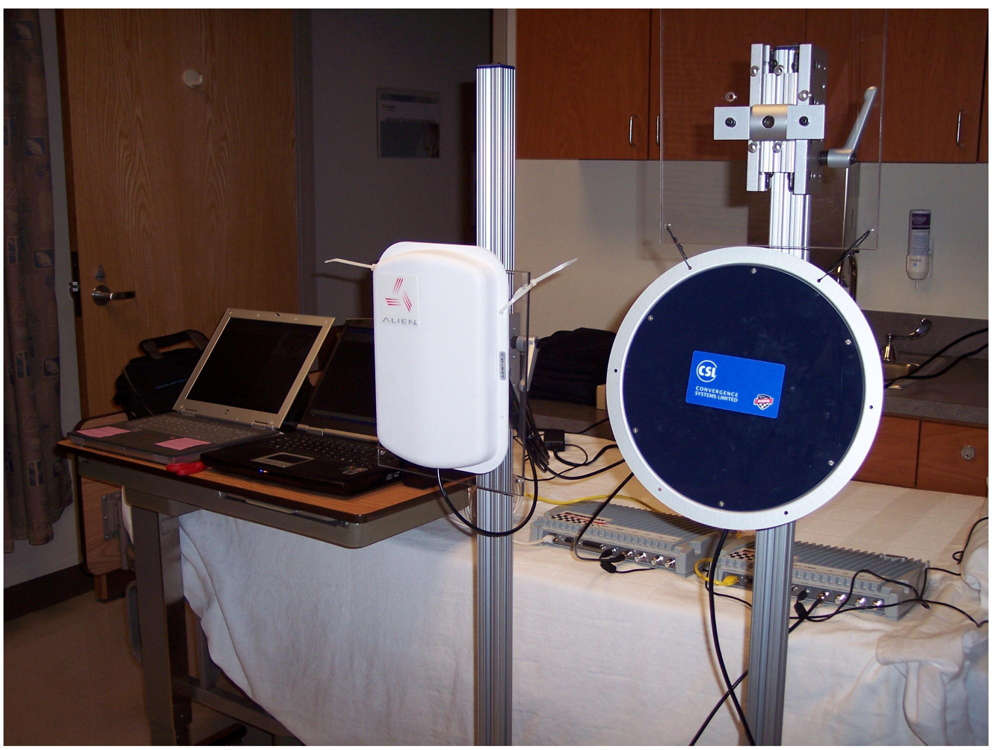

Photo 2

The white rectangle in the center of the photo is the far field antenna and the circle in the right side of the photo is the near field antenna

Photo 3
Interference as seen on a 12 Lead EKG recorder

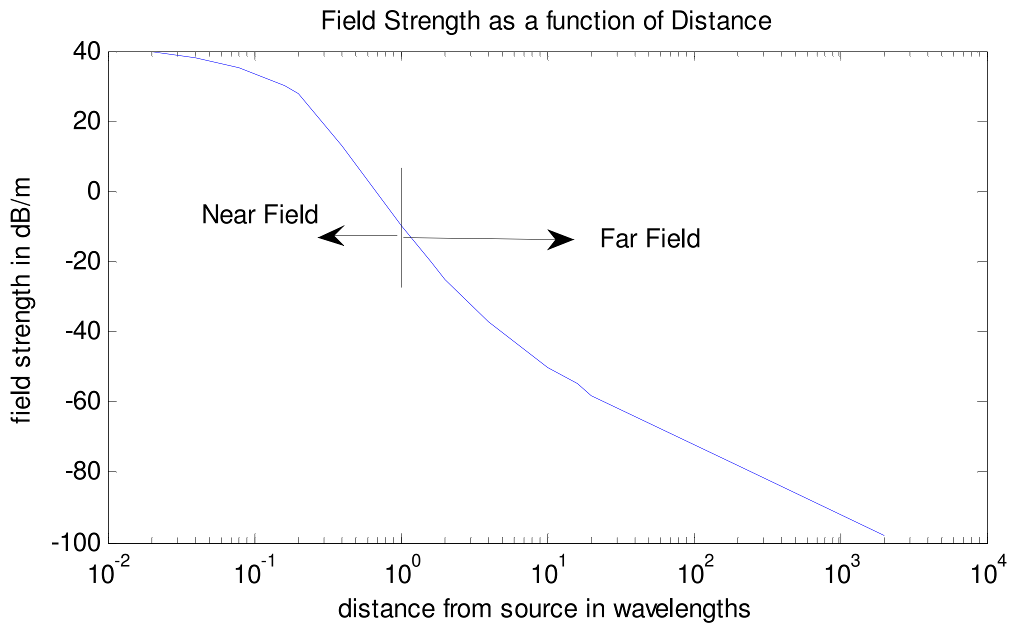

Diagram 1

magnetic field strength decay in relation to the distance from the antenna