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Intelligent Management System for Personnel, Supplies, and Equipment Information in Operating Rooms Based on RFID Technology: Postprint

Authors: Yang Liping; Wu Lingyu; Chen Meihao

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Abstract

Objective: To achieve intelligent management of personnel, items, and equipment information in the operating room through radio frequency identification (RFID) technology. Methods: A total of 200 surgical patients from our hospital were enrolled, with 100 cases assigned to the observation group that utilized RFID technology and the other 100 cases assigned to the control group that employed conventional manual management methods, such as manual verification of identities between medical staff and patients and preoperative preparation of equipment and items. Both groups were observed for preoperative preparation time, item inventory management, and postoperative infection status. The two groups were compared in terms of instrument delivery errors, equipment utilization rate, surgery frequency, and costs. Additionally, the satisfaction of medical staff and patients and operating room work quality were compared between the groups. Results: The preoperative preparation time, item inventory error rate, and postoperative infection rate in the observation group were all significantly lower than those in the control group ($P<0.05$). The effective utilization rate (99% vs 91%), daily surgery volume (5.38 ± 1.23 cases vs 3.17 ± 0.74 cases), and surgical costs (5482.38 ± 1231.23 yuan vs 7032.49 ± 1536.74 yuan) in the observation group were all significantly better than those in the control group ($P<0.05$). Patient satisfaction was 96%, physician satisfaction was 94%, nurse satisfaction was 97%, and the operating room work quality assessment score was 92.37 ± 3.13 points in the observation group, all significantly higher than those in the control group ($P<0.05$). Conclusion: RFID technology facilitates comprehensive management of operating room personnel, items, and equipment, improves work efficiency, and reduces the incidence of medical accidents and medical costs.

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Full Text

Intelligent Management System for Operating Room Personnel, Items, and Equipment Based on Radio Frequency Identification Technology

YANG Liping, WU Lingyu, CHEN Meihao
Operating Room, Xili People' s Hospital, Shenzhen 518055, China

Abstract

Objective: To achieve intelligent information management of operating room personnel, items, and equipment through radio frequency identification (RFID) technology.

Methods: A total of 200 surgical patients in our hospital were selected and randomly divided into an observation group (n=100) that applied RFID technology and a control group (n=100) that used conventional manual management methods, such as manual verification of medical staff and patient identification, and preoperative equipment and item preparation. We observed preoperative preparation time, item inventory management, and postoperative infection rates between the two groups, and compared instrument delivery errors, equipment utilization rates, operation frequency, and costs. Additionally, we assessed and compared satisfaction levels among medical staff and patients, as well as operating room work quality.

Results: The observation group demonstrated significantly shorter preoperative preparation time, lower item inventory error rates, and lower postoperative infection rates compared to the control group ($P<0.05$). The observation group also showed superior performance in equipment effective utilization rate (99% vs 91%), daily operation volume (5.38±1.23 vs 3.17±0.74 cases), and operation costs (5482.38±1231.23 vs 7032.49±1536.74 yuan) ($P<0.05$). Patient satisfaction (96% vs 88%), physician satisfaction (94% vs 86%), nurse satisfaction (97% vs 89%), and operating room work quality assessment scores (92.37±3.13 vs 81.46±2.99 points) were all significantly higher in the observation group ($P<0.05$).

Conclusion: RFID technology facilitates comprehensive management of operating room personnel, items, and equipment, improves work efficiency, reduces medical accident incidence and healthcare costs.

Keywords: radio frequency identification technology; operating room; intelligent information management

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Radio frequency identification (RFID) technology enables the identification of specific targets and reading/writing of relevant data through radio signals. This technology has been applied across multiple fields to accelerate workflow and im-

prove efficiency [1-2]. Developed countries such as the United States and Japan have pioneered research on this technology, applying it to various healthcare domains including infant anti-theft management, special patient location tracking, electronic file labeling, drug safety, and medical waste disposal, achieving remarkable results [3-5]. Currently, intelligent hospital information management has become an emerging trend in China, with attempts to introduce RFID technology into the medical industry, though most research has focused on medical equipment information management [6-9]. During implementation, RFID technology still faces challenges including cost issues, international standard formulation and promotion, privacy concerns, and electromagnetic interference [10]. Nevertheless, this study proposes embedding long-range, contactless RFID technology into key medical instruments, items, patient wristbands, and staff ID cards in operating rooms to establish an "Internet of Things" platform that interconnects medical equipment, patients, medical staff, and information systems. This platform enables real-time acquisition of medical resource usage status and creates a surgical medical resource traceability system, providing favorable conditions for transparent and safe surgical medical services. Through comparative analysis, we found that introducing RFID technology in operating rooms not only improves work efficiency but also enhances surgical safety, particularly by assisting in surgical safety verification, reducing medical error rates, and thereby improving both economic and social benefits for hospitals [11]. The results are reported below.

1.1 General Information

We randomly selected 200 patients who underwent surgery in our hospital between January 2014 and December 2016 as study subjects. Patients were randomly divided into an observation group and a control group (n=100 each) according to the chronological order of surgery dates. The observation group consisted of 63 males and 37 females with an average age of 46.38±18.41 years, while the control group had 61 males and 39 females with an average age of 44.17±19.24 years. There were no statistically significant differences in gender or age between the two groups ($P>0.05$).

1.2 Management Methods

The control group received conventional operating room management methods, including manual verification of medical staff and patient identification, and preoperative equipment and item preparation. The observation group underwent optimized management using RFID technology, with the following specific procedures:

1.2.1 Hardware Equipment System Establishment This component included an electronic tag identification system for personnel, items, and equipment; a sensor reception system distributed across different areas of the operating room; and an interconnecting system linking the sensors, computer equip-

ment, and the Hospital Information System (HIS).

1.2.2 Automatic Analysis Software Development Using Microsoft Visual C# and SQL Server as the database development platform, we designed a Windows-based operating system capable of running in network environments and connecting with the hospital' s HIS. The system could export database data and modify database information according to system changes.

1.2.3 Module Management The system automatically analyzed and managed movement information of tagged objects (personnel, items, equipment) and integrated with the HIS to export corresponding analysis data. The modules included: (1) Automatic management module for storage and use of sterile items, disposable materials, and high-value consumables in the operating room: tagged items moving between different areas could be identified by sensors at various locations, automatically generating flow records, and once used in the operating room and eligible for billing, automatically generating charge items; (2) Operating room equipment usage management module: identified equipment used in different operating rooms, automatically generating usage records and charge items; (3) Operating room scheduling module: after receiving surgical notifications, dragging the electronic version into the operating room view completed scheduling while importing patient, surgeon, anesthesiologist, and nurse information into that operating room to facilitate subsequent surgical safety verification; (4) Assisted surgical safety verification module: when surgeons, anesthesiologists, nurses, and patients entered the operating room, sensors automatically identified personnel and compared them with scheduled staff, triggering alarms for discrepancies to prevent wrong-patient errors and automatically verifying whether relevant equipment and items were ready; (5) Automatic billing module: during surgery, scanning and confirming items, drugs, and equipment to be used, connecting with the HIS system to automatically generate charges and import usage personnel into the accounting system to enable performance tracking.

1.3 Observation Indicators

We observed preoperative preparation time, surgical item inventory management, postoperative infection rates, instrument delivery errors, equipment utilization rates, operation frequency and costs, patient satisfaction, medical staff satisfaction, and operating room work quality scores [12].

1.4 Statistical Methods

Data were processed using statistical software. Measurement data were expressed as mean ± standard deviation and compared using t-tests. Count data were analyzed using ^{2} tests. $P<0.05$ was considered statistically significant.

2.1 Comparison of Preoperative Preparation, Item Inventory, and Postoperative Infection

The observation group' s average preoperative preparation time was 1.53±0.69 days, with only 2 cases of item inventory errors and 1 case of postoperative infection, all significantly lower than the control group (P<0.05,).

2.2 Comparison of Instrument Delivery Errors, Equipment Utilization, Operation Frequency, and Costs

There was no statistically significant difference in instrument delivery errors between the two groups. The observation group' s equipment effective utilization rate was 99%, daily operation volume was greater than the control group (5.38±1.23 vs 3.17±0.74 cases, P<0.05), and operation costs were lower than the control group (5482.38±1231.23 vs 7032.49±1536.74 yuan, P<0.05,).

2.3 Comparison of Patient and Medical Staff Satisfaction and Operating Room Work Quality

Patient satisfaction, physician satisfaction, and nurse satisfaction in the observation group were all higher than in the control group (P<0.05). The operating room work quality assessment score was 92.37±3.13 points, significantly higher than the control group' s 81.46±2.99 points (P<0.05,).

3 Discussion

Intelligent hospital information management has become a crucial component of modern hospital construction. Although the introduction of HIS has greatly facilitated patient care and improved hospital diagnosis and treatment levels, personnel scheduling and item/equipment configuration in operating rooms still cannot avoid manual management errors. Therefore, how to apply information systems to improve medical service quality, ensure patient safety, and enable full utilization of medical resources represents a key focus of current hospital information management construction [13]. Reports indicate that RFID technology integration into routine operating room management helps strengthen coordinated management of patients, medical staff, and medical equipment, establishes a unified dynamic information management platform, significantly improves medical staff work efficiency, enhances medical equipment monitoring and integration, increases equipment utilization rates, and thereby reduces medical accidents and costs while ensuring safe medical operations [14].

RFID technology utilizes radio frequency signals for information transmission, featuring long-distance, contactless automated identification. Compared with conventional magnetic cards and IC cards, RFID offers advantages including larger memory capacity, stronger penetration, and higher security [15], and has been widely applied in logistics, retail, manufacturing, and other fields with favorable economic benefits [10]. Based on these characteristics, this study attempted to embed RFID technology for intelligent information management of

operating room personnel, items, and equipment according to operating room workflow characteristics. The findings revealed that RFID technology introduction shortened preoperative preparation time, reduced item inventory error rates, and improved equipment utilization rates in the observation group, reflecting the high efficiency and practicality of RFID automated identification and consistent with other research results [16]. Because RFID technology emphasizes scientific information verification and precise data, proper medical staff arrangement and readiness of surgical items and equipment resulted in lower postoperative infection rates in the observation group compared to the control group, highlighting the importance of surgical information for patient safety [17-19]. Due to intelligent surgical scheduling that saved considerable manpower and followed strict verification protocols with timely automatic cost generation, work efficiency improved and unnecessary surgical expenses were reduced. Consequently, the observation group showed increased daily average operation volume and decreased average operation costs, consistent with Xu Tao' s research conclusions [20]. The observation group' s medical staff and patient satisfaction and operating room work quality assessment scores were all significantly higher than the control group' s, demonstrating that RFID technology application makes hospital resources transparent, public, and data-driven, reduces medical staff workload, and allows more time for communication with patients while enabling patients to obtain medical information promptly, reducing consultation time and receiving more medical care [21].

In summary, applying RFID technology for intelligent information management of operating room personnel, items, and equipment helps shorten preoperative preparation time, reduce item inventory error rates and postoperative infection rates, improve equipment utilization, save operation costs, enhance satisfaction among medical staff and patients, and improve operating room work quality, demonstrating clear economic and social benefits worthy of further clinical implementation and promotion.

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